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HDF Command-line Utilities
Chapter 1

Introduction to HDF

1.1 Chapter Overview

This chapter provides a general description of HDF including its native object structures, application programming interface, and accompanying command-line utilities. It also provides a short discussion of HDF’s original purpose and philosophy, and concludes with a list of the platforms that HDF has been ported to.

1.2 What is HDF?

The Hierarchical Data Format, or HDF, is a multiobject file format for sharing scientific data in a distributed environment. HDF was created at the National Center for Supercomputing Applications to serve the needs of diverse groups of scientists working on projects in various fields. HDF was designed to address many requirements for storing scientific data, including:

- Support for the types of data and metadata commonly used by scientists.
- Efficient storage of and access to large data sets.
- Platform independence.
- Extensibility for future enhancements and compatibility with other standard formats.

In this document, the term HDF data structures will be used to describe the primary constructs HDF provides to store data. These constructs include raster image, palette, scientific data set, annotation, vdata, and vgroup. They are illustrated in Figure 1a on page 2. Note that the construct vgroup is designed for the purpose of grouping HDF data structures.

HDF files are self-describing. The term “self-description” means that, for each HDF data structure in a file, there is comprehensive information about the data and its location in the file. This information is often referred to as metadata. Also, many types of data can be included within an HDF file. For example, it is possible to store symbolic, numerical and graphical data within an HDF file by using appropriate HDF data structures.
HDF can be viewed as several interactive levels. At its lowest level, HDF is a physical file format for storing scientific data. At its highest level, HDF is a collection of utilities and applications for manipulating, viewing, and analyzing data stored in HDF files. Between these levels, HDF is a software library that provides high-level and low-level programming interfaces. It also includes supporting software that make it easy to store, retrieve, visualize, analyze, and manage data in HDF files. See Figure 1b on page 3 for an illustration of the interface levels.

The basic interface layer, or the **low-level API**, is reserved for software developers. It was designed for direct file I/O of data streams, error handling, memory management, and physical storage. It is a software toolkit for experienced HDF programmers who wish to make HDF do something more than what is currently available through the higher-level interfaces. Low-level routines are available only in C.

The HDF **application programming interfaces**, or **APIs**, include several independent sets of routines, with each set specifically designed to simplify the process of storing and accessing one type of data. These interfaces are represented in Figure 1b as the second layer from the top. Although each interface requires programming, all the low-level details can be ignored. In most cases, all one must do is make the correct function call at the correct time, and the interface will take care of the rest. Most HDF interface routines are available in both FORTRAN-77 and C. A complete list of the high-level interfaces is provided in Section 1.4 on page 4.
Three Levels of Interaction with the HDF File

On the highest level, **general applications**, HDF includes various **command-line utilities** for managing and viewing HDF files, several **NCSA applications** that support data visualization and analysis, and a variety of **third-party applications**. The HDF utilities are included in the NCSA HDF distribution.

Source code and documentation for the HDF libraries, as well as binaries for supported platforms, is freely available but subject to the restrictions listed with the copyright notice at the beginning of this guide. This material is available via NCSA's anonymous FTP server `ftp.ncsa.uiuc.edu` in the directory `/HDF/`. (The HDF FTP server at `http://hdf.ncsa.uiuc.edu` mirrors this material in the directory `/pub/dist/HDF/`.) Applications supported by NCSA, as well as applications contributed by members of the worldwide HDF user community, are available on these servers.

### 1.3 Why Was HDF Created?

Scientists commonly generate and process data files on several different machines, use various software packages to process files and share data files with others who use different machines and software. Also, they may include different kinds of information within one particular file, or within a group of files, and the mixture of these different kinds of information may vary from one file to another. Files may be conceptually related but physically separated. For example, some data may be dispersed among different files and some in program code. It is also possible that data may be related only in the scientist’s conception of the data; no physical relationship may exist.

HDF addresses these problems by providing a general-purpose file structure that:

- Provides the mechanism for programs to obtain information about the data in a file from within the file, rather than from another source.
- Lets the user store mixtures of data from different sources into a single file as well as store the data and its related information in separate files, even when the files are processed by the same application program.
- Standardizes the formats and descriptions of many types of commonly-used data sets, such as raster images and multidimensional arrays.
- Encourages the use of a common data format by all machines and programs that produce files containing specific data.
- Can be adapted to accommodate virtually any kind of data.
1.4 High-Level HDF APIs

HDF APIs are divided into two categories: multi-file interfaces (new) and single-file interfaces (old). The multi-file interfaces are those that provide simultaneous access to several HDF files from within an application, which is an important feature that the single-file interfaces do not support. It is recommended that the user explore the new interfaces and their features since they are an improvement over the old interfaces. The old interfaces remain simply because of the need for backward compatibility.

The HDF I/O library consists of C and FORTRAN-77 routines for accessing objects and associated information. Although there is some overlap among object types, in most cases an API operates on data of only one type. Therefore, you need only familiarize yourself with the APIs specific to your needs to access data in an HDF file.

The following lists include all of the currently available HDF interfaces and the data that each interface supports.

The new multi-file interfaces are:

- **SD API**: Stores, manages and retrieves multidimensional arrays of character or numeric data, along with their dimensions and attributes, in more than one file. It is described in Chapter 3, Scientific Data Sets (SD API).

- **VS API**: Stores, manages and retrieves multivariate data stored as records in a table. It is described in Chapter 4, Vdata (VS API).

- **V API**: Creates groups of any primary HDF data structures. It is described in Chapter 5, Vgroups (V API).

- **GR API**: Stores, manages and retrieves raster images, their dimensions and palettes in more than one file. It can also manipulate unattached palettes in more than one file. It is described in Chapter 8, General Raster Images (GR API).

- **AN API**: Stores, manages and retrieves text used to describe a file or any of the data structures contained in the file. This interface can operate on several files at once. It is described in Chapter 10, Annotations (AN API).

The old single-file interfaces are:

- **DFR8 API**: Stores, manages and retrieves 8-bit raster images, with their dimensions and palettes in one file. It is described in Chapter 6, 8-Bit Raster Images (DFR8 API).

- **DF24 API**: Stores, manages and retrieves 24-bit images and their dimensions in one file. It is described in Chapter 7, 24-bit Raster Images (DF24 API).

- **DFP API**: Stores and retrieves 8-bit palettes in one file. It is described in Chapter 9, Palettes (DFP API).

- **DFAN API**: Stores, manages and retrieves text strings used to describe a file or any of the data structures contained in the file. This interface only operates on one file at a time. It is described in Chapter 11, Single-file Annotations (DFAN API).

- **DFSD API**: Stores, manages and retrieves multidimensional arrays of integer or floating-point data, along with their dimensions and attributes, in one file. It is described in Chapter 12, Single-File Scientific Data Sets (DFSD API).

As these interfaces are the tools used to read and write HDF files, they are the primary focus of this manual.

In every interface, various programming examples are provided to illustrate the use of the interface routines. Both C and FORTRAN-77 versions are available. Their source code, in ASCII for-
Note that the goal of these examples is to illustrate the use of the interface routines; thus, for simplicity, many assumptions have been made, such as the availability or the authentication of the data. Based on these assumptions, these examples skip the verification of the returned status of each function. In practice, it is strongly recommended that the user verify the returned value of every function to ensure the reliability of the user application.

1.5 NCSA HDF Command-Line Utilities and Visualization Tools

HDF application software fall within the following three categories:
1. The FORTRAN-77 and C APIs described in Section 1.4 on page 4.
2. Scientific visualization and analysis tools that read and write HDF files.
3. Command-line utilities that operate directly on HDF files.

Scientific visualization and analysis software that can read and write HDF files is available. This software includes NCSA-developed tools such as JHV (the Java-based HDF Viewer), user-developed software, and commercial packages. The use of HDF files guarantees the interoperability of such tools. Some tools operate on raster images, others on color palettes. Some use images, others color palettes, still others data and annotations, and so forth. HDF provides the range of data types that these tools need, in a format that allows different tools with different data requirements to operate on the same files without confusion.

The HDF command-line utilities are application programs that can be executed by entering them at the command prompt, like UNIX commands. They perform common operations on HDF files for which one would otherwise have to write a program. The HDF utilities are described in detail in Chapter 15, HDF Command-line Utilities.

1.6 Primary HDF Platforms

The HDF library and utilities are maintained on a number of different machines and operating systems. Table 1A lists the primary machines and operating systems HDF is ported to.

<table>
<thead>
<tr>
<th>Machine</th>
<th>Operating System</th>
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<tbody>
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<td>Sun Sun4</td>
<td>SunOS, Solaris</td>
</tr>
<tr>
<td>SGI Indy, PowerChallenge, Origin</td>
<td>Irix</td>
</tr>
<tr>
<td>H/P HP9000</td>
<td>HPUX</td>
</tr>
<tr>
<td>SGI/Cray</td>
<td>UNICOS</td>
</tr>
<tr>
<td>DEC Alpha</td>
<td>Digital Unix, OpenVMS</td>
</tr>
<tr>
<td>DEC VAX</td>
<td>OpenVMS</td>
</tr>
<tr>
<td>PC</td>
<td>Solaris86, Linux, FreeBSD</td>
</tr>
<tr>
<td>PC</td>
<td>Windows NT/95</td>
</tr>
<tr>
<td>Apple Power Macintosh</td>
<td>MacOS</td>
</tr>
</tbody>
</table>

For a complete list of the machines, operating systems (with versions), C and FORTRAN-77 compilers (also with versions), refer to the file named “INSTALL” in the root directory of the HDF distribution.
1.7 HDF4 versus HDF5

Backward compatibility has always been an integral part of the design of HDF Versions 1, 2, 3, and 4 and the HDF4 library can access files from all earlier versions. This manual describes HDF4 and, to the extent appropriate, the earlier versions.

To take advantage of the capabilities of many of the more recent computing platforms and to meet the requirements of science applications that require ever-larger data sets, HDF5 had to be a completely new product, with a new format and a new library. HDF5 is conceptually related to HDF4 but incompatible; it cannot directly read or work with HDF4 files or the HDF4 library. HDF5 software and documentation are available at the following location:

http://hdf.ncsa.uiuc.edu/HDF5/

Both HDF4 and HDF5 are supported by the HDF Group at NCSA. The HDF Group will continue to maintain HDF4 as long as funds are available to do so. There are no plans to add any new features to HDF4, but bugs are fixed and and the library is regularly built and tested on new operating system versions.

The HDF Group strongly recommends using HDF5, especially if you are a new user and are not constrained by existing applications to using HDF4. We also recommend that you consider migrating existing applications from HDF4 to HDF5 to take advantage of the improved features and performance of HDF5. Information about converting from HDF4 to HDF5 and tools to facilitate that conversion are available at the following location:

http://hdf.ncsa.uiuc.edu/h4toh5/

See Section 15.19, “Working with Both HDF4 and HDF5 File Formats” on page 457, for further discussions of and links to some of these tools.
Chapter 2

HDF Fundamentals

2.1 Chapter Overview

This chapter provides necessary information for the creation and manipulation of HDF files. It includes an overview of the HDF file format, basic operations on HDF files, and programming language issues pertaining to the use of Fortran and ANSI C in HDF programming.

2.2 HDF File Format

An HDF file contains a file header, at least one data descriptor block, and zero or more data elements as depicted in Figure 2a.

The Physical Layout of an HDF File Containing One Data Object

The file header identifies the file as an HDF file. A data descriptor block contains a number of data descriptors. A data descriptor and a data element together form a data object, which is the basic conglomerate structure for encapsulating data in the HDF file. Each of these terms is described in the following sections.
2.2.1 File Header

The first component of an HDF file is the file header, which takes up the first four bytes of the HDF file. Specifically, it consists of four one-byte values that are ASCII representations of control characters: the first is a control-N, the second is a control-C, the third is a control-S and the fourth is a control-A (^N^C^S^A).

Note that, on some machines, the order of bytes in the file header might be swapped when the header is written to an HDF file, causing these characters to be written in little-endian order. To maintain the portability of HDF file header data when developing software for such machines, this byte swapping must be counteracted by ensuring the characters are read and written in the desired order.

2.2.2 Data Object

A data object is comprised of a data descriptor and a data element. The data descriptor consists of information about the type, location, and size of the data element. The data element contains the actual data. This organization of HDF data makes HDF files **self-describing**. Figure 2b shows two examples of data objects.

![Two Data Objects](image)

**Data Descriptors**  
---

<table>
<thead>
<tr>
<th>Data Descriptors</th>
<th>Data Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>rank and dimensions</td>
<td>2 90 by 100</td>
</tr>
<tr>
<td>data</td>
<td>63.2, 54.5, 12.3, ...</td>
</tr>
<tr>
<td></td>
<td>18.2, 103.6, -7.4, ...</td>
</tr>
<tr>
<td></td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>12.1, 6.9, 83.6, ...</td>
</tr>
</tbody>
</table>

2.2.2.1 Data Descriptor

All data descriptors are twelve bytes long and contain four fields, as depicted in Figure 2c. These fields are: a 16-bit **tag**, a 16-bit **reference number**, a 32-bit **data offset** and a 32-bit **data length**.

![The Contents of a Data Descriptor](image)

**Tag**

A **tag** is the data descriptor field that identifies the type of data stored in the corresponding data element. A tag is a 16-bit unsigned integer between 1 and 65,535, and is associated with a mnemonic name to promote ease to use and the readability of user programs.
If a data descriptor has no corresponding data element, the value of its tag is DFTAG_NULL (or 0).

Tags are assigned by the HDF Group as part of the HDF specification. The following are the ranges of tag values and their descriptions:

- 1 to 32,767 - Tags reserved for HDF Group use
- 32,768 to 64,999 - User-definable tags
- 65,000 to 65,535 - Tags reserved for expansion of the HDF specification

A list of commonly-used tags and their descriptions is included in Appendix A, NCSA HDF Tags, of this document.

**Reference Number**

For each occurrence of a tag in an HDF file, a unique reference number is assigned by the library with the tag in the data descriptor. A reference number is a 16-bit unsigned integer and can not be changed during the life of the data object that the reference number specifies.

The combination of a tag and a reference number uniquely identifies the corresponding data object in the file.

Reference numbers are not necessarily assigned consecutively, so it cannot be assumed that the value of a reference number has any meaning beyond providing a way of distinguishing among objects with the same tag. While application programmers may find it convenient to impart some additional meaning to reference numbers in their code, it is emphasized that the HDF library will not internally recognize any such meaning.

**Data Offset and Length**

The data offset field points to the location of the data element in the file by storing the number of bytes from the beginning of the file to the beginning of the data element. The length field contains the size of the data element in bytes. The data offset and the length are both 32-bit signed integers. This results in a file-size limit of 2 gigabytes.

2.2.2.2 Data Elements

The data element is the raw data portion of a data object.

2.2.3 Data Descriptor Block

Data descriptors are physically stored in a linked list of blocks called data descriptor blocks. The relationship between the data descriptor block to the other components of an HDF file is illustrated in Figure 2a on page 7. The individual components of a data descriptor block are depicted in Figure 2d on page 10. Each data descriptor in a data descriptor block is assumed to be associated with a data element unless it contains the tag DFTAG_NULL (or 0), which indicates that there is no associated data element. By default, a data descriptor block contains 16 (defined as DEF_NDDS) data descriptors. The user may reset this limit when creating the HDF file. Refer to Section 2.3.2 on page 11 for more details.

In addition to data descriptors, each data descriptor block contains a data descriptor header. The data descriptor header contains two fields: block size and next block. The block size field is a 16-bit unsigned integer indicating the number of data descriptors in the data descriptor block. The next block field is a 32-bit unsigned integer indicating the offset of the next data descriptor block, if one exists. The last data descriptor header in the list contains a value of 0 in its next block field.

Figure 2d illustrates the layout of a data descriptor block.
2.2.4 Grouping Data Objects in an HDF File

Data objects containing related data in HDF files are usually grouped together by the library. These groups of data objects are called data sets. The HDF user uses the application interface to manipulate data sets in a file. As an example, an 8-bit raster image data set requires three objects: a group object identifying the members of the set, an image object containing the image data, and a dimension object indicating the size of the image.

Data objects are individually accessible even if they are included in a set, therefore data objects can belong to more than one set and sets can be included in larger groups. For example, a palette object included in one raster image set may also be a part of another raster image set if its tag and reference number are included in a data descriptor within that second set.

Additional information about data objects, including the options available for storing them, can be found in the HDF Specifications and Developer’s Guide v3.2 from the HDF WWW home page at http://hdf.ncsa.uiuc.edu/.

2.3 Basic Operations on HDF Files Using the Multifile Interfaces

This section describes the basic file operations, some of which are required in working with HDF files using the multifile interfaces. Except for the SD interface, all applications using other multifile interfaces must explicitly use the routines Hopen and Hclose to control accesses to the HDF files. In an application using the HDF file format, the file is accessed via its identifier, referred to as file identifier. The following subsections describe the file identifier and the basic file operations common to most multifile interfaces.

2.3.1 File Identifiers

The HDF programming model specifies that a data file is first explicitly created or opened by an application, manipulated, then explicitly closed by the application. A file identifier is a unique number that the HDF library assigns to an HDF file when creating or opening the file. The HDF library creates the file identifier for an HDF file when given its file name, as represented in the native file system. Interface routines use only the file identifier to access and manipulate the file. When all operations on the file are complete, the file identifier must be discarded by explicitly closing the file before terminating the application.

As every file is assigned its own identifier, the order in which files are accessed is very flexible. For example, it is valid to open a file and obtain an identifier for it, then open a second file without closing the first file or disposing of the first file identifier. The only requirement made by HDF is that all file identifiers be individually discarded before the termination of the calling program.

File identifiers created by the routine of one HDF interface can be used by the routines of any other interfaces, except SD’s.
2.3.2 Opening HDF Files: Hopen

The routine **Hopen** creates or opens an HDF data file, depending on the access mode specified, and returns the file identifier that the HDF library has assigned to the file. The **Hopen** syntax is as follows:

**C:**
```c
file_id = Hopen(filename, access_mode, num_dds_block);
```

**FORTRAN:**
```fortran
file_id = hopen(filename, access_mode, num_dds_block)
```

The **Hopen** parameters are defined in Table 2A and the following discussion.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hopen</strong></td>
<td>filename</td>
<td>char*</td>
<td>File name</td>
</tr>
<tr>
<td>([int32] hopen)</td>
<td>access_mode</td>
<td>intn</td>
<td>File access mode</td>
</tr>
<tr>
<td></td>
<td>num_dds_block</td>
<td>int16</td>
<td>Number of data descriptors in a block</td>
</tr>
</tbody>
</table>

The parameter **filename** is a character string representing the name of the HDF file to be accessed.

The parameter **access_mode** specifies how the file should be accessed. All the access modes are listed in Table 2B. If the access mode is **DFACC_CREATE** and the file already exists, the file will be replaced by the new one. If the access mode is **DFACC_READ** and the file does not exist, **Hopen** will return **FAIL** (or -1). If the access mode is **DFACC_WRITE** and the file does not exist, a new file will be created.

The parameter **num_dds_block** specifies the number of data descriptors in a block when the access mode specified is create. If the access mode is not create, the value of **num_dds_block** is ignored. The default number of data descriptors in a block is 16 (defined as **DEF_NDDS**) data descriptors. The user may specify 0 to keep the default or any non-negative integer to reset this limit when creating the HDF file.

Note that, in the SD interface, **SDstart** is used to open files instead of **Hopen**. (Refer to Chapter 3, *Scientific Data Sets (SD API)*, of this document for more information on **SDstart**.)

<table>
<thead>
<tr>
<th>File Access Flag</th>
<th>Flag Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFACC_READ</td>
<td>1</td>
<td>Read access</td>
</tr>
<tr>
<td>DFACC_WRITE</td>
<td>2</td>
<td>Read and write access</td>
</tr>
<tr>
<td>DFACC_CREATE</td>
<td>4</td>
<td>Create with read and write access</td>
</tr>
</tbody>
</table>

2.3.3 Closing HDF Files: Hclose

The **Hclose** routine closes the file designated by the file identifier specified by the parameter **file_id**. The **Hclose** syntax is as follows:

**C:**
```c
status = Hclose(file_id);
```

**FORTRAN:**
```fortran
status = hclose(file_id)
```
**Hclose** returns a value of **SUCCEED** (or 0) if successful or **FAIL** (or −1) otherwise. The parameter name and type are listed in Table 2C. Refer also to the *HDF Reference Manual* for additional information regarding **Hclose**.

Note that **Hclose** is not used to close files in the SD interface. **SDend** is used for this purpose. (Refer to Chapter 3, *Scientific Data Sets (SD API)*, of this document for more information on **SDend**.)

### TABLE 2C

**Hclose Parameter List**

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hclose</strong> [intn] (hclose)</td>
<td>file_id</td>
<td>int32 integer</td>
<td>File identifier</td>
</tr>
</tbody>
</table>

### 2.3.4 Getting the HDF Library and File Versions: **Hgetlibversion** and **Hgetfileversion**

**Hgetlibversion** returns the version of the HDF library currently being used, as well as additional textual information regarding the library. The parameter names and data types are listed in Table 2D. Refer also to the *HDF Reference Manual* for additional information regarding **Hgetlibversion**.

**Hgetfileversion** returns the version information of the HDF file specified by the parameter **file_id**, as well as additional textual information regarding the nature of the file. The parameter names and data types are listed in Table 2D. Refer also to the *HDF Reference Manual* for additional information regarding **Hgetfileversion**.

The syntax of these routines is as follows:

**C:**

```c
status = Hgetlibversion(&major_v, &minor_v, &release, string);
status = Hgetfileversion(file_id, &major_v, &minor_v, &release, string);
```

**FORTRAN:**

```fortran
status = hglibver(major_v, minor_v, release, string)
status = hgfilver(file_id, major_v, minor_v, release, string)
```

Both routines return a value of **SUCCEED** (or 0) if successful or **FAIL** (or −1) otherwise.

### TABLE 2D

**Hgetlibversion and Hgetfileversion Parameter Lists**

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hgetlibversion</strong> [intn] (hglibver)</td>
<td>major_v</td>
<td>uint32* integer</td>
<td>Major version number</td>
</tr>
<tr>
<td></td>
<td>minor_v</td>
<td>uint32* integer</td>
<td>Minor version number</td>
</tr>
<tr>
<td></td>
<td>release</td>
<td>uint32* integer</td>
<td>Complete library version number</td>
</tr>
<tr>
<td></td>
<td>string</td>
<td>char* character*(*)</td>
<td>Additional information about the library version</td>
</tr>
<tr>
<td><strong>Hgetfileversion</strong> [intn] (hgfilver)</td>
<td>file_id</td>
<td>int32 integer</td>
<td>File identifier</td>
</tr>
<tr>
<td></td>
<td>major_v</td>
<td>uint32* integer</td>
<td>Major version number</td>
</tr>
<tr>
<td></td>
<td>minor_v</td>
<td>uint32* integer</td>
<td>Minor version number</td>
</tr>
<tr>
<td></td>
<td>release</td>
<td>uint32* integer</td>
<td>Complete library version number</td>
</tr>
<tr>
<td></td>
<td>string</td>
<td>char* character*(*)</td>
<td>Additional information about the library version</td>
</tr>
</tbody>
</table>
2.4 Determining whether a File Is an HDF File: Hishdf/hishdff

The Hishdf routine is used to determine whether the file filename is an HDF file. The Hishdf syntax is as follows:

C:     status = Hishdf(filename)

FORTRAN: status = hishdff(filename)

This routine returns a value of TRUE (or 1) if the file is an HDF file or FALSE (or 0) otherwise.

---

### TABLE 2E

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hishdf</td>
<td>filename</td>
<td>char*</td>
<td>Filename</td>
</tr>
</tbody>
</table>

---

2.5 Programming Issues

This section introduces information relevant to the process of developing programs that use the HDF library, such as the names of necessary header files, lists of common definitions and issues concerning FORTRAN-77 and C programming.

2.5.1 Header File Information

The header file hdf.h must be included in every HDF application program written in C, except for programs that call routines in the SD interface. The header file mfhdf.h must be included in all programs that call SD interface routines.

Fortran programmers who use compilers that allow file inclusion can include the files hdf.inc and dffunc.inc. If a Fortran compiler that does not support file inclusion is used, HDF library definitions must be explicitly defined in the Fortran program as they are included in the header files of the HDF library.

2.5.2 HDF Definitions

The HDF library provides several sets of definitions which can be used easily in the user applications. These sets include the definitions of the data types, the data type flags, and the limits that set various maximum values. The definitions of the data types supported by HDF are located in the hdf.h header file, and the data type flags are located in the dntdefs.h header file. Both are also included in Table 2F on page 14, Table 2G on page 14, and Table 2H on page 15. HDF data types are used for portability in the declaration of variables, and data type flags are used as parameters in various HDF interface routines.

2.5.2.1 Standard HDF Data Types

The definitions of the fundamental data types are in Table 2F. Although DFNT_FLOAT (or 5), DFNT_UCHAR (or 3), and DFNT_CHAR (or 4) have not been added to this table, they are also supported by the HDF library for backward compatibility.

If the machine used is big-endian, using these data types will result in no byte-order conversion being performed. If the machine used is little-endian, the library will convert the byte-order of the variables to big-endian.
TABLE 2F

Standard HDF Data Types and Flags

<table>
<thead>
<tr>
<th>HDF Data Type</th>
<th>Data Type Flag and Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>char8</td>
<td>DFNT_CHAR8 (4)</td>
<td>8-bit character type</td>
</tr>
<tr>
<td>uchar8</td>
<td>DFNT_UCHAR8 (3)</td>
<td>8-bit unsigned character type</td>
</tr>
<tr>
<td>int8</td>
<td>DFNT_INT8 (20)</td>
<td>8-bit integer type</td>
</tr>
<tr>
<td>uint8</td>
<td>DFNT_UINT8 (21)</td>
<td>8-bit unsigned integer type</td>
</tr>
<tr>
<td>int16</td>
<td>DFNT_INT16 (22)</td>
<td>16-bit integer type</td>
</tr>
<tr>
<td>uint16</td>
<td>DFNT_UINT16 (23)</td>
<td>16-bit unsigned integer type</td>
</tr>
<tr>
<td>int32</td>
<td>DFNT_INT32 (24)</td>
<td>32-bit integer type</td>
</tr>
<tr>
<td>uint32</td>
<td>DFNT_UINT32 (25)</td>
<td>32-bit unsigned integer type</td>
</tr>
<tr>
<td>float32</td>
<td>DFNT_FLOAT32 (5)</td>
<td>32-bit floating-point type</td>
</tr>
<tr>
<td>float64</td>
<td>DFNT_FLOAT64 (6)</td>
<td>64-bit floating-point type</td>
</tr>
</tbody>
</table>

Fortran programmers should refer to Section 2.5.3 on page 16 for a discussion of the Fortran data types.

2.5.2.2 Native Format Data Types

When a native format data type is specified, the corresponding numbers are stored in the HDF file exactly as they appear in memory, without conversion. For example, on a Cray Y-MP, 8 bytes of memory, or one Cray word, is used to store most integers. Therefore, an 8-bit signed integer, represented by the DFNT_NATIVE flag, on a Cray Y-MP uses 8 bytes of memory. Consequently, when the data type DFNT_NATIVE | DFNT_INT32 (DFNT_NATIVE bitwise-ORed with DFNT_INT32) is used on a Cray Y-MP to specify the data type of an HDF SDS or vdata, each integer stored in the HDF file is 8 bytes.

The method for constructing the data type flag for each native data type described in the previous paragraph is used for any of the native data types: the DFNT_NATIVE flag is bitwise-ORed with the flag of the corresponding standard data type.

The definitions of the native format data types and the corresponding data type flags appear in Table 2G.

TABLE 2G

Native Format Data Type Definitions

<table>
<thead>
<tr>
<th>HDF Data Type</th>
<th>HDF Data Type Flag and Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>int8</td>
<td>DFNT_HINT8 (4116)</td>
<td>8-bit native integer type</td>
</tr>
<tr>
<td>uint8</td>
<td>DFNT_HUINT8 (4117)</td>
<td>8-bit native unsigned integer type</td>
</tr>
<tr>
<td>int16</td>
<td>DFNT_HINT16 (4118)</td>
<td>16-bit native integer type</td>
</tr>
<tr>
<td>uint16</td>
<td>DFNT_HUINT16 (4119)</td>
<td>16-bit native unsigned integer type</td>
</tr>
<tr>
<td>int32</td>
<td>DFNT_HINT32 (4120)</td>
<td>32-bit native integer type</td>
</tr>
<tr>
<td>uint32</td>
<td>DFNT_HUINT32 (4121)</td>
<td>32-bit native unsigned integer type</td>
</tr>
<tr>
<td>float32</td>
<td>DFNT_HFLOAT32 (4101)</td>
<td>32-bit native floating-point type</td>
</tr>
<tr>
<td>float64</td>
<td>DFNT_HFLOAT64 (4102)</td>
<td>64-bit native floating-point type</td>
</tr>
</tbody>
</table>

2.5.2.3 Little-Endian Data Types

HDF normally writes data in big-endian format, but provides a little-endian option forcing all data written to disk to be written in little-endian format. This is primarily for users of Intel-based machines who do not want to incur the cost of reordering data when writing to an HDF file. Note
that direct conversions are supported between little-endian and all other byte-order formats supported by HDF.

The method for constructing the data type flag for each little-endian data type is similar to the method for constructing native format data type flags: the `DFNT_LIEND` flag is bitwise-ORed with the flag of the corresponding standard data type.

If the user is on a little-endian machine, using these data types will result in no conversion. If the user is on a big-endian machine, the HDF library will perform big-to-little-endian conversion.

The definitions of the little-endian data types and the corresponding data type flags appear in Table 2H.

**TABLE 2H**

Little-Endian Format Data Type Definitions

<table>
<thead>
<tr>
<th>HDF Data Type</th>
<th>HDF Data Type Flag and Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>int8</td>
<td>DFNT_LINT8 (16404)</td>
<td>8-bit little-endian integer type</td>
</tr>
<tr>
<td>uint8</td>
<td>DFNT_LUINT8 (16405)</td>
<td>8-bit little-endian unsigned integer type</td>
</tr>
<tr>
<td>int16</td>
<td>DFNT_LINT16 (16406)</td>
<td>16-bit little-endian integer type</td>
</tr>
<tr>
<td>uint16</td>
<td>DFNT_LUINT16 (16407)</td>
<td>16-bit little-endian unsigned integer type</td>
</tr>
<tr>
<td>int32</td>
<td>DFNT_LINT32 (16408)</td>
<td>32-bit little-endian integer type</td>
</tr>
<tr>
<td>uint32</td>
<td>DFNT_LUINT32 (16409)</td>
<td>32-bit little-endian unsigned integer type</td>
</tr>
<tr>
<td>float32</td>
<td>DFNT_LFLOAT32 (16389)</td>
<td>32-bit little-endian floating-point type</td>
</tr>
<tr>
<td>float64</td>
<td>DFNT_LFLOAT64 (16390)</td>
<td>64-bit little-endian floating-point type</td>
</tr>
</tbody>
</table>

**2.5.2.4 Tag Definitions**

These definitions identify the object tags defined and used by the HDF interface library. The concept of object tags is introduced in Section 2.2.2.1 on page 8, and a list of tags can be found in Appendix A of this manual. Note that tags can also identify properties of data objects.

**2.5.2.5 Limit Definitions**

These definitions declare the maximum size of specific data object parameters, such as the maximum length of a vdata field or the maximum number of objects in a vgroup. They are located in the header file `hlimts.h`. A selection of the most-commonly-used limit definitions appears in Table 2I.

**TABLE 2I**

Limit Definitions

<table>
<thead>
<tr>
<th>Definition Name</th>
<th>Definition Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIELDNAMELENMAX</td>
<td>128</td>
<td>Maximum length of a vdata field in bits - 16 characters</td>
</tr>
<tr>
<td>VNAMELENMAX</td>
<td>64</td>
<td>Maximum length of a vdata name in bytes - 64 characters</td>
</tr>
<tr>
<td>VGROUPNAMELENMAX</td>
<td>64</td>
<td>Maximum length of a vgroup name in bytes - 64 characters</td>
</tr>
<tr>
<td>VFIELDMAX</td>
<td>256</td>
<td>Maximum number of fields per vdata (64 for Macintosh)</td>
</tr>
<tr>
<td>VDEFAULTBLKSIZE</td>
<td>4096</td>
<td>Default block size in a vdata</td>
</tr>
<tr>
<td>VDEFAULTNBLKS</td>
<td>32</td>
<td>Default number of blocks in a vdata</td>
</tr>
<tr>
<td>MAXVELT</td>
<td>64</td>
<td>Maximum number of objects in a vdata</td>
</tr>
<tr>
<td>MAX_ORDER</td>
<td>65535</td>
<td>Maximum order of a vdata field</td>
</tr>
<tr>
<td>MAX_FIELD_SIZE</td>
<td>65535</td>
<td>Maximum length of a field</td>
</tr>
<tr>
<td>MAX_NC_DIMS</td>
<td>5000</td>
<td>Maximum number of dimensions per file</td>
</tr>
<tr>
<td>MAX_NC_ATTRS</td>
<td>3000</td>
<td>Maximum number of file or variable attributes</td>
</tr>
<tr>
<td>MAX_NC_VARS</td>
<td>5000</td>
<td>Maximum number of file attributes</td>
</tr>
</tbody>
</table>
2.5.3 FORTRAN-77 and C Language Issues

HDF provides both FORTRAN-77 and C versions of most of its interface routines. In order to make the FORTRAN-77 and C versions of each routine as similar as possible, some compromises have been made in the process of simplifying the interface for both programming languages.

FORTRAN-77-to-C Translation

Nearly all of the HDF library code is written in C. A FORTRAN-77 HDF interface routine translates all parameter data types to C data types, then calls the C routine that performs the functionality of the interface routine. For example, `d8aimg` is the FORTRAN-77 equivalent for `DFR8addimage`. Calls to either routine execute the same C code that adds an 8-bit raster image to an HDF file. See Figure 2e.

<table>
<thead>
<tr>
<th>MAX_VAR_DIMS</th>
<th>32</th>
<th>Maximum number of variable attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX_NC_NAME</td>
<td>256</td>
<td>Maximum length of a name - NC interface</td>
</tr>
<tr>
<td>MAX_PATH_LEN</td>
<td>1024</td>
<td>Maximum length of an external file name</td>
</tr>
<tr>
<td>MAX_FILE</td>
<td>32</td>
<td>Maximum number of open files</td>
</tr>
<tr>
<td>MAX_GROUPS</td>
<td>8</td>
<td>Maximum number of groups</td>
</tr>
<tr>
<td>MAX_GR_NAME</td>
<td>256</td>
<td>Maximum length of a name - GR interface</td>
</tr>
<tr>
<td>MAX_VAR_DIMS</td>
<td>32</td>
<td>Maximum number of dimensions per variable</td>
</tr>
<tr>
<td>MAX_REF</td>
<td>65535</td>
<td>The largest number that will fit into a 16-bit word reference variable</td>
</tr>
<tr>
<td>MAX_BLOCK_SIZE</td>
<td>65536</td>
<td>Maximum size of blocks in linked blocks</td>
</tr>
</tbody>
</table>

FIGURE 2e

Use of a Function Call Converter to Route FORTRAN-77 HDF Calls to the C Library

Case Sensitivity

FORTRAN-77 identifiers generally are not case sensitive, whereas C identifiers are. Although all of the FORTRAN-77 routines shown in this manual are written in lower case, FORTRAN-77 programs can generally call them using either upper- or lower-case letters without loss of meaning.

Name Length

Because some FORTRAN-77 compilers only interpret identifier names with seven or fewer characters, the first seven characters of the FORTRAN-77 HDF routine names are unique.

Header Files

The inclusion of header files is not generally permitted by FORTRAN-77 compilers. However, it is sometimes available as an option. On UNIX systems, for example, the macro processors `m4` and `cpp` let the compiler include and preprocess header files. If this capability is not available, the user may have to copy the declarations, definitions, or values needed from the files `dfunc.inc` and `hdf.inc` into the user application. If the capability is available, the files can be included in the FORTRAN code. These two files reside in the include directory after the library is installed on the user's system.
Data Type Specifications

When mixing machines, compilers, and languages, it is difficult to maintain consistent data type definitions. For instance, on some machines an integer is a 32-bit quantity and on others, a 16-bit quantity. In addition, the differences between FORTRAN-77 and C lead to difficulties in describing the data types found in the argument lists of HDF routines. To maintain portability, the HDF library expects assigned names for all data types used in HDF routines. See Table 2J.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>FORTRAN</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-bit signed integer</td>
<td>character*1 **</td>
<td>int8</td>
</tr>
<tr>
<td>8-bit unsigned integer</td>
<td>character*1</td>
<td>uint8</td>
</tr>
<tr>
<td>16-bit signed integer</td>
<td>integer*2</td>
<td>int16</td>
</tr>
<tr>
<td>16-bit unsigned integer</td>
<td>Not supported</td>
<td>uint16</td>
</tr>
<tr>
<td>32-bit signed integer</td>
<td>integer*4 **</td>
<td>int32</td>
</tr>
<tr>
<td>32-bit unsigned integer</td>
<td>Not supported</td>
<td>uint32</td>
</tr>
<tr>
<td>32-bit floating point number</td>
<td>real*4 **</td>
<td>float32</td>
</tr>
<tr>
<td>64-bit floating point number</td>
<td>real*8 **</td>
<td>float64</td>
</tr>
<tr>
<td>Native signed integer</td>
<td>integer</td>
<td>intn</td>
</tr>
<tr>
<td>Native unsigned integer</td>
<td>Not supported</td>
<td>uintn</td>
</tr>
</tbody>
</table>

** if the compiler supports this data type

When using a FORTRAN-77 data type that is not supported, the general practice is to use another data type of the same size. For example, an 8-bit signed integer can be used to store an 8-bit unsigned integer variable.

String and Array Specifications

The following conventions are followed in the specification of arrays in this manual:

- `character*(*)` defines a string of an indefinite number of characters. It is the responsibility of the calling program to allocate enough space to hold the data to be stored in the string.
- `real x(*)` means that x refers to an array of reals of indefinite size and of indefinite rank. It is the responsibility of the calling program to allocate an actual array with the correct number of dimensions and dimension sizes.
- `<valid numeric data type> x` means that x may have one of the numeric data types listed in the Description column of Table 2J above.
- `<valid data type> x` means that x may have any of the data types listed in the Description column of Table 2J above.

FORTRAN-77 and ANSI C

As much as possible, we have ensured that the HDF interface routines conform to the implementations of Fortran and C that are in most common use today, namely FORTRAN-77 and ANSI C.

As Fortran-90 is a superset of FORTRAN-77, HDF programs should compile and run correctly when using a Fortran-90 compiler. However, an HDF library interface that makes full use of Fortran-90 enhancements is being considered.
Chapter 3

Scientific Data Sets (SD API)

3.1 Chapter Overview

This chapter describes the scientific data model and the interface routines provided by HDF for creating and accessing the data structures included in the model. This interface is known as the SD interface or the SD API.

3.2 The Scientific Data Set Data Model

The scientific data set, or SDS, is a group of data structures used to store and describe multidimensional arrays of scientific data. Refer to Figure 3a for a graphical overview of the SD data set. Note that in this chapter the terms *SDS, SD data set,* and *data set* are used interchangeably; the terms *SDS array* and *array* are also used interchangeably.

A scientific data set consists of required and optional components, which will be discussed in the following subsections.

FIGURE 3a
The Contents of a Scientific Data Set

<table>
<thead>
<tr>
<th>SDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Components</td>
</tr>
<tr>
<td>SDS Array</td>
</tr>
<tr>
<td>Name</td>
</tr>
<tr>
<td>Data Type</td>
</tr>
<tr>
<td>Dimensions</td>
</tr>
<tr>
<td>Optional Components</td>
</tr>
<tr>
<td>Predefined Attributes</td>
</tr>
<tr>
<td>User-defined Attributes</td>
</tr>
<tr>
<td>Dimension Scales</td>
</tr>
</tbody>
</table>
3.2.1 Required SDS Components

Every SDS must contain the following components: an *SDS array*, a *name*, a *data type*, and the *dimensions* of the SDS, which are actually the dimensions of the SDS array.

**SDS Array**

An *SDS array* is a multidimensional data structure that serves as the core structure of an SDS. This is the primary data component of the SDS model and can be compressed (refer to Section 3.5.2 on page 45 for a description of SDS compression) and/or stored in external files (refer to the Section 3.5.3.3 on page 52 for a description of external SDS storage). Users of netCDF should note that SDS arrays are conceptually equivalent to *variables* in the netCDF data model.

An SDS has an index and a reference number associated with it. The *index* is a non-negative integer that describes the relative position of the data set in the file. A valid index ranges from 0 to the total number of data sets in the file minus 1. The *reference number* is a unique positive integer assigned to the data set by the SD interface when the data set is created. Various SD interface routines can be used to obtain an SDS index or reference number depending on the available information about the SDS. The index can also be determined if the sequence in which the data sets are created in the file is known.

In the SD interface, an *SDS identifier* uniquely identifies a data set within the file. The identifier is created by the SD interface access routines when a new SDS is created or an existing one is selected. The identifier is then used by other SD interface routines to access the SDS until the access to this SDS is terminated. For an existing data set, the index of the data set can be used to obtain the identifier. Refer to Section 3.4.1 on page 26 for a description of the SD interface routine that creates SDSs and assigns identifiers to them.

**SDS Name**

The *name* of an SDS can be provided by the calling program, or is set to "DataSet" by the HDF library at the creation of the SDS. The name consists of case-sensitive alphanumeric characters, is assigned only when the data set is created, and cannot be changed. SDS names do not have to be unique within a file, but their uniqueness makes it easy to semantically distinguish among data sets in the file.

**Data Type**

The data contained in an SDS array has a *data type* associated with it. The standard data types supported by the SD interface include 32- and 64-bit floating-point numbers, 8-, 16- and 32-bit signed integers, 8-, 16- and 32-bit unsigned integers, and 8-bit characters. The SD interface also allows the creation of SD data sets consisting of data elements of non-standard lengths (1 to 32 bits). See Section 3.7.8 on page 71 for more information.

**Dimensions**

SDS *dimensions* specify the shape and size of an SDS array. The number of dimensions of an array is referred to as the *rank* of the array. Each dimension has an index and an identifier assigned to it. A dimension also has a size and may have a name associated with it.

A dimension *identifier* is a positive number uniquely assigned to the dimension by the library. This dimension identifier can be retrieved via an SD interface routine. Refer to Section 3.8.1 on page 73 for a description of how to obtain dimension identifiers.

---

A dimension **index** is a non-negative number that describes the ordinal location of a dimension among others in a data set. In other words, when an SDS dimension is created, an index number is associated with it and is one greater than the index associated with the last created dimension that belongs to the same data set. The dimension index is convenient in a sequential search or when the position of the dimension among other dimensions in the SDS is known.

**Names** can optionally be assigned to dimensions, however, dimension names are not treated in the same way as SDS array names. For example, if a name assigned to a dimension was previously assigned to another dimension the SD interface treats both dimensions as the same data component and any changes made to one will be reflected in the other.

The size of a dimension is a positive integer. Also, one dimension of an SDS array can be assigned the predefined size **SD_UNLIMITED** (or 0). This dimension is referred to as an **unlimited dimension**, which, as the name suggests, can grow to any length. Refer to Section 3.5.1.3 on page 40 for more information on unlimited dimensions.

### 3.2.2 Optional SDS Components

There are three types of optional SDS components: **user-defined attributes**, **predefined attributes**, and **dimension scales**. These optional components are only created when specifically requested by the calling program.

**Attributes** describe the nature and/or the intended usage of the file, data set, or dimension they are attached to. Attributes have a name and value which contains one or more data entries of the same data type. Thus, in addition to name and value, the data type and number of values are specified when the attribute is created.

**User-Defined Attributes**

**User-defined attributes** are defined by the calling program and contain auxiliary information about a file, SDS array, or dimension. They are more fully described in Section 3.9 on page 85.

**Predefined Attributes**

**Predefined attributes** have reserved names and, in some cases, predefined data types and/or number of data entries. Predefined attributes are useful because they establish conventions that applications can depend on. They are further described in Section 3.10 on page 96.

**Dimension Scales**

A dimension scale is a sequence of numbers placed along a dimension to demarcate intervals along it. Dimension scales are described in Section 3.8.4 on page 75.

### 3.2.3 Annotations and the SD Data Model

In the past, annotations were supported in the SD interface to allow the HDF user to attach descriptive information (called metadata) to a data set. With the expansion of the SD interface to include user-defined attributes, the use of annotations to describe metadata should be eliminated. Metadata once stored as an annotation is now more conveniently stored as an attribute. However, to ensure backward compatibility with scientific data sets and applications relying on annotations, the AN annotation interface, described in Chapter 10, **Annotations (AN API)** can be used to annotate SDSs.

There is no cross-compatibility between attributes and annotations; creating one does not automatically create the other.
3.3 The SD Interface

The SD interface provides routines that store, retrieve, and manipulate scientific data using the SDS data model. The SD interface supports simultaneous access to more than one SDS in more than one HDF file. In addition, the SD interface is designed to support a general scientific data model which is very similar to the netCDF data model developed by the Unidata Program Center1.

For those users who have been using the DFSD interface, the SD interface provide a model compatible with that supported by the DFSD interface. It is recommended that DFSD users apply the SD model and interface to their applications since the DFSD interface is less flexible and less powerful than the SD interface and will eventually be removed from the HDF library.

This section specifies the header file to be used with the SD interface and lists all available SD interface routines, each of which is accompanied by its purpose and the section where the routine is discussed.

3.3.1 Header and Include Files Used by the SD Interface

The “mfhdf.h” header file must be included in programs that invoke SD interface routines. FORTRAN-77 users should refer to Section 2.5.3 on page 16.

3.3.2 SD Interface Routines

All C routines in the SD interface begin with the prefix "SD". The equivalent FORTRAN-77 routines use the prefix "sf". These routines are categorized as follows:

- **Access routines** initialize and terminate access to HDF files and data sets.
- **Read and write routines** read and write data sets.
- **General inquiry routines** return information about the location, contents, and description of the scientific data sets in an HDF file.
- **Dimension routines** access and define characteristics of dimensions within a data set.
- **Dimension scale routines** define and access dimension scales within a data set.
- **User-defined attribute routines** describe and access characteristics of an HDF file, data set or dimension defined by the HDF user.
- **Predefined attribute routines** access previously-defined characteristics of an HDF file, data set, or dimension.
- **Compression routines** compress SDS data.
- **Chunking/tiling routines** manage chunked data sets.
- **Miscellaneous routines** provide other operations such as external file, n-bit data set, and compatibility operations.

The SD routines are listed in the following table and are discussed in the following sections of this document.

---

## SD Interface Routines

<table>
<thead>
<tr>
<th>Category</th>
<th>Routine Name</th>
<th>Description and Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Access</strong></td>
<td>C</td>
<td>FORTRAN-77</td>
</tr>
<tr>
<td></td>
<td>SDstart</td>
<td>sfstart</td>
</tr>
<tr>
<td></td>
<td>SDcreate</td>
<td>sfcreate</td>
</tr>
<tr>
<td></td>
<td>SDselect</td>
<td>sfselect</td>
</tr>
<tr>
<td></td>
<td>SDendaccess</td>
<td>sfendaccess</td>
</tr>
<tr>
<td></td>
<td>SDend</td>
<td>sfend</td>
</tr>
<tr>
<td><strong>Read and Write</strong></td>
<td>SDbreaddata</td>
<td>sfreaddata/sfrcdata</td>
</tr>
<tr>
<td></td>
<td>SDbwrittenata</td>
<td>sfwdata/sfwcdata</td>
</tr>
<tr>
<td><strong>General Inquiry</strong></td>
<td>SDfileinfo</td>
<td>sffinfo</td>
</tr>
<tr>
<td></td>
<td>SDgetinfo</td>
<td>sfqinfo</td>
</tr>
<tr>
<td></td>
<td>SDcheckempty</td>
<td>sfcheckempty</td>
</tr>
<tr>
<td></td>
<td>SDidtoref</td>
<td>sfid2ref</td>
</tr>
<tr>
<td></td>
<td>SDiscoordvar</td>
<td>sfiscvar</td>
</tr>
<tr>
<td></td>
<td>SDisrecord</td>
<td>sfisrcrd</td>
</tr>
<tr>
<td><strong>Dimensions</strong></td>
<td>SDdiminfo</td>
<td>sfgdinfo</td>
</tr>
<tr>
<td></td>
<td>SDgetdimid</td>
<td>sfdimid</td>
</tr>
<tr>
<td></td>
<td>SDsetdimname</td>
<td>sfsetdimname</td>
</tr>
<tr>
<td><strong>Dimension Scales</strong></td>
<td>SDgetdimscale</td>
<td>sfgdscale</td>
</tr>
<tr>
<td></td>
<td>SDsetdimscale</td>
<td>sfsetdsscale</td>
</tr>
<tr>
<td><strong>User-defined Attributes</strong></td>
<td>SDattrinfo</td>
<td>sfgainfo</td>
</tr>
<tr>
<td></td>
<td>SDfindattr</td>
<td>sfattr</td>
</tr>
<tr>
<td></td>
<td>SDbreadattr</td>
<td>sfreadattr/sfrcatt</td>
</tr>
<tr>
<td></td>
<td>SDsetattr</td>
<td>sfsetattr/sfsetattr</td>
</tr>
</tbody>
</table>
### 3.3.3 Tags in the SD Interface

A complete list of SDS tags and their descriptions appears in Table D in Appendix A. Refer to Section 2.2.2.1 on page 8 for a description of tags.

<table>
<thead>
<tr>
<th>Tag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDgetcal</td>
<td>Retrieves calibration information (Section 3.10.6.2 on page 104)</td>
</tr>
<tr>
<td>SDgetdatastrs</td>
<td>Returns the predefined attribute strings of a data set (Section 3.10.2.2 on page 98)</td>
</tr>
<tr>
<td>SDgetdimstrs</td>
<td>Returns the predefined attribute strings of a dimension (Section 3.10.3.2 on page 99)</td>
</tr>
<tr>
<td>SDgetfillvalue</td>
<td>Reads the fill value if it exists (Section 3.10.5.2 on page 102)</td>
</tr>
<tr>
<td>SDgetrange</td>
<td>Retrieves the range of values in the specified data set (Section 3.10.4.2 on page 101)</td>
</tr>
<tr>
<td>SDsetcal</td>
<td>Defines the calibration information (Section 3.10.6.1 on page 103)</td>
</tr>
<tr>
<td>SDsetdatastrs</td>
<td>Sets predefined attributes of the specified data set (Section 3.10.2.1 on page 98)</td>
</tr>
<tr>
<td>SDsetdimstrs</td>
<td>Sets predefined attributes of the specified dimension (Section 3.10.3.1 on page 99)</td>
</tr>
<tr>
<td>SDsetfillvalue</td>
<td>Defines the fill value for the specified data set (Section 3.10.5.1 on page 102)</td>
</tr>
<tr>
<td>SDsetfillmode</td>
<td>Sets the fill mode to be applied to all data sets in the specified file (Section 3.10.5.3 on page 102)</td>
</tr>
<tr>
<td>SDsetrange</td>
<td>Defines the maximum and minimum values of the specified data set (Section 3.10.4.1 on page 100)</td>
</tr>
<tr>
<td>SDsetcompress</td>
<td>Compresses a data set using a specified compression method (Section 3.5.2 on page 45)</td>
</tr>
<tr>
<td>SDsetnbitdataset</td>
<td>Defines the non-standard bit length of the data set data (Section 3.7.8 on page 71)</td>
</tr>
<tr>
<td>SDgetcompress</td>
<td>Retrieves data set compression type and compression information. (See the HDF Reference Manual)</td>
</tr>
<tr>
<td>SDgetchunkinfo</td>
<td>Obtains information about a chunked data set (Section 3.11.5 on page 110)</td>
</tr>
<tr>
<td>SDreadchunk</td>
<td>Reads data from a chunked data set (Section 3.11.4 on page 110)</td>
</tr>
<tr>
<td>SDsetchunk</td>
<td>Makes a non-chunked data set a chunked data set (Section 3.11.1 on page 105)</td>
</tr>
<tr>
<td>SDsetchunkcache</td>
<td>Sets the size of the chunk cache (Section 3.11.2 on page 107)</td>
</tr>
<tr>
<td>SDwritechunk</td>
<td>Writes data to a chunked data set (Section 3.11.3 on page 108)</td>
</tr>
<tr>
<td>SDsetblocksize</td>
<td>Sets the block size used for storing data sets with unlimited dimension (Section 3.5.1.5 on page 41)</td>
</tr>
<tr>
<td>SDsetexternalfile</td>
<td>Specifies that a data set is to be stored in an external file (Section 3.5.3.3 on page 52)</td>
</tr>
<tr>
<td>SDisdimval_bcomp</td>
<td>Determines the current compatibility mode of a dimension (Section 3.8.3.2 on page 74)</td>
</tr>
<tr>
<td>SDisdimval_comp</td>
<td>Sets the future compatibility mode of a dimension (Section 3.8.3.1 on page 74)</td>
</tr>
</tbody>
</table>
3.4 Programming Model for the SD Interface

This section describes the routines used to initialize the SD interface, create a new SDS or access an existing one, terminate access to that SDS, and shut down the SD interface. Writing to existing scientific data sets will be described in Section 3.5 on page 30.

To support multi-file access, the SD interface relies on the calling program to initiate and terminate access to files and data sets. The SD programming model for creating and accessing an SDS in an HDF file is as follows:

1. Open a file and initialize the SD interface.
2. Create a new data set or open an existing one using its index.
3. Perform desired operations on this data set.
4. Terminate access to the data set.
5. Terminate access to the SD interface and close the file.

To access a single SDS in an HDF file, the calling program must contain the following calls:

C:

\[
\begin{align*}
\text{sd_id} &= \text{SDstart}(\text{filename}, \text{access_mode}); \\
\text{sd_id} &= \text{SDend}(\text{sd_id}); \\
\text{sds_id} &= \text{SDselect}(\text{sd_id}, \text{sds_index}); \\
\text{sds_id} &= \text{SDcreate}(\text{sd_id}, \text{sds_name}, \text{data_type}, \text{rank}, \text{dim_sizes}); \\
\text{status} &= \text{SDendaccess}(\text{sds_id}); \\
\text{status} &= \text{SDend}(\text{sd_id});
\end{align*}
\]

OR

\[
\begin{align*}
\text{sd_id} &= \text{SDstart}(\text{filename}, \text{access_mode}); \\
\text{sd_id} &= \text{SDselect}(\text{sd_id}, \text{sds_index}); \\
\text{sds_id} &= \text{SDcreate}(\text{sd_id}, \text{sds_name}, \text{data_type}, \text{rank}, \text{dim_sizes}); \\
\text{status} &= \text{SDendaccess}(\text{sds_id}); \\
\text{status} &= \text{SDend}(\text{sd_id});
\end{align*}
\]

FORTRAN:

\[
\begin{align*}
\text{sd_id} &= \text{sfstart}(\text{filename}, \text{access_mode}); \\
\text{sd_id} &= \text{sfselect}(\text{sd_id}, \text{sds_index}); \\
\text{sds_id} &= \text{sfcreate}(\text{sd_id}, \text{sds_name}, \text{data_type}, \text{rank}, \text{dim_sizes}); \\
\text{status} &= \text{sfendacc}(\text{sds_id}); \\
\text{status} &= \text{sfend}(\text{sd_id});
\end{align*}
\]

To access several files at the same time, a program must obtain a separate SD file identifier (sd_id) for each file to be opened. Likewise, to access more than one SDS, a calling program must obtain a separate SDS identifier (sds_id) for each SDS. For example, to open two SDSs stored in two files a program would execute the following series of function calls.

C:

\[
\begin{align*}
\text{sd_id}_1 &= \text{SDstart}(\text{filename}_1, \text{access_mode}); \\
\text{sd_id}_1 &= \text{SDselect}(\text{sd_id}_1, \text{sds_index}_1); \\
\text{sd_id}_2 &= \text{SDstart}(\text{filename}_2, \text{access_mode}); \\
\text{sd_id}_2 &= \text{SDselect}(\text{sd_id}_2, \text{sds_index}_2); \\
\text{status} &= \text{SDendaccess}(\text{sds_id}_1); \\
\text{status} &= \text{SDend}(\text{sd_id}_1); \\
\text{status} &= \text{SDendaccess}(\text{sds_id}_2); \\
\text{status} &= \text{SDend}(\text{sd_id}_2);
\end{align*}
\]

FORTRAN:

\[
\begin{align*}
\text{sd_id}_1 &= \text{sfstart}(\text{filename}_1, \text{access_mode}); \\
\text{sd_id}_1 &= \text{sfselect}(\text{sd_id}_1, \text{sds_index}_1); \\
\text{sd_id}_2 &= \text{sfstart}(\text{filename}_2, \text{access_mode}); \\
\text{sd_id}_2 &= \text{sfselect}(\text{sd_id}_2, \text{sds_index}_2); \\
\text{status} &= \text{sfendacc}(\text{sds_id}_1);
\end{align*}
\]
status = sfend(sd_id_1)
status = sfendacc(sds_id_2)
status = sfend(sd_id_2)

3.4.1 Establishing Access to Files and Data Sets: SDstart, SDcreate, and SDselect

In the SD interface, SDstart is used to open files rather than Hopen. SDstart takes two arguments, filename and access_mode, and returns the SD interface identifier, sd_id. Note that the SD interface identifier, sd_id, is not interchangeable with the file identifier, file_id, created by Hopen and used in other HDF APIs.

The argument filename is the name of an HDF or netCDF file.

The argument access_mode specifies the type of access required for operations on the file. All the valid values for access_mode are listed in Table 3B. If the file does not exist, specifying DFACC_READ or DFACC_WRITE will cause SDstart to return a FAIL (or -1). Specifying DFACC_CREATE creates a new file with read and write access. If DFACC_CREATE is specified and the file already exists, the contents of this file will be replaced.

<table>
<thead>
<tr>
<th>File Access Flag</th>
<th>Flag Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFACC_READ</td>
<td>1</td>
<td>Read only access</td>
</tr>
<tr>
<td>DFACC_WRITE</td>
<td>2</td>
<td>Read and write access</td>
</tr>
<tr>
<td>DFACCCREATE</td>
<td>4</td>
<td>Create with read and write access</td>
</tr>
</tbody>
</table>

The SD interface identifiers can be obtained and discarded in any order and all SD interface identifiers must be individually discarded, by SDend, before the termination of the calling program.

Although it is possible to open a file more than once, it is recommended that the appropriate access mode be specified and SDstart called only once per file. Repeatedly calling SDstart on the same file and with different access modes may cause unexpected results.

SDstart returns an SD identifier or a value of FAIL (or -1). The parameters of SDstart are defined in Table 3C on page 27.

SDcreate defines a new SDS using the arguments sd_id, sds_name, data_type, rank, and dim_sizes and returns the data set identifier, sds_id.

The parameter sds_name is a character string containing the name to be assigned to the SDS. The SD interface will generate a default name, "Data Set", for the SDS, if one is not provided, i.e., when the parameter sds_name is set to NULL in C, or an empty string in FORTRAN-77. The maximum length of an SDS name is 64 characters and, if sds_name contains more than 64 characters, the name will be truncated before being assigned.

The parameter data_type is a defined name, prefaced by DFNT, and specifies the type of the data to be stored in the data set. The header file "hntdefs.h" contains the definitions of all valid data types, which are described in Chapter 2, HDF Fundamentals, and listed in Table 2F on page 14.

The parameter rank is a positive integer specifying the number of dimensions of the SDS array. The maximum rank of an SDS array is defined by MAX_VAR_DIMS (or 32), which is defined in the header file "netcdf.h".

Each element of the one-dimensional array dim_sizes specifies the length of the corresponding dimension of the SDS array. The size of dim_sizes must be the value of the parameter rank. To
create a data set with an unlimited dimension, assign the value of \textbf{SD\_UNLIMITED} (or 0) to \texttt{dim\_sizes[0]} in C, and to \texttt{dim\_sizes(rank)} in FORTRAN-77. See the notes regarding the potential performance impact of unlimited dimension data sets in Section 14.4.3, "Unlimited Dimension Data Sets (SDSs and Vdatas) and Performance."

Once an SDS is created, you cannot change its name, data type, size, or shape. However, it is possible to modify the data set data or to create an empty data set and later add values. To add data or modify an existing data set, use \textbf{SDselect} to get the data set identifier instead of \textbf{SDcreate}.

Note that the SD interface retains no definitions about the size, contents, or rank of an SDS from one SDS to the next, or from one file to the next.

\textbf{SDselect} initiates access to an existing data set. The routine takes two arguments: \texttt{sd\_id} and \texttt{sds\_index} and returns the SDS identifier \texttt{sds\_id}. The argument \texttt{sd\_id} is the SD interface identifier returned by \textbf{SDstart}, and \texttt{sds\_index} is the position of the data set in the file. The argument \texttt{sds\_index} is zero-based, meaning that the index of first SDS in the file is 0.

Similar to SD interface identifiers, SDS identifiers can be obtained and discarded in any order as long as they are discarded properly. Each SDS identifier must be individually disposed of, by \textbf{SDendaccess}, before the disposal of the identifier of the interface in which the SDS is opened.

\textbf{SDcreate} and \textbf{SDselect} each returns an SDS identifier or a value of \texttt{FAIL} (or \texttt{-1}). The parameters of \textbf{SDstart}, \textbf{SDcreate}, and \textbf{SDselect} are further described in Table 3C.

### 3.4.2 Terminating Access to Files and Data Sets: SDendaccess and SDend

\textbf{SDendaccess} terminates access to the data set and disposes of the data set identifier \texttt{sds\_id}. The calling program must make one \textbf{SDendaccess} call for every \textbf{SDselect} or \textbf{SDcreate} call made during its execution. Failing to call \textbf{SDendaccess} for each call to \textbf{SDselect} or \textbf{SDcreate} may result in a loss of data.

\textbf{SDend} terminates access to the file and the SD interface and disposes of the file identifier \texttt{sd\_id}. The calling program must make one \textbf{SDend} call for every \textbf{SDstart} call made during its execution. Failing to call \textbf{SDend} for each \textbf{SDstart} may result in a loss of data.

\textbf{SDendaccess} and \textbf{SDend} each returns either a value of \texttt{SUCCEED} (or 0) or \texttt{FAIL} (or \texttt{-1}). The parameters of \textbf{SDendaccess} and \textbf{SDend} are further described in Table 3C.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\textbf{SDstart} \ [int32] \ (sfstart)</td>
<td>\texttt{sd_id}</td>
<td>int32 integer</td>
<td>SD interface identifier</td>
</tr>
<tr>
<td>\texttt{access_mode}</td>
<td>int32 integer</td>
<td>Type of access</td>
<td></td>
</tr>
<tr>
<td>\texttt{filename}</td>
<td>char* character*(*</td>
<td>Name of the HDF or netCDF file</td>
<td></td>
</tr>
<tr>
<td>\textbf{SDcreate} \ [int32] \ (sfcreate)</td>
<td>\texttt{sds_name}</td>
<td>char* character*(*</td>
<td>ASCII string containing the name of the data set</td>
</tr>
<tr>
<td>\texttt{data_type}</td>
<td>int32 integer</td>
<td>Data type of the data set</td>
<td></td>
</tr>
<tr>
<td>\texttt{rank}</td>
<td>int32 integer</td>
<td>Number of dimensions in the array</td>
<td></td>
</tr>
<tr>
<td>\texttt{dim_sizes}</td>
<td>int32[] integer*</td>
<td>Array defining the size of each dimension</td>
<td></td>
</tr>
<tr>
<td>\textbf{SDselect} \ [int32] \ (ssselect)</td>
<td>\texttt{sd_id}</td>
<td>int32 integer</td>
<td>SD interface identifier</td>
</tr>
<tr>
<td>\texttt{sds_index}</td>
<td>int32 integer</td>
<td>Position of the data set within the file</td>
<td></td>
</tr>
</tbody>
</table>
EXAMPLE 1.

Creating an HDF file and an Empty SDS.

This example illustrates the use of SDstart/sfstart, SDcreate/sfcreate, SDendaccess/sfendacc, and SDend/sfend to create the HDF file named SDS.hdf, and an empty data set with the name SDStemplate in the file.

Note that the Fortran program uses a transformed array to reflect the difference between C and Fortran internal data storages. When the actual data is written to the data set, SDS.hdf will contain the same data regardless of the language being used.

C:

```c
#include "mfhdf.h"

#define FILE_NAME "SDS.hdf"
#define SDS_NAME "SDStemplate"
#define X_LENGTH 5
#define Y_LENGTH 16
#define RANK 2 /* Number of dimensions of the SDS */

int32 sd_id, sds_id; /* SD interface and data set identifiers */
int32 dim_sizes[2]; /* sizes of the SDS dimensions */
intn status; /* status returned by some routines; has value SUCCEED or FAIL */

main( )
{
    /*********** Variable declaration ******************/
    /*
    sd_id, sds_id; /* SD interface and data set identifiers */
    int32 dim_sizes[2]; /* sizes of the SDS dimensions */
    intn status; /* status returned by some routines; has value SUCCEED or FAIL */
    
    /*********** End of variable declaration ******************/
    /*
    * Create the file and initialize the SD interface.
    */
    sd_id = SDstart (FILE_NAME, DFACC_CREATE);

    /*
    * Define the dimensions of the array to be created.
    */
    dim_sizes[0] = Y_LENGTH;
    dim_sizes[1] = X_LENGTH;

    /*
    * Create the data set with the name defined in SDS_NAME. Note that
    * DFNT_INT32 indicates that the SDS data is of type int32. Refer to
    * Table 2E for definitions of other types.
    */
    sds_id = SDcreate (sd_id, SDS_NAME, DFNT_INT32, RANK, dim_sizes);

    /*
    * Terminate access to the data set.
    */
    status = SDendaccess (sds_id);
    */
```
* Terminate access to the SD interface and close the file. */
    status = SDend (sd_id);
}

FORTRAN:

program create_SDS
    implicit none
    C
    C     Parameter declaration.
    C
    character*7  FILE_NAME
    character*11 SDS_NAME
    integer      X_LENGTH, Y_LENGTH, RANK
    parameter   (FILE_NAME = 'SDS.hdf',
                  SDS_NAME = 'SDStemplate',
                  X_LENGTH = 5,
                  Y_LENGTH = 16,
                  RANK     = 2)
    integer      DFACC_CREATE, DFNT_INT32
    parameter   (DFACC_CREATE = 4,
                  DFNT_INT32 = 24)
    C
    C     Function declaration.
    C
    integer sfstart, sfcreate, sfendacc, sfend
    C
    C**** Variable declaration *******************************************
    C
    integer sd_id, sds_id, dim_sizes(2)
    integer status
    C
    C**** End of variable declaration ************************************
    C

    Create the file and initialize the SD interface.
    sd_id = sfstart(FILE_NAME, DFACC_CREATE)
    C
    Define dimensions of the array to be created.
    dim_sizes(1) = X_LENGTH
    dim_sizes(2) = Y_LENGTH
    C
    Create the array with the name defined in SDS_NAME.
    Note that DFNT_INT32 indicates that the SDS data is of type
    integer. Refer to Tables 2E and 2I for the definition of other types.
    sds_id = sfcreate(sd_id, SDS_NAME, DFNT_INT32, RANK,
                      dim_sizes)
    C
    Terminate access to the data set.
    status = sfendacc(sds_id)
    C
    Terminate access to the SD interface and close the file.
    status = sfend(sd_id)
    end
3.5 Writing Data to an SDS

An SDS can be written partially or entirely. Partial writing includes writing to a contiguous region of the SDS and writing to selected locations in the SDS according to patterns defined by the user. This section describes the routine SDwritedata and how it can write data to part of an SDS or to an entire SDS. The section also illustrates the concepts of compressing SDSs and using external files to store scientific data.

3.5.1 Writing Data to an SDS Array: SDwritedata

SDwritedata can completely or partially fill an SDS array or append data along the dimension that is defined to be of unlimited length (see Section 3.5.1.3 on page 40 for a discussion of unlimited-length dimensions). It can also skip a specified number of SDS array elements between write operations along each dimension.

To write to an existing SDS, the calling program must contain the following sequence of routine calls:

C:
```c
sds_id = SDselect(sd_id, sds_index);
status = SDwritedata(sds_id, start, stride, edges, data);
```

FORTRAN:
```fortran
sds_id = sfselect(sd_id, sds_index)
status = sfwdata(sds_id, start, stride, edges, data)
```

OR
```fortran
status = sfwcdata(sds_id, start, stride, edges, data)
```

To write to a new SDS, simply replace the call SDselect with the call SDcreate, which is described in Section 3.4.1 on page 26.

SDwritedata takes five arguments: sds_id, start, stride, edges, and data. The argument sds_id is the data set identifier returned by SDcreate or SDselect.

Before proceeding with the description of the remaining arguments, an explanation of the term hyperslab (or slab, as it will be used in this chapter) is in order. A slab is a group of SDS array elements that are stored in consecutive locations. It can be of any size and dimensionality as long as it is a subset of the array, which means that a single array element and the entire array can both be considered slabs. A slab is defined by the multidimensional coordinate of its initial vertex and the lengths of each dimension.

Given this description of the slab concept, the usage of the remaining arguments should become apparent. The argument start is a one-dimensional array specifying the location in the SDS array at which the write operation will begin. The values of each element of the array start are relative to 0 in both the C and FORTRAN-77 interfaces. The size of start must be the same as the number of dimensions in the SDS array. In addition, each value in start must be smaller than its corresponding SDS array element unless the dimension is unlimited. Violating any of these conditions causes SDwritedata to return FAIL.

The argument stride is a one-dimensional array specifying, for each dimension, the interval between values to be written. For example, setting the first element of the array stride equal to 1 writes data to every location along the first dimension. Setting the first element of the array stride to 2 writes data to every other location along the first dimension. Figure 3b illustrates this example, where the shading elements are written and the white elements are skipped. If the argument stride is set to NULL in C (or either 0 or 1 in FORTRAN-77), SDwritedata operates as if every element of stride contains a value of 1, and a contiguous write is performed. For better performance, it is recommended that the value of stride be defined as NULL (i.e., 0 or 1 in FORTRAN-77) rather than being set to 1.
The size of the array \texttt{stride} must be the same as the number of dimensions in the SDS array. Also, each value in \texttt{stride} must be smaller than or equal to its corresponding SDS array dimension unless the dimension is unlimited. Violating any of these conditions causes \texttt{SDwritedata} to return \texttt{FAIL}.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{strides.png}
\caption{An Example of Access Pattern ("Strides")}
\end{figure}

\texttt{stride[0]} = 2

The argument \texttt{edges} is a one-dimensional array specifying the length of each dimension of the slab to be written. If the slab has fewer dimensions than the SDS data set has, the size of \texttt{edges} must still be equal to the number of dimensions in the SDS array and all the elements corresponding to the additional dimensions must be set to 1.

Each value in the array \texttt{edges} must not be larger than the length of the corresponding dimension in the SDS data set unless the dimension is unlimited. Attempting to write slabs larger than the size of the SDS data set will result in an error condition.

In addition, the sum of each value in the array \texttt{edges} and the corresponding value in the \texttt{start} array must be smaller than or equal to its corresponding SDS array dimension unless the dimension is unlimited. Violating any of these conditions causes \texttt{SDwritedata} to return \texttt{FAIL}.

The parameter \texttt{data} contains the SDS data to be written. If the SDS array is smaller than the buffer \texttt{data}, the amount of data written will be limited to the maximum size of the SDS array.

Be aware that the mapping between the dimensions of a slab and the order in which the slab values are stored in memory is different between C and FORTRAN-77. In C, the values are stored with the assumption that the last dimension of the slab varies fastest (or "row-major order" storage), but in FORTRAN-77 the first dimension varies fastest (or "column-major order" storage). These storage order conventions can cause some confusion when data written by a C program is read by a FORTRAN-77 program or vice versa.

There are two FORTRAN-77 versions of this routine: \texttt{sfwdata} and \texttt{sfwcdat}a. The routine \texttt{sfwdata} writes numeric scientific data and \texttt{sfwcdat}a writes character scientific data.

\texttt{SDwritedata} returns either a value of \texttt{SUCCEED} (or 0) or \texttt{FAIL} (or -1). The parameters of this routine are described in Table 3D.
TABLE 3D

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDwritedata</td>
<td>sds_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>start</td>
<td>int32[]</td>
<td>integer(*)</td>
</tr>
<tr>
<td></td>
<td>stride</td>
<td>int32[]</td>
<td>integer(*)</td>
</tr>
<tr>
<td></td>
<td>edges</td>
<td>int32[]</td>
<td>integer(*)</td>
</tr>
<tr>
<td></td>
<td>data</td>
<td>VOIDP</td>
<td>&lt;valid numeric data type&gt;(<em>)/character</em>(+)</td>
</tr>
</tbody>
</table>

3.5.1.1 Filling an Entire Array

Filling an array is a simple slab operation where the slab begins at the origin of the SDS array and fills every location in the array. **SDwritedata** fills an entire SDS array with data when all elements of the array **start** are set to 0, the argument **stride** is set equal to **NULL** in C or each element of the array **stride** is set to 1 in both C and FORTRAN-77, and each element of the array **edges** is equal to the length of each dimension.

**EXAMPLE 2. Writing to an SDS.**

This example illustrates the use of the routines **SDselect/sfselect** and **SDwritedata/sfwrite** to select the first SDS in the file **SDS.hdf** created in Example 1 and to write actual data to it.

C:
```
#include "mfhdf.h"
#define FILE_NAME     "SDS.hdf"
#define X_LENGTH      5
#define Y_LENGTH      16

main( )
{
    /**************************** Variable declaration ***************************/
    int32 sd_id, sds_id, sds_index;
    intn status;
    int32 start[2], edges[2];
    int32 data[Y_LENGTH][X_LENGTH];
    int i, j;

    /* End of variable declaration*****************************/

    /* Data set data initialization. */
    for (j = 0; j < Y_LENGTH; j++) {
        for (i = 0; i < X_LENGTH; i++)
            data[j][i] = (i + j) + 1;
    }
```

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* Open the file and initialize the SD interface.
*/
sd_id = SDstart (FILE_NAME, DFACC_WRITE);

/*
* Attach to the first data set.
*/
sds_index = 0;
sds_id = SDselect (sd_id, sds_index);

/*
* Define the location and size of the data to be written to the data set.
*/
start[0] = 0;
start[1] = 0;
edges[0] = Y_LENGTH;
edges[1] = X_LENGTH;

/*
* Write the stored data to the data set. The third argument is set to NULL
* to specify contiguous data elements. The last argument must
* be explicitly cast to a generic pointer since SDwritedata is designed
* to write generic data.
*/
status = SDwritedata (sds_id, start, NULL, edges, (VOIDP)data);

/*
* Terminate access to the data set.
*/
status = SDendaccess (sds_id);

/*
* Terminate access to the SD interface and close the file.
*/
status = SDend (sd_id);

FORTRAN:
program write_data
  implicit none
C  Parameter declaration.
C  C
C    character*7  FILE_NAME
C    character*11 SDS_NAME
C    integer     X_LENGTH, Y_LENGTH, RANK
C    parameter   (FILE_NAME = ’SDS.hdf’,
+                  SDS_NAME = ’SDStemplate’,
+                  X_LENGTH = 5,
+                  Y_LENGTH = 16,
+                  RANK = 2)
C    integer     DFACC_WRITE, DFNT_INT32
C    parameter   (DFACC_WRITE = 2,
+                  DFNT_INT32 = 24)
C  Function declaration.
C  C
C    integer sfstart, sfselect, sfwdata, sfendacc, sfend
C  C**** Variable declaration **************************************************
integer sd_id, sds_id, sds_index, status
integer start(2), edges(2), stride(2)
integer i, j
integer data(X_LENGTH, Y_LENGTH)

C
**** End of variable declaration #################################***
C
C
C     Data set data initialization.
C
      do 20 j = 1, Y_LENGTH
         do 10 i = 1, X_LENGTH
            data(i, j) = i + j - 1
         10    continue
      20    continue

C     Open the file and initialize the SD interface.
C
      sd_id = sfstart(FILE_NAME, DFACC_WRITE)

C     Attach to the first data set.
C
      sds_index = 0
      sds_id = sfselect(sd_id, sds_index)

C     Define the location and size of the data to be written
C     to the data set. Note that setting values of the array stride to 1
C     specifies the contiguous writing of data.
C
      start(1) = 0
      start(2) = 0
      edges(1) = X_LENGTH
      edges(2) = Y_LENGTH
      stride(1) = 1
      stride(2) = 1

C     Write the stored data to the data set named in SDS_NAME.
C     Note that the routine sfwdata is used instead of sfwcdata
C     to write the numeric data.
C
      status = sfwdata(sds_id, start, stride, edges, data)

C     Terminate access to the data set.
C
      status = sfendacc(sds_id)

C     Terminate access to the SD interface and close the file.
C
      status = sfend(sd_id)

end
3.5.1.2 Writing Slabs to an SDS Array

To allow preexisting data to be modified, the HDF library does not prevent SDwritedata from overwriting one slab with another. As a result, the calling program is responsible for managing any overlap when writing slabs. The HDF library will issue an error if a slab extends past the valid boundaries of the SDS array. However, appending data along an unlimited dimension is allowed.

**EXAMPLE 3. Writing a Slab of Data to an SDS.**

This example shows how to fill a 3-dimensional SDS array with data by writing series of 2-dimensional slabs to it.

**C:**

```
#include "mfhdf.h"
#define FILE_NAME "SLABS.hdf"
#define SDS_NAME  "FilledBySlabs"
#define X_LENGTH  4
#define Y_LENGTH  5
#define Z_LENGTH  6
#define RANK      3

main( )
{
    /********************************************************** Variable declaration **********************************************************/
    int32 sd_id, sds_id;
    intn status;
    int32 dim_sizes[3], start[3], edges[3];
    int32 data[Z_LENGTH][Y_LENGTH][X_LENGTH];
    int32 zx_data[Z_LENGTH][X_LENGTH];
    int i, j, k;
    /********************************************************** End of variable declaration **********************************************************/

    /*
     * Data initialization.
     */
    for (k = 0; k < Z_LENGTH; k++)
        for (j = 0; j < Y_LENGTH; j++)
            for (i = 0; i < X_LENGTH; i++)
                data[k][j][i] = (i + 1) + (j + 1) + (k + 1);

    /*
     * Create the file and initialize the SD interface.
     */
    sd_id = SDstart (FILE_NAME, DFACC_CREATE);

    /*
     * Define dimensions of the array to be created.
     */
    dim_sizes[0] = Z_LENGTH;
    dim_sizes[1] = Y_LENGTH;
    dim_sizes[2] = X_LENGTH;

    /*
     * Create the array with the name defined in SDS_NAME.
     */
    sds_id = SDcreate (sd_id, SDS_NAME, DFNT_INT32, RANK, dim_sizes);
```
* Set the parameters start and edges to write
* a 6x4 element slab of data to the data set; note
* that edges[1] is set to 1 to define a 2-dimensional slab
* parallel to the ZX plane.
* start[1] (slab position in the array) is initialized inside
* the for loop.
*/
edges[0] = Z_LENGTH;
edges[1] = 1;
edges[2] = X_LENGTH;
start[0] = start[2] = 0;
for (j = 0; j < Y_LENGTH; j++)
{
    start[1] = j;
    /*
    * Initialize zx_data buffer (data slab).
    */
    for (k = 0; k < Z_LENGTH; k++)
    {
        for (i = 0; i < X_LENGTH; i++)
        {
            zx_data[k][i] = data[k][j][i];
        }
    }
    /*
    * Write the data slab into the SDS array defined in SDS_NAME.
    * Note that the 3rd parameter is NULL which indicates that consecutive
    * slabs in the Y direction are written.
    */
    status = SDwritedata (sds_id, start, NULL, edges, (VOIDP)zx_data);
}
/*
* Terminate access to the data set.
*/
status = SDendaccess (sds_id);
/*
* Terminate access to the SD interface and close the file.
*/
status = SDend (sd_id);

FORTRAN:

program write_slab
    implicit none
    C
    C     Parameter declaration.
    C
    character*9     FILE_NAME
    character*13    SDS_NAME
    integer         X_LENGTH, Y_LENGTH, Z_LENGTH, RANK
    parameter (FILE_NAME = 'SLABS.hdf',
                SDS_NAME = 'FilledBySlabs',
                X_LENGTH = 4,
                Y_LENGTH = 5,
                Z_LENGTH = 6,
                RANK = 3)
    integer         DFACC_CREATE, DFNT_INT32
    parameter (DFACC_CREATE = 4,
Function declaration.

integer sfstart, sfcreate, sfwdata, sfendacc, sfend

Variable declaration

integer sd_id, sds_id
integer dim_sizes(3), start(3), edges(3), stride(3)
integer i, j, k, status
integer data(X_LENGTH, Y_LENGTH, Z_LENGTH)
integer xz_data(X_LENGTH, Z_LENGTH)

End of variable declaration

Data initialization.

do 30 k = 1, Z_LENGTH
   do 20 j = 1, Y_LENGTH
      do 10 i = 1, X_LENGTH
         data(i, j, k) = i + j + k
      10   continue
   20    continue
30    continue

Create the file and initialize the SD interface.

sd_id = sfstart(FILE_NAME, DFACC_CREATE)

Define dimensions of the array to be created.

dim_sizes(1) = X_LENGTH
dim_sizes(2) = Y_LENGTH
dim_sizes(3) = Z_LENGTH

Create the data set with the name defined in SDS_NAME.

sds_id = sfcreate(sd_id, SDS_NAME, DFNT_INT32, RANK, .
   .   .   dim_sizes)

Set the parameters start and edges to write
a 4x6 element slab of data to the data set;
note that edges(2) is set to 1 to define a 2 dimensional slab
parallel to the XZ plane;
start(2) (slab position in the array) is initialized inside the
for loop.

edges(1) = X_LENGTH
edges(2) = 1
edges(3) = Z_LENGTH
start(1) = 0
start(3) = 0
stride(1) = 1
stride(2) = 1
stride(3) = 1

do 60 j = 1, Y_LENGTH
   start(2) = j - 1
60    continue

Initialize the buffer xz_data (data slab).
EXAMPLE 4.

Altering Values within an SDS Array.

This example demonstrates how the routine \texttt{SDFwritedata} can be used to alter the values of the elements in the 10th and 11th rows, at the 2nd column, in the SDS array created in the Example 1 and written in Example 2. FORTRAN-77 routine \texttt{sfwdata} is used to alter the elements in the 2nd row, 10th and 11th columns, to reflect the difference between C and Fortran internal storage.

\begin{verbatim}
C:

#include "mfhdf.h"

#define FILE_NAME "SDS.hdf"

main( )
{
  /*************************************************************************
  * Variable declaration **************************************************************************

  int32 sd_id, sds_id, sds_index;
  intn  status;
  int32 start[2], edges[2];
  int32 new_data[2];
  int   i, j;

  /************************************************************************** End of variable declaration ****************************************************************************

  /* Open the file and initialize the SD interface with write access. */
  sd_id = SDstart (FILE_NAME, DFACC_WRITE);

  /*
  * Select the first data set.
  */
  sds_index = 0;
  sds_id = SDselect (sd_id, sds_index);

  /*
  * Set up the start and edge parameters to write new element values
  * into 10th row, 2nd column place, and 11th row, 2nd column place.

  do 50 k = 1, Z_LENGTH
  do 40 i = 1, X_LENGTH
      xz_data(i, k) = data(i, j, k)
  40      continue
  50     continue

C
  C     Write the data slab into SDS array defined in SDS_NAME.
  C     Note that the elements of array stride are set to 1 to
  C     specify that the consecutive slabs in the Y direction are written.
  C
  status = sfwdata(sds_id, start, stride, edges, xz_data)

  60    continue

C
  C     Terminate access to the data set.

  C
  status = sfendacc(sds_id)

  C
  C     Terminate access to the SD interface and close the file.

  C
  status = sfend(sd_id)

end
\end{verbatim}
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start[0] = 9;     /* starting at 10th row */
start[1] = 1;     /* starting at 2nd column */
edges[0] = 2;     /* rows 10th and 11th */
edges[1] = 1;     /* column 2nd only */

/* Initialize buffer with the new values to be written. */
new_data[0] = new_data[1] = 1000;

/* Write the new values. */
status = SDwritedata (sds_id, start, NULL, edges, (VOIDP)new_data);

/* Terminate access to the data set. */
status = SDendaccess (sds_id);

/* Terminate access to the SD interface and close the file. */
status = SDend (sd_id);
}

FORTRAN:

program alter_data
  implicit none

  character*7  FILE_NAME
  integer      DFACC_WRITE
  parameter   (FILE_NAME = 'SDS.hdf',
                +       DFACC_WRITE = 2)

  integer sfstart, sfselect, sfwdata, sfendacc, sfend

**** Variable declaration ************************************

  integer sd_id, sds_id, sds_index
  integer start(2), edges(2), stride(2)
  integer status
  integer new_data(2)

**** End of variable declaration **********************

  sd_id = sfstart(FILE_NAME, DFACC_WRITE)
  sds_index = 0
  sds_id = sfselect(sd_id, sds_index)
C
C     Initialize the start, edge, and stride parameters to write
C     two elements into 2nd row, 10th column and 11th column places.
C
C     Specify 2nd row.
C
C     start(1) = 1
C
C     Specify 10th column.
C
C     start(2) = 9
edges(1) = 1
C
C     Two elements are written along 2nd row.
C
edges(2) = 2
C     strides(1) = 1
C     strides(2) = 1
C
C     Initialize the new values to be written.
C
new_data(1) = 1000
new_data(2) = 1000
C
C     Write the new values.
C
status = sfwdata(sds_id, start, stride, edges, new_data)
C
C     Terminate access to the data set.
C
status = sfendacc(sds_id)
C
C     Terminate access to the SD interface and close the file.
C
status = sfend(sd_id)
end

3.5.1.3 Appending Data to an SDS Array along an Unlimited Dimension

An SDS array can be made appendable, however, only along one dimension. This dimension must be specified as an **appendable dimension** when it is created.

In C, only the first element of the **SDcreate** parameter `dim_sizes` (i.e., the dimension of the lowest rank or the slowest-changing dimension) can be assigned the value `SD_UNLIMITED` (or 0) to make the first dimension unlimited. In FORTRAN-77, only the last dimension (i.e., the dimension of the highest rank or the slowest-changing dimension) can be unlimited. In other words, in FORTRAN-77 `dim_sizes(rank)` must be set to the value `SD_UNLIMITED` to make the last dimension appendable.

To append data to a data set without overwriting previously-written data, the user must specify the appropriate coordinates in the `start` parameter of the **SDwritedata** routine. For example, if 15 data elements have been written to an unlimited dimension, appending data to the array requires a `start` coordinate of 15. Specifying a starting coordinate less than the current number of elements written to the unlimited dimension will result in data being overwritten. In either case, all of the coordinates in the array except the one corresponding to the unlimited dimension must be equal to or less than the lengths of their corresponding dimensions.

Any time an unlimited dimension is appended to, the HDF library will automatically adjust the dimension record to the new length. If the newly-appended data begins beyond the previous
length of the dimension, the locations between the old data and the beginning of the newly-appended data are initialized to the assigned fill value if there is one defined by the user, or the default fill value if none is defined. Refer to Section 3.10.5 on page 101 for a discussion of fill value.

3.5.1.4 Determining whether an SDS Array is Appendable: SDisrecord

SDisrecord determines whether the data set identified by the parameter sds_id is appendable, which means that the slowest-changing dimension of the SDS array is declared unlimited when the data set is created. The syntax of SDisrecord is as follows:

C:    status = SDisrecord(sds_id);

FORTRAN:    status = sfisrcrd(sds_id)

SDisrecord returns TRUE (or 1) when the data set specified by sds_id is appendable and FALSE (or 0) otherwise. The parameter of this routine is defined in Table 3E.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDisrecord</td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
</tbody>
</table>

3.5.1.5 Setting the Block Size: SDsetblocksize

SDsetblocksize sets the size of the blocks used for storing the data for unlimited dimension data sets. This is used only when creating new data sets; it does not have any affect on existing data sets. The syntax of this routine is as follows:

C:    status = SDsetblocksize(sds_id, block_size);

FORTRAN:    status = sfsblsz(sds_id, block_size)

SDsetblocksize must be called after SDcreate or SDselect and before SDwritedata. The parameter block_size should be set to a multiple of the desired buffer size.

SDsetblocksize returns a value of SUCCEED (or 0) or FAIL (or -1). Its parameters are further described in Table 3F.

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDsetblocksize [int32] (sfsblsz)</td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
</tbody>
</table>

EXAMPLE 5.

Appending Data to an SDS Array with an Unlimited Dimension.

This example creates a 10x10 SDS array with one unlimited dimension and writes data to it. The file is reopened and the routine SDisrecord/sfisrcrd is used to determine whether the selected SDS array is appendable. Then new data is appended, starting at the 11th row.
C:

#include "mfhdf.h"

#define FILE_NAME "SDSUNLIMITED.hdf"
#define SDS_NAME "AppendableData"
#define X_LENGTH 10
#define Y_LENGTH 10
#define RANK 2

main( )
{
    /**********************************************************************
     * Variable declaration
     **********************************************************************/
    int32 sd_id, sds_id, sds_index;
    intn status;
    int32 dim_sizes[2];
    int32 data[Y_LENGTH][X_LENGTH], append_data[X_LENGTH];
    int32 start[2], edges[2];
    int i, j;

    /**********************************************************************
     * Data initialization.
     **********************************************************************/
    for (j = 0; j < Y_LENGTH; j++)
    {
        for (i = 0; i < X_LENGTH; i++)
        {
            data[j][i] = (i + 1) + (j + 1);
        }
    }

    /**********************************************************************
     * Create the file and initialize the SD interface.
     **********************************************************************/
    sd_id = SDstart (FILE_NAME, DFACC_CREATE);

    /**********************************************************************
     * Define dimensions of the array. Make the first dimension
     * appendable by defining its length to be unlimited.
     **********************************************************************/
    dim_sizes[0] = SD_UNLIMITED;
    dim_sizes[1] = X_LENGTH;

    /**********************************************************************
     * Create the array data set.
     **********************************************************************/
    sds_id = SDcreate (sd_id, SDS_NAME, DFNT_INT32, RANK, dim_sizes);

    /**********************************************************************
     * Define the location and the size of the data to be written
     * to the data set.
     **********************************************************************/
    start[0] = start[1] = 0;
    edges[0] = Y_LENGTH;
    edges[1] = X_LENGTH;

    /**********************************************************************
     * Write the data.
     **********************************************************************/
    status = SDwritedata (sds_id, start, NULL, edges, (VOIDP)data);
}
* Terminate access to the array data set, terminate access
  * to the SD interface, and close the file.
  */
status = SDendaccess (sds_id);
status = SDend (sd_id);

  /*
  * Store the array values to be appended to the data set.
  */
for (i = 0; i < X_LENGTH; i++)
  append_data[i] = 1000 + i;

  /*
  * Reopen the file and initialize the SD interface.
  */
sd_id = SDstart (FILE_NAME, DFACC_WRITE);

  /*
  * Select the first data set.
  */
sds_index = 0;
sds_id = SDselect (sd_id, sds_index);

  /*
  * Check if selected SDS is unlimited. If it is not, then terminate access
  * to the SD interface and close the file.
  */
if ( SDisrecord (sds_id) )
{
  /*
  * Define the location of the append to start at the first column
  * of the 11th row of the data set and to stop at the end of the
  * eleventh row.
  */
  start[0] = Y_LENGTH;
  start[1] = 0;
  edges[0] = 1;
  edges[1] = X_LENGTH;

  /*
  * Append data to the data set.
  */
  status = SDwritedata (sds_id, start, NULL, edges, (VOIDP)append_data);
}

  /*
  * Terminate access to the data set.
  */
  status = SDendaccess (sds_id);

  /*
  * Terminate access to the SD interface and close the file.
  */
  status = SDend (sd_id);
}

FORTRAN:

  program append_sds
    implicit none

    C
    C Parameter declaration.
C
character*16  FILE_NAME
character*14  SDS_NAME
integer       X_LENGTH, Y_LENGTH, RANK
parameter    (FILE_NAME = 'SDSUNLIMITED.hdf',
+              SDS_NAME = 'AppendableData',
+              X_LENGTH = 10,
+              Y_LENGTH = 10,
+              RANK     = 2)
integer       DFACC_CREATE, DFACC_WRITE, SD_UNLIMITED,
+              DFNT_INT32
parameter    (DFACC_CREATE = 4,
+              DFACC_WRITE = 2,
+              SD_UNLIMITED = 0,
+              DFNT_INT32 =   24)
C
Function declaration.
C
integer sfstart, sfcreate, sfwdata, sfselect
integer sfendacc, sfend
C
C**** Variable declaration ********************************************
C
integer sd_id, sds_id, sds_index, status
integer dim_sizes(2)
integer start(2), edges(2), stride(2)
integer i, j
integer data (X_LENGTH, Y_LENGTH), append_data(X_LENGTH)
C
C**** End of variable declaration *************************************
C
C
Data initialization.
C
C     C     Data initialization.
C     do 20 j = 1, Y_LENGTH
C         do 10 i = 1, X_LENGTH
C             data(i, j) = i + j
C     10    continue
C     20    continue
C
C     Create the file and initialize the SD interface.
C
C     sd_id = sfstart(FILE_NAME, DFACC_CREATE)
C
C     Define dimensions of the array. Make the
C     last dimension appendable by defining its length as unlimited.
C
C     dim_sizes(1) = X_LENGTH
C     dim_sizes(2) = SD_UNLIMITED
C
C     Create the array data set.
C     sds_id = sfcreate(sd_id, SDS_NAME, DFNT_INT32, RANK,
C                      .
C     .                      dim_sizes)
C
C     Define the location and the size of the data to be written
C     to the data set. Note that the elements of array stride are
C     set to 1 for contiguous writing.
C
C     start(1) = 0
C     start(2) = 0
C     edges(1) = X_LENGTH
C     edges(2) = Y_LENGTH
C     stride(1) = 1
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3.5.2 Compressing SDS Data: SDsetcompress

The SDsetcompress routine compresses an existing data set or creates a new compressed data set. It is a simplified interface to the HCcreate routine, and should be used instead of HCcreate unless the user is familiar with the lower-level routines.

The compression algorithms currently supported by SDsetcompress are:

- Adaptive Huffman
- GZIP "deflation" (Lempel/Ziv-77 dictionary coder)
- Run-length encoding
In the future, the following algorithms may be included: Lempel/Ziv-78 dictionary coding, an arithmetic coder, and a faster Huffman algorithm.

The syntax of the routine **SDsetcompress** is as follows:

**C**: status = SDsetcompress(sds_id, comp_type, &c_info);

**FORTRAN**: status = sfscompress(sds_id, comp_type, comp_prm)

The parameter `comp_type` specifies the compression type definition and is set to `COMP_CODE_RLE` (or 1) for run-length encoding (RLE), `COMP_CODE_SKPHUFF` (or 3) for Skipping Huffman, `COMP_CODE_DEFLATE` (or 4) for GZIP compression, or `COMP_CODE_NONE` (or 0) for no compression.

Compression information is specified by the parameter `c_info` in C, and by the parameter `comp_prm` in FORTRAN-77. The parameter `c_info` is a pointer to a union structure of type `comp_info`. (Refer to the **SDsetcompress** entry in the *HDF Reference Manual* for the description of the `comp_info` structure.) If `comp_type` is set to `COMP_CODE_NONE` or `COMP_CODE_RLE`, the parameters `c_info` and `comp_prm` are not used; `c_info` can be set to NULL and `comp_prm` can be undefined. If `comp_type` is set to `COMP_CODE_SKPHUFF`, then the structure `skphuff` in the union `comp_info` in C (`comp_prm(1)` in FORTRAN-77) must be provided with the size, in bytes, of the data elements. If it is set to `COMP_CODE_DEFLATE`, the deflate structure in the union `comp_info` in C (`comp_prm(1)` in FORTRAN-77) must be provided with the information about the compression effort.

For example, to compress signed 16-bit integer data using the adaptive Huffman algorithm, the following definition and **SDsetcompress** call are used.

**C**: comp_info c_info;
    c_info.skphuff.skp_size = sizeof(int16);
    status = SDsetcompress(sds_id, COMP_CODE_SKPHUFF, &c_info);

**FORTRAN**: comp_prm(1) = 2
    COMP_CODE_SKPHUFF = 3
    status = sfscompress(sds_id, COMP_CODE_SKPHUFF, comp_prm)

To compress a data set using the gzip deflation algorithm with the maximum effort specified, the following definition and **SDsetcompress** call are used.

**C**: comp_info c_info;
    c_info.deflate.level = 9;
    status = SDsetcompress(sds_id, COMP_CODE_DEFLATE, &c_info);

**FORTRAN**: comp_prm(1) = 9
    COMP_CODE_DEFLATE = 4
    status = sfscompress(sds_id, COMP_CODE_DEFLATE, comp_prm)

**SDsetcompress** functionality is currently limited to the following:

- Write the compressed data, in its entirety, to the data set. The data set is built in-core then written in a single write operation.
- Append to a compressed data set. The data of the data set is read into memory, appended with data along the unlimited dimension, then compressed and written back to the data set.

The existing compression algorithms supported by HDF do not allow partial modification to a compressed data stream. Overwriting the contents of existing data sets may be supported in the future. Note also that **SDsetcompress** performs the compression of the data, not **SDwritedata**.
**SDsetcompress** returns a value of **SUCCEED** (or 0) or **FAIL** (or −1). The C version parameters are further described in Table 3G and the FORTRAN-77 version parameters are further described in Table 3H.

**Note:** Compressed data sets cannot be stored in external files (see Section 3.5.3).

### TABLE 3G

**SDsetcompress Parameter List**

<table>
<thead>
<tr>
<th>Routine Name [Return Type]</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SDsetcompress</strong> [intn]</td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>comp_type</td>
<td>int32</td>
<td>Compression method</td>
</tr>
<tr>
<td></td>
<td>c_info</td>
<td>comp_info*</td>
<td>Pointer to compression information structure</td>
</tr>
</tbody>
</table>

### TABLE 3H

**sfscompress Parameter List**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>sfscompress</strong></td>
<td>sds_id</td>
<td>integer</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>comp_type</td>
<td>integer</td>
<td>Compression method</td>
</tr>
<tr>
<td></td>
<td>comp_prm</td>
<td>integer(*)</td>
<td>Compression parameters array</td>
</tr>
</tbody>
</table>

### Compressing SDS Data.

This example uses the routine **SDsetcompress/sfscompress** to compress SDS data with the GZIP compression method. See comments in the program regarding the use of the Skipping Huffman or RLE compression methods.

**C:**

```c
#include "mfhdf.h"

#define FILE_NAME      "SDScompressed.hdf"
define SDS_NAME       "SDSgzip"
define X_LENGTH       5
define Y_LENGTH       16
define RANK           2

main( )
{
    /******************* Variable declaration *******************/
    int32     sd_id, sds_id, sds_index;
inbn     status;
int32     comp_type;    /* Compression flag */
comp_info c_info;   /* Compression structure */
int32     start[2], edges[2], dim_sizes[2];
int32     data[Y_LENGTH][X_LENGTH];
int       i, j;

    /* End of variable declaration */
    /*
    * Buffer array data and define array dimensions.
    */
    for (j = 0; j < Y_LENGTH; j++)
    {
```
for (i = 0; i < X_LENGTH; i++)
    data[j][i] = (i + j) + 1;
}
dim_sizes[0] = Y_LENGTH;
dim_sizes[1] = X_LENGTH;

/*
* Create the file and initialize the SD interface.
*/
sd_id = SDstart (FILE_NAME, DFACC_CREATE);

/*
* Create the data set with the name defined in SDS_NAME.
*/
sds_id = SDcreate (sd_id, SDS_NAME, DFNT_INT32, RANK, dim_sizes);

/*
* Initialize compression structure element and compression
* flag for GZIP compression and call SDsetcompress.
* To use the Skipping Huffman compression method, initialize
*     comp_type = COMP_CODE_SKPHUFF
*     c_info.skphuff.skp_size = value
* To use the RLE compression method, initialize
*     comp_type = COMP_CODE_RLE
* No structure element needs to be initialized.
*/
comp_type = COMP_CODE_DEFLATE;
c_info.deflate.level = 6;
status = SDsetcompress (sds_id, comp_type, &c_info);

/*
* Define the location and size of the data set
* to be written to the file.
*/
start[0] = 0;
start[1] = 0;
edges[0] = Y_LENGTH;
edges[1] = X_LENGTH;

/*
* Write the stored data to the data set. The last argument
* must be explicitly cast to a generic pointer since SDwritedata
* is designed to write generic data.
*/
status = SDwritedata (sds_id, start, NULL, edges, (VOIDP)data);

/*
* Terminate access to the data set.
*/
status = SDendaccess (sds_id);

/*
* Terminate access to the SD interface and close the file.
*/
status = SDend (sd_id);
FORTRAN:

```fortran
program write_compressed_data
  implicit none

  C Parameter declaration.
  C
  character*17 FILE_NAME
  character*7 SDS_NAME
  integer X_LENGTH, Y_LENGTH, RANK
  parameter (FILE_NAME = 'SDScompressed.hdf',
             SDS_NAME = 'SDSgzip',
             X_LENGTH = 5,
             Y_LENGTH = 16,
             RANK = 2)
  integer DFACC_CREATE, DFNT_INT32
  parameter (DFACC_CREATE = 4,
             DFNT_INT32 = 24)
  integer COMP_CODE_DEFLATE
  parameter (COMP_CODE_DEFLATE = 4)
  integer DEFLATE_LEVEL
  parameter (DEFLATE_LEVEL = 6)

  C To use Skipping Huffman compression method, declare
  C    integer COMP_CODE.SKPHUFF
  C    parameter(COMP_CODE.SKPHUFF = 3)
  C To use RLE compression method, declare
  C    integer COMP_CODE.RLE
  C    parameter(COMP_CODE.RLE = 1)

  C Function declaration.
  C
  integer sfstart, sfcreate, sfwdata, sfendacc, sfend,
       sfscompress

  C**** Variable declaration *******************************************
  C
  integer sd_id, sds_id, status
  integer start(2), edges(2), stride(2), dim_sizes(2)
  integer comp_type
  integer comp_prm(1)
  integer data(X_LENGTH, Y_LENGTH)
  integer i, j

  C**** End of variable declaration *************************************
  C
  C Buffer array data and define array dimensions.
  C
  do 20 j = 1, Y_LENGTH
    do 10 i = 1, X_LENGTH
      data(i, j) = i + j - 1
    10     continue
  20     continue
  dim_sizes(1) = X_LENGTH
  dim_sizes(2) = Y_LENGTH

  C Open the file and initialize the SD interface.
  C
  sd_id = sfstart(FILE_NAME, DFACC_CREATE)

  C Create the data set with the name SDS_NAME.
```

NOTE: This code snippet is from the HDF User's Guide and demonstrates how to write compressed data using different compression methods in Fortran.
```c
sds_id = sfcreate(sd_id, SDS_NAME, DFNT_INT32, RANK, dim_sizes)
C
C     Initialize compression parameter (deflate level)
C     and call sfscompress function
C     For Skipping Huffman compression, comp_prm(1) should be set
to skipping sizes value (skp_size).
C
comp_type   = COMP_CODE_DEFLATE
comp_prm(1) = deflate_level
status      = sfscompress(sds_id, comp_type, comp_prm(1))
C
C     Define the location and size of the data that will be written to
C     the data set.
C
start(1) = 0
start(2) = 0
edges(1) = X_LENGTH
edges(2) = Y_LENGTH
stride(1) = 1
stride(2) = 1
C
C     Write the stored data to the data set.
C
status = sfwdata(sds_id, start, stride, edges, data)
C
C     Terminate access to the data set.
C
status = sfendacc(sds_id)
C
C     Terminate access to the SD interface and close the file.
C
status = sfend(sd_id)
end
```

### 3.5.3 External File Operations

The HDF library provides routines to store SDS arrays in an external file that is separate from the primary file containing the metadata for the array. Such an SDS array is called an external SDS array. With external arrays, it is possible to link data sets in the same HDF file to multiple external files or data sets in different HDF files to the same external file.

External arrays are functionally identical to arrays in the primary data file. The HDF library keeps track of the beginning of the data set and adds data at the appropriate position in the external file. When data is written or appended along a specified dimension, the HDF library writes along that dimension in the external file and updates the appropriate dimension record in the primary file.

There are two methods for creating external SDS arrays. The user can create a new data set in an external file or move data from an existing internal data set to an external file. In either case, only the array values are stored externally, all metadata remains in the primary HDF file.

When an external array is created, a sufficient amount of space is reserved in the external file for the entire data set. The data set will begin at the specified byte offset and extend the length of the data set. The write operation will overwrite the target locations in the external file. The external file may be of any format, provided the data types, byte ordering, and dimension ordering are supported by HDF. However, the primary file must be an HDF file.
Routines for manipulating external SDS arrays can only be used with HDF files. Unidata-formatted netCDF files are not supported by these routines.

**Note:** Compressed data sets (see Section 3.5.2) cannot be stored in external files.

### 3.5.3.1 Specifying the Directory Search Path of an External File: HXsetdir

There are three filesystem locations the HDF external file routines check when determining the location of an external file. They are, in order of search precedence:

1. The directory path specified by the last call to the HXsetdir routine.
2. The directory path specified by the $HDFEXTDIR shell environment variable.
3. The file system locations searched by the standard open(3) routine.

The syntax of HXsetdir is as follows:

**C:**
```
status = HXsetdir(dir_list);
```

**FORTRAN:**
```
status = hxisdir(dir_list, dir_length)
```

HXsetdir has one argument, a string specifying the directory list to be searched. This list can consist of one directory name or a set of directory names separated by colons. The FORTRAN-77 version of this routine takes an additional argument, dir_length, which specifies the length of the directory list string.

If an error condition is encountered, HXsetdir leaves the directory search path unchanged. The directory search path specified by HXsetdir remains in effect throughout the scope of the calling program.

HXsetdir returns a value of SUCCEED (or 0) or FAIL (or -1). The parameters of HXsetdir are described in Table 3I on page 52.

### 3.5.3.2 Specifying the Location of the Next External File to be Created: HXsetcreatedir

HXsetcreatedir specifies the directory location of the next external file to be created. It overrides the directory location specified by $HDFEXTCREATEDIR and the locations searched by the open(3) call in the same manner as HXsetdir. Specifically, the search precedence is:

1. The directory specified by the last call to the HXsetcreatedir routine.
2. The directory specified by the $HDFEXTCREATEDIR shell environment variable.
3. The locations searched by the standard open(3) routine.

The syntax of HXsetcreatedir is as follows:

**C:**
```
status = HXsetcreatedir(dir);
```

**FORTRAN:**
```
status = hxiscdir(dir, dir_length)
```

HXsetcreatedir has one argument, the directory location of the next external file to be created. The FORTRAN-77 version of this routine takes an additional argument, dir_length, which specifies the length of the directory list string. If an error is encountered, the directory location is left unchanged.

HXsetcreatedir returns a value of SUCCEED (or 0) or FAIL (or -1). The parameters of HXsetcreatedir are described in Table 3I.
### TABLE 3I

**HXsetdir and HXsetcreatedir Parameter Lists**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HXsetdir</td>
<td>dir_list</td>
<td>char *</td>
<td>Directory list to be searched</td>
</tr>
<tr>
<td></td>
<td>dir_length</td>
<td>Not applicable</td>
<td>Length of the dir_list string</td>
</tr>
<tr>
<td>HXsetcreatedir</td>
<td>dir</td>
<td>char *</td>
<td>Directory location of the next external file to be created</td>
</tr>
<tr>
<td></td>
<td>dir_length</td>
<td>Not applicable</td>
<td>Length of the dir string</td>
</tr>
</tbody>
</table>

#### 3.5.3.3 Creating a Data Set with Data Stored in an External File: SDsetexternalfile

Creating a data set in an external file involves the following steps:

1. Create the data set.
2. Specify that an external data file is to be used.
3. Write data to the data set.
4. Terminate access to the data set.

To create a data set with data stored in an external file, the calling program must make the following calls.

**C:**

```c
sds_id = SDcreate(sd_id, name, data_type, rank, dim_sizes);
status = SDsetexternalfile(sds_id, filename, offset);
status = SDwritedata(sds_id, start, stride, edges, data);
status = SDendaccess(sds_id);
```

**FORTRAN:**

```fortran
sds_id = sfcreate(sd_id, name, data_type, rank, dim_sizes)
status = sfsetxf(sds_id, filename, offset)
status = sfwdata(sds_id, start, stride, edges, data)
status = sfendacc(sds_id)
```

**OR**

```fortran
status = sfwcdata(sds_id, start, stride, edges, data)
```

For a newly-created data set, **SDsetexternalfile** marks the SDS identified by *sds_id* as one whose data is to be written to an external file. It does not actually write data to an external file; it marks the data set as an external data set for all subsequent **SDwritedata** operations.

Note that data can only be moved once for any given data set, i.e., **SDsetexternalfile** can only be called once after a data set has been created. It is the user’s responsibility to make sure that the external data file is kept with the primary HDF file.

The parameter **filename** is the name of the external data file and **offset** is the number of bytes from the beginning of the external file to the location where the first byte of data should be written. If a file with the name specified by **filename** exists in the current directory search path, HDF will access it as the external file. If the file does not exist, HDF will create one in the directory named in the last call to **HXsetcreatefile**. If an absolute pathname is specified, the external file will be created at the location specified by the pathname, overriding the location specified by the last call to **HXsetcreatefile**. Use caution when writing to existing external or primary files since the HDF library starts the write operation at the specified offset without determining whether data is being overwritten.

Once the name of an external file is established, it cannot be changed without breaking the association between the data set’s metadata and the data it describes.
**SDsetexternalfile** returns a value of **SUCCEED** (or 0) or **FAIL** (or -1). The parameters of **SDsetexternalfile** are described in Table 3J.

<table>
<thead>
<tr>
<th>Routine Name [Return Type]</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>[C] <strong>SDsetexternalfile</strong></td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
<tr>
<td>[FORTRAN-77]</td>
<td>filename</td>
<td>char *</td>
<td>Name of the file to contain the external data set</td>
</tr>
<tr>
<td></td>
<td>offset</td>
<td>int32</td>
<td>Offset in bytes from the beginning of the external file to where the SDS data will be written</td>
</tr>
</tbody>
</table>

### 3.5.3.4 Moving Existing Data to an External File

Data can be moved from a primary file to an external file. The following steps perform this task:

1. Select the data set.
2. Specify the external data file.
3. Terminate access to the data set.

To move data set data to an external file, the calling program must make the following calls:

**C:**

```c
sds_id = SDselect(sd_id, sds_index);
status = SDsetexternalfile(sds_id, filename, offset);
status = SDendaccess(sds_id);
```

**FORTRAN:**

```fortran
sds_id = sfselect(sd_id, sds_index)
status = sfsextf(sds_id, filename, offset)
status = sfendacc(sds_id)
```

For an existing data set, **SDsetexternalfile** moves the data to the external file. Any data in the external file that occupies the space reserved for the external array will be overwritten as a result of this operation. Data of an existing data set in the primary file can only be moved to the external file once. During the operation, the data is written to the external file as a contiguous stream regardless of how it is stored in the primary file. Because data is moved as is, any unwritten locations in the data set are preserved in the external file. Subsequent read and write operations performed on the data set will access the external file.

### Example 7: Moving Data to the External File.

This example illustrates the use of the routine **SDsetexternalfile/sfsextf** to move the SDS data written in Example 2 to the external file.

**C:**

```c
#include "mfhdf.h"
#define FILE_NAME "SDS.hdf"
#define EXT_FILE_NAME "ExternalSDS"
#define OFFSET 24

main( )
{

    int32 sd_id, sds_id, sds_index, offset;

    /*****************************************************************************/
```
intn status;

/************************ End of variable declaration *************************/

/
* Open the file and initialize the SD interface. *
*/
sd_id = SDstart (FILE_NAME, DFACC_WRITE);

/
* Select the first data set. *
*/
.sd_index = 0;
sds_id = SDselect (sd_id, sds_index);

/
* Create a file with the name EXT_FILE_NAME and move the data set *
* values into it, starting at byte location OFFSET. *
*/
status = SDsetexternalfile (sds_id, EXT_FILE_NAME, OFFSET);

/
* Terminate access to the data set, SD interface, and file. *
*/
status = SDendaccess (sds_id);
status = SDend (sd_id);
}

FORTRAN:

program write_extfile
implicit none
C
C     Parameter declaration.
C
character*7 FILE_NAME
character*11 EXT_FILE_NAME
integer OFFSET
integer DFACC_WRITE
parameter (FILE_NAME = 'SDS.hdf',
 + EXT_FILE_NAME = 'ExternalSDS',
 + OFFSET = 24,
 + DFACC_WRITE = 2)
C
C     Function declaration.
C
integer sfstart, sfselect, sfextf, sfendacc, sfend
C
C**** Variable declaration ****************************************************
C
integer sd_id, sds_id, sds_index, offset
integer status
C
C**** End of variable declaration **********************************************
C
C
Open the HDF file and initialize the SD interface.
C
sd_id = sfstart(FILE_NAME, DFACC_WRITE)
C
Select the first data set.
C
3.6 Reading Data from an SDS Array: SDreaddata

Data of an SDS array can be read as an entire array, a subset of the array, or a set of samples of the array. SDS data is read from an external file in the same way that it is read from a primary file; whether the SDS array is stored in an external file is transparent to the user. Reading data from an SDS array involves the following steps:

1. Select the data set.
2. Define the portion of the data to be read.
3. Read data portion as defined.

To read data from an SDS array, the calling program must contain the following function calls:

C:
```c
sds_id = SDselect(sd_id, sds_index);
status = SDreaddata(sds_id, start, stride, edges, data);
```

FORTRAN:
```fortran
sds_id = sfselect(sd_id, sds_index)
status = sfrdata(sds_id, start, stride, edges, data)
```

OR
```fortran
status = sfrcdata(sds_id, start, stride, edges, data)
```

Note that step 2 is not illustrated in the function call syntax; it is carried out by assigning values to the parameters `start`, `stride`, and `edges` before the routine `SDreaddata` is called in step 3.

`SDreaddata` reads the data according to the definition specified by the parameters `start`, `stride`, and `edges` and stores the data into the buffer provided, `data`. The argument `sds_id` is the SDS identifier returned by `SDcreate` or `SDselect`. As with `SDwritedata`, the arguments `start`, `stride`, and `edges` describe the starting location, the number of elements to skip after each read, and the number of elements to be read, respectively, for each dimension. For additional information on the parameters `start`, `stride`, and `edges`, refer to Section 3.5.1 on page 30.

There are two FORTRAN-77 versions of this routine: `sfrdata` reads numeric data and `sfrcdata` reads character data.

`SDreaddata` returns a value of `SUCCEED` (or 0), including the situation when the data set does not contain data, or `FAIL` (or -1). The parameters of `SDreaddata` are further described in Table 3K.
EXTRACTION 8.

This example uses the routine **SDreaddata*/sfrdata to read the data that has been written in Example 2, modified in Example 4, and moved to the external file in the Example 7. Note that the original file SDS.hdf that contains the SDS metadata and the external file ExternalSDS that contains the SDS raw data should reside in the same directory. The fact that raw data is in the external file is transparent to the user’s program.

**C:**

```c
#include "mfhdf.h"

#define FILE_NAME "SDS.hdf"
#define X_LENGTH 5
#define Y_LENGTH 16

int32 sd_id, sds_id, sds_index;
intn status;
int32 start[2], edges[2];
int32 data[Y_LENGTH][X_LENGTH];
int i, j;

main( )
{
  /******************************************************************************
  Variable declaration ******************************************************************************/

  /****************************************************************************** End of variable declaration ******************************************************************************/

  /*
  * Open the file for reading and initialize the SD interface.
  */
  sd_id = SDstart (FILE_NAME, DFACC_READ);

  /*
  * Select the first data set.
  */
  sds_index = 0;
  sds_id = SDselect (sd_id, sds_index);

  /*
  * Set elements of array start to 0, elements of array edges
  * to SDS dimensions, and use NULL for the argument stride in SDreaddata
  */
```
* to read the entire data. */
start[0] = 0;
start[1] = 0;
edges[0] = Y_LENGTH;
edges[1] = X_LENGTH;

/*
* Read entire data into data array.
*/
status = SDreaddata (sds_id, start, NULL, edges, (VOIDP)data);

/*
* Print 10th row; the following numbers should be displayed.
*   10 1000 12 13 14
*/
for (j = 0; j < X_LENGTH; j++) printf ("%d ", data[9][j]);
printf ("\n");

/*
* Terminate access to the data set.
*/
status = SDendaccess (sds_id);

/*
* Terminate access to the SD interface and close the file.
*/
status = SDend (sd_id);
}

FORTRAN:

program  read_data
implicit none
C
C     Parameter declaration.
C
Ccharacter*7  FILE_NAME
integer      X_LENGTH, Y_LENGTH
parameter   (FILE_NAME  = 'SDS.hdf',
+             X_LENGTH = 5,
+             Y_LENGTH = 16)
integer      DFACC_READ, DFNT_INT32
parameter   (DFACC_READ = 1,
+             DFNT_INT32 = 24)
C
C     Function declaration.
C
integer sfstart, sfselect, sfrdata, sfendacc, sfend
C
C**** Variable declaration *******************************************
C
integer sd_id, sds_id, sds_index, status
integer start(2), edges(2), stride(2)
integer data(X_LENGTH, Y_LENGTH)
integer j
C
C**** End of variable declaration ************************************
C
C
C     Open the file and initialize the SD interface.
EXAMPLE 9. Reading Subsets of an SDS.

This example shows how parameters start, stride, and edges of the routine SDreadata/sfrdata can be used to read three subsets of an SDS array.

C:

For the first subset, the program reads every 3rd element of the 2nd column starting at the 4th row of the data set created in Example 2 and modified in Examples 4 and 7.

For the second subset the program reads the first 4 elements of the 10th row.

For the third subset, the program reads from the same data set every 6th element of each column and 4th element of each row starting at 1st column, 3d row.
FORTRAN-77:

Fortran program reads transposed data to reflect the difference in C and Fortran internal storage.

C:

```c
#include "mfhdf.h"

#define FILE_NAME     "SDS.hdf"
#define SUB1_LENGTH   5
#define SUB2_LENGTH   4
#define SUB3_LENGTH1  2
#define SUB3_LENGTH2  3

main( )
{
    int32 sd_id, sds_id, sds_index;
    intn status;
    int32 start[2], edges[2], stride[2];
    int32 sub1_data[SUB1_LENGTH];
    int32 sub2_data[SUB2_LENGTH];
    int32 sub3_data[SUB3_LENGTH2][SUB3_LENGTH1];
    int i, j;

    /*****************************************************************
    ** Variable declaration ******************************************/
    /*****************************************************************

    /*
    * Open the file for reading and initialize the SD interface.
    */
    sd_id = SDstart (FILE_NAME, DFACC_READ);

    /*
    * Select the first data set.
    */
    sds_index = 0;
    sds_id = SDselect (sd_id, sds_index);

    /*
    * Reading the first subset.
    * Set elements of start, edges, and stride arrays to read
    * every 3rd element in the 2nd column starting at 4th row.
    */
    start[0] = 3;   /* 4th row */
    start[1] = 1;   /* 2nd column */
    edges[0] = SUB1_LENGTH; /* SUB1_LENGTH elements are read along 2nd column*/
    edges[1] = 1;
    stride[0] = 3;  /* every 3rd element is read along 2nd column */
    stride[1] = 1;

    /*
    * Read the data from the file into sub1_data array.
    */
    status = SDreaddata (sds_id, start, stride, edges, (VOIDP)sub1_data);

    /*
    * Print what we have just read; the following numbers should be displayed:
    */
    for (j = 0; j < SUB1_LENGTH; j++) printf ("%d ", sub1_data[j]);
    printf ("\n");
```
/ * Reading the second subset. *
 * Set elements of start and edges arrays to read * first 4 elements of the 10th row. */
 start[0] = 9; /* 10th row */
 start[1] = 0; /* 1st column */
 edges[0] = 1;
 edges[1] = SUB2_LENGTH; /* SUB2_LENGTH elements are read along 10th row */

/* * Read data from the file into sub2_data array. Note that the third * parameter is set to NULL for contiguous reading. */
status = SDreaddata (sds_id, start, NULL, edges, (VOIDP)sub2_data);

/* * Print what we have just read; the following numbers should be displayed: * 10 1000 12 13 */
for (j = 0; j < SUB2_LENGTH; j++) printf ("%d ", sub2_data[j]);
printf ("\n");

/* * Reading the third subset. * Set elements of the arrays start, edges, and stride to read * every 6th element in the column and 4th element in the row * starting at 1st column, 3rd row. */
start[0] = 2; /* 3rd row */
start[1] = 0; /* 1st column */
edges[0] = SUB3_LENGTH2; /* SUB3_LENGTH2 elements are read along each column */
edges[1] = SUB3_LENGTH1; /* SUB3_LENGTH1 elements are read along each row */
stride[0] = 6; /* read every 6th element along each column */
stride[1] = 4; /* read every 4th element along each row */

/* * Read the data from the file into sub3_data array. */
status = SDreaddata (sds_id, start, stride, edges, (VOIDP)sub3_data);

/* * Print what we have just read; the following numbers should be displayed: * 3 7 * 9 13 * 15 19 */
for (j = 0; j < SUB3_LENGTH2; j++) {
  for (i = 0; i < SUB3_LENGTH1; i++) printf ("%d ", sub3_data[j][i]);
  printf ("\n");
}
/* * Terminate access to the data set. */
status = SDendaccess (sds_id);
/*
* Terminate access to the SD interface and close the file.
*/
status = SDend (sd_id);
}

FORTRAN:

program read_subsets
implicit none
C
C  Parameter declaration.
C
C  parameter (FILE_NAME = 'SDS.hdf')
integer DFACC_READ, DFNT_INT32
parameter (DFACC_READ = 1, +
            DFNT_INT32 = 24)
integer SUB1_LENGTH, SUB2_LENGTH, SUB3_LENGTH1, +
        SUB3_LENGTH2
parameter (SUB1_LENGTH = 5, +
            SUB2_LENGTH = 4, +
            SUB3_LENGTH1 = 2, +
            SUB3_LENGTH2 = 3)
C
C  Function declaration.
C
integer sfstart, sfselect, sfrdata, sfendacc, sfend
C
**** Variable declaration ****************************
C
integer sd_id, sds_id, sds_index, status
integer start(2), edges(2), stride(2)
integer sub1_data(SUB1_LENGTH)
integer sub2_data(SUB2_LENGTH)
integer sub3_data(SUB3_LENGTH1, SUB3_LENGTH2)
integer i, j
C
**** End of variable declaration ****************************
C
C  Open the file and initialize the SD interface.
C
sd_id = sfstart(FILE_NAME, DFACC_READ)
C
Select the first data set.
C
sds_index = 0
sds_id = sfselect(sd_id, sds_index)
C
Reading the first subset.
C
Set elements of start, stride, and edges arrays to read
C every 3d element in in the 2nd row starting in the 4th column.
C
start(1) = 1
start(2) = 3
edges(1) = 1
edges(2) = SUB1_LENGTH
stride(1) = 1
stride(2) = 3
C
C Read the data from sub1_data array.
status = sfrdata(sds_id, start, stride, edges, sub1_data)

C Print what we have just read, the following numbers should be displayed:
C
5 8 1000 14 17
C
write(*,*) (sub1_data(j), j = 1, SUB1_LENGTH)
C
Reading the second subset.
C
C Set elements of start, stride, and edges arrays to read
C first 4 elements of 10th column.
C
start(1) = 0
start(2) = 9
edges(1) = SUB2_LENGTH
edges(2) = 1
stride(1) = 1
stride(2) = 1
C
C Read the data into sub2_data array.
C
status = sfrdata(sds_id, start, stride, edges, sub2_data)
C
C Print what we have just read; the following numbers should be displayed:
C
10 1000 12 13
C
write(*,*) (sub2_data(j), j = 1, SUB2_LENGTH)
C
Reading the third subset.
C
C Set elements of start, stride and edges arrays to read
C every 6th element in the row and every 4th element in the column
C starting at 1st row, 3rd column.
C
start(1) = 0
start(2) = 2
edges(1) = SUB3_LENGTH1
edges(2) = SUB3_LENGTH2
stride(1) = 4
stride(2) = 6
C
C Read the data from the file into sub3_data array.
C
status = sfrdata(sds_id, start, stride, edges, sub3_data)

C Print what we have just read; the following numbers should be displayed:
C
3 9 15
C
7 13 19
C
do 50 i = 1, SUB3_LENGTH1
   write(*,*) (sub3_data(i,j), j = 1, SUB3_LENGTH2)
50 continue
C
C Terminate access to the data set.
status = sfendacc(sds_id)
C
C     Terminate access to the SD interface and close the file.
C
status = sfend(sd_id)
end

3.7 Obtaining Information about SD Data Sets

The routines covered in this section provide methods for obtaining information about all scientific data sets in a file, for identifying the data sets that meet certain criteria, and for obtaining information about specific data sets.

**SDfileinfo** obtains the numbers of data sets and file attributes, set by SD interface routines, in a file. **SDgetinfo** provides information about an individual SDS. To retrieve information about all data sets in a file, a calling program can use **SDfileinfo** to determine the number of data sets, followed by repeated calls to **SDgetinfo** to obtain the information about a particular data set.

**SDnametoindex** or **SDreftoindex** can be used to obtain the index of an SDS in a file knowing its name or reference number, respectively. Refer to Section 3.2.1 on page 20 for a description of the data set index and reference number. **SDidtoref** is used when the reference number of an SDS is required by another routine and the SDS identifier is available.

These routines are described individually in the following subsections.

3.7.1 Obtaining Information about the Contents of a File: SDfileinfo

**SDfileinfo** determines the number of scientific data sets and the number of file attributes contained in a file. This information is often useful in index validation or sequential searches. The syntax of **SDfileinfo** is as follows:

```c
status = SDfileinfo(sd_id, &n_datasets, &n_file_attrs);
```

**FORTRAN**: `status = sffinfo(sd_id, n_datasets, n_file_attrs)`

**SDfileinfo** stores the numbers of scientific data sets and file attributes in the parameters `n_datasets` and `n_file_attrs`, respectively. Note that the value returned by `n_datasets` will include the number of SDS arrays and the number of dimension scales. Refer to Section 3.8.4 on page 75 and Section 3.8.4.4 on page 82 for the description of dimension scales and its association with SDS arrays as well as how to distinguish between SDS arrays and dimension scales. The file attributes are those that are created by **SDsetattr** for an SD interface identifier instead of an SDS identifier. Refer to Section 3.9.1 on page 86 for the discussion of **SDsetattr**.

**SDfileinfo** returns a value of **SUCCEED** (or 0) or **FAIL** (or -1). The parameters of **SDfileinfo** are specified in Table 3L on page 65.

3.7.2 Obtaining Information about a Specific SDS: SDgetinfo

**SDgetinfo** provides basic information about an SDS array. Often information about an SDS array is needed before reading and working with the array. For instance, the rank, dimension sizes, and/or data type of an array are needed to allocate the proper amount of memory to work with the array. **SDgetinfo** takes an SDS identifier as input, and retrieves the name, rank, dimension sizes, data type, and number of attributes for the corresponding SDS. The syntax of this routine is as follows:
C:             status = SDgetinfo(sds_id, sds_name, &rank, dim_sizes, &data_type, 
               &n_attrs);

FORTRAN:     status = sfginfo(sds_id, sds_name, rank, dim_sizes, data_type, 
               n_attrs)

SDgetinfo stores the name, rank, dimension sizes, data type, and number of attributes of the specified data set into the parameters sds_name, rank, dim_sizes, data_type, and n_attrs, respectively. The parameter sds_name is a character string. Note that the name of the SDS is limited to 64 characters.

If the data set is created with an unlimited dimension, then in the C interface, the first element of the dim_sizes array (corresponding to the slowest-changing dimension) contains the number of records in the unlimited dimension; in the FORTRAN-77 interface, the last element of the array dim_sizes (corresponding to the slowest-changing dimension) contains this information.

The parameter data_type contains any type that HDF supports for the scientific data. Refer to Table 2F on page 14, for the list of supported data types and their corresponding defined values. The parameter n_attrs only reflects the number of attributes assigned to the data set specified by sds_id; file attributes are not included. Use SDfileinfo to get the number of file attributes.

SDgetinfo returns a value of SUCCEED (or 0) or FAIL (or -1). The parameters of SDgetinfo are specified in Table 3L.

3.7.3 Obtaining Data Set Compression Information: SDgetcompress

SDgetcompress retrieves the compression information used to create or write an SDS data set.

The compression algorithms currently supported SDS data set compression are as follows:

- Adaptive Huffman
- GZIP "deflation" (Lempel/Ziv-77 dictionary coder)
- Run-length encoding

SDgetcompress takes one input parameter, sds_id, a data set identifier, and two return parameters, comp_type, identifying the type of compression used, and either c_info (in C) or comp_prm (in FORTRAN-77), containing further compression information.

The syntax of the routine SDsetcompress is as follows:

C:         status = SDsetcompress(sds_id, comp_type, c_info);

FORTRAN:   status = sfgcompress(sds_id, comp_type, comp_prm)

See Section 3.5.2, "Compressing SDS Data: SDsetcompress," for a discussion of comp_type, c_info, and comp_prm, and a list of supported compression modes.

SDgetcompress returns a value of SUCCEED (or 0) or FAIL (or -1).

3.7.4 Determining whether an SDS is empty: SDcheckempty

SDcheckempty takes an SDS identifier, sds_id, as input, and returns a single parameter indicating whether the SDS is empty. The syntax of this routine is as follows:

C:         status = SDcheckempty(sds_id, emptySDS);

FORTRAN:   status = sfcheckempty(sds_id, emptySDS)

The output parameter, emptySDS, indicates whether the SDS is empty or non-empty.
**SDcheckempty** returns a value of **SUCCEED** (or 0) or **FAIL** (or –1). The parameters of **SDcheckempty** are specified in Table 3L.

### TABLE 3L

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SDcheckempty</strong> [int32] (schempty)</td>
<td>sds_id</td>
<td>int32</td>
<td>SDS interface identifier</td>
</tr>
<tr>
<td></td>
<td>n_datasets</td>
<td>int32 *</td>
<td>Number of data sets in the file</td>
</tr>
<tr>
<td></td>
<td>n_file_attrs</td>
<td>int32 *</td>
<td>Number of global attributes in the file</td>
</tr>
<tr>
<td><strong>SDfileinfo</strong> [intn] (sfileinfo)</td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>sds_name</td>
<td>char*</td>
<td>Name of the data set</td>
</tr>
<tr>
<td></td>
<td>rank</td>
<td>int32 *</td>
<td>Number of dimensions in the data set</td>
</tr>
<tr>
<td></td>
<td>dim_sizes</td>
<td>int32 []</td>
<td>Size of each dimension in the data set</td>
</tr>
<tr>
<td></td>
<td>data_type</td>
<td>int32 *</td>
<td>Data type of the data in the data set</td>
</tr>
<tr>
<td></td>
<td>n_attrs</td>
<td>int32 *</td>
<td>Number of attributes in the data set</td>
</tr>
<tr>
<td><strong>SDgetinfo</strong> [intn] (sfiginfo)</td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>sds_name</td>
<td>char*</td>
<td>Name of the data set</td>
</tr>
<tr>
<td></td>
<td>rank</td>
<td>int32 *</td>
<td>Number of dimensions in the data set</td>
</tr>
<tr>
<td></td>
<td>dim_sizes</td>
<td>int32 []</td>
<td>Size of each dimension in the data set</td>
</tr>
<tr>
<td></td>
<td>data_type</td>
<td>int32 *</td>
<td>Data type of the data in the data set</td>
</tr>
<tr>
<td></td>
<td>n_attrs</td>
<td>int32 *</td>
<td>Number of attributes in the data set</td>
</tr>
<tr>
<td><strong>SDgetcompress</strong> [intn] (sfgcompress)</td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>comp_type</td>
<td>compCoder_t</td>
<td>Type of compression</td>
</tr>
<tr>
<td></td>
<td>c_info</td>
<td>comp_info</td>
<td>Pointer to compression information structure</td>
</tr>
<tr>
<td></td>
<td>comp_prm(1)</td>
<td>N/A</td>
<td>Compression parameter in array format</td>
</tr>
<tr>
<td><strong>SDcheckempty</strong> [int32] (schempty)</td>
<td>emptySDS</td>
<td>intn *</td>
<td>SDS status indicator (empty, not empty)</td>
</tr>
</tbody>
</table>

### EXAMPLE 10.

**Getting Information about a File and an SDSs.**

This example illustrates the use of the routine **SDfileinfo/sfileinfo** to obtain the number of data sets in the file **SDS.hdf** and the routine **SDgetinfo/sfiginfo** to retrieve the name, rank, dimension sizes, data type and number of attributes of the selected data set.

**C:**

```c
#include "mfhdf.h"

#define FILE_NAME    "SDS.hdf"

int32 sd_id, sds_id;
intn status;
int32 n_datasets, n_file_attrs, index;
int32 dim_sizes[MAX_VAR_DIMS];
int32 rank, data_type, n_attrs;
char  name[MAX_NC_NAME];
int  i;

/* ************* Variable declaration ***********************/
int32 sd_id, sds_id;
intn status;
int32 n_datasets, n_file_attrs, index;
int32 dim_sizes[MAX_VAR_DIMS];
int32 rank, data_type, n_attrs;
char  name[MAX_NC_NAME];
int  i;

/* ************* End of variable declaration ***********************/

/*
* Open the file and initialize the SD interface.
*/
sd_id = SDstart (FILE_NAME, DFACC_READ);
```
* Determine the number of data sets in the file and the number
* of file attributes.
*/
status = SDfileinfo (sd_id, &n_datasets, &n_file_attrs);

/*
* Access every data set and print its name, rank, dimension sizes,
* data type, and number of attributes.
* The following information should be displayed:
*
* name = SDStemplate
* rank = 2
* dimension sizes are : 16  5
* data type is  24
* number of attributes is  0
*/
for (index = 0; index < n_datasets; index++)
{
  sds_id = SDselect (sd_id, index);
  status = SDgetinfo (sds_id, name, &rank, dim_sizes,
                     &data_type, &n_attrs);

  printf ("name = %s\n", name);
  printf ("rank = %d\n", rank);
  printf ("dimension sizes are : ");
  for (i=0; i< rank; i++) printf ("%d  ", dim_sizes[i]);
  printf ("\n");
  printf ("data type is  %d\n", data_type);
  printf ("number of attributes is  %d\n", n_attrs);
  
  /*
  * Terminate access to the data set.
  */
  status = SDendaccess (sds_id);
}

/*
* Terminate access to the SD interface and close the file.
*/
status = SDend (sd_id);

FORTRAN:

program get_data_set_info
  implicit none
C
C  Parameter declaration.
C
character*7  FILE_NAME
parameter (FILE_NAME = 'SDS.hdf')
integer  DFACC_READ, DFNT_INT32
parameter (DFACC_READ = 1,
+  DFNT_INT32 = 24)
integer  MAX_NC_NAME, MAX_VAR_DIMS
parameter (MAX_NC_NAME = 256,
+  MAX_VAR_DIMS = 32)
C
C  Function declaration.
C
integer sfstart, sffinfo, sfselect, sfginfo
integer sfendacc, sfend
C**** Variable declaration *******************************************
C
integer sd_id, sds_id
integer n_datasets, n_file_attrs, index
integer status, n_attrs
integer rank, data_type
integer dim_sizes(MAX_VAR_DIMS)
character name *(MAX_NC_NAME)
integer i
C
C**** End of variable declaration ************************************
C
C
C     Open the file and initialize the SD interface.
C
sd_id = sfstart(FILE_NAME, DFACC_READ)
C
C     Determine the number of data sets in the file and the number of
C     file attributes.
C
status = sffinfo(sd_id, n_datasets, n_file_attrs)
C
C     Access every data set in the file and print its name, rank,
C     dimension sizes, data type, and number of attributes.
C     The following information should be displayed:
C
C                name = SDStemplate
C                rank =   2
C                dimension sizes are :   5  16
C                data type is   24
C                number of attributes is   0
C
do 10 index = 0, n_datasets - 1
  sds_id = sfselect(sd_id, index)
  status = sfginfo(sds_id, name, rank, dim_sizes, data_type,
                  n_attrs)
  write(*,*)  "name = ", name(1:15)
  write(*,*)  "rank = ", rank
  write(*,*)  "dimension sizes are : ", (dim_sizes(i), i=1, rank)
  write(*,*)  "data type is ", data_type
  write(*,*)  "number of attributes is ", n_attrs
C
C     Terminate access to the current data set.
C
  status = sfendacc(sds_id)
10    continue
C
C     Terminate access to the SD interface and close the file.
C
  status = sfend(sd_id)

end

3.7.5 Locating an SDS by Name: SDnametoindex

SDnametoindex determines and returns the index of a data set in a file given the data set’s name.
The syntax of this routine is as follows:

C: sds_index = SDnametoindex(sd_id, sds_name);
FORTRAN: \( \text{sds\_index = sfn2index(sd\_id, sds\_name)} \)

The parameter \( sds\_name \) is a character string with the maximum length of 64 characters. If more than one data set has the name specified by \( sds\_name \), SDnametoindex will return the index of the first data set. The index can then be used by SDselect to obtain an SDS identifier for the specified data set.

The SDnametoindex routine is case-sensitive to the name specified by \( sds\_name \) and does not accept wildcards as part of that name. The name must exactly match the name of the SDS being searched for.

SDnametoindex returns the index of a data set or FAIL (or -1). The parameters of SDnametoindex are specified in Table 3M.

### 3.7.6 Locating an SDS by Reference Number: SDreftoindex

SDreftoindex determines and returns the index of a data set in a file given the data set’s reference number. The syntax of this routine is as follows:

C: \( \text{sds\_index = SDreftoindex(sd\_id, ref)} \)

FORTRAN: \( \text{sds\_index = sfref2index(sd\_id, ref)} \)

The reference number can be obtained using SDidtoref if the SDS identifier is available. Remember that reference numbers do not necessarily adhere to any ordering scheme.

SDreftoindex returns either the index of an SDS or FAIL (or -1). The parameters of this routine are specified in Table 3M.

### 3.7.7 Obtaining the Reference Number Assigned to the Specified SDS: SDidtoref

SDidtoref returns the reference number of the data set identified by the parameter \( sds\_id \) if the data set is found, or FAIL (or -1) otherwise. The syntax of this routine is as follows:

C: \( \text{sds\_ref = SDidtoref(sds\_id)} \)

FORTRAN: \( \text{sds\_ref = sfid2ref(sds\_id)} \)

This reference number is often used by Vadtagref to add the data set to a vgroup. Refer to Chapter 5, Vgroups (V API), for more information.

The parameter of SDidtoref is specified in Table 3M.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDnametoindex (int32)</td>
<td>sd_id</td>
<td>int32</td>
<td>SD interface identifier</td>
</tr>
<tr>
<td></td>
<td>sds_name</td>
<td>char +</td>
<td>Name of the data set</td>
</tr>
<tr>
<td>SDreftoindex (int32)</td>
<td>sd_id</td>
<td>int32</td>
<td>SD interface identifier</td>
</tr>
<tr>
<td></td>
<td>ref</td>
<td>int32</td>
<td>Reference number of the specified data set</td>
</tr>
<tr>
<td>SDidtoref (int32)</td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
</tbody>
</table>
EXAMPLE 11. Locating an SDS by Its Name.

This example uses the routine SDnametoindex/sfn2index to locate the SDS with the specified name and then reads the data from it.

C:

```c
#include "mfhdf.h"

#define FILE_NAME     "SDS.hdf"
#define SDS_NAME      "SDStemplate"
#define WRONG_NAME    "WrongName"
#define X_LENGTH      5
#define Y_LENGTH      16

main( )
{
    /****************************************** Variable declaration ******************************************/
    int32 sd_id, sds_id, sds_index;
    intn status;
    int32 start[2], edges[2];
    int32 data[Y_LENGTH][X_LENGTH];
    int   i, j;

    /****************************************** End of variable declaration ******************************************/

    /*
    * Open the file for reading and initialize the SD interface.
    */
    sd_id = SDstart (FILE_NAME, DFACC_READ);

    /*
    * Find index of the data set with the name specified in WRONG_NAME.
    * Error condition occurs, since the data set with that name does not exist
    * in the file.
    */
    sds_index = SDnametoindex (sd_id, WRONG_NAME);
    if (sds_index == FAIL)
        printf ("Data set with the name \"WrongName\" does not exist\n");

    /*
    * Find index of the data set with the name specified in SDS_NAME and use
    * the index to select the data set.
    */
    sds_index = SDnametoindex (sd_id, SDS_NAME);
    sds_id = SDselect (sd_id, sds_index);

    /*
    * Set elements of the array start to 0, elements of the array edges to
    * SDS dimensions, and use NULL for stride argument in SDreaddata to read
    * the entire data.
    */
    start[0] = 0;
    start[1] = 0;
    edges[0] = Y_LENGTH;
    edges[1] = X_LENGTH;

    /*
    * Read the entire data into the buffer named data.
    */
    status = SDreaddata (sds_id, start, NULL, edges, (VOIDP)data);
```
/*
 * Print 10th row; the following numbers should be displayed:
 * 10 1000 12 13 14
 */
for (j = 0; j < X_LENGTH; j++) printf ("%d ", data[9][j]);
printf ("\n");

/*
 * Terminate access to the data set.
 */
status = SDendaccess (sds_id);

/*
 * Terminate access to the SD interface and close the file.
 */
status = SDend (sd_id);
}

FORTRAN:

program locate_by_name
implicit none

parameters FILE_NAME = 'SDS.hdf',
        SDS_NAME = 'SDStemplate',
        WRONG_NAME = 'WrongName',
        X_LENGTH = 5,
        Y_LENGTH = 16
parameters DFACC_READ = 1,
        DFNT_INT32 = 24

C**** Variable declaration ****************************************************
integer sd_id, sds_id, sds_index, status
integer start(2), edges(2), stride(2)
integer data(X_LENGTH, Y_LENGTH)
integer j
C**** End of variable declaration *********************************************
C
C     Open the file and initialize the SD interface.
C
sd_id = sfstart(FILE_NAME, DFACC_READ)
C
C     Find index of the data set with the name specified in WRONG_NAME.
C     Error condition occurs, since a data set with this name
C     does not exist in the file.
C
sds_index = sfn2index(sd_id, WRONG_NAME)
if (sds_index .eq. -1) then
  write(*,*) "Data set with the name ", WRONG_NAME,
+ " does not exist"
endif

Find index of the data set with the name specified in SDS_NAME
and use the index to attach to the data set.

sds_index = sfn2index(sd_id, SDS_NAME)
sds_id    = sfselect(sd_id, sds_index)

Set elements of start array to 0, elements of edges array
to SDS dimensions, and elements of stride array to 1 to read entire data.

start(1) = 0
start(2) = 0
edges(1) = X_LENGTH
edges(2) = Y_LENGTH
stride(1) = 1
stride(2) = 1

Read entire data into array named data.

status = sfrdata(sds_id, start, stride, edges, data)

Print 10th column; the following numbers should be displayed:

10 1000 12 13 14

write(*,*) (data(j,10), j = 1, X_LENGTH)

Terminate access to the data set.

status = sfendacc(sds_id)

Terminate access to the SD interface and close the file.

status = sfend(sd_id)

end

3.7.8 Creating SDS Arrays Containing Non-standard Length Data:
SDsetnbitdataset

Starting with version 4.0r1, HDF provides the routine SDsetnbitdataset, allowing the HDF user
to specify that a particular SDS array contains data of a non-standard length.

SDsetnbitdataset specifies that the data set identified by the parameter sds_id will contain data
of a non-standard length defined by the parameters start_bit and bit_len. Additional information
about the non-standard bit length decoding are specified in the parameters sign_ext and
fill_one. The syntax of SDsetnbitdataset is as follows:

C:  status = SDsetnbitdataset(sds_id, start_bit, bit_len, sign_ext,
               fill_one);

FORTRAN: status = sfsnbit(sds_id, start_bit, bit_len, sign_ext, fill_one)

Any length between 1 and 32 bits can be specified. After SDsetnbitdataset has been called for an
SDS array, any read or write operations will convert between the new data length of the SDS array
and the data length of the read or write buffer.
Bit lengths of all data types are counted from the right of the bit field starting with 0. In a bit field containing the values 01111011, bits 2 and 7 are set to 0 and all the other bits are set to 1.

The parameter `start_bit` specifies the left-most position of the variable-length bit field to be written. For example, in the bit field described in the preceding paragraph a parameter `start_bit` set to 4 would correspond to the fourth bit value of 1 from the right.

The parameter `bit_len` specifies the number of bits of the variable-length bit field to be written. This number includes the starting bit and the count proceeds toward the right end of the bit field - toward the lower-bit numbers. For example, starting at bit 5 and writing 4 bits of the bit field described in the preceding paragraph would result in the bit field 1110 being written to the data set. This would correspond to a `start_bit` value of 5 and a `bit_len` value of 4.

The parameter `sign_ext` specifies whether to use the left-most bit of the variable-length bit field to sign-extend to the left-most bit of the data set data. For example, if 9-bit signed integer data is extracted from bits 17-25 and the bit in position 25 is 1, then when the data is read back from disk, bits 26-31 will be set to 1. Otherwise bit 25 will be 0 and bits 26-31 will be set to 0. The `sign_ext` parameter can be set to `TRUE` (or 1) or `FALSE` (or 0); specify `TRUE` to sign-extend.

The parameter `fill_one` specifies whether to fill the "background" bits with the value 1 or 0. This parameter is also set to either `TRUE` (or 1) or `FALSE` (or 0).

The "background" bits of a non-standard length data set are the bits that fall outside of the non-standard length bit field stored on disk. For example, if five bits of an unsigned 16-bit integer data set located in bits 5 to 9 are written to disk with the parameter `fill_one` set to `TRUE` (or 1), then when the data is reread into memory bits 0 to 4 and 10 to 15 would be set to 1. If the same 5-bit data was written with a `fill_one` value of `FALSE` (or 0), then bits 0 to 4 and 10 to 15 would be set to 0.

The operation on `fill_one` is performed before the operation on `sign_ext`. For example, using the `sign_ext` example above, bits 0 to 16 and 26 to 31 will first be set to the background bit value, and then bits 26 to 31 will be set to 1 or 0 based on the value of the 25th bit.

`SDsetnbitdataset` returns a value of `SUCCEED` (or 0) or `FAIL` (or -1). The parameters for `SDsetnbitdataset` are specified in Table 3N.

**TABLE 3N**

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDsetnbitdataset [int] (sfsnbit)</td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>start_bit</td>
<td>intn</td>
<td>Leftmost bit of the field to be written</td>
</tr>
<tr>
<td></td>
<td>bit_len</td>
<td>intn</td>
<td>Length of the bit field to be written</td>
</tr>
<tr>
<td></td>
<td>sign_ext</td>
<td>intn</td>
<td>Sign-extend specifier</td>
</tr>
<tr>
<td></td>
<td>fill_one</td>
<td>intn</td>
<td>Background bit specifier</td>
</tr>
</tbody>
</table>

### 3.8 SDS Dimension and Dimension Scale Operations

The concept of dimensions is introduced in Section 3.2.1 on page 20. This section describes SD interface routines which store and retrieve information on dimensions and dimension scales. When a dimension scale is set for a dimension, the library stores the dimension and its associated information as an SDS array. In the following discussion, we will refer to that array (recall NetCDF) as a **coordinate variable** or **dimension record**. The section concludes with consideration of related data sets and sharable dimensions.
3.8.1 Selecting a Dimension: SDgetdimid

SDS dimensions are uniquely identified by dimension identifiers, which are assigned when a dimension is created. These dimension identifiers are used within a program to refer to a particular dimension, its scale, and its attributes. Before working with a dimension, a program must first obtain a dimension identifier by calling the SDgetdimid routine as follows:

C:  
    dim_id = SDgetdimid(sds_id, dim_index);

FORTRAN:  
    dim_id = sfdimid(sds_id, dim_index)

SDgetdimid takes two arguments, sds_id and dim_index, and returns a dimension identifier, dim_id. The argument dim_index is an integer from 0 to the number of dimensions minus 1. The number of dimensions in a data set is specified at the time the data set is created. Specifying a dimension index equal to or larger than the number of dimensions in the data set causes SDgetdimid to return a value of FAIL (or -1).

Unlike file and data set identifiers, dimension identifiers do not require explicit disposal. SDgetdimid returns a dimension identifier or FAIL (or -1). The parameters of SDgetdimid are specified in Table 30 on page 73.

3.8.2 Naming a Dimension: SDsetdimname

SDsetdimname assigns a name to a dimension. If two dimensions have the same name, they will be represented in the file by only one SDS. Therefore changes to one dimension will be reflected in the other. Naming dimensions is optional but encouraged. Dimensions that are not explicitly named by the user will have names generated by the HDF library. Use SDdiminfo to read existing dimension names. The syntax of SDsetdimname is as follows:

C:  
    status = SDsetdimname(dim_id, dim_name);

FORTRAN:  
    status = sfsdmname(dim_id, dim_name)

The argument dim_id in SDsetdimname is the dimension identifier returned by SDgetdimid. The parameter dim_name is a string of alphanumeric characters representing the name for the selected dimension. An attempt to rename a dimension using SDsetdimname will cause the old name to be deleted and a new one to be assigned.

Note that when naming dimensions the name of a particular dimension must be set before attributes are assigned; once the attributes have been set, the name must not be changed. In other words, SDsetdimname must only be called before any calls to SDsetdimscale (described in Section 3.8.4.1 on page 75), SDsetattr (described in Section 3.9.1 on page 86) or SDsetdimstrs (described in Section 3.10.2.1 on page 98).

SDsetdimname returns a value of SUCCEED (or 0) or FAIL (or -1). The parameters of SDsetdimname are described in Table 30.

### TABLE 30

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDgetdimid</td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>dim_index</td>
<td>intn</td>
<td>Dimension index</td>
</tr>
<tr>
<td>SDsetdimname</td>
<td>dim_id</td>
<td>int32</td>
<td>Dimension identifier</td>
</tr>
<tr>
<td></td>
<td>dim_name</td>
<td>char *</td>
<td>Dimension name</td>
</tr>
</tbody>
</table>

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3.8.3 Old and New Dimension Implementations

Up to and including HDF version 4.0 beta1, dimensions were vgroup objects (described in Chapter 5, Vgroups (V API), containing a single field vdata (described in Chapter 4, Vdatas (VS API)), with a class name of DimVal0.0. The vdata had the same number of records as the size of the dimension, which consisted of the values 0, 1, 2, ..., n - 1, where n is the size of the dimension. These values were not strictly necessary. Consider the case of applications that create large one dimensional data sets: the disk space taken by these unnecessary values nearly doubles the size of the HDF file. To avoid these situations, a new representation of dimensions was implemented for HDF version 4.0 beta 2 and later versions.

Dimensions are still vgroups in the new representation, but the vdata has only one record with a value of <dimension size> and the class name of the vdata has been changed to DimVal0.1 to distinguish it from the old version.

Between HDF versions 4.0 beta1 and 4.1, the old and new dimension representations were written by default for each dimension created, and both representations were recognized by routines that operate on dimensions. From HDF version 4.1 forward, SD interface routines recognize only the new representation. Two compatibility mode routines, SDsetdimval_comp and SDisdimval_bwcomp, are provided to allow HDF programs to distinguish between the two dimension representations, or compatibility modes.

3.8.3.1 Setting the Future Compatibility Mode of a Dimension: SDsetdimval_comp

SDsetdimval_comp sets the compatibility mode for the dimension identified by the parameter dim_id. This operation determines whether the dimension will have the old and new representations or the new representation only. The syntax of SDsetdimval_comp is as follows:

C: status = SDsetdimval_comp(dim_id, comp_mode);

FORTRAN: status = sfsdmvc(dim_id, comp_mode)

The parameter comp_mode specifies the compatibility mode. It can be set to either SD_DIMVAL_BW_COMP (or 1), which specifies compatible mode and that the old and new dimension representations will be written to the file, or SD_DIMVAL_BW_INCOMP (or 0), which specifies incompatible mode and that only the new dimension representation will be written to file. As of HDF version 4.1r1, the default mode is backward-incompatible. Subsequent calls to SDsetdimval_comp will override the settings established in previous calls to the routine.

Unlimited dimensions are always backward compatible. Therefore SDsetdimval_comp takes no action when the dimension identified by dim_id is unlimited.

SDsetdimval_comp returns a value of SUCCEED (or 0) or FAIL (or -1). The parameters of SDsetdimval_comp are specified in Table 3P on page 75.

3.8.3.2 Determining the Current Compatibility Mode of a Dimension: SDisdimval_bwcomp

SDisdimval_bwcomp determines whether the specified dimension has the old and new representations or the new representation only. The syntax of SDisdimval_bwcomp is as follows:

C: comp_mode = SDisdimval_bwcomp(dim_id);

FORTRAN: comp_mode = sfisdmcv(dim_id)

SDisdimval_bwcomp returns one of the three values: SD_DIMVAL_BW_COMP (or 1), SD_DIMVAL_BW_INCOMP (or 0), and FAIL (or -1). The interpretation of SD_DIMVAL_BW_COMP and SD_DIMVAL_BW_INCOMP are as that in the routine SDsetdimval_comp.

The parameters of SDisdimval_bwcomp are specified in Table 3P.
### 3.8.4 Dimension Scales

A **dimension scale** can be thought of as a series of numbers demarcating intervals along a dimension. One scale is assigned per dimension. Users of netCDF can think of them as analogous to **coordinate variables**. In the SDS data model, each dimension scale is a one-dimensional array with name and size equal to its assigned dimension name and size.

For example, if a dimension of length 6 named "depth" is assigned a dimension scale, its scale is a one-dimensional array of length 6 and is also assigned the name "depth". The name of the dimension will also appear as the name of the dimension scale.

Recall that when dimension scale is assigned to a dimension, the dimension is implemented as an SDS array with data being the data scale. Although dimension scales are conceptually different from SDS arrays, they are implemented as SDS arrays by the SDS interface and are treated similarly by the routines in the interface. For example, when the `SDfileinfo` routine returns the number of data sets in a file, it includes dimension scales in that number. The `SDiscoordvar` routine (described in Section 3.8.4.4 on page 82) distinguishes SDS data sets from dimension scales.

#### 3.8.4.1 Writing Dimension Scales: `SDsetdimscale`

`SDsetdimscale` stores scale information for the dimension identified by the parameter `dim_id`. The syntax of this routine is as follows:

**C:**
```
status = SDsetdimscale(dim_id, n_values, data_type, data);
```

**FORTRAN:**
```
status = sfsdscale(dim_id, n_values, data_type, data)
```

The argument `n_values` specifies the number of scale values along the specified dimension. For a fixed size dimension, `n_values` must be equal to the size of the dimension. The parameter `data_type` specifies the data type for the scale values and `data` is an array containing the scale values.

`SDsetdimscale` returns a value of `SUCCEED` (or 0) or `FAIL` (or -1). The parameters of this routine are specified in Table 3Q on page 76.

#### 3.8.4.2 Obtaining Dimension Scale and Other Dimension Information: `SDdiminfo`

Before working with an existing dimension scale, it is often necessary to determine its characteristics. For instance, to allocate the proper amount of memory for a scale requires knowledge of its size and data type. `SDdiminfo` provides this basic information, as well as the name and the number of attributes for a specified dimension.

The syntax of this routine is as follows:

**C:**
```
status = SDdiminfo(dim_id, dim_name, &dim_size, &data_type, &n_atts);
```

---

**TABLE 3P**

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>SDsetdimval_comp</code> [intn] (sfsdmvc)</td>
<td>dim_id</td>
<td>int32 integer</td>
<td>Dimension identifier</td>
</tr>
<tr>
<td></td>
<td>comp_mode</td>
<td>intn integer</td>
<td>Compatibility mode</td>
</tr>
<tr>
<td><code>SDisdimval_bwcomp</code> [intn] (sfsdmvc)</td>
<td>dim_id</td>
<td>int32 integer</td>
<td>Dimension identifier</td>
</tr>
</tbody>
</table>
**FORTRAN:**

```fortran
status = sfgdinfo(dim_id, dim_name, dim_size, data_type, n_attrs)
```

SDdiminfo retrieves and stores the dimension’s name, size, data type, and number of attributes into the parameters `dim_name`, `dim_size`, `data_type`, and `n_attrs`, respectively.

The parameter `dim_name` will contain the dimension name set by `SDsetdimname` or the default dimension name, `fakeDim[x]`, if `SDsetdimname` has not been called, where `[x]` denotes the dimension index. If the name is not desired, the parameter `dim_name` can be set to `NULL` in C or an empty string in FORTRAN-77.

An output value of 0 for the parameter `dim_size` indicates that the dimension specified by the parameter `dim_id` is unlimited. Use `SDgetinfo` to get the number of elements of the unlimited dimension.

If scale information is available for the specified dimension, i.e., `SDsetdimscale` has been called, the parameter `data_type` will contain the data type of the scale values; otherwise, `data_type` will contain 0.

SDdiminfo returns a value of `SUCCEED` (or 0) or `FAIL` (or -1). The parameters of this routine are specified in Table 3Q.

### 3.8.4.3 Reading Dimension Scales: SDgetdimscale

SDgetdimscale retrieves the scale values of a dimension. These values have previously been stored by `SDsetdimscale`. The syntax of this routine is as follows:

**C:**

```c
status = SDgetdimscale(dim_id, data);
```

**FORTRAN:**

```fortran
status = sfgdscale(dim_id, data)
```

SDgetdimscale reads all the scale values and stores them in the buffer `data` which is assumed to be sufficiently allocated to hold all the values. SDdiminfo should be used to determine whether the scale has been set for the dimension and to obtain the data type and the number of scale values for space allocation before calling `SDgetdimscale`. Refer to Section 3.8.4.2 on page 75 for a discussion of SDdiminfo.

Note that it is not possible to read a subset of the scale values. `SDgetdimscale` returns all of the scale values stored with the given dimension.

The fact that `SDgetdimscale` returns `SUCCEED` should not be interpreted as meaning that scale values have been defined for the data set. This function should always be used with SDdiminfo, which is used first to determine whether a scale has been set, the number of scale values, their data type, etc. If SDdiminfo indicates that no scale values have been set, the values returned by `SDgetdimscale` in `data` should be ignored.

SDgetdimscale returns a value of `SUCCEED` (or 0) or `FAIL` (or -1). The parameters of this routine are specified in Table 3Q.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDsetdimscale</td>
<td>dim_id</td>
<td>int32</td>
<td>Dimension identifier</td>
</tr>
<tr>
<td></td>
<td>n_values</td>
<td>int32</td>
<td>Number of scale values</td>
</tr>
<tr>
<td></td>
<td>data_type</td>
<td>int32</td>
<td>Data type to be set for the scale values</td>
</tr>
<tr>
<td></td>
<td>data</td>
<td>VOIDP</td>
<td>Buffer containing the scale values to be set</td>
</tr>
</tbody>
</table>

### Table 3Q

**TABLE 3Q**

<table>
<thead>
<tr>
<th>Routine Name, SDDiminfo, and SDgetdimscale Parameter Lists</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDsetdimscale</td>
<td>dim_id</td>
<td>int32</td>
<td>Dimension identifier</td>
</tr>
<tr>
<td>SDsetdimscale</td>
<td>n_values</td>
<td>int32</td>
<td>Number of scale values</td>
</tr>
<tr>
<td>SDsetdimscale</td>
<td>data_type</td>
<td>int32</td>
<td>Data type to be set for the scale values</td>
</tr>
<tr>
<td>SDsetdimscale</td>
<td>data</td>
<td>VOIDP</td>
<td>Buffer containing the scale values to be set</td>
</tr>
</tbody>
</table>
EXAMPLE 12.

Setting and Retrieving Dimension Information.

This example illustrates the use of the routines SDgetdimid/sfdimid, SDsetdimname/sfsdmname, SDsetdimscale/sfdscale, SDdiminfo/sfgdinfo, and SDgetdimscale/sfgdscale to set and retrieve the dimensions names and dimension scales of the SDS created in Example 2 and modified in Examples 4 and 7.

C:

```c
#include "mfhdf.h"

#define FILE_NAME     "SDS.hdf"
#define SDS_NAME      "SDStemplate"
#define DIM_NAME_X     "X_Axis"
#define DIM_NAME_Y     "Y_Axis"
#define NAME_LENGTH   6
#define X_LENGTH      5
#define Y_LENGTH      16
#define RANK          2

int32   sd_id, sds_id, sds_index;
intn    status;
intn    dim_index, dim_id;
intn    n_values, data_type, n_attrs;
intn    nrow;
intn    data_X[X_LENGTH];    /* X dimension dimension scale */
intn    data_Y[Y_LENGTH];  /* Y dimension dimension scale */
char    dim_name[NAME_LENGTH];
int     i, j;

main( )
{
    /*************************************************************************
    ** Variable declaration ***************************************************/

    /**************************************************************************/
    ** End of variable declaration ******************************************/

    /**************************************************************************/
    ** Initialize dimension scales. **
    /*
    for (i=0; i < X_LENGTH; i++) data_X[i] = i;
    for (i=0; i < Y_LENGTH; i++) data_Y[i] = 0.1 * i;

    /**************************************************************************/
    ** Open the file and initialize SD interface. **
    /*
    sd_id = SDstart (FILE_NAME, DFACC_WRITE);

    /**************************************************************************/
    ** Get the index of the data set specified in SDS_NAME. **
    ```
```
sds_index = SDnametoindex (sd_id, SDS_NAME);

*/
/*
* Select the data set corresponding to the returned index.
*/
sds_id = SDselect (sd_id, sds_index);

*/
/* For each dimension of the data set specified in SDS_NAME,
* get its dimension identifier and set dimension name
* and dimension scale. Note that data type of dimension scale
* can be different between dimensions and can be different from
* SDS data type.
*/
for (dim_index = 0; dim_index < RANK; dim_index++)
{
    /*
    * Select the dimension at position dim_index.
    */
    dim_id = SDgetdimid (sds_id, dim_index);

    /*
    * Assign name and dimension scale to selected dimension.
    */
    switch (dim_index)
    {
        case 0: status = SDsetdimname (dim_id, DIM_NAME_Y);
            n_values = Y_LENGTH;
            status = SDsetdimscale (dim_id,n_values,DFNT_FLOAT64, (VOIDP)data_Y);
            break;
        case 1: status = SDsetdimname (dim_id, DIM_NAME_X);
            n_values = X_LENGTH;
            status = SDsetdimscale (dim_id,n_values,DFNT_INT16, (VOIDP)data_X);
            break;
        default: break;
    }

    /*
    * Get and display info about the dimension and its scale values.
    * The following information is displayed:
    *
    * Information about 1 dimension:
    * dimension name is Y_Axis
    * number of scale values is 16
    * dimension scale data type is float64
    * number of dimension attributes is 0
    *
    * Scale values are :
    * 0.000  0.100  0.200  0.300
    * 0.400  0.500  0.600  0.700
    * 0.800  0.900  1.000  1.100
    * 1.200  1.300  1.400  1.500
    *
    * Information about 2 dimension:
    * dimension name is X_Axis
    * number of scale values is 5
    * dimension scale data type is int16
    * number of dimension attributes is 0
    *
    * Scale values are :
    * 0 1 2 3 4
status = SDdiminfo (dim_id, dim_name, &n_values, &data_type, &n_attrs);
printf ("Information about %d dimension:\n", dim_index+1);
printf ("dimension name is %s\n", dim_name);
printf ("number of scale values is %d\n", n_values);
if( data_type == DFNT_FLOAT64)
  printf ("dimension scale data type is float64\n");
if( data_type == DFNT_INT16)
  printf ("dimension scale data type is int16\n");
printf ("number of dimension attributes is %d\n", n attrs);
printf ("\n");
printf ("Scale values are :\n");
switch (dim_index) {
case 0:  status = SDgetdimscale (dim_id, (VOIDP)data_Y_out);
nrow = 4;
  for (i=0; i<n_values/nrow; i++ )
  {
    for (j=0; j<nrow; j++)
      printf (" %-6.3f", data_Y_out[i*nrow + j]);
    printf ("\n");
  }
  break;
case 1:  status = SDgetdimscale (dim_id, (VOIDP)data_X_out);
  for (i=0; i<n_values; i++) printf (" %d", data_X_out[i]);
  break;
default: break;
}
printf ("\n");
} /*for dim_index */

/*
* Terminate access to the data set.
*/
status = SDendaccess (sds_id);

/*
* Terminate access to the SD interface and close the file.
*/
status = SDend (sd_id);
parameter (DFACC_WRITE = 2,
+           DFNT_INT16 = 22,
+           DFNT_FLOAT64 = 6)

C  Function declaration.
C  integer sfstart, sfn2index, sfdimid, sfgdinfo
integer sfdsdscale, sfgdscale, sfdsdmname, sfendacc
integer sfend, sfselect
C
C**** Variable declaration *******************************************
C
integer sd_id, sds_id, sds_index, status
integer dim_index, dim_id
integer n_values, n_attr, data_type
integer*2 data_X(X_LENGTH)
integer*2 data_X_out(X_LENGTH)
real*8    data_Y(Y_LENGTH)
real*8    data_Y_out(Y_LENGTH)
character*6 dim_name
integer i
C
C**** End of variable declaration ************************************
C
C     Initialize dimension scales.
C
do 10 i = 1, X_LENGTH
   data_X(i) = i - 1
10     continue

do 20 i = 1, Y_LENGTH
   data_Y(i) = 0.1 * (i - 1)
20     continue

C     Open the file and initialize SD interface.
C
sd_id = sfstart(FILE_NAME, DFACC_WRITE)
C
C     Get the index of the data set with the name specified in SDS_NAME.
C
sds_index = sfn2index(sd_id, SDS_NAME)
C
C     Select the data set corresponding to the returned index.
C
sds_id = sfselect(sd_id, sds_index)
C
C     For each dimension of the data set,
C     get its dimension identifier and set dimension name
C     and dimension scales. Note that data type of dimension scale can
C     be different between dimensions and can be different from SDS data type.
C
do 30 dim_index = 0, RANK - 1
C
   Select the dimension at position dim_index.
C
dim_id = sfdimid(sds_id, dim_index)
C
   Assign name and dimension scale to the dimension.
C
   if (dim_index .eq. 0) then
      status = sfdsdmname(dim_id, DIM_NAME_X)
   endif
n_values = X_LENGTH
status = sfsdscale(dim_id, n_values, DFNT_INT16, data_X)
end if
if (dim_index .eq. 1) then
status = sfsdmname(dim_id, DIM_NAME_Y)
n_values = Y_LENGTH
status = sfsdscale(dim_id, n_values, DFNT_FLOAT64, data_Y)
end if

C Get and display information about dimension and its scale values.
The following information is displayed:

C Information about 1 dimension :
dimension name is X_Axis
number of scale values is 5
dimension scale data type is int16
number of dimension attributes is 0
Scale values are:
  0  1  2  3  4

C Information about 2 dimension :
dimension name is Y_Axis
number of scale values is 16
dimension scale data type is float64
number of dimension attributes is 0

Scale values are:
  0.000  0.100  0.200  0.300
  0.400  0.500  0.600  0.700
  0.800  0.900  1.000  1.100
  1.200  1.300  1.400  1.500

status = sfgdinfo(dim_id, dim_name, n_values, data_type, n_attrs)

write(*,*) "Information about ", dim_index+1," dimension :"
write(*,*) "dimension name is ", dim_name
write(*,*) "number of scale values is ", n_values
if (data_type. eq. 22) then
write(*,*) "dimension scale data type is int16"
endif
if (data_type. eq. 6) then
write(*,*) "dimension scale data type is float64"
endif
write(*,*) "number of dimension attributes is ", n_attrs

C Write scale values:
if (dim_index .eq. 0) then
status = sfgdscale(dim_id, data_X_out)
write(*,*) (data_X_out(i), i= 1, X_LENGTH)
endif
if (dim_index .eq. 1) then
status = sfgdscale(dim_id, data_Y_out)
write(*,100) (data_Y_out(i), i= 1, Y_LENGTH)
100 format(4(1x,f10.3)/)
endif
30 continue

C Terminate access to the data set.
status = sfendacc(sds_id)

C Terminate access to the SD interface and close the file.
C
    status = sfend(sd_id)
end

3.8.4.4 Distinguishing SDS Arrays from Dimension Scales: SDiscoordvar

The HDF library stores SDS dimensions as data sets. HDF therefore provides the routine SDiscoordvar to determine whether a particular data set contains the data of an SDS or an SDS dimension with dimension scale or attribute assigned to it. The syntax of SDiscoordvar this routine is as follows:

C:    status = SDiscoordvar(sds_id);

FORTRAN:   status = sfiscvar(sds_id)

If the data set, identified by the parameter sds_id, contains the dimension data, a subsequent call to SDgetinfo will fill the specified arguments with information about a dimension, rather than a data set.

SDiscoordvar returns TRUE (or 1) if the specified data set represents a dimension scale and FALSE (or 0), otherwise. This routine is further defined in Table 3R.

<table>
<thead>
<tr>
<th>Routine Name [Return Type]</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDiscoordvar [intn] (sfiscvar)</td>
<td>sds_id</td>
<td>int32</td>
<td>integer</td>
</tr>
</tbody>
</table>

Table 3R

EXAMPLE 13. Distinguishing a Dimension Scale from a Data Set in a File.

This example illustrates the use of the routine SDiscoordvar/sfiscvar to determine whether the selected SDS array is a data set or a dimension stored as an SDS array (coordinate variable) (see discussion in Section 3.8.4) and displays the name of the data set or dimension.

C:

#include "mfhdf.h"
#define FILE_NAME     "SDS.hdf"
main( )
{
    /**************************************************************************
     * Variable declaration **************************************************/
    int32 sd_id, sds_id, sds_index;
    intn  status;
    int32 rank, data_type, dim_sizes[MAX_VAR_DIMS];
    int32 n_datasets, n_file_attr, n_atts;
    char  sds_name[MAX_NC_NAME];

    /**************************************************************************
     * End of variable declaration ******************************************/
    
    /*
     * Open the file and initialize the SD interface.
     */
    sd_id = SDstart(FILE_NAME, DFACC_READ);
/*
* Obtain information about the file.
*/
status = SDfileinfo(sd_id, &n_datasets, &n_file_attr);

/* Get information about each SDS in the file.
* Check whether it is a coordinate variable, then display retrieved
* information.
* Output displayed:
*  * SDS array with the name SDStemplate
*  * Coordinate variable with the name Y_Axis
*  * Coordinate variable with the name X_Axis
*/
for (sds_index=0; sds_index< n_datasets; sds_index++)
{
    sds_id = SDselect(sd_id, sds_index);
    status = SDgetinfo(sds_id, sds_name, &rank, dim_sizes, &data_type,
                      &n_attrs);
    if (SDiscoordvar(sds_id))
        printf(" Coordinate variable with the name \%s\n", sds_name);
    else
        printf(" SDS array with the name \%s\n", sds_name);
    /*
    * Terminate access to the selected data set.
    */
    status = SDendaccess(sds_id);
}

/*
* Terminate access to the SD interface and close the file.
*/
status = SDend(sd_id);

FORTRAN:
program  sds_vrs_coordvar
implicit none
C
C     Parameter declaration.
C
C character*7  FILE_NAME
parameter  (FILE_NAME = 'SDS.hdf')
integer      DFACC_READ, DFNT_INT32
parameter   (DFACC_READ = 1,  
+            DFNT_INT32 = 24)
integer      MAX_VAR_DIMS
parameter   (MAX_VAR_DIMS = 32)
C
C     Function declaration.
C
C integer sfstart, sfselect, sfiscvar, sffinfo, sfginfo
integer sfendacc, sfend
C
C**** Variable declaration **************************************************
C
integer      sd_id, sds_id, sds_index, status
integer      rank, data_type
integer      n_datasets, n_file_attr, n_attrs
C**** End of variable declaration *******************************************
C
C Open the file and initialize the SD interface.
C
sd_id = sfstart(FILE_NAME, DFACC_READ)
C
C Obtain information about the file.
C
status = sffinfo(sd_id, n_datasets, n_file_attrs)
C
C Get information about each SDS in the file.
C
C Check whether it is a coordinate variable, then display retrieved
C information.
C
C Output displayed:
C
SDS array with the name SDStemplate
Coordinate variable with the name X_Axis
Coordinate variable with the name Y_Axis
C
do 10 sds_index = 0, n_datasets-1
sds_id = sfselect(sd_id, sds_index)
status = sfginfo(sds_id, sds_name, rank, dim_sizes,
+ data_type, n_attrs)
status = sfiscvar(sds_id)
if (status .eq. 1) then
  write(*,*) "Coordinate variable with the name ",
+ sds_name(1:6)
else
  write(*,*) "SDS array with the name ",
+ sds_name(1:11)
endif
C
C Terminate access to the data set.
C
status = sfendacc(sds_id)
10 continue
C
C Terminate access to the SD interface and close the file.
C
status = sfend(sd_id)
end

3.8.5 Related Data Sets

SD data sets with one or more dimensions with the same name and size are considered to be related. Examples of related data sets are cross-sections from the same simulation, frames in an animation, or images collected from the same apparatus. HDF attempts to preserve this relationship by unifying their dimension scales and attributes. To understand how related data sets are handled, it is necessary to understand what dimension records are and how they are created.

In the SD interface, dimension records are only created for dimensions of a unique name and size. To illustrate this, consider a case where there are three scientific data sets, each representing a unique variable, in an HDF file. (See Figure 3c.) The first two data sets have two dimensions each and the third data set has three dimensions. There are a total of five dimensions in the file and the name mapping between the data sets and the dimensions are shown in the figure. Note that if, for example, the creation of a second dimension named "Altitude" is attempted and the size of the
dimension is different from the existing dimension named "Altitude", an error condition will be generated.

As expected, assigning a dimension attribute to dimension 1 of either data set will create the required dimension scale and assign the appropriate attribute. However, because related data sets share dimension records, they also share dimension attributes. Therefore, it is impossible to assign an attribute to a dimension without assigning the same attribute to all dimensions of identical name and size, either within one data set or related data sets.

FIGURE 3c

Dimension Records and Attributes Shared Between Related Data Sets

3.9 User-defined Attributes

User-defined attributes are defined by the calling program and contain auxiliary information about a file, SDS array, or dimension. This auxiliary information is sometimes called metadata because it is data about data. There are two ways to store metadata: as user-defined attributes or as predefined attributes.

Attributes take the form \texttt{label=value}, where \texttt{label} is a character string containing \texttt{MAX_NC_NAME} (or 256) or fewer characters and \texttt{value} contains one or more entries of the same data type as defined at the time the attribute is created. Attributes can be attached to files, data sets, and dimensions. These are referred to, respectively, as \texttt{file attributes}, \texttt{data set attributes}, and \texttt{dimension attributes}:

- \texttt{File attributes} describe an entire file. They generally contain information pertinent to all HDF data sets in the file and are sometimes referred to as \texttt{global attributes}.
- \texttt{Data set attributes} describe individual SDSs. Because their scope is limited to an individual SDS, data set attributes are sometimes referred to as \texttt{local attributes}.
- \texttt{Dimension attributes} provide information applicable to an individual SDS dimension. It is possible to assign a unit to one dimension in a data set without assigning a unit to the remaining dimensions.

For each attribute, an \texttt{attribute count} is maintained that identifies the number of values in the attribute. Each attribute has a unique \texttt{attribute index}, the value of which ranges from 0 to the total number of attributes minus 1. The attribute index is used to locate an attribute in the object which the attribute is attached to. Once the attribute is identified, its values and information can be retrieved.

The data types permitted for attributes are the same as those allowed for SDS arrays. SDS arrays with general attributes of the same name can have different data types. For example, the attribute \texttt{valid_range} specifying the valid range of data values for an array of 16-bit integers might be of...
type 16-bit integer, whereas the attribute valid_range for an array of 32-bit floats could be of type 32-bit floating-point integer.

Attribute names follow the same rules as dimension names. Providing meaningful names for attributes is important, however using standardized names may be necessary if generic applications and utility programs are to be used. For example, every variable assigned a unit should have an attribute named "units" associated with it. Furthermore, if an HDF file is to be used with software that recognizes "units" attributes, the values of the "units" attributes should be expressed in a conventional form as a character string that can be interpreted by that software.

The SD interface uses the same functions to access all attributes regardless of the objects they are assigned to. The difference between accessing a file, array, or dimension attribute lies in the use of identifiers. File identifiers, SDS identifiers, and dimension identifiers are used to respectively access file attributes, SDS attributes, and dimension attributes.

### 3.9.1 Creating or Writing User-defined Attributes: SDsetattr

SDsetattr creates or modifies an attribute for one of the objects: the file, the data set, or the dimension. If the attribute with the specified name does not exist, SDsetattr creates a new one. If the named attribute already exists, SDsetattr resets all the values that are different from those provided in its argument list. The syntax of this routine is as follows:

**C:**
```c
status = SDsetattr(obj_id, attr_name, data_type, n_values, values);
```

**FORTRAN:**
```fortran
status = sfsnatt(obj_id, attr_name, data_type, n_values, values)
OR status = sfscatt(obj_id, attr_name, data_type, n_values, values)
```

The parameter `obj_id` is the identifier of the HDF data object to which the attribute is assigned and can be a file identifier, SDS identifier, or dimension identifier. If `obj_id` specifies an SD interface identifier (`sd_id`), a global attribute will be created which applies to all objects in the file. If `obj_id` specifies a data set identifier (`sds_id`), an attribute will be attached only to the specified data set. If `obj_id` specifies a dimension identifier (`dim_id`), an attribute will be attached only to the specified dimension.

The parameter `attr_name` is an ASCII character string containing the name of the attribute. It represents the label in the `label = value` equation and can be no more than `MAX_NC_NAME` (or 256) characters. If this is set to the name of an existing attribute, the value portion of the attribute will be overwritten. Do not use SDsetattr to assign a name to a dimension, use SDsetdimname instead.

The arguments `data_type`, `n_values`, and `values` describe the right side of the `label = value` equation. The argument `values` contains one or more values of the same data type. The argument `data_type` contains any HDF supported data type (see Table 2F on page 14). The parameter `n_values` specifies the total number of values in the attribute.

There are two FORTRAN-77 versions of this routine: sfsnatt and sfscatt. The routine sfsnatt writes numeric attribute data and sfscatt writes character attribute data.

SDsetattr returns a value of `SUCCEED` (or 0) or `FAIL` (or -1). The parameters of SDsetattr are further described in Table 3S on page 91.

This example shows how the routines SDsetattr/sfscatt/sfsnatt are used to set the attributes of the file, data set, and data set dimension created in the Examples 2, 4, and 12.

C:

```c
#include "mfhdf.h"

#define FILE_NAME      "SDS.hdf"
#define FILE_ATTR_NAME "File_contents"
#define SDS_ATTR_NAME  "Valid_range"
#define DIM_ATTR_NAME  "Dim_metric"

main( )
{
    /**************************************************************************
    Variable declaration **************************************************************************/

    int32   sd_id, sds_id, sds_index;
    intn    status;
    int32   dim_id, dim_index;
    int32   n_values;                /* number of values of the file, SDS or
dimension attribute                          */
    char8   file_values[] = "Storm_track_data";  /* values of the file attribute */
    float32 sds_values[2] = {2., 10.};       /* values of the SDS attribute */
    char8   dim_values[]  = "Seconds";       /* values of the dimension attribute */

    /************************************************************************** End of variable declaration **************************************************************************/

    /*
    * Open the file and initialize the SD interface.
    */
    sd_id = SDstart (FILE_NAME, DFACC_WRITE);

    /*
    * Set an attribute that describes the file contents.
    */
    n_values = 16;
    status = SDsetattr (sd_id, FILE_ATTR_NAME, DFNT_CHAR8, n_values, (VOIDP)file_values);

    /*
    * Select the first data set.
    */
    sds_index = 0;
    sds_id = SDselect (sd_id, sds_index);

    /*
    * Assign attribute to the first SDS. Note that attribute values
    * may have different data type than SDS data.
    */
    n_values = 2;
    status = SDsetattr (sds_id, SDS_ATTR_NAME, DFNT_FLOAT32, n_values, (VOIDP)sds_values);

    /*
    * Get the the second dimension identifier of the SDS.
    */
    dim_index = 1;
    dim_id = SDgetdimid (sds_id, dim_index);
```
/*
 * Set an attribute of the dimension that specifies the dimension metric.
 */

n_values = 7;
status = SDsetattr (dim_id, DIM_ATTR_NAME, DFNT_CHAR8, n_values,
    (VOIDP)dim_values);

/*
 * Terminate access to the data set.
 */
status = SDendaccess (sds_id);

/*
 * Terminate access to the SD interface and close the file.
 */
status = SDend (sd_id);
}

FORTRAN:

program set_attribs
implicit none

C Parameter declaration.
C
character*7  FILE_NAME
character*13 FILE_ATTR_NAME
character*11 SDS_ATTR_NAME
character*10 DIM_ATTR_NAME
parameter   (FILE_NAME = 'SDS.hdf',
    + FILE_ATTR_NAME = 'File_contents',
    + SDS_ATTR_NAME = 'Valid_range',
    + DIM_ATTR_NAME = 'Dim_metric')
integer      DFACC_WRITE, DFNT_CHAR8, DFNT_FLOAT32
parameter   (DFACC_WRITE = 2,
    + DFNT_CHAR8  = 4,
    + DFNT_FLOAT32 = 5)
C Function declaration.
C
integer sfstart, sfscatt, sfsnatt, sfselect, sfdimid
integer sfendacc, sfend
C**** Variable declaration ************************************************************
C
integer sd_id, sds_id, sds_index, status
integer dim_id, dim_index
integer n_values
character*16 file_values
real     sds_values(2)
character*7  dim_values
file_values   = 'Storm_track_data'
sds_values(1) = 2.
sds_values(2) = 10.
dim_values    = 'Seconds'
C**** End of variable declaration *******************************************************
C
C Open the file and initialize the SD interface.
C
sd_id = sfstart(FILE_NAME, DFACC_WRITE)
Set an attribute that describes the file contents.

```
    n_values = 16
    status = sfscatt(sd_id, FILE_ATTR_NAME, DFNT_CHAR8, n_values,
                     file_values)
```

Select the first data set.

```
    sds_index = 0
    sds_id = sfselect(sd_id, sds_index)
```

Assign attribute to the first SDS. Note that attribute values may have different data type than SDS data.

```
    n_values = 2
    status = sfsnatt(sds_id, SDS_ATTR_NAME, DFNT_FLOAT32, n_values,
                     sds_values)
```

Get the identifier for the first dimension.

```
    dim_index = 0
    dim_id = sfdimid(sds_id, dim_index)
```

Set an attribute to the dimension that specifies the dimension metric.

```
    n_values = 7
    status = sfscatt(dim_id, DIM_ATTR_NAME, DFNT_CHAR8, n_values,
                     dim_values)
```

Terminate access to the data set.

```
    status = sfendacc(sds_id)
```

Terminate access to the SD interface and close the file.

```
    status = sfend(sd_id)
```

### 3.9.2 Querying User-defined Attributes: SDfindattr and SDattrinfo

Given a file, SDS, or dimension identifier and an attribute name, `SDfindattr` returns a valid attribute index if the corresponding attribute exists. The attribute index can then be used to retrieve information about the attribute or its values. Given a file, SDS, or dimension identifier and a valid attribute index, `SDattrinfo` retrieves the information about the corresponding attribute if it exists.

The syntax for `SDfindattr` and `SDattrinfo` are as follows:

- **C:**
  ```
  attr_index = SDfindattr(obj_id, attr_name);
  status = SDattrinfo(obj_id, attr_index, attr_name, &data_type, &n_values);
  ```

- **FORTRAN:**
  ```
  attr_index = sffattr(obj_id, attr_name)
  status = sfgainfo(obj_id, attr_index, attr_name, data_type, n_values)
  ```
**SDfindattr** returns the index of the attribute, which belongs to the object identified by the parameter `obj_id` and whose name is specified by the parameter `attr_name`.

The parameter `obj_id` can be either an SD interface identifier (`sd_id`), a data set identifier (`sds_id`), or a dimension identifier (`dim_id`). **SDfindattr** is case-sensitive in searching for the name specified by the parameter `attr_name` and does not accept wildcards as part of that name.

**SDattrinfo** retrieves the attribute’s name, data type, and number of values into the parameters `attr_name`, `data_type`, and `n_values`, respectively.

The parameter `attr_index` specifies the relative position of the attribute within the specified object. An attribute index may also be determined by either keeping track of the number and order of attributes as they are written or dumping the contents of the file using the HDF dumping utility, hdp, which is described in Chapter 15, *HDF Command-line Utilities*.

**SDfindattr** returns an attribute index or a value of `FAIL` (or -1). **SDattrinfo** returns a value of `SUCCEED` (or 0) or `FAIL` (or -1). The parameters of **SDfindattr** and **SDattrinfo** are further described in Table 3S on page 91.

### 3.9.3 Reading User-defined Attributes: SDreadattr

Given a file, SDS, or dimension identifier and an attribute index, **SDreadattr** reads the values of an attribute that belongs to either a file, an SDS, or a dimension. The syntax of this routine is as follows:

```c
C: status = SDreadattr(obj_id, attr_index, values);
```

```fortran
FORTRAN: status = sfrattr(obj_id, attr_index, values)
OR    status = sfrnatt(obj_id, attr_index, values)
OR    status = sfrcatt(obj_id, attr_index, values)
```

**SDreadattr** stores the attribute values in the buffer `values`, which is assumed to be sufficiently allocated. The size of the buffer must be at least `n_values*sizeof (data_type)` bytes long, where `n_values` and `data_type` are the number of attribute values and their type. The values of `n_values` and `data_type` can be retrieved using **SDattrinfo**. Note that the size of the data type must be determined at the local machine where the application is running. **SDreadattr** will also read attributes and annotations created by the DFSD interface.

The parameter `obj_id` can be either an SD interface identifier (`sd_id`), a data set identifier (`sds_id`), or a dimension identifier (`dim_id`).

The parameter `attr_index` specifies the relative position of the attribute within the specified object. An attribute index may also be determined by either keeping track of the number and order of attributes as they are written or dumping the contents of the file using the HDF dumping utility, hdp, which is described in Chapter 15, *HDF Command-line Utilities*.

There are three FORTRAN-77 versions of this routine: `sfrattr`, `sfrnatt`, and `sfrcatt`. The routine `sfrattr` reads data of all valid data types, `sfrnatt` reads numeric attribute data and `sfrcatt` reads character attribute data.

**SDreadattr** returns a value of `SUCCEED` (or 0) or `FAIL` (or -1). The parameters of **SDreadattr** are further described in Table 3S.
### TABLE 3S

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SDsetattr</strong></td>
<td>sd_id, sds_id or dim_id</td>
<td>int32</td>
<td>SD interface, data set, or dimension identifier</td>
</tr>
<tr>
<td></td>
<td>attr_name</td>
<td>char *</td>
<td>Name of the attribute</td>
</tr>
<tr>
<td></td>
<td>data_type</td>
<td>int32</td>
<td>Data type of the attribute</td>
</tr>
<tr>
<td></td>
<td>n_values</td>
<td>int32</td>
<td>Number of values in the attribute</td>
</tr>
<tr>
<td></td>
<td>values</td>
<td>VOIDP</td>
<td>Buffer containing the data to be written</td>
</tr>
<tr>
<td><strong>SDfindattr</strong></td>
<td>sd_id, sds_id or dim_id</td>
<td>int32</td>
<td>SD interface, data set, or dimension identifier</td>
</tr>
<tr>
<td></td>
<td>attr_name</td>
<td>char *</td>
<td>Attribute name</td>
</tr>
<tr>
<td><strong>SDattrinfo</strong></td>
<td>sd_id, sds_id or dim_id</td>
<td>int32</td>
<td>SD interface, data set, or dimension identifier</td>
</tr>
<tr>
<td></td>
<td>attr_index</td>
<td>int32</td>
<td>Index of the attribute to be read</td>
</tr>
<tr>
<td></td>
<td>attr_name</td>
<td>char *</td>
<td>Buffer for the name of the attribute</td>
</tr>
<tr>
<td></td>
<td>data_type</td>
<td>int32 *</td>
<td>Buffer for the data type of the values in the attribute</td>
</tr>
<tr>
<td></td>
<td>n_values</td>
<td>int32 *</td>
<td>Buffer for the total number of values in the attribute</td>
</tr>
<tr>
<td><strong>SDreadattr</strong></td>
<td>sd_id, sds_id or dim_id</td>
<td>int32</td>
<td>SD interface, data set, or dimension identifier</td>
</tr>
<tr>
<td></td>
<td>attr_index</td>
<td>int32</td>
<td>Index of the attribute to be read</td>
</tr>
<tr>
<td></td>
<td>values</td>
<td>VOIDP</td>
<td>Buffer for the attribute values</td>
</tr>
</tbody>
</table>

#### Reading Attributes.

This example uses the routines `SDfindattr/sffattr`, `SDattrinfo/sfgainfo`, and `SDreadattr/sfrattr` to find and read attributes of the file, data set, and data set dimension created in the Example 14.

**C:**

```c
#include "mfhdf.h"

#define FILE_NAME   "SDS.hdf"
#define FILE_ATTR_NAME  "File_contents"
#define SDS_ATTR_NAME  "Valid_range"
#define DIM_ATTR_NAME  "Dim_metric"

main( ) {
    /*-------------------------- Variable declaration --------------------------*/
    int32   sd_id, sds_id, dim_id;
    intn    status;
    int32   attr_index, data_type, n_values;
    char    attr_name[MAX_NC_NAME];
    int8    *file_data;
    int8    *dim_data;
    float32 *sds_data;
    int     i;
```
/* Open the file and initialize SD interface. */
sd_id = SDstart (FILE_NAME, DFACC_READ);

/* Find the file attribute defined by FILE_ATTR_NAME. */
attr_index = SDfindattr (sd_id, FILE_ATTR_NAME);

/* Get information about the file attribute. Note that the first parameter is an SD interface identifier. */
status = SDattrinfo (sd_id, attr_index, attr_name, &data_type, &n_values);

/* Allocate a buffer to hold the attribute data. */
file_data = (int8 *)malloc (n_values * sizeof (data_type));

/* Read the file attribute data. */
status = SDreadattr (sd_id, attr_index, file_data);

/* Print out file attribute value. */
printf ("File attribute value is : %s\n", file_data);

/* Select the first data set. */
sds_id = SDselect (sd_id, 0);

/* Find the data set attribute defined by SDS_ATTR_NAME. Note that the first parameter is a data set identifier. */
attr_index = SDfindattr (sds_id, SDS_ATTR_NAME);

/* Get information about the data set attribute. */
status = SDattrinfo (sds_id, attr_index, attr_name, &data_type, &n_values);

/* Allocate a buffer to hold the data set attribute data. */
sds_data = (float32 *)malloc (n_values * sizeof (data_type));

/* Read the SDS attribute data. */
status = SDreadattr (sds_id, attr_index, sds_data);

/* Print out SDS attribute data type and values. */
if (data_type == DFNT_FLOAT32)
    printf ("SDS attribute data type is : float32\n");
printf ("SDS attribute values are : ");
for (i=0; i<n_values; i++) printf (" %f", sds_data[i]);
printf ("\n");

/*
 * Get the identifier for the second dimension of the SDS.
 */
dim_id = SDgetdimid (sds_id, 1);

/*
 * Find dimension attribute defined by DIM_ATTR_NAME.
 */
attr_index = SDfindattr (dim_id, DIM_ATTR_NAME);

/*
 * Get information about the dimension attribute.
 */
status = SDattrinfo (dim_id, attr_index, attr_name, &data_type, &n_values);

/*
 * Allocate a buffer to hold the dimension attribute data.
 */
dim_data = (int8 *)malloc (n_values * sizeof (data_type));

/*
 * Read the dimension attribute data.
 */
status = SDreadattr (dim_id, attr_index, dim_data);

/*
 * Print out dimension attribute value.
 */
printf ("Dimensional attribute values is : %s\n", dim_data);

/*
 * Terminate access to the data set and to the SD interface and
 * close the file.
 */
status = SDendaccess (sds_id);
status = SDend (sd_id);

/*
 * Free all buffers.
 */
free (dim_data);
free (sds_data);
free (file_data);

/* Output of this program is :
 * File attribute value is : Storm_track_data
 * SDS attribute data type is : float32
 * SDS attribute values are :  2.000000 10.000000
 * Dimensional attribute values is : Seconds
 */
}
FORTRAN:

program attr_info
implicit none

C Parameter declaration.
C
character*7  FILE_NAME
character*13 FILE_ATTR_NAME
character*11 SDS_ATTR_NAME
character*10 DIM_ATTR_NAME
parameter   (FILE_NAME = 'SDS.hdf',
+             FILE_ATTR_NAME = 'File_contents',
+             SDS_ATTR_NAME  = 'Valid_range',
+             DIM_ATTR_NAME  = 'Dim_metric')
integer      DFACC_READ, DFNT_FLOAT32
parameter   (DFACC_READ   = 1,
+             DFNT_FLOAT32 = 5)

C Function declaration.
C
integer sfstart, sffattr, sfgainfo, sfrattr, sfselect
integer sfdimid, sfendacc, sfend

C**** Variable declaration ************************************************
C
integer sd_id, sds_id, dim_id
integer attr_index, data_type, n_values, status
real   sds_data(2)
character*20 attr_name
character*16 file_data
character*7 dim_data
integer i

C**** End of variable declaration ***************************************
C
C Open the file and initialize SD interface.
C
sd_id = sfstart(FILE_NAME, DFACC_READ)

C Find the file attribute defined by FILE_ATTR_NAME.
C Note that the first parameter is an SD interface identifier.
C
attr_index = sffattr(sd_id, FILE_ATTR_NAME)

C Get information about the file attribute.
C
status = sfgainfo(sd_id, attr_index, attr_name, data_type,
+                   n_values)

C Read the file attribute data.
C
status = sfrattr(sd_id, attr_index, file_data)

C Print file attribute value.
C
write(*,*) "File attribute value is : ", file_data

C Select the first data set.
C
sds_id = sfselect(sd_id, 0)
Find the data set attribute defined by SDS_ATTR_NAME.
Note that the first parameter is a data set identifier.

attr_index = sffattr(sds_id, SDS_ATTR_NAME)

Get information about the data set attribute.

status = sfgainfo(sds_id, attr_index, attr_name, data_type,
               n_values)

Read the SDS attribute data.

status = sfrattr(sds_id, attr_index, sds_data)

Print SDS attribute data type and values.

if (data_type .eq. DFNT_FLOAT32)  then
    write(*,*) "SDS attribute data type is : float32 "
endif
write(*,*) "SDS attribute values are  : 
write(*,*)  (sds_data(i), i=1, n_values)

Get the identifier for the first dimension of the SDS.

dim_id = sfdimid(sds_id, 0)

Find the dimensional attribute defined by DIM_ATTR_NAME.
Note that the first parameter is a dimension identifier.

attr_index = sffattr(dim_id, DIM_ATTR_NAME)

Get information about dimension attribute.

status = sfgainfo(dim_id, attr_index, attr_name, data_type,
               n_values)

Read the dimension attribute data.

status = sfrattr(dim_id, attr_index, dim_data)

Print dimension attribute value.

write(*,*) "Dimensional attribute value is : ", dim_data

Terminate access to the data set.

status = sfendacc(sds_id)

Terminate access to the SD interface and close the file.

status = sfend(sd_id)

Output of this program is :

File attribute value is : Storm_track_data
SDS attribute data type is : float32
SDS attribute values are  :
    2.00000   10.00000
Dimensional attribute value is : Seconds
3.10 Predefined Attributes

Predefined attributes use reserved names and in some cases predefined data type names. Predefined attributes are categorized as follows:

- **Labels** can be thought of as variable names. They are often used as keys in searches to find a particular predefined attribute.

- **Units** are a means of declaring the units pertinent to a specific discipline. A freely-available library of routines is available to convert between character string and binary forms of unit specifications and to perform useful operations on the binary forms. This library is used in some netCDF applications and is recommended for use with HDF applications. For more information, refer to the netCDF User's Guide for C which can be obtained at http://www.unidata.ucar.edu/packages/netcdf/guidec/.

- **Formats** describe the format in which numeric values will be printed and/or displayed. The recommended convention is to use standard FORTRAN-77 notation for describing the data format. For example, "F7.2" means to display seven digits with two digits to the right of the decimal point.

- **Coordinate systems** contain information that should be used when interpreting or displaying the data. For example, the text strings "cartesian", "polar" and "spherical" are recommended coordinate system descriptions.

- **Ranges** define the maximum and minimum values of a selected valid range. The range may cover the entire data set, values outside the data set, or a subset of values within a data set. Because the HDF library does not check or update the range attribute as data is added or removed from the file, the calling program may assign any values deemed appropriate as long as they are of the same data type as the SDS array.

- **Fill value** is the value used to fill the areas between non-contiguous writes to SDS arrays. For more information about fill values, refer to Section 3.10.5 on page 101.

- **Calibration** stores scale and offset values used to create calibrated data in SDS arrays. When data are calibrated, they are typically reduced from floats, double, or large integers into 8-bit or 16-bit integers and "packed" into an appropriately sized array. After the scale and offset values are applied, the packed array will return to its original form.

Predefined attributes are useful because they establish conventions that applications can depend on and because they are understood by the HDF library without users having to define them. Predefined attributes also ensure backward compatibility with earlier versions of the HDF library. They can be assigned only to data sets and dimensions. Table 3T lists the predefined attributes and the types of object each attribute can be assigned to.

<table>
<thead>
<tr>
<th>HDF Data Object Type</th>
<th>Attribute Category</th>
<th>Attribute Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDS Array or Dimension</td>
<td>Label</td>
<td>long_name</td>
<td>Name of the array</td>
</tr>
<tr>
<td></td>
<td>Unit</td>
<td>units</td>
<td>Units used for all dimensions and data</td>
</tr>
<tr>
<td></td>
<td>Format</td>
<td>format</td>
<td>Format for displaying dim scales and array values</td>
</tr>
</tbody>
</table>
While the following netCDF naming conventions are not predefined in HDF, they are highly recommended to promote consistency of information-sharing among generic applications. Refer to the netCDF User’s Guide for C for further information.

- **missing_value**: An attribute containing a value used to fill areas of an array not intended to contain either valid data or a fill value. The scope of this attribute is local to the array. An example of this would be a region where information is unavailable, as in a geographical grid containing ocean data. The part of the grid where there is land might not have any data associated with it and in such a case the missing_value value could be supplied. The missing_value attribute is different from the _FillValue attribute in that fill values are intended to indicate data that was expected but did not appear, whereas missing values are used to indicate data that were never expected.

- **title**: A global file attribute containing a description of the contents of a file.

- **history**: A global file attribute containing the name of a program and the arguments used to derive the file. Well-behaved generic filters (programs that take HDF or netCDF files as input and produce HDF or netCDF files as output) would be expected to automatically append their name and the parameters with which they were invoked to the history attribute of an input file.

### 3.10.1 Accessing Predefined Attributes

The SD interface provides two methods for accessing predefined attributes. The first method uses the general attribute routines for user-defined attributes described in Section 3.9 on page 85; the second employs routines specifically designed for each attribute and will be discussed in the following sections. Although the general attribute routines work well and are recommended in most cases, the specialized attribute routines are sometimes easier to use, especially when reading or writing related predefined attributes. This is true for two reasons. First, because predefined attributes are guaranteed unique names, the attribute index is unnecessary. Second, attributes with several components may be read as a group. For example, using the SD routine designed to read the predefined calibration attribute returns all five components with a single call, rather than five separate calls.

There is one exception: unlike predefined data set attributes, predefined dimension attributes should be read or written using the specialized attribute routines only.

The predefined attribute parameters are described in Table 3U. Creating a predefined attribute with parameters different from these will produce unpredictable results when the attribute is read using the corresponding predefined-attribute routine.
TABLE 3U

Predefined Attribute Definitions

<table>
<thead>
<tr>
<th>Category</th>
<th>Attribute Name</th>
<th>Data Type</th>
<th>Number of Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Label</td>
<td>long_name</td>
<td>DFNT_CHAR8</td>
<td>String length</td>
<td>String</td>
</tr>
<tr>
<td>Unit</td>
<td>units</td>
<td>DFNT_CHAR8</td>
<td>String length</td>
<td>String</td>
</tr>
<tr>
<td>Format</td>
<td>format</td>
<td>DFNT_CHAR8</td>
<td>String length</td>
<td>String</td>
</tr>
<tr>
<td>Coordinate System</td>
<td>coordsys</td>
<td>DFNT_CHAR8</td>
<td>String length</td>
<td>String</td>
</tr>
<tr>
<td>Range</td>
<td>valid_range</td>
<td>&lt;valid data type&gt;</td>
<td>2</td>
<td>Minimum and maximum values in 2-element array</td>
</tr>
<tr>
<td>Fill Value</td>
<td>_FillValue</td>
<td>&lt;valid data type&gt;</td>
<td>1</td>
<td>Fill value</td>
</tr>
<tr>
<td>Calibration</td>
<td>scale_factor</td>
<td>DFNT_FLOAT64</td>
<td>1</td>
<td>Scale</td>
</tr>
<tr>
<td></td>
<td>scale_factor_err</td>
<td>DFNT_FLOAT64</td>
<td>1</td>
<td>Scale error</td>
</tr>
<tr>
<td></td>
<td>add_offset</td>
<td>DFNT_FLOAT64</td>
<td>1</td>
<td>Offset</td>
</tr>
<tr>
<td></td>
<td>add_offset_err</td>
<td>DFNT_FLOAT64</td>
<td>1</td>
<td>Offset error</td>
</tr>
<tr>
<td></td>
<td>calibrated_nt</td>
<td>DFNT_INT32</td>
<td>1</td>
<td>Data type</td>
</tr>
</tbody>
</table>

In addition to SDreadattr, SDfindattr and SDattrinfo are also valid general attribute routines to use when reading a predefined attribute. SDattrinfo is always useful for determining the size of an attribute whose value contains a string.

3.10.2 SDS String Attributes

This section describes the predefined string attributes of the SDSs and the next section describes those of the dimensions. Predefined string attributes of an SDS include the *label*, *unit*, *format*, and *coordinate system*.

3.10.2.1 Writing String Attributes of an SDS: SDsetdatastrs

SDsetdatastrs assigns the predefined string attributes label, unit, format, and coordinate system to an SDS array. The syntax of this routine is as follows:

C:  
    status = SDsetdatastrs(sds_id, label, unit, format, coord_system);

FORTRAN:  
    status = sfsdtstr(sds_id, label, unit, format, coord_system)

If you do not wish to set an attribute, set the corresponding parameter to NULL in C and an empty string in FORTRAN-77. SDsetdatastrs returns a value of SUCCEED (or 0) or FAIL (or -1). Its arguments are further described in Table 3V on page 99.

3.10.2.2 Reading String Attributes of an SDS: SDgetdatastrs

SDgetdatastrs reads the predefined string attributes label, unit, format, and coordinate system from an SDS. These string attributes have previously been set by the routine SDsetdatastrs. The syntax of SDgetdatastrs is as follows:

C:  
    status = SDgetdatastrs(sds_id, label, unit, format, coord_system, len);

FORTRAN:  
    status = sfgdtstr(sds_id, label, unit, format, coord_system, len)

SDgetdatastrs stores the predefined attributes into the parameters label, unit, format, and coord_system, which are character string buffers. If a particular attribute has not been set by SDsetdatastrs, the first character of the corresponding returned string will be NULL for C and 0 for FORTRAN-77. Each string buffer is assumed to be at least len characters long, including the
space to hold the NULL termination character. If you do not wish to get a predefined attribute of this SDS, set the corresponding parameter to NULL in C and an empty string in FORTRAN-77.

**SDgetdatastrs** returns a value of SUCCCEED (or 0) or FAIL (or -1). Its parameters are further described in Table 3V.

### Table 3V
**SDsetdatastrs and SDgetdatastrs Parameter Lists**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SDsetdatastrs</strong></td>
<td>sds_id int32</td>
<td>Data set identifier</td>
</tr>
<tr>
<td>[C]</td>
<td>label char *</td>
<td>Label for the data</td>
</tr>
<tr>
<td>[FORTRAN-77]</td>
<td>unit char *</td>
<td>Definition of the units</td>
</tr>
<tr>
<td></td>
<td>format char *</td>
<td>Description of the data format</td>
</tr>
<tr>
<td></td>
<td>coord_syst</td>
<td>Description of the coordinate sys</td>
</tr>
<tr>
<td></td>
<td>em char *</td>
<td>tem</td>
</tr>
<tr>
<td></td>
<td>len intn</td>
<td>Minimum length of the string bu</td>
</tr>
</tbody>
</table>

### 3.10.3 String Attributes of Dimensions

Predefined string attributes of a dimension include **label**, **unit**, and **format**. They adhere to the same definitions as those of the label, unit, and format strings for SDS attributes.

#### 3.10.3.1 Writing a String Attribute of a Dimension: **SDsetdimstrs**

**SDsetdimstrs** assigns the predefined string attributes label, unit, and format to an SDS dimension and its scales. The syntax of this routine is as follows:

**C:**

```c
status = SDsetdimstrs(dim_id, label, unit, format);
```

**FORTRAN:**

```fortran
status = sfsdmstr(dim_id, label, unit, format)
```

The argument **dim_id** is the dimension identifier, returned by **SDgetdimid**, and identifies the dimension to which the attributes will be assigned. If you do not wish to set an attribute, set the corresponding parameter to NULL in C and an empty string in FORTRAN-77.

**SDsetdimstrs** returns a value of SUCCCEED (or 0) or FAIL (or -1). Its parameters are further described in Table 3W.

#### 3.10.3.2 Reading a String Attribute of a Dimension: **SDgetdimstrs**

**SDgetdimstrs** reads the predefined string attributes label, unit, and format from an SDS dimension. These string attributes have previously been set by the routine **SDsetdimstrs**. The syntax of **SDgetdimstrs** is as follows:

**C:**

```c
status = SDgetdimstrs(dim_id, label, unit, format, len);
```

**FORTRAN:**

```fortran
status = sfgdmstr(dim_id, label, unit, format, len)
```
**SDgetdimstrs** stores the predefined attributes of the dimension into the arguments `label`, `unit`, and `format`, which are character string buffers. If a particular attribute has not been set by **SDsetdimstrs**, the first character of the corresponding returned string will be `NULL` for C and 0 for FORTRAN-77. Each string buffer is assumed to be at least `len` characters long, including the space to hold the `NULL` termination character. If you do not wish to get a predefined attribute of this dimension, set the corresponding parameter to `NULL` in C and an empty string in FORTRAN-77.

**SDgetdimstrs** returns a value of **SUCCEED** (or 0) or **FAIL** (or -1). Its parameters are further described in Table 3W.

### TABLE 3W

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SDsetdimstrs</strong></td>
<td>dim_id</td>
<td>int32 integer</td>
<td>Dimension identifier</td>
</tr>
<tr>
<td>(sfdcstr)</td>
<td>label</td>
<td>char * character*(*</td>
<td>Label describing the specified dimension</td>
</tr>
<tr>
<td></td>
<td>unit</td>
<td>char * character*(*</td>
<td>Units to be used with the specified dimension</td>
</tr>
<tr>
<td></td>
<td>format</td>
<td>char * character*(*</td>
<td>Format to use when displaying the scale values</td>
</tr>
<tr>
<td></td>
<td>len</td>
<td>intn integer</td>
<td>Maximum length of the string attributes</td>
</tr>
</tbody>
</table>

#### 3.10.4 Range Attributes

The attribute **range** contains user-defined maximum and minimum values in a selected range. Since the HDF library does not check or update the range attribute as data is added or removed from the file, the calling program may assign any values deemed appropriate. Also, because the maximum and minimum values are supposed to relate to the data set, it is assumed that they are of the same data type as the data.

#### 3.10.4.1 Writing a Range Attribute: **SDsetrange**

**SDsetrange** sets the maximum and minimum range values for the data set identified by `sds_id` to the values provided by the parameters `max` and `min`. The syntax of the routine is as follows:

**C:**

```c
status = SDsetrange(sds_id, max, min);
```

**FORTRAN:**

```fortran
status = sfsrange(sds_id, max, min)
```

**SDsetrange** does not compute the maximum and minimum range values, it only stores the values as given. As a result, the maximum and minimum range values may not always reflect the actual maximum and minimum range values in the data set data. Recall that the type of `max` and `min` is assumed to be the same as that of the data set data.

**SDsetrange** returns a value of **SUCCEED** (or 0) or **FAIL** (or -1). Its parameters are further described in Table 3X.
3.10.4.2 Reading a Range Attribute: SDgetrange

SDgetrange reads the maximum and minimum valid values of a data set. The syntax of this routine is as follows:

C: status = SDgetrange(sds_id, &max, &min);

FORTRAN: status = sfgrange(sds_id, max, min)

The maximum and minimum range values are stored in the parameters max and min, respectively, and must have previously been set by SDsetrange. Recall that the type of max and min is assumed to be the same as that of the data set data.

SDgetrange returns a value of SUCCEED (or 0) or FAIL (or -1). Its parameters are further described in Table 3X.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDsetrange</td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>max</td>
<td>VOIDP</td>
<td>Maximum value to be stored</td>
</tr>
<tr>
<td></td>
<td>min</td>
<td>VOIDP</td>
<td>Minimum value to be stored</td>
</tr>
<tr>
<td>SDgetrange</td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>max</td>
<td>VOIDP</td>
<td>Buffer for the maximum value</td>
</tr>
<tr>
<td></td>
<td>min</td>
<td>VOIDP</td>
<td>Buffer for the minimum value</td>
</tr>
</tbody>
</table>

3.10.5 Fill Values and Fill Mode

A fill value is the value used to fill the spaces between non-contiguous writes to SDS arrays; it can be set with SDsetfillvalue. If a fill value is set before writing data to an SDS, the entire array is initialized to the specified fill value. By default, any location not subsequently overwritten with SDS data will contain the fill value.

A fill value must be of the same data type as the array to which it is written. To avoid conversion errors, use data-specific fill values instead of special architecture-specific values, such as infinity and Not-a-Number or NaN.

A fill mode specifies whether the fill value is to be written to all the SDSs in the file; it can be set with SDsetfillmode.

Writing fill values to an SDS can involve more I/O overhead than is necessary, particularly in situations where the data set is to be contiguously filled with data before any read operation is made. In other words, writing fill values is only necessary when there is a possibility that the data set will be read before all gaps between writes are filled with data, i.e., before all elements in the array have been assigned values. Thus, for a file that has only data sets containing contiguous data, the fill mode should be set to SD_NOPFILL (or 256). Avoiding unnecessary filling can substantially increase the application performance.

For a non-contiguous data set, the array elements that have no actual data values must be filled with a fill value before the data set is read. Thus, for a file that has a non-contiguous data set, the fill mode should be set to SD.FILL (or 0) and a fill value will be written to all the data sets in the file.

Note that, currently, SDsetfillmode specifies the fill mode of all data sets in the file. Thus, either all data sets are in SD_FILL mode or all data sets are in SD_NOPFILL mode. However, when a spe-
specific SDS needs to be written with a fill value while others in the file do not, the following procedure can be used: set the fill mode to `SD_FILL`, write data to the data set requiring fill values, then set the fill mode back to `SD_NOFILL`. This procedure will produce one data set with fill values while the remaining data sets have no fill values.

### 3.10.5.1 Writing a Fill Value Attribute: SDsetfillvalue

SDsetfillvalue assigns a new value to the fill value attribute for an SDS array. The syntax of this routine is as follows:

**C:**

```
status = SDsetfillvalue(sds_id, fill_val);
```

**FORTRAN:**

```
status = sfsfill(sds_id, fill_val)
```

**OR**

```
status = sfscfill(sds_id, fill_val)
```

The argument `fill_val` is the new fill value. It is recommended that you set the fill value before writing data to an SDS array, as calling SDsetfillvalue after data is written to an SDS array only changes the fill value attribute — it does not update the existing fill values.

There are two FORTRAN-77 versions of this routine: `sfsfill` and `sfscfill`. `sfsfill` writes numeric fill value data and `sfscfill` writes character fill value data.

SDsetfillvalue returns a value of SUCCEED (or 0) or FAIL (or -1). Its parameters are further described in Table 3Y on page 103.

### 3.10.5.2 Reading a Fill Value Attribute: SDgetfillvalue

SDgetfillvalue reads in the fill value of an SDS array as specified by a SDsetfillvalue call or its equivalent. The syntax of this routine is as follows:

**C:**

```
status = SDgetfillvalue(sds_id, &fill_val);
```

**FORTRAN:**

```
status = sfgfill(sds_id, fill_val)
```

**OR**

```
status = sfgcfill(sds_id, fill_val)
```

The fill value is stored in the argument `fill_val` which is previously allocated based on the data type of the SDS data.

There are two FORTRAN-77 versions of this routine: `sfgfill` and `sfgcfill`. The `sfgfill` routine reads numeric fill value data and `sfgcfill` reads character fill value data.

SDgetfillvalue returns a value of SUCCEED (or 0) if a fill value is retrieved successfully, or FAIL (or -1) otherwise, including when the fill value has not been set. The parameters of SDgetfillvalue are further described in Table 3Y.

### 3.10.5.3 Setting the Fill Mode for all SDSs in the Specified File: SDsetfillmode

SDsetfillmode sets the fill mode for all data sets contained in the file identified by the parameter `sd_id`. The syntax of SDsetfillmode is as follows:

**C:**

```
old_fmode = SDsetfillmode(sd_id, fill_mode);
```

**FORTRAN:**

```
old_fmode = sfsflmd(sd_id, fill_mode)
```

The argument `fill_mode` is the fill mode to be applied and can be set to either `SD_FILL` (or 0) or `SD_NOFILL` (or 256). `SD_FILL` specifies that fill values will be written to all SDSs in the specified file by default. If SDsetfillmode is never called before SDsetfillvalue, `SD_FILL` is the default fill mode. `SD_NOFILL` specifies that, by default, fill values will not be written to all SDSs in the speci-
fied file. This can be overridden for a specific SDS by calling **SDsetfillmode** then writing data to this data set before closing the file.

Note that whenever a file has been newly opened, or has been closed and then re-opened, the default **SD_FILL** fill mode will be in effect until it is changed by a call to **SDsetfillmode**.

**SDsetfillmode** returns the fill mode value before it is reset or a value of **FAIL** (or -1). The parameters of this routine are further described in Table 3Y.

### TABLE 3Y

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>[Return Type]</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SDsetfillvalue</strong></td>
<td>[intn] (sdfsfill/ sfsfill)</td>
<td>sds_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fill_val</td>
<td>VOIDP &lt;valid numeric data type&gt;/ character*(*)</td>
<td>Fill value to be set</td>
</tr>
<tr>
<td><strong>SDgetfillvalue</strong></td>
<td>[intn] (sfgsfill/ sfgcfill)</td>
<td>sds_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fill_val</td>
<td>VOIDP &lt;valid numeric data type&gt;/ character*(*)</td>
<td>Buffer for the fill value</td>
</tr>
<tr>
<td><strong>SDsetfillmode</strong></td>
<td>[intn] (sdfsfill)</td>
<td>sd_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fill_mode</td>
<td>intn</td>
<td>integer</td>
</tr>
</tbody>
</table>

### 3.10.6 Calibration Attributes

The *calibration attributes* are designed to store calibration information associated with data set data. When data is calibrated, the values in an array can be represented using a smaller data type than the original. For instance, an array containing data of type `float` could be stored as an array containing data of type 8- or 16-bit integer. Note that neither function performs any operation on the data set.

#### 3.10.6.1 Setting Calibration Information: **SDsetcal**

**SDsetcal** stores the scale factor, offset, scale factor error, offset error, and the data type of the uncalibrated data set for the specified data set. The syntax of this routine is as follows:

**C:**

```c
status = SDsetcal(sds_id, cal, cal_error, offset, off_err, data_type);
```

**FORTRAN:**

```fortran
status = sfscal(sds_id, cal, cal_error, offset, off_err, data_type)
```

**SDsetcal** has six arguments; `sds_id`, `cal`, `cal_error`, `offset`, `off_err`, and `data_type`. The argument `cal` represents a single value that when multiplied against every value in the calibrated data array reproduces the original data array (assuming an `offset` of 0). The argument `offset` represents a single value that when subtracted from every value in the calibrated array reproduces the original data (assuming a `cal` of 1). The values of the calibrated data array relate to the values of the original data array according to the following equation:

\[ \text{orig_value} = \text{cal} \times (\text{cal_value} - \text{offset}) \]

In addition to `cal` and `offset`, **SDsetcal** also includes the scale and offset errors. The argument `cal_error` contains the potential error of the calibrated data due to scaling; `offset_error` contains the potential error for the calibrated data due to the offset.

**SDsetcal** returns a value of **SUCCEED** (or 0) or **FAIL** (or -1). Its parameters are further described in Table 3Z.
3.10.6.2 Reading Calibrated Data: SDgetcal

SDgetcal reads calibration attributes for an SDS array as previously written by SDsetcal. The syntax of this routine is as follows:

**C:**
```c
status = SDgetcal(sds_id, &cal, &cal_error, &offset, &offset_err, &data_type);
```

**FORTRAN:**
```fortran
status = sfgcal(sds_id, cal, cal_error, offset, offset_err, data_type)
```

Because the HDF library does not actually apply calibration information to the data, SDgetcal can be called anytime before or after the data is read. If a calibration record does not exist, SDgetcal returns FAIL. SDgetcal takes six arguments: sds_id, cal, cal_error, offset, offset_error, and data_type. Refer to Section 3.10.6.1 for the description of these arguments.

SDgetcal returns a value of SUCCEED (or 0) or FAIL (or -1). The parameters of SDgetcal are described in Table 3Z.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDsetcal</td>
<td>sds_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>cal</td>
<td>float64</td>
<td>real*8</td>
</tr>
<tr>
<td></td>
<td>cal_error</td>
<td>float64</td>
<td>real*8</td>
</tr>
<tr>
<td></td>
<td>offset</td>
<td>float64</td>
<td>real*8</td>
</tr>
<tr>
<td></td>
<td>offset_err</td>
<td>float64</td>
<td>real*8</td>
</tr>
<tr>
<td></td>
<td>data_type</td>
<td>int32</td>
<td>integer</td>
</tr>
</tbody>
</table>

| SDgetcal     | sds_id    | int32          | integer     | Data set identifier |
|              | cal       | float64 *      | real*8      | Calibration factor  |
|              | cal_error | float64 *      | real*8      | Calibration error   |
|              | offset    | float64 *      | real*8      | Uncalibrated offset |
|              | offset_err| float64 *      | real*8      | Uncalibrated offset error |
|              | data_type | int32 *        | integer     | Data type of uncalibrated data |

**EXAMPLE 16.**

Calibrating Data.

Suppose the values in the calibrated array cal_val are the following integers:

```
cal_val[6] = {2, 4, 5, 11, 26, 81}
```

By applying the calibration equation orig = cal * (cal_val - offset) with cal = 0.50 and offset = -2000.0, the calibrated array cal_val[] returns to its original floating-point form:

```
original_val[6] = {1001.0, 1002.0, 1002.5, 1005.5, 1013.0, 1040.5}
```
3.11 Chunked (or Tiled) Scientific Data Sets

NOTE: It is strongly encouraged that HDF users who wish to use the SD chunking routines first read the section on SD chunking in Chapter 14, *HDF Performance Issues*. In that section the concepts of chunking are explained, as well as their use in relation to HDF. As the ability to work with chunked data has been added to HDF functionality for the purpose of addressing specific performance-related issues, you should first have the necessary background knowledge to correctly determine how chunking will positively or adversely affect your application.

This section will refer to both "tiled" and "chunked" SDSs as simply *chunked SDSs*, as tiled SDSs are the two-dimensional case of chunked SDSs.

3.11.1 Making an SDS a Chunked SDS: SDsetchunk

In HDF, an SDS must first be created as a generic SDS through the SDcreate routine, then SDsetchunk is called to make that generic SDS a chunked SDS. Note that there are two restrictions that apply to chunked SDSs. The maximum number of chunks in a single HDF file is 65,535 and a chunked SDS cannot contain an unlimited dimension. SDsetchunk sets the chunk size and the compression method for a data set. The syntax of SDsetchunk is as follows:

C:  
status = SDsetchunk(sds_id, c_def, flag);

FORTRAN:  
status = sfchunk(sds_id, dim_length, comp_type, comp_prm)

The chunking information is provided in the parameters c_def and flag in C, and the parameters comp_type and comp_prm in FORTRAN-77.

In C:

The parameter c_def has type HDF_CHUNK_DEF which is defined as follows:

```c
typedef union hdf_chunk_def_u {
    int32 chunk_lengths[MAX_VAR_DIMS];
    struct {
        int32 chunk_lengths[MAX_VAR_DIMS];
        int32 comp_type;
        comp_info cinfo;
    } comp;
    struct {
        int32 chunk_lengths[MAX_VAR_DIMS];
        intn start_bit;
        intn bit_len;
        intn sign_ext;
        intn fill_one;
    } nbit;
} HDF_CHUNK_DEF
```

Refer to the reference manual page for SDsetcompress for the definition of the structure comp_info.

The parameter flag specifies the type of the data set, i.e., if the data set is chunked or chunked and compressed with either RLE, Skipping Huffman, GZIP, or NBIT compression methods. Valid values of flag are HDF_CHUNK for a chunked data set, (HDF_CHUNK | HDF_COMP) for a chunked data set compressed with RLE, Skipping Huffman, and GZIP compression methods, and (HDF_CHUNK | HDF_NBIT) for a chunked NBIT-compressed data set.
There are three pieces of chunking and compression information which should be specified: chunking dimensions, compression type, and, if needed, compression parameters.

If the data set is chunked, i.e., flag value is HDF_CHUNK, then the elements of the array chunk_lengths in the union c_def (c_def.chunk_lengths[]) have to be initialized to the chunk dimension sizes.

If the data set is chunked and compressed using RLE, Skipping Huffman, or GZIP methods (i.e., flag value is set up to (HDF_CHUNK | HDF_COMP)), then the elements of the array chunk_lengths of the structure comp in the union c_def (c_def.comp.chunk_lengths[]) have to be initialized to the chunk dimension sizes.

If the data set is chunked and NBIT compression is applied (i.e., flag values is set up to (HDF_CHUNK | HDF_NBIT)), then the elements of the array chunk_lengths of the structure nbit in the union c_def (c_def.nbit.chunk_lengths[]) have to be initialized to the chunk dimension sizes.

The values of HDF_CHUNK, HDF_COMP, and HDF_NBIT are defined in the header file hproto.h.

Compression types are passed in the field comp_type of the structure cinfo, which is an element of the structure comp in the union c_def (c_def.comp.cinfo.comp_type). Valid compression types are: COMP_CODE_RLE for RLE, COMP_CODE_SKPHUFF for Skipping Huffman, COMP_CODE_DEFLATE for GZIP compression.

For Skipping Huffman and GZIP compression, parameters are passed in corresponding fields of the structure cinfo. Specify skipping size for Skipping Huffman compression in the field c_def.comp.cinfo.skphuff.skp_size; this value cannot be less than 1. Specify deflate level for GZIP compression in the field c_def.comp.cinfo.deflate_level. Valid values of deflate levels are integers from 0 to 9 inclusive.

NBIT compression parameters are specified in the fields start_bit, bit_len, sign_ext, and fill_one in the structure nbit of the union c_def.

In FORTRAN-77:

The dim_length array specifies the chunk dimensions.

The comp_type parameter specifies the compression type. Valid compression types and their values are defined in the hdf.inc file, and are listed below:

- COMP_CODE_NONE (or 0) for uncompressed data
- COMP_CODE_RLE (or 1) for data compressed using the RLE compression algorithm
- COMP_CODE_NBIT (or 2) for data compressed using the NBIT compression algorithm
- COMP_CODE_SKPHUFF (or 3) for data compressed using the Skipping Huffman compression algorithm
- COMP_CODE_DEFLATE (or 4) for data compressed using the GZIP compression algorithm

The parameter comp_prm(1) specifies the skipping size for the Skipping Huffman compression method and the deflate level for the GZIP compression method.

For NBIT compression, the four elements of the array comp_prm correspond to the four NBIT compression parameters listed in the structure nbit. The array comp_prm should be initialized as follows:

\[
\begin{align*}
\text{comp_prm}(1) &= \text{value of start_bit} \\
\text{comp_prm}(2) &= \text{value of bit_len} \\
\text{comp_prm}(3) &= \text{value of sign_ext} \\
\text{comp_prm}(4) &= \text{value of fill_one}
\end{align*}
\]
Refer to the description of the union `HDF_CHUNK_DEF` and of the routine `SDsetbitdataset` for NBIT compression parameter definitions.

`SDsetchunk` returns either a value of `SUCCEED` (or 0) or `FAIL` (or -1). Refer to Table 3AA and Table 3AB for the descriptions of the parameters of both versions.

### 3.11.2 Setting the Maximum Number of Chunks in the Cache: `SDsetchunkcache`

To maximize the performance of the HDF library routines when working with chunked SDSs, the library maintains a separate area of memory specifically for cached data chunks. `SDsetchunkcache` sets the maximum number of chunks of the specified SDS that are cached into this segment of memory. The syntax of `SDsetchunkcache` is as follows:

- **C:**
  ```c
  status = SDsetchunkcache(sds_id, maxcache, flag);
  ```

- **FORTRAN:**
  ```fortran
  status = sfscchnk(sds_id, maxcache, flag)
  ```

When the chunk cache has been filled, any additional chunks written to cache memory are cached according to the Least-Recently-Used (LRU) algorithm. This means that the chunk that has resided in the cache the longest without being reread or rewritten will be written over with the new chunk.

By default, when a generic SDS is made a chunked SDS, the parameter `maxcache` is set to the number of chunks along the fastest changing dimension. If needed, `SDsetchunkcache` can then be called again to reset the size of the chunk cache.

Essentially, the value of `maxcache` cannot be set to a value less than the number of chunks currently cached. If the chunk cache is not full, then the size of the chunk cache is reset to the new value of `maxcache` only if it is greater than the current number of chunks cached. If the chunk cache has been completely filled with cached data, `SDsetchunkcache` has already been called, and the value of the parameter `maxcache` in the current call to `SDsetchunkcache` is larger than the value of `maxcache` in the last call to `SDsetchunkcache`, then the value of `maxcache` is reset to the new value.
Currently the only allowed value of the parameter flag is 0, which designates default operation. In the near future, the value HDF_CACHEALL will be provided to specify that the entire SDS array is to be cached.

SDsetchunkcache returns the maximum number of chunks that can be cached (the value of the parameter maxcache) if successful and FAIL (or -1) otherwise. The parameters of SDsetchunkcache are further described in Table 3AC.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDsetchunkcache</td>
<td>sds_id</td>
<td>int32, integer</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>maxcache</td>
<td>int32, integer</td>
<td>Maximum number of chunks to cache</td>
</tr>
<tr>
<td></td>
<td>flag</td>
<td>int32, integer</td>
<td>Flag determining the default caching behavior</td>
</tr>
</tbody>
</table>

### 3.11.3 Writing Data to Chunked SDSs: SDwritechunk and SDwritedata

Both SDwritedata and SDwritechunk can be used to write to a chunked SDS. Later in this chapter, situations where SDwritechunk may be a more appropriate routine than SDwritedata will be discussed, but, for the most part, both routines achieve the same results. SDwritedata is discussed in Section 3.5.1 on page 30. The syntax of SDwritechunk is as follows:

**C:**

```c
status = SDwritechunk(sds_id, origin, datap);
```

**FORTRAN:**

```fortran
status = sfwchnk(sds_id, origin, datap)
```

**OR**

```fortran
status = sfwcchnk(sds_id, origin, datap)
```

The location of data in a chunked SDS can be specified in two ways. The first is the standard method used in the routine SDwritedata that access both chunked and non-chunked SDSs; this method refers to the starting location as an offset in elements from the origin of the SDS array itself. The second method is used by the routine SDwritechunk that only access chunked SDSs; this method refers to the origin of the chunk as an offset in chunks from the origin of the chunk array itself. The parameter origin specifies this offset; it also may be considered as chunk’s coordinates in the chunk array. Figure 3d on page 109 illustrates this method of chunk indexing in a 4-by-4 element SDS array with 2-by-2 element chunks.
SDwritechunk is used when an entire chunk is to be written and requires the chunk offset to be known. SDwritedata is used when the write operation is to be done regardless of the chunking scheme used in the SDS. Also, as SDwritechunk is written specifically for chunked SDSs and does not have the overhead of the additional functionality supported by the SDwritedata routine, it is much faster than SDwritedata. Note that attempting to use SDwritechunk for writing to a non-chunked data set will return a FAIL (or -1).

The parameter datap must point to an array containing the entire chunk of data. In other words, the size of the array must be the same as the chunk size of the SDS to be written to, or an error condition will result.

There are two FORTRAN-77 versions of this routine: sfwchnk writes numeric data and sfwcchnk writes character data.

SDwritechunk returns either a value of SUCCEED (or 0) or FAIL (or -1). The parameters of SDwritechunk are in Table 3AD. The parameters of SDwritedata are listed in Table 3D on page 32.

### SDwritechunk Parameter List

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDwritechunk [int] (sfwchnk/sfwcchnk)</td>
<td>sds_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>origin</td>
<td>int32 *</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>datap</td>
<td>VOIDP</td>
<td>Buffer containing the data to be written</td>
</tr>
</tbody>
</table>

TABLE 3AD

**FIGURE 3d**

Chunk Indexing as an Offset in Chunks

![Image of Chunk Indexing](image.png)

This chunk is in location (0, 0)

Y Dimension

X Dimension

This chunk is in location (0, 0)
3.11.4 Reading Data from Chunked SDSs: SDreadchunk and SDreaddata

As both SDwritedata and SDwritechunk can be used to write data to a chunked SDS, both SDreaddata and SDreadchunk can be used to read data from a chunked SDS. SDreaddata is discussed in Section 3.5.1 on page 30. The syntax of SDreadchunk is as follows:

**C:**
```c
status = SDreadchunk(sds_id, origin, datap);
```

**FORTRAN:**
```fortran
status = sfrcchnk(sds_id, origin, datap)
```

SDreaddata is used when an entire chunk of data is to be read. SDreaddata is used when the read operation is to be done regardless of the chunking scheme used in the SDS. Also, SDreadchunk is written specifically for chunked SDSs and does not have the overhead of the additional functionality supported by the SDreaddata routine. Therefore, it is much faster than SDreaddata. Note that SDreadchunk will return FAIL (or -1) when an attempt is made to read from a non-chunked data set.

As with SDwritechunk, the parameter origin specifies the coordinates of the chunk to be read, and the parameter datap must point to an array containing enough space for an entire chunk of data. In other words, the size of the array must be the same as or greater than the chunk size of the SDS to be read, or an error condition will result.

There are two FORTRAN-77 versions of this routine: sfrcnk reads numeric data and sfrcchk reads character data.

SDreadchunk returns either a value of SUCCEED (or 0) or FAIL (or -1). The parameters of SDreadchunk are further described in Table 3AE. The parameters of SDreaddata are listed in Table 3K on page 56.

### Table 3AE

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDreadchunk</td>
<td>sds_id</td>
<td>int32 * integer</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>origin</td>
<td>int32 * integer(*)</td>
<td>Coordinates of the origin of the chunk to be read</td>
</tr>
<tr>
<td></td>
<td>datap</td>
<td>VOIDP &lt;valid numeric data type&gt;(<em>)/character(</em>)</td>
<td>Buffer for the returned chunk data</td>
</tr>
</tbody>
</table>

3.11.5 Obtaining Information about a Chunked SDS: SDgetchunkinfo

SDgetchunkinfo is used to determine whether an SDS is chunked and how the chunk is defined. The syntax of this routine is as follows:

**C:**
```c
status = SDgetchunkinfo(sds_id, c_def, flag);
```

**FORTRAN:**
```fortran
status = sfgichnk(sds_id, dim_length, flag)
```

Currently, only information about chunk dimensions is retrieved into the corresponding structure element `c_def` for each type of compression in C, and into the array `dim_length` in Fortran. No information on compression parameters is available in the structure `comp` of the union `HDF_CHUNK_DEF`. For specific information on `c_def`, refer to Section 3.11.1 on page 105.
The value returned in the parameter flag indicates the data set type (i.e., whether the data set is not chunked, chunked, or chunked and compressed).

If the data set is not chunked, the value of flag will be HDF_NONE (or -1). If the data set is chunked, the value of flag will be HDF_CHUNK (or 0). If the data set is chunked and compressed with either RLE, Skipping Huffman, or GZIP compression algorithm, then the value of flag will be HDF_CHUNK | HDF_COMP (or 1). If the data set is chunked and compressed with NBIT compression, then the value of flag will be HDF_CHUNK | HDF_NBIT (or 2).

If the chunk length for each dimension is not needed, NULL can be passed in as the value of the parameter c_def in C.

SDgetchunkinfo returns either a value of SUCCEED (or 0) or FAIL (or -1). Refer to Table 3AF and Table 3AG for the description of the parameters of both versions.

### Table 3AF
**SDgetchunkinfo Parameter List**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDgetchunkinfo</td>
<td>sds_id</td>
<td>int32</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>c_def</td>
<td>HDF_CHUNK_DEF *</td>
<td>Union structure containing information about the chunks in the SDS</td>
</tr>
<tr>
<td></td>
<td>flag</td>
<td>int32 *</td>
<td>Flag determining the behavior of the routine</td>
</tr>
</tbody>
</table>

### Table 3AG
**sgichickn Parameter List**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sglichk</td>
<td>sds_id</td>
<td>integer</td>
<td>Data set identifier</td>
</tr>
<tr>
<td></td>
<td>dim_length</td>
<td>integer(*)</td>
<td>Sizes of the chunk dimensions</td>
</tr>
<tr>
<td></td>
<td>comp_type</td>
<td>integer</td>
<td>Compression type</td>
</tr>
</tbody>
</table>

### Writing and Reading a Chunked SDS.

This example demonstrates the use of the routines SDsetchunk/sfschnk, SDwritedata/sfwdata, SDWritechunk/sfwchunk, SDgetchunkinfo/sglichk, SDreaddata/sfreada, and SDreadchunk/sfrchnk to create a chunked data set, write data to it, get information about the data set, and read the data back. Note that the Fortran example uses transpose data to reflect the difference between C and Fortran internal storage.

C:

```c
#include "mfhdf.h"

#define FILE_NAME  "SDSchunked.hdf"
#define SDS_NAME   "ChunkedData"
#define RANK       2

main()
{
    /*************************************************************** Variable declaration *******************************************/
    int32  sd_id, sds_id, sds_index;
    intn   status;
    int32  flag, maxcache, new_maxcache;
    int32  dim_sizes[2], origin[2];
```
HDF_CHUNK_DEF c_def, c_def_out; /* Chunking definitions */
int32 comp_flag, c_flags;
int16 all_data[9][4];
int32 start[2], edges[2];
int16 chunk_out[3][2];
int16 row[2] = { 5, 5 };
int16 column[3] = { 4, 4, 4 };
int16 fill_value = 0; /* Fill value */
int i,j;
/
* Declare chunks data type and initialize some of them. */
*/
int16 chunk1[3][2] = { 1, 1,
1, 1,
1, 1 };

int16 chunk2[3][2] = { 2, 2,
2, 2,
2, 2 };

int16 chunk3[3][2] = { 3, 3,
3, 3,
3, 3 };

int16 chunk6[3][2] = { 6, 6,
6, 6,
6, 6 };

/******************************************************************************
* End of variable declaration ***********************************************/
/*
* Define chunk’s dimensions.
* In this example we do not use compression.
* To use chunking with BZIP, Skipping Huffman, and GZIP
* compression, initialize
*
* c_def.comp.chunk_lengths[0] = 3;
* c_def.comp.chunk_lengths[1] = 2;
*
* To use chunking with NBIT, initialize
*
* c_def.nbit.chunk_lengths[0] = 3;
* c_def.nbit.chunk_lengths[1] = 2;
*
.isNullOrEmpty
*/
c_def.chunk_lengths[0] = 3;
c_def.chunk_lengths[1] = 2;

/*
* Create the file and initialize SD interface.
*/
sd_id = SDstart (FILE_NAME, DFACC_CREATE);

/*
* Create 9x4 SDS.
*/
dim_sizes[0] = 9;
dim_sizes[1] = 4;
sds_id = SDcreate (sd_id, SDS_NAME, DFNT_INT16, RANK, dim_sizes);

/*
* Fill the SDS array with the fill value.
*/
status = SDsetfillvalue (sds_id, (VOIDP)&fill_value);
/*
 * Create chunked SDS.
 * In this example we do not use compression ( third
 * parameter of SDsetchunk is set to HDF_CHUNK).
 * To use RLE compression, set compression type and flag
 *   c_def.comp.comp_type = COMP_CODE_RLE;
 *   comp_flag = HDF_CHUNK | HDF_COMP;
 * To use Skipping Huffman compression, set compression type, flag
 * and skipping size skp_size
 *   c_def.comp.comp_type = COMP_CODE_SKPHUFF;
 *   c_def.comp.cinfo.skphuff.skp_size = value;
 *   comp_flag = HDF_CHUNK | HDF_COMP;
 * To use GZIP compression, set compression type, flag and
 * deflate level
 *   c_def.comp.comp_type = COMP_CODE_DEFLATE;
 *   c_def.comp.cinfo.deflate.level = value;
 *   comp_flag = HDF_CHUNK | HDF_COMP;
 * To use NBIT compression, set compression flag and
 * compression parameters
 *   comp_flag = HDF_CHUNK | HDF_NBIT;
 *   c_def.nbit.start_bit = value1;
 *   c_def.nbit.bit_len   = value2;
 *   c_def.nbit.sign_ext  = value3;
 *   c_def.nbit.fill_one  = value4;
*/
comp_flag = HDF_CHUNK;
status = SDsetchunk (sds_id, c_def, comp_flag);
/*
 * Set chunk cache to hold maximum of 3 chunks.
 */
maxcache = 3;
flag = 0;
new_maxcache = SDsetchunkcache (sds_id, maxcache, flag);
/*
 * Write chunks using SDwritechunk function.
 * Chunks can be written in any order.
 */

/* Write the chunk with the coordinates (0,0).
*/
origin[0] = 0;
origin[1] = 0;
status = SDwritechunk (sds_id, origin, (VOIDP) chunk1);
/*
 * Write the chunk with the coordinates (1,0).
*/
origin[0] = 1;
origin[1] = 0;
status = SDwritechunk (sds_id, origin, (VOIDP) chunk3);
origin[0] = 0;
origin[1] = 1;
status = SDwritechunk (sds_id, origin, (VOIDP) chunk2);

start[0] = 6;
start[1] = 2;
edges[0] = 3;
edges[1] = 2;
status = SDwritedata (sds_id, start, NULL, edges, (VOIDP) chunk6);

start[0] = 3;
start[1] = 3;
edges[0] = 3;
edges[1] = 1;
status = SDwritedata (sds_id, start, NULL, edges, (VOIDP) column);

start[0] = 7;
start[1] = 0;
edges[0] = 1;
edges[1] = 2;
status = SDwritedata (sds_id, start, NULL, edges, (VOIDP) row);

status = SDendaccess (sds_id);

status = SDend (sd_id);

sd_id = SDstart (FILE_NAME, DFACC_READ);
sds_index = 0;
sds_id = SDselect (sd_id, sds_index);

status = SDgetchunkinfo (sds_id, &c_def_out, &c_flags);
if (c_flags == HDF_CHUNK )
    printf(" SDS is chunked\nChunk’s dimensions %dx%d\n",...
c_def_out.chunk_lengths[0],
c_def_out.chunk_lengths[1];
else if (c_flags == (HDF_CHUNK | HDF_COMP))
    printf("SDS is chunked and compressed
    Chunk's dimensions %dx%d
",  
c_def_out.comp.chunk_lengths[0],
c_def_out.comp.chunk_lengths[1]);
else if (c_flags == (HDF_CHUNK | HDF_NBIT))
    printf("SDS is chunked (NBIT)
    Chunk's dimensions %dx%d
", 
c_def_out.nbit.chunk_lengths[0],
c_def_out.nbit.chunk_lengths[1]);

/*
 * Read the entire data set using SDreaddata function.
 */
start[0] = 0;
start[1] = 0;
edges[0] = 9;
edges[1] = 4;
status = SDreaddata (sds_id, start, NULL, edges, (VOIDP)all_data);

/*
 * Print out what we have read.
 * The following information should be displayed:
 *
 * SDS is chunked
 * Chunk's dimensions 3x2
 *  1 1 2
 *  1 1 2 2
 *  1 1 2 2
 *  3 3 0 4
 *  3 3 0 4
 *  3 3 0 4
 *  0 0 6 6
 *  5 5 6 6
 *  0 0 6 6
 */
for (j=0; j<9; j++)
{
    for (i=0; i<4; i++) printf(" %d", all_data[j][i]);
    printf("\n");
}

/*
 * Read chunk with the coordinates (2,0) and display it.
 */
origin[0] = 2;
origin[1] = 0;
status = SDreadchunk (sds_id, origin, chunk_out);
printf(" Chunk (2,0) \n");
for (j=0; j<3; j++)
{
    for (i=0; i<2; i++) printf(" %d", chunk_out[j][i]);
    printf("\n");
}

/*
 * Read chunk with the coordinates (1,1) and display it.
 */
origin[0] = 1;
origin[1] = 1;
status = SDreadchunk (sds_id, origin, chunk_out);
printf(" Chunk (1,1) \n");
for (j=0; j<3; j++)
{ 
    for (i=0; i<2; i++) printf("%d", chunk_out[j][i]);
    printf("\n");
}

/* The following information is displayed: *
*  Chunk (2,0)
*  0 0
*  5 5
*  0 0
*  Chunk (1,1)
*  0 4
*  0 4
*  0 4
*/

/*
* Terminate access to the data set.
*/
status = SDendaccess (sds_id);

/*
* Terminate access to the SD interface and close the file.
*/
status = SDend (sd_id);
}

FORTRAN:

program chunk_examples
    implicit none
    C
    C     Parameter declaration.
    C
    character*14 FILE_NAME
    character*11 SDS_NAME
    integer      RANK
    parameter   (FILE_NAME = 'SDSchunked.hdf',
                  SDS_NAME = 'ChunkedData',
                  RANK = 2)
    integer      DFACC_CREATE, DFACC_READ, DFNT_INT16
    parameter   (DFACC_CREATE = 4,
                  DFACC_READ = 1,
                  DFNT_INT16 = 22)
    integer      COMP_CODE_NONE
    parameter   (COMP_CODE_NONE = 0)
    C
    C     This example does not use compression.
    C
    C     To use RLE compression, declare:
    C
    integer      COMP_CODE_RLE
    parameter   (COMP_CODE_RLE = 1)
    C
    C     To use NBIT compression, declare:
    C
    integer      COMP_CODE_NBIT
    parameter   (COMP_CODE_NBIT = 2)
    C
    C     To use Skipping Huffman compression, declare:
    C
    integer      COMP_CODE_SKPHUFF
To use GZIP compression, declare:

integer COMP_CODE_DEFLATE
parameter (COMP_CODE_DEFLATE = 4)

Function declaration.

C
C**** Variable declaration *******************************************
C
C     Compression flag and parameters.
C
C     Chunk's dimensions.
C
C     Initialize four chunks
C
C     Initialize row and column arrays.
C
C**** End of variable declaration ************************************
C
C
C     Define chunk's dimensions.
C
C     Create the file and initialize SD interface.
C
sd_id = sfstart(FILE_NAME, DFACC_CREATE)
Create 4x9 SDS

dim_sizes(1) = 4
dim_sizes(2) = 9
sds_id = sfcreate(sd_id, SDS_NAME, DFNT_INT16,
                     RANK, dim_sizes)

Fill SDS array with the fill value.

fill_value = 0
status = sfsfill( sds_id, fill_value)

Create chunked SDS.

In this example we do not use compression.

To use RLE compression, initialize comp_type parameter before the call to sfschnk function.

comp_type = COMP_CODE_RLE

To use NBIT, Skipping Huffman, or GZIP compression, initialize comp_prm array and comp_type parameter before call to sfschnk function

NBIT:

comp_prm(1) = value_of(sign_ext)
comp_prm(2) = value_of(fill_one)
comp_prm(3) = value_of(start_bit)
comp_prm(4) = value_of(bit_len)
comp_type = COMP_CODE_NBIT

Skipping Huffman:

comp_prm(1) = value_of(skp_size)
comp_type = COMP_CODE_SKPHUFF

GZIP:

comp_prm(1) = value_of(deflate_level)
comp_type = COMP_CODE_DEFLATE

comp_type = COMP_CODE_NONE
status = sfschnk(sds_id, dim_length, comp_type, comp_prm)

Set chunk cache to hold maximum 2 chunks.

flag = 0
maxcache = 2
new_maxcache = sfscchnk(sds_id, maxcache, flag)

Write chunks using SWritechunk function.

Chunks can be written in any order.

Write chunk with the coordinates (1,1).

origin(1) = 1
origin(2) = 1
status = sfwchnk(sds_id, origin, chunk1)

Write chunk with the coordinates (1,2).

origin(1) = 1
origin(2) = 2
status = sfwchnk(sds_id, origin, chunk3)
Write chunk with the coordinates (2,1).

origin(1) = 2
origin(2) = 1
status = sfwchnk(sds_id, origin, chunk2)

Write chunk with the coordinates (2,3).

origin(1) = 2
origin(2) = 3
status = sfwchnk(sds_id, origin, chunk6)

Fill second row in the chunk with the coordinates (2,2).

start(1) = 3
start(2) = 3
edges(1) = 1
edges(2) = 3
stride(1) = 1
stride(2) = 1
status = sfwdata(sds_id, start, stride, edges, row)

Fill second column in the chunk with the coordinates (1,3).

start(1) = 0
start(2) = 7
edges(1) = 2
edges(2) = 1
stride(1) = 1
stride(2) = 1
status = sfwdata(sds_id, start, stride, edges, column)

Terminate access to the data set.

status = sfendacc(sds_id)

Terminate access to the SD interface and close the file.

status = sfend(sd_id)

Reopen the file and access the first data set.

sd_id = sfstart(FILE_NAME, DFACC_READ)
sds_index = 0
sds_id = sfselect(sd_id, sds_index)

Get information about the SDS.

status = sfgichnk(sds_id, dim_length_out, comp_flag)
if (comp_flag .eq. 0) then
   write(*,*) 'SDS is chunked'
endif
if (comp_flag .eq. 1) then
   write(*,*) 'SDS is chunked and compressed'
endif
if (comp_flag .eq. 2) then
   write(*,*) 'SDS is chunked and NBIT compressed'
endif
write(*,*) 'Chunks dimensions are ', dim_length_out(1), 
   + ' x', dim_length_out(2)

Read the whole SDS using sfndata function and display
what we have read. The following information will be displayed:

SDS is chunked
Chunks dimensions are 2 x 3

```
start(1) = 0
start(2) = 0
edges(1) = 4
edges(2) = 9
stride(1) = 1
stride(2) = 1
status = sfardata(sds_id, start, stride, edges, all_data)
```

Display the SDS.

```
write(*,*)
do 10 i = 1,4
   write(*,*) (all_data(i,j), j=1,9)
10    continue
```

Read chunks with the coordinates (2,2) and (1,3) and display. The following information will be shown:

```
Chunk (2,2)
  0 0 0
  4 4 4

Chunk (1,3)
  0 5 0
  0 5 0
```

```
origin(1) = 2
origin(2) = 2
status = sfrcnk(sds_id, origin, chunk_out)
write(*,*) 'Chunk (2,2)'
write(*,*)
do 20 i = 1,2
   write(*,*) (chunk_out(i,j), j=1,3)
20    continue
```

```
origin(1) = 1
origin(2) = 3
status = sfrcnk(sds_id, origin, chunk_out)
write(*,*) 'Chunk (1,3)'
write(*,*)
do 30 i = 1,2
   write(*,*) (chunk_out(i,j), j=1,3)
30    continue
```

Terminate access to the data set.

```
status = sfendacc(sds_id)
```
3.12 Ghost Areas

In cases where the size of the SDS array is not an even multiple of the chunk size, regions of excess array space beyond the defined dimensions of the SDS will be created. Refer to the following illustration.

These "ghost areas" can be accessed only by SDreadchunk and SDwritechunk; they cannot be accessed by either SDreaddata or SDwritedata. Therefore, storing data in these areas is not recommended. Future versions of the HDF library may not include the ability to write to these areas.

If the fill value has been set, the values in these array locations will be initialized to the fill value. It is highly recommended that users set the fill value before writing to chunked SDSs so that garbage values won’t be read from these locations.

3.13 netCDF

HDF supports the netCDF data model and interface developed at the Unidata Program Center (UPC). Like HDF, netCDF is an interface to a library of data access programs that store and retrieve data. The file format developed at the UPC to support netCDF uses XDR (eXternal Data Representation), a non-proprietary external data representation developed by Sun Microsystems for describing and encoding data. Full documentation on netCDF and the Unidata netCDF interface is available at [http://www.unidata.ucar.edu/packages/netcdf/](http://www.unidata.ucar.edu/packages/netcdf/).

The netCDF data model is interchangeable with the SDS data model in so far as it is possible to use the netCDF calling interface to place an SDS into an HDF file and conversely the SDS interface will read from an XDR-based netCDF file. Because the netCDF interface has not changed and netCDF files stored in XDR format are readable, existing netCDF programs and data are still usable, although programs will need to be relinked to the new library. However, there are impor-
tant conceptual differences between the HDF and the netCDF data model that must be understood to effectively use HDF in working with netCDF data objects and to understand enhancements to the interface that will be included in the future to make the two APIs much more similar.

In the HDF model, when a multidimensional SDS is created by **SDcreate**, HDF data objects are also created that provide information about the individual dimensions — one for each dimension. Each SDS contains within its internal structure the array data as well as pointers to these dimensions. Each dimension is stored in a structure that is in the HDF file but separate from the SDS array.

If more than one SDS have the same dimension sizes, they may share dimensions by pointing to the same dimensions. This can be done in application programs by calling **SDsetdimname** to assign the same dimension name to all dimensions that are shared by several SDSs. For example, suppose you make the following sequence of calls for every SDS in a file:

```c
    dim_id = SDgetdimid(sds_id, 0);
    ret = SDsetdimname(dim_id, "Lat");
    dim_id = SDgetdimid(sds_id, 1);
    ret = SDsetdimname(dim_id, "Long");
```

This will create a shared dimension named "Lat" that is associated with every SDS as the first dimension and a dimension named "Long" as the second dimension.

This same result is obtained differently in netCDF. Note that a netCDF "variable" is roughly the same as an HDF SDS. The netCDF interface requires application programs to define all dimensions, using **ncdimdef**, before defining variables. Those defined dimensions are then used to define variables in **ncvardef**. Each dimension is defined by a name and a size. All variables using the same dimension will have the same dimension name and dimension size.

Although the HDF SDS interface will read from and write to existing XDR-based netCDF files, HDF cannot be used to create XDR-based netCDF files.

There is currently no support for mixing HDF data objects that are not SDSs and netCDF data objects. For example, a raster image can exist in the same HDF file as a netCDF data object, but you must use one of the HDF raster image APIs to read the image and the HDF SD or netCDF interface to read the netCDF data object. The other HDF APIs are currently being modified to allow multfile access. Closer integration with the netCDF interface will probably be delayed until the end of that project.

### 3.13.1 HDF Interface vs. netCDF Interface

Existing netCDF applications can be used to read HDF files and existing HDF applications can be used to read XDR-based netCDF files. To read an HDF file using a netCDF application, the application must be recompiled using the HDF library. For example, recompiling the netCDF utility **ncdump** with HDF creates a utility that can dump scientific data sets from both HDF and XDR-based files. To read an XDR-based file using an HDF application, the application must be relinked to the HDF library.

The current version of HDF contains several APIs that support essentially the same data model:

- The multfile SD interface.
- The netCDF or NC interface.
- The single-file DFSID interface.
- The multfile GR interface.

The first three models can create, read, and write SDSs in HDF files. Both the SD and NC interfaces can read from and write to XDR-based netCDF files, but they cannot create them. This
interoperability means that a single program may contain both SD and NC function calls and thus transparently read and write scientific data sets to HDF or XDR-based files.

The SD interface is the only HDF interface capable of accessing the XDR-based netCDF file format. The DFSD interface cannot access XDR-based files and can only access SDS arrays, dimension scales, and predefined attributes. A summary of file interoperability among the three interfaces is provided in Table 3AH.

<table>
<thead>
<tr>
<th>Summary of HDF and XDR File Compatibility for the HDF and netCDF APIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Files Created by DFSD interface</td>
</tr>
<tr>
<td>HDF</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Accessed by DFSD</td>
</tr>
<tr>
<td>Accessed by SD</td>
</tr>
<tr>
<td>Accessed by NC</td>
</tr>
</tbody>
</table>

A summary of NC function calls and their SD equivalents is presented in Table 3AI.

<table>
<thead>
<tr>
<th>NC Interface Routine Calls and their SD Equivalents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Operations</td>
</tr>
<tr>
<td></td>
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<tr>
<td>Dimensions</td>
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<td></td>
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<tr>
<td>Variables</td>
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<td></td>
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<tr>
<td>Attributes</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>ncattinq</td>
</tr>
<tr>
<td>ncattcopy</td>
</tr>
<tr>
<td>ncattget</td>
</tr>
<tr>
<td>ncattname</td>
</tr>
<tr>
<td>ncattrename</td>
</tr>
<tr>
<td>ncattdel</td>
</tr>
</tbody>
</table>
Chapter 4

Vdatas (VS API)

4.1 Chapter Overview

This chapter describes the vdata data model, the Vdata interface (also called the VS interface or the VS API), and the vdata programming model.

4.2 The Vdata Model

The HDF Vdata model provides a framework for storing customized tables, or vdatas, in HDF files. The term “vdata” is an abbreviation of “vertex data”, alluding to the fact that the object was first implemented in HDF to store the vertex and edge information of polygon sets. The vdata design has since been generalized to apply to a broader variety of applications.

A vdata is like a table that consists of a collection of records whose values are stored in fixed-length fields. All records have the same structure and all values in each field have the same data type. Vdatas are uniquely identified by a name, a class, and a series of individual field names. (See Figure 4a.)

FIGURE 4a

Vdata Table Structure

<table>
<thead>
<tr>
<th>Field_1</th>
<th>Field_2</th>
<th>Field_3</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.9</td>
<td>5.3</td>
<td>6.93</td>
</tr>
<tr>
<td>2.3</td>
<td>1.5</td>
<td>23.50</td>
</tr>
<tr>
<td>0.5</td>
<td>3.5</td>
<td>1.22</td>
</tr>
<tr>
<td>1.8</td>
<td>2.6</td>
<td>0.00</td>
</tr>
</tbody>
</table>

A vdata name is a label typically assigned to describe the contents of a vdata. It often serves as a search key to locate a vdata in a file. A vdata class further distinguishes a particular vdata by identifying the purpose or the use of its data. Finally, vdata field names are labels assigned to the fields in the vdata.
4.2.1 Records and Fields

Each record in a vdata is composed of one or more fixed-length fields. Vdata records and fields are identified by an index. The record and field indexes are zero-based and are separately incremented by one for each additional record and field in the vdata.

Every field in a vdata is assigned a data type when the vdata is created. The data type of a field may be any basic HDF data type: character, 8-bit, 16-bit, and 32-bit signed and unsigned integers, and 32-bit and 64-bit floating point numbers. The maximum length of a vdata record is 65,535 bytes.

The Vdata model allows multiple entries per field as long as they have the same data type. The number of entries or components in a field is called the order of the field.

The organizational structure of a vdata is often determined by the data types of its data set or sets. For example, given a data set describing the location (“X,Y”) and temperature (“Temp”) of points in a plane, there are several ways to organize the data. (See Figure 4b.) If the “X”, “Y” and “Temp” values are of the same data type, they could be stored as three single-component fields, as a two-component “X,Y” field and a single-component “Temp” field, or as a three-component “X,Y,Temp” field. Generally the “X,Y” data is stored in a single field, but HDF places no restrictions on the organization of field data and there are no significant HDF performance issues involved in choosing one organizational regime over another.

![Three Different Vdata Structures for Data of the Same Number Type](image)

4.3 The Vdata Interface

The Vdata interface consists of routines that are used to store and retrieve information about vdata and their contents.

4.3.1 Header Files Used by the Vdata Interface

The header file “hdf.h” must be included in programs that invoke Vdata interface routines.

4.3.2 Vdata Library Routines

Vdata routines begin with the prefixes “VS”, “VF”, “VSQ”, and “VH” in C, and “vsf”, “vf”, “vsq”, and “vh” in FORTRAN-77. Vdata routines perform most general vdata operations, VF routines query information about vdata fields, and VSQ routines query information about specific vdata. VH routines are high-level procedures that write to single-field vdata.

Vdata routines let you define, organize and manipulate vdata. They are categorized as follows and are listed in Table 4A by their categories:
Access routines control access to files and vdatas. Data transfer to and from a vdata can only occur after the access to the vdata has been initiated and before it is terminated. Some Vgroup interface routines are included since they are used interchangeably between the Vdata and Vgroup interfaces. Refer to Chapter 5, Vgroups (V API), for a description of the Vgroup interface.

Read and write routines store and retrieve the contents of and the information about a vdata.

File inquiry routines provide information about how vdatas are stored in a file. They are useful for locating vdatas in the file.

Vdata inquiry routines provide specific information about a given vdata, including the vdata’s name, class, number of records, tag and reference number pairs, size, and interlace mode.

Field inquiry routines provide specific information about the fields in a given vdata, including the field’s size, name, order, and type, and the number of fields in the vdata.

<table>
<thead>
<tr>
<th>Vdata Interface Routines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
</tr>
<tr>
<td>Access/Create</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Read and Write</td>
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<tr>
<td></td>
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<tr>
<td>Vdata Inquiry</td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>VSattrinfo</td>
</tr>
<tr>
<td>VSelts</td>
</tr>
<tr>
<td>VSfexist</td>
</tr>
<tr>
<td>VSfindex</td>
</tr>
<tr>
<td>VSfnattrs</td>
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<tr>
<td>VSfindattr</td>
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<tr>
<td>VSgetattr</td>
</tr>
<tr>
<td>VSgetclass</td>
</tr>
<tr>
<td>VSgetfields</td>
</tr>
<tr>
<td>VSgetinterlace</td>
</tr>
<tr>
<td>VSgetname</td>
</tr>
<tr>
<td>VSinquire</td>
</tr>
<tr>
<td>VSisattr</td>
</tr>
<tr>
<td>VSnattrs</td>
</tr>
<tr>
<td>VSQuerycount</td>
</tr>
<tr>
<td>VSQueryfields</td>
</tr>
<tr>
<td>VSQueryinterlace</td>
</tr>
<tr>
<td>VSQueryname</td>
</tr>
<tr>
<td>VSQueryref</td>
</tr>
<tr>
<td>VSQuerytag</td>
</tr>
<tr>
<td>VSQuerysize</td>
</tr>
<tr>
<td>VSsetattr</td>
</tr>
<tr>
<td>VSsizof</td>
</tr>
</tbody>
</table>
4.3.3 Identifying Vdatas in the Vdata Interface

The Vdata interface identifies vdatas in several ways. Before an existing vdata is accessible, it is uniquely identified by its **reference number**. The reference number of a vdata can be obtained from the name or the class of the vdata, or by sequentially traversing the file. The concept of reference number is discussed in Section 2.2.2.1 on page 8.

When a vdata is attached, it is assigned with an identifier, called **vdata id**, which is used by the Vdata interface routines in accessing the vdata.

4.3.4 Programming Model for the Vdata Interface

The programming model for accessing vdatas is as follows:

1. Open the file.
2. Initialize the Vdata interface.
3. Create a new vdata or open an existing one using its reference number.
4. Perform the desired operations on the vdata.
5. Terminate access to the vdata.
6. Terminate access to the Vdata interface.
7. Close the file.

To access a vdata, the calling program must contain the following calls, which are individually explained in the following subsections:

**C:**

```
file_id = Hopen(filename, file_access_mode, num_dds_block);
status = Vstart(file_id);
vdata_id = VSattach(file_id, vdata_ref, vdata_access_mode);
<Optional operations>
status = VSdetach(vdata_id);
status = Vend(file_id);
status = Hclose(file_id);
```

**FORTRAN:**

```
file_id = hopen(filename, file_access_mode, num_dds_block)
status = vfstart(file_id)
vdata_id = vsfatch(file_id, vdata_ref, vdata_access_mode)
```
<Optional operations>
status = vsftrch(vdata_id)
status = vfend(file_id)
status = hclose(file_id)

4.3.5 Accessing Files and Vdatas: Vstart and VSattach

An HDF file must be opened by Hopen before it can be accessed using the Vdata interface. Hopen is described in Chapter 2, HDF Fundamentals.

Vstart must be called for every file to be accessed. This routine initializes the internal vdata structures used by the Vdata interface. Vstart has only one argument, the file identifier (file_id) returned by Hopen, and returns either SUCCEED (or 0) or FAIL (or -1). Note that the Vstart routine is used by both the Vdata and Vgroup interfaces.

VSattach initiates access to a vdata and must be called before any operations on the vdata may occur. VSattach takes three arguments: file_id, vdata_ref, and vdata_access_mode, and returns either a vdata identifier or FAIL (or -1).

The argument file_id is the file identifier returned by Hopen and vdata_ref is the reference number that identifies the vdata to be accessed. Specifying vdata_ref with a value of -1 will create a new vdata; specifying vdata_ref with a nonexistent reference number will return an error code of FAIL (or -1); and specifying vdata_ref with a valid reference number will initiate access to the corresponding vdata.

If an existing vdata’s reference number is unknown, it must be obtained prior to the VSattach call. (Refer to Chapter 2, HDF Fundamentals, for a description of reference numbers.) The HDF library provides two routines for this purpose, Vfind and Vsetid. Vfind can be used to obtain the reference number of a vdata when the vdata’s name is known. Vsetid can be used to obtain the reference number when only the location of the vdata within the file is known; this is often discovered by sequentially traversing the file. These routines are discussed in Section 4.7.2 on page 167 and Section 4.7.3 on page 167.

The argument vdata_access_mode specifies the access mode (“r” for read-only access or “w” for read and write access) for subsequent operations on the specified vdata. Although several HDF user programs may simultaneously read from one vdata, only one write access is allowed at a time. The “r” access mode may only be used with existing vdatas; the “w” access mode is valid with both new vdatas (vdata_ref = -1) and existing vdatas.

Note that, although a vdata can be created without being written with data, either the routine Vsetname or Vsetfields must be called in order for the vdata to exist in the file.

The parameters for Vstart and VSattach are further defined in Table 4B on page 131.

4.3.6 Terminating Access to Vdatas and Files: Vsdetach and Vend

Vsdetach terminates access to a vdata by updating pertinent information and freeing all memory associated with the vdata and initialized by VSattach. Once access to the vdata is terminated, its identifier becomes invalid and any attempt to access it will result in an error condition. Vsdetach takes only one argument, the vdata identifier that is returned by VSattach, and returns either SUCCEED (or 0) or FAIL (or -1).

Vend releases all internal data structures allocated by Vstart. Vend must be called once for each call to Vstart and only after access to all vdatas have been terminated (i.e., all calls to Vsdetach have been made). Attempts to call Vdata interface routines after calling Vend will result in an error condition. Vend takes one argument, the file identifier that is returned by Hopen, and returns
either `SUCCEED` (or 0) or `FAIL` (or -1). Note that the `Vend` routine is used by both the Vdata and Vgroup interfaces.

In summary, successfully terminating access to a vdata requires one `VSdetach` call for each call to `VSattach` and one `Vend` call for each call to `Vstart`.

The parameters for `VSdetach` and `Vend` are further defined in Table 4B. `Hclose` terminates access to a file and should only be called after all `Vend` calls have been made to close the Vdata interface. Refer to Chapter 2, *HDF Fundamentals*, for a description of `Hclose`.

### TABLE 4B

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Vstart</code></td>
<td><code>file_id</code></td>
<td>int32</td>
</tr>
<tr>
<td><code>VSattach</code></td>
<td><code>vdata_ref</code></td>
<td>int32</td>
</tr>
<tr>
<td><code>VSdetach</code></td>
<td><code>vdata_id</code></td>
<td>int32</td>
</tr>
<tr>
<td><code>Vend</code></td>
<td><code>file_id</code></td>
<td>int32</td>
</tr>
</tbody>
</table>

### EXAMPLE 1.

**Accessing a Vdata in an HDF File**

This example illustrates the use of `Hopen/hopen`, `Vstart/vfstart`, `VSattach/vsfatch`, `VSdetach/vsfitch`, `Vend/vfend`, and `Hclose/hclose` to create and to access different vdatas from different HDF files.

The program creates an HDF file, named "General_Vdatas.hdf", containing a vdata. The program also creates a second HDF file, named "Two_Vdatas.hdf", containing two vdatas. Note that, in this example, the program does not write data to these vdatas. Also note that before closing the file, the access to its vdatas and its corresponding Vdata interface must be terminated. These examples request information about a specific vdata.

**C:**

```c
#include "hdf.h"

#define FILE1_NAME "General_Vdatas.hdf"
#define FILE2_NAME "Two_Vdatas.hdf"
#define VDATA_NAME "Vdata 1"
#define VDATA_CLASS "Empty Vdatas"

main( )
{
    /*************** Variable declaration *******************/
    intn status_n; /* returned status for functions returning an intn */
    int32 status_32, /* returned status for functions returning an int32 */
    file1_id, file2_id,
    vdata_id, vdatal_id, vdata2_id,
    vdata_ref = -1; /* ref number of a vdata, set to -1 to create */
```
/* Create the first HDF file. */
file1_id = Hopen (FILE1_NAME, DFACC_CREATE, 0);

/* Initialize the VS interface associated with the first HDF file. */
status_n = Vstart (file1_id);

/* Create a vdata in the first HDF file. */
vdata_id = VSattach (file1_id, vdata_ref, "w");

/* Assign a name to the vdata. */
status_32 = VSsetname (vdata_id, VDATA_NAME);

/* Other operations on the vdata identified by vdata_id can be carried out starting from this point. */

/* Create the second HDF file. */
file2_id = Hopen (FILE2_NAME, DFACC_CREATE, 0);

/* Initialize the VS interface associated with the second HDF file. */
status_n = Vstart (file2_id);

/* Create the first vdata in the second HDF file. */
vdata1_id = VSattach (file2_id, vdata_ref, "w");

/* Create the second vdata in the second HDF file. */
vdata2_id = VSattach (file2_id, vdata_ref, "w");

/* Assign a class name to these vdatas. */
status_32 = VSsetclass (vdata1_id, VDATA_CLASS);
status_32 = VSsetclass (vdata2_id, VDATA_CLASS);

/* Other operations on the vdatas identified by vdata1_id and vdata2_id can be carried out starting from this point. */

/* Terminate access to the first vdata in the second HDF file. */
status_32 = VSdetach (vdata1_id);
Terminate access to the second vdata in the second HDF file.

```
status_32 = VSdetach (vdata2_id);
```

From this point on, any operations on the vdatas identified by vdata1_id and vdata2_id are invalid but not on the vdata identified by vdata_id.

```
status_n = Vend (file2_id);
```

Close the second HDF file.

```
status_n = Hclose (file2_id);
```

Terminate access to the vdata in the first HDF file.

```
status_32 = VSdetach (vdata_id);
```

Terminate access to the VS interface associated with the first HDF file.

```
status_n = Vend (file1_id);
```

Close the first HDF file.

```
status_n = Hclose (file1_id);
```

```FORTRAN:

program create_vdatas
    implicit none

    parameter (FILE1_NAME = 'General_Vdatas.hdf',
              FILE2_NAME = 'Two_Vdatas.hdf',
              VDATA_NAME = 'Vdata 1',
              VDATA_CLASS = 'Empty Vdatas')

    integer DFACC_CREATE
    parameter (DFACC_CREATE = 4)

    integer hopen, hclose
    integer vfstart, vsfatch, vsfsnam, vsfscls, vsfdtch, vfend

    **** Variable declaration **************************************************
integer status
integer file1_id, file2_id
integer vdata_id, vdata1_id, vdata2_id
integer vdata_ref

C
C**** End of variable declaration ************************************
C
C
C     Create the first HDF file.
C
file1_id = hopen(FILE1_NAME, DFACC_CREATE, 0)
C
C     Initialize the VS interface associated with the first HDF file.
C
status = vfstart(file1_id)
C
C     Create a vdata in the first HDF file.
C
vdata_ref = -1
vdata_id = vsfatch(file1_id, vdata_ref, 'w')
C
C     Assign a name to the vdata.
C
status = vsfsnam(vdata_id, VDATA_NAME)
C
C     Other operations on the vdata identified by vdata_id can be carried out
C     starting from this point.
C
C     Create the second HDF file.
C
file2_id = hopen(FILE2_NAME, DFACC_CREATE, 0)
C
C     Initialize the VS interface associated with the second HDF file.
C
status = vfstart(file2_id)
C
C     Create the first vdata in the second HDF file.
C
vdata1_id = vsfatch(file2_id, vdata_ref, 'w')
C
C     Create the second vdata in the second HDF file.
C
vdata2_id = vsfatch(file2_id, vdata_ref, 'w')
C
C     Assign a class name to these vdatas.
C
status = vsfscls(vdata1_id, VDATA_CLASS)
status = vsfscls(vdata2_id, VDATA_CLASS)
C
C     Other operations on the vdatas identified by vdata1_id and vdata2_id
C     can be carried out starting from this point.
C
C     Terminate access to the first vdata in the second HDF file.
C
status = vsfdtch(vdata1_id)
C
C     Terminate access to the second vdata in the second HDF file.
C
status = vsfdtch(vdata2_id)
C
C     Terminate access to the VS interface associated with the second HDF file.
C
status = vfend(file2_id)
C      Close the second HDF file.
C
status = hclose(file2_id)
C
C      Terminate access to the vdata in the first HDF file.
C
status = vsfdtch(vdata_id)
C
C      terminate access to the VS interface associated with the first HDF file.
C
status = vfend(file1_id)
C
C      Close the first HDF file.
C
status = hclose(file1_id)
end

4.4 Creating and Writing to Single-Field Vdatas: VHstoredata and VHstoredatam

There are two methods of writing vdatas that contain one field per record. One requires the use of several VS routines and the other involves the use of **VHstoredata** or **VHstoredatam**, two high-level routines that encapsulate several VS routines into one.

The high-level VH routines are useful when writing one-field vdatas and complete information about each vdata is available. If you cannot provide full information about a vdata, you must use the VS routines described in the next section.

Figure 4c shows two examples of single-field vdatas. The fields can be single-component or multi-component fields. With a multi-component field, they may contain one or more values of the same data type.

**FIGURE 4c**

**Single- and Multi-component Vdatas**

**VHstoredata** creates then writes a vdata with one single-component field. **VHstoredatam** creates and writes a vdata with one multi-component field. In both cases the following steps are involved:

1. Open the file.
2. Initialize the Vdata interface.
3. Store (create then write to) the vdata.
4. Terminate access to the Vdata interface.
5. Close the file.

These steps correspond to the following sequence of function calls:

**C:**
```c
file_id = Hopen(filename, file_access_mode, num_dds_block);
status = Vstart(file_id);
/* Either VHstoredata or VHstoredatam can be called here. */
vdata_ref = VHstoredata(file_id, fieldname, buf, n_records,
data_type, vdata_name, vdata_class);
OR
vdata_ref = VHstoredatam(file_id, fieldname, buf, n_records,
data_type, vdata_name, vdata_class, order);
status = Vend(file_id);
status = Hclose(file_id);
```

**FORTRAN:**
```fortran
file_id = hopen(filename, file_access_mode, num_dds_block)
status = vfstart(file_id)
C Either vhfsd/vhfscd or vhfsdm/vhfscdm can be called here.
vdata_ref = vhfsd(file_id, fieldname, buf, n_records, data_type,
vdata_name, vdata_class)
OR
vdata_ref = vhfsdm(file_id, fieldname, buf, n_records, data_type,
vdata_name, vdata_class)
OR
vdata_ref = vhfsdm(file_id, fieldname, buf, n_records, data_type,
vdata_name, vdata_class, order)
OR
vdata_ref = vhfsdm(file_id, fieldname, buf, n_records, data_type,
vdata_name, vdata_class, order)
status = vfend(file_id)
status = hclose(file_id)
```

The first seven parameters of **VHstoredata** and **VHstoredatam** are the same. The parameter `file_id` is the file identifier returned by `Hopen`. The parameter `fieldname` specifies the name of the vdata field. The parameter `buf` contains the data to be stored into the vdata. In C, the data type of the parameter `buf` is `uint8`; in FORTRAN-77, it is the data type of the data to be stored. The parameters `n_records` and `data_type` contain the number of records in the vdata and the data type of the vdata data. The parameters `vdata_name` and `vdata_class` specify the name and class of the vdata. The parameter `order` of **VHstoredatam** specifies the order of the field. The maximum length of the vdata name is given by the `VSNAMELENMAX` (or 64) as defined in the header file “hlimits.h”.

Note that these two routines do not overwrite existing vdatas but only create new ones before storing the data.

The FORTRAN-77 version of **VHstoredata** has two routines: `vhfsd` for numeric data and `vhfscd` for character data; the FORTRAN-77 version of **VHstoredatam** has two routines: `vhfsdm` for numeric data and `vhfscdm` for character data.

Both routines return the reference number of the newly-created vdata or `FAIL` (or -1) if the operation is unsuccessful. The parameters for **VHstoredata** and **VHstoredatam** are further described in Table 4C.
TABLE 4C

VHstorededata and VHstoredatam Parameter Lists

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHstorededata</td>
<td>file_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>VHstorededata</td>
<td>fieldname</td>
<td>char *</td>
<td>character(*)</td>
</tr>
<tr>
<td>VHstorededata</td>
<td>buf</td>
<td>uint8 *</td>
<td>&lt;valid numeric data type&gt;(<em>)/character(</em>)</td>
</tr>
<tr>
<td>VHstoredatam</td>
<td>file_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>VHstoredatam</td>
<td>fieldname</td>
<td>char *</td>
<td>character(*)</td>
</tr>
<tr>
<td>VHstoredatam</td>
<td>buf</td>
<td>uint8 *</td>
<td>&lt;valid numeric data type&gt;(<em>)/character(</em>)</td>
</tr>
<tr>
<td>VHstoredatam</td>
<td>n_records</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>VHstoredatam</td>
<td>data_type</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>VHstoredatam</td>
<td>vdata_name</td>
<td>char *</td>
<td>character(*)</td>
</tr>
<tr>
<td>VHstoredatam</td>
<td>vdata_class</td>
<td>char *</td>
<td>character(*)</td>
</tr>
</tbody>
</table>

Creating and Storing One-field Vdatas Using VHstorededata and VHstoredatam

This example illustrates the use of VHstorededata/vhfscd and VHstoredatam/vhfsdm to create single-field vdatas.

This example creates and writes two vdatas to the file "General_Vdatas.hdf". The first vdata is named "First Vdata", contains 5 records, and belongs to a class named "5x1 Array". The second vdata is named "Second Vdata", contains 6 records, and belongs to a class named "6x4 Array". The field of the first vdata is a single-component field, i.e., order of 1, and named "Single-component Field". The field of the second vdata has an order of 4 and is named "Multi-component Field".

In these examples two vdatas are created. The first vdata has five records with one field of order 1 and is created from a 5 x 1 array in memory. The second vdata has six records with one field of order 4 and is created from a 6 x 4 array in memory.

C:

```c
#include "hdf.h"
#define FILE_NAME       "General_Vdatas.hdf"
#define CLASS1_NAME     "$5x1 Array"
#define CLASS2_NAME     "$6x4 Array"
#define VDATA1_NAME     "First Vdata"
#define VDATA2_NAME     "Second Vdata"
#define FIELD1_NAME     "Single-component Field"
#define FIELD2_NAME     "Multi-component Field"
#define N_RECORDS_1     5 /* number of records the first vdata contains */
#define N_RECORDS_2     6 /* number of records the second vdata contains */
#define ORDER_2         4 /* order of the field in the second vdata */
main( )
/* Note that the order of the field in the first vdata is 1 */
```
{  
    /***************************************************************************  
    Variable declaration ***************************************************************************/  
    int n status_n;      /* returned status for functions returning an int */  
    int32 status_32;     /* returned status for functions returning an int32 */  
    int32 file_id, vdata1_ref, vdata2_ref;  
    
    /***************************************************************************  
    Define an array to buffer the data of the first vdata. */  
    char8 vdata1_buf [N_RECORDS_1] = {'V', 'D', 'A', 'T', 'A'};  
    
    /***************************************************************************  
    Define an array to buffer the data of the second vdata. */  
    int32 vdata2_buf [N_RECORDS_2][ORDER_2] = {{1, 2, 3, 4}, {2, 4, 6, 8},  
      {3, 6, 9, 12}, {4, 8, 12, 16},  
      {5, 10, 15, 20}, {6, 12, 18, 24}};  
    
    /***************************************************************************/  
    
    /***************************************************************************/  
    
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    /***************************************************************************/  
    
    /***************************************************************************/  
   FORTRAN:  
    
    program create_onefield_vdatas  
        implicit none  
        C  
        Parameter declaration  
        C  
        character*18 FILE_NAME  
        character*9 CLASS1_NAME  
        character*9 CLASS2_NAME  
    }
character*11 VDATA1_NAME
character*12 VDATA2_NAME
character*22 FIELD1_NAME
character*21 FIELD2_NAME
integer N_RECORDS_1, N_RECORDS_2
integer ORDER_2

parameter (FILE_NAME   = 'General_Vdatas.hdf',
           CLASS1_NAME = '5x1 Array',
           CLASS2_NAME = '6x4 Array',
           VDATA1_NAME = 'First Vdata',
           VDATA2_NAME = 'Second Vdata',
           FIELD1_NAME = 'Single-component Field',
           FIELD2_NAME = 'Multi-component Field')

parameter (N_RECORDS_1 = 5,
           N_RECORDS_2 = 6,
           ORDER_2     = 4)

integer DFACC_WRITE, DFNT_CHAR8, DFNT_INT32

parameter (DFACC_WRITE = 2,
           DFNT_CHAR8  = 4,
           DFNT_INT32  = 24)

C
C     Function declaration
C
integer hopen, hclose
integer vfstart, vhscd, vhfsdm, vfend

C**** Variable declaration *******************************************

integer status
integer file_id
integer vdata1_ref, vdata2_ref
character vdata1_buf(N_RECORDS_1)
integer vdata2_buf(ORDER_2, N_RECORDS_2)
data vdata1_buf /'V','D','A','T','A'/
data vdata2_buf / 1, 2, 3, 4,
+     2, 4, 6, 8,
+     3, 6, 9, 12,
+     4, 8, 12, 16,
+     5, 10, 15, 20,
+     6, 12, 18, 24/

C**** End of variable declaration ************************************

C Open the HDF file for writing.

file_id = hopen(FILE_NAME, DFACC_WRITE, 0)

C Initialize the VS interface.

status = vfstart(file_id)

C Create the first vdata and populate it with data from vdata1_buf array.

vdata1_ref = vhscd(file_id, FIELD1_NAME, vdata1_buf, N_RECORDS_1,
                       DFNT_CHAR8, VDATA1_NAME, CLASS1_NAME)

C Create the second vdata and populate it with data from vdata2_buf array.

vdata2_ref = vhfsdm(file_id, FIELD2_NAME, vdata2_buf, N_RECORDS_2,
4.5 Writing to Multi-Field Vdatas

There are several steps involved in creating general vdatas with more than one field: define the vdata, define the fields of the vdata, and write the vdata to the file. These steps are usually executed within a single program, although it is also possible to define an empty vdata in anticipation of writing data to it at a later time.

4.5.1 Creating Vdatas

Creating an empty vdata involves the following steps:

1. Open a file.
2. Initialize the Vdata interface.
3. Create the new vdata.
4. Assign a vdata name. (optional)
5. Assign a vdata class. (optional)
6. Define the fields.
7. Initialize fields for writing.
8. Set the interlace mode.
9. Dispose of the vdata identifier.
10. Terminate access to the Vdata interface.

Like the high-level VH interface, the Vdata interface does not retain default settings from one operation to the next or from one file to the next. Each time a vdata is created, its definitions must be explicitly reset.

To create a multi-field vdata, the calling program must contain the following:

C:

```c
+            DFNT_INT32, VDATA2_NAME, CLASS2_NAME,
+            ORDER_2)

C
C              Terminate access to the VS interface and close the HDF file.
C
status = vfend(file_id)
status = hclose(file_id)
end

file_id = Hopen(filename, file_access_mode, num_dd_blocks);
status = Vstart(file_id);
vdata_id = VSattach(file_id, -1, vdata_access_mode);
status = VSsetname(vdata_id, vdata_name);
status = VSsetclass(vdata_id, vdata_class);
status = VSfdefine(vdata_id, fieldname1, data_type1, order1);
. . . . . . . . .
status = VSfdefine(vdata_id, fieldnameN, data_typeN, orderN);
status = VSsetfields(vdata_id, fieldname_list);
status = VSsetinterlace(vdata_id, interlace_mode);
status = VSdetach(vdata_id);
status = Vend(file_id);
status = Hclose(file_id);
```
In the routines that follow, vdata_id is the vdata identifier returned by VSAttach.

### 4.5.1.1 Assigning a Vdata Name and Class: VSsetname and VSsetclass

VSsetname assigns a name to a vdata. If not explicitly named by a call to VSsetname, the name of the vdata is set by default to NULL. A name may be assigned and reassigned at any time after the vdata is created. The parameter vdata_name contains the name to be assigned to the vdata.

VSsetclass assigns a class to a vdata. If VSsetclass is not called, the vdata’s class is set by default to NULL. As with the vdata name, the class may be assigned and reassigned any time after the vdata is created. The parameter vdata_class contains the class name to be assigned to the vdata.

VSsetname and VSsetclass return either SUCCEED (or 0) or FAIL (or -1). The parameters for these routines are further defined in Table 4E on page 143.

### 4.5.1.2 Defining a Field within a Vdata: VSdefine

VSdefine defines a field within a newly-created vdata. Each VSdefine call assigns the name contained in the argument fieldname, the data type contained in the argument data_type, and the order contained in the argument order to one new field. Once data is written to a vdata, the name, data type and order of the field may not be modified or deleted.

The Vdata interface also provides certain predefined fields. A predefined field has a specific name, data type, and order, so there is no need to call VSdefine to define a predefined field. Some applications may require the use of predefined fields in vdatas. Available predefined fields are discussed in Table 4D.

Note that VSdefine does not allocate memory for the field, but simply introduces the field. The field definition must be completed by VSsetfields, which is discussed in Section 4.5.1.3 on page 142.

VSdefine returns either SUCCEED (or 0) or FAIL (or -1). The parameters for VSdefine are further described in Table 4E on page 143.

### TABLE 4D

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Coordinate Point Field Names</th>
<th>Normal Component Field Names</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x-coordinate</td>
<td>y-coordinate</td>
</tr>
<tr>
<td>float</td>
<td>PX</td>
<td>PY</td>
</tr>
<tr>
<td>integer</td>
<td>IX</td>
<td>IY</td>
</tr>
</tbody>
</table>
4.5.1.3 Initializing the Fields for Write Access: VSsetfields

`VSsetfields` initializes read and write access to the fields in a vdata. It must be called prior to read or write operations. Initializing for read access is discussed in Section 4.6.1 on page 158. For writing, `VSsetfields` specifies the fields to be written and the order in which they are to be placed.

The parameter `fieldname_list` is a comma-separated list of the field names, with no white space included. The fields can be either the predefined fields or the fields that have been previously introduced by `VSfdefine`. `VSfdefine` allows a user to declare a field, along with its data type and order, but `VSsetfields` finalizes the definition by allowing the user to select the fields that are to be included in the vdata. Thus, any fields created by `VSfdefine` that are not in the parameter `fieldname_list` of `VSsetfields` will be ignored. This feature was originally intended for interactive-mode users. The combined width of the fields in the parameter `fieldname_list` is also the length of the record and must be less than `MAX_FIELD_SIZE` (or 65535). An attempt to create a larger record will cause `VSsetfields` to return `FAIL` (or -1).

`VSsetfields` returns either `SUCCEED` (or 0) or `FAIL` (or -1). The parameters for `VSsetfields` are further defined in Table 4E on page 143.

4.5.1.4 Specifying the Interlace Mode: VSsetinterlace

The Vdata interface supports two types of interlacing: file interlacing and buffer interlacing. File interlacing determines how data is stored in a file and buffer interlacing determines how data is stored in memory. The Vdata interface can write data from a buffer to a file in an interlaced or non-interlaced manner. It can also read data from a file in an interlaced or non-interlaced manner.

The `VSread` and `VSwrite` routines set the buffer’s interlace mode. The `VSwrite` routine will be discussed in Section 4.5.2.2 on page 145 and the `VSread` routine will be discussed in Section 4.6.2 on page 158.

`VSsetinterlace` sets the file interlacing mode for a vdata. Setting the parameter `interlace_mode` to `FULL_INTERLACE` (or 0) fills the vdata by record, whereas specifying `NO_INTERLACE` (or 1) fills the vdata by field. (See Figure 4d.) For multi-component fields, all components are treated as a single field.

As with file interlacing, the default buffer interlace mode is `FULL_INTERLACE` because it is more efficient to write complete records than it is to write fields if the file and buffer interlace modes are the same, although both require the same amount of disk space.

In Figure 4d, the illustrated vdata has four fields and three records.

![Interlaced and Non-Interlaced Vdata Contents](image)
**VSsetinterlace** returns either **SUCCEED** (or 0) or **FAIL** (or -1). The parameters for **VSsetinterlace** are further described in Table 4E.

### TABLE 4E

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VSsetname</strong></td>
<td>vdata_id</td>
<td>integer</td>
</tr>
<tr>
<td>[int32] (vsfsnam)</td>
<td>vdata_name</td>
<td>char*</td>
</tr>
<tr>
<td><strong>VSsetclass</strong></td>
<td>vdata_id</td>
<td>int32</td>
</tr>
<tr>
<td>[int32] (vsfsclas)</td>
<td>vdata_class</td>
<td>char*</td>
</tr>
<tr>
<td><strong>VSfdefine</strong></td>
<td>vdata_id</td>
<td>int32</td>
</tr>
<tr>
<td>[intn] (vsffdef)</td>
<td>vdata_id</td>
<td>int32</td>
</tr>
<tr>
<td>fieldname</td>
<td>char*</td>
<td>character*(*)</td>
</tr>
<tr>
<td>data_type</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>order</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td><strong>VSsetfields</strong></td>
<td>vdata_id</td>
<td>int32</td>
</tr>
<tr>
<td>[intn] (vsfsfld)</td>
<td>vdata_id</td>
<td>int32</td>
</tr>
<tr>
<td>fieldname_list</td>
<td>char*</td>
<td>character*(*)</td>
</tr>
<tr>
<td><strong>VSsetinterlace</strong></td>
<td>vdata_id</td>
<td>int32</td>
</tr>
<tr>
<td>[intn] (vsfsint)</td>
<td>vdata_id</td>
<td>int32</td>
</tr>
<tr>
<td>interlace_mode</td>
<td>int32</td>
<td>integer</td>
</tr>
</tbody>
</table>

### 4.5.2 Writing Data to Vdatas

This section describes the vdata writing operation (**VSwrite**), random access to vdata (**VSseek**), and packing and unpacking mechanisms that allow storing vdata fields of different data types (**VSfpack**).

Writing to a vdata requires the following steps:

1. Open a file.
2. Initialize the Vdata interface.
3. Initialize fields for writing.
4. Initiate access to the vdata.
5. Seek to the target record.
6. Write the data.
7. Dispose of the vdata identifier.
8. Terminate access to the Vdata interface.

These steps correspond to the following sequence of function calls:

**C:**

```c
file_id = Hopen(filename, file_access_mode, num_dds_block);
status = Vstart(file_id);
vdata_id = VSattach(file_id, vdata_ref, vdata_access_mode);
status = VSsetfields(vdata_id, fieldname_list);
record_pos = VSseek(vdata_id, record_index);
num_of_recs = VSwrite(vdata_id, databuf, n_records, interlace_mode);
status = VSdetach(vdata_id);
status = Vend(file_id);
status = Hclose(file_id);
```
4.5.2.1 Resetting the Current Position within Vdatas: VSseek

VSseek provides a mechanism for random access to fully-interlaced vdatas. Random-access for non-interlaced vdatas is not available. The parameter record_index is the position of the record to be written. The position of the first record in a vdata is specified by record_index = 0. Any vdata operation will be performed on this record by default; vdata operations on other records require that VSseek be called first to specify the target record.

Note that VSseek has been designed for the purpose of overwriting data, not appending data. That means VSseek puts the current record pointer at the beginning of the sought record and the subsequent write will overwrite the record. To append data to a vdata, the current record pointer must be put at the end of the last record. Thus, you must seek to the last record then read this record so that the current record pointer will be put at the end of the record. A write operation will now start at the end of the last record in the vdata. Figure 4e illustrates a situation where VSseek can be misused while attempting to append data to the vdata and how VSread is called to correctly place the record pointer at the end of the vdata for appending.

Note that, because the record location numbering starts at 0, the record location and the value of the parameter record_index are off by 1. For example, reading the fourth record in the buffer requires record_index to be set to 3.

See the notes regarding the potential performance impact of appendable data sets in Section 14.4.3, "Unlimited Dimension Data Sets (SDSs and Vdatas) and Performance."
In this illustration, the vdata to which we plan to append data contains 4 records. Using `VSseek` to seek to the end of the fourth record by setting the parameter `record_index` to 4 results in an error condition. Setting the parameter `record_index` to 3 places the current record pointer at the beginning of the fourth record. We then use `VSread` to read the contents of the fourth record into a buffer; this moves the current record pointer to the end of the fourth record. The contents of the buffer can then be discarded and a write operation can be called to append data to the end of the vdata.

`VSseek` returns the sought record location or `FAIL` (or `-1`). Its parameters are further defined in Table 4F.

**4.5.2.2 Writing to a Vdata: VSwrite**

`VSwrite` writes buffered data to a specified vdata. The parameter `databuf` is a buffer containing the records to be stored in the vdata. The parameter `n_records` specifies the number of records to be stored.

Recall that the *file interlacing* is set by `VSsetinterlace` when the vdata is created, and the *buffer interlacing* is specified by the parameter `interlace_mode` in the call to `VSwrite` when data is written to the file. The array `databuf` is assumed to be organized in memory as specified by `interlace_mode`. Setting `interlace_mode` to `FULL_INTERLACE` (or 0) indicates that the array in memory is organized by record, whereas to `NO_INTERLACE` (or 1) indicates that the array is organized by field. (See Figure 4f.) `VSwrite` will write interlaced or non-interlaced data to a vdata in a file: interlaced data in the buffer can be written to the vdata in the file as non-interlaced data and vice versa. If the data is to be stored with an interlace mode different from that of the buffer, `VSsetinterlace` (described in Section 4.5.1.4 on page 142) must be called prior to `VSwrite`. Multiple write operations can only be used on fully-interlaced vdata in the file.
Writing Interlaced or Non-interlaced Buffers into Interlaced or Non-interlaced Vdatas

The data in the array `databuf` is assumed to contain the exact amount of data in the order needed to fill the fields defined in the last call to `VSsetfields`. Because `VSwrite` writes the contents of `databuf` contiguously to the vdata, any “padding” due to record alignment must be removed before attempting to write from `databuf` to the vdata. For more information on alignment padding see Section 4.5.2.4 on page 151.

It should be remembered that `VSwrite` writes whole records, not individual fields. If a modification to one field within a previously-written record is needed, the contents of the record must first be preserved by reading it to a buffer with `VSread`, which will be described in Section 4.6.2 on page 158; the record must then be updated in the buffer and written back to the file with `VSwrite`.

To store a vdata to the file after being created, either `VSsetname`, `VSsetfields`, or `VSwrite` must be called before `VSdetach` for the vdata. If `VSwrite` is not called, the vdata created will be empty.

The FORTRAN-77 version of `VSwrite` has three routines: `vsfwrt` is for buffered numeric data, `vsfwrtc` is for buffered character data and `vsfwrit` is for generic packed data.

`VSwrite` returns the total number of records written or `FAIL` (or -1). Its parameters are further defined in Table 4F.

### TABLE 4F

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSseek [int32] (vsfseek)</td>
<td>vdata_id</td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td>record_index</td>
<td>int32</td>
<td>Index of the record to seek to</td>
</tr>
<tr>
<td>VSwrite [int32] (vsfwrt/vsfwrtc/vsfwrit)</td>
<td>vdata_id</td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td>databuf</td>
<td>&lt;valid data type&gt; / character* / integer</td>
<td>Buffer containing data to be written</td>
</tr>
<tr>
<td></td>
<td>n_records</td>
<td>int32</td>
<td>Number of records to be written</td>
</tr>
<tr>
<td></td>
<td>interface_mode</td>
<td>int32</td>
<td>Interface mode of the buffered data</td>
</tr>
</tbody>
</table>
EXAMPLE 3.

Writing a Vdata of Homogeneous Type

This example illustrates the use of \texttt{VSdefine/vsffdef}, \texttt{VSsetname/vsfsvnam}, \texttt{VSsetclass/vsfsccls}, \texttt{VSsetfields/vsfslfd}, and \texttt{VSwrite/vsfwr} to create and write a three-field vdata to the file "General_Vdatas.hdf". Although the fields have data of the same type, they have different orders.

To clarify the illustration, let us assume that the vdata is used to contain the data of some particles collected from an experiment. Each record of the data includes the position of a particle, its weight, and the minimum and maximum temperature the particle can endure. The vdata is named "Solid Particle", contains 10 records, and belongs to a class, named "Particle Data". The fields of the vdata include "Position", "Mass", and "Temperature". The field "Position" has an order of 3 for the x, y, and z values representing the position of a particle. The field "Mass" has an order of 1. The field "Temperature" has an order of 2 for the minimum and maximum temperature. The program creates the vdata, sets its name and class name, defines its fields, and then writes the data to it.

C:

```c
#include "hdf.h"

#define FILE_NAME "General_Vdatas.hdf"
#define N_RECORDS 10 /* number of records the vdata contains */
#define ORDER_1 3 /* order of first field */
#define ORDER_2 1 /* order of second field */
#define ORDER_3 2 /* order of third field */
#define CLASS_NAME "Particle Data"
#define VDATA_NAME "Solid Particle"
#define FIELD1_NAME "Position" /* contains x, y, z values */
#define FIELD2_NAME "Mass" /* contains weight values */
#define FIELD3_NAME "Temperature" /* contains min and max values */
#define FIELDNAME_LIST "Position,Mass,Temperature" /* No spaces b/w names */
#define N_VALS_PER_REC (ORDER_1 + ORDER_2 + ORDER_3)

main()
{
    int status_n; /* returned status for functions returning an intn */
    int32 status_32, /* returned status for functions returning an int32 */
        file_id, vdata_id, vdata_ref = -1, /* ref number of a vdata, set to -1 to create */
        num_of_records; /* number of records actually written to vdata */
    int16 rec_num; /* current record number */
    float32 data_buf[N_RECORDS][N_VALS_PER_REC]; /* buffer for vdata values */

    /*************** Variable declaration *******************/

    /* Open the HDF file for writing. */
    file_id = Hopen (FILE_NAME, DFACC_WRITE, 0);

    /* Initialize the VS interface. */
    status_n = Vstart (file_id);

    /* Create a new vdata.
```
/*
  vdata_id = VSAttach (file_id, vdata_ref, "w");
*/

/*
* Set name and class name of the vdata.
*/
status_32 = VSsetname (vdata_id, VDATA_NAME);
status_32 = VSsetclass (vdata_id, CLASS_NAME);

/*
* Introduce each field's name, data type, and order. This is the first
* part in defining a field.
*/
status_n = VSfdefine (vdata_id, FIELD1_NAME, DFNT_FLOAT32, ORDER_1 );
status_n = VSfdefine (vdata_id, FIELD2_NAME, DFNT_FLOAT32, ORDER_2 );
status_n = VSfdefine (vdata_id, FIELD3_NAME, DFNT_FLOAT32, ORDER_3 );

/*
* Finalize the definition of the fields.
*/
status_n = VSsetfields (vdata_id, FIELDNAME_LIST);

/*
* Buffer the data by the record for fully interlaced mode. Note that the
* first three elements contain the three values of the first field, the
* fourth element contains the value of the second field, and the last two
* elements contain the two values of the third field.
*/
for (rec_num = 0; rec_num < N_RECORDS; rec_num++)
{
data_buf[rec_num][0] = 1.0 * rec_num;
data_buf[rec_num][1] = 2.0 * rec_num;
data_buf[rec_num][2] = 3.0 * rec_num;
data_buf[rec_num][3] = 0.1 + rec_num;
data_buf[rec_num][4] = 0.0;
data_buf[rec_num][5] = 65.0;
}

/*
* Write the data from data_buf to the vdata with full interlacing mode.
*/
num_of_records = VSwrite (vdata_id, (uint8 *)data_buf, N_RECORDS,
                       FULL_INTERLACE);

/*
* Terminate access to the vdata and to the VS interface, then close
* the HDF file.
*/
status_32 = VSdetach (vdata_id);
status_n  = Vend (file_id);
status_32 = Hclose (file_id);
}

FORTRAN:
program write_to_vdata
  implicit none
  C    Parameter declaration
  C
  character*18 FILE_NAME
  character*13 CLASS_NAME
  character*14 VDATA_NAME
character*8  FIELD1_NAME  
character*4  FIELD2_NAME  
character*11 FIELD3_NAME  
character*27 FIELDNAME_LIST  
integer      N_RECORDS  
integer      ORDER_1, ORDER_2, ORDER_3  
integer      N_VALS_PER_REC  

C

parameter (FILE_NAME       = 'General_Vdatas.hdf',
+          CLASS_NAME      = 'Particle Data',
+          VDATA_NAME      = 'Solid Particle',
+          FIELD1_NAME     = 'Position',
+          FIELD2_NAME     = 'Mass',
+          FIELD3_NAME     = 'Temperature',
+          FIELDNAME_LIST = 'Position,Mass,Temperature')

parameter (N_RECORDS = 10,
+          ORDER_1   = 3,
+          ORDER_2   = 1,
+          ORDER_3   = 2,
+          N_VALS_PER_REC = ORDER_1 + ORDER_2 + ORDER_3)

integer DFACC_WRITE, DFNT_FLOAT32, FULL_INTERLACE

parameter (DFACC_WRITE    = 2,
+           DFNT_FLOAT32   = 5,
+           FULL_INTERLACE = 0)

C
Function declaration
C
integer hopen, hclose
integer vfstart, vsfatch, vsfsnam, vsfscls, vsffdef, vsfsfld,
+       vsfwrt, vsfdtch, vfend

C**** Variable declaration ****************************************************
C
integer status
integer file_id, vdata_id
integer vdata_ref, rec_num, num_of_records
real    data_buf(N_VALS_PER_REC, N_RECORDS)

C**** End of variable declaration ************************************************
C
C
C     Open the HDF file for writing.
C
file_id = hopen(FILE_NAME, DFACC_WRITE, 0)

C     Initialize the VS interface.
C
status = vfstart(file_id)

C     Create a new vdata.
C
vdata_ref = -1
vdata_id = vsfatch(file_id, vdata_ref, 'w')

C     Set name and class name of the vdata.
C
status = vsfsnam(vdata_id, VDATA_NAME)
status = vsfscls(vdata_id, CLASS_NAME)

C     Introduce each field’s name, data type, and order. This is the
C     first part in defining a field.
status = vsffdef(vdata_id, FIELD1_NAME, DFNT_FLOAT32, ORDER_1)
status = vsffdef(vdata_id, FIELD2_NAME, DFNT_FLOAT32, ORDER_2)
status = vsffdef(vdata_id, FIELD3_NAME, DFNT_FLOAT32, ORDER_3)

C
Finalize the definition of the fields.

C
status = vsfsfld(vdata_id, FIELDNAME_LIST)

C
Buffer the data by the record for fully interlaced mode. Note that the
first three elements contain the three values of the first field,
the forth element contains the value of the second field, and the last two
elements contain the two values of the third field.

do 10 rec_num = 1, N_RECORDS
   data_buf(1, rec_num) = 1.0 * rec_num
   data_buf(2, rec_num) = 2.0 * rec_num
   data_buf(3, rec_num) = 3.0 * rec_num
   data_buf(4, rec_num) = 0.1 + rec_num
   data_buf(5, rec_num) = 0.0
   data_buf(6, rec_num) = 65.0
10 continue

C
Write the data from data_buf to the vdata with the full interlacing mode.

C
num_of_records = vsfwrt(vdata_id, data_buf, N_RECORDS,
   + FULL_INTERLACE)

C
Terminate access to the vdata and to the VS interface, and
close the HDF file.

C
status = vsfdtch(vdata_id)
status = vfend(file_id)
status = hclose(file_id)
end

4.5.2.3 Setting Up Linked Block Vdatas: VSsetblocksize and VSsetnumblocks

Unless otherwise specified, Vdata data sets stored in linked blocks employ a default size and number
of linked blocks, as set in HDF_APPENDABLE_BLOCK_LEN and HDF_APPENDABLE_BLOCK_NUM,
respectively. VSsetblocksize and VSsetnumblocks provide a mechanism for managing these values
when the defaults are not appropriate.

VSsetblocksize and VSsetnumblocks can be called to change the default linked block settings.
The parameter vdata_id identifies the Vdata. The size of blocks is specified in bytes in
block_size and number of blocks in num_blocks.

VSsetblocksize and VSsetnumblocks must be called before any data is written to a Vdata; once a
linked block element has been created, neither the block size nor the number blocks can be
changed. Further note that VSsetblocksize sets the block size only for blocks following the first
block.

See the notes regarding the potential performance impact of block size in Section 14.4.2, "Tuning
Linked Block Size to Enhance Performance."

VSsetblocksize and VSsetnumblocks both return SUCCESS (or 0) upon successful completion or
FAIL (or -1). Their parameters are further defined in Table 4G.
### 4.5.2.4 Packing or Unpacking Field Data: VSfpack

Storing fields of mixed data types is an efficient use of disk space and is useful in applications that use structures. However, while data structures in memory containing fields of variable lengths can contain alignment bytes, field data stored in a vdata cannot include them. This is true for both fully-interlaced and non-interlaced data. Because of this storing limitation, when variable-length field types are used, it is generally not possible to write data directly from a structure in memory into a vdata in a file with a VSwrite call or to read data directly into a buffer from the vdata with a call to VSread. Thus, when writing, VSfpack is used to pack field data into a temporary buffer by removing the padding, or alignment bytes, and when reading, to unpack field data into vdata fields by adding necessary alignment bytes. The syntax for VSfpack is as follows:

**C:**

```c
status = VSfpack(vdata_id, action, fields_in_buf, buf, buf_size, n_records, fieldname_list, bufptrs);
```

**FORTRAN:**

```fortran
status = vsfcap(vdata_id, action, fields_in_buf, buf, buf_size, n_records, fieldname_list, bufptrs)
```

The process of removing the alignment bytes is called "packing the array." An illustration of this process is provided in Figure 4g. The data provided by the user is stored in the structure in memory. The field values are aligned with padded bytes. VSfpack packs the data into the array in memory after removing the padded bytes. The packed data is then written to the vdata in the file by VSwrite.

#### Removing Alignment Bytes When Writing Data From a C Structure to a Vdata

The process illustrated in Figure 4g can be read in the reverse direction for "un packing the array," that is when using VSfpack to fill a structure in memory with vdata field data. In this case, align-
ment bytes are added to the field data to make the data conform to the specific alignment requirements of the platform.

**VSfpack** performs both tasks, packing and unpacking, and the parameter *action* specifies the appropriate action for the routine. Valid values for the parameter *action* are _HDF_VSPACK_ (or 0) for packing and _HDF_VSPACK_ (or 1) for unpacking.

The calling program must allocate sufficient space for the buffer *buf* to hold all packed or unpacked fields. The parameter *buf_size* specifies the size of the buffer *buf* and should be at least *n_records* *(*(the total size of all fields specified in *fields_in_buf)*).

When **VSfpack** is called to pack field values into *buf*, the parameter *fields_in_buf* must specify all fields of the vdata. This can be accomplished either by listing all of the field names in *fields_in_buf* or by setting *fields_in_buf* to **NULL** in C or to one blank character in FORTRAN-77.

When **VSfpack** is called to unpack field values, the parameter *fields_in_buf* may specify a subset of the vdata fields. The parameter *fields_in_buf* can be set to **NULL** in C or to one space character in FORTRAN-77 to specify all fields in the vdata.

The parameter *fieldname_list* specifies the field(s) to be packed or unpacked. The parameter *bufptrs* provides pointers to the buffers for each field to be packed or unpacked. The calling program is responsible for allocating sufficient space for each field buffer. Significant differences between the C and FORTRAN-77 functionality are described in the following paragraphs.

In C, *fieldname_list* can list either all of the fields specified by *fields_in_buf* or a subset of those fields. Only if *fields_in_buf* specifies all of the vdata fields, then *fields_in_buf* can be set to **NULL** to specify all vdata fields. The parameter *bufptrs* contains an array of pointers to the buffers where field data will be packed or unpacked.

The FORTRAN-77 routines can pack or unpack only one field at a time, so the parameter *fieldname_list* contains only the name of that field. The parameter *bufptrs* is the buffer for that field.

The FORTRAN-77 version of **VSfpack** has two routines: **vsfcpak** packs or unpacks character data and **vsfnpak** packs or unpacks numeric data. Refer to the FORTRAN-77 version in Example 4 for a more specific illustration.

**VSfpack** returns either **SUCCEED** (or 0) or **FAIL** (or -1). The parameters for **VSfpack** are described in Table 4H.
TABLE 4H

VSfpack Parameter List

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSfpack</td>
<td>vdata_id</td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td>action</td>
<td>intn</td>
<td>Action to be performed</td>
</tr>
<tr>
<td></td>
<td>fields_in_buf</td>
<td>char *</td>
<td>Fields in the buffer to write or read from the vdata</td>
</tr>
<tr>
<td></td>
<td>buf</td>
<td>VOIDP</td>
<td>Buffer for the vdata values</td>
</tr>
<tr>
<td></td>
<td>buf_size</td>
<td>intn</td>
<td>Buffer size in bytes</td>
</tr>
<tr>
<td></td>
<td>n_records</td>
<td>intn</td>
<td>Number of records to pack or unpack</td>
</tr>
<tr>
<td></td>
<td>fieldname_list</td>
<td>char *</td>
<td>Names of the fields to be packed or unpacked</td>
</tr>
<tr>
<td></td>
<td>bufptrs</td>
<td>VOIDP</td>
<td>Array of pointers to the field buffers in C and field buffer in FORTRAN-77</td>
</tr>
</tbody>
</table>

Writing a Multi-field and Mixed-type Vdata with Packing

This example illustrates the use of VSfpack/vsfnpak/vsfcpak and VSwrite/vsfwrit to write a vdata with data of different types. Note that the approach used in Example 3 makes it difficult for the vdata to have mixed-type data.

In this example, the program creates an HDF file, named "Packed_Vdata.hdf", then defines a vdata which is named "Mixed Data Vdata" and belongs to class "General Data Class". The vdata contains four order-1 fields, "Temp", "Height", "Speed", and "Ident" of type float32, int16, float32, and char8, respectively. The program then packs the data in fully interlaced mode into a databuf and writes the packed data to the vdata. Note that, in the C example, a VSfpack call packs all N_RECORDS and a VSwrite call writes out all N_RECORDS records. In the Fortran example, N_RECORDS of each field are packed using separate calls to vsfnpak and vsfcpak; vsfwrit writes packed data to the vdata.

C:

```c
#include "hdf.h"
#define FILE_NAME        "Packed_Vdata.hdf"
#define VDATA_NAME       "Mixed Data Vdata"
#define CLASS_NAME       "General Data Class"
#define FIELD1_NAME      "Temp"
#define FIELD2_NAME      "Height"
#define FIELD3_NAME      "Speed"
#define FIELD4_NAME      "Ident"
#define ORDER            1    /* number of values in the field */
#define N_RECORDS        20   /* number of records the vdata contains */
#define N_FIELDS         4    /* number of fields in the vdata */
#define FIELDNAME_LIST   "Temp,Height,Speed,Ident" /* No spaces b/w names */

/* number of bytes of the data to be written, i.e., the size of all the field values combined times the number of records */
#define BUF_SIZE (2*sizeof(float32) + sizeof(int16) + sizeof(char)) * N_RECORDS

main ( )
{  
    /************************* Variable declaration **************************/
    intn status_n; /* returned status for functions returning an intn */
```
```c
int32 status_32, /* returned status for functions returning an int32 */
    file_id, vdata_id,
    vdata_ref = -1, /* vdata's reference number, set to -1 to create */
    num_of_records; /* number of records actually written to the vdata */
float32 temp[N_RECORDS]; /* buffer to hold values of first field */
int16   height[N_RECORDS]; /* buffer to hold values of second field */
float32 speed[N_RECORDS];   /* buffer to hold values of third field */
char8   ident[N_RECORDS];   /* buffer to hold values of fourth field */
VOIDP   fldbufptrs[N_FIELDS];/* pointers to be pointing to the field buffers*/
uint16  databuf[BUF_SIZE]; /* buffer to hold the data after being packed*/
    int    i;

/************************** End of variable declaration **************************/

/*
* Create an HDF file.
*/
file_id = Hopen (FILE_NAME, DFACC_CREATE, 0);

/*
* Initialize the VS interface.
*/
status_n = Vstart (file_id);

/*
* Create a new vdata.
*/
  vdata_id = VSattach (file_id, vdata_ref, "w");

/*
* Set name and class name of the vdata.
*/
  status_32 = VSsetname (vdata_id, VDATA_NAME);
  status_32 = VSsetclass (vdata_id, CLASS_NAME);

/*
* Introduce each field's name, data type, and order. This is the first
* part in defining a vdata field.
*/
status_n = VSfdefine (vdata_id, FIELD1_NAME, DFNT_FLOAT32, ORDER);
status_n = VSfdefine (vdata_id, FIELD2_NAME, DFNT_INT16, ORDER);
status_n = VSfdefine (vdata_id, FIELD3_NAME, DFNT_FLOAT32, ORDER);
status_n = VSfdefine (vdata_id, FIELD4_NAME, DFNT_CHAR8, ORDER);

/*
* Finalize the definition of the fields of the vdata.
*/
status_n = VSsetfields (vdata_id, FIELDNAME_LIST);

/*
* Enter data values into the field buffers by the records.
*/
for (i = 0; i < N_RECORDS; i++)
{
    temp[i] = 1.11 * (i+1);
    height[i] = i;
    speed[i] = 1.11 * (i+1);
    ident[i] = 'A' + i;
}

/*
* Build an array of pointers each of which points to a field buffer that
```
* holds all values of the field.
*/
fldbufptrs[0] = &temp[0];
fldbufptrs[1] = &height[0];
fldbufptrs[2] = &speed[0];
fldbufptrs[3] = &ident[0];

/*
* Pack all data in the field buffers that are pointed to by the set of
* pointers fldbufptrs, and store the packed data into the buffer
* databuf.  Note that the second parameter is _HDF_VSPACK for packing.
*/
status_n = VSfpack (vdata_id,_HDF_VSPACK, NULL, (VOIDP)databuf,
                    BUF_SIZE, N_RECORDS, NULL, (VOIDP)fldbufptrs);

/*
* Write all records of the packed data to the vdata.
*/
um_of_records = VSwrite (vdata_id, (uint8 *)databuf, N_RECORDS,
                       FULL_INTERLACE);

/*
* Terminate access to the vdata and the VS interface, then close
* the HDF file.
*/
status_32 = VSdetach (vdata_id);
status_n = Vend (file_id);
status_32 = Hclose (file_id);
}

FORTRAN:

program write_mixed_vdata
implicit none
C
C     Parameter declaration
C
character*16 FILE_NAME    
character*18 CLASS_NAME   
character*16 VDATA_NAME   
character*4  FIELD1_NAME  
character*6  FIELD2_NAME  
character*5  FIELD3_NAME  
character*5  FIELD4_NAME  
character*23 FIELDNAME_LIST
integer      N_RECORDS, N_FIELDS, ORDER
integer      BUF_SIZE
C
parameter (FILE_NAME        = 'Packed_Vdata.hdf',
+            CLASS_NAME       = 'General Data Class',
+            VDATA_NAME       = 'Mixed Data Vdata',
+            FIELD1_NAME     = 'Temp',
+            FIELD2_NAME     = 'Height',
+            FIELD3_NAME     = 'Speed',
+            FIELD4_NAME     = 'Ident',
+            FIELDNAME_LIST  = 'Temp,Height,Speed,Ident')
parameter (N_RECORDS = 20,
+            N_FIELDS  = 4,
+            ORDER     = 1,
+            BUF_SIZE  = (4 + 2 + 4 + 1)*N_RECORDS)

integer DFACC_WRITE, DFNT_FLOAT32, DFNT_INT16, DFNT_CHAR8,
+            FULL_INTERLACE, HDF_VSPACK
C **** Variable declaration *******************************************
C
integer   status
integer   file_id, vdata_id
integer   vdata_ref, num_of_records
real      temp(N_RECORDS)
integer*2 height(N_RECORDS)
real      speed(N_RECORDS)
character ident(N_RECORDS)
integer   i
C Buffer for packed data should be big enough to hold N_RECORDS.
C integer   databuf(BUF_SIZE/4 + 1)
C**** End of variable declaration ************************************
C
C     Open the HDF file for writing.
C
file_id = hopen(FILE_NAME, DFACC_WRITE, 0)
C
C     Initialize the VS interface.
C
status = vfstart(file_id)
C
C Create a new vdata.
C
vdata_ref = -1
vdata_id = vsfatch(file_id, vdata_ref, 'w')
C
C Set name and class name of the vdata.
C
status = vsfsnam(vdata_id, VDATA_NAME)
status = vsfscls(vdata_id, CLASS_NAME)
C
C Introduce each field's name, data type, and order. This is the
C first part in defining a field.
C
status = vsffdef(vdata_id, FIELD1_NAME, DFNT_FLOAT32, ORDER)
status = vsffdef(vdata_id, FIELD2_NAME, DFNT_INT16, ORDER)
status = vsffdef(vdata_id, FIELD3_NAME, DFNT_FLOAT32, ORDER)
status = vsffdef(vdata_id, FIELD4_NAME, DFNT_CHAR8, ORDER)
C
C Finalize the definition of the fields.
C
status = vsfsfld(vdata_id, FIELDNAME_LIST)
C
C Enter data values into the field databufs by the records.
do 10 i = 1, N_RECORDS
   temp(i) = 1.11 * i
   height(i) = i - 1
   speed(i) = 1.11 * i
   ident(i) = char(64+i)
10    continue

Pack N_RECORDS of data into databuf. In Fortran, each field is packed using separate calls to vsfnpak or vsfcpak.

status = vsfnpak(vdata_id, HDF_VSPACK, ' ', databuf, BUF_SIZE, + N_RECORDS, FIELD1_NAME, temp)
status = vsfnpak(vdata_id, HDF_VSPACK, ' ', databuf, BUF_SIZE, + N_RECORDS, FIELD2_NAME, height)
status = vsfnpak(vdata_id, HDF_VSPACK, ' ', databuf, BUF_SIZE, + N_RECORDS, FIELD3_NAME, speed)
status = vsfcpak(vdata_id, HDF_VSPACK, ' ', databuf, BUF_SIZE, + N_RECORDS, FIELD4_NAME, ident)

Write all the records of the packed data to the vdata.

num_of_records = vsfwrit(vdata_id, databuf, N_RECORDS, + FULL_INTERLACE)

Terminate access to the vdata and to the VS interface, and close the HDF file.

status = vsfdtch(vdata_id)
status = vfend(file_id)
status = hclose(file_id)
end

4.6 Reading from Vdatas

Reading from vdatas is more complicated than writing to vdatas, as it usually involves searching for a particular vdata, then searching within that vdata, before actually reading data. The process of reading from vdatas can be summarized as follows:

10. Identify the appropriate vdata in the file.
11. Obtain information about the vdata.
12. Read in the desired data.

Only Step 3 will be covered in this section assuming that the vdata of interest and its data information is known. Step 1 is covered in Section 4.7 on page 166 and Step 2 is covered in Section 4.9 on page 180.

Step 3 can be expanded into the following:

1. Open the file.
2. Initialize the Vdata interface.
3. Initiate access to the vdata.
4. Optionally seek to the appropriate record.
5. Initialize the fields to be read.
6. Read the data.
7. If the fields have different data types, unpack the field data.
8. Terminate access to the vdata.
9. Terminate access to the Vdata interface.

The following sequence of function calls corresponds to the above steps:

**C:**
```c
file_id = Hopen(filename, file_access_mode, num_dds_block);
status = Vstart(file_id);
vdata_id = VSAttach(file_id, vdata_ref, vdata_access_mode);
record_pos = VSseek(vdata_id, record_index);
status = VSsetfields(vdata_id, fieldname_list);
records_read = VSread(vdata_id, databuf, n_records, interlace_mode);
status = VSfpack(vdata_id, action, fields_in_buf, buf, buf_size, n_records, fieldname_list, bufptrs);
status = VSdetach(vdata_id);
status = Vend(file_id);
status = Hclose(file_id);
```

**FORTRAN:**
```fortran
file_id = hopen(filename, file_access_mode, num_dds_block)
status = vfstart(file_id)
vdata_id = vsfatch(file_id, vdata_ref, vdata_access_mode)
record_pos = vsfseek(file_id, record_index)
status = vsfsfld(file_id, fieldname_list)
records_read = vsfrd(file_id, databuf, n_records, interlace_mode)
OR
records_read = vsfrdc(file_id, databuf, n_records, interlace_mode)
status = vsfcpak(file_id, action, fields_in_buf, buf, buf_size, n_records, fieldname_list, bufptrs)
OR
status = vsfnpak(file_id, action, fields_in_buf, buf, buf_size, n_records, fieldname_list, bufptrs)
status = vsfdtch(file_id)
status = vfend(file_id)
status = hclose(file_id)
```

### 4.6.1 Initializing the Fields for Read Access: VSsetfields

**VSsetfields** establishes access to the fields to be read by the next read operation. The argument `fieldname_list` is a comma-separated string of the field names with no white space. The order the field names occur in `fieldname_list` is the order in which the fields will be read. For example, assume that a vdata contains fields named A, B, C, D, E, F in that order. The following declarations demonstrate how to use `fieldname_list` to read a single field, a collection of random fields, and all the fields in reverse order:

- **Single field:** `fieldname_list = “B”`
- **Collection of fields:** `fieldname_list = “A,E”`
- **Reverse order:** `fieldname_list = “F,E,D,C,B,A”`

**VSsetfields** returns either **SUCCEED** (or 0) or **FAIL** (or -1). The parameters for **VSsetfields** are further defined in Table 4E on page 143.

### 4.6.2 Reading from the Current Vdata: VSread

**VSread** sequentially retrieves data from the records in a vdata. The parameter `databuf` is the buffer to store the retrieved data, `n_records` specifies the number of records to retrieve, and
interlace_mode specifies the interlace mode, FULL_INTERLACE (or 0) or NO_INTERLACE (or 1), to be used in the contents of databuf.

Prior to the first VSread call, VSsetfields must be called.

If a VSread call is successful, the data returned in databuf is formatted according to the interlace mode specified by the parameter interlace_mode and the data fields appear in the order specified in the last call to VSsetfields for that vdata.

By default, VSread reads from the first vdata record. To retrieve an arbitrary record from a vdata, use VSseek to specify the record position before calling VSread. VSseek is described in Section 4.5.2.1 on page 144.

The FORTRAN-77 version of VSread has three routines: vsfrd reads buffered numeric data, vsfrdc reads buffered character data and vsfread reads generic packed data.

VSread returns the total number of records read if successful and FAIL (or -1) otherwise. The parameters for VSread are further defined in Table 4I.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSread</td>
<td>vdata_id</td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td>databuf</td>
<td>uint8*</td>
<td>Buffer for the retrieved data</td>
</tr>
<tr>
<td></td>
<td>n_records</td>
<td>int32</td>
<td>Number of records to be retrieved</td>
</tr>
<tr>
<td></td>
<td>interlace_mode</td>
<td>int32</td>
<td>Interlace mode of the buffered data</td>
</tr>
</tbody>
</table>

VSsetfields and VSread may be called several times to read from the same vdata. However, note that VSread operations are sequential. Thus, in the following code segment, the first call to VSread returns ten “A” data values from the first ten elements in the vdata, while the second call to VSread returns ten “B” data values from the second ten elements (elements 10 to 19) in the vdata.

```fortran
status = VSsetfields(vdata_id, "A");
records_read = VSread(vdata_id, bufferA, 10, interlace_mode);
status = VSsetfields(vdata_id, "B");
records_read = VSread(vdata_id, bufferB, 10, interlace_mode);
```

To read the first ten “B” data values, the access routine VSseek must be called to explicitly position the read pointer back to the position of the first record. The following code segment reads the first ten “A” and “B” values into two separate float arrays bufferA and bufferB.

```fortran
status = VSsetfields(vdata_id, "A");
records_read = VSread(vdata_id, bufferA, 10, interlace_mode);
record_pos = VSseek(vdata_id, 0); /* seeks to first record */
status = VSsetfields(vdata_id, "B");
records_read = VSread(vdata_id, bufferB, 10, interlace_mode);
```
EXAMPLE 5.

**Reading a Vdata of Homogeneous Type**

This example illustrates the use of `VSfind/vsfind` to locate a vdata given its name, `VSseek/vsfseek` to move the current position to a desired record, and `VSread/vsfread` to read the data of several records. The function `VSfind` will be discussed in Section 4.7.3. The approach used in this example can only read data written by a program such as that in Example 3, i.e., without packing. Reading mixed data vdatas must use the approach illustrated in Example 6.

The program reads 5 records starting from the fourth record of the two fields "Position" and "Temperature" in the vdata "Solid Particle" from the file "General_Vdatas.hdf". After the program uses `VSfind/vsfind` to obtain the reference number of the vdata, it uses `VSseek/vsfseek` to place the current position at the fourth record, then starts reading 5 records, and displays the data.

C:

```c
#include "hdf.h"
#define FILE_NAME "General_Vdatas.hdf"
#define VDATA_NAME "Solid Particle"
#define N_RECORDS 5 /* number of records the vdata contains */
#define RECORD_INDEX 3 /* position where reading starts - 4th record */
#define ORDER_1 3 /* order of first field to be read */
#define ORDER_2 2 /* order of second field to be read */
#define FIELDNAME_LIST "Position,Temperature" /* only two fields are read */
#define N_VALS_PER_REC (ORDER_1 + ORDER_2) /* number of values per record */

main( ) {
    /***********************************************************************
    ** Variable declaration ***********************************************
    ***********************************************************************/
    int status_n; /* returned status for functions returning an intn */
    int32 status_32, /* returned status for functions returning an int32 */
    file_id, vdata_id,
    vdata_ref, /* vdata's reference number */
    num_of_records, /* number of records actually written to the vdata */
    record_pos; /* position of the current record */
    int16 i, rec_num; /* current record number in the vdata */
    float32 databuf[N_RECORDS][N_VALS_PER_REC]; /* buffer for vdata values */

    /***********************************************************************************/
    /* */
    /* Open the HDF file for reading. */
    /*
    file_id = Hopen (FILE_NAME, DFACC_READ, 0);
    */
    /* */
    /* Initialize the VS interface. */
    /*
    status_n = Vstart (file_id);
    */
    /* */
    /* Get the reference number of the vdata, whose name is specified in */
    /* VDATA_NAME, using VSfind, which will be discussed in Section 4.7.3. */
    /*
    vdata_ref = VSfind (file_id, VDATA_NAME);
    */
    /* */
    /* Attach to the vdata for reading if it is found, otherwise */
    /* exit the program. */
```
if (vdata_ref == 0) exit;
vdata_id = VSAttach (file_id, vdata_ref, "r");

/*
 * Specify the fields that will be read.
*/
status_n = VSsetfields (vdata_id, FIELDNAME_LIST);

/*
 * Place the current point to the position specified in RECORD_INDEX.
*/
record_pos = VSseek (vdata_id, RECORD_INDEX);

/*
 * Read the next N_RECORDS records from the vdata and store the data
 * in the buffer databuf with fully interlaced mode.
*/
um_of_records = VSread (vdata_id, (uint8 *)databuf, N_RECORDS,
                      FULL_INTERLACE);

/*
 * Display the read data as many records as the number of records
 * returned by VSread.
*/
printf ("\n Particle Position Temperature Range\n\n");
for (rec_num = 0; rec_num < num_of_records; rec_num++)
{
    printf (" %6.2f, %6.2f, %6.2f %6.2f\n",
            databuf[rec_num][0], databuf[rec_num][1], databuf[rec_num][2],
            databuf[rec_num][3], databuf[rec_num][4]);
}

/*
 * Terminate access to the vdata and to the VS interface, then close
 * the HDF file.
*/
status_32 = VSdetach (vdata_id);
status_n = Vend (file_id);
status_32 = Hclose (file_id);

---

FORTRAN:

program read_from_vdata
    implicit none
    C
    C     Parameter declaration
    C
    character*18 FILE_NAME
    character*14 VDATA_NAME
    character*20 FIELDNAME_LIST
    integer      N_RECORDS, RECORD_INDEX
    integer      ORDER_1, ORDER_2
    integer      N_VALS_PER_REC
    C
    parameter (FILE_NAME = 'General_Vdatas.hdf',
               VDATA_NAME = 'Solid Particle',
               FIELDNAME_LIST = 'Position, Temperature')
    parameter (N_RECORDS = 5,
               RECORD_INDEX = 3,
               ORDER_1 = 3,
               ORDER_2 = 2,
               N_VALS_PER_REC = ORDER_1 + ORDER_2 )
integer DFACC_READ, FULL_INTERLACE
parameter (DFACC_READ = 1,
+       FULL_INTERLACE = 0)

C Function declaration
integer hopen, hclose
integer vfstart, vsffnd, vsfatch, vsfsfld, vsfrd, vsfseek, 
+       vsfdtch, vfend

C**** Variable declaration ****************************************************
integer status
integer file_id, vdata_id
integer vdata_ref, rec_num, num_of_records, rec_pos
real    databuf(N_VALS_PER_REC, N_RECORDS)
integer i

C**** End of variable declaration **********************************************
C
C Open the HDF file for reading.
file_id = hopen(FILE_NAME, DFACC_READ, 0)
C
C Initialize the VS interface.
status = vfstart(file_id)
C
C Get the reference number of the vdata, whose name is specified in
C VDATA_NAME, using vsffnd, which will be discussed in Section 4.7.3.
C
vdata_ref = vsffnd(file_id, VDATA_NAME)
C
C Attach to the vdata for reading if it is found,
C otherwise exit the program.
if (vdata_ref .eq. 0) stop
vdata_id = vsfatch(file_id, vdata_ref, 'r')
C
C Specify the fields that will be read.
status = vsfsfld(vdata_id, FIELDNAME_LIST)
C
C Place the current point to the position specified in RECORD_INDEX.
rec_pos = vsfseek(vdata_id, RECORD_INDEX)
C
C Read the next N_RECORDS from the vdata and store the data in the buffer
databuf with fully interlace mode.
num_of_records = vsfrd(vdata_id, databuf, N_RECORDS,
+                  FULL_INTERLACE)
C
C Display the read data as many records as the number of records returned
by vsfrd.
write(*,*) '  Particle Position     Temperature Range'
write(*,*)
do 10 rec_num = 1, num_of_records
   write(*,1000) (databuf(i, rec_num), i = 1, N_VALS_PER_REC)
EXAMPLE 6.

Reading a Multi-field and Mixed-type Vdata with Packing

This example illustrates the use of **VSread/vsfread** to read part of a mixed data vdata and **VSfpack/vsfnpak/vsfcpak** to unpack the data read.

The program reads the vdata "Mixed Data Vdata" that was written to the file "Packed_Vdata.hdf" by the program in Example 4. In Example 6, all values of the fields "Temp" and "Ident" are read. The program unpacks and displays all the values after reading is complete. Again, note that in C only one call to **VSread** and one call to **VSfpack** are made to read and unpack all N_RECORDS records. In Fortran, data is read with one call to **vsfread**, but each field is unpacked using separate calls to **vsfnpak** and **vsfcpak**

C:

```c
#include "hdf.h"

#define N_RECORDS 20      /* number of records to be read */
#define N_FIELDS 2       /* number of fields to be read */
#define FILE_NAME "Packed_Vdata.hdf"
#define VDATA_NAME "Mixed Data Vdata"
#define FIELDNAME_LIST "Temp,Ident"

/* number of bytes of the data to be read */
#define BUFFER_SIZE ( sizeof(float32) + sizeof(char)) * N_RECORDS

main () {
    /*---------------------------- Variable declaration -----------------------------*/
    int n status_n;      /* returned status for functions returning an int */
    int32 status_32,       /* returned status for functions returning an int32 */
    file_id, vdata_id,
    num_of_records,       /* number of records actually read */
    vdata_ref,            /* reference number of the vdata to be read */
    buffer_size;          /* number of bytes the vdata can hold */
    float32 itemp[N_RECORDS]; /* buffer to hold values of first field */
    char idents[N_RECORDS]; /* buffer to hold values of fourth field */
    uint8 databuf[BUFFER_SIZE]; /* buffer to hold read data, still packed */
    VOIDP fldbufptrs[N_FIELDS]; /* pointers to be pointing to the field buffers */
    int i;

    /*---------------------------- End of variable declaration -----------------------------*/

    /*
    * Open the HDF file for reading.
    */
    file_id = Hopen (FILE_NAME, DFACC_READ, 0);
    /*
/* Initialize the VS interface. */
status_n = Vstart (file_id);

/*
* Get the reference number of the vdata, whose name is specified in
* VDATA_NAME, using VSfind, which will be discussed in Section 4.7.3.
*/
vdata_ref = VSfind (file_id, VDATA_NAME);

/*
* Attach to the vdata for reading.
*/
vdata_id = VSattach (file_id, vdata_ref, "r");

/*
* Specify the fields that will be read.
*/
status_n = VSsetfields(vdata_id, FIELDNAME_LIST);

/*
* Read N_RECORDS records of the vdata and store the values into the
* buffer databuf.
*/
num_of_records = VSread (vdata_id, (uint8 *)databuf, N_RECORDS,
FULL_INTERLACE);

/*
* Build an array of pointers each of which points to an array that
* will hold all values of a field after being unpacked.
*/
fldbufptrs[0] = &itemp[0];
fldbufptrs[1] = &idents[0];

/*
* Unpack the data from the buffer databuf and store the values into the
* appropriate field buffers pointed to by the set of pointers fldbufptrs.
* Note that the second parameter is _HDF_VSUNPACK for unpacking and the
* number of records is the one returned by VSread.
*/
status_n = VSfpack (vdata_id, _HDF_VSUNPACK, FIELDNAME_LIST, (VOIDP)databuf,
BUFFER_SIZE, num_of_records, NULL, (VOIDP)fldbufptrs);

/*
* Display the read data being stored in the field buffers.
*/
printf ("\n Temp     Ident\n");
for (i=0; i < num_of_records; i++)
    printf (" %6.2f     %c\n", itemp[i], idents[i]);

/*
* Terminate access to the vdata and the VS interface, then close
* the HDF file.
*/
status_32 = VSdetach (vdata_id);
status_n = Vend (file_id);
status_32 = Hclose (file_id);
}
FORTRAN:

```fortran
program read_mixed_vdata
  implicit none
  
  Parameter declaration
  
  character*16 FILE_NAME
  character*16 VDATA_NAME
  character*4  FIELD1_NAME
  character*5  FIELD2_NAME
  character*10 FIELDNAME_LIST
  integer      N_RECORDS, N_FIELDS
  integer      BUFFER_SIZE
  
  parameter (FILE_NAME = 'Packed_Vdata.hdf',
             VDATA_NAME = 'Mixed Data Vdata',
             FIELD1_NAME = 'Temp',
             FIELD2_NAME = 'Ident',
             FIELDNAME_LIST = 'Temp,Ident')
  parameter (N_RECORDS = 20,
             N_FIELDS = 2,
             BUFFER_SIZE = (4 + 1)*N_RECORDS)

  integer DFACC_READ, DFNT_FLOAT32, DFNT_CHAR8,
          FULL_INTERLACE, HDF_VSUNPACK
  parameter (DFACC_READ = 1,
             DFNT_FLOAT32 = 5,
             DFNT_CHAR8 = 4,
             FULL_INTERLACE = 0,
             HDF_VSUNPACK = 1)

  Function declaration

  integer hopen, hclose
  integer vfstart, vsfatch, vsffnd, vsfsfld,
          vsfnpak, vsfcpak, vsfread, vsfdtch, vfend

  **** Variable declaration *******************************************

  integer   status
  integer   file_id, vdata_id
  integer   vdata_ref, num_of_records
  real      temp(N_RECORDS)
  character ident(N_RECORDS)
  integer   i

  Buffer for read packed data should be big enough to hold N_RECORDS.

  integer databuf(BUFFER_SIZE/4 + 1)

  **** End of variable declaration ************************************

  Open the HDF file for reading.

  file_id = hopen(FILE_NAME, DFACC_READ, 0)

  Initialize the VS interface.

  status = vfstart(file_id)
```
Get the reference number of the vdata, whose name is specified in VDATA_NAME, using vsffnd, which will be discussed in Section 4.7.3.

vdata_ref = vsffnd(file_id, VDATA_NAME)

Attach to the vdata for reading if it is found, otherwise exit the program.

if (vdata_ref .eq. 0) stop
vdata_id = vsfatch(file_id, vdata_ref, 'r')

Specify the fields that will be read.

status = vsfsfld(vdata_id, FIELDNAME_LIST)

Read N_RECORDS records of the vdata and store the values into the databuf.

num_of_records = vsfread(vdata_id, databuf, N_RECORDS, FULL_INTERLACE)

Unpack N_RECORDS from databuf into temp and ident arrays.

In Fortran, each field is unpacked using separate calls to vsfnpak or vsfcpak.

status = vsfnpak(vdata_id, HDF_VSUNPACK, FIELDNAME_LIST, databuf, BUFFER_SIZE, num_of_records, FIELD1_NAME, temp)
status = vsfcpak(vdata_id, HDF_VSUNPACK, FIELDNAME_LIST, databuf, BUFFER_SIZE, num_of_records, FIELD2_NAME, ident)

Display the read data being stored in the field databufs.

write (*,*) '    Temp  Ident'
do 10 i = 1, num_of_records
   write(*,1000) temp(i), ident(i)
10    continue
1000  format (3x,F6.2, 4x, a)

Terminate access to the vdata and to the VS interface, and close the HDF file.

status = vsfdtch(vdata_id)
status = vfend(file_id)
status = hclose(file_id)
end

4.7 Searching for Vdatas in a File

There are several HDF library routines that perform searches for a specific vdata in a file. In this section, we introduce these routines; methods for obtaining information about the members of a given vdata are described in the following section.

4.7.1 Finding All Vdatas that are Not Members of a Vgroup: VSlone

A lone vdata is one that is not a member of a vgroup. Vgroups are HDF objects that contain sets of HDF objects, including vgroups. Vgroups are described in Chapter 5, Vgroups (VAPI).
**VS lone** searches an HDF file and retrieves the reference numbers of lone vdatas in the file. The syntax of **VS lone** is as follows:

**C:** 
num_of_lone_vdatas = VS lone(file_id, ref_array, maxsize);

**FORTRAN:** 
num_of_lone_vdatas = vsflone(file_id, ref_array, maxsize)

The parameter ref_array is an array allocated to hold the retrieved reference numbers of lone vdatas and the argument maxsize specifies the maximum size of ref_array. At most, maxsize reference numbers will be returned in ref_array.

The space that should be allocated for ref_array is dependent upon on how many lone vdatas are expected in the file. A size of MAX FIELD SIZE (or 65535) integers is adequate to handle any case. To use dynamic memory instead of allocating such a large array, first call **VS lone** with maxsize set to a small value like 0 or 1, then use the returned value to allocate memory for ref_array to be passed to a subsequent call to **VS lone**.

**VS lone** returns the number of lone vdatas or FAIL (or -1). The parameters for **VS lone** are listed in Table 4J on page 168.

### 4.7.2 Sequentially Searching for a Vdata: **VS getid**

**VS getid** sequentially searches through an HDF file to obtain the vdata immediately following the vdata specified by the reference number in the parameter vdata_ref. The syntax of **VS getid** is as follows:

**C:** 
ref_num = VS getid(file_id, vdata_ref);

**FORTRAN:** 
ref_num = vsfgid(file_id, vdata_ref)

To obtain the reference number of the first vdata in the file, the user must set the parameter vdata_ref to -1. Thus, **VS getid** can be repeatedly called, with the initial value of vdata_ref set to -1 so that the routine will sequentially return the reference number of each vdata in the file, starting from the first vdata. After the last vdata is reached, subsequent calls to **VS getid** will return FAIL (or -1).

**VS getid** returns a vdata reference number or FAIL (or -1). The parameters for **VS getid** are listed in Table 4J on page 168.

### 4.7.3 Determining a Reference Number from a Vdata Name: **VS find**

**VS find** searches an HDF file for a vdata with the specified name and returns the vdata reference number. The syntax of **VS find** is as follows:

**C:** 
ref_num = VS find(file_id, vdata_name);

**FORTRAN:** 
ref_num = vsffnd(file_id, vdata_name)

The parameter vdata_name is the search key. Although there may be several identically named vdatas in the file, **VS find** will only return the reference number of the first vdata in the file with the specified name.

**VS find** returns either the vdata reference number if the named vdata is found or 0 otherwise. The parameters for **VS find** are listed in Table 4J.
4.7.4 Searching for a Vdata by Field Name: VSfexist

**VSfexist** queries a vdata for a set of specified field names and is often useful for locating vdatas containing particular field names. The syntax of the **VSfexist** function is as follows:

C: \[
\text{status} = \text{VSfexist}(vdata\_id, \text{fieldname\_list});
\]

FORTRAN: \[
\text{status} = \text{vsfex}(vdata\_id, \text{fieldname\_list})
\]

The parameter fieldname_list is a string of comma-separated field names containing no white space, for example, "PX, PY, PZ".

**VSfexist** returns SUCCEED (or 0) if all of the fields specified in the parameter fieldname_list are found and FAIL (or -1) otherwise. The parameters for **VSfexist** are listed in Table 4J.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VSlone</strong></td>
<td>file_id</td>
<td>int32</td>
<td>File identifier</td>
</tr>
<tr>
<td>(vslone)</td>
<td>ref_array</td>
<td>int32 [ ]</td>
<td>Buffer for a list of lone vdata reference numbers</td>
</tr>
<tr>
<td></td>
<td>maxsize</td>
<td>int32</td>
<td>Maximum number of reference numbers to be buffered</td>
</tr>
<tr>
<td><strong>VSgetid</strong></td>
<td>file_id</td>
<td>int32</td>
<td>File identifier</td>
</tr>
<tr>
<td>(vsfgid)</td>
<td>vdata_ref</td>
<td>int32</td>
<td>Reference number of the vdata preceding the vdata</td>
</tr>
<tr>
<td><strong>VSfind</strong></td>
<td>file_id</td>
<td>int32</td>
<td>File identifier</td>
</tr>
<tr>
<td>(vsffnd)</td>
<td>vdata_name</td>
<td>char *</td>
<td>Name of the vdata to find</td>
</tr>
<tr>
<td><strong>VSfexist</strong></td>
<td>vdata_id</td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td>(vsfex)</td>
<td>fieldname_list</td>
<td>char *</td>
<td>Names of the fields to be queried</td>
</tr>
</tbody>
</table>

### TABLE 4J

**VSfexist** queries a vdata for a set of specified field names and is often useful for locating vdatas containing particular field names. The syntax of the **VSfexist** function is as follows:

C: \[
\text{status} = \text{VSfexist}(vdata\_id, \text{fieldname\_list});
\]

FORTRAN: \[
\text{status} = \text{vsfex}(vdata\_id, \text{fieldname\_list})
\]

The parameter fieldname_list is a string of comma-separated field names containing no white space, for example, "PX, PY, PZ".

**VSfexist** returns SUCCEED (or 0) if all of the fields specified in the parameter fieldname_list are found and FAIL (or -1) otherwise. The parameters for **VSfexist** are listed in Table 4J.

---

**Locating a Vdata Containing Specified Field Names**

This example illustrates the use of **VSgetid/vsfgid** to obtain the reference number of each vdata in an HDF file and the use of **VSfexist/vsfex** to determine whether a vdata contains specific fields.

In this example, the program searches the HDF file "General_Vdatas.hdf" to locate the first vdata containing the fields "Position" and "Temperature". The HDF file is an output of the program in Example 3.

C:

```c
#include "hdf.h"

#define FILE_NAME         "General_Vdatas.hdf"
#define SEARCHED_FIELDS   "Position, Temperature"

main( )
{
    /****************************************** Variable declaration ******************************************/

    intn status_n; /* returned status for functions returning an intn */
    int32 status_32, /* returned status for functions returning an int32 */
        file_id, vdata_id, vdata_ref,
        index = 0; /* index of the vdata in the file - manually kept */
    int8 found_fields; /* TRUE if the specified fields exist in the vdata */

    /****************************************** End of variable declaration ******************************************/
```
/* 
* Open the HDF file for reading.
*/
file_id = Hopen (FILE_NAME, DFACC_READ, 0);

/* 
* Initialize the VS interface.
*/
status_n = Vstart (file_id);

/* 
* Set the reference number to -1 to start the search from 
* the beginning of file.
*/
vdata_ref = -1;

/* 
* Assume that the specified fields are not found in the current vdata.
*/
found_fields = FALSE;

/* 
* Use VSgetid to obtain each vdata by its reference number then 
* attach to the vdata and search for the fields. The loop 
* terminates when the last vdata is reached or when a vdata which 
* contains the fields listed in SEARCHED_FIELDS is found.
*/
while ((vdata_ref = VSgetid (file_id, vdata_ref)) != FAIL)
{
  vdata_id = VSattach (file_id, vdata_ref, "r");
  if ((status_n = Vsexist (vdata_id, SEARCHED_FIELDS)) != FAIL)
    { 
      found_fields = TRUE;
      break;
    }

  /* 
  * Detach from the current vdata before continuing searching. 
  */
  status_32 = Vsdetach (vdata_id);
  index++; /* advance the index by 1 for the next vdata */
}

/* 
* Print the index of the vdata containing the fields or a "not found" 
* message if no such vdata is found. Also detach from the vdata found. 
*/
if (!found_fields)
  printf ("Fields Position and Temperature were not found.\n");
else
  {
    printf ("Fields Position and Temperature found in the vdata at position %d\n",
            index);
    status_32 = Vsdetach (vdata_id);
  }

/* 
* Terminate access to the VS interface and close the HDF file. 
*/
status_n = Vend (file_id);
status_32 = Hclose (file_id);
}

FORTRAN:

program locate_vdata
implicit none
C
C     Parameter declaration
C
character*18 FILE_NAME
character*20 SEARCHED_FIELDS
C
parameter (FILE_NAME = 'General_Vdatas.hdf',
           SEARCHED_FIELDS = 'Position, Temperature')
integer DFACC_READ
parameter (DFACC_READ = 1)
C
C     Function declaration
C
integer hopen, hclose
integer vfstart, vsfatch, vsfgid, vsfex, vsfdtch, vfend
C
C**** Variable declaration ******************************************
C
integer status
integer file_id, vdata_id, vdata_ref
integer index
logical found_fields
C
C**** End of variable declaration ************************************
C
C Open the HDF file for reading.
C
file_id = hopen(FILE_NAME, DFACC_READ, 0)
C
C Initialize the VS interface.
C
status = vfstart(file_id)
index = 0
C
C Set the reference number to -1 to start the search from the beginning
C of the file.
C
vdata_ref = -1
C
C Assume that the specified fields are not found in the current vdata.
C
found_fields = .FALSE.
10 continue
C
Use vsfgid to obtain each vdata by its reference number then
attach to the vdata and search for the fields. The loop terminates
when the last vdata is reached or when a vdata which contains the
fields listed in SEARCHED_FIELDS is found.
C
vdata_ref = vsfgid(file_id, vdata_ref)
if (vdata_ref .eq. -1) goto 100
vdata_id = vsfatch(file_id, vdata_ref, 'r')
status = vsfex(vdata_id, SEARCHED_FIELDS)
if (status .ne. -1) then
found_fields = .TRUE.
goto 100
endif
status = vsfdtch(vdata_id)
index = index + 1
goto 10
100   continue
C
C     Print the index of the vdata containing the fields or a ‘not found’
C     message if no such vdata is found. Also detach from the vdata found.
C
if(.NOT.found_fields) then
   write(*,*) 'Fields Positions and Temperature were not found'
else
   write(*,*)
   + 'Fields Positions and Temperature were found in the vdata',
   + ' at position ', index
C
C     Terminate access to the vdata
C
   status = vsfdtch(vdata_id)
endif
C
C     Terminate access to the VS interface and close the HDF file.
C
   status = vsfdtch(vdata_id)
   status = vfend(file_id)
   status = hclose(file_id)
end

4.8  Vdata Attributes

HDF version 4.1r1 and later include the ability to assign attributes to a vdata and/or a vdata field. The concept of attributes is fully explained in Chapter 3, **Scientific Data Sets (SD API)**. To review briefly: an attribute has a name, a data type, a number of attribute values, and the attribute values themselves. All attribute values must be of the same data type. For example, an integer cannot be added to an attribute value consisting of ten characters, or a character value cannot be included in an attribute value consisting of 2 32-bit integers.

Any number of attributes can be assigned to either a vdata or any single field in a vdata. However, each attribute name should be unique within its scope. In other words, the name of a field’s attribute must be unique among all attributes that belong to that same field, and the name of a vdata’s attribute must be unique among all attributes assigned to the same vdata.

The following subsections describe routines that retrieve various information about vdata and vdata field attributes. Those routines that access field attributes require the field index as a parameter (**field_index**).

4.8.1  Querying the Index of a Vdata Field Given the Field Name: VSfindex

**VSfindex** retrieves the index of a field given its name, **field_name**, and stores the value in the parameter **field_index**. The syntax of **VSfindex** is as follows:

**C:**
```
status = VSfindex(vdata_id, field_name, &field_index);
```

**FORTRAN:**
```
status = vsffidx(vdata_id, field_name, field_index)
```
The parameter `field_index` is the index number that uniquely identifies the location of the field within the vdata. Field index numbers are assigned in increasing order and are zero-based: for example, a `field_index` value of 4 would refer to the fifth field in the vdata.

`VSfindex` returns `SUCCEED` (or 0) if successful and `FAIL` (or -1) otherwise. The parameters for `VSfindex` are further defined in Table 4K.

### Table 4K

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>VSfindex</code> (vsfindx)</td>
<td>vdata_id</td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td>field_name</td>
<td>char *</td>
<td>Name of the vdata field</td>
</tr>
<tr>
<td></td>
<td>field_index</td>
<td>int32 *</td>
<td>Index of the vdata field</td>
</tr>
</tbody>
</table>

#### 4.8.2 Setting the Attribute of a Vdata or Vdata Field: VSsetattr

`VSsetattr` attaches an attribute to a vdata or a vdata field. The syntax of `VSsetattr` is as follows:

**C:**
```c
status = VSsetattr(vdata_id, field_index, attr_name, data_type,
                   n_values, values);
```

**FORTRAN:**
```fortran
status = vsfsnat(vdata_id, field_index, attr_name, data_type,
                  n_values, values)
```

OR
```fortran
status = vsfscat(vdata_id, field_index, attr_name, data_type,
                 n_values, values)
```

If the attribute has already been attached, the new attribute values will replace the current values, provided the data type and the number of attribute values (`n_values`) have not been changed. If either of these have been changed, `VSsetattr` will return `FAIL` (or -1).

Set the parameter `field_index` to `_HDF_VDATA` (or -1) to set an attribute for a vdata or to a valid field index to set attribute for a vdata field. A valid field index is a zero-based integer value representing the ordinal location of a field within the vdata.

The parameter `attr_name` specifies the name of the attribute to be set and can contain `VSNAMELEN-MAX` (or 64) characters. The parameter `data_type` specifies the data type of the attribute values. Data types supported by HDF are listed in Table 2F on page 14. The parameter `values` contains attribute values to be written.

The FORTRAN-77 version of `VSsetattr` has two routines: `vsfsnat` sets numeric attribute data and `vsfscat` sets character attribute data.

`VSsetattr` returns `SUCCEED` (or 0) if successful and `FAIL` (or -1) otherwise. The parameters for `VSsetattr` are described in Table 4L.

#### 4.8.3 Querying the Values of a Vdata or Vdata Field Attribute: VSgetattr

`VSgetattr` returns all of the values of the specified attribute of the specified vdata field or vdata. The syntax of `VSgetattr` is as follows:

**C:**
```c
status = VSgetattr(vdata_id, field_index, attr_index, values);
```

**FORTRAN:**
```fortran
status = vsfgnat(vdata_id, field_index, attr_index, values)
```

OR
```fortran
status = vsfgscat(vdata_id, field_index, attr_index, values)
```
Set the parameter field_index to _HDF_VDATA (or -1) to retrieve the values of the attribute attached to the vdata identified by the parameter vdata_id. Set field_index to a zero-based integer value to retrieve the values of an attribute attached to a vdata field; the value of field_index will be used as the index of the vdata field. In both cases, the values returned will be those of the attribute located at the position specified by the parameter attr_index, the zero-based index of the target attribute.

The parameter values must be sufficiently allocated to hold the retrieved attribute values. Use VSattrinfo to obtain information about the attribute values for appropriate memory allocation.

The FORTRAN-77 versions of VSgetattr has two routines: vsfngat gets numeric attribute data and vsfscat gets character attribute data. VSgetattr returns SUCCEED (or 0) if successful and FAIL (or -1) otherwise. The parameters for VSgetattr are described in Table 4L.

### TABLE 4L

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSsetattr</td>
<td>vdata_id</td>
<td>int32 integer</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td>field_index</td>
<td>int32 integer</td>
<td>_HDF_VDATA or index of the field</td>
</tr>
<tr>
<td></td>
<td>attr_name</td>
<td>char * character(*)</td>
<td>Name of the attribute</td>
</tr>
<tr>
<td></td>
<td>data_type</td>
<td>int32 integer</td>
<td>Data type of the attribute</td>
</tr>
<tr>
<td></td>
<td>n_values</td>
<td>int32 integer</td>
<td>Number of values the attribute contains</td>
</tr>
<tr>
<td></td>
<td>values</td>
<td>VOIDP &lt;valid numeric data type(<em>)/character(</em>)</td>
<td>Buffer containing the attribute values</td>
</tr>
<tr>
<td>VSgetattr</td>
<td>vdata_id</td>
<td>int32 integer</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td>field_index</td>
<td>int32 integer</td>
<td>_HDF_VDATA or index of the field</td>
</tr>
<tr>
<td></td>
<td>attr_index</td>
<td>intn integer</td>
<td>Index of the attribute</td>
</tr>
<tr>
<td></td>
<td>values</td>
<td>VOIDP &lt;valid numeric data type(<em>)/character(</em>)</td>
<td>Buffer containing attribute values</td>
</tr>
</tbody>
</table>

### 4.8.4 Querying the Total Number of Vdata and Vdata Field Attributes: VSnattrs

VSnattrs returns the total number of attributes of the specified vdata *and* the fields contained in the vdata. This is different from the VSfnattrs routine, which returns the number of attributes of the specified vdata *or* a specified field contained in the specified vdata. The syntax of VSnattrs is as follows:

**C:**
```
num_of_attrs = VSnattrs(vdata_id);
```

**FORTRAN:**
```
num_ofAttrs = vsfnattrs(vdata_id)
```

VSnattrs returns the total number of attributes assigned to the vdata and its fields when successful, and FAIL (or -1) otherwise. The parameters for VSnattrs are described in Table 4M.

### 4.8.5 Querying the Number of Attributes of a Vdata or a Vdata Field:
VSfnattrs

VSfnattrs returns the number of attributes attached to the vdata field specified by the parameter field_index or the number of attributes attached to the vdata identified by vdata_id. This is different from the routine VSnattrs, which returns the total number of attributes of the specified vdata and the fields contained in it. The syntax of VSfnattrs is as follows:

C: num_ofAttrs = VSfnattrs(vdata_id, field_index);

FORTRAN: num_ofAttrs = vsffnas(vdata_id, field_index)

If field_index is set to a zero-based integer value, it will be used as the index of the vdata field, and the number of attributes attached to that field will be returned. If field_index is set to _HDF_VDATA (or -1), the number of attributes attached to the vdata specified by vdata_id will be returned.

VSfnattrs returns the number of attributes assigned to the specified vdata or to the specified vdata field when successful, and FAIL (or -1) otherwise. The parameters for VSfnattrs are described in Table 4M.

TABLE 4M

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSnattrs</td>
<td>vdata_id</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td>VSfnattrs</td>
<td>vdata_id</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td>field_index</td>
<td>_HDF_VDATA or index of the field</td>
</tr>
</tbody>
</table>

4.8.6 Retrieving the Index of a Vdata or Vdata Field Attribute Given the Attribute Name: VSfindattr

VSfindattr returns the index of an attribute with the specified name. The attribute must be attached to either a vdata or one of its fields. The syntax of VSfindattr is as follows:

C: attr_index = VSfindattr(vdata_id, field_index, attr_name);

FORTRAN: attr_index = vsffdat(vdata_id, field_index, attr_name)

If field_index is set to _HDF_VDATA (or -1), the index of the attribute identified by the parameter attr_name and attached to the vdata specified by vdata_id will be returned.

If the parameter field_index is set to a zero-based integer value, the value will be used as the index of the vdata field. Then, the index of the attribute named by the parameter attr_name and attached to the field specified by the parameter field_index will be returned.

VSfindattr returns an attribute index if successful, and FAIL (or -1) otherwise. The parameters for VSfindattr are described in Table 4N on page 175.

4.8.7 Querying Information on a Vdata or Vdata Field Attribute:
**VSattrinfo**

**VSattrinfo** returns the name, data type, number of values, and the size of the values of the specified attribute of the specified vdata field or vdata. The syntax of **VSattrinfo** is as follows:

**C:**
```c
status = VSattrinfo(vdata_id, field_index, attr_index, attr_name, &data_type, &n_values, &size);
```

**FORTRAN:**
```fortran
status = vsfainf(vdata_id, field_index, attr_index, attr_name, data_type, n_values, size)
```

In C, the parameters attr_name, data_type, n_values, and size can be set to NULL, if the information returned by these parameters are not needed.

The parameter field_index is the same as the parameter field_index in **VSsetattr**; it can be set either to a nonnegative integer to specify the field or to **_HDF_VDATA** (or -1) to specify the vdata referred to by vdata_id.

**VSattrinfo** returns **SUCCEED** (or 0) if successful and **FAIL** (or -1) otherwise. The parameters for **VSattrinfo** are described in Table 4N.

### 4.8.8 Determining whether a Vdata Is an Attribute: **VSisattr**

The HDF library stores vdata attributes and vdata field attributes as vdatas. HDF therefore provides the routine **VSisattr** to determine whether a particular vdata contains attribute data. The syntax of **VSisattr** is as follows:

**C:**
```c
status = VSisattr(vdata_id);
```

**FORTRAN:**
```fortran
status = vsfisat(vdata_id)
```

**VSisattr** returns **TRUE** (or 1) if the vdata contains an attribute data and **FALSE** (or 0) otherwise. The parameters for **VSisattr** are described in Table 4N.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>[Return Type]</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VSfindattr</strong></td>
<td>[intn] (vsffdat)</td>
<td>vdata_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>field_index</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>attr_name</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td><strong>VSattrinfo</strong></td>
<td>[intn] (vsfainf)</td>
<td>vdata_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>field_index</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>attr_name</td>
<td>intn</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>attr_name</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>data_type</td>
<td>int32 *</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>n_values</td>
<td>int32 *</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>size</td>
<td>int32 *</td>
<td>integer</td>
</tr>
<tr>
<td><strong>VSisattr</strong></td>
<td>[intn] (vsfisat)</td>
<td>vdata_id</td>
<td>int32</td>
<td>integer</td>
</tr>
</tbody>
</table>
EXAMPLE 8.

**Operations on Field and Vdata Attributes**

This example illustrates the use of `VSetattr/vsfsset/vsfscat` to attach an attribute to a vdata and to a field in a vdata, the use of `VSattrinfo/vsfainf` to get information about a field attribute and a vdata attribute, and the use of `VGetattr/vsfsget/vsfsgnat` to get the values of an attribute of a vdata and the values of an attribute of a field in a vdata. The example also shows the use of `VSfnattrs/vsfnas` to obtain the number of attributes attached to a field of a vdata and the use of `VSfnattrs/vsfnat` to obtain the total number of attributes attached to both a vdata and its fields.

In this example, the program finds the vdata, named "Solid Particle", in the HDF file "General_Vdatas.hdf" produced by Example 3. It then obtains the index of the field, named "Mass", in the vdata. An attribute named "Site Ident" is attached to the vdata to contain the identification of the experiment sites. Another attribute named "Scales" is attached to the field for its scale values. The vdata attribute has 3 character values and the field attribute has 4 integer values.

C:

```c
#include "hdf.h"
#define  FILE_NAME        "General_Vdatas.hdf"
#define  VDATA_NAME       "Solid Particle"
#define  FIELD_NAME       "Mass"
#define  VATTR_NAME       "Site Ident"      /* name of the vdata attribute */
#define  FATTR_NAME       "Scales"          /* name of the field attribute */
#define  VATTR_N_VALUES   3      /* number of values in the vdata attribute */
#define  FATTR_N_VALUES   4      /* number of values in the field attribute */

main( )
{
    /************************** Variable declaration **********************/
    intn status_n;      /* returned status for functions returning an intn */
    int32 status_32,     /* returned status for functions returning an int32 */
    file_id, vdata_ref, vdata_id,
    field_id, vdata_ref, vdata_id,
    field_index,   /* index of a field within the vdata */
    n_vdattrs,     /* number of vdata attributes */
    n_fldattrs,    /* number of field attributes */
    vdata_type,    /* to hold the type of vdata's attribute */
    vdata_n_values,/* to hold the number of vdata's attribute values */
    vdata_size,    /* to hold the size of vdata's attribute values */
    field_type,    /* to hold the type of field's attribute */
    field_n_values,/* to hold the number of field's attribute values */
    field_size;    /* to hold the size of field's attribute values */
    char  vd_attr[VATTR_N_VALUES] = {'A', 'B', 'C'}; /* vdata attribute values*/
    int32 fld_attr[FATTR_N_VALUES] = {2, 4, 6, 8}; /* field attribute values*/
    char  vattr_buf[VATTR_N_VALUES];     /* to hold vdata attribute's values */
    int32 fattr_buf[FATTR_N_VALUES];     /* to hold field attribute's values */
    char  vattr_name[30],                /* name of vdata attribute */
    fattr_name[30];                /* name of field attribute */
    /************************** End of variable declaration ***************/

    /*
    * Open the HDF file for writing.
    */
    file_id = Hopen (FILE_NAME, DFACC_WRITE, 0);

    /*
    * Initialize the VS interface.
    */
    status_n = Vstart (file_id);

```
/*
 * Get the reference number of the vdata named VDATA_NAME.
 */
vdata_ref = VSfind (file_id, VDATA_NAME);

/*
 * Attach to the vdata for writing.
 */
vdata_id = VSattach (file_id, vdata_ref, "w");

/*
 * Attach an attribute to the vdata, i.e., indicated by the second parameter.
 */
status_n = VSsetattr (vdata_id, _HDF_VDATA, VATTR_NAME, DFNT_CHAR,
  VATTR_N_VALUES, vd_attr);

/*
 * Get the index of the field FIELD_NAME within the vdata.
 */
status_n = VSfindex (vdata_id, FIELD_NAME, &field_index);

/*
 * Attach an attribute to the field field_index.
 */
status_n = VSsetattr (vdata_id, field_index, FATTR_NAME, DFNT_INT32,
  FATTR_N_VALUES, fld_attr);

/*
 * Get the number of attributes attached to the vdata's first
 * field - should be 0.
 */
n_fldattrs = VSfnattrs (vdata_id, 0);
printf ( "Number of attributes of the first field of the vdata: %d\n",
  n_fldattrs);

/*
 * Get the number of attributes attached to the field specified by
 * field_index - should be 1.
 */
n_fldattrs = VSfnattrs (vdata_id, field_index);
printf ( "Number of attributes of field %s: %d\n", FIELD_NAME, n_fldattrs);

/*
 * Get the total number of the field’s and vdata’s attributes - should be 2.
 */
n_vdattrs = VSnattrs (vdata_id);
printf ( "Number of attributes of the vdata and its fields: %d\n",
  n_vdattrs);

/*
 * Get information about the vdata’s first attribute, indicated
 * by the third parameter which is the index of the attribute.
 */
status_n = VSattrinfo (vdata_id, _HDF_VDATA, 0, vattr_name,
  &vdata_type, &vdata_n_values, &vdata_size);

/*
 * Get information about the first attribute of the field specified by
 * field_index.
 */
status_n = VSattrinfo (vdata_id, field_index, 0, fattr_name, &field_type,
  &field_n_values, &field_size);
/*
* Get the vdata's first attribute.
*/
status_n = VSgetattr (vdata_id, _HDF_VDATA, 0, vattr_buf);
printf("Values of the vdata attribute = %c %c %c\n", vattr_buf[0],
vattr_buf[1], vattr_buf[2]);

/*
* Get the first attribute of the field specified by field_index.
*/
status_n = VSgetattr (vdata_id, field_index, 0, fattr_buf);
printf("Values of the field attribute = %d %d %d %d\n", fattr_buf[0],
fattr_buf[1], fattr_buf[2], fattr_buf[3]);

/*
* Terminate access to the vdata and to the VS interface, then close
* the HDF file.
*/
status_32 = VSdetach (vdata_id);
status_n  = Vend (file_id);
status_32 = Hclose (file_id);
}

FORTRAN:

program vdata_attributes
implicit none
C
C     Parameter declaration
C
character*18 FILE_NAME
character*14 VDATA_NAME
character*4 FIELD_NAME
character*10 VATTR_NAME
character*6 FATTR_NAME
integer VATTR_N_VALUES, FATTR_N_VALUES
C
parameter (FILE_NAME    = 'General_Vdatas.hdf',
+           VDATA_NAME   = 'Solid Particle',
+           FIELD_NAME   = 'Mass',
+           VATTR_NAME   = 'Site Ident',
+           FATTR_NAME   = 'Scales')
parameter (VATTR_N_VALUES = 3,
+           FATTR_N_VALUES = 4)
C
integer DFACC_WRITE, FULL_INTERLACE, HDF_VDATA
integer DFNT_INT32, DFNT_CHAR8
parameter (DFACC_WRITE    =  2,
+           FULL_INTERLACE =  0,
+           HDF_VDATA      = -1,
+           DFNT_INT32     = 24,
+           DFNT_CHAR8     =  4)
C
C     Function declaration
C
integer hopen, hclose
integer vfstart, vsffnd, vsfatch, vsfscat, vsfsnat,
+       vsfns, vsfidx, vsfnats, vsfainf, vsfgcat, vsfgnat,
+       vsfdtch, vfend
C
C**** Variable declaration **************************************************
C
integer status
integer file_id, vdata_id, vdata_ref
integer field_index, n_vdattrs, n_fldattrs
integer vdata_type, vdata_n_values, vdata_size
integer field_type, field_n_values, field_size
character vd_attr(VATTR_N_VALUES)
integer fld_attr(FATTR_N_VALUES)
character vattr_buf(VATTR_N_VALUES)
character fattr_buf(FATTR_N_VALUES)
character vattr_name_out(30), fattr_name_out(30)
data vd_attr /'A', 'B', 'C'/
data fld_attr /2, 4, 6, 8/
C**** End of variable declaration ************************************
C
C     Open the HDF file for writing.
C
file_id = hopen(FILE_NAME, DFACC_WRITE, 0)
C
C     Initialize the VS interface.
C
status = vfstart(file_id)
C
C     Get the reference number of the vdata named VDATA_NAME.
C
vdata_ref = vsffnd(file_id, VDATA_NAME)
C
C     Attach to the vdata for writing.
C
vdata_id = vsfatch(file_id, vdata_ref, 'w')
C
C     Attach an attribute to the vdata, as it is indicated by second parameter.
C
status = vsfscat(vdata_id, HDF_VDATA, VATTR_NAME, DFNT_CHAR8,
+               VATTR_N_VALUES, vd_attr)
C
C     Get the index of the field FIELD_NAME within the vdata.
C
status = vsffidx(vdata_id, FIELD_NAME, field_index)
C
C     Attach an attribute to the field with the index field_index.
C
status = vsfsnat(vdata_id, field_index, FATTR_NAME, DFNT_INT32,
+               FATTR_N_VALUES, fld_attr)
C
C     Get the number of attributes attached to the vdata’s first
C     field - should be 0.
C
n_fldattrs = vsffnas(vdata_id, 0)
write(*,*) 'Number of attributes of the first field' 
write(*,*) ' of the vdata: ', n_fldattrs
C
C     Get the number of the attributes attached to the field specified by
C     index field_index - should be 1.
C
n_fldattrs = vsffnas(vdata_id, field_index)
write(*,*) 'Number of attributes of field ', FIELD_NAME,
+      n_fldattrs
C
C     Get the total number of the field’s and vdata’s attributes - should be 2.
4.9 Obtaining Information about a Specific Vdata

Once a vdata has been located, its contents must be obtained. In this section four categories of routines that obtain vdata information are described:

- A general inquiry routine named VSinquire.
- A set of vdata query routines with names prefaced by “VSQuery”.
- A set of vdata inquiry routines prefixed by “VS”. Some of these routines retrieve specific vdata information which can also be retrieved by the general inquiry routine VSinquire.
- A set of field query routines with names prefaced by “VF”.

4.9.1 Obtaining Vdata Information: VSinquire

VSinquire retrieves information about the vdata identified by the parameter vdata_id. The routine has the following syntax:

**C:**

```c
status = VSinquire(vdata_id, &n_records, &interlace_mode,
                   fieldname_list, &vdata_size, vdata_name);
```

**FORTRAN:**

```fortran
status = vsflsq(vdata_id, n_records, interchange_mode, fieldname_list,
                vdata_size, vdata_name)
```
The parameter `n_records` contains the returned number of records in the vdata, the parameter `interlace_mode` contains the returned interlace mode of the vdata contents, the parameter `fieldname_list` is a comma-separated list of the returned names of all the fields in the vdata, the parameter `vdata_size` is the returned size, in bytes, of the vdata record, and the parameter `vdata_name` contains the returned name of the vdata.

If any of the parameters are set to `NULL` in C, the corresponding data will not be returned.

**VSinquire** returns either **SUCCEED** (or 0) or **FAIL** (or -1). The parameters for **VSinquire** are further defined in Table 4O.

To summarize the table:

### Table 4O

**VSinquire Parameter List**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VSinquire</strong></td>
<td><code>vdata_id</code></td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td><code>n_records</code></td>
<td>int32 *</td>
<td>Number of records in the vdata</td>
</tr>
<tr>
<td></td>
<td><code>interlace_mode</code></td>
<td>int32 *</td>
<td>Interlace mode</td>
</tr>
<tr>
<td></td>
<td><code>fieldname_list</code></td>
<td>char *</td>
<td>Buffer for the list of field names</td>
</tr>
<tr>
<td></td>
<td><code>vdata_size</code></td>
<td>int32 *</td>
<td>Size in bytes of the vdata record</td>
</tr>
<tr>
<td></td>
<td><code>vdata_name</code></td>
<td>char *</td>
<td>Name of the vdata</td>
</tr>
</tbody>
</table>

**EXAMPLE 9.**

**Obtaining Vdata Information**

This example illustrates the use of **VSgetid/vsfgid** and **VSinquire/vsfnq** to obtain information about all vdatas in an HDF file.

In this example, the program uses **VSgetid** to locate all vdatas in the HDF file "General_Vdatas.hdf", which is the output of Example 3. For each vdata found, if it is not the storage of an attribute, the program uses **VSinquire/vsfnq** to obtain information about the vdata and displays its information. Recall that an attribute is also stored as a vdata; the function **VSiattr/vsfisat** checks whether a vdata is a storage of an attribute.

**C:**

```c
#include "hdf.h"
#define FILE_NAME      "General_Vdatas.hdf"
#define FIELD_SIZE     80         /* maximum length of all the field names */

main( )
{
    /**************** End of variable declaration ******************/

    intn status_n; /* returned status for functions returning an intn */
    int32 status_32, /* returned status for functions returning an int32 */
    n_records, /* to retrieve the number of records in the vdata */
    interlace_mode, /* to retrieve the interlace mode of the vdata */
    file_id, vdata_ref, vdata_id;
    char fieldname_list[FIELD_SIZE], /* buffer to retrieve the vdata data */
    vdata_name[VSNAMELENMAX]; /* buffer to retrieve the vdata name */

    /**************** End of variable declaration ******************/

    /*
     * Open the HDF file for reading.
     */
```
file_id = Hopen (FILE_NAME, DFACC_READ, 0);

/* Initialize the VS interface. */
status_n = Vstart (file_id);

/* Set vdata_ref to -1 to start the search from the beginning of file. */
vdata_ref = -1;

/* Use VSgetid to obtain each vdata by its reference number then attach */
/* to the vdata and get its information. The loop terminates when */
/* the last vdata is reached. */
while ((vdata_ref = VSgetid (file_id, vdata_ref)) != FAIL)
{
    /* Attach to the current vdata for reading. */
    vdata_id = VSattach (file_id, vdata_ref, "r");
    
    /* Test whether the current vdata is not a storage of an attribute, then */
    /* obtain and display its information. */
    if( VSisattr (vdata_id) != TRUE )
    {
        status_n = VSinquire (vdata_id, &n_records, &interlace_mode,
                               &vdata_size, vdata_name);
        printf ("Vdata %s: - contains %d records\n\tInterlace mode: %s \n\tFields: %s - %d bytes\n\n", vdata_name, n_records, interlace_mode == FULL_INTERLACE ? "FULL" : "NONE",
                                      fieldname_list, vdata_size );
    }
    /* Detach from the current vdata. */
    status_32 = VSdetach (vdata_id);
} /* while */

/* Terminate access to the VS interface and close the HDF file. */
status_n = Vend (file_id);
status_32 = Hclose (file_id);

FORTRAN:

program vdata_info
implicit none

C  Parameter declaration
C
character*18 FILE_NAME
integer     DFACC_READ, FULL_INTERLACE
integer     FIELD_SIZE
C

parameter (FILE_NAME = 'General_Vdatas.hdf',
+           DFACC_READ   = 1,
+           FULL_INTERFACE = 0,
+           FIELD_SIZE   = 80)

C
C   Function declaration
C
integer hopen, hclose
integer vfstart, vsfatch, vsfgid, vsfinq,
+           vsfisat, vsfdtch, vfend

C**** Variable declaration *******************************************
C
integer      status
integer      file_id, vdata_id, vdata_ref
integer      n_records, interlace_mode, vdata_size
character*64 vdata_name
character*80 fieldname_list

C**** End of variable declaration ************************************
C
C     Open the HDF file for reading.
C
file_id = hopen(FILE_NAME, DFACC_READ, 0)

C     Initialize the VS interface.
C
status = vfstart(file_id)

C     Set the reference number to -1 to start the search from the beginning
C     of the file.
C
vdata_ref = -1

10   continue
C
C     Use vsfgid to obtain each vdata by its reference number then
C     attach to the vdata and get information. The loop terminates
C     when the last vdata is reached.
C
vdata_ref = vsfgid(file_id, vdata_ref)
if (vdata_ref .eq. -1) goto 100

C     Attach to the current vdata for reading.
C
vdata_id = vsfatch(file_id, vdata_ref, 'r')

C     Test whether the current vdata is not a storage for an attribute,
C     then obtain and display its information.
C     if (vsfisat(vdata_id) .ne. 1) then
      status = vsfinq(vdata_id, n_records, interlace_mode,
+                  fieldname_list, vdata_size, vdata_name)
      write(***,*) 'Vdata: ', vdata_name
      write(***,*) 'contains ', n_records, ' records'
      if (interlace_mode .eq. 0) then
        write(***,*) 'Interlace mode: FULL'
      else
        write(***,*) 'Interlace mode: NONE'
      endif
      write(***,*) 'Fields: ', fieldname_list(1:30)
      write(***,*) 'Vdata record size in bytes :', vdata_size


write(*,*)
endif
C
C     Detach from the current vdata.
C
status = vsfdtch(vdata_id)
goto 10
100   continue
C
C     Terminate access to the vdata and to the VS interface, and
C     close the HDF file.
C
status = vsfdtch(vdata_id)
status = vfend(file_id)
status = hclose(file_id)
end

4.9.2 Obtaining Linked Block Information: VSgetblockinfo

VSgetblockinfo retrieves the block size and number of blocks employed in a linked block Vdata data element. The parameter vdata_id identifies the Vdata. The size of blocks, in bytes, is returned in block_size and the number of blocks in num_blocks.

If either the block size or the number of blocks used in a particular Vdata is likely to differ from the default setting, VSgetblockinfo must be called before any data is read from a Vdata.

VSgetblockinfo returns SUCCESS (or 0) upon successful completion or FAIL (or -1). Its parameters are further defined in Table 4P.

<table>
<thead>
<tr>
<th>Routine Name (Return Type)</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSgetblockinfo</td>
<td>vdata_id int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td>block_size int32</td>
<td>Size of each block, in bytes</td>
</tr>
<tr>
<td></td>
<td>num_blocks int32</td>
<td>Number of linked blocks</td>
</tr>
</tbody>
</table>

4.9.3 VSQuery Vdata Information Retrieval Routines

The syntax of the VSQuery routines are as follows:

C:
status = VSQueryname(vdata_id, vdata_name);
status = VSQueryfields(vdata_id, fields);
status = VSQueryinterlace(vdata_id, &interlace_mode);
status = VSQuerycount(vdata_id, &n_records);
vdata_tag = VSQuerytag(vdata_id);
vdata_ref = VSQueryref(vdata_id);
status = VSQueryvsize(vdata_id, &vdata_vsize);

FORTRAN:
status = vsqfname(vdata_id, vdata_name)
status = vsqfflds(vdata_id, fields)
status = vsqfintr(vdata_id, interlace_mode)
status = vsqfnelt(vdata_id, n_records)
vdata_tag = vsqtag(vdata_id)
vdata_ref = vsqpref(vdata_id)
status = vsqfvsiz(vdata_id, vdata_vsize)

All VSQuery routines except VSQueryTag and VSQueryRef have two arguments. The first argument identifies the vdata to be queried. The second argument is the type of vdata information being requested.

- VSQueryname retrieves the name of the specified vdata.
- VSQueryFields retrieves the names of the fields in the specified vdata.
- VSQueryInterlace retrieves the interlace mode of the specified vdata.
- VSQueryCount retrieves the number of records in the specified vdata.
- VSQueryTag returns the tag of the specified vdata.
- VSQueryRef returns the reference number of the specified vdata.
- VSQueryVsize retrieves the size, in bytes, of a record in the specified vdata.

VSQueryTag and VSQueryRef return the tag and reference number, respectively, or FAIL (or -1). All other routines return SUCCEEDED (or 0) or FAIL (or -1). The parameters for these routines are listed in Table 4Q.

### Table 4Q

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VSQueryname</strong></td>
<td>vdata_id int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td><strong>VSQueryFields</strong></td>
<td>vdata_id int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td><strong>VSQueryInterlace</strong></td>
<td>vdata_id int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td><strong>VSQueryCount</strong></td>
<td>vdata_id int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td><strong>VSQueryVsize</strong></td>
<td>vdata_id int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td><strong>VSQueryTag</strong></td>
<td>vdata_id int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td><strong>VSQueryRef</strong></td>
<td>vdata_id int32</td>
<td>Vdata identifier</td>
</tr>
</tbody>
</table>

### 4.9.4 Other Vdata Information Retrieval Routines

The routines described in this section, with names prefaced by “VS”, are used to obtain specific types of vdata information. The syntax of these routines are as follows:

**C:**

```c
num_of_records = VSelts(vdata_id);
num_of_fields = VSgetfields(vdata_id,fieldname_list);
interlace_mode = VSgetinterlace(vdata_id);
size_of_fields = VSsizeof(vdata_id,fieldname_list);
status = VSgetname(vdata_id, vdata_name);
status = VSgetclass(vdata_id, vdata_class);
```
WITH THE EXCEPTION OF VSgetclass, THE INFORMATION OBTAINED THROUGH THESE ROUTINES CAN ALSO BE OBTAINED THROUGH VSinquire. VSinquire PROVIDES A WAY TO QUERY COMMONLY USED VDATA INFORMATION WITH ONE ROUTINE CALL. THE VS ROUTINES IN THIS SECTION ARE USEFUL IN SITUATIONS WHERE THE HDF PROGRAMMER WISHES TO OBTAIN ONLY SPECIFIC INFORMATION.

- **VSelts** returns the number of records in the specified vdata or **FAIL** (or −1).
- **VSgetfields** retrieves the names of all the fields in the specified vdata and returns the number of retrieved fields or **FAIL** (or −1).
- **VSgetinterlace** returns the interlace mode of the specified vdata or **FAIL** (or −1).
- **VSsizeof** returns the size, in bytes, of the specified fields or **FAIL** (or −1).
- **VSgetname** retrieves the name of the specified vdata and returns either **SUCCEED** (or 0) or **FAIL** (or −1).
- **VSgetclass** retrieves the class of the specified vdata and returns either **SUCCEED** (or 0) or **FAIL** (or −1).

THE PARAMETERS FOR THESE ROUTINES ARE DESCRIBED IN TABLE 4R.

---

### TABLE 4R

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSelts [int32]</td>
<td>vdata_id</td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td>VSgetfields [int32]</td>
<td>vdata_id</td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td>fieldname_list</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td>VSgetinterlace [int32]</td>
<td>vdata_id</td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td>VSsizeof [int32]</td>
<td>vdata_id</td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td>fieldname_list</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td>VSgetname [int32]</td>
<td>vdata_id</td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td>VSgetclass [int32]</td>
<td>vdata_id</td>
<td>int32</td>
<td>Vdata identifier</td>
</tr>
<tr>
<td></td>
<td>vdata_class</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
</tbody>
</table>

### 4.9.5 VF Field Information Retrieval Routines

ROUTINES WHOSE NAMES ARE PREFACED BY “VF” ARE USED FOR OBTAINING INFORMATION ABOUT SPECIFIC FIELDS IN A VDATA. THE SYNTAX OF THESE ROUTINES ARE AS FOLLOWS:

**C:**

```c
field_name = VFfieldname(vdata_id, field_index);
field_file_size = VFfieldesize(vdata_id, field_index);
field_mem_size = VFfieldisize(vdata_id, field_index);
num_of_fields = VFnfields(vdata_id);
```
The functionality of each of the VF routines is as follows:

- **VFfieldname** returns the name of the specified field.
- **VFfieldsize** returns the size of the specified field as stored in the HDF file. This is the size of the field as tracked by the HDF library.
- **VFfieldsize** returns the size of the specified field as stored in memory. This is the native machine size of the field.
- **VFfields** returns the number of fields in the specified vdata.
- **VFfieldorder** returns the order of the specified field.
- **VFfieldtype** returns the data type of the specified field.

If the operations are unsuccessful, these routines return **FAIL** (or -1). The parameters for all of these routines are described in Table 4S.

### VF Routines Parameter Lists

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Return Type (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VFfieldname</strong></td>
<td>char * (vffname)</td>
<td>vdata_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>field_index</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>field_name</td>
<td>character*</td>
<td></td>
</tr>
<tr>
<td><strong>VFfieldsize</strong></td>
<td>int32 (vffesiz)</td>
<td>vdata_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>field_index</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td><strong>VFfieldsize</strong></td>
<td>int32 (vfisiz)</td>
<td>vdata_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>field_index</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td><strong>VFfields</strong></td>
<td>int32 (vfnfls)</td>
<td>vdata_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td><strong>VFfieldorder</strong></td>
<td>int32 (vffordr)</td>
<td>vdata_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>field_index</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td><strong>VFfieldtype</strong></td>
<td>int32 (vfftype)</td>
<td>vdata_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>field_index</td>
<td>int32</td>
<td>integer</td>
</tr>
</tbody>
</table>
Chapter 5

Vgroups (V API)

5.1 Chapter Overview

This chapter describes the vgroup data model and the Vgroup interface (also called the V interface or the V API). The first section describes the vgroup data model. The second section introduces the Vgroup interface, followed by a presentation of a programming model for vgroups. The next three sections describe the use of the Vgroup interface in accessing and creating vgroups. The final two sections cover vgroup attributes and obsolete Vgroup interface routines.

5.2 The Vgroup Data Model

A vgroup is a structure designed to associate related data objects. The general structure of a vgroup is similar to that of the UNIX file system in that the vgroup may contain references to other vgroups or HDF data objects just as the UNIX directory may contain subdirectories or files (see Figure 5a). In previous versions of HDF, the data objects in a vgroup were limited to vdats and vgroups. The data objects that belong to a vgroup are often referred to as the vgroup’s members.

5.2.1 Vgroup Names and Classes

A vgroup has a required vgroup name and an optional vgroup class associated with it. The vgroup name and class are used in describing and classifying the data objects belonging to the vgroup.
A vgroup name is a character string and is used to semantically distinguish between vgroups in an HDF file. If the user does not assign a name to a vgroup, then the HDF library will assign a zero-length string as the name of the vgroup. Multiple vgroups in a file can have the same name; however, unique names make it easier to distinguish among vgroups and are recommended.

A vgroup class is a character string and can be used to classify data objects by their intended use. For example, a vdata object named "Storm Tracking Data - 5/11/94" and another vdata object named "Storm Tracking Data - 6/23/94" can be grouped together under a vgroup named "Storm Tracking Data - 1994". If the data was collected in Anchorage, Alaska the class name might be "Anchorage Data", particularly if other vgroups contain storm track data collected in different locations. A class name is not required for a vgroup, therefore the HDF library will not assign a class name to the vgroup if one is not defined by the user.

The specific use of the vgroup name and class name is solely determined by HDF users.

5.2.2 Vgroup Organization

There are many ways to organize vgroups through the use of the Vgroup interface. Vgroups may contain any number of vgroups and data objects, including data objects and vgroups that are members of other vgroups. Therefore, a data object may have more than one parent vgroup. For example, Data object A and Vgroup B, shown in Figure 5b, are members of multiple vgroups with different organizational structures.

A vgroup can contain any combination of data objects. Figure 5c illustrates a vgroup that contains two raster images and a vdata.
5.2.3 An Example Using Vgroups

Although vgroups can contain any combination of HDF data objects, it is often useful to establish conventions on the content and structure of vgroups. This section, with the illustration in Figure 5d, describes an example of a vgroup convention that is used by scientific and graphics programmers to describe the surfaces of a mathematical or material object as well as its properties.

This vgroup consists of one list of coordinate data, one list of connectivity data, and one list of node property data. These three lists are stored in separate vdata objects within the vgroup.

Each 2-dimensional coordinate in the list of coordinate data defines the relative location of a vertex, or node. Each entry in the list of connectivity data is an ordered list of node numbers which describes a polygon. This ordered list is referred to as the connectivity list. For example, the number "2" as an item in a connectivity list would represent the second entry in the node table. Node properties are user-defined values attached to each node within the polygon and can be numbers or characters.

For example, consider a heated mesh of 400 triangles formed by connecting 1000 nodes. A vgroup describing this mesh might contain the coordinates of the vertices, the temperature value of the vertices, and a connectivity list describing the edges of the triangles.
5.3 The Vgroup Interface

The Vgroup interface consists of routines for creating and accessing vgroups, and getting information about vgroups and their members.

5.3.1 Vgroup Interface Routines

Vgroup interface routine names are prefaced by "V" in C and by "vf" in FORTRAN-77. These routines are categorized as follows:

- **Access/Create routines** control access to the Vgroup interface and to individual vgroups.
- **Manipulation routines** modify vgroups' characteristics, and add and delete vgroups' members.
- **Vgroup inquiry routines** obtain information about vgroups. Some of these routines are useful for locating vgroups in a file.
- **Member inquiry routines** obtain information about members of vgroups.
- **Attributes routines** provide information about vgroups' attributes.

The Vgroup interface routines are listed in Table 5A below and described in the following sections.

<table>
<thead>
<tr>
<th>Category</th>
<th>Routine Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access/Create</td>
<td>Vstart</td>
<td>Initializes the Vdata and Vgroup interfaces (Section 5.4.1 on page 194)</td>
</tr>
<tr>
<td></td>
<td>Vattach</td>
<td>Establishes access to a vgroup (Section 5.4.1 on page 194)</td>
</tr>
<tr>
<td></td>
<td>Vedtach</td>
<td>Terminates access to a vgroup (Section 5.4.2 on page 195)</td>
</tr>
<tr>
<td></td>
<td>Vend</td>
<td>Terminates access to the Vdata and Vgroup interfaces (Section 5.4.2 on page 195)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>Routine Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manipulation</td>
<td>Vfstart</td>
<td>Initializes the Vdata and Vgroup interfaces (Section 5.4.1 on page 194)</td>
</tr>
<tr>
<td></td>
<td>Vfattach</td>
<td>Establishes access to a vgroup (Section 5.4.1 on page 194)</td>
</tr>
<tr>
<td></td>
<td>Vfdtach</td>
<td>Terminates access to a vgroup (Section 5.4.2 on page 195)</td>
</tr>
<tr>
<td></td>
<td>Vfend</td>
<td>Terminates access to the Vdata and Vgroup interfaces (Section 5.4.2 on page 195)</td>
</tr>
</tbody>
</table>

**TABLE 5A**

<table>
<thead>
<tr>
<th>Category</th>
<th>Routine Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>FORTRAN-77</td>
<td></td>
</tr>
<tr>
<td>Access/Create</td>
<td>Vstart</td>
<td>Vfstart</td>
</tr>
<tr>
<td></td>
<td>Vattach</td>
<td>Vfattach</td>
</tr>
<tr>
<td></td>
<td>Vedtach</td>
<td>Vfdtach</td>
</tr>
<tr>
<td></td>
<td>Vend</td>
<td>Vfend</td>
</tr>
<tr>
<td>Manipulation</td>
<td>Method</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Vaddtagref</td>
<td>vfadtr</td>
<td>Adds an HDF data object to a vgroup (Section 5.5.2 on page 197)</td>
</tr>
<tr>
<td>Vdelete</td>
<td>vdelete</td>
<td>Removes a vgroup from a file (Section 5.7.1 on page 222)</td>
</tr>
<tr>
<td>Vdeleteetagref</td>
<td>vfdtr</td>
<td>Detaches a member from a vgroup (Section 5.7.2 on page 223)</td>
</tr>
<tr>
<td>Vinsert</td>
<td>vfinstr</td>
<td>Adds a vgroup or vdata to an existing vgroup (Section 5.5.3 on page 197)</td>
</tr>
<tr>
<td>Vsetclass</td>
<td>vfscls</td>
<td>Assigns a class name to a vgroup (Section 5.5.1 on page 197)</td>
</tr>
<tr>
<td>Vsetname</td>
<td>vfsnam</td>
<td>Assigns a name to a vgroup (Section 5.5.1 on page 197)</td>
</tr>
<tr>
<td>Vfind</td>
<td>vfind</td>
<td>Returns the reference number of a vgroup given its name (Section 5.6.1.5 on page 211)</td>
</tr>
<tr>
<td>Vfindclass</td>
<td>vfncls</td>
<td>Returns the reference number of a vgroup specified by class name (Section 5.6.1.4 on page 211)</td>
</tr>
<tr>
<td>Vgetclass</td>
<td>vfcls</td>
<td>Retrieves the class of a vgroup (Section 5.6.1.4 on page 211)</td>
</tr>
<tr>
<td>Vgetid</td>
<td>vfid</td>
<td>Returns the reference number for the next vgroup in the HDF file (Section 5.6.1.2 on page 210)</td>
</tr>
<tr>
<td>Vgetname</td>
<td>vfsnam</td>
<td>Retrieves the name of a vgroup (Section 5.6.1.3 on page 210)</td>
</tr>
<tr>
<td>Vgetversion</td>
<td>vfver</td>
<td>Returns the vgroup version of a vgroup (Section 5.8.1 on page 223)</td>
</tr>
<tr>
<td>Vinquire</td>
<td>vfinq</td>
<td>Retrieves general information about a vgroup (Section 5.9.2 on page 231)</td>
</tr>
<tr>
<td>Vlone</td>
<td>vflone</td>
<td>Retrieves the reference numbers of vgroups that are not members of other vgroups (Section 5.6.1.1 on page 209)</td>
</tr>
<tr>
<td>Vntagrefs</td>
<td>vfnt</td>
<td>Returns the number of tag/reference number pairs contained in the specified vgroup (Section 5.6.2.1 on page 215)</td>
</tr>
<tr>
<td>Vqueryref</td>
<td>vqref</td>
<td>Returns the reference number of a vgroup (Section 5.6.2.9 on page 218)</td>
</tr>
<tr>
<td>Vquerytag</td>
<td>vqtag</td>
<td>Returns the tag of a vgroup (Section 5.6.2.10 on page 218)</td>
</tr>
<tr>
<td>Vlocate</td>
<td>vfloc</td>
<td>Locates a vdata in a vgroup given a list of field names (Section 5.6.2.7 on page 217)</td>
</tr>
<tr>
<td>Vgetnext</td>
<td>vfgnx</td>
<td>Returns the identifier of the next vgroup or vdata in a vgroup (Obsolete) (Section 5.9.1 on page 230)</td>
</tr>
<tr>
<td>Vgettagref</td>
<td>vfgtr</td>
<td>Retrieves a tag/reference number pair for a data object in the vgroup (Section 5.6.2.2 on page 215)</td>
</tr>
<tr>
<td>Vgettagrefs</td>
<td>vfgtrs</td>
<td>Retrieves the tag/reference number pairs of all the data objects belonging to a vgroup (Section 5.6.2.3 on page 216)</td>
</tr>
<tr>
<td>Vntagref</td>
<td>vfnqtr</td>
<td>Determines whether a data object belongs to a vgroup (Section 5.6.2.4 on page 216)</td>
</tr>
<tr>
<td>Visvg</td>
<td>vfsvg</td>
<td>Determines whether a data object is a vgroup within another vgroup (Section 5.6.2.3 on page 217)</td>
</tr>
<tr>
<td>Visvs</td>
<td>vfsvs</td>
<td>Determines whether a data object is a vdata within a vgroup (Section 5.6.2.6 on page 217)</td>
</tr>
<tr>
<td>Vnrefs</td>
<td>vfnrefs</td>
<td>Retrieves the number of tags of a given tag type in a vgroup (Section 5.6.2.8 on page 218)</td>
</tr>
<tr>
<td>Vattrinfo</td>
<td>vfsinfo</td>
<td>Retrieves information of a vgroup attribute (Section 5.8.2 on page 224)</td>
</tr>
<tr>
<td>Vfindattr</td>
<td>vffdatt</td>
<td>Returns the index of a vgroup attribute given the attribute name (Section 5.8.6 on page 226)</td>
</tr>
</tbody>
</table>
| Vgetattr                         | vfgatt/ | Retrieves the values of a vgroup attribute (Section 5.8.5 on  
vfreqcatt  | page 225) |
| Vnattrts                         | vfsatts| Returns the total number of vgroup attributes (Section 5.8.3 on page 224)     |
| Vsetattr                         | vfsatt/ | Sets the attribute of a vgroup (Section 5.8.4 on page 225)                   |

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5.3.2 Identifying Vgroups in the Vgroup Interface

The Vgroup interface identifies vgroups in several ways. In some cases, a vgroup can be accessed directly through the use of its unique reference number. In other cases, the reference number and the routine `Vattach` are used to obtain a vgroup identifier. The reference number of a vgroup can be obtained from the name or the class of the vgroup, or by sequentially traversing the file. The concept of reference number is discussed in Section 2.2.2.1 on page 8.

When a vgroup is attached or created, it is assigned an identifier, called `vgroup id`. After a vgroup has been attached or created, its identifier is used by the Vgroup interface routines in accessing the vgroup.

5.4 Programming Model for the Vgroup Interface

The programming model for accessing vgroups is as follows:

1. Open an HDF file.
2. Initialize the Vgroup interface.
3. Create a new vgroup or open an existing one.
4. Perform the desired operations on the vgroup.
5. Terminate access to the vgroup.
6. Terminate access to the Vgroup interface.
7. Close the file.

These steps correspond to the following sequence of function calls:

**C:**
```
    file_id = Hopen(filename, file_access_mode, num_dds_block);
    status = Vstart(file_id);
    vgroup_id = Vattach(file_id, vgroup_ref, vg_access_mode);
    <Optional operations>
    status = Vdetach(vgroup_id);
    status = Vend(file_id);
    status = Hclose(file_id);
```

**FORTRAN:**
```
    file_id = hopen(filename, file_access_mode, num_dds_block)
    status = vfstart(file_id)
    vgroup_id = vfatch(file_id, vgroup_ref, vg_access_mode)
    <Optional operations>
    status = vfdtch(vgroup_id)
    status = vfend(file_id)
    status = hclose(file_id)
```

The calling program must obtain a separate vgroup identifier for each vgroup to be accessed.

5.4.1 Accessing Files and Vgroups: Vstart and Vattach

An HDF file must be opened by `Hopen` before it can be accessed using the Vgroup interface. `Hopen` is described in Chapter 2, *HDF Fundamentals*.

The Vgroup interface routines are used in a similar manner to the Vdata interface routines. Before performing operations on a vgroup, a calling program must call `Vstart` for every file to be accessed. `Vstart` initializes the internal vgroup structures in a file. `Vstart` takes one argument, the file identifier returned by `Hopen`, and returns either `SUCCEED` (or 0) or `FAIL` (or -1). Note that the `Vstart` routine is used by both the Vdata and Vgroup interfaces.
The calling program must also call one **Vattach** for every vgroup to be accessed. **Vattach** provides access to an individual vgroup for all read and write operations. **Vattach** takes three arguments: `file_id`, `vgroup_ref`, and `vg_access_mode`, and returns either a vgroup identifier or **FAIL** (or -1).

The argument `file_id` is the file identifier returned by **Hopen**. The parameter `vgroup_ref` is the reference number that identifies the vgroup to be accessed. Specifying `vgroup_ref` with a value of -1 will create a new vgroup; specifying `vgroup_ref` with a nonexistent reference number will return an error code of **FAIL** (or -1); and specifying `vgroup_ref` with a valid reference number will initiate access to the corresponding vgroup.

When a new vgroup is created, it does not have any members. Additional operations must be performed to add other HDF data objects to the vgroup. Refer to Section 5.5 on page 196 for information.

To access an existing vdata, its reference number must be obtained. The Vgroup interface includes two routines for this purpose, **Vfind** and **Vgetid**. **Vfind** can be used to obtain the reference number of a vgroup when the vgroup’s name is known. **Vgetid** can be used to obtain the reference number by sequentially traversing the file. These routines are discussed in Section 5.6.1.5 on page 211 and Section 5.6.1.2 on page 210.

The parameter `vg_access_mode` in **Vattach** specifies the type of access ("r" or "w") required for operations on the selected vgroup.

Multiple attaches may be made to a vgroup, which will result in several vgroup identifiers being assigned to the same vgroup. Termination must be properly handled as described in the next section.

The parameters of **Vstart** and **Vattach** are defined in Table 5B on page 196.

### 5.4.2 Terminating Access to Vgroups and Files: Vdetach and Vend

Successfully terminating access to a vgroup requires one **Vdetach** call for every **Vattach** call made. Similarly, successfully terminating access to the Vgroup interface requires one **Vend** call for every **Vstart** call made.

**Vdetach** terminates access to a vgroup by updating internal library structures and freeing all memory associated with the vgroup and allocated by **Vattach**. Once a vgroup is detached, its identifier is invalid and any attempts to access this vgroup identifier will result in an error condition. **Vdetach** takes one argument, `vgroup_id`, the vgroup identifier returned by **Vattach**, and returns either **SUCCEED** (or 0) or **FAIL** (or -1).

**Vend** releases all internal data structures allocated by **Vstart**. Attempts to use the Vgroup interface identifier after calling **Vend** will produce errors. **Vend** takes one argument, `file_id`, the file identifier returned by **Hopen**, and returns either **SUCCEED** (or 0) or **FAIL** (or -1). Note that the first **Vend** call to a file must occur after all **Vdetach** calls for the vgroups in the same file have been made. Note also that the **Vend** routine is used by both the Vdata and Vgroup interfaces.

**Hclose** must be used to terminate access to the HDF file and only after all proper **Vend** calls are made. **Hclose** is described in Chapter 2, *HDF Fundamentals*.

The parameters of **Vdetach** and **Vend** are also defined in Table 5B.
There are two steps involved in the creation of a vgroup: creating the vgroup and inserting data objects into it. Any HDF data object can be inserted into a vgroup. Creation and insertion operations are usually performed at the same time, but that is not required.

HDF provides two routines that insert an HDF data object into a vgroup, Vaddtagref and Vinsert. Vaddtagref can insert any HDF data object into a vgroup, but requires that the tag and reference number of the object be available. Refer to Section 2.2.2.1 on page 8 for the description of tags and reference numbers for HDF data objects. Vinsert only inserts a vdata or a vgroup to a vgroup, but only requires the identifier of the vdata or the vgroup.

Creating a vgroup with a member involves the following steps:

1. Open the HDF file.
2. Initialize the Vgroup interface.
3. Create the new vgroup.
4. Optionally assign a vgroup name.
5. Optionally assign a vgroup class.
6. Insert a data object.
7. Terminate access to the vgroup.
8. Terminate access to the Vgroup interface.

These steps correspond to the following sequence of function calls:

C:

```c
file_id = Hopen(filename, file_access_mode, num_dds_block);
status = Vstart(file_id);
vgroup_id = Vattach(file_id, vgroup_ref, vg_access_mode);
status = Vsetname(vgroup_id, vgroup_name);
status = Vsetclass(vgroup_id, vgroup_class);
/* Use either Vinsert to add a vdata or a vgroup, or
   Vaddtagref to add any data object */
num_of_tag_refs = Vaddtagref(vgroup_id, obj_tag, obj_ref);
OR
obj_pos = Vinsert(vgroup_id, v_id);
status = Vdetach(vgroup_id, vgaccess_mode);
status = Vend(file_id);
status = Hclose(file_id);
```
status = Vdetach(vgroup_id);
status = Vend(file_id);
status = Hclose(file_id);

FORTRAN:    file_id = hopen(filename, file_access_mode, num_dds_block)
status = vfstart(file_id)
vgroup_id = vfatch(file_id, vgroup_ref, vg_access_mode)
status = vfsnam(vgroup_id, vdata_name)
status = vfscls(vgroup_id, vdata_class)

C Use either Vinsert to add a vdata or a vgroup, or Vaddtagref to
C add any data object
num_of_tag_refs = vfadtr(vgroup_id, obj_tag, obj_ref)
OR
obj_pos = vfinsrt(vgroup_id, v_id)
status = vfdch(vgroup_id)
status = vfend(file_id)
status = hclose(file_id)

The parameter v_id in the calling sequence is either a vdata or vgroup identifier. The parameter vgroup_id is the vgroup identifier returned by Vattach.

When a new vgroup is created, the value of vgroup_ref must be set to -1 and the value of vg_access_mode must be "w".

5.5.1 Assigning a Vgroup Name and Class: Vsetname and Vsetclass

Vsetname assigns a name to a vgroup. The parameter vgroup_name is a character string with the name to be assigned to the vgroup. If Vsetname is not called, the vgroup name is set to a zero-length character string. A name may be assigned and reset any time after the vgroup is created.

Vsetclass assigns a class to a vgroup. The parameter vgroup_class is a character string with the class name to be assigned to the vgroup. If Vsetclass is not called, the vgroup class is set to a zero-length string. As with the vgroup names, the class may be set and reset at any time after the vgroup is created.

Vsetname and Vsetclass return either SUCCEED (or 0) or FAIL (or -1). The parameters of these routines are further described in Table 5C on page 198.

5.5.2 Inserting Any HDF Data Object into a Vgroup: Vaddtagref

Vaddtagref inserts HDF data objects into the vgroup identified by vgroup_id. HDF data objects may be added to a vgroup when the vgroup is created or at any point thereafter.

The parameters obj_tag and obj_ref in Vaddtagref are the tag and reference number, respectively, of the data object to be inserted into the vgroup. Note that duplicated tag and reference number pairs are allowed.

Vaddtagref returns the total number of tag and reference number pairs, i.e., the total number of data objects, in the vgroup if the operation is successful, and FAIL (or -1) otherwise. The parameters of Vaddtagref are further described in Table 5C.

5.5.3 Inserting a Vdata or Vgroup Into a Vgroup: Vinsert

Vinsert is a routine designed specifically for inserting vdatas or vgroups into a parent vgroup. To use Vinsert, you must provide the identifier of the parent vgroup, vgroup_id, as well as the identifier of the vdata or vgroup to be inserted, v_id.
The parameter \( v\_id \) of \texttt{Vinsert} is either a \texttt{vdata} identifier or a \texttt{vgroup} identifier, depending on whether a \texttt{vdata} or \texttt{vgroup} is to be inserted.

\texttt{Vinsert} returns the index of the inserted \texttt{vdata} or \texttt{vgroup} if the operation is successful, and \texttt{FAIL} (or \texttt{-1}) otherwise. The parameters of \texttt{Vinsert} are further defined in Table 5C.

**TABLE 5C**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{Vsetname}</td>
<td>\texttt{int32}</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td>\texttt{(vfnam)}</td>
<td>\texttt{vgroup_id}</td>
<td>integer</td>
</tr>
<tr>
<td>\texttt{vgroup_name}</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td>\texttt{Vsetclass}</td>
<td>\texttt{int32}</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td>\texttt{(vfscls)}</td>
<td>\texttt{vgroup_id}</td>
<td>integer</td>
</tr>
<tr>
<td>\texttt{vgroup_class}</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td>\texttt{Vaddtagref}</td>
<td>\texttt{int32}</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td>\texttt{(vfadtr)}</td>
<td>\texttt{vgroup_id}</td>
<td>integer</td>
</tr>
<tr>
<td>\texttt{obj_tag}</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>\texttt{obj_ref}</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>\texttt{Vinsert}</td>
<td>\texttt{int32}</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td>\texttt{(vfnst)}</td>
<td>\texttt{vgroup_id}</td>
<td>integer</td>
</tr>
<tr>
<td>\texttt{v_id}</td>
<td>int32</td>
<td>integer</td>
</tr>
</tbody>
</table>

**EXAMPLE 1. Creating HDF Files and Vgroups**

This example illustrates the use of \texttt{Hopen/hopen}, \texttt{Vstart/vfstart}, \texttt{Vattach/vfatch}, \texttt{Vdetach/vfdtch}, \texttt{Vend/vfend}, and \texttt{Hclose/hclose} to create and to access two \texttt{vgroups} in an HDF file.

The program creates the HDF file, named "Two_Vgroups.hdf", and two \texttt{vgroups} stored in the file. Note that, in this example, the program only create two empty \texttt{vgroups}.

C:

```c
#include "hdf.h"
#define  FILE_NAME    "Two_Vgroups.hdf"

main()
{
    /**************************** Variable declaration ***************************/
    intn  status_n;      /* returned status for functions returning an intn */
    int32 status_32,     /* returned status for functions returning an int32 */
    vgroup_ref = -1,
    vgroup1_id, vgroup2_id, file_id;

    /**************************** End of variable declaration *****************************/

    /*
     * Create the HDF file.
     */
    file_id = Hopen (FILE_NAME, DFACC_CREATE, 0);

    /*
     * Initialize the V interface.
     */
    status_n = Vstart (file_id);
    /*
```
* Create the first vgroup. Note that the vgroup reference number is set to -1 for creating and the access mode is "w" for writing. */

vgroup1_id = Vattach (file_id, vgroup_ref, "w");

/*
* Create the second vgroup. */

vgroup2_id = Vattach (file_id, vgroup_ref, "w");

/*
* Any operations on the vgroups. */

/*
* Terminate access to the first vgroup. */

status_32 = Vdetach (vgroup1_id);

/*
* Terminate access to the second vgroup. */

status_32 = Vdetach (vgroup2_id);

/*
* Terminate access to the V interface and close the HDF file. */

status_n = Vend (file_id);
status_n = Hclose (file_id);
}

FORTRAN:

program create_vgroup

C
C     Parameter declaration
C
character*15 FILE_NAME
C
parameter (FILE_NAME = 'Two_Vgroups.hdf')
integer DFACC_CREATE
parameter (DFACC_CREATE = 4)

C Function declaration

integer hopen, hclose
integer vfstart, vfatch, vfdtch, vfend

C
C**** Variable declaration ****************************************
C
integer status
integer file_id
integer vgroup1_id, vgroup2_id, vgroup_ref

C**** End of variable declaration ********************************
C
C Create the HDF file.

c file_id = hopen(FILE_NAME, DFACC_CREATE, 0)
Initialize the V interface.
status = vfstart(file_id)

Create the first vgroup. Note that the vgroup reference number is set to -1 for creating and the access mode is 'w' for writing.
vgroup_ref = -1
vgroup1_id = vfatch(file_id, vgroup_ref, 'w')

Create the second vgroup.
vgroup2_id = vfatch(file_id, vgroup_ref, 'w')

Any operations on the vgroups.

Terminate access to the first vgroup.
status = vfdtch(vgroup1_id)

Terminate access to the second vgroup.
status = vfdtch(vgroup2_id)

Terminate access to the V interface and close the HDF file.
status = vfend(file_id)
status = hclose(file_id)
end

EXAMPLE 2.

Adding an SDS to a New Vgroup

This example illustrates the use of `Vaddtagref/vfadtr` to add an HDF data object, an SDS specifically, to a vgroup.

In this example, the program first creates the HDF file "General_Vgroups.hdf", then an SDS in the SD interface, and a vgroup in the Vgroup interface. The SDS is named "Test SD" and is a one-dimensional array of type int32 of 10 elements. The vgroup is named "SD Vgroup" and is of class "Common Vgroups". The program then adds the SDS to the vgroup using `Vaddtagref/vfadtr`. Notice that, when the operations are complete, the program explicitly terminates access to the SDS, the vgroup, the SD interface, and the Vgroup interface before closing the HDF file. Refer to Chapter 3, *Scientific Data Sets (SD API)* for the discussion of the SD routines used in this example.
C:

#include  "hdf.h"  /* Note: in this example, hdf.h can be omitted...*/
#include  "mfhdf.h"    /* ...since mfhdf.h already includes hdf.h */

#define  FILE_NAME    "General_Vgroups.hdf"
#define  SDS_NAME     "Test SD"
#define  VG_NAME      "SD Vgroup"
#define  VG_CLASS     "Common Vgroups"

main()
{
    /******************************************************************************
    ******** Variable declaration ********
    /******************************************************************************/
    int n   status_n;     /* returned status for functions returning an intn  */
    int32 status_32,    /* returned status for functions returning an int32 */
    sd_id,        /* SD interface identifier */
    sds_id,       /* data set identifier */
    sds_ref,      /* reference number of the data set */
    dim_sizes[1], /* dimension of the data set - only one */
    rank = 1,     /* rank of the data set array */
    vgroup_id,    /* vgroup identifier */
    file_id;      /* HDF file identifier, same for V interface */
    /******************************************************************************
    ******** End of variable declaration ********
    /******************************************************************************/

    /******************************************************************************
    * Create the HDF file. *
    /******************************************************************************
    file_id = Hopen (FILE_NAME, DFACC_CREATE, 0);
    /******************************************************************************
    * Initialize the V interface. *
    /******************************************************************************
    status_n = Vstart (file_id);
    /******************************************************************************
    * Initialize the SD interface. *
    /******************************************************************************
    sd_id = SDstart (FILE_NAME, DFACC_WRITE);
    /******************************************************************************
    * Set the size of the SDS's dimension. *
    /******************************************************************************
    dim_sizes[0] = 10;
    /******************************************************************************
    * Create the SDS. *
    /******************************************************************************
    sds_id = SDcreate (sd_id, SDS_NAME, DFNT_INT32, rank, dim_sizes);
    /******************************************************************************
    * Create a vgroup and set its name and class. *
    /******************************************************************************
    vgroup_id = Vattach (file_id, -1, "w");
    status_32 = Vsetname (vgroup_id, VG_NAME);
    status_32 = Vsetclass (vgroup_id, VG_CLASS);
    /******************************************************************************
    * Obtain the reference number of the SDS using its identifier. *
    /******************************************************************************
    sds_ref = SDidtoref (sds_id);
/*
 * Add the SDS to the vgroup. Note: the tag DFTAG_NDG is used
 * when adding an SDS. Refer to Appendix A for the entire list of tags.
 */
status_32 = Vaddtagref (vgroup_id, DFTAG_NDG, sds_ref);

/*
 * Terminate access to the SDS and to the SD interface.
 */
status_n = SDendaccess (sds_id);
status_n = SDend (sd_id);

/*
 * Terminate access to the vgroup and to the V interface, and
 * close the HDF file.
 */
status_32 = Vdetach (vgroup_id);
status_n = Vend (file_id);
status_n = Hclose (file_id);
}

FORTRAN:

program add_SDS_to_a_vgroup
implicit none

C
C     Parameter declaration
C
character*19 FILE_NAME
character*7  SDS_NAME
character*9  VG_NAME
character*13 VG_CLASS

parameter (FILE_NAME = ’General_Vgroups.hdf’,
+    SDS_NAME = ’Test SD’,
+    VG_NAME = ’SD Vgroup’,
+    VG_CLASS = ’Common Vgroups’)
integer DFACC_CREATE, DFACC_WRITE
parameter (DFACC_CREATE = 4, DFACC_WRITE = 2)
integer DFNT_INT32
parameter (DFNT_INT32 = 24)
integer DFTAG_NDG
parameter (DFTAG_NDG = 720)
C
C     Function declaration
C
integer hopen, hclose
integer vfstart, vfetch, vfsnam, vfscls, vfadtr, vfdtc, vfend
integer sfstart, sfcreate, sfid2ref, sfendacc, sfend

C
C**** Variable declaration ***************************************************************
C
integer status
integer file_id
integer vgroup_id
integer sd_id, sds_id, sds_ref
integer dim_sizes(1), rank
C
C**** End of variable declaration ***************************************************************
C
C Create the HDF file.
```c

file_id = hopen(FILE_NAME, DFACC_CREATE, 0)

Initialize the V interface.
status = vfstart(file_id)

Initialize SD interface.
sd_id = sfstart(FILE_NAME, DFACC_WRITE)

Set the rank and the size of SDS's dimension.
rank = 1
dim_sizes(1) = 10

Create the SDS.
sds_id = sfcreate(sd_id, SDS_NAME, DFNT_INT32, rank, dim_sizes)

Create a vgroup and set its name and class.
vgroup_id = vfatch(file_id, -1, 'w')
status = vfsnam(vgroup_id, VG_NAME)
status = vfscls(vgroup_id, VG_CLASS)

Obtain the reference number of the SDS using its identifier.
sds_ref = sfid2ref(sds_id)

Add the SDS to the vgroup. Note: the tag DFTAG_NDG is used when adding an SDS. Refer to HDF Reference Manual, Section III, Table 3K, for the entire list of tags.
status = vfadtr(vgroup_id, DFTAG_NDG, sds_ref)

Terminate access to the SDS and to the SD interface.
status = sfendacc(sds_id)
status = sfend(sd_id)

Terminate access to the vgroup.
status = vfdtch(vgroup_id)

Terminate access to the V interface and close the HDF file.
status = vfend(file_id)
status = hclose(file_id)
end
```

**EXAMPLE 3. Adding Three Vdatas into a Vgroup**

This example illustrates the use of `Vinsrt` to add a vdata to a vgroup. Note that `Vaddtagref/vfadtrf`, used in the previous example, performs the same task and only differs in the argument list.

In this example, the program creates three vdatas and a vgroup in the existing HDF file "General_Vgroups.hdf" then adds the three vdatas to the vgroup. Notice that the vdatas and the
vgroup are created in the same interface that is initialized by the call \texttt{Vstart/vfstart}. The first vdata is named "X,Y Coordinates" and has two order-1 fields of type float32. The second vdata is named "Temperature" and has one order-1 field of type float32. The third vdata is named "Node List" and has one order-3 field of type int16. The vgroup is named "Vertices" and is of class "Vertex Set". The program uses \texttt{Vinsert/vfinst} to add the vdatas to the vgroup using the vdata identifiers. Refer to Chapter 4, \textit{Vdatas (VS API)}, for the discussion of the VS routines used in this example.

\begin{center}
\begin{tabular}{|c|c|c|}
\hline
\text{Vdata} & \text{Name: PX, PY} & \text{Class: Node List} \\
\hline
\text{Vdata} & \text{Name: TMP} & \text{Class: Property List} \\
\hline
\text{Vdata} & \text{Name: PLIST} & \text{Class: Connectivity List} \\
\hline
\end{tabular}
\end{center}

C:

\begin{verbatim}
#include "hdf.h"

#define FILE_NAME "General_Vgroups.hdf"
#define N_RECORDS 30       /* number of records in the vdatas */
#define ORDER 3        /* order of field FIELD_VD2 */
#define VG_NAME "Vertices"
#define VG_CLASS "Vertex Set"
#define VD1_NAME "X,Y Coordinates"   /* first vdata to hold X,Y...*/
#define VD1_CLASS "Position"          /*...values of the vertices */
#define VD2_NAME "Temperature"       /* second vdata to hold the...*/
#define VD2_CLASS "Property List"     /*...temperature field */
#define VD3_NAME "Node List"         /* third vdata to hold...*/
#define VD3_CLASS "Mesh"             /*...the list of nodes */
#define FIELD1_VD1 "PX"    /* first field of first vdata - X values */
#define FIELD2_VD1 "PY"/* second field of first vdata - Y values */
#define FIELD_VD2 "TMP"/* field of third vdata */
#define FIELD_VD3 "PLIST"/* field of second vdata */
#define FIELDNAME_LIST "PX,PY" /* field name list for first vdata */
/* Note that the second and third vdatas can use the field names as */
/* the field name lists unless more fields are added to a vdata. */
/* Then a field name list is needed for that vdata */

main( ) {

    /***************************************************************************/
    int32     file_id, vgroup_id, vd1_id, vd2_id, vd3_id;
    int32     num_of_records, vd_index;
    float32    pxy[N_RECORDS][2] = /* buffer for data of the first vdata */

    /***************************************************************************/
}
\end{verbatim}
{-1.5, 2.3, -1.5, 1.98, -2.4, .67, 
-3.4, 1.46, -.65, 3.1, -.62, 1.23, 
-.4, 3.8, -3.55, 2.3, -1.43, 2.44, 
.23, 1.13, -1.4, 5.43, -1.4, 5.8, 
-3.4, 3.85, -.55, .3, -.21, 1.22, 
-1.44, 1.9, -1.4, 2.8, .94, 1.78, 
-.4, 2.32, -.87, 1.99, -.54, 4.11, 
-1.5, 1.35, -1.4, 2.21, -.22, 1.8, 
-1.1, 4.55, -.44, .54, -1.11, 3.93, 
-.76, 1.9, -2.34, 1.7, -2.2, 1.21};

float32  tmp[N_RECORDS];          /* buffer for data of the second vdata */
int16    plist[N_RECORDS][3];     /* buffer for data of the third vdata */

/***************************************** End of variable declaration *******************************************/

/*
* Open the HDF file for writing.
*/
file_id = Hopen (FILE_NAME, DFACC_WRITE, 0);

/*
* Initialize the V interface.
*/
status_n = Vstart (file_id);

/*
* Buffer the data for the second and third vdatas.
*/
for (i = 0; i < N_RECORDS; i++)
  for (j = 0; j < ORDER; j++)
    plist[i][j] = ++k;

for (i = 0; i < N_RECORDS; i++)
  tmp[i] = i * 10.0;

/*
* Create the vgroup then set its name and class. Note that the vgroup's
* reference number is set to -1 for creating and the access mode is "w" for
* writing.
*/
vgroup_id = Vattach (file_id, -1, "w");
status_32 = Vsetname (vgroup_id, VG_NAME);
status_32 = Vsetclass (vgroup_id, VG_CLASS);

/*
* Create the first vdata then set its name and class. Note that the vdata's
* reference number is set to -1 for creating and the access mode is "w" for
* writing.
*/
vdata1_id = VSattach (file_id, -1, "w");
status_32 = VSsetname (vdata1_id, VD1_NAME);
status_32 = VSsetclass (vdata1_id, VD1_CLASS);

/*
* Introduce and define the fields of the first vdata.
*/
status_n = VSfdefine (vdata1_id, FIELD1_VD1, DFNT_FLOAT32, 1);
status_n = VSfdefine (vdata1_id, FIELD2_VD1, DFNT_FLOAT32, 1);
status_n = VSsetfields (vdata1_id, FIELDNAME_LIST);

/*
* Write the buffered data into the first vdata with full interlace mode.
*/
num_of_records = VSwrite (vdata1_id, (uint8 *)pxy, N_RECORDS, FULL_INTERLACE);

/*
* Insert the vdata into the vgroup using its identifier.
*/
v_index = Vinsert (vgroup_id, vdata1_id);

/*
* Detach from the first vdata.
*/
status_32 = VSdetach (vdata1_id);

/*
* Create, write, and insert the second vdata to the vgroup using
* steps similar to those used for the first vdata.
*/
vdata2_id = VSattach (file_id, -1, "w");
status_32 = VSsetname (vdata2_id, VD2_NAME);
status_32 = VSsetclass (vdata2_id, VD2_CLASS);
status_n = VSfdefine (vdata2_id, FIELD_VD2, DFNT_FLOAT32, 1);
status_n = VSsetfields (vdata2_id, FIELD_VD2);
num_of_records = VSwrite (vdata2_id, (uint8 *)tmp, N_RECORDS, FULL_INTERLACE);
v_index = Vinsert (vgroup_id, vdata2_id);
status_32 = VSdetach (vdata2_id);

/*
* Create, write, and insert the third vdata to the vgroup using
* steps similar to those used for the first and second vdatas.
*/
vdata3_id = VSattach (file_id, -1, "w");
status_32 = VSsetname (vdata3_id, VD3_NAME);
status_32 = VSsetclass (vdata3_id, VD3_CLASS);
status_n = VSfdefine (vdata3_id, FIELD_VD3, DFNT_INT16, 3);
status_n = VSsetfields (vdata3_id, FIELD_VD3);
num_of_records = VSwrite (vdata3_id, (uint8 *)plist, N_RECORDS, FULL_INTERLACE);
v_index = Vinsert (vgroup_id, vdata3_id);
status_32 = VSdetach (vdata3_id);

/*
* Terminate access to the vgroup "Vertices".
*/
status_32 = Vdetach (vgroup_id);

/*
* Terminate access to the V interface and close the HDF file.
*/
status_n = Vend (file_id);
status_n = Hclose (file_id);
}

FORTRAN:

program add_vdatas_to_a_vgroup
implicit none
C
C Parameter declaration
C
character*19 FILE_NAME
character*8 VG_NAME
character*10 VG_CLASS
parameter (FILE_NAME = 'General_Vgroups.hdf',
+           VG_NAME   = 'Vertices',
+           VG_CLASS  = 'Vertex Set')
parameter (VD1_NAME  = 'X,Y Coordinates',
+           VD2_NAME  = 'Temperature',
+           VD3_NAME  = 'Node List')
parameter (VD1_CLASS = 'Position',
+           VD2_CLASS = 'Property List',
+           VD3_CLASS = 'Mesh')

character*2 FIELD1_VD1
character*2 FIELD2_VD1
character*3 FIELD_VD2
character*4 FIELD_VD3
character*5 FIELDNAME_LIST
parameter (FIELD1_VD1 = 'PX',
+           FIELD2_VD1 = 'PY',
+           FIELD_VD2 = 'TMP',
+           FIELD_VD3 = 'PLIST',
+           FIELDNAME_LIST = 'PX,PY')

integer N_RECORDS
parameter (N_RECORDS = 30)

integer DFACC_WRITE
parameter (DFACC_WRITE = 2)
integer DFNT_FLOAT32, DFNT_INT16
parameter (DFNT_FLOAT32 = 5, DFNT_INT16 = 22)
integer FULL_INTERLACE
parameter (FULL_INTERLACE = 0)

C  
C     Function declaration
C
integer hopen, hclose
integer vfstart, vfatch, vfsnam, vfscls, vfinsrt, vfdtch, vfend
integer vsfatch, vsfsnam, vsfscls, vsffdef, vsfsfld,
+ vsfwrt, vsfwr.tc, vsfdtch

C  
C**** Variable declaration *******************************************
C
integer status
integer file_id
integer vgroup_id
integer vdata1_id, vdata2_id, vdata3_id, vd_index
integer num_of_records
integer i, j, k
real pxy(2,N_RECORDS), tmp(N_RECORDS)
integer plist(3,N_RECORDS)
data pxy /-1.5, 2.3, -1.5, 1.98, -2.4, .67,
+ -3.4, 1.46, -.65, 3.1, -.62, 1.23,
+ -.4, 3.8, -3.55, 2.3, -1.43, 2.44,
+ .23, 1.13, -1.4, 5.43, -1.4, 5.8,
+ -3.4, 3.85, -.55, .3, -.21, 1.22,
+ -1.44, 1.9, -1.4, 2.8, .94, 1.78,
+ -.4, 2.32, -.87, 1.99, -.54, 4.11,
+ -1.5, 1.35, -1.4, 2.21, -.22, 1.8,
+ -1.1, 4.55, -.44, .54, -1.11, 3.93,
C**** End of variable declaration *********************************************
C
C     Open the HDF file for writing.
C
file_id = hopen(FILE_NAME, DFACC_WRITE, 0)
C
C     Initialize the V interface.
C
status = vfstart(file_id)
C
C     Buffer the data for the third and second vdatas.
C
do 20 i = 1, N_RECORDS
   do 10 j = 1, 3
      plist(j,i) = k
      k = k+1
   10       continue
20    continue

C     Create a vgroup and set its name and class. Note that the vgroup’s reference number is set to -1 for creating and the access mode is ‘w’ for writing.
C
vgroup_id = vfatch(file_id, -1, 'w')
status = vfsnam(vgroup_id, VG_NAME)
status = vfscls(vgroup_id, VG_CLASS)
C
C     Create the first vdata then set its name and class. Note that the vdata’s reference number is set to -1 for creating and the access mode is ‘w’ for writing.
C
vdata1_id = vsfatch(file_id, -1, 'w')
status = vsfsnam(vdata1_id, VD1_NAME)
status = vsfscls(vdata1_id, VD1_CLASS)
C
C     Introduce and define the fields of the first vdata.
C
status = vsffdef(vdata1_id, FIELD1_VD1, DFNT_FLOAT32, 1)
status = vsffdef(vdata1_id, FIELD2_VD1, DFNT_FLOAT32, 1)
status = vsfsfld(vdata1_id, FIELDNAME_LIST)
C
C     Write the buffered data into the first vdata.
C
num_of_records = vsfwrt(vdata1_id, pxy, N_RECORDS, +
                       FULL_INTERLACE)
C
C     Insert the vdata into the vgroup using its identifier.
C
vd_index = vfinsrt(vgroup_id, vdata1_id)
C
C     Detach from the first vdata.
C
status = vsfdtch(vdata1_id)
C
C     Create, write, and insert the second vdata to the vgroup using steps similar to those used for the first vdata.
vdata2_id = vsfatch(file_id, -1, 'w')
status = vsfsnam(vdata2_id, VD2_NAME)
status = vsfscls(vdata2_id, VD2_CLASS)
status = vsffdef(vdata2_id, FIELD_VD2, DFNT_FLOAT32, 1)
status = vsfsfld(vdata2_id, FIELD_VD2)
num_of_records = vsfwrt(vdata2_id, tmp, N_RECORDS, +
                        FULL_INTERLACE)
vd_index = vfinsrt(vgroup_id, vdata2_id)
status = vsfdtch(vdata2_id)

C Create, write, and insert the third vdata to the vgroup using
C steps similar to those used for the first and second vdatas.

vdata3_id = vsfatch(file_id, -1, 'w')
status = vsfsnam(vdata3_id, VD3_NAME)
status = vsfscls(vdata3_id, VD3_CLASS)
status = vsffdef(vdata3_id, FIELD_VD3, DFNT_INT16, 3)
status = vsfsfld(vdata3_id, FIELD_VD3)
num_of_records = vsfwrtc(vdata3_id, plist, N_RECORDS, +
                        FULL_INTERLACE)
vd_index = vfinsrt(vgroup_id, vdata3_id)
status = vsfdtch(vdata3_id)

C Terminate access to the vgroup 'Vertices'.

C status = vsfdtch(vgroup_id)
C Terminate access to the V interface and close the HDF file.

C status = vfend(file_id)
status = hclose(file_id)
end

5.6 Reading from Vgroups

Reading from vgroups is more complicated than writing to vgroups. The process of reading from
groups involves two steps: locating the appropriate vgroup and obtaining information about the
member or members of a vgroup.

Reading from vgroups is more complicated than writing to vgroups. This section describes rou-
tines that locate the appropriate vgroup and obtain information about the member or members of a
vgroup.

5.6.1 Locating Vgroups and Obtaining Vgroup Information

There are several routines provided for the purpose of locating a particular vgroup, each corre-
sponding to an identifying aspect of a vgroup. These aspects include whether the vgroup has
vgroups included in it, the identification of the vgroup in the file based on its reference number,
and the name and class name of the vgroup. The routines are described in the following subsec-
tions.

5.6.1.1 Locating Lone Vgroups: Vlone

A lone vgroup is one that is not a member of any other vgroups, i.e., not linked with any other
vgroups. Vlone searches the file specified by the parameter file_id and retrieves the reference
numbers of lone vgroups in the file. This routine is useful for locating unattached vgroups in a file
or the vgroups at the top of a grouping hierarchy. The syntax of Vlone is as follows:
The parameter `ref_array` is an array allocated to hold the reference numbers of the found vgroups. The argument `maxsize` specifies the maximum size of `ref_array`. At most `maxsize` reference numbers will be retrieved in `ref_array`. The value of `max_size`, the space allocated for `ref_array`, depends on how many lone vgroups are expected to be found.

To use dynamic memory instead of allocating an unnecessarily large array (i.e., one that will hold the maximum possible number of reference numbers), call `Vlone` twice. In the first call to `Vlone`, set `maxsize` to a small value, for example, 0 or 1, then use the returned value (the total number of lone vgroups in the file) to allocate memory for `ref_array`. This array is then passed into the second call to `Vlone`.

`Vlone` returns the total number of lone vgroups or `FAIL` (or -1). The parameters of this routine are further defined in Table 5D on page 210.

5.6.1.2 Sequentially Searching for a Vgroup: Vgetid

`Vgetid` sequentially searches through an HDF file to obtain the reference number of the vgroup immediately following the vgroup specified by the reference number, `vgroup_ref`. The syntax of `Vgetid` is as follows:

C: \[ \text{ref_num} = \text{Vgetid}(\text{file_id}, \text{vgroup_ref}); \]

FORTRAN: \[ \text{ref_num} = \text{vfgid}(\text{file_id}, \text{vgroup_ref}); \]

To initiate a search, `Vgetid` may be called with `vgroup_ref` set to -1. Doing so returns the reference number of the first vgroup in the file. Any attempt to search past the last vgroup in a file will cause `Vgetid` to return a value of `FAIL` (or -1).

`Vgetid` returns a vgroup reference number or `FAIL` (or -1). The parameters of `Vgetid` are further defined in Table 5D.

### Table 5D: Vlone and Vgetid Parameter Lists

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vlone [int32] (vflone)</td>
<td><code>file_id</code></td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td><code>ref_array</code></td>
<td>int32 *</td>
<td>integer (*)</td>
</tr>
<tr>
<td></td>
<td><code>maxsize</code></td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>Vgetid [int32] (vfgid)</td>
<td><code>file_id</code></td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td><code>vgroup_ref</code></td>
<td>int32</td>
<td>integer</td>
</tr>
</tbody>
</table>

5.6.1.3 Obtaining the Name of a Vgroup: Vgetname

`Vgetname` retrieves the name of the vgroup identified by the parameter `vgroup_id` into the parameter `vgroup_name`. The syntax of `Vgetname` is as follows:

C: \[ \text{status} = \text{Vgetname}(\text{vgroup_id}, \text{vgroup_name}); \]

FORTRAN: \[ \text{status} = \text{vfgnam}(\text{vgroup_id}, \text{vgroup_name}); \]

The maximum length of the vgroup name is defined by `VGNAMELENMAX` (or 64).
**Vgetname** returns either **SUCCEED** (or 0) or **FAIL** (or -1). The parameters of this routine are further defined in Table 5E on page 211.

### 5.6.1.4 Obtaining the Class Name of a Vgroup: Vgetclass

**Vgetclass** retrieves the class name of the vgroup specified by the parameter **vgroup_id** into the parameter **vgroup_class**. The syntax of **Vgetclass** is as follows:

**C:**
```
status = Vgetclass(vgroup_id, vgroup_class);
```

**FORTRAN:**
```
status = vfgcls(vgroup_id, vgroup_class)
```

The maximum length of the class name is defined by **VGNAMELENMAX** (or 64).

**Vgetclass** returns either **SUCCEED** (or 0) or **FAIL** (or -1). The parameters of this routine are further defined in Table 5E.

### TABLE 5E
**Vgetname and Vgetclass Parameter Lists**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vgetname</strong> ([int32]</td>
<td>vgroup_id</td>
<td>int32 integer</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td>([vfnam])</td>
<td>vgroup_name</td>
<td>char * character(*)</td>
<td>Buffer for the name of the vgroup</td>
</tr>
<tr>
<td><strong>Vgetclass</strong> ([int32]</td>
<td>vgroup_id</td>
<td>int32 integer</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td>([vfcls])</td>
<td>vgroup_class</td>
<td>char * character(*)</td>
<td>Buffer for the vgroup class</td>
</tr>
</tbody>
</table>

### 5.6.1.5 Locating a Vgroup Given Its Name: Vfind

**Vfind** searches the file identified by **file_id** for a vgroup with the name specified by the parameter **vgroup_name**. The syntax for **Vfind** is as follows:

**C:**
```
vgroup_ref = Vfind(file_id, vgroup_name);
```

**FORTRAN:**
```
vgroup_ref = vfind(file_id, vgroup_name)
```

**Vfind** returns the reference number of the vgroup if one is found, or 0 otherwise. If more than one vgroup has the same name, **Vfind** will return the reference number of the first one.

The parameters of **Vfind** are further defined in Table 5F.

### 5.6.1.6 Locating a Vgroup Given Its Class Name: Vfindclass

**Vfindclass** searches the file identified by **file_id** for a vgroup with the class name specified by the parameter **vgroup_class**. The syntax of **Vfindclass** is as follows:

**C:**
```
vgroup_ref = Vfindclass(file_id, vgroup_class);
```

**FORTRAN:**
```
vgroup_ref = vfndcls(file_id, vgroup_class)
```

**Vfindclass** returns the reference number of the vgroup if one is found, or 0 otherwise. If more than one vgroup has the same class name, **Vfindclass** will return the reference number of the first one.

The parameters of **Vfindclass** are further defined in Table 5F.
TABLE 5F

<table>
<thead>
<tr>
<th>Routine Name (FORTRAN-77)</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Vfind</code></td>
<td>file_id</td>
<td>integer</td>
</tr>
<tr>
<td><code>vfnd</code></td>
<td>vgroup_name</td>
<td>character*(*)</td>
</tr>
<tr>
<td><code>Vfindclass</code></td>
<td>file_id</td>
<td>integer</td>
</tr>
<tr>
<td><code>vfndcls</code></td>
<td>vgroup_class</td>
<td>character*(*)</td>
</tr>
</tbody>
</table>

EXAMPLE 4.

**Obtaining Information about Lone Vgroups**

This example illustrates the use of `Vlone/vflone` to obtain the list of reference numbers of all lone vgroups in the file and the use of `Vgetname/vfgnam` and `Vgetclass/vfgcls` to obtain the name and the class of each vgroup.

In this example, the program calls `Vlone/vflone` twice. The first call is to obtain the number of lone vgroups in the file so that sufficient space can be allocated; the later call is to obtain the actual reference numbers of the lone vgroups. The program then goes through the list of lone vgroup reference numbers to get and display the name and class of each lone vgroup. The file used in this example is "General_Vgroups.hdf".

C:

```c
#include "hdf.h"

#define FILE_NAME "General_Vgroups.hdf"

int status_n; /* returned status for functions returning an intn */
int32 status_32; /* returned status for functions returning an int32 */
int32 file_id, vgroup_id;
int32 lone_vg_number, /* current lone vgroup number */
    num_of_lones = 0, /* number of lone vgroups */
    *ref_array; /* buffer to hold the ref numbers of lone vgroups */
char vgroup_name[VGNAMELENMAX], vgroup_class[VGNAMELENMAX];

C:\include "hdf.h"

#define FILE_NAME "General_Vgroups.hdf"

int main( )
{
    /******************************************************************************
     * Variable declaration ****************************************************/
    /******************************************************************************

    intn status_n; /* returned status for functions returning an intn */
    int32 status_32; /* returned status for functions returning an int32 */
    file_id, vgroup_id;
    int32 lone_vg_number, /* current lone vgroup number */
        num_of_lones = 0, /* number of lone vgroups */
    int32 *ref_array; /* buffer to hold the ref numbers of lone vgroups */
    char vgroup_name[VGNAMELENMAX], vgroup_class[VGNAMELENMAX];

    /******************************************************************************
     * Open the HDF file for reading. 
    /******************************************************************************

    file_id = Hopen (FILE_NAME, DFACC_READ, 0);

    /******************************************************************************
     * Initialize the V interface. 
    /******************************************************************************

    status_n = Vstart (file_id);

    /******************************************************************************
     * Get and print the names and class names of all the lone vgroups. 
    /******************************************************************************

    * First, call Vlone with num_of_lones set to 0 to get the number of 
    * lone vgroups in the file, but not to get their reference numbers. 
    * num_of_lones = Vlone (file_id, NULL, num_of_lones );
```
/*
 * Then, if there are any lone vgroups,
 */
if (num_of_lones > 0)
{
    /*
    * use the num_of_lones returned to allocate sufficient space for the
    * buffer ref_array to hold the reference numbers of all lone vgroups,
    */
    ref_array = (int32 *) malloc(sizeof(int32) * num_of_lones);
    
    /*
    * and call Vlone again to retrieve the reference numbers into
    * the buffer ref_array.
    */
    num_of_lones = Vlone (file_id, ref_array, num_of_lones);
    
    /*
    * Display the name and class of each lone vgroup.
    */
    printf ("Lone vgroups in this file are:\n");
    for (lone_vg_number = 0; lone_vg_number < num_of_lones; lone_vg_number++)
    {
        /*
        * Attach to the current vgroup then get and display its
        * name and class. Note: the current vgroup must be detached before
        * moving to the next.
        */
        vgroup_id = Vattach (file_id, ref_array[lone_vg_number], "r");
        status_32 = Vgetname (vgroup_id, vgroup_name);
        status_32 = Vgetclass (vgroup_id, vgroup_class);
        printf (" Vgroup name %s and class %s\n", vgroup_name, vgroup_class);
        status_32 = Vdetach (vgroup_id);
    } /* for */
} /* if */

/*
 * Terminate access to the V interface and close the file.
 */
status_n = Vend (file_id);
status_n = Hclose (file_id);

/*
 * Free the space allocated by this program.
 */
free (ref_array);
}

FORTRAN:

program getinfo_about_vgroup
implicit none
C
C     Parameter declaration
C
character*19 FILE_NAME
C
parameter (FILE_NAME = 'General_Vgroups.hdf')
integer DFACC_READ
parameter (DFACC_READ = 1)
integer SIZE
parameter(SIZE = 10)

C     Function declaration
C
integer hopen, hclose
integer vfstart, vfatch, vfgnam, vfgcls, vflone, vfdtch, vfend

C**** Variable declaration *******************************************
C
integer status
integer file_id
integer vgroup_id
integer lone_vg_number, num_of_lones
character*64 vgroup_name, vgroup_class
integer ref_array(SIZE)
integer i

C**** End of variable declaration ************************************
C
C     Initialize ref_array.
C
   do 10 i = 1, SIZE
       ref_array(i) = 0
   10    continue
C
C     Open the HDF file for reading.
C
file_id = hopen(FILE_NAME, DFACC_READ, 0)
C
C     Initialize the V interface.
C
status = vfstart(file_id)
C
C     Get and print the name and class name of all lone vgroups.
C     First, call vflone with num_of_lones set to 0 to get the number of
C     lone vgroups in the file and check whether size of ref_array is
C     big enough to hold reference numbers of ALL lone groups.
C     If ref_array is not big enough, exit the program after displaying an
C     informative message.
C
num_of_lones = 0
num_of_lones = vflone(file_id, ref_array, num_of_lones)
if (num_of_lones .gt. SIZE) then
   write(*,*) num_of_lones, 'lone vgroups is found'
   write(*,*) 'increase the size of ref_array to hold reference '
   write(*,*) 'numbers of all lone vgroups in the file'
   stop
endif
C
C     If there are any lone groups in the file,
C
if (num_of_lones .gt. 0) then
C
call vflone again to retrieve the reference numbers into ref_array.
C
num_of_lones = vflone(file_id, ref_array, num_of_lones)
C
C     Display the name and class of each vgroup.
C
write(*,*) 'Lone vgroups in the file are:'
do 20 lone_vg_number = 1, num_of_lones
C
C     Attach to the current vgroup, then get and display its name and class.
C     Note: the current vgroup must be detached before moving to the next.
C
vgroup_name = ' '
vgroup_class = ' '
vgroup_id = vfatch(file_id, ref_array(lone_vg_number), 'r')
status    = vfgnam(vgroup_id, vgroup_name)
status    = vfgcls(vgroup_id, vgroup_class)
write(*,*) 'Vgroup name ' ,  vgroup_name
write(*,*) 'Vgroup class ' , vgroup_class
write(*,*)
status = vfdtch(vgroup_id)
20    continue

endif
C
C     Terminate access to the V interface and close the HDF file.
C
status = vfend(file_id)
status = hclose(file_id)
end

5.6.2 Obtaining Information about the Contents of a Vgroup

This section describes the Vgroup interface routines that allow the user to obtain various information about the contents of vgroups.

5.6.2.1 Obtaining the Number of Objects in a Vgroup: Vntagrefs

Vntagrefs returns the number of tag/reference number pairs (i.e., the number of vgroup members) stored in the specified vgroup. The syntax of Vntagrefs is as follows:

C:       num_of_tagrefs = Vntagrefs(vgroup_id);
FORTRAN: num_of_tagrefs = vfntr(vgroup_id)

Vntagrefs can be used together with Vgettagrefs or Vgettagref to identify the data objects linked to a given vgroup.

Vntagrefs returns 0 or a positive number representing the number of HDF data objects linked to the vgroup if successful, or FAIL (or -1) otherwise. The parameter of Vntagrefs is further defined in Table 5G on page 216.

5.6.2.2 Obtaining the Tag/Reference Number Pair of a Data Object within a Vgroup: Vgettagref

Vgettagref retrieves the tag/reference number pair of a specified data object stored within the vgroup identified by the parameter vgroup_id. The syntax of Vgettagref is as follows:

C:       status = Vgettagref(vgroup_id, index, &obj_tag, &obj_ref);
FORTRAN: status = vfgttr(vgroup_id, index, obj_tag, obj_ref)

Vgettagref stores the tag and reference number in the parameters obj_tag and obj_ref, respectively. The parameter index specifies the location of the data object within the vgroup and is zero-based.
Often, this routine is called in a loop to identify the tag/reference number pair of each data object belong to a vgroup. In this case, `Vntagrefs` is used to obtain the loop boundary.

`Vgettagref` returns either `SUCCEED` (or 0) or `FAIL` (or -1). The parameters of this routine are further defined in Table 5G on page 216.

**5.6.2.3 Obtaining the Tag/Reference Number Pairs of Data Objects in a Vgroup: `Vgettagrefs`**

`Vgettagrefs` retrieves the tag/reference number pairs of the members of a vgroup and returns the number of pairs retrieved. The syntax of `Vgettagrefs` is as follows:

**C:**
```c
num_of_pairs = Vgettagrefs(vgroup_id, tag_array, ref_array, maxsize);
```

**FORTRAN:**
```fortran
num_of_pairs = vfgttrs(vgroup_id, tag_array, ref_array, maxsize)
```

`Vgettagrefs` stores the tags into the array `tag_array` and the reference numbers into the array `ref_array`. The parameter `maxsize` specifies the maximum number of tag/reference number pairs to return, therefore each array must be at least `maxsize` in size.

`Vgettagrefs` can be used to obtain the value of `maxsize` if the tag/reference number pairs for all members of the vgroup are desired. To do this, set `maxsize` to 1 in the first call to `Vgettagrefs`.

`Vgettagrefs` returns the number of tag/reference number pairs or `FAIL` (or -1). The parameters of this routine are further defined in Table 5G.

**TABLE 5G**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>Vntagrefs</code> [int32] (vfntr)</td>
<td>vgroup_id</td>
<td>int32</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td><code>Vgettagref</code> [intn] (vfgttr)</td>
<td>vgroup_id</td>
<td>int32</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>index</td>
<td>Index of the tag/reference number pair to be retrieved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>obj_tag</td>
<td>Tag of the data object</td>
</tr>
<tr>
<td></td>
<td></td>
<td>obj_ref</td>
<td>Reference number of the data object</td>
</tr>
<tr>
<td><code>Vgettagrefs</code> [int32] (vfgttrs)</td>
<td>vgroup_id</td>
<td>int32</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tag_array</td>
<td>Buffer for the returned tags</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ref_array</td>
<td>Buffer for the returned reference numbers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maxsize</td>
<td>Maximum number of tag/reference number pairs to be returned</td>
</tr>
</tbody>
</table>

**5.6.2.4 Testing Whether a Data Object Belongs to a Vgroup: `Vinqtagref`**

`Vinqtagref` determines whether a data object is a member of the vgroup specified by the parameter `vgroup_id`. The syntax of `Vinqtagref` is as follows:

**C:**
```c
true_false = Vinqtagref(vgroup_id, obj_tag, obj_ref);
```

**FORTRAN:**
```fortran
true_false = vfinqtr(vgroup_id, obj_tag, obj_ref)
```

The data object is specified by its tag/reference number pair in the parameters `obj_tag` and `obj_ref`. `Vinqtagref` returns `TRUE` (or 1) if the object belongs to the vgroup, and `FALSE` (or 0) otherwise. The parameters of this routine are further defined in Table 5H on page 217.
5.6.2.5 Testing Whether a Data Object within a Vgroup is a Vgroup: Visvg

Visvg determines whether the data object specified by its reference number, obj_ref, is a vgroup and is a member of the vgroup identified by the parameter vgroup_id. The syntax of Visvg is as follows:

C: \[\text{true_false} = \text{Visvg}(\text{vgroup_id, obj_ref});\]
FORTRAN: \[\text{true_false} = \text{vfisvg}(\text{vgroup_id, obj_ref})\]

Visvg returns either TRUE (or 1) or FALSE (or 0). The parameters of this routine are further defined in Table 5H on page 217.

5.6.2.6 Testing Whether an HDF Object within a Vgroup is a Vdata: Visvs

Visvs determines whether the data object specified by its reference number, obj_ref, is a vdata and is a member of the vgroup identified by the parameter vgroup_id. The syntax of Visvs is as follows:

C: \[\text{true_false} = \text{Visvs}(\text{vgroup_id, obj_ref});\]
FORTRAN: \[\text{true_false} = \text{vfisvs}(\text{vgroup_id, obj_ref})\]

Visvs returns either TRUE (or 1) or FALSE (or 0). The parameters of this routine are further defined in Table 5H.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinqtagref</td>
<td>vgroup_id</td>
<td>int32 integer</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td></td>
<td>obj_tag</td>
<td>int32 integer</td>
<td>Tag of the data object to be queried</td>
</tr>
<tr>
<td></td>
<td>obj_ref</td>
<td>int32 integer</td>
<td>Reference number of the data object to be queried</td>
</tr>
<tr>
<td>Visvg</td>
<td>vgroup_id</td>
<td>int32 integer</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td></td>
<td>obj_ref</td>
<td>int32 integer</td>
<td>Data object reference number to be queried</td>
</tr>
<tr>
<td>Visvs</td>
<td>vgroup_id</td>
<td>int32 integer</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td></td>
<td>obj_ref</td>
<td>int32 integer</td>
<td>Data object reference number to be queried</td>
</tr>
</tbody>
</table>

5.6.2.7 Locating a Vdata in a Vgroup Given Vdata Fields: Vlocate

Vlocate locates a vdata that belongs to the vgroup identified by the parameter vgroup_id and contains the fields specified in the parameter fieldname_list. The syntax of Vlocate is as follows:

C: \[\text{vdata_ref} = \text{Vlocate}(\text{vgroup_id, fieldname_list});\]
FORTRAN: \[\text{vdata_ref} = \text{vffloc}(\text{vgroup_id, fieldname_list})\]

The parameter fieldname_list is a string of comma-separated field names containing no white space, for example, “PX,PY,PZ”. Note that a vdata must contain all of the fields specified in fieldname_list to be qualified.

Vlocate returns the reference number of the vdata, if one is found, and FAIL (or -1) otherwise. The parameters of this routine are further defined in Table 5I.
5.6.2.8 Retrieving the Number of Tags of a Given Type in a Vgroup: \texttt{Vnrefs}

\texttt{Vnrefs} returns the number of tags of the type specified by the parameter \texttt{tag\_type} in the vgroup identified by the parameter \texttt{vgroup\_id}. The syntax of \texttt{Vnrefs} is as follows:

\begin{verbatim}
C: num_of_tags = Vnrefs(vgroup_id, tag_type);
FORTRAN: num_of_tags = vnrefs(vgroup_id, tag_type)
\end{verbatim}

Possible values of the parameter \texttt{tag\_type} are defined in Appendix A of this manual. \texttt{Vnrefs} returns 0 or the number of tags if successful, and \texttt{FAIL} (or \texttt{-1}) otherwise. The parameters of this routine are further defined in Table 5I.

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{Vlocate} [int32] (vflocate)</td>
<td>vgroup_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>fieldname_list</td>
<td>char*</td>
<td>character*(*)</td>
</tr>
<tr>
<td>\texttt{Vnrefs} [int32] (vnrefs)</td>
<td>vgroup_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>tag_type</td>
<td>int32</td>
<td>Tag type</td>
</tr>
</tbody>
</table>

5.6.2.9 Retrieving the Reference Number of a Vgroup: \texttt{VQueryref}

\texttt{VQueryref} returns the reference number of the vgroup identified by the parameter \texttt{vgroup\_id}, or \texttt{FAIL} (or \texttt{-1}) if unsuccessful. The syntax of \texttt{VQueryref} is as follows:

\begin{verbatim}
C: vgroup\_ref = VQueryref(vgroup\_id);
FORTRAN: vgroup\_ref = vqref(vgroup\_id)
\end{verbatim}

\texttt{VQueryref} is further defined in Table 5J.

5.6.2.10 Retrieving the Tag of a Vgroup: \texttt{VQuerytag}

\texttt{VQuerytag} returns \texttt{DFTAG\_VG} (or \texttt{1965}), which would be the tag of the vgroup identified by the parameter \texttt{vgroup\_id}, or \texttt{FAIL} (or \texttt{-1}) if unsuccessful. The syntax of \texttt{VQuerytag} is as follows:

\begin{verbatim}
C: vgroup\_tag = VQuerytag(vgroup\_id);
FORTRAN: vgroup\_tag = vqtag(vgroup\_id)
\end{verbatim}

\texttt{VQuerytag} is further defined in Table 5J.

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{VQueryref} [int32] (vqref)</td>
<td>vgroup_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td>\texttt{VQuerytag} [int32] (vqtag)</td>
<td>vgroup_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vgroup identifier</td>
</tr>
</tbody>
</table>
EXAMPLE 5.

Operations on Vgroup Attributes

This example illustrates the use of \texttt{Vfind/vfind} to locate a vgroup by its name, \texttt{Vsetattr/vfscatt} to attach an attribute to the vgroup, \texttt{Vattrinfo/vfainfo} to obtain information about the vgroup attribute, and \texttt{Vgetattr/vfgcatt} to obtain the attribute values.

The program obtains the version of the group then sets an attribute named "First Attribute" for the vgroup named "SD Vgroup". Next, the program gets the number of attributes that the vgroup has, and obtains and displays the name, the number of values, and the values of each attribute.

C:

```c
#include "hdf.h"
#define FILE_NAME "General_Vgroups.hdf"
#define VGROUP_NAME "SD Vgroup"
#define VGATTR_NAME "First Attribute"
#define N_ATT_VALUES 7 /* number of values in the attribute */

main()
{
    /**************************************************************************
    ** Variable declaration ************************************************/
    /**************************************************************************

    int status_n, /* returned status for functions returning an intn */
    n_attrs;    /* number of attributes of the vgroup */
    int32 status_32, /* returned status for functions returning an int32 */
    file_id, vgroup_ref, vgroup_id,
    attr_index, i, vg_version,
    data_type, n_values, size;
    char vg_attr[N_ATT_VALUES] = {'v','g','r','o','u','p','\0'};
    char vgattr_buf[N_ATT_VALUES], attr_name[30];

    /**************************************************************************
    ** End of variable declaration ******************************************/

    /*
    * Open the HDF file for writing.
    */
    file_id = Hopen (FILE_NAME, DFACC_WRITE, 0);

    /*
    * Initialize the V interface.
    */
    status_n = Vstart (file_id);

    /*
    * Get the reference number of the vgroup named VGROUP_NAME.
    */
    vgroup_ref = Vfind (file_id, VGROUP_NAME);

    /*
    * Attach to the vgroup found.
    */
    vgroup_id = Vattach (file_id, vgroup_ref, "w");

    /*
    * Get and display the version of the attached vgroup.
    */
    vg_version = Vgetversion (vgroup_id);
    switch (vg_version) {
        case VSET_NEW_VERSION:
            printf ("\nVgroup %s is of the newest version, version 4\n", VGROUP_NAME);
            break;
        /*
        */
    }
}
```
break;
case VSET_VERSION:
    printf ("Vgroup %s is of a version between 3.2 and 4.0r2\n", VGROUP_NAME);
    break;
case VSET_OLD_VERSION:
    printf ("Vgroup %s is of version before 3.2\n", VGROUP_NAME);
    break;
default:
    printf ("Unknown version = %d\n", vg_version);
} /* switch */

/*
* Add the attribute named VGATTR_NAME to the vgroup.
*/
status_n = Vsetattr (vgroup_id, VGATTR_NAME, DFNT_CHAR, N_ATT_VALUES, vg_attr);

/*
* Get and display the number of attributes attached to this vgroup.
*/
n attrs = Vnattrs (vgroup_id);
printf ("\nThis vgroup has %d attribute(s)\n", n attrs);

/*
* Get and display the name and the number of values of each attribute.
* Note that the fourth and last parameters are set to NULL because the type
* and the size of the attribute are not desired.
*/
for (attr_index = 0; attr_index < n attrs; attr_index++)
{
    status_n = Vattrinfo (vgroup_id, attr_index, attr_name, NULL, &n_values, NULL);
    printf ("\nAttribute #%d is named %s and has %d values: ",
            attr_index+1, attr_name, n_values);
    /*
    * Get and display the attribute values.
    */
    status_n = Vgetattr (vgroup_id, attr_index, vgattr_buf);
    for (i = 0; i < n_values; i++)
        printf ("%c ", vgattr_buf[i]);
    printf ("\n");
}

/*
* Terminate access to the vgroup and to the V interface, and close
* the HDF file.
*/
status_32 = Vdetach (vgroup_id);
status_n = Vend (file_id);
status_n = Hclose (file_id);
}

FORTRAN:

program vgroup_attribute
    implicit none
    C
    C    Parameter declaration
    C
character*19 FILE_NAME
character*9  VGROUP_NAME
character*15 VGATTR_NAME
C
parameter (FILE_NAME = 'General_Vgroups.hdf',
+    VGROUP_NAME = 'SD Vgroup',
+    VGATTR_NAME = 'First Attribute')
integer VSET_NEW_VERSION, VSET_VERSION, VSET_OLD_VERSION
parameter (VSET_NEW_VERSION = 4,
+    VSET_VERSION = 3,
+    VSET_OLD_VERSION = 2)
integer DFACC_WRITE
parameter (DFACC_WRITE = 2)
integer DFNT_CHAR
parameter (DFNT_CHAR = 4)
integer N_ATT_VALUES
parameter (N_ATT_VALUES = 6)
C
C     Function declaration
C
integer hopen, hclose
integer vfstart, vfatch, vfgver, vfscatt, vfnatts, vfainfo,
+    vfind, vfscatt, vfdtch, vfend
C
C**** Variable declaration ***************************************
C
integer status, n_attrs
integer file_id
integer vgroup_id, vgroup_ref, vg_version
integer attr_index, i
integer data_type, n_values, size
character vg_attr(N_ATT_VALUES)
character vgattr_buf(N_ATT_VALUES), attr_name(30)
data vg_attr /'v','g','r','o','u','p'/
C
C**** End of variable declaration ************************************
C
C
Open the HDF file for reading/writing.

file_id = hopen(FILE_NAME, DFACC_WRITE, 0)
C
Initialize the V interface.

status = vfstart(file_id)
C
Get the reference number of the vgroup named VGROUP_NAME.

vgroup_ref = vfind(file_id, VGROUP_NAME)
C
Attach to the vgroup found.

vgroup_id = vfatch(file_id, vgroup_ref, 'w')
C
Get and display the version of the attached vgroup.

vg_version = vfgver(vgroup_id)
if (vg_version .eq. VSET_NEW_VERSION) write(*,*)
+    'VGROUP_NAME, ' is of the newest version, version 4'
if (vg_version .eq. VSET_VERSION) write(*,*)
+    'VGROUP_NAME, ' is of a version between 3.2 and 4.0r2'
if(vg_version .eq. VSET_OLD VERSION) write(*,*)
+    ' VGROUP_NAME, ' is of version before 3.2'
if ((vg_version .ne. VSET_NEW_VERSION) .and. 
+   (vg_version .ne. VSET_VERSION) .and. 
+   (vg_version .ne. VSET_OLD_VERSION)) write(*,*) 
+   'Unknown version'

C
C     Add the attribute named VGATTR_NAME to the vgroup.
C
status = vfscatt(vgroup_id, VGATTR_NAME, DFNT_CHAR, N_ATT_VALUES, 
+                 vg_attr)
C
C     Get and display the number of attributes attached to this group.
C
n_attrs = vfnatts(vgroup_id)
write(*,*) 'This group has', n_attrs, ' attributes'
C
C     Get and display the name and the number of values of each attribute.
C
do 10 attr_index=1, n_attrs
    status = vfainfo(vgroup_id, attr_index-1, attr_name, data_type, 
+                   n_values, size)
    write(*,*) 'Attribute #', attr_index-1, ' is named ', attr_name 
+              ' and has ', n_values, ' values:
C
C     Get and display the attribute values.
C
status = vfgcatt(vgroup_id, attr_index-1, vgattr_buf) 
write(*,*) (vgattr_buf(i), i=1,n_values)
10  continue
C
C     Terminate access to the vgroup.
C
status = vfdtch(vgroup_id)
C
C     Terminate access to the V interface and close the HDF file.
C
status = vfend(file_id)
status = hclose(file_id)
end

5.7 Deleting Vgroups and Data Objects within a Vgroup

The Vgroup interface includes two routines for deletion: one deletes a vgroup from a file and the other deletes a data object from a vgroup. These routines are discussed in the following subsections.

5.7.1 Deleting a Vgroup from a File: Vdelete

Vdelete removes the vgroup identified by the parameter vgroup_id from the file identified by the parameter file_id. The syntax of Vdelete is as follows:

C:        status = Vdelete(file_id, vgroup_id);
FORTRAN:  status = vdelete(file_id, vgroup_id)

This routine will remove the vgroup from the internal data structures and from the file.

Vdelete returns either SUCCEED (or 0) or FAIL (or -1). The parameters of Vdelete are further described in Table 5K on page 223.
5.7.2 Deleting a Data Object from a Vgroup: Vdeletetagref

Vdeletetagref deletes the data object, specified by the parameters obj_tag and obj_ref, from the vgroup, identified by the parameter vgroup_id. The syntax of Vdeletetagref is as follows:

C: \[ \text{status} = \text{Vdeletetagref} (\text{vgroup}_\text{id}, \text{obj}_\text{tag}, \text{obj}_\text{ref}); \]

FORTRAN: \[ \text{status} = \text{vfdtr} (\text{vgroup}_\text{id}, \text{obj}_\text{tag}, \text{obj}_\text{ref}) \]

Vinqtagref should be used to determine whether the tag/reference number pair exists before calling Vdeletetagref. If duplicate tag/reference number pairs are found in the vgroup, Vdeletetagref deletes the first occurrence. Vinqtagref should also be used to determine whether duplicate tag/reference number pairs exist in the vgroup.

Vdeletetagref returns either SUCCEED (or 0) or FAIL (or -1). The parameters of this routine are further described in Table 5K.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vdelete</td>
<td>file_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>vgroup_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>Vdeletetagref</td>
<td>obj_tag</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>obj_ref</td>
<td>int32</td>
<td>integer</td>
</tr>
</tbody>
</table>

5.8 Vgroup Attributes

HDF version 4.1r1 and later include the ability to assign attributes to a vgroup. The concept of attributes is fully explained in Chapter 3, Scientific Data Sets (SD API). To review briefly, an attribute has a name, a data type, a number of attribute values, and the attribute values themselves. All attribute values must be of the same data type. For example, an attribute value cannot consist of ten characters and one integer, or a character value cannot be included in an attribute value consisting of two 32-bit integers.

Any number of attributes can be assigned to a vgroup, however, each attribute name must be unique among all attributes in the vgroup.

5.8.1 Obtaining the Vgroup Version Number of a Given Vgroup: Vgetversion

The structure of the vgroup has gone through several changes since HDF was first written. Determining the version of any particular vgroup is necessary as some of the older versions of vgroups do not support some of the newer features, such as attributes. Vgetversion returns the version number of the vgroup identified by the parameter vgroup_id. The syntax of Vgetversion is as follows:

C: \[ \text{version_num} = \text{Vgetversion} (\text{vgroup}_\text{id}); \]

FORTRAN: \[ \text{version_num} = \text{vfgver} (\text{vgroup}_\text{id}) \]

There are three valid version numbers: VSET_OLD_VERSION (or 2), VSET_VERSION (or 3), and VSET_NEW_VERSION (or 4).
**VSET OLD VERSION** is returned when the vgroup is of a version that corresponds to an HDF library version before version 3.2.

**VSET_VERSION** is returned when the vgroup is of a version that corresponds to an HDF library version between versions 3.2 and 4.0 release 2.

**VSET NEW VERSION** is returned when the vgroup is of a version that corresponds to an HDF library version of version 4.1 release 1 or higher.

**Vgetversion** returns the vgroup version number if successful, and **FAIL** (or -1) otherwise. This routine is further defined in Table 5L on page 225.

### 5.8.2 Obtaining Information on a Given Vgroup Attribute: Vattrinfo

**Vattrinfo** retrieves the name, data type, number of values, and the size of the values of an attribute that belongs to the vgroup identified by the parameter **vgroup_id**. The syntax of **Vattrinfo** is as follows:

**C:**
```
c: status = Vattrinfo(vgroup_id, attr_index, attr_name, &data_type, 
                      &n_values, &size);
```

**FORTRAN:**
```
status = vfainfo(vgroup_id, attr_index, attr_name, data_type, 
                 n_values, size)
```

**Vattrinfo** stores the name, data type, number of values, and the size of the value of the attribute into the parameters **attr_name**, **data_type**, **n_values**, and **size**, respectively.

The attribute is specified by its index, **attr_index**. The valid values of **attr_index** range from 0 to the total number of attributes attached to the vgroup - 1. The number of vgroup attributes can be obtained using the routine **Vnattrs**.

The parameter **data_type** is an integer number. Refer to Table 2F on page 14 for the definitions of the data types to interpret this value. The parameter **size** contains the number of bytes taken by an attribute value.

In C, the parameters **attr_name**, **data_type**, **n_values**, and **size** can be set to **NULL** if the information returned by these parameters is not needed.

**Vattrinfo** returns either **SUCCEED** (or 0) or **FAIL** (or -1). The parameters of this routine are further described in Table 5L.

### 5.8.3 Obtaining the Total Number of Vgroup Attributes: Vnattrs

**Vnattrs** returns the number of attributes assigned to the vgroup specified by the parameter **vgroup_id**. The syntax of **Vnattrs** is as follows:

**C:**
```
c: num_of_attrs = Vnattrs(vgroup_id);
```

**FORTRAN:**
```
num_of_attrs = vfnatts(vgroup_id)
```

**Vnattrs** returns either the number of attributes or **FAIL** (or -1). This routine is further defined in Table 5L.
5.8.4 Setting the Attribute of a Vgroup: Vsetattr

Vsetattr attaches an attribute to the vgroup specified by the parameter vgroup_id. The syntax of Vsetattr is as follows:

C: status = Vsetattr(vgroup_id, attr_name, data_type, n_values, attr_values);

FORTRAN: status = vfsnatt(vgroup_id, attr_name, data_type, n_values, attr_values)

OR status = vfscatt(vgroup_id, attr_name, data_type, n_values, attr_values)

If the attribute with the name specified in the parameter attr_name already exists, the new values will replace the current ones, provided the data type and count are not different. If either the data type or the count have been changed, Vsetattr will return FAIL (or -1).

The parameter data_type is an integer number specifying the data type of the attribute values. Refer to Table 2F on page 14 for the definition of the data types to interpret this value. The parameter n_values specifies the number of values to be stored in the attribute. The buffer attr_values contains the values to be stored in the attribute.

Note that the FORTRAN-77 version of Vsetattr has two routines; vfsnatt sets a numeric value attribute and vfscatt sets a character value attribute.

Vsetattr returns either SUCCEED (or 0) or FAIL (or -1). The parameters of this routine are further defined in Table 5M on page 226.

5.8.5 Retrieving the Values of a Given Vgroup Attribute: Vgetattr

Vgetattr retrieves the values of an attribute of the vgroup specified by the parameter vgroup_id. The syntax of Vgetattr is as follows:

C: status = Vgetattr(vgroup_id, attr_index, attr_values);

FORTRAN: status = vfgnatt(vgroup_id, attr_index, attr_values)

OR status = vfgcatt(vgroup_id, attr_index, attr_values)
The attribute is specified by its index, \texttt{attr_index}. The valid values of \texttt{attr_index} range from 0 to the total number of attributes attached to the vgroup - 1. The number of vgroup attributes can be obtained using the routine \texttt{Vnattrs}.

The buffer \texttt{attr_values} must be sufficiently allocated to hold the retrieved attribute values. Use \texttt{Vattrinfo} to obtain information about the attribute values for appropriate memory allocation.

This routine is often used with \texttt{Vinquire} in a loop to retrieve the total number of attributes.

Note that the FORTRAN-77 version of \texttt{Vgetattr} has two routines; \texttt{vgnatt} gets a numeric value attribute and \texttt{vgcatt} gets a character value attribute.

\texttt{Vgetattr} returns either \texttt{SUCCEED} (or 0) or \texttt{FAIL} (or -1). The parameters of this routine are further defined in Table 5M on page 226.

5.8.6 Retrieving the Index of a Vgroup Attribute Given the Attribute Name: \texttt{Vfindattr}

\texttt{Vfindattr} searches the vgroup, identified by the parameter \texttt{vgroup_id}, for the attribute with the name specified by the parameter \texttt{attr_name}, and returns the index of that attribute. The syntax of this routine is as follows:

\begin{verbatim}
C: attr_index = Vfindattr(vgroup_id, attr_name);
FORTRAN: attr_index = vffdatt(vgroup_id, attr_name)
\end{verbatim}

\texttt{Vfindattr} returns either an attribute index or \texttt{FAIL} (or -1). The parameters of this routine are further defined in Table 5M.

---

**TABLE 5M**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vsetattr</td>
<td>vgroup_id</td>
<td>int32</td>
<td>integer Vgroup identifier</td>
</tr>
<tr>
<td></td>
<td>attr_name</td>
<td>char *</td>
<td>Name of the attribute</td>
</tr>
<tr>
<td></td>
<td>data_type</td>
<td>int32</td>
<td>Data type of the attribute</td>
</tr>
<tr>
<td></td>
<td>n_values</td>
<td>int32</td>
<td>Number of values the attribute contains</td>
</tr>
<tr>
<td></td>
<td>attr_values</td>
<td>VOIDP</td>
<td>Buffer containing the attribute values</td>
</tr>
<tr>
<td>Vgetattr</td>
<td>vgroup_id</td>
<td>int32</td>
<td>integer Vgroup identifier</td>
</tr>
<tr>
<td></td>
<td>attr_index</td>
<td>intn</td>
<td>Index of the attribute</td>
</tr>
<tr>
<td></td>
<td>attr_values</td>
<td>VOIDP</td>
<td>Buffer containing attribute values</td>
</tr>
<tr>
<td>Vfindattr</td>
<td>vgroup_id</td>
<td>int32</td>
<td>integer Vgroup identifier</td>
</tr>
<tr>
<td></td>
<td>attr_name</td>
<td>char *</td>
<td>Name of the target attribute</td>
</tr>
</tbody>
</table>

---

**EXAMPLE 6.**

Obtaining Information about the Contents of a Vgroup

This example illustrates the use of \texttt{Vgetid/vfgid} to get the reference number of a vgroup, \texttt{Vntagrefs/vfntr} to get the number of HDF data objects in the vgroup, \texttt{Vgettagref/vfgttr} to get the tag/reference number pair of a data object within the vgroup, and \texttt{Visvg/vfisvg} and \texttt{Visvs/vfisvs} to determine whether a data object is a vgroup and a vdata, respectively.
In the example, the program traverses the HDF file "General_Vgroups.hdf" from the beginning and obtains the reference number of each vgroup so it can be attached. Once a vgroup is attached, the program gets the total number of tag/reference number pairs in the vgroup and displays some information about the vgroup. The information displayed includes the position of the vgroup in the file, the tag/reference number pair of each of its data objects, and the message stating whether the object is a vdata, vgroup, or neither.

```c
#include "hdf.h"
#define FILE_NAME "General_Vgroups.hdf"

main( )
{
    /*************** Variable declaration ***************
    intn   status_n;     /* returned status for functions returning an intn  */
    int32  status_32,    /* returned status for functions returning an int32 */
            file_id, vgroup_id, vgroup_ref,
            obj_index,    /* index of an object within a vgroup */
            num_of_pairs, /* number of tag/ref number pairs, i.e., objects */
            obj_tag, obj_ref,     /* tag/ref number of an HDF object */
            vgroup_pos = 0;       /* position of a vgroup in the file */
    /*************** End of variable declaration ***************

    /*
    * Open the HDF file for reading.
    */
    file_id = Hopen (FILE_NAME, DFACC_READ, 0);

    /*
    * Initialize the V interface.
    */
    status_n = Vstart (file_id);

    /*
    * Obtain each vgroup in the file by its reference number, get the
    * number of objects in the vgroup, and display the information about
    * that vgroup.
    */
    vgroup_ref = -1;        /* set to -1 to search from the beginning of file */
    while (TRUE)
    {
        /*
        * Get the reference number of the next vgroup in the file.
        */
        vgroup_ref = Vgetid (file_id, vgroup_ref);

        /*
        * Attach to the vgroup for reading or exit the loop if no more vgroups
        * are found.
        */
        if (vgroup_ref == -1) break;
        vgroup_id = Vattach (file_id, vgroup_ref, "r");

        /*
        * Get the total number of objects in the vgroup.
        */
        num_of_pairs = Vntagrefs (vgroup_id);
    }
```
* If the vgroup contains any object, print the tag/ref number
* pair of each object in the vgroup, in the order they appear in the
* file, and indicate whether the object is a vdata, vgroup, or neither.
*/
if (num_of_pairs > 0)
{
    printf ("\nVgroup #%d contains:\n", vgroup_pos);
    for (obj_index = 0; obj_index < num_of_pairs; obj_index++)
    {
        /*
         * Get the tag/ref number pair of the object specified
         * by its index, obj_index, and display them.
         */
        status_n = Vgettagref (vgroup_id, obj_index, &obj_tag, &obj_ref);
        printf ("tag = %d, ref = %d", obj_tag, obj_ref);
        /*
         * State whether the HDF object referred to by obj_ref is a vdata,
         * a vgroup, or neither.
         */
        if (Visvg (vgroup_id, obj_ref))
            printf (" <!-- is a vgroup\n");
        else if (Visvs (vgroup_id, obj_ref))
            printf (" <!-- is a vdata\n");
        else
            printf (" <!-- neither vdata nor vgroup\n");
    } /* for */
} /* if */
else
    printf ("Vgroup #%d contains no HDF objects\n", vgroup_pos);
/*
* Terminate access to the current vgroup.
*/
status_32 = Vdetach (vgroup_id);
/*
* Move to the next vgroup position.
*/
vgroup_pos++;
} /* while */
/*
* Terminate access to the V interface and close the file.
*/
status_n = Vend (file_id);
status_n = Hclose (file_id);
}

FORTRAN:

program vgroup_contents
    implicit none
    C
    Parameter declaration
    C
    character*19 FILE_NAME
    C
    parameter (FILE_NAME = 'General_Vgroups.hdf')
    integer DFACC_READ
    parameter (DFACC_READ = 1)
    C
Function declaration

```
C     Function declaration
C
integer hopen, hclose
integer vfstart, vfatch, vfgid, vntrc, vfgtr, vfisvg,
     +       vfisvs, vfdtch, vfend

C**** Variable declaration ***************************************
C
integer status
integer file_id
integer vgroup_id, vgroup_ref, vgroup_pos
integer obj_index, num_of_pairs
integer obj_tag, obj_ref

C**** End of variable declaration ***********************************
C
C
C     Open the HDF file for reading.
C
file_id = hopen(FILE_NAME, DFACC_READ, 0)
C
C     Initialize the V interface.
C
status = vfstart(file_id)
C
C     Obtain each vgroup in the file by its reference number, get the
C     number of objects in the vgroup, and display the information
C     about that vgroup.
C
vgroup_ref = -1
vgroup_pos = 0
10   continue
C
C     Get the reference number of the next vgroup in the file.
C
vgroup_ref = vfgid(file_id, vgroup_ref)
C
C     Attach to the vgroup or go to the end if no additional vgroup is found.
C
if(vgroup_ref. eq. -1) goto 100
vgroup_id = vfatch(file_id, vgroup_ref, 'r')
C
C     Get the total number of objects in the vgroup.
C
num_of_pairs = vntrc(vgroup_id)
C
C     If the vgroup contains any object, print the tag/ref number
C     pair of each object in vgroup, in the order they appear in the
C     file, and indicate whether the object is a vdata, vgroup, or neither.
C
if (num_of_pairs .gt. 0) then
  write(*,*) 'Vgroup # ', vgroup_pos, ' contains:
  do 20 obj_index = 1, num_of_pairs
C     Get the tag/ref number pair of the object specified by its index
C     and display them.
C
  status = vfgtr(vgroup_id, obj_index-1, obj_tag, obj_ref)
C
C     State whether the HDF object referred to by obj_ref is a vdata,
C     a vgroup, or neither.
```
if( vfisvg(vgroup_id, obj_ref) .eq. 1) then
  write(*,*) 'tag = ', obj_tag, ' ref = ', obj_ref,
  +     ' <--- is a vgroup '
else if ( vfiivsv(vgroup_id, obj_ref) .eq. 1) then
  write(*,*) 'tag = ', obj_tag, ' ref = ', obj_ref,
  +     ' <--- is a vdata '
else
  write(*,*) 'tag = ', obj_tag, ' ref = ', obj_ref,
  +     ' <--- neither vdata nor vgroup '
endif
20       continue
else
  write (*,*) 'Vgroup #', vgroup_pos, ' contains no HDF objects'
endif
vgroup_pos = vgroup_pos + 1
goto 10
100   continue
C
C     Terminate access to the vgroup.
C
status = vfdtch(vgroup_id)
C
C     Terminate access to the V interface and close the HDF file.
C
status = vfend(file_id)
status = hclose(file_id)
end

5.9 Obsolete Vgroup Interface Routines

The following routines have been replaced by newer routines with similar functionality. These routines are still supported by the Vgroup interface, but their use is not recommended. HDF may not support these routines in a future version.

5.9.1 Determining the Next Vgroup or Vdata Identifier: Vgetnext

Vgetnext gets the reference number of the next member of a vgroup. This member can be either a vgroup or vdata. The syntax for Vgetnext is as follows:

C:  
ref_num = Vgetnext(vgroup_id, v_ref);

FORTRAN:  
ref_num = vfgetnext(vgroup_id, v_ref)

Vgetnext searches the vgroup, identified by the parameter vgroup_id, for the vgroup or vdata whose reference number is specified by the parameter v_ref. If this vgroup or vdata is found, Vgetnext finds the next vgroup or vdata and returns its reference number. If v_ref is set to -1, the routine will return the reference number of the first vgroup or vdata in the vgroup.

Vgetnext is now obsolete as the routine Vgettagref provides the same functionality. In addition, Vgettagref is not restricted to searching for members that are vgroups or vdatas.

Vgetnext returns a reference number if the next vgroup or vdata is found, or FAIL (or -1) when an error occurs or when there are no more vdatas or vgroups in the vgroup. The parameters of Vgetnext are further defined in Table 5N.
5.9.2 Determining the Number of Members and Vgroup Name: Vinquire

*Vinquire* retrieves the number of data objects and the name of the vgroup identified by the parameter `vgroup_id`. The syntax for *Vinquire* is as follows:

**C:**

\[
\text{status} = \text{Vinquire}(\text{vgroup\_id}, \&n\_members, \text{vgroup\_name});
\]

**FORTRAN:**

\[
\text{status} = \text{vfinq}(\text{vgroup\_id}, n\_members, \text{vgroup\_name})
\]

*Vinquire* stores the number of data objects and the vgroup name in the parameters `n_members` and `vgroup_name`, respectively. In C, if either `n_members` or `vgroup_name` is set to `NULL`, the corresponding data is not returned. The maximum length of the vgroup’s name is defined by `VGNAME-LENMAX` (or 64).

*Vinquire* is now obsolete as the *Vntagrefs* routine can be used to get the number of data objects in a vgroup and *Vgetname* can be used to retrieve the name of a vgroup.

*Vinquire* returns either `SUCCEED` (or 0) or `FAIL` (or -1). The parameters of this routines are further defined in Table 5N.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vgetnext</td>
<td>vgroup_id</td>
<td>int32</td>
<td>Vgroup identifier of the parent vgroup</td>
</tr>
<tr>
<td></td>
<td>v_ref</td>
<td>int32</td>
<td>Reference number for the target vgroup</td>
</tr>
<tr>
<td>Vinquire</td>
<td>vgroup_id</td>
<td>int32</td>
<td>Vgroup identifier</td>
</tr>
<tr>
<td></td>
<td>n_members</td>
<td>int32 *</td>
<td>Pointer to the number of entries in the vgroup</td>
</tr>
<tr>
<td></td>
<td>vgroup_name</td>
<td>char *</td>
<td>Buffer for the name of the vgroup</td>
</tr>
</tbody>
</table>

5.10 Vgroup Backward Compatibility Issues

5.10.1 Vset Implementation Integrated into the Vgroup Interface

In HDF versions before 2.0, vsets were created and manipulated through an interface separate from the other HDF interfaces. A pointer to a specially-defined vset structure was returned by the Vset interface and data type definitions specific to the Vset interface were used. The names of these definitions were prefaced by "LOCAL_".

After HDF version 2.0, the `vgroup_id` identifier replaced the pointer to the vset structure, the "LOCAL_" data type definitions were made obsolete by newer definitions, and all vset functionality was integrated into the Vgroup interface routines. HDF programs written for HDF libraries earlier than version 2.0 should be modified accordingly in order to function correctly with newer versions of HDF.
Chapter 6

8-Bit Raster Images (DFR8 API)

6.1 Chapter Overview

This chapter describes the 8-bit raster image data model and the single-file DFR8 interface routines. The DFR8 interface is a single-file interface that consists of routines for reading and writing raster image sets.

6.2 The 8-Bit Raster Data Model

The data model for the 8-bit raster image set, or RIS8, an acronym for "Raster Image Set, 8-bit", supports three types of objects; two-dimensional 8-bit raster images, dimensions and palettes. The latter two items occur once per RIS8. The following figure shows the contents of an 8-bit raster image set.

**FIGURE 6a** 8-Bit Raster Image Set Contents

6.2.1 Required 8-Bit Raster Image Data Set Objects

Every RIS8 object requires an image and dimension object. Required objects are created by the HDF library using information provided at the time the image is written.

6.2.1.1 8-Bit Raster Image Data Representation

An 8-bit raster image is a two-dimensional array of 8-bit numbers which represent pixels or "picture elements". The first row of pixels corresponds to the top row of the image, the second row of pixels to the second row of the image and so forth. Pixel values range from 0 to 255, and indicate to the hardware which colors to use when mapping the corresponding pixels to the screen display. A color lookup table, or palette, provides the means of correlating pixel values to colors.
As an example, consider a stream of 8-bit numbers representing a raster image. (See Figure 6b.) When the image is displayed, the color associated with the first number in the data stream is placed in the upper left corner of the image. The remainder of the first line is then painted from left-to-right using as many values from the data stream as is necessary to complete the line. The remainder of the rows are similarly painted from left-to-right and top-to-bottom until every value in the data stream appears represented by one pixel in the image.

FIGURE 6b

The Data Representation of an 8-Bit Raster Image

An 8-bit raster image (a) is a set of rows displayed from left-to-right consisting of rows of pixel information (b) where each pixel (c) is represented by values stored as a single stream of 8-bit numbers (d).

6.2.1.2 8-Bit Raster Image Dimension

The dimensions of an image are its height and width in pixels.

6.2.2 Optional 8-Bit Raster Image Data Set Objects

6.2.2.1 Palettes

A palette is a lookup table consisting of 256 unique numerical values, each of which map to the 256 possible pixel color values and is stored in a RIS8 object. For more details on HDF palettes refer to Chapter 9, titled Palettes (DFP API).

6.2.3 Compression Method

The compression method indicates if and how the image is compressed. It can be, at the programmer’s option, explicitly set or left as its default setting of no compression. Compression schemes supported by HDF version 4.0 are run-length encoding or RLE, joint photographic expert group compression, or JPEG, and image compression, or IMCOMP. The list of compression methods is
presented below. (See Table 6A.) The HDF tags COMP_RLE, COMP_IMCOMP and COMP_JPEG are respectively defined as the values 11, 12 and 2 in the "hcomp.h" header file.

<table>
<thead>
<tr>
<th>Compression Method</th>
<th>Type</th>
<th>Compression Code</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>N/A</td>
<td>COMP_NONE</td>
<td>Image data only (default setting).</td>
</tr>
<tr>
<td>RLE</td>
<td>Lossless</td>
<td>COMP_RLE</td>
<td>Image data only.</td>
</tr>
<tr>
<td>JPEG</td>
<td>Lossy</td>
<td>COMP_JPEG</td>
<td>Image data, quality factor and compatibility factor.</td>
</tr>
<tr>
<td>IMCOMP</td>
<td>Lossy</td>
<td>COMP_IMCOMP</td>
<td>Image data and palette.</td>
</tr>
</tbody>
</table>

### 8-Bit Raster Image Compression Method List

**RLE Compression**

The **RLE** method is a lossless compression method recommended for images where data retention is critical. The RLE algorithm compresses images by condensing strings of identical pixel values into two bytes. The first byte identifies the number of pixels in the string and the second byte records the pixel value for the string.

The amount of space saved by RLE depends upon how much repetition there is among adjacent pixels. If there is a great deal of repetition, more space is saved and if there is little repetition, the savings can be very small. In the worst case when every pixel is different from the one that precedes it an extra byte is added for every 127 bytes in the image.

### JPEG Compression

The **JPEG**, or Joint Photographic Expert Group, compression method is a lossy compression algorithm whose use is recommended for photographic or scanned images. Using JPEG compression to reduce the size of an image changes the values of the pixels and hence may alter the meaning of the corresponding data. Version 5.0 of the JPEG library is available in HDF version 4.0.

JPEG compression requires two parameters, the first the level of image quality and the second, compatibility. The **quality factor** determines how much of the data will be lost and thus directly impacts the size of the compressed image. A quality factor of 1 specifies the lowest quality or maximum image compression. A quality factor of 100 specifies the highest quality or minimum image compression. Note that all images compressed using the JPEG algorithm are stored in a lossy manner, even those stored with a quality factor of 100. Usually, it is best to experiment with the quality factor to find the most acceptable one.

The **baseline** parameter determines whether the contents of the quantization tables used during compression are forced into the range of 0 to 255. The **baseline** parameter is normally set to the value 1 which forces baseline results. You should set the value of the **baseline** parameter to values other than 1 only if you are familiar with the JPEG algorithm.

### IMCOMP Compression

**IMCOMP** is a lossy compression method available in earlier versions of HDF. IMCOMP compression is generally of inferior quality to JPEG compression and is not recommended unless your images will be viewed on a 16-color monitor. For backward compatibility, IMCOMP compression is supported in the HDF library. For details on IMCOMP refer to Appendix F, titled *Backward Compatibility Issues*. 
6.3 The 8-Bit Raster Image Interface

The HDF library contains routines for reading and writing 8-bit raster image sets. The functions `DFR8addimage`, `DFR8putimage` and `DFR8getimage` are sufficient for most reading and writing operations.

6.3.1 8-Bit Raster Image Library Routines

The names of all C functions in the 8-bit raster image interface are prefaced by "DFR8" and the names of the equivalent FORTRAN-77 functions are prefaced by "d8". These routines are divided into the following categories:

- **Write routines** create raster image sets and store them in new files or append them to existing files.
- **Read routines** determine the dimensions and palette assignment for an image set, read the actual image data and provide sequential or random read access to any raster image set.

The DFR8 function calls are further defined in Table 6B and in the *HDF Reference Guide*.

<table>
<thead>
<tr>
<th>Category</th>
<th>Routine Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write</td>
<td><code>DFR8addimage</code></td>
<td>d8aimg</td>
</tr>
<tr>
<td></td>
<td><code>DFR8putimage</code></td>
<td>d8pimg</td>
</tr>
<tr>
<td></td>
<td><code>DFR8setcompress</code></td>
<td>d8setcomp</td>
</tr>
<tr>
<td></td>
<td><code>DFR8setpalette</code></td>
<td>d8spal</td>
</tr>
<tr>
<td></td>
<td><code>DFR8writeref</code></td>
<td>d8wref</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>d8jpeg</td>
</tr>
<tr>
<td>Read</td>
<td><code>DFR8getdims</code></td>
<td>d8gdims</td>
</tr>
<tr>
<td></td>
<td><code>DFR8getimage</code></td>
<td>d8gimg</td>
</tr>
<tr>
<td></td>
<td><code>DFR8getpalref</code></td>
<td>None</td>
</tr>
<tr>
<td></td>
<td><code>DFR8lastref</code></td>
<td>d8lref</td>
</tr>
<tr>
<td></td>
<td><code>DFR8nimages</code></td>
<td>d8nims</td>
</tr>
<tr>
<td></td>
<td><code>DFR8readref</code></td>
<td>d8rref</td>
</tr>
<tr>
<td></td>
<td><code>DFR8restart</code></td>
<td>d8first</td>
</tr>
</tbody>
</table>

6.4 Writing 8-Bit Raster Images

The DFR8 programming model for writing an 8-bit raster image sets is as follows:

1. Set the compression type if the image is to be compressed. (optional)
2. Identify the palette if one is to be stored with the image. (optional)
3. Write the raster data to the file.

The two optional steps can be invoked in any order, as long as they are executed before Step 3. By default, images are stored uncompressed with no associated palette.
6.4.1 Storing a Raster Image: DFR8putimage and DFR8addimage

To write a raster image to an HDF file, the calling program must contain the following:

C:
status = DFR8putimage(filename, image, width, height, compress);

FORTRAN: status = d8pimg(filename, image, width, height, compress)

OR

C:
status = DFR8addimage(filename, image, width, height, compress);

FORTRAN: status = d8aimg(filename, image, width, height, compress)

DFR8putimage and DFR8addimage write an 8-bit raster image to an HDF file named by the filename parameter. When given a new filename, DFR8putimage and DFR8addimage create a new file and write the raster image as the first raster image in the file. When given an existing filename, DFR8putimage overwrites the file whereas DFR8addimage appends data to the end of the file.

In the DFR8putimage and DFR8addimage functions, the raster data is passed in the image parameter and the width and height of the image are passed in the width and height parameters. The compression algorithm used to store the image is passed in the compress parameter. Valid compress values include COMP_NONE, COMP_RLE, COMP_JPEG and COMP_IMCOMP. COMP_NONE represents no compression (storage only), COMP_RLE represents run-length encoding, COMP_JPEG represents JPEG compression and COMP_IMCOMP represents IMCOMP encoding.

Parameters for DFR8putimage and DFR8addimage are further described below. Table 6C on page 237

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFR8putimage</td>
<td>char *</td>
<td>Name of file the raster image will be stored in.</td>
</tr>
<tr>
<td>[intn]</td>
<td>VOIDP &lt;valid numeric data type&gt;</td>
<td>Image data array.</td>
</tr>
<tr>
<td>(d8pimg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFR8addimage</td>
<td>int32</td>
<td>Number of columns in the raster image.</td>
</tr>
<tr>
<td>[intn]</td>
<td>integer</td>
<td></td>
</tr>
<tr>
<td>(d8aimg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>width</td>
<td>int32</td>
<td></td>
</tr>
<tr>
<td>height</td>
<td>int32</td>
<td></td>
</tr>
<tr>
<td>compress</td>
<td>int16</td>
<td>Compression type.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EXAMPLE 1.

Writing an 8-Bit Raster Image to an HDF File

In the following code examples, DFR8addimage and d8aimg are used to write an 8-bit image to a file named "Example1.hdf". Note that the order in which the dimensions for the image array are declared differs between C and FORTRAN-77.

C version

C:

#include "hdf.h"
#define WIDTH 5
#define HEIGHT 6

main( )
{

...
Initializing the image array:

```c
/* Initialize the image array */
static uint8 raster_data[HEIGHT][WIDTH] =
    { 1, 2, 3, 4, 5,
       6, 7, 8, 9, 10,
       11, 12, 13, 14, 15,
       16, 17, 18, 19, 20,
       21, 22, 23, 24, 25,
       26, 27, 28, 29, 30
    };
```

Writing the 8-bit raster image to file:

```c
/* Write the 8-bit raster image to file */
status = DFR8addimage("Example1.hdf", raster_data,
       WIDTH, HEIGHT, 0);
```

FORTRAN-77 version

FORTRAN:

```fortran
PROGRAM RASTER8

character*1 raster_data(5,6)
integer retn, d8aimg

integer*4 WIDTH, HEIGHT
parameter(WIDTH = 5, HEIGHT = 6)

C     Initialize the image array
    data raster_data / 1, 2, 3, 4, 5,
       6, 7, 8, 9, 10,
       11, 12, 13, 14, 15,
       16, 17, 18, 19, 20,
       21, 22, 23, 24, 25,
       26, 27, 28, 29, 30 /

C     Write the 8-bit raster image to the file
    retn = d8aimg(Example1.hdf, raster_data, WIDTH, HEIGHT, 0)
end
```

6.4.2 Adding a Palette to an RIS8 Object: DFR8setpalette

DFR8setpalette identifies the palette to be used for the subsequent write operations. It may be used to assign a palette to a single image or several images. After a palette has been set, it acts as the current palette until it is replaced by another call to DFR8setpalette. To create a raster image set containing a palette, the calling program must contain the following:

```c
C:     status = DFR8setpalette(palette);
       status = DFR8addimage(filename, image, width, height, compress);
```

```fortran
FORTRAN: status = d8spal(palette)
       status = d8aimg(filename, image, width, height, compress)
```

DFR8setpalette takes palette as its only parameter. To set the default palette to “no palette”, pass NULL as the palette parameter. DFR8setpalette is further defined in the following table.
Writing a Palette and an Image in RIS8 Format

These examples demonstrate how a palette stored in the array colors and the raw image stored in the 20 x 20 array picture is written to a RIS8 object. The image is not compressed and, in these examples, uninitialized. The raster image set is stored as the first image in "Example2.hdf". Note that because DFR8putimage recreates the file, anything previously contained in this file will be erased.

**C version**

```c
#include "hdf.h"

#define WIDTH 20
#define HEIGHT 20

main( )
{
    uint8 colors[256*3], picture[HEIGHT][WIDTH];
    uint8 i, j;
    int16 status;

    /* Initialize image arrays. */
    for (j = 0; j < WIDTH; j++) {
        for (i = 0; i < HEIGHT; i++)
            picture[j][i] = 1;
    }

    /* Set the current palette. */
    status = DFR8setpalette(colors);

    /* Write the image data to the file. */
    status = DFR8putimage("Example2.hdf", picture, WIDTH, HEIGHT, COMP_NONE);
}
```

**FORTRAN-77 version**

```fortran
PROGRAM WRITE UNCOMPRESSED RIS8

integer   d8spal, d8pimg, status, i, j
integer   colors(768)
integer*4   WIDTH, HEIGHT, COMP_NONE
parameter (COMP_NONE = 0,
            WIDTH = 20,
            HEIGHT = 20)
integer   picture(WIDTH, HEIGHT)

C   Initialize the image data.
```
do 20 j = 1, WIDTH
    do 10 i = 1, HEIGHT
        picture(j, i) = 1
    10    continue
20    continue

C    Set the current palette.
    status = d8spal(colors)

C    Write the image data to the file.
    status = d8pimg('Example2.hdf', picture, WIDTH, HEIGHT,
+                         COMP_NONE)
end

6.4.3 Compressing 8-Bit Raster Image Data: DFR8setcompress

The compression type is determined by the tag passed as the fifth argument in calls to the
DFR8putimage and DFR8addimage routines. DFR8setcompress is currently required only to
reset the default JPEG compression options. However, future versions of this routine will support
additional compression schemes.

To set non-default compression parameters, the calling program should contain the following
sequence of routines:

C:    status = DFR8setcompress(type, c_info);
    status = DFR8addimage(filename, image, width, height, compress);

FORTRAN:    status = d8scomp(type)
             <compression-specific code>
             status = d8aimg(filename, image, width, height, compress)

Notice that the calling sequence for C differs from the calling sequence for FORTRAN-77. Once
the compression is set, the parameter type in the DFR8setcompress routine, or d8scomp in
FORTRAN-77, specifies the compression method that will be used when storing the raster
images. However, the c_info parameter, which is a pointer to a structure that contains informa-
tion specific to the compression scheme indicated by the type parameter in DFR8setcompress, is
missing from d8scomp. Because data structures of variable size are not supported in FORTRAN-
77, another routine specific to the compression library is required in the FORTRAN-77 calling
sequence.

The c_info union is described in Chapter 3, titled Scientific Data Sets (SD API). The values con-
tained in this union are passed into the d8sjpeg FORTRAN-77-specific routine.

Parameters for DFR8setcompress and d8sjpeg are further described in Table 6E below.

<table>
<thead>
<tr>
<th>Routine Name [Return Type]</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FORTRAN-77)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFR8setcompress [int]</td>
<td>type</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>c_info</td>
<td>comp_info *</td>
<td>None</td>
</tr>
<tr>
<td>d8scomp [integer]</td>
<td>quality</td>
<td>none</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>baseline</td>
<td>none</td>
<td>integer</td>
</tr>
</tbody>
</table>

TABLE 6E

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EXAMPLE 3.

Writing a Set of Compressed 8-Bit Raster Images

These examples contain a series of calls in which four 20 x 20 images are written to the same file. The first two use palette paletteA and are compressed using the RLE method; the third and fourth use palette paletteB and are not compressed.

C version

C:

```c
#include "hdf.h"

#define WIDTH 20
#define HEIGHT 20

main ( )
{
    uint8 paletteA[256*3], paletteB[256*3];
    uint8 picture1[HEIGHT][WIDTH], picture2[HEIGHT][WIDTH];
    uint8 picture3[HEIGHT][WIDTH], picture4[HEIGHT][WIDTH];
    uint8 i, j;
    int16 status;

    /* Initialize image arrays. */
    for (j = 0; j < WIDTH; j++) {
        for (i = 0; i < HEIGHT; i++) {
            picture1[j][i] = 1;
            picture2[j][i] = 1;
            picture3[j][i] = 1;
            picture4[j][i] = 1;
        }
    }

    /* Set the first palette. */
    status = DFR8setpalette(paletteA);

    /* Write the compressed image data to the HDF file. */
    status = DFR8putimage("Example3.hdf", (VOIDP)picture1, WIDTH, HEIGHT, \COMP_RLE);
    status = DFR8addimage("Example3.hdf", (VOIDP)picture2, WIDTH, HEIGHT, \COMP_RLE);

    /* Set the second palette. */
    status = DFR8setpalette(paletteB);

    /* Write the uncompressed image data to the HDF file. */
    status = DFR8addimage("Example3.hdf", (VOIDP)picture3, WIDTH, HEIGHT, \COMP_NONE);
    status = DFR8addimage("Example3.hdf", (VOIDP)picture4, WIDTH, HEIGHT, \COMP_NONE);
}
```

FORTRAN-77 version

FORTRAN:

```
PROGRAM WRITE IMAGE SETS

integer d8spal, d8pimg, d8aimg, status
integer*4 COMP_RLE, COMP_NONE, WIDTH, HEIGHT
parameter (COMP_RLE = 11,
+ COMP_NONE = 0,
```

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EXAMPLE 4.

Compressing and Writing a 8-Bit Raster Image

In the following examples, DFR8addimage and DFR8compress are used to compress an 8-bit image and write it to an HDF file named "Example2.hdf". Notice that compressing an image in C requires only one function call, whereas compressing an image using FORTRAN-77 requires two. The second FORTRAN-77 call is required because it is not valid to pass a structure as a parameter in FORTRAN-77.

C version

C:

```c
#include "hdf.h"
#include "hcomp.h"

#define WIDTH 3
#define HEIGHT 5
#define PIXEL_DEPTH 3

main( )
{
    /* Initialize the image array. */
    static uint8 raster_data[HEIGHT][WIDTH][PIXEL_DEPTH] =
        { 1, 2, 3, 4, 5, 6, 7, 8, 9,
            ...,
            ...,
        };
```
static comp_info compress_info;
intn status;

/* Initialize JPEG compression structure. */
compress_info.jpeg.quality = 60;
compress_info.jpeg.force_baseline = 1;

/* Set JPEG compression for storing the image. */
status = DFR8setcompress(COMP_JPEG, &compress_info);

/* Write the 8-bit image data to file. */
status = DFR8addimage("Example2.hdf", (VOIDP)raster_data, WIDTH,
                     HEIGHT, COMP_JPEG);
}

FORTRAN-77 version

FORTRAN:

PROGRAM COMPRESS RIS8

  integer d8aimg, d8scomp, d8sjpeg, status
  integer*4 WIDTH, HEIGHT, PIXEL_DEPTH, COMP_JPEG

  COMP_JPEG is defined in hcomp.h.
  parameter(WIDTH = 3,
            HEIGHT = 5,
            COMP_JPEG = 1,
            PIXEL_DEPTH = 3)

  character raster_data(PIXEL_DEPTH, WIDTH, HEIGHT)

  Initialize the image array.
  data raster_data
    + /  1, 2, 3,  4, 5, 6,  7, 8, 9,
       10,11,12, 13,14,15, 16,17,18,
       19,20,21, 22,23,24, 25,26,27,
       28,29,30, 31,32,33, 34,35,36,
       37,38,39, 40,41,42, 43,44,45  /

  Set compression.
  status = d8scomp(COMP_JPEG)

  Set JPEG parameters to quality = 60, and turn compatibility on.
  status = d8sjpeg(60, 1)

  Write the 8-bit image data to the HDF file.
  status = d8aimg('Example2.hdf', raster_data, WIDTH, HEIGHT,
                  + COMP_JPEG)

  end
6.4.4 Specifying the Reference Number of an RIS8: DFR8writeref

DFR8writeref specifies the reference number of the image to be written when DFR8addimage or DFR8putimage is called. Use the following calling sequence to invoke DFR8writeref:

C:
status = DFR8writeref(filename, ref);
status = DFR8addimage(filename, image, width, height, compress);

FORTRAN:
status = d8wref(filename, ref)
status = d8aimg(filename, image, width, height, compress)

DFR8writeref assigns the reference number passed in the ref parameter to the next image the file specified by the filename parameter. If the value of ref is the same as the reference number of an existing RIS8, the existing raster image data will be overwritten. The parameters for DFR8writeref are further described below. (See Table 6F.)

It is unlikely that you will need this routine, but if you do, use it with caution. It is not safe to assume that a reference number indicates the file position of the corresponding image as there is no guarantee that reference numbers appear in sequence in an HDF file.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFR8writeref</td>
<td>filename char * character*(*)</td>
<td>Name of the HDF file containing the raster image.</td>
</tr>
<tr>
<td></td>
<td>ref uint16 integer</td>
<td>Reference number for next call to DFR8getimage.</td>
</tr>
</tbody>
</table>

TABLE 6F

6.5 Reading 8-Bit Raster Images

The DFR8 programming model for reading an 8-bit raster image set is as follows:

1. Determine the dimensions of the image if they are not known prior to the read operation.
2. Read the image from the file.

6.5.1 Reading a Raster Image: DFR8getimage

If dimensions of the image are known, DFR8getimage is the only function call needed to read a raster image. If a file is being opened for the first time, DFR8getimage returns the first image in the file. Additional calls will return successive images in the file, therefore images are read in the order which they were written to the file. DFR8getdims is called before DFR8getimage so that space allocations for the image and palette can be checked and the dimensions verified. If this information is already known, DFR8getdims may be omitted.

To read a raster image from an HDF file, the calling program must contain the following:

C:
status = DFR8getimage(filename, image, width, height, palette);

FORTRAN: status = d8gimg(filename, image, width, height, palette)

DFR8getimage retrieves the next 8-bit image from the HDF file name specified by the filename parameter. If the image in the file is compressed, DFR8getimage first decompresses it then places it in memory at the location pointed to by the image parameter. The dimensions of the array allocated to hold the image are specified by the width and height parameters and may be larger than the actual image. The palette, if present, is stored in memory at the location pointed to by the pal-
ette parameter. If it contains a NULL value the palette is not loaded, even if there is one stored with the image. The parameters for DFR8getimage are defined further in Table 6G below.

Notice that in Example 4, as in the case of DFR8addimage, the order in which the dimensions for the image array are declared differs between C and FORTRAN-77. FORTRAN-77 declarations require the width before the height while the C declaration requires the height before the width as FORTRAN-77 arrays are stored in column-major order, while C arrays are stored in row-major order. (row-major order implies that the second coordinate varies fastest). When d8gimg reads an image from a file, it assumes column-major order.

6.5.2 Querying the Dimensions of an 8-Bit Raster Image: DFR8getdims

DFR8getdims opens a named file, finds the next image or the first image if the file is being opened for the first time, retrieves the dimensions of the image and determines if there is a palette associated with the image. If the file is being opened for the first time, DFR8getdims returns information about the first image in the file. If an image has already been read, DFR8getdims finds the next image. In this way, images are read in the same order in which they were written to the file.

To determine the dimensions of an image before attempting to read it, the calling program must include the following routines:

**C:**
```
status = DFR8getdims(filename, width, height, haspalette);
status = DFR8getimage(filename, image, width, height, palette);
```

**FORTRAN:**
```
status = d8gdim(filename, width, height, haspalette)
status = d8gimg(filename, image, width, height, palette)
```

DFR8getdims retrieves dimension and palette information about the next 8-bit image in the file specified by filename. The returned information is pointed to by the width and height parameters. The haspalette parameter determines the presence of a palette and returns a value of 1 if it exists and 0 otherwise. The parameters for DFR8getdims are defined further in the following table.

**TABLE 6G**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFR8getdims</td>
<td>filename</td>
<td>char *</td>
<td>Name of the HDF file containing the set of raster images.</td>
</tr>
<tr>
<td></td>
<td>width</td>
<td>int32 *</td>
<td>Number of columns in the next raster image.</td>
</tr>
<tr>
<td></td>
<td>height</td>
<td>int32 *</td>
<td>Number of rows in the next raster image.</td>
</tr>
<tr>
<td></td>
<td>haspalette</td>
<td>intn *</td>
<td>“1” if a palette exists, otherwise “0”.</td>
</tr>
<tr>
<td>DFR8getimage</td>
<td>filename</td>
<td>char *</td>
<td>Name of HDF file with the raster image.</td>
</tr>
<tr>
<td></td>
<td>image</td>
<td>uint8 *</td>
<td>Buffer for the raster image.</td>
</tr>
<tr>
<td></td>
<td>width</td>
<td>int32 *</td>
<td>Width of the raster image buffer.</td>
</tr>
<tr>
<td></td>
<td>height</td>
<td>int32 *</td>
<td>Height of the raster image buffer.</td>
</tr>
<tr>
<td></td>
<td>palette</td>
<td>uint8 *</td>
<td>Palette assigned to the raster image.</td>
</tr>
</tbody>
</table>
EXAMPLE 5.

**Reading an 8-Bit Raster Image**

The following examples search the "Example1.hdf" file created in Example 1 for the dimensions of an 8-bit image. Although the DFR8getdims call is optional, it is included as a demonstration of how to check the dimensions of an image. This example also assumes that the data set does not include a palette, therefore NULL is passed as the palette parameter. If the palette argument is NULL (or "0" in FORTRAN-77), all palette data is ignored.

**C version**

```
C:
#include "hdf.h"

#define WIDTH 5
#define HEIGHT 6

main( )
{
    uint8 raster_data[HEIGHT][WIDTH];
    int32 width, height;
    intn haspal, status;

    /* Get the dimensions of the image */
    status = DFR8getdims("Example1.hdf", &width, &height, &haspal);

    /* Read the raster data if the dimensions are correct */
    if (width <= WIDTH && height <= HEIGHT)
        status = DFR8getimage("Example1.hdf", (VOIDP)raster_data, width, height, NULL);
}
```

**FORTRAN-77 version**

```
FORTRAN:

PROGRAM RASTER8

    character*1 image(5, 6)
    integer status, height, width, d8gimg, d8gdims, haspal
    integer*4 width, height

    C Get the dimensions of the image.
    status = d8gdims('Example1.hdf', width, height, haspal)

    C Read the raster data if the dimensions are correct.
    if (width .le. 5 .and. height .le. 6) then
        status = d8gimg('Example1.hdf', image, width, height, 0)
    endif

end
```

**6.5.3 Reading an Image with a Given Reference Number: DFR8readref**

DFR8readref accesses specific images that are stored in files containing multiple raster image sets. It is an optionally used before DFR8getimage to set the access pointer to the specified raster image. DFR8readref can be used in connection with vgroups, which identify their members by tag/reference number pairs. See Chapter 5, titled Vgroups (V API), for a discussion of vgroups and tag/reference number pairs.
To access a specific raster image set, use the following calling sequence:

**C:**
```c
status = DFR8readref(filename, ref);
status = DFR8getimage(filename, image, width, height, palette);
```

**FORTRAN:**
```fortran
status = d8rref(filename, ref)
status = d8gimg(filename, image, width, height, palette)
```

DFR8readref specifies that the target for the next read operation performed on the HDF file specified by the `filename` parameter is the object with the reference number named in the `ref` parameter. The parameters required for DFR8readref are defined further in the following table.

### TABLE 6H

DFR8readref Parameter List

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFR8readref [int] (d8rref)</td>
<td>filename</td>
<td>char*</td>
<td>Name of HDF file containing the raster image.</td>
</tr>
<tr>
<td></td>
<td>ref</td>
<td>uint16</td>
<td>Reference number for next call to DFR8getimage.</td>
</tr>
</tbody>
</table>

#### 6.5.4 Specifying the Next 8-Bit Raster Image to be Read: DFR8restart

DFR8restart causes the next call to DFR8getimage or DFR8getdims to read the first raster image set in the file. Use the following call to invoke DFR8restart:

**C:**
```c
status = DFR8restart( );
```

**FORTRAN:**
```fortran
status = d8first( )
```

#### 6.6 8-Bit Raster Image Information Retrieval Routines

#### 6.6.1 Querying the Total Number of 8-Bit Raster Images: DFR8nimages

DFR8nimages returns the total number of 8-bit raster image sets in a file and has the following syntax:

**C:**
```c
num_of_images = DFR8nimages(filename);
```

**FORTRAN:**
```fortran
num_of_images = d8nimg(filename)
```

### TABLE 6I

DFR8nimages Parameter List

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFR8nimages [int] (d8nims)</td>
<td>filename</td>
<td>char*</td>
<td>Name of the HDF file.</td>
</tr>
</tbody>
</table>
6.6.2 Determining the Reference Number of the Most-Recently-Accessed 8-Bit Raster Image: DFR8lastref

DFR8lastref returns the reference number most recently used in writing or reading an 8-bit raster image. This routine is primarily used for attaching annotations to images and adding images to vgroups. (See Chapters 8, titled Annotations (DFAN API) and Chapter 5, titled Vgroups (V API) for more detailed information on how to use reference numbers in connection with these applications.)

The following calling sequence uses DFR8lastref to find the reference number of the 8-bit raster image most recently added to an HDF file:

C:
status = DFR8addimage(filename, image, width, height, compress);
lastref = DFR8lastref();

FORTRAN:
status = d8aimg(filename, image, width, height, compress)
lastref = d8lref()

DFR8putimage or DFR8getimage can be used instead of DFR8addimage with similar results.

6.6.3 Determining the Reference Number of the Palette of the Most-Recently-Accessed 8-Bit Raster Image: DFR8getpalref

DFR8getpalref returns the reference number of the palette associated with the most recently used in writing or reading an 8-bit raster image. The DFR8getdims routine must be called before DFR8getpalref, as DFR8getdims initializes internal structures required by DFR8getpalref.

There is currently no FORTRAN-77 version of the DFR8getpalref routine.

### Table 6J

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFR8nimages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.7 RIS8 Backward Compatibility Issues

6.7.1 Attribute "long_name" Included in HDF for netCDF Compatibility

In several routines of the RIS8 interface, the value returned by label is the value of the attribute named "long_name" and that the value returned by coordsys is the value of the attribute named "cordsys".

This was done in order to provide HDF with the ability to read netCDF files. While this aspect of HDF functionality will not affect its ability to read HDF data files written by programs compiled with earlier versions of HDF, it is advisable for HDF users to know this to be aware of the significance of the "long_name" and "cordsys" attribute names in a list of attributes.

6.7.2 Raster Image Group Implementation with New RIS8 Tags

As HDF has evolved, a variety of structures have been used to store raster image sets. For instance, HDF first began grouping 8-bit raster images together with dimensions and palettes by insuring that their reference numbers fell in a certain pattern. This method of organizing raster
images quickly lead to very complicated collections of images, dimension records, and palettes, and eventually was replaced by an specific grouping structure known as a Raster Image Group, or RIG, with a completely new set of tags.

To maintain backward compatibility with older versions of HDF, the RIS8 interface supported by HDF version 4.1 and later recognizes raster images stored using either set of HDF tags. Details on the different tags and structures used to store raster images can be found in the HDF Specifications and Developer's Guide v3.2 from the HDF WWW home page at http://hdf.ncsa.uiuc.edu/.
7.1 Chapter Overview

This chapter describes the 24-bit raster data model and the single-file DF24 routines available for storing and retrieving 24-bit raster images.

7.2 The 24-Bit Raster Data Model

The 24-bit raster image set, or RIS24, data model supports two primary data objects: two-dimensional 24-bit raster images and dimensions. The primary member of the set is the 24-bit raster image, a two-dimensional array of pixels or picture elements. Each pixel is represented by three 8-bit numbers of image data. An optional compression method describes the method used, if any, to compress the image. Figure 7a shows the contents of a 24-bit raster image set.

![Diagram of 24-Bit Raster Image Set Contents](image)

7.2.1 Required 24-Bit Raster Image Data Set Objects

All 24-bit raster images must contain image data and a dimension record. These objects are created by the HDF library using information provided at the time the image is written to file.

7.2.1.1 24-Bit Raster Image Data Representation

The 24-bit raster image object contains a set of 24-bit pixel values, each of which has three 8-bit components: one for the red, one for the green, and one for the blue color component of the image. These values, referred to as RGB values, are arranged in one of three specific ways, as described in Section 7.2.2.2 on page 253. The pixel values are arranged in rows, painted from left-to-right,
top-to-bottom. As each pixel in a 24-bit image is represented in the image data by three 8-bit numbers, palettes are unnecessary and are not included in the 24-bit raster data model.

As an example, consider a stream of 24-bit numbers representing a raster image (Fig. 4.1a). To display the image, the color associated with the first number in the data stream appears in the upper left corner of the image. The remainder of the first line is then painted from left-to-right using as many values from the data stream as necessary to complete the line. The remainder of the rows are similarly painted from left-to-right, top-to-bottom until every value in the data stream appears as one pixel in the image.

**FIGURE 7b**

The Numerical Representation of a 24-Bit Raster Image

A 24-bit raster image (a) is a set of rows displayed from left-to-right consisting of rows of pixels (b) whose values are stored as three 8-bit numbers (c) in a stream of data (d). In this figure, the image is interleaved by pixel.

### 7.2.1.2 24-Bit Raster Image Dimension

The *dimensions* of an image are the height and width of the image in pixels.

### 7.2.2 Optional 24-Bit Raster Image Data Set Objects

#### 7.2.2.1 Compression Method

The only 24-bit compression method currently available in HDF is the JPEG algorithm. The applicable HDF compression tags are `COMP_JPEG` and `COMP_NONE`. (See Table 7A.) The HDF tags `COMP_JPEG` and `COMP_NONE` are defined as the values 2, and 0 respectively in the "hdf.h" header file.
TABLE 7A

24-Bit Raster Image Compression Method List

<table>
<thead>
<tr>
<th>Compression Method</th>
<th>Type</th>
<th>Compression Code</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Lossless</td>
<td>COMP_NONE</td>
<td>Image data only (default setting).</td>
</tr>
<tr>
<td>JPEG</td>
<td>Lossy</td>
<td>COMP_JPEG</td>
<td>Image data, quality factor and compatibility factor.</td>
</tr>
</tbody>
</table>

JPEG Compression

The JPEG compression method is a lossy compression algorithm whose use is recommended for photographic or scanned images. Using JPEG compression to reduce the size of an image changes the values of the pixels and therefore may alter the meaning of the corresponding data.

For more information on the JPEG algorithm, refer to Chapter 6, 8-Bit Raster Images (DFR8 API).

7.2.2.2 Interlace Modes

Because graphics applications and hardware devices vary in the way they access image data, HDF supports three interlace formats. By storing an image using a format that is consistent with the expected application or device, it is possible to achieve substantial improvements in performance.

HDF provides three options for organizing the color components in 24-bit raster images. These options consist of pixel interlacing, scan-line interlacing, and scan-plane interlacing. (See Figure 7c.) Storing the color components grouped by pixel, as in red-green-blue, red-green-blue, etc., is called pixel interlacing. Storing the color components by line, as in one row of red, one row of green, one row of blue, one row red, etc., is called scan-line interlacing. Finally, storing the color components grouped by color plane, as in the red components first, the green components second, and the blue components last, is called scan-plane interlacing. Unless otherwise specified, the HDF 24-bit raster model assumes that all 24-bit images are stored using pixel interlacing.

FIGURE 7c

RGB Interlace Format for 24-Bit Raster Images

An interlace format describes both the physical format of an image as it is stored in memory and in the file. When writing to a file, HDF stores a 24-bit image using the same interlace format as it has in memory. However, when reading from a file, it is possible to make the in-core interlacing mode different from that used in the file. The following table contains a summary of the interlacing format available in the DF24 interface.
7.3 The 24-Bit Raster Interface

The HDF library currently contains several routines for storing 24-bit raster images in the HDF format. The DF24addimage, DF24putimage, and DF24getimage routines are sufficient for most reading and writing operations.

7.3.1 24-Bit Raster Image Library Routines

The names of all C routines in the 24-bit raster image interface are prefaced by "DF24". The equivalent FORTRAN-77 routines are prefaced by "d2". These routines are divided into the following categories:

- **Write routines** create raster image sets and store them in new files or append them to existing files.
- **Read routines** determine the dimensions and interlace format of an image set, read the actual image data, and provide sequential or random read access to any raster image set.

The DF24 function calls are more explicitly defined in Table 7C and on their respective pages in the HDF Reference Manual.

### TABLE 7B
24-Bit Raster Image Interlace Format

<table>
<thead>
<tr>
<th>format</th>
<th>Description</th>
<th>DF24setil or d2setil Parameter</th>
<th>Size of Image Array</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel</td>
<td>Components grouped by pixel.</td>
<td>DFIL_PIXEL</td>
<td>Width x Height x 3</td>
</tr>
<tr>
<td>Scan-line</td>
<td>Components grouped by row.</td>
<td>DFIL_LINE</td>
<td>Width x 3 x Height</td>
</tr>
<tr>
<td>Scan-plane</td>
<td>Components grouped by plane.</td>
<td>DFIL_PLANE</td>
<td>3 x Width x Height</td>
</tr>
</tbody>
</table>

### TABLE 7C
DF24 Library Routines

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Routine Name</th>
<th>C</th>
<th>FORTRAN-77</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write</td>
<td>DF24addimage</td>
<td>d2aimg</td>
<td></td>
<td>Appends a 24-bit raster image to a file.</td>
</tr>
<tr>
<td></td>
<td>DF24lastref</td>
<td>d2lref</td>
<td></td>
<td>Reports the last reference number assigned to a 24-bit raster image.</td>
</tr>
<tr>
<td></td>
<td>DF24putimage</td>
<td>d2pimg</td>
<td></td>
<td>Writes a 24-bit raster image to file by overwriting all existing data.</td>
</tr>
<tr>
<td></td>
<td>DF24setcompress</td>
<td>d2acomp</td>
<td></td>
<td>Sets the compression method for the next raster image written to the file.</td>
</tr>
<tr>
<td></td>
<td>DF24setdims</td>
<td>d2adims</td>
<td></td>
<td>Sets the dimensions for the next raster image written to the file.</td>
</tr>
<tr>
<td></td>
<td>DF24setil</td>
<td>d2asetil</td>
<td></td>
<td>Sets the interlace format of the next raster image written to the file.</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>d2ajpeg</td>
<td></td>
<td>Fortran-specific routine for setting the parameters needed for the JPEG compression algorithm.</td>
</tr>
<tr>
<td>Read</td>
<td>DF24getdims</td>
<td>d2gdims</td>
<td></td>
<td>Retrieves the dimensions before reading the next raster image.</td>
</tr>
<tr>
<td></td>
<td>DF24getimage</td>
<td>d2gimg</td>
<td></td>
<td>Reads the next 24-bit raster image.</td>
</tr>
<tr>
<td></td>
<td>DF24nimage</td>
<td>d2nimg</td>
<td></td>
<td>Reports the number of 24-bit raster images in a file.</td>
</tr>
<tr>
<td></td>
<td>DF24readref</td>
<td>d2rref</td>
<td></td>
<td>Reads 24-bit raster image with the specified reference number.</td>
</tr>
<tr>
<td></td>
<td>DF24reqil</td>
<td>d2reqil</td>
<td></td>
<td>Retrieves the interlace format before reading the next raster image.</td>
</tr>
<tr>
<td></td>
<td>DF24restart</td>
<td>d2first</td>
<td></td>
<td>Returns to the first 24-bit raster image in the file.</td>
</tr>
</tbody>
</table>
7.4 Writing 24-Bit Raster Images

The DF24 programming model for writing a 24-bit raster image set is as follows:

1. Set the interlace format if the interlacing is to be different from pixel interlacing. (optional)
2. Set the compression type if the image is to be compressed. (optional)
3. Write the raster data to the file.

Steps 1 and 2 can be invoked in any order, as long as they are executed before Step 3. By default, images are stored uncompressed using pixel interlacing.

7.4.1 Writing a 24-Bit Raster Image: DF24putimage and DF24addimage

To write a raster image to an HDF file, the calling program must contain one of the following function calls:

C: status = DF24putimage(filename, image, width, height);
FORTRAN: status = d2pimg(filename, image, width, height)

OR

C: status = DF24addimage(filename, image, width, height);
FORTRAN: status = d2aimg(filename, image, width, height)

DF24putimage and DF24addimage write a 24-bit raster images to the HDF file specified by the filename parameter. When given a new file name, DF24putimage and DF24addimage create a new file and write the raster image as the first raster image in the file. If a file with the specified filename exists, DF24putimage overwrites the previous contents of the file whereas DF24addimage appends data to the end of the file.

DF24putimage and DF24addimage passes the raster data in the image parameter and the width and height of the image in the width and height parameters. The array image is assumed to be the width times the height times three bytes in length for each color component. The parameters for DF24putimage and DF24addimage are further defined below. Table 7D on page 255

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF24putimage [intn] (d2pimg)</td>
<td>filename</td>
<td>char *</td>
<td>Name of file to store the raster image.</td>
</tr>
<tr>
<td></td>
<td>image</td>
<td>VOIDP</td>
<td>Raster image to be written.</td>
</tr>
<tr>
<td></td>
<td>width</td>
<td>int32</td>
<td>Number of columns in the image.</td>
</tr>
<tr>
<td></td>
<td>height</td>
<td>int32</td>
<td>Number of rows in the image.</td>
</tr>
<tr>
<td>DF24addimage [intn] (d2aimg)</td>
<td>filename</td>
<td>char *</td>
<td>Name of file to store the raster image.</td>
</tr>
<tr>
<td></td>
<td>image</td>
<td>VOIDP</td>
<td>Raster image to be written.</td>
</tr>
<tr>
<td></td>
<td>width</td>
<td>int32</td>
<td>Number of columns in the image.</td>
</tr>
<tr>
<td></td>
<td>height</td>
<td>int32</td>
<td>Number of rows in the image.</td>
</tr>
</tbody>
</table>
EXAMPLE 1.

Writing a 24-Bit Raster Image to an HDF File

In the following examples, **DF24addimage** and **d2aimg** are used to write a 24-bit image to an HDF file named "Example1.hdf." **DF24addimage** assumes row-major order. Therefore, the FORTRAN-77 declaration requires the width (rows) before the height (columns), whereas the C declaration requires the height before the width. The interlace format setting is the default (pixel interlacing).

C:

```c
#include "hdf.h"
#define WIDTH 5
#define HEIGHT 6
#define PIXEL_DEPTH 3

main( )
{
    /* Initialize the image array. */
    static uint8 raster_data[HEIGHT][WIDTH][PIXEL_DEPTH] =
    {  1, 2, 3,  4, 5, 6,  7, 8, 9, 10,11,12, 13,14,15,
       16,17,18,19,20,21, 22,23,24, 25,26,27, 28,29,30,
       31,32,33,34,35,36, 37,38,39, 40,41,42, 43,44,45,
       46,47,48,49,50,51, 52,53,54, 55,56,57, 58,59,60,
       61,62,63,64,65,66, 67,68,69, 70,71,72, 73,74,75,
       76,77,78,79,80,81, 82,83,84, 85,86,87, 88,89,90 };
    intn status;

    /* Write the 24-bit raster image to the file. */
    status = DF24addimage("Example1.hdf", (VOIDP)raster_data, WIDTH, \
                         HEIGHT);
}
```

FORTRAN:

```fortran
PROGRAM WRITE RIS24

    integer status, d2aimg
    integer*4 WIDTH, HEIGHT, PIXEL_DEPTH
    parameter (WIDTH = 5,
               HEIGHT = 6,
               PIXELDEPTH = 3)

    character raster_data(PIXEL_DEPTH, WIDTH, HEIGHT)

    C Initialize the image array.
    data raster_data
          + /  1, 2, 3,  4, 5, 6,  7, 8, 9, 10,11,12, 13,14,15,
          + 16,17,18,19,20,21, 22,23,24, 25,26,27, 28,29,30,
          + 31,32,33,34,35,36, 37,38,39, 40,41,42, 43,44,45,
          + 46,47,48,49,50,51, 52,53,54, 55,56,57, 58,59,60,
          + 61,62,63,64,65,66, 67,68,69, 70,71,72, 73,74,75,
          + 76,77,78,79,80,81, 82,83,84, 85,86,87, 88,89,90 /

    C Write the 24-bit raster image to the file.
    status = d2aimg('Example1.hdf', raster_data, WIDTH, \
                     HEIGHT)

end
```
7.4.2 Setting the Interlace Format: DF24setil

DF24setil indicates the interlace format to be used for all subsequent write operations. DF24setil changes the default setting from pixel interlacing to the selected format. When the format is set, it acts as the default until it is reset by another call to DF24setil. To change the default interlace format, the calling program must contain the following routines:

**C:**
```
status = DF24setil(il);
status = DF24addimage(filename, image, width, height);
```

**FORTRAN:**
```
status = d2setil(il)
```

DF24setil takes il as its only parameter. Valid values for il are DFIL_PIXEL, DFIL_LINE, and DFIL_PLANE. The parameters for DF24setil are further defined below. Table 7E on page 259

---

**EXAMPLE 2. Writing 24-Bit Raster Images Using Scan-plane Interlacing**

In the following examples, DF24addimage is used to write a 24-bit image to an HDF file called "Example2.hdf". The DF24setil function used here to change the default format setting from pixel interlacing to scan-plane interlacing.

**C:**
```
#include "hdf.h"
#include "hcomp.h"

#define WIDTH 5
#define HEIGHT 6
#define PIXEL_DEPTH 3

main( )
{

    /* Initialize the image array. */
    static uint8 raster_data[HEIGHT][WIDTH][PIXEL_DEPTH] =
    {  1, 2, 3,  4, 5, 6,  7, 8, 9, 10,11,12, 13,14,15,
        16,17,18, 19,20,21, 22,23,24, 25,26,27,  28,29,30,
        31,32,33, 34,35,36, 37,38,39,  40,41,42,  43,44,45,
        46,47,48, 49,50,51, 52,53,54,  55,56,57,  58,59,60,
        61,62,63, 64,65,66, 67,68,69,  70,71,72,  73,74,75,
        76,77,78, 79,80,81, 82,83,84,  85,86,87,  88,89,90 
    };

    intn status;

    /* Change interlace from pixel to scan-plane. */
    status = DF24setil(DFIL_PLANE);

    /* Write the 24-bit image data to file. */
    status = DF24addimage("Example2.hdf", (VOIDP)raster_data,
                          WIDTH, HEIGHT);

}
```

**FORTRAN:**
```
PROGRAM CHANGE INTERLACE

integer status, d2aimg, d2setil
integer*4 WIDTH, HEIGHT, PIXEL_DEPTH, DFIL_PLANE
parameter (WIDTH = 5,
          + HEIGHT = 6,
          + PIXEL_DEPTH = 3,
          + DFIL_PLANE = 3)
```
integer raster_data(PIXEL_DEPTH, WIDTH, HEIGHT)

C     Initialize the image array.
data raster_data
+ /  1, 2, 3,  4, 5, 6,  7, 8, 9,  10,11,12,  13,14,15,
+ 16,17,18, 19,20,21, 22,23,24,  25,26,27,  28,29,30,
+ 31,32,33, 34,35,36, 37,38,39,  40,41,42,  43,44,45,
+ 46,47,48, 49,50,51, 52,53,54,  55,56,57,  58,59,60,
+ 61,62,63, 64,65,66, 67,68,69,  70,71,72,  73,74,75,
+ 76,77,78, 79,80,81, 82,83,84,  85,86,87,  88,89,90  /

C     Change interlace from pixel to scan plane.
status = d2setil(DFIL_PLANE)

C     Write the 24-bit raster image to the file.
status = d2aimg('Example2.hdf', raster_data, WIDTH,
+           HEIGHT)
end

7.4.3 Compressing Image Data: DF24setcompress and d2sjpeg

DF24setcompress invokes JPEG compression and sets the JPEG quality and baseline options. To store a 24-bit raster image using JPEG compression, the calling program must contain the following function calls:

C:
status = DF24setcompress(type, c_info);
status = DF24addimage(filename, image, width, height);

FORTRAN:
status = d2scomp(type)
OR
status = d2sjpeg(quality, baseline)
status = d2aimg(filename, image, width, height, compress)

Notice that the calling sequence for C is different from the calling sequence for FORTRAN-77. Once it is set, the parameter type in the DF24setcompress routine, or d2scomp in FORTRAN-77, routine specifies the compression method that will be used to store the raster images. However, the c_info parameter in DF24setcompress is missing from d2scomp which is a pointer to a structure that contains information specific to the compression method indicated by the type parameter. Because data structures of variable size are not supported in FORTRAN-77, a second compression-specific routine (d2sjpeg) is required in the FORTRAN-77 calling sequence.

For more information about the c_info structure refer to Chapter 6, 8-Bit Raster Images (DFR8 API).

Default values for quality and baseline (quality=75%, baseline=on) are used if c_info is a null structure or d2sjpeg is omitted. Parameters for DF24setcompress and d2sjpeg are further described in Table 7E below.
TABLE 7E

DF24setil and DF24setcompress Parameter List

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF24setil</td>
<td>il</td>
<td>int32</td>
<td>Interface format to be set.</td>
</tr>
<tr>
<td>(d2bil)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DF24setcompress</td>
<td>type</td>
<td>int32</td>
<td>COMP_JPEG</td>
</tr>
<tr>
<td>(d2scomp)</td>
<td>c_info</td>
<td>comp_info *</td>
<td>Pointer to JPEG information structure.</td>
</tr>
<tr>
<td></td>
<td>quality</td>
<td>None</td>
<td>JPEG compression quality specification.</td>
</tr>
<tr>
<td>(d2sjpeg)</td>
<td>baseline</td>
<td>None</td>
<td>JPEG compression baseline specification.</td>
</tr>
</tbody>
</table>

EXAMPLE 3.

Compressing and Writing a 24-Bit Raster Image

In the following examples, **DF24addimage** and **DF24compress** are used to compress a 24-bit image and write it to an HDF file named "Example2.hdf". Notice that compressing an image in C requires only one function call, whereas compressing an image using FORTRAN-77 requires two. The second FORTRAN-77 call is required because it is not valid to pass a structure as a parameter in FORTRAN-77.

C:

```
#include "hdf.h"
#include "hcomp.h"

#define WIDTH 3
#define HEIGHT 5
#define PIXEL_DEPTH 3

main( )
{
    /* Initialize the image array. */
    static uint8 raster_data[HEIGHT][WIDTH][PIXEL_DEPTH] =
        { 1, 2, 3,  4, 5, 6,  7, 8, 9,
          10,11,12, 13,14,15, 16,17,18,
          19,20,21, 22,23,24, 25,26,27,
          28,29,30, 31,32,33, 34,35,36,
          37,38,39, 40,41,42, 43,44,45 };
    static comp_info compress_info;
    intn status;

    /* Initialize JPEG compression structure. */
    compress_info.jpeg.quality = 60;
    compress_info.jpeg.force_baseline = 1;

    /* Set JPEG compression for storing the image. */
    status = DF24setcompress(COMP_JPEG, &compress_info);

    /* Write the 24-bit image data to file. */
    status = DF24addimage("Example2.hdf", (VOIDP)raster_data,
                            WIDTH, HEIGHT);
}
```
FORTRAN:

```fortran
PROGRAM COMPRESS_RIS24

    integer d2aimg, d2scomp, d2sjpeg, status
    integer*4 WIDTH, HEIGHT, PIXEL_DEPTH
    parameter(WIDTH = 3,
              HEIGHT = 5,
              PIXEL_DEPTH = 3)
    character raster_data(PIXEL_DEPTH, WIDTH, HEIGHT)

    C     Initialize the image array.
    data raster_data
        + /  1, 2, 3,  4, 5, 6,  7, 8, 9,
        +  10,11,12, 13,14,15, 16,17,18,
        + 19,20,21, 22,23,24, 25,26,27,
        + 28,29,30, 31,32,33, 34,35,36,
        + 37,38,39, 40,41,42, 43,44,45  /

    C     Set compression.
    status = d2scomp(COMP_JPEG)

    C     Set JPEG parameters to quality = 60, and turn compatibility on.
    status = d2sjpeg(60, 1)

    C     Write the 24-bit image data to the HDF file.
    status = d2aimg('Example2.hdf', raster_data, WIDTH, HEIGHT)
end
```

7.5 Reading 24-Bit Raster Images

The DF24 programming model for reading a 24-bit raster image set is as follows:

1. Determine the dimensions for an image if necessary.
2. Specify the interlace format to use when reading the image. (optional)
3. Read the image data from the file.

7.5.1 Reading a Raster Image: DF24getimage

If the dimensions and interlace format of the image are known, `DF24getimage` is the only function call required to read a raster image. If a file is being opened for the first time, `DF24getimage` returns the first image in the file. Additional calls will return successive images in the file, therefore images are read in the same order in which they were written to the file. Normally, `DF24getdims` and `DF24getil` are called before `DF24getimage` so that, if necessary, space allocations and interlace format for the image can be checked and the dimensions verified. If this information is already known, both function calls may be omitted.

The syntax of the `DF24getimage` routine is as follows:

```c
C:   status = DF24getimage(filename, image, width, height);
```

```fortran
FORTRAN:   status = d2gimg(filename, image, width, height)
```

`DF24getimage` retrieves the next 24-bit image from the HDF file specified by the `filename` parameter. If the image is compressed, `DF24getimage` decompresses it and places it in memory at the location pointed to by the `image` parameter. `DF24getimage` assumes the data is stored using pixel interlacing. The space allocated to hold the image is specified by the `width` and `height`. 
parameters and may be larger than the actual image. The parameters for **DF24getimage** are further defined below. Table 7F on page 261

### 7.5.2 Determining the Dimensions of an Image: DF24getdims

**DF24getdims** opens a named file, finds the next image or the first image if the file is being opened for the first time, retrieves the dimensions of the image, then determines the interlace format of the image. Images are read in the order they were written.

To determine the dimensions and interlace format for an image, the calling program must call the following routines:

- **C:**
  ```
  status = DF24getdims(filename, width, height, il);
  status = DF24getimage(filename, image, width, height);
  ```
- **FORTRAN:**
  ```
  status = d2gdim(filename, width, height, il)
  status = d2gimg(filename, image, width, height)
  ```

**DF24getdims** takes four parameters: `filename`, `width`, `height`, and `il`. It retrieves dimension and interlace format information of the next 24-bit image stored in the HDF file specified by the `filename` parameter. The width and height are returned in the space pointed to by the `width` and `height` parameters respectively. The `il` parameter is used to determine the interlace format. The parameters for **DF24getdims** are further defined below. (See Table 7F.)

### 7.5.3 Modifying the Interlacing of an Image: DF24reqil

**DF24reqil** specifies an interlace format to be used when reading a 24-bit image from a file into memory. Regardless of what interlace format is used to store the image, **DF24reqil** forces the image to be loaded into memory using the specified interlace format.

To set or reset the interlace format, the calling program should call the following routines:

- **C:**
  ```
  status = DF24reqil(il);
  status = DF24getimage(filename, image, width, height);
  ```
- **FORTRAN:**
  ```
  status = d2reqil(il)
  status = d2gimg(filename, image, width, height)
  ```

**DF24reqil** takes `il` as its only parameter. Valid `il` values are `DFIL_PIXEL`, `DFIL_LINE` and `DFIL_PLANE`. As a call to **DF24reqil** may require a substantial reordering of the data, a much slower I/O performance than would be achieved if the interlace format wasn’t reset may result.

The parameters of **DF24reqil** is further defined below. (See Table 7F.)

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filename</td>
<td>char *</td>
<td>Name of the HDF file containing the raster image.</td>
</tr>
<tr>
<td>image</td>
<td>VOIDP</td>
<td>Buffer for the raster image.</td>
</tr>
<tr>
<td>width</td>
<td>int32</td>
<td>Width of the raster image buffer.</td>
</tr>
<tr>
<td>height</td>
<td>int32</td>
<td>Height of the raster image buffer.</td>
</tr>
</tbody>
</table>
EXAMPLE 4.

Reading a 24-Bit Raster Image from an HDF File

The following examples read a 24-bit image from the "Example2.hdf" HDF file created in Example 2. Although the DF24getdims function call is optional, it is included as a demonstration of how to verify the image dimensions and interlace format before reading the image data. If the image dimensions and interlace format are known, only the DF24getimage call is required.

C:

```c
#include "hdf.h"

#define WIDTH 5
#define HEIGHT 6
#define PIXEL_DEPTH 3

int width, height;
intn interlace, status;

main( )
{
    uint8 raster_data[PIXEL_DEPTH][HEIGHT][WIDTH];
    int32 width, height;
    intn interlace, status;

    /* Get the image dimensions from the HDF file. */
    status = DF24getdims("Example2.hdf", &width, &height,
                        &interlace);

    /* Read raster data if the dimensions are correct. */
    if (width <= WIDTH && height <= HEIGHT)
        status = DF24getimage("Example2.hdf", (VOIDP)raster_data,
                              width, height);
}
```

FORTRAN:

```fortran
PROGRAM READ RIS24

integer d2gimg, d2gdims, status, width, height, interlace
integer*4 X_LENGTH, Y_LENGTH, PIXEL_DEPTH
parameter(X_LENGTH = 5, Y_LENGTH = 6, PIXEL_DEPTH = 3)
integer raster_data(PIXEL_DEPTH, X_LENGTH, Y_LENGTH)

C Read the dimensions raster image.
C status = d2gdims(Example2.hdf, width, height, interlace)

C Read image data from the HDF file if the dimensions are correct.
C if (width .eq. X_LENGTH .and. height .eq. Y_LENGTH) then
```
7.5.4 Reading a 24-Bit Raster Image with a Given Reference Number: DF24readref

DF24readref is used to access specific images stored in files containing multiple raster image sets. It is optionally used before DF24getimage. DF24readref can be used in connection with vgroups, which identify their members by tag/reference number pairs. See Chapter 5, Vgroups (V API), for a discussion of vgroups and tag/reference number pairs.

To access a specific raster image set, use the following sequence of routine calls:

C:
status = DF24readref(filename, ref);
status DF24getimage(filename, image, width, height);

FORTRAN:
status = d2rref(filename, ref)
status = d2gimg(filename, image, width, height)

DF24readref sets the reference number for the next read operation performed on the HDF file filename to the reference number contained in ref. Because reference numbers are not always assigned in sequence, it is not guaranteed that a reference number represents the location of the image in the file.

The parameters of DF24readref are further described in the following table.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF24readref</td>
<td>filename</td>
<td>char *</td>
<td>Name of HDF file containing the raster image.</td>
</tr>
<tr>
<td></td>
<td>ref</td>
<td>uint16</td>
<td>Reference number for the next call to DF24getimage.</td>
</tr>
</tbody>
</table>

7.5.5 Specifying that the Next Image Read to be the First 24-Bit Raster Image in the File: DF24restart

DF24restart causes the next call to DF24getimage or DF24getdims to read from the first raster image set in the file, rather than the RIS24 following the one that was most recently read. Use the following call to invoke DF24restart:

C: status = DF24restart();

FORTRAN: status = d2first();

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF24restart</td>
<td>None</td>
<td>None</td>
<td>None.</td>
</tr>
</tbody>
</table>
7.6 24-Bit Raster Image Information Retrieval Routines

7.6.1 Querying the Total Number of Images in a File: DF24nimages

DF24nimages returns the total number of 24-bit raster image sets in a file, and has the following syntax:

C: num_of_images = DF24nimages(filename);

FORTRAN: num_of_images = d2nimg(filename)

TABLE 7I
DF24nimages Parameter List

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF24nimages [intn] (d2nimg)</td>
<td>filename</td>
<td>Name of the HDF file.</td>
</tr>
</tbody>
</table>

7.6.2 Querying the Reference Number of the Most Recently Read or Written 24-Bit Raster Image: DF24lastref

DF24lastref returns the reference number of the 24-bit raster image most recently read or written. This routine is used for attaching annotations to images and adding images to vgroups. (See Chapter 5, Vgroups (V API) and Chapter 10, Annotations (AN API), for details on how to use reference numbers in connection with these applications.

The following calling sequence uses DF24lastref to find the reference number of the RIS24 most recently added to an HDF file:

C: status = DF24addimage(filename, image, width, height, compress);
    lastref = DF24lastref();

FORTRAN: status = d2aimg(filename, image, width, height, compress)
    lastref = d2lref()

DF4putimage or DF4getimage can be used in place of DF24addimage with similar results.

TABLE 7J
DF24lastref Parameter List

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF24lastref [uint16] (d2lref)</td>
<td>None</td>
<td>None.</td>
</tr>
</tbody>
</table>
Chapter 8

General Raster Images (GR API)

8.1 Chapter Overview

This chapter describes the general raster (GR) data model, the GR interface (also called the GR API), and the interface routines used to manipulate GR data objects. The GR data model is designed to provide a flexible means of manipulating raster images. In addition to the GR interface, HDF provides two interfaces for manipulating raster data. The DFR8 interface works with 8-bit raster images and is described in Chapter 6, 8-Bit Raster Images (DFR8 API). The DF24 interface is designed for 24-bit raster images and is described in Chapter 7, 24-bit Raster Images (DF24 API).

8.2 The GR Data Model

HDF users familiar with the SD interface will find certain aspects of the GR data model similar to the SD data model. The interfaces are similar in that both interfaces support data storage in multiple files, attributes, compression, and chunking. They are dissimilar in that palettes can be created and attached to an image through GR interface routines, customized dimension information is not supported in the GR interface, and GR dataset chunking is constrained to two dimensions.

FIGURE 8a

GR Data Set Contents

<table>
<thead>
<tr>
<th>Raster Image</th>
<th>Required Components</th>
<th>Optional Components</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Name</td>
<td>Palette</td>
</tr>
<tr>
<td></td>
<td>Dimensions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2D Array of Pixels</td>
<td>Attribute</td>
</tr>
<tr>
<td></td>
<td>Pixel Type</td>
<td></td>
</tr>
</tbody>
</table>

The terms **GR data set**, **raster image**, and **image** are used interchangeably in this chapter.
Refer to Figure 8a on page 265 for a graphical overview of the raster image, or GR data set, structure. Note that GR data sets consist of required and optional components.

### 8.2.1 Required GR Data Set Components

Every GR data set must contain the following components: *image array, name, pixel type*, and *dimensions*. The name, dimensions, and pixel type must be supplied by the user at the time the GR data set is defined.

**Image Array**

An *image array* is a two-dimensional array of pixels. This is the primary data component of the GR model and will be discussed later in this section; it can be compressed, chunked, and/or stored in external files. Refer to Section 8.6.2 on page 281 for a description of raster image compression and Section 8.6.3 on page 282 for a description of external image storage.

A raster image has an index and a reference number associated with it. The *index* is a non-negative integer that describes the relative position of the raster image in the file. A valid index ranges from 0 to the total number of images in the file minus 1. The *reference number* is a unique positive integer assigned to the raster image by the GR interface when the image is created. Various GR interface routines can be used to obtain an image index or reference number depending on the available information about the raster image. The index can also be determined if the sequence in which the images are created in the file is known.

In the GR interface, a *raster image identifier* uniquely identifies a raster image within the file. The identifier is generated by the GR interface access routines when a new GR data set is created or an existing one is selected. The identifier is then used by other GR interface routines to access the raster image until the access to this image is terminated. For an existing raster image, the index of the image can be used to obtain the identifier.

**Image Array Name**

Each image array has a *name* consisting of a string of case-sensitive alphanumeric characters. The name must be provided by the calling program at the time the image is created, and cannot be changed afterward. Image array names do not have to be unique within a file, but if they are not it can be difficult to distinguish among the raster images in the file.

**Pixels and Pixel Type**

Each element in an image array corresponds to one *pixel* and each pixel can consist of a number of color component values or *pixel components*, e.g., Red-Green-Blue or RGB, Cyan-Magenta-Yellow-Black or CMYK, etc. Pixel components can be represented by different methods (8-bit lookup table or 24-bit direct representation, graphically depicted by Figure 6a on page 233 and Figure 7b on page 252, respectively) and may have different data types.

The data type of pixel components and the number of components in each pixel are collectively known as the *pixel type*. The GR data model supports all of the HDF-supported data types. A list of these data types appears provided in Table 2F on page 14.

Pixels can be composed of any number of components.

**Dimensions**

Image array *dimensions* specify the shape of the image array. A raster image array has two limited dimensions. The size of each dimension must be specified at the creation of the image and must be greater than 0.
The GR library does not allow the HDF user to add attributes to a dimension or to set dimension scale.

8.2.2 Optional GR Data Set Components

There are two types of optional components available for inclusion in a GR data set: palettes and attributes. These components are only created when specifically requested by the calling program; the GR interface does not provide predefined palettes or attributes.

Palettes

Palettes are lookup tables attached to images and define a set of color values for each pixel value in the image array. The GR interface provides similar capabilities for storing and manipulating palettes as the DFP interface described in Chapter 9, Palettes (DFP API). However, the DFP interface is restricted to single-file operations while the GR interface allows multi-file palette operations.

Eventually, all palette manipulation functionality will reside only within the GR interface. In the meantime, the single-file DFP routines are fully compatible with palettes created with the GR palette routines. The GR palette routines are described in Section 8.11 on page 306.

Attributes

Attributes contain auxiliary information about a file, a raster image, or both. The concept of attributes is described in Chapter 3, Scientific Data Sets (SD API).

The GR interface does not support dimension attributes.

8.3 The GR Interface

The GR consists of routines for storing, retrieving, and manipulating the data in GR data sets.

8.3.1 GR Interface Routines

All C routine names in the GR interface have the prefix GR and the equivalent FORTRAN-77 routine names are prefaced by mg. All GR routines are classifiable within one of the following categories:

- Access routines initialize and terminate access to the GR interface and raster images.
- Raster image manipulation routines modify the data and metadata contained in a GR data set.
- LUT manipulation routines modify the palettes, also called color lookup tables or LUTs, contained in a GR data set.
- Maintenance routines create the data and metadata contained in a GR data set and modify global settings governing the format of the stored data.
- Inquiry routines return information about data contained in a GR data set.
- Chunking routines are used to define data chunking parameters, to retrieve chunking information, and to write and read chunked GR data sets.

The GR routines are listed in the following table and described further in subsequent sections of this chapter.
<table>
<thead>
<tr>
<th>Purpose</th>
<th>Routine Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>FORTRAN-77</td>
</tr>
<tr>
<td>Access</td>
<td>GRstart</td>
<td>mgsstart</td>
</tr>
<tr>
<td></td>
<td>GRcreate</td>
<td>mgcreate</td>
</tr>
<tr>
<td></td>
<td>GRselect</td>
<td>mgselect</td>
</tr>
<tr>
<td></td>
<td>GRendaccess</td>
<td>mgendac</td>
</tr>
<tr>
<td></td>
<td>GRend</td>
<td>mgend</td>
</tr>
<tr>
<td></td>
<td>GRgetattr</td>
<td>mggnatt/ mggcatt</td>
</tr>
<tr>
<td></td>
<td>GRidtoref</td>
<td>mgid2rf</td>
</tr>
<tr>
<td></td>
<td>GRnametoindex</td>
<td>mgn2ndx</td>
</tr>
<tr>
<td></td>
<td>GRreadimage</td>
<td>mgrdimg/ mgcimg</td>
</tr>
<tr>
<td></td>
<td>GRreftoindex</td>
<td>mg2idx</td>
</tr>
<tr>
<td></td>
<td>GRsetattr</td>
<td>mgsnatt/ mgscatt</td>
</tr>
<tr>
<td></td>
<td>GRwriteimage</td>
<td>mgwrimg/ mgwcimg</td>
</tr>
<tr>
<td></td>
<td>GRreqimageil</td>
<td>mgrimil</td>
</tr>
<tr>
<td>Raster Image</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manipulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GRgetlutid</td>
<td>mggltid</td>
</tr>
<tr>
<td></td>
<td>GLUTtoref</td>
<td>mglt2rf</td>
</tr>
<tr>
<td></td>
<td>GRreadlut</td>
<td>mgrdlut/ mgcrolut</td>
</tr>
<tr>
<td></td>
<td>GRwritelut</td>
<td>mgwrlut/ mgwcrolut</td>
</tr>
<tr>
<td></td>
<td>GRreqlutil</td>
<td>mgrltil</td>
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<tr>
<td></td>
<td>GRgetnluts</td>
<td>mgnluts</td>
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<tr>
<td>LUT</td>
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<tr>
<td>Manipulation</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>GRsetcompress</td>
<td>mgacomp</td>
</tr>
<tr>
<td></td>
<td>GRgetcompress</td>
<td>mgccompress</td>
</tr>
<tr>
<td></td>
<td>GRsetexternalfile</td>
<td>mgxfl1</td>
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<tr>
<td>Maintenance</td>
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</tr>
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<td></td>
<td>GRattrinfo</td>
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</tr>
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<tr>
<td></td>
<td>GFileinfo</td>
<td>mginfo</td>
</tr>
<tr>
<td></td>
<td>GRgetinfo</td>
<td>mgginfo</td>
</tr>
<tr>
<td></td>
<td>GRgetlutinfo</td>
<td>mgglinf</td>
</tr>
</tbody>
</table>

TABLE 8A: GR Library Routines

- **Access**: GRstart initializes the GR interface (Section 8.5.1 on page 270)
- **Creation**: GRcreate creates a new raster image (Section 8.5.1 on page 270)
- **Selection**: GRselect selects the raster image (Section 8.5.1 on page 270)
- **Termination**: GRendaccess terminates access to the raster image (Section 8.5.2 on page 271)
- **Termination**: GRend terminates access to the GR interface (Section 8.5.2 on page 271)
- **Attribute Read**: GRgetattr reads an attribute of a raster image or a file (Section 8.10.4 on page 301)
- **Attribute Mapping**: GRidtoref maps a raster image identifier to a reference number (Section 8.9.3 on page 291)
- **Name to Index**: GRnametoindex maps the name of a raster image name to an index (Section 8.9.5 on page 292)
- **Image Read**: GRreadimage reads raster image data (Section 8.7.1 on page 284)
- **Reference to Index**: GRreftoindex maps the reference number of a raster image to its index (Section 8.9.4 on page 292)
- **Attribute Assignment**: GRsetattr assigns an attribute to a raster image or a file (Section 8.10.2 on page 297)
- **Image Write**: GRwriteimage writes raster image data (Section 8.6.1 on page 272)
- **Image Interlace**: GRreqimageil sets the interlace mode of the image read for subsequent read operations (Section 8.7.2 on page 284)
- **Palette Read**: GRgetlutid gets a palette identifier given the palette’s index (Section 8.11.1 on page 306)
- **Palette Mapping**: GLUTtoref maps a palette identifier to a reference number (Section 8.11.3 on page 307)
- **Image Read**: GRreadlut reads palette data from a raster image (Section 8.11.7 on page 309)
- **Image Write**: GRwritelut writes palette data to a raster image (Section 8.11.5 on page 308)
- **Image Interlace**: GRreqlutil sets the interlace mode of the next palette for subsequent read operations (Section 8.7.2 on page 284)
- **Palette Retrieval**: GRgetnluts retrieves the number of palettes associated with an image (See the HDF Reference Manual)
- **Image Compression**: GRsetcompress specifies whether the raster image will be stored in a file as a compressed raster image (Section 8.6.2 on page 281)
- **Image Compression**: GRgetcompress retrieves image compression type and compression information (See the HDF Reference Manual)
- **Image External File**: GRsetexternalfile specifies that the raster image will be written to an external file (Section 8.6.3.1 on page 282)
- **Attribute Information**: GRattrinfo retrieves information about an attribute (Section 8.10.3 on page 301)
- **Attribute Index**: GRfindattr finds the index of a data object's attribute given an attribute name (Section 8.10.3 on page 301)
- **File Information**: GFileinfo retrieves the number of raster images and the number of global attributes in the file (Section 8.9.1 on page 290)
- **General Information**: GRgetinfo retrieves general information about a raster image (Section 8.9.2 on page 291)
- **Palette Information**: GRgetlutinfo retrieves information about a palette (Section 8.11.4 on page 307)
8.4 Header Files Required by the GR Interface

The header file "hdf.h" must be included in any program that utilizes GR interface routines.

8.5 Programming Model for the GR Interface

As with the SD interface, the GR interface relies on the calling program to initiate and terminate access to files and data sets to support multiframe access. The GR programming model for accessing a raster image is as follows:

1. Open an HDF file.
2. Initialize the GR interface.
3. Open an existing raster image or create a new raster image.
4. Perform desired operations on the raster image.
5. Terminate access to the raster image.
6. Terminate access to the GR interface by disposing of the interface identifier.
7. Close the HDF file.

To access a single raster image data set in an HDF file, the calling program must contain the following calls:

C:

```c
file_id = Hopen(filename, access_mode, n_dds_block);
gr_id = GRstart(file_id);
ri_id = GRselect(gr_id, ri_index);
OR
ri_id = GRcreate(gr_id, name, n_comps, data_type, interlace_mode, dim_sizes);
```

```c
<Optional operations>
status = GRendaccess(ri_id);
status = GRend(gr_id);
status = Hclose(file_id);
```

FORTRAN:

```fortran
file_id = hopen(filename, access_mode, n_dds_block)
gr_id = mgstart(file_id)
ri_id = mgselct(gr_id, ri_index)
OR
ri_id = mgcreat(gr_id, name, n_comps, data_type, interlace_mode, dim_sizes)
```

```fortran
<Optional operations>
status = mgendac(ri_id)
status = mgend(gr_id)
status = hclose(file_id)
```
To access several files at the same time, a calling program must obtain a separate interface identifier for each file to be opened. Similarly, to access more than one raster image, a calling program must obtain a separate data set identifier for each data set.

Because every file and raster image is assigned its own identifier, the order in which files and data sets are accessed is very flexible as long as all file and raster image identifiers are individually discarded before the end of the calling program.

8.5.1 Accessing Images and Files: GRstart, GRselect, and GRcreate

In the GR interface, Hopen opens the files and GRstart initiates the GR interface. Note the contrast to the SD interface, where SDstart performs both tasks. For information on the use of Hopen, refer to Chapter 2, HDF Fundamentals. For information on SDstart, refer to Chapter 3, Scientific Data Sets (SD API).

GRstart initializes the GR interface and must be called once after Hopen and before any other GR routines are called. It takes one argument, file_id, the file identifier returned by Hopen, and returns the interface identifier gr_id or FAIL (or -1) upon unsuccessful completion. Hopen and GRstart can be called several times to access more than one file.

GRselect specifies the given image as the current image to be accessed. It takes two arguments, the GR interface identifier gr_id and the raster image index ri_index, and returns the raster image identifier ri_id or FAIL (or -1) upon unsuccessful completion. The GR interface identifier is returned by GRstart. The raster image index specifies the position of the image relative to the beginning of the file; it is zero-based, meaning that the index of the first image in the file is 0. The index of a raster image can be obtained from the image’s name using the routine GRnametoindex or from the image’s reference number using GRreftoindex. These routines are discussed in Section 8.9.4 on page 292 and Section 8.9.5 on page 292. The index value must be less than the total number of raster images in the file; that number can be obtained using GRfileinfo, described in Section 8.9.1 on page 290.

The parameters for GRstart and GRselect are further defined in Table 8B on page 271.

GRcreate defines a new raster image using the arguments gr_id, name, n_comps, data_type, interlace_mode, and dim_sizes. Once a data set is created, you cannot change its name, data type, dimension, or number of components. GRcreate does not actually write the image to the file; this occurs only when GRrendaccess is called. Thus, failing to call GRrendaccess properly will cause a loss of data.

The buffer name contains the name of the image; it must not exceed MAX_GR_NAME (or 256). The parameter n_comps specifies the number of pixel components in the raster image; it must have a value of at least 1. The parameter data_type specifies the data type of the image data; it can be any of the data types supported by the HDF library. The HDF supported data type are defined in the header file “hntdefs.h” and listed in Table 2F on page 14.

The parameter interlace_mode specifies the interlacing in which the raster image is to be written; it can be set to either MFGR_INTERLACE_PIXEL (or 0), MFGR_INTERLACE_LINE (or 1), or MFGR_INTERLACE_COMPONENT (or 2). These definitions respectively correspond to pixel interlacing, line interlacing, and component interlacing. The first two interlacing modes are illustrated for the instance of 24-bit pixel representation in Figure 7c on page 253 of Chapter 7, 24-bit Raster Images (DF24 API). Component interlacing, as the name implies, describes interlacing raster data by color component. (Images created with the GR interface are actually written to disk in pixel interlace mode; any user-specified interlace mode is stored in the file with the image and the image is automatically converted to that mode when it is read with a GR interface function.)
The parameter `dim_sizes` specifies the size of the two dimensions of the image. The dimension sizes must be specified; their values must be at least 1.

`GRcreate` returns the value of the raster image identifier if successful or `FAIL` (or −1) otherwise. The parameters for `GRstart`, `GRselect`, and `GRcreate` are further defined in (See Table 8B.).

8.5.2 Terminating Access to Images and Files: GRendaccess and GRend

`GRendaccess` disposes of the raster image identifier `ri_id` and terminates access to the data set initiated by the corresponding call to `GRselect` or `GRcreate`. The calling program must make one `GRendaccess` call for every `GRselect` or `GRcreate` call made during its execution. Failing to call `GRendaccess` for each call to `GRselect` or `GRcreate` may result in a loss of data.

`GRend` disposes of the GR interface identifier `gr_id` and terminates access to the GR interface initiated by the corresponding call to `GRstart`. The calling program must make one `GRend` call for every `GRstart` call made during its execution; failing to call `GRend` for each `GRstart` may result in a loss of data.

`GRendaccess` and `GRend` return `SUCCEED` (or 0) or `FAIL` (or −1). The parameters of these routines are further defined in Table 8B.

`Hclose` terminates access to an HDF file and should only be called after `GRend` has been called properly. Refer to Chapter 2, *HDF Fundamentals*, for a description of `Hclose`.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>GRstart</code></td>
<td>file_id</td>
<td>int32</td>
<td>File identifier</td>
</tr>
<tr>
<td>[int32]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mgstart)</td>
<td></td>
<td>FORTRAN-77</td>
<td></td>
</tr>
<tr>
<td><code>GRselect</code></td>
<td>gr_id</td>
<td>int32</td>
<td>GR interface identifier</td>
</tr>
<tr>
<td>[int32]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mgselct)</td>
<td></td>
<td>FORTRAN-77</td>
<td></td>
</tr>
<tr>
<td>ri_index</td>
<td>int32</td>
<td>integer</td>
<td>Position of the raster image within the file</td>
</tr>
<tr>
<td><code>GRcreate</code></td>
<td>gr_id</td>
<td>int32</td>
<td>GR interface identifier</td>
</tr>
<tr>
<td>[int32]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mgcreat)</td>
<td></td>
<td>FORTRAN-77</td>
<td></td>
</tr>
<tr>
<td>name</td>
<td>char *</td>
<td>character(*)</td>
<td>Name of the image</td>
</tr>
<tr>
<td>n_comps</td>
<td>int32</td>
<td>integer</td>
<td>Number of components in each pixel</td>
</tr>
<tr>
<td>data_type</td>
<td>int32</td>
<td>integer</td>
<td>Data type of the pixel component</td>
</tr>
<tr>
<td>interlace_mode</td>
<td>int32</td>
<td>integer</td>
<td>Interface mode to be used when writing to the data set</td>
</tr>
<tr>
<td><code>GRendaccess</code></td>
<td>ri_id</td>
<td>int32</td>
<td>Raster image identifier</td>
</tr>
<tr>
<td>[intn]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mgendac)</td>
<td></td>
<td>FORTRAN-77</td>
<td></td>
</tr>
<tr>
<td><code>GRend</code></td>
<td>gr_id</td>
<td>int32</td>
<td>GR interface identifier</td>
</tr>
<tr>
<td>[intn]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mgend)</td>
<td></td>
<td>FORTRAN-77</td>
<td></td>
</tr>
</tbody>
</table>
8.6 Writing Raster Images

A raster image can be written partially or entirely. Partial writing includes writing to a contiguous region of the image and writing to selected locations in the image according to patterns defined by the user. This section describes the routine **GRwriteimage** and how it can write data to part of an image or to an entire image. The section also illustrates the concepts of compressing raster images and the use of external files to store image data.

8.6.1 Writing Raster Images: GRwriteimage

**GRwriteimage** is used to either completely or partially fill an image array.

Writing data to an image array involves the following steps:

1. Open a file and initialize the GR interface.
2. Select an existing raster image or create a new one.
3. Write data to the image array.
4. Terminate access to the raster image.
5. Terminate access to the GR interface and close the file.

The calling program must contain the following sequence of calls:

**C:**

```c
file_id = Hopen(filename, access_mode, num_dds_block);
gr_id = GRstart(file_id);
ri_id = GRselect(gr_id, ri_index);
OR ri_id = GRcreate(gr_id, name, n_comps, number_type, interlace_mode,
                   dim_sizes);
status = GRwriteimage(ri_id, start, stride, edges, data);
status = GRendaccess(gr_id);
status = GRend(ri_id);
status = Hclose(file_id);
```

**FORTRAN:**

```fortran
file_id = hopen(filename, access_mode, num_dds_block)
gr_id = mgstart(file_id)
ri_id = mgselct(gr_id, ri_index);
OR ri_id = mgcreate(gr_id, name, n_comps, number_type, interlace_mode,
                   dim_sizes);
status = mgwimg(ri_id, start, stride, edges, data)
OR status = mgwrcmg(ri_id, start, stride, edges, data)
status = mgendac(ri_id)
status = mgend(gr_id)
status = hclose(file_id)
```

As with SD arrays, whole raster images, subsamples, and slabs can be written. The data to be written is defined by the values of the parameters `start`, `stride`, and `edges`, which correspond to the coordinate location of the data origin, number of values to be skipped along each dimension during write operation, and number of elements to be written along each dimension.

The array `start` specifies the starting location of the data to be written. Valid values of each element in the array `start` are 0 to the size of the corresponding raster image dimension - 1. The first element of the array `start` specifies an offset from the beginning of the array `data` along the fastest-changing dimension, which is the second dimension in C and the first dimension in FORTRAN-77. The second element of the array `start` specifies an offset from the beginning of the
array data along the second fastest-changing dimension, which is the first dimension in C and the second dimension in FORTRAN-77. For example, if the first value of the array start is 2 and the second value is 3, the starting location of the data to be written is at the fourth row and third column in C, and at the third row and fourth column in FORTRAN-77. Note that the correspondence between elements in the array start and the raster image dimensions in the GR interface is different from that in the SD interface. See Section 3.6 on page 55 on SDreaddata for an example of this.

The array stride specifies the writing pattern along each dimension. For example, if one of the elements of the array stride is 1, then every element along the corresponding dimension of the array data will be written. If one of the elements of the stride array is 2, then every other element along the corresponding dimension of the array data will be written, and so on. The correspondence between elements of the array stride and the dimensions of the array data is the same as described above for the array start.

Note that the FORTRAN-77 version of GRwriteimage has two routines; mgwring writes buffered numeric data and mgwcimg writes buffered character data. GRwriteimage returns either SUCCEED (or 0) or FAIL (or –1). The parameters for GRwriteimage are described in Table 8C.

### Table 8C

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ri_id</td>
<td>int32</td>
<td>integer</td>
<td>Raster image identifier returned by GRcreate</td>
</tr>
<tr>
<td>start</td>
<td>int32 [2]</td>
<td>integer (2)</td>
<td>Array containing the x,y-coordinate location where the write will start for each dimension</td>
</tr>
<tr>
<td>stride</td>
<td>int32 [2]</td>
<td>integer (2)</td>
<td>Array containing the number of data locations the current location is to be moved forward before the next write</td>
</tr>
<tr>
<td>edges</td>
<td>int32 [2]</td>
<td>integer (2)</td>
<td>Array containing the number of data elements that will be written along each dimension</td>
</tr>
<tr>
<td>data</td>
<td>VOIDP</td>
<td>&lt;valid numeric data type(<em>)/character(</em>)&gt;</td>
<td>Buffer for the image data to be written</td>
</tr>
</tbody>
</table>

### Creating and Writing a Raster Image

This example illustrates the use of the routines Hopen/hopen, GRstart/mgstart, GRcreate/mgcreat, GRwriteimage/mgwring, GRendaccess/mgendac, GRend/mgend, and Helose/hclose to create an HDF file and store a raster image in it.

In this example, the program creates the HDF file called "General_RImages.hdf" and a raster image in the file. The image created is of size 5x10 and named "Image Array 1", and has data of the int16 data type, 2 components, and interlace mode MFGR_INTERLACE_PIXEL. Then the program writes the image data, terminates access to the image and the GR interface, and closes the file.

```
C:
#include "hdf.h"

#define FILE_NAME "General_RImages.hdf"
#define IMAGE_NAME "Image Array 1"
#define X_LENGTH 10 /* number of columns in the image */
```
#define Y_LENGTH 5    /* number of rows in the image */
#define N_COMPS 2     /* number of components in the image */

main( )
{
    /**************************************** Variable declaration ****************************************/
    intn status;         /* status for functions returning an intn */
    int32 file_id,        /* HDF file identifier */
    gr_id,          /* GR interface identifier */
    ri_id,          /* raster image identifier */
    start[2],       /* start position to write for each dimension */
    edges[2],       /* number of elements to be written along each dimension */
    dim_sizes[2],   /* dimension sizes of the image array */
    interlace_mode, /* interlace mode of the image */
    data_type,      /* data type of the image data */
    i, j;
    int16 image_buf[Y_LENGTH][X_LENGTH][N_COMPS];

    /**************************************** End of variable declaration ****************************************/

    /*
    * Create and open the file.
    */
    file_id = Hopen (FILE_NAME, DFACC_CREATE, 0);

    /*
    * Initialize the GR interface.
    */
    gr_id = GRstart (file_id);

    /*
    * Set the data type, interlace mode, and dimensions of the image.
    */
    data_type = DFNT_INT16;
    interlace_mode = MFGR_INTERLACE_PIXEL;
    dim_sizes[0] = X_LENGTH;
    dim_sizes[1] = Y_LENGTH;

    /*
    * Create the raster image array.
    */
    ri_id = GRcreate (gr_id, IMAGE_NAME, N_COMPS, data_type,
                        interlace_mode, dim_sizes);

    /*
    * Fill the image data buffer with values.
    */
    for (i = 0; i < Y_LENGTH; i++)
    {
        for (j = 0; j < X_LENGTH; j++)
        {
            image_buf[i][j][0] = (i + j) + 1;    /* first component */
            image_buf[i][j][1] = (i + j) + 1;    /* second component */
        }
    }

    /*
    * Define the size of the data to be written, i.e., start from the origin and go as long as
    * the length of each dimension.
    */
    start[0] = start[1] = 0;
edges[0] = X_LENGTH;
edges[1] = Y_LENGTH;

/*
* Write the data in the buffer into the image array.
*/
status = GRwriteimage(ri_id, start, NULL, edges, (VOIDP)image_buf);

/*
* Terminate access to the raster image and to the GR interface and,
* close the HDF file.
*/
status = GRendaccess (ri_id);
status = GRend (gr_id);
status = Hclose (file_id);
}

FORTRAN:

program create_raster_image
implicit none
C
C     Parameter declaration
C
character*19 FILE_NAME
character*13 IMAGE_NAME
integer      X_LENGTH
integer      Y_LENGTH
integer      N_COMPS
C
parameter (FILE_NAME  = 'General_RImages.hdf',
+           IMAGE_NAME = 'Image Array 1',
+           X_LENGTH   = 10,
+           Y_LENGTH   = 5,
+           N_COMPS    = 2)
integer DFACC_CREATE, DFNT_INT16, MFGR_INTERLACE_PIXEL
parameter (DFACC_CREATE = 4,
+           DFNT_INT16   = 22,
+           MFGR_INTERLACE_PIXEL = 0)
C
C     Function declaration
C
integer hopen, hclose
integer mgstart, mgcreat, mgwrimg, mgendac, mgend
C
C**** Variable declaration *******************************************
C
integer status
integer file_id
integer gr_id, ri_id, num_type, interlace_mode
integer start(2), stride(2), edges(2), dimsizes(2)
integer i, j, k
integer*2  image_buf(N_COMPS, X_LENGTH, Y_LENGTH)
C
C**** End of variable declaration ************************************
C
C Create and open the file.
C
file_id = hopen(FILE_NAME, DFACC_CREATE, 0)
C
C Initialize the GR interface.
gr_id = mgstart(file_id)

Set the number type, interlace mode, and dimensions of the image.

num_type = DFNT_INT16
interlace_mode = MFGR_INTERLACE_PIXEL
dimsizes(1) = X_LENGTH
dimsizes(2) = Y_LENGTH

Create the raster image array.

ri_id = mgcreat(gr_id, IMAGE_NAME, N_COMPS, num_type, +
                   interlace_mode, dimsizes)

Fill the image data buffer with values.

do 30 i = 1, Y_LENGTH
   do 20 j = 1, X_LENGTH
      do 10 k = 1, N_COMPS
         image_buf(k,j,i) = (i+j) - 1
      10 continue
   20 continue
30 continue

Define the size of the data to be written, i.e., start from the origin
and go as long as the length of each dimension.

start(1) = 0
start(2) = 0
edges(1) = X_LENGTH
edges(2) = Y_LENGTH
stride(1) = 1
stride(2) = 1

Write the data in the buffer into the image array.

status = mgwrimg(ri_id, start, stride, edges, image_buf)

Terminate access to the raster image and to the GR interface,
and close the HDF file.

status = mgendac(ri_id)
status = mgend(gr_id)
status = hclose(file_id)
end

EXAMPLE 2.

Modifying an Existing Raster Image

This example illustrates the use of the routines GRselect/mgselect to obtain an existing raster image and GRwrite/mgwrimg to modify image data.

In this example, the program selects the only raster image in the file "General_RImages.hdf" created and written in Example 1, and modifies image data. The program also creates another raster image that is named "Image Array 2" and has 3 components with dimension size of 4x6, data type of DFNT_CHAR8, and interlace mode of MFGR_INTERLACE_PIXEL.
C:

#include "hdf.h"
#define FILE_NAME "General_RImages.hdf"
#define X1_LENGTH 5 /* number of columns in the first image being modified */
#define Y1_LENGTH 2 /* number of rows in the first image being modified */
#define N1_COMPS 2 /* number of components in the first image */
#define IMAGE1_NAME "Image Array 1"
#define IMAGE2_NAME "Image Array 2"
#define X2_LENGTH 6 /* number of columns in the second image */
#define Y2_LENGTH 4 /* number of rows in the second image */
#define N2_COMPS 3 /* number of components in the second image */

main( )
{
    /************************* Variable declaration ***************************/
    int status; /* status for functions returning an int */
    int32 file_id, /* HDF file identifier */
    gr_id, /* GR interface identifier */
    ri1_id, /* raster image identifier */
    start1[2], /* start position to write for each dimension */
    edges1[2], /* number of elements to be written along each dimension */
    ri2_id, /* raster image identifier */
    start2[2], /* start position to write for each dimension */
    edges2[2], /* number of elements to be written along each dimension */
    dims_sizes[2], /* sizes of the two dimensions of the image array */
    data_type, /* data type of the image data */
    interlace_mode; /* interlace mode of the image */
    int16 i, j; /* indices for the dimensions */
    int16 image1_buf[Y1_LENGTH][X1_LENGTH][N1_COMPS]; /* data of first image */
    char image2_buf[Y2_LENGTH][X2_LENGTH][N2_COMPS]; /* data of second image */

    /****************************** End of variable declaration *****************************/

    /*
    * Open the HDF file for writing.
    */
    file_id = Hopen (FILE_NAME, DFACC_WRITE, 0);

    /*
    * Initialize the GR interface.
    */
    gr_id = GRstart (file_id);

    /*
    * Select the first raster image in the file.
    */
    ri1_id = GRselect (gr_id, 0);

    /*
    * Fill the first image data buffer with values.
    */
    for (i = 0; i < Y1_LENGTH; i++)
    {
        for (j = 0; j < X1_LENGTH; j++)
        {
            image1_buf[i][j][0] = 0; /* first component */
image1_buf[i][j][1] = 0; /* second component */
}
}

/*
* Define the size of the data to be written, i.e., start from the origin
* and go as long as the length of each dimension.
*/
start1[0] = start1[1] = 0;
edges1[0] = X1_LENGTH;
edges1[1] = Y1_LENGTH;

/*
* Write the data in the buffer into the image array.
*/
status = GRwriteimage (ri1_id, start1, NULL, edges1, (VOIDP)image1_buf);

/*
* Set the interlace mode and dimensions of the second image.
*/
data_type = DFNT_CHAR8;
interlace_mode = MFGR_INTERLACE_PIXEL;
dims_sizes[0] = X2_LENGTH;
dims_sizes[1] = Y2_LENGTH;

/*
* Create the second image in the file.
*/
ri2_id = GRcreate (gr_id, IMAGE2_NAME, N2_COMPS, data_type,
                  interlace_mode, dims_sizes);

/*
* Fill the second image data buffer with values.
*/
for (i = 0; i < Y2_LENGTH; i++)
{
    for (j = 0; j < X2_LENGTH; j++)
    {
        image2_buf[i][j][0] = 'A';     /* first component */
        image2_buf[i][j][1] = 'B';     /* second component */
        image2_buf[i][j][2] = 'C';     /* third component */
    }
}

/*
* Define the size of the data to be written, i.e., start from the origin
* and go as long as the length of each dimension.
*/
for (i = 0; i < 2; i++)
{
    start2[i] = 0;
edges2[i] = dims_sizes[i];
}

/*
* Write the data in the buffer into the second image array.
*/
status = GRwriteimage (ri2_id, start2, NULL, edges2, (VOIDP)image2_buf);

/*
* Terminate access to the raster images and to the GR interface, and
* close the HDF file.
*/
status = GRendaccess (ri1_id);
status = GRendaccess (ri2_id);
status = GEnd (gr_id);
status = Hclose (file_id);
}

FORTRAN:
program modify_image
implicit none
C
C     Parameter declaration
C
character*19 FILE_NAME
character*13 IMAGE1_NAME
integer      X1_LENGTH
integer      Y1_LENGTH
integer      N1_COMPS
character*13 IMAGE2_NAME
integer      X2_LENGTH
integer      Y2_LENGTH
integer      N2_COMPS
C
parameter (FILE_NAME   = 'General_RImages.hdf',
+           IMAGE1_NAME = 'Image Array 1',
+           IMAGE2_NAME = 'Image Array 2',
+           X1_LENGTH   = 5,
+           Y1_LENGTH   = 2,
+           N1_COMPS    = 2,
+           X2_LENGTH   = 6,
+           Y2_LENGTH   = 4,
+           N2_COMPS    = 3)
integer DFACC_WRITE, DFNT_INT16, DFNT_CHAR8,
+        MFGR_INTERLACE_PIXEL
parameter (DFACC_WRITE  = 2,
+           DFNT_CHAR8   = 4,
+           DFNT_INT16   = 22,
+           MFGR_INTERLACE_PIXEL = 0)
C
C     Function declaration
C
integer hopen, hclose
integer mgstart, mgselct, mgcreat, mgwrimg, mgendac, mgend
C
C**** Variable declaration *********************************************************
C
integer status
integer file_id
integer gr_id, ri1_id, ri2_id, data_type, interlace_mode
integer start1(2), stride1(2), edges1(2)
integer start2(2), stride2(2), edges2(2), dim_sizes(2)
integer i, j, k
integer*2 image1_buf(N1_COMPS, X1_LENGTH, Y1_LENGTH)
character image2_buf(N2_COMPS, X2_LENGTH, Y2_LENGTH)
C
C**** End of variable declaration ***************************************************
C
C
Open the HDF file for writing.
C
file_id = hopen(FILE_NAME, DFACC_WRITE, 0)
Initialize the GR interface.

```
gr_id = mgstart(file_id)
```

Select the first raster image in the file.

```
ri1_id = mgselct(gr_id, 0)
```

Fill the buffer with values.

```
do 20 i = 1, Y1_LENGTH
   do 10 j = 1, X1_LENGTH
      image1_buf(1,j,i) = 0
      image1_buf(2,j,i) = 0
   10 continue
20 continue
```

Define the part of the data in the first image that will be overwritten with the new values from image1_buf.

```
start1(1) = 0
start1(2) = 0
edges1(1) = X1_LENGTH
edges1(2) = Y1_LENGTH
stride1(1) = 1
stride1(2) = 1
```

Write the data in the buffer into the image array.

```
status = mgwrimg(ri1_id, start1, stride1, edges1, image1_buf)
```

Set the number type, interlace mode, and dimensions of the second image.

```
data_type = DFNT_CHAR8
interlace_mode = MFGR_INTERLACE_PIXEL
dim_sizes(1) = X2_LENGTH
dim_sizes(2) = Y2_LENGTH
```

Create the second image in the file.

```
ri2_id = mgcreat(gr_id, IMAGE2_NAME, N2_COMPS, data_type,
                 interlace_mode, dim_sizes)
```

Fill the image data buffer with values.

```
do 60 i = 1, Y2_LENGTH
   do 50 j = 1, X2_LENGTH
      do 40 k = 1, N2_COMPS
         image2_buf(k,j,i) = char(65 + k - 1)
   40 continue
50 continue
60 continue
```

Define the size of the data to be written, i.e., start from the origin and go as long as the length of each dimension.

```
start2(1) = 0
start2(2) = 0
edges2(1) = dim_sizes(1)
edges2(2) = dim_sizes(2)
stride2(1) = 1
```
8.6.2 Compressing Raster Images: GRsetcompress

Images can be compressed using the routine GRsetcompress. GRsetcompress compresses the image data at the time it is called and supports all standard HDF compression algorithms. The syntax of the routine GRsetcompress is as follows:

C:
```
status = GRsetcompress(ri_id, comp_type, c_info);
```

FORTRAN:  
```
status = mgscompress(ri_id, comp_type, comp_prm)
```

The compression method is specified by the parameter `comp_type`. Valid values of the parameter `comp_type` are:

- `COMP_CODE_NONE` (or 0) for no compression
- `COMP_CODE_RLE` (or 1) for RLE run-length encoding
- `COMP_CODE_SKPHUFF` (or 3) for Skipping Huffman compression
- `COMP_CODE_DEFLATE` (or 4) for GZIP compression
- `COMP_CODE_JPEG` (or 6) for JPEG compression

The compression parameters are specified by the parameter `c_info` in C and the parameter `comp_prm` in FORTRAN-77. The parameter `c_info` has type `comp_info` and contains algorithm-specific information for the library compression routines. The type `comp_info` is described in the header file “hcomp.h” and in the Reference Manual page for SDsetcompress. Compression parameters are only needed when Skipping Huffman or GZIP compression methods are applied.

The skipping size for the Skipping Huffman algorithm is specified in the field `c_info.skphuff.skp_size` in C and in the parameter `comp_prm(1)` in FORTRAN-77.

The deflate level for the GZIP algorithm is specified in the field `c_info.deflate.level` in C and in the parameter `comp_prm(1)` in FORTRAN-77.

GRsetcompress returns either `SUCCEED` (or 0) or `FAIL` (or -1). The GRsetcompress parameters are further described in Table 8D.
8.6.3 External File Operations Using the GR Interface

An external image array is one that is stored in a file that is not the file containing the metadata for the image. The HDF file containing the metadata is known as the primary HDF file; the file containing the external image array is known as an external file. The concept of externally stored data is described in Chapter 3, Scientific Data Sets (SD API). The GR interface supports the same external file functionality as the SD interface.

8.6.3.1 Creating a Raster Image in an External File: GRsetexternalfile

Creating an image with the data stored in an external file involves the same general steps as with the SD interface:

1. Create the image array.
2. Specify that an external data file is to be used.
3. Write data to the image array.
4. Terminate access to the image.

To create a data set containing image array stored in an external file, the calling program must make the following calls.

C:

```c
ri_id = GRcreate(gr_id, name, n_comps, data_type, interlace_mode, 
dim_sizes);
status = GRsetexternalfile(ri_id, filename, offset);
status = GRwriteimage(ri_id, start, stride, edges, image_data);
status = GRendaccess(ri_id);
```

FORTRAN:

```fortran
ri_id = mgcreate(gr_id, name, n_comps, data_type, interlace_mode, 
dim_sizes)
status = mgsxfile(ri_id, filename, offset)
status = mgwimg(ri_id, start, stride, edges, image_data)
status = mgendac(ri_id)
```

GRsetexternalfile marks the image identified by the parameter ri_id as one whose data is to be written to an external file. The parameter filename is the name of the external file, and the parameter offset specifies the number of bytes from the beginning of the external file to the location where the first byte of data will be written.

GRsetexternalfile can only be called once per data set. If a file with the same name as filename exists in the current directory, HDF will use it as the external file. If the file does not exist, HDF will create one. Once the name of the external file is specified, it is impossible to change it without breaking the association between the raster image and its data.

Use caution when writing to existing files because the routine GRwriteimage begins its write at the specified offset without checking whether existing data is being overwritten. When different
data sets have arrays being stored the same external file, the calling program is responsible for avoiding any overlap between them.

**GRsetexternalfile** returns either **SUCCEED** (or 0) or **FAIL** (or −1). The parameters of **GRsetexternalfile** are further defined in Table 8E.

### TABLE 8E

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GRsetexternalfile</strong></td>
<td>ri_id</td>
<td>int32</td>
<td>Raster image identifier</td>
</tr>
<tr>
<td></td>
<td>filename</td>
<td>char*</td>
<td>Name of the external file</td>
</tr>
<tr>
<td></td>
<td>offset</td>
<td>int32</td>
<td>Offset in bytes from the beginning of the external file to the image data</td>
</tr>
</tbody>
</table>

#### 8.6.3.2 Moving Raster Images to an External File

Images can be moved from the primary HDF file to an external file. To do so requires the following steps:

1. Select the image.
2. Specify the external data file.
3. Terminate access to the image.

The calling program must make the following calls:

**C:**

```c
ri_id = GRselect(gr_id, ri_index);
status = GRsetexternalfile(ri_id, filename, offset);
status = GRendaccess(ri_id);
```

**FORTRAN:**

```fortran
ri_id = mgselct(gr_id, ri_index);
status = mgsxfil(ri_id, filename, offset)
status = mgendac(ri_id);
```

When **GRsetexternalfile** is used in conjunction with **GRselect**, it will immediately write the existing data to the external file; any data in the external file that occupies the space reserved for the external array will be overwritten as a result of this operation. A data set can only be moved to an external file once.

During the operation, the data is written to the external file as a contiguous stream regardless of how it is stored in the primary file. Because data is moved “as is,” any unwritten locations in the data set are preserved in the external file. Subsequent read and write operations performed on the data set will access the external file.

#### 8.7 Reading Raster Images

Image array data can be read as an entire array or as a subsample of the array. Raster image data is read from an external file in the same way that it is read from a primary file; whether the image array is stored in an external file is transparent to the user. This section describes how **GRreadimage** is used to read an entire image and part of an image. The section also describes the routine **GRreqimageil** that sets the interlacing for reading image data.
8.7.1 Reading Data from an Image: GRreadimage

Reading data subsamples from an image array involves the following steps:

1. Select a data set.
2. Read data from the image array.
3. Terminate access to the data set.

To read data from an image array, the calling program must contain the following function calls:

C:
 Rihanna = GRselect(gr_id, ri_index);
status = GRreadimage(ri_id, start, stride, edges, data);
status = GRendaccess(ri_id);

FORTRAN:
 riaa = mgselect(gr_id, ri_index)
status = mgreadimg(ri_id, start, stride, edges, data)
OR
status = mgcimg(ri_id, start, stride, edges, data)
status = mgenendac(gr_id)

GRreadimage can be used to read either an entire image or a subsample of the image. The ri_id argument is the raster image identifier returned by GRselect. As with GRwriteimage, the arguments start, stride, and edges respectively describe the starting location for the read operation, the number of locations the current image array location will be moved forward after each read, and the length of each dimension to be read. Refer to Section 8.6.1 on page 272 for detailed descriptions of the parameters start, stride, and edges. If the image array is smaller than the data argument array, the amount of data read will be limited to the maximum size of the image array.

Note that the FORTRAN-77 version of GRreadimage has two routines; mgdimg reads numeric image data and mgcimg reads character image data.

GRreadimage returns either SUCCEED (or 0) or FAIL (or -1). The parameters for GRreadimage are further defined in (See Table 8F.).

8.7.2 Setting the Interlace Mode for an Image Read: GRreqimageil

The GRreqimageil routine sets the interlace mode for the next image read. The syntax of this routine is as follows:

C:
 status = GRreqimageil(ri_id, interlace_mode);

FORTRAN:
 status = mgimil(ri_id, interlace_mode)

GRreqimageil can be called at any time before the read operation and takes two parameters, ri_id and interlace_mode. The parameter ri_id is the raster image identifier returned by the GRselect routine and the parameter interlace_mode specifies the interlace mode that will be in effect for the image read operation. Refer to Section 8.5.1 on page 270 for a description of the GR interlace modes.

GRreqimageil may be called more than once; the interlace mode setting specified by the last call to the routine will be used for the next read operation.

GRreqimageil returns either SUCCEED (or 0) or FAIL (or -1). The parameters of this routine are further defined in Table 8F.
EXAMPLE 3. Reading a Raster Image.

This example illustrates the use of the routine `GRreadimage/mgrdimg` to read an image and its subsets.

In this example, the program reads the image written by Example 1 and modified by Example 2 in the file "General_RImages.hdf". Recall that this image has two components and has 5 rows and 10 columns. The program first reads the entire image, then reads a subset of the image, 3 rows and 2 columns starting at the 2nd row and the 4th column, and finally reads the image skipping all the even rows and all the odd columns. Reading patterns are applied to all components.

C:

```c
#include "hdf.h"
#define FILE_NAME "General_RImages.hdf"
#define N_COMPS 2
#define X_LENGTH 10 /* number of columns of the entire image */
#define Y_LENGTH 5 /* number of rows of the entire image */
#define PART_COLS 2 /* number of columns read for partial image */
#define PART_ROWS 3 /* number of rows read for partial image */
#define SKIP_COLS 5 /* number of columns read for skipped image */
#define SKIP_ROWS 3 /* number of rows read for skipped image */
#define COLS_PART_START 3 /* starting column to read partial image */
#define ROWS_PART_START 1 /* starting row to read partial image */
#define COLS_SKIP_START 1 /* starting column to read skipped image */
#define ROWS_SKIP_START 0 /* starting row to read skipped image */
#define N_STRIDES 2 /* number of elements to skip on each dim. */

main( )
{
    /**************************************************************************
    Variable declaration **************************************************/

    intn status;    /* status for functions returning an intn */
    int32 index;
    int32 file_id, gr_id, ri_id,
    start[2],    /* start position to write for each dimension */
    edges[2],    /* number of elements to rewritten along each dimension */
    stride[2],    /* number of elements to skip on each dimension */
```
dim_sizes[2]; /* dimension sizes of the image array */
int16 entire_image[Y_LENGTH][X_LENGTH][N_COMPS],
    partial_image[PART_ROWS][PART_COLS][N_COMPS],
    skipped_image[SKIP_ROWS][SKIP_COLS][N_COMPS];
int32 i, j;

/********************** End of variable declaration **********************/

/*
* Open the HDF file for reading.
*/
file_id = Hopen (FILE_NAME, DFACC_READ, 0);

/*
* Initialize the GR interface.
*/
gr_id = GRstart (file_id);

/*
* Select the first raster image in the file.
*/
ri_id = GRselect (gr_id, 0);

/*
* Define the size of the data to be read, i.e., start from the origin
* and go as long as the length of each dimension.
*/
start[0] = start[1] = 0;
edges[0] = X_LENGTH;
edges[1] = Y_LENGTH;

/*
* Read the data from the raster image array.
*/
status = GRreadimage (ri_id, start, NULL, edges, (VOIDP)entire_image);

/*
* Display only the first component of the image since the two components
* have the same data in this example.
*/
printf ("First component of the entire image:\n");
for (i = 0; i < Y_LENGTH; i++)
{
    for (j = 0; j < X_LENGTH; j++)
        printf ("%d ", entire_image[i][j][0]);
    printf ("\n");
}

/*
* Define the size of the data to be read.
*/
start[0] = COLS_PART_START;
start[1] = ROWS_PART_START;
edges[0] = PART_COLS;
edges[1] = PART_ROWS;

/*
* Read a subset of the raster image array.
*/
status = GRreadimage (ri_id, start, NULL, edges, (VOIDP)partial_image);

/*
* Display the first component of the read sample.
*/
printf ("Three rows & two cols at 2nd row and 4th column");
printf (" of the first component:\n");
for (i = 0; i < PART_ROWS; i++)
{
    for (j = 0; j < PART_COLS; j++)
        printf ("%d ", partial_image[i][j][0]);
    printf ("\n");
}

/*
* Define the size and the pattern to read the data.
*/
start[0] = COLS_SKIP_START;
start[1] = ROWS_SKIP_START;
edges[0] = SKIP_COLS;
edges[1] = SKIP_ROWS;
stride[0] = stride[1] = N_STRIDES;

/*
* Read all the odd rows and even columns of the image.
*/
status = GRreadimage (ri_id, start, stride, edges, (VOIDP)skipped_image);

/*
* Display the first component of the read sample.
*/
printf ("All odd rows and even columns of the first component:\n");
for (i = 0; i < SKIP_ROWS; i++)
{
    for (j = 0; j < SKIP_COLS; j++)
        printf ("%d ", skipped_image[i][j][0]);
    printf ("\n");
}

/*
* Terminate access to the raster image and to the GR interface, and
* close the HDF file.
*/
status = GRendaccess (ri_id);
status = GRend (gr_id);
status = Hclose (file_id);
}

FORTRAN:

program read_raster_image
    implicit none

    C Parameter declaration
    C
    character*19 FILE_NAME
    integer X_LENGTH
    integer Y_LENGTH
    integer N_COMPS

    C parameter (FILE_NAME = 'General_RImages.hdf',
       + X_LENGTH = 10,
       + Y_LENGTH = 5,
       + N_COMPS = 2)
    integer PART_COLS, PART_ROWS, SKIP_COLS, SKIP_ROWS
    integer COLS_PART_START, ROWS_PART_START
    integer COLS_SKIP_START, ROWS_SKIP_START

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C
C**** Variable declaration *******************************************
C
integer status
integer file_id
integer gr_id, ri_id
integer start(2), stride(2), edges(2)
integer i, j
integer*2 entire_image(N_COMPS, X_LENGTH, Y_LENGTH)
integer*2 partial_image(N_COMPS, PART_ROWS, PART_COLS)
integer*2 skipped_image(N_COMPS, SKIP_ROWS, SKIP_COLS)
C
C**** End of variable declaration ************************************
C
C Open the HDF file for reading.
C
file_id = hopen(FILE_NAME, DFACC_READ, 0)
C
C Initialize the GR interface.
C
gr_id = mgstart(file_id)
C
C Select the first raster image in the file.
C
ri_id = mgselct(gr_id, 0)
C
C Define the size of the data to be read, i.e., start from the origin
C and go as long as the length of each dimension.
C
start(1) = 0
start(2) = 0
edges(1) = X_LENGTH
edges(2) = Y_LENGTH
stride(1) = 1
stride(2) = 1
C
C Read the data from the raster image array.
C
status = mgrdimg(ri_id, start, stride, edges, entire_image)
C
C Display only the first component of the image since the two components
C have the same data in this example.
C
write(*,*) 'First component of the entire image'
write(*,*)
do 10 i = 1, X_LENGTH
    write(*,1000) (entire_image(1,i,j), j = 1, Y_LENGTH)
10 continue
write(*,*)
C     Define the size of the data to be read.
C     start(1) = ROWS_PART_START
start(2) = COLS_PART_START
edges(1) = PART_ROWS
edges(2) = PART_COLS
stride(1) = 1
stride(2) = 1
C     Read a subset of the raster image array.
C     status = mgrdimg(ri_id, start, stride, edges, partial_image)
C     Display only the first component of the read sample.
write(*,*)
+  'Two rows and three columns at 4th row and 2nd column',
+  ' of the first component'
write(*,*)
do 20 i = 1, PART_ROWS
   write(*,1000) (partial_image(1,i,j), j = 1, PART_COLS)
20    continue
write(*,*)
C     Define the size and the pattern to read the data.
C     start(1) = ROWS_SKIP_START
start(2) = COLS_SKIP_START
edges(1) = SKIP_ROWS
edges(2) = SKIP_COLS
stride(1) = N_STRIDES
stride(2) = N_STRIDES
C     Read all the odd rows and even columns of the image.
C     status = mgrdimg(ri_id, start, stride, edges, skipped_image)
C     Display only the first component of the read sample.
write(*,*)
+  'All even rows and odd columns of the first component'
write(*,*)
do 30 i = 1, SKIP_ROWS
   write(*,1000) (skipped_image(1,i,j), j = 1, SKIP_COLS)
30    continue
write(*,*)
C     Terminate access to the raster image and to the GR interface,
C     and close the HDF file.
status = mgendac(ri_id)
status = mgend(gr_id)
status = hclose(file_id)
1000  format(1x, 5(I4))
end
8.8 **Difference between the SD and GR Interfaces**

There is a difference between the SD and GR interfaces that becomes important in applications or tools that must manipulate both images and two-dimensional SDs.

The SD and GR interfaces differ in the correspondence between the dimension order in parameter arrays such as `start`, `stride`, `edge`, and `dimsizes` and the dimension order in the `data` array. See the **SDreaddata** and **GRreadimage** reference manual pages for discussions of the SD and GR approaches, respectively.

When writing applications or tools to manipulate both images and two-dimensional SDs, this crucial difference between the interfaces must be taken into account. While the underlying data is stored in row-major order in both cases, the API parameters are not expressed in the same way. Consider the example of an SD data set and a GR image that are stored as identically-shaped arrays of X columns by Y rows and accessed via the **SDreaddata** and **GRreadimage** functions, respectively. Both functions take the parameters `start`, `stride`, and `edge`.

- For **SDreaddata**, those parameters are expressed in `(y,x)` or `[row,column]` order. For example, `start[0]` is the starting point in the Y dimension and `start[1]` is the starting point in the X dimension. The same ordering holds true for all SD data set manipulation functions.
- For **GRreadimage**, those parameters are expressed in `(x,y)` or `[column,row]` order. For example, `start[0]` is the starting point in the X dimension and `start[1]` is the starting point in the Y dimension. The same ordering holds true for all GR functions manipulating image data.

8.9 **Obtaining Information about Files and Raster Images**

The routines covered in this section provide methods for obtaining information about all of the images in a file, for identifying images that meet certain criteria, and for obtaining information about specific raster images.

**GRfileinfo** retrieves the number of images and file attributes in a file. **GRgetiminfo** provides information about individual images. To retrieve information about all images in a file, a calling program can use **GRfileinfo** to determine the number of images, followed by repeated calls to **GRgetiminfo** to obtain information about each image.

**GRnametoindex** or **GRreftoindex** can be used to obtain the index of a raster image in a file knowing its name or reference number, respectively. Refer to Section 8.2.1 on page 266 for a description of the raster image index and reference number. **GRidtoref** is used when the reference number of an image is required by another routine and the raster image identifier is available.

These routines are described individually in the following subsections.

8.9.1 **Obtaining Information about the Contents of a File: GRfileinfo**

**GRfileinfo** retrieves the number of raster images and the number of file attributes contained in a file. This information is often useful in index validation, sequential searches, or memory allocation. The syntax of **GRfileinfo** is as follows:

```c
C:     status = GRfileinfo(gr_id, &n_images, &n_file_atts);
```

```fortran
FORTRAN:     status = mgfinfo(gr_id, n_images, n_file_atts)
```

The number of images in the file and the total number of file attributes will be stored in the arguments `n_images` and `n_file_atts`, respectively.
GRfileinfo returns **SUCCEED** (or 0) if successful or **FAIL** (or -1) otherwise. The parameters for GRfileinfo are further described in Table 8G on page 291.

### 8.9.2 Obtaining Information about an Image: GRgetiminfo

It is impossible to allocate the proper amount of memory to buffer the image data when the number of components, dimension sizes, and/or data type of the image are unknown. The routine GRgetiminfo retrieves this required information. To access information about an image, the calling program must contain the following:

```c
status = GRgetiminfo(ri_id, name, &n_comps, &data_type, 
                      &interlace_mode, dim_sizes, &n_attrs);
```

```fortran
status = mggiinf(ri_id, name, n_comps, data_type, interlace_mode, 
                 dim_sizes, n_attrs)
```

GRgetiminfo takes a raster image identifier as input, and returns the name, number of components, data type, interlace mode, dimension size, and number of attributes for the corresponding image in the arguments `name`, `n_comps`, `data_type`, `interlace_mode`, `dim_sizes`, and `n_attrs` respectively. The number of components of an image array element corresponds to the order of a `vdata` field, therefore this implementation of image components in the GR interface is flexible enough to accommodate any representation of pixel data. The calling program determines this representation; the GR interface recognizes only the raw byte configuration of the data. The attribute count will only reflect the number of attributes assigned to the image array; file attributes are not included.

GRgetiminfo returns either **SUCCEED** (or 0) or **FAIL** (or -1). The parameters of this routine are further defined in Table 8G.

### TABLE 8G

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRfileinfo</td>
<td>gr_id</td>
<td>int32</td>
<td>GR interface identifier</td>
</tr>
<tr>
<td></td>
<td>n_images</td>
<td>int32 *</td>
<td>Number of raster images in the file</td>
</tr>
<tr>
<td></td>
<td>n_file_attrs</td>
<td>int32 *</td>
<td>Number of global attributes in the file</td>
</tr>
<tr>
<td>GRgetiminfo</td>
<td>ri_id</td>
<td>int32</td>
<td>Raster image identifier</td>
</tr>
<tr>
<td></td>
<td>name</td>
<td>char *</td>
<td>Name of the raster image</td>
</tr>
<tr>
<td></td>
<td>n_comps</td>
<td>int32 *</td>
<td>Number of pixel components in the pixel</td>
</tr>
<tr>
<td></td>
<td>data_type</td>
<td>int32 *</td>
<td>Pixel data type</td>
</tr>
<tr>
<td></td>
<td>interlace_mode</td>
<td>int32 *</td>
<td>Interlace mode of the data in the raster image</td>
</tr>
<tr>
<td></td>
<td>dim_sizes</td>
<td>int32 [2]</td>
<td>Array containing the size of each dimension in the raster image</td>
</tr>
<tr>
<td></td>
<td>n_attrs</td>
<td>int32 *</td>
<td>Number of raster image attributes</td>
</tr>
</tbody>
</table>

### 8.9.3 Obtaining the Reference Number of a Raster Image from Its Identifier: GRidtoref

GRidtoref returns either the reference number of the raster image identified by the parameter `ri_id`, or **FAIL** (or -1) upon unsuccessful completion. The syntax of GRidtoref is as follows:

```c
ref = GRidtoref(ri_id);
```

```fortran
ref = mgid2rf(ri_id)
```
This routine is further defined in Table 8H on page 293.

8.9.4 Obtaining the Index of a Raster Image from Its Reference Number: GRreftoindex

GRreftoindex returns either the index of the raster image specified by its reference number, ref, or FAIL (or -1) upon unsuccessful completion. The syntax of GRreftoindex is as follows:

C:
ri_index = GRreftoindex(gr_id, ref);

FORTRAN: ri_index = mgr2idx(gr_id, ref)

This routine is further defined in Table 8H.

8.9.5 Obtaining the Index of a Raster Image from Its Name: GRnametoindex

GRnametoindex returns the index of the raster image specified by its name or FAIL (or -1) upon unsuccessful completion. The syntax of GRnametoindex is as follows:

C:
ri_index = GRnametoindex(gr_id, name);

FORTRAN: ri_index = mgr2idx(gr_id, name)

This routine is further defined in Table 8H.

8.9.6 Obtaining Compression Information for a Raster Image: GRgetcompress

GRgetcompress retrieves the type of compression used to store a raster image and, when appropriate, the required compression parameters.

GRgetcompress takes one input parameter, ri_id, a raster image identifier, and two output parameters, comp_type, for the type of compression used when the image was written, and either c_info (a C struct) or comp_prm (a FORTRAN-77 array) for the returned compression parameters.

Valid comp_type values are as follows:

- COMP_CODE_NONE (or 0) for no compression
- COMP_CODE_RLE (or 1) for RLE run-length encoding
- COMP_CODE_SKPHUFF (or 3) for Skipping Huffman compression
- COMP_CODE_DEFLATE (or 4) for GZIP compression
- COMP_CODE_JPEG (or 6) for JPEG compression

The c_info struct is of type comp_info, contains algorithm-specific information for the library compression routines, and is described in the hcomp.h header file.

The comp_prm parameter is an array of one element. With Skipping Huffman compression, comp_prm(1) contains the skip value, skphuff_skp_size. In the case of GZIP compression, comp_prm(1) contains the deflation value, deflate_value. comp_prm is ignored for other compression types.

GRgetcompress returns SUCCESS (or 0) if it is successful or FAIL (or -1) upon unsuccessful completion.
The syntax of `GRgetcompress` is as follows:

```c
status = GRgetcompress(ri_id, comp_type, c_info);
```

```fortran
status = mggcompress(ri_id, comp_type, comp_prm)
```

This routine is further defined in Table 8H.

### Table 8H

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>GRidtoref</code> [uint16]</td>
<td>ri_id</td>
<td>int32</td>
<td>integer Raster image identifier</td>
</tr>
<tr>
<td><code>GRreftoindex</code> [int32]</td>
<td>gr_id</td>
<td>int32</td>
<td>integer GR interface identifier</td>
</tr>
<tr>
<td><code>GRnometoindex</code> [int32]</td>
<td>gr_id</td>
<td>int32</td>
<td>integer GR interface identifier</td>
</tr>
<tr>
<td></td>
<td>ref</td>
<td>uint16</td>
<td>integer Reference number of the raster image</td>
</tr>
<tr>
<td><code>GRgetcompress</code> [intn]</td>
<td>ri_id</td>
<td>int32</td>
<td>integer Raster image identifier</td>
</tr>
<tr>
<td></td>
<td>comp_type</td>
<td>int32</td>
<td>integer Type of compression</td>
</tr>
<tr>
<td></td>
<td>c_info</td>
<td>N/A</td>
<td>Pointer to compression information structure</td>
</tr>
<tr>
<td></td>
<td>comp_prm(1)</td>
<td>N/A</td>
<td>integer Compression parameter in array format</td>
</tr>
</tbody>
</table>

### Obtaining File and Image Information.

This example illustrates the use of the routines `GRfileinfo/mginfo` and `GRgetinfo/mggiinf` to obtain information such as the number of images and attributes in an HDF file and the characteristics of a raster image in the file.

In this example, the program gets the number of images in the file using the routine `GRfileinfo/mginfo`. For each image, the program then obtains and displays its name, number of components, data type, interlace mode, dimension sizes, and number of attributes using the routine `GRgetinfo/mggiinf`.

```c
#include "hdf.h"

#define FILE_NAME "General_RImages.hdf"

main( )
{
    int status; /* status for functions returning an intn */
    int32 file_id, gr_id, ri_id,
    n_rimages, /* number of raster images in the file */
    n_fileattrs, /* number of file attributes */
    ri_index, /* index of an image */
    dim_sizes[2], /* dimensions of an image */
    n_comps, /* number of components an image contains */
    interlace_mode, /* interlace mode of an image */
    data_type, /* number type of an image */
    n_attrs, /* number of attributes belong to an image */
    char name[MAX_GR_NAME], /* name of an image */
    type_string, /* mapped text of a number type */
```
**interlace_string; /* mapped text of an interlace mode */

/**************************** End of variable declaration ****************************/

/*
 * Open the file for reading.
 */
file_id = Hopen (FILE_NAME, DFACC_READ, 0);

/*
 * Initialize the GR interface.
 */
gr_id = GRstart (file_id);

/*
 * Determine the contents of the file.
 */
status = GRfileinfo (gr_id, &n_rimages, &n_file_attrs);

/*
 * For each image in the file, get and display the image information.
 */
printf ("RI# Name Components Type Interlace   
Dimensions Attributes\n\n");
for (ri_index = 0; ri_index < n_rimages; ri_index++)
{
    ri_id = GRselect (gr_id, ri_index);
    status = GRgetiminfo (ri_id, &name, &n_comps, &data_type, 
    &interlace_mode, &dim_sizes, &n_attrs);
    /*
     * Map the number type and interlace mode into text strings for output
     * readability. Note that, in this example, only two possible types
     * are considered because of the simplicity of the example. For real
     * problems, all possible types should be checked and if reading the
     * data is desired, the size of the type must be determined based on the
     * machine where the program resides.
     */
    if (data_type == DFNT_CHAR8)
        type_string = "Char8";
    else if (data_type == DFNT_INT16)
        type_string = "Int16";
    else
        type_string = "Unknown";
    switch (interlace_mode)
    {
    case MFGR_INTERLACE_PIXEL:
        interlace_string = "MFGR_INTERLACE_PIXEL";
        break;
    case MFGR_INTERLACE_LINE:
        interlace_string = "MFGR_INTERLACE_LINE";
        break;
    case MFGR_INTERLACE_COMPONENT:
        interlace_string = "MFGR_INTERLACE_COMPONENT";
        break;
    default:
        interlace_string = "Unknown";
        break;
    } /* switch */
    /*
     * Display the image information for the current raster image.
     */
/* Terminate access to the current raster image. */  
status = GRendaccess (ri_id);
}

/* Terminate access to the GR interface and close the HDF file. */  
status = GRend (gr_id);
status = Hclose (file_id);

FORTRAN:

program image_info
implicit none
C
C     Parameter declaration
C
character*19 FILE_NAME
C
parameter (FILE_NAME = 'General_RImages.hdf')
integer DFACC_READ
parameter (DFACC_READ = 1)
C
C     Function declaration
C
integer hopen, hclose
C
integer mgstart, mgselct, mgfinfo, mggiinf, mgendac, mgend

C**** Variable declaration *******************************************
C
integer status
integer file_id, gr_id, ri_id
integer n_rimages, n_file_attrs, ri_index
integer n_comps, interlace_mode, n_attrs, data_type
integer dim_sizes(2)
character*10 type_string
character*24 interlace_string
character*64 name
C
C**** End of variable declaration ************************************
C
C     Open the HDF file for reading.
C
file_id = hopen(FILE_NAME, DFACC_READ, 0)
C
C     Initialize the GR interface.
C
gr_id = mgstart(file_id)
C
C     Determine the contents of the file.
C
status = mgfinfo(gr_id, n_rimages, n_file_attrs)
C
C     For each image in the file, get and display image information.
do 100 ri_index = 0, n_rimages-1
   ri_id = mgselct(gr_id, ri_index)
   status = mgiinf(ri_id, name, n_comps, data_type,
          +   interlace_mode, dim_sizes, n_attrs)
C
C     Map the number type and interlace mode into text strings for
C     output readability.
C
   if(data_type .eq. 4) then
      type_string = 'DFNT_CHAR8'
   else if(data_type .eq. 22) then
      type_string = 'DFNT_INT16'
   else
      type_string = 'Unknown'
   endif
   if (interlace_mode .eq. 0) then
      interlace_string = 'MFGR_INTERLACE_PIXEL'
   else if(interlace_mode .eq. 1) then
      interlace_string = 'MFGR_INTERLACE_LINE'
   else if(interlace_mode .eq. 2) then
      interlace_string = 'MFGR_INTERLACE_COMPONENT'
   else
      interlace_string = 'Unknown'
   endif
C
C     Display the image information for the current image.
C
   write(*,*) 'Image index: ', ri_index
   write(*,*) 'Image name: ', name
   write(*,*) 'Number of components: ', n_comps
   write(*,*) 'Number type: ', type_string
   write(*,*) 'Interlace mode: ', interlace_string
   write(*,*) 'Dimmesions: ', dim_sizes(1), dim_sizes(2)
   write(*,*) 'Number of image attributes: ', n_attrs
   write(*,*)
C
C     Terminate access to the current raster image.
C
   status = mgendac(ri_id)
100   continue
C
C     Terminate access to the GR interface and close the HDF file.
status = mgend(gr_id)
status = hclose(file_id)
end
8.10 GR Data Set Attributes

The GR interface provides tools that attach attributes to particular images. This capability is similar to, though more limited than, attribute function capabilities of the SD interface. The concepts of user-defined and predefined attributes are explained in Chapter 3, Scientific Data Sets (SD API). The GR implementation of attributes is similar to the SD implementation. Attributes are not written out to a file until access to the object the attribute is attached to is terminated.

8.10.1 Predefined GR Attributes

The GR API library has only one predefined attribute: FILL_ATTR. This attribute defines a fill pixel, which is analogous to a fill value in the SD interface. It represents the default value that is written to each element of an image array not explicitly written to by the calling program, i.e., when only a portion of the entire image array is filled with data. This value must of the same data type as the rest of the initialized image data. The routine used to set the fill value, GRsetattr, is explained in the next section.

8.10.2 Setting User-defined Attributes: GRsetattr

GRsetattr creates or modifies an attribute for either a file or a raster image. If the attribute with the specified name does not exist, GRsetattr creates a new one. If the named attribute already exists, GRsetattr resets all the values that are different from those provided in its argument list. The syntax of GRsetattr is as follows:

C:
status = GRsetattr(obj_id, attr_name, data_type, n_values, attr_value);

FORTRAN:
status = mgsnatt(obj_id, attr_name, data_type, n_values, attr_value)
OR
status = mgscatt(obj_id, attr_name, data_type, n_values, attr_value)

The first argument, obj_id, can either be the GR interface identifier or raster image identifier. The argument attr_name contains the name of the attribute and can be no more than MAX_GR_NAME (or 256) characters in length. Passing the name of an existing attribute will overwrite the value portion of that attribute.

The arguments data_type, n_values, and attr_value describe the right side of the label=value equation. The attr_value argument contains one or more values of the same data type. The data_type argument describes the data type for all values in the attribute and n_values contains the total number of values in the attribute.

Note that the FORTRAN-77 version of GRsetattr has two routines; mgsnatt writes numeric attribute data and mgscatt writes character attribute data.

GRsetattr returns either SUCCEED (or 0) or FAIL (or -1). The parameters for GRsetattr are further described in Table 8I on page 302.

EXAMPLE 5.

Operations on File and Raster Image Attributes.

This example illustrates the use of the routines GRsetattr/mgsnatt/mgscatt to assign attributes to an HDF file and to an image.

In this example, the program sets two attributes to the existing file "General_RImages.hdf" and two attributes to the image named "Image Array 2". The file is created by the program in Example 1 and the image is created by the program in Example 2. The values of the second attribute of the image are of type int16 and the values of the other three attributes are of type char8.
C:

#include "hdf.h"

#define FILE_NAME        "General_RImages.hdf"
#define IMAGE_NAME       "Image Array 2"
#define F_ATT1_NAME      "File Attribute 1"
#define F_ATT2_NAME      "File Attribute 2"
#define R1_ATT1_NAME     "Image Attribute 1"
#define R1_ATT2_NAME     "Image Attribute 2"
#define F_ATT1_VAL       "Contents of First FILE Attribute"
#define F_ATT2_VAL       "Contents of Second FILE Attribute"
#define F_ATT1_N_VALUES  32
#define F_ATT2_N_VALUES  33
#define R1_ATT1_VAL      "Contents of IMAGE’s First Attribute"
#define R1_ATT1_N_VALUES 35
#define R1_ATT2_N_VALUES  6

main( )
{
    /************************* Variable declaration **************************/
    intn status;         /* status for functions returning an intn */
    int32 gr_id, ri_id, file_id,
    ri_index;
    int16 ri_attr_2[R1_ATT2_N_VALUES] = {1, 2, 3, 4, 5, 6};
    /************************ End of variable declaration **************************/
    /*
    * Open the HDF file.
    */
    file_id = Hopen (FILE_NAME, DFACC_WRITE, 0);
    /*
    * Initialize the GR interface.
    */
    gr_id = GRstart (file_id);
    /*
    * Set two file attributes to the file with names, data types, numbers of
    * values, and values of the attributes specified.
    */
    status = GRsetattr (gr_id, F_ATT1_NAME, DFNT_CHAR8, F_ATT1_N_VALUES,
    (VOIDP)F_ATT1_VAL);
    status = GRsetattr (gr_id, F_ATT2_NAME, DFNT_CHAR8, F_ATT2_N_VALUES,
    (VOIDP)F_ATT2_VAL);
    /*
    * Obtain the index of the image named IMAGE_NAME.
    */
    ri_index = GRnametoindex (gr_id, IMAGE_NAME);
    /*
    * Obtain the identifier of this image.
    */
    ri_id = GRselect (gr_id, ri_index);
    /*
    * Set two attributes to the image with names, data types, numbers of
    * values, and values of the attributes specified.
    */
status = GRsetattr (ri_id, RI_ATT1_NAME, DFNT_CHAR8, RI_ATT1_N_VALUES, (VOIDP)RI_ATT1_VAL);

status = GRsetattr (ri_id, RI_ATT2_NAME, DFNT_INT16, RI_ATT2_N_VALUES, (VOIDP)ri_attr_2);

/*
 * Terminate access to the image and to the GR interface, and close the
 * HDF file.
 */
status = GRendaccess (ri_id);
status = GRend (gr_id);
status = Hclose (file_id);
}

FORTRAN:

program set_attribute
implicit none

C
C     Parameter declaration
C
character*19 FILE_NAME
character*13 IMAGE_NAME
character*16 F_ATT1_NAME
character*16 F_ATT2_NAME
character*17 RI_ATT1_NAME
character*17 RI_ATT2_NAME
character*32 F_ATT1_VAL
character*33 F_ATT2_VAL
integer      F_ATT1_N_VALUES
integer      F_ATT2_N_VALUES
character*35 RI_ATT1_VAL
integer      RI_ATT1_N_VALUES
integer      RI_ATT2_N_VALUES

C
C     Function declaration
C
ingeger hopen, hclose

C**** Variable declaration *************************************************
integer status
integer file_id, gr_id, ri_id, ri_index
integer*2 ri_attr_2(RI_ATT2_N_VALUES)
integer i

   do 10 i = 1, RI_ATT2_N_VALUES
      ri_attr_2(i) = i
   10 continue

C**** End of variable declaration *******************************
C
C  Open the HDF file.
C
   file_id = hopen(FILE_NAME, DFACC_WRITE, 0)
C
C  Initialize the GR interface.
C
   gr_id = mgstart(file_id)
C
C  Set two file attributes to the file with names, data type, numbers of
C  values, and values of attributes specified.
C
   status = mgscatt(gr_id, F_ATT1_NAME, DFNT_CHAR8,
                      F_ATT1_N_VALUES, F_ATT1_VAL)
   status = mgscatt(gr_id, F_ATT2_NAME, DFNT_CHAR8,
                      F_ATT2_N_VALUES, F_ATT2_VAL)
C
C  Obtain the index of the image named IMAGE_NAME.
C
   ri_index = mgn2ndx(gr_id, IMAGE_NAME)
C
C  Obtain the identifier of this image.
C
   ri_id = mgselct(gr_id, ri_index)
C
C  Set two attributes of the image with names, data types, number of
C  values, and values of the attributes specified.
C
   status = mgscatt(ri_id, RI_ATT1_NAME, DFNT_CHAR8,
                      RI_ATT1_N_VALUES, RI_ATT1_VAL)
   status = mgsnatt(ri_id, RI_ATT2_NAME, DFNT_INT16,
                      RI_ATT2_N_VALUES, ri_attr_2)
C
C  Terminate access to the image and to the GR interface,
C  and close the HDF file.
C
   status = mgendac(ri_id)
   status = mgend(gr_id)
   status = hclose(file_id)
end
8.10.3 Querying User-Defined Attributes: GRfindattr and GRattrinfo

Each attribute associated with an object has a unique attribute index, a value ranging from 0 to the total number of attributes attached to the object - 1. Given a GR interface or raster image identifier and an attribute name, GRfindattr will return a valid attribute index of the file or raster image attribute if the attribute exists. The attribute index can then be used to retrieve information about the attribute or its values. Given a GR interface or raster image identifier and a valid attribute index, GRattrinfo returns the name, data type, and number of values for the file or raster image attribute if the attribute exists.

The syntax for GRfindattr and GRattrinfo is as follows:

C:
attr_index = GRfindattr(obj_id, attr_name);
status = GRattrinfo(obj_id, attr_index, attr_name, &data_type,
                   &n_values);

FORTRAN:
attr_index = mgfndat(obj_id, attr_name)
status = mgatinf(obj_id, attr_index, attr_name, data_type, n_values)

The parameter obj_id is either a GR interface identifier or a raster image identifier. The parameter attr_name specifies the name of the attribute. The parameter attr_index specifies the index of the attribute to be read. The attribute index is a zero-based integer and must be less than the total number of attributes assigned to the specified object. The parameter data_type specifies the data type of the attribute. And the parameter n_values specifies the number of attribute values.

GRfindattr returns the attribute index if successful and FAIL (or -1) otherwise. GRattrinfo returns SUCCEED (or 0) if successful and FAIL (or -1) otherwise. The parameters for GRfindattr and GRattrinfo are further described in Table 8I.

8.10.4 Reading User-defined Attributes: GRgetattr

GRgetattr reads the values of an attribute assigned to the object identified by the parameter obj_id. The syntax for GRgetattr is as follows:

C:
status = GRgetattr(obj_id, attr_index, values);

FORTRAN:
status = mggnatt(obj_id, attr_index, values)
OR
status = mggcatt(obj_id, attr_index, values)

The parameter obj_id is either a GR interface identifier or a raster image identifier. The parameter attr_index specifies the index of the attribute to be read. The attribute index is a zero-based integer and must be less than the total number of attributes assigned to the specified object.

It is assumed that the buffer values, allocated to hold the attribute values, is large enough to hold the data; if not, the data read will be truncated to the size of the buffer. The size of the buffer should be at least n_values*sizeof(data_type) bytes long. If an attribute contains multiple values, GRgetattr will return all of them. It is not possible to read a subset of values.

Note that the FORTRAN-77 version of GRgetattr has two routines; mggnatt reads numeric attribute data and mggcatt reads character attribute data.

GRgetattr returns SUCCEED (or 0) if successful and FAIL (or -1) otherwise. The parameters for GRgetattr are further described in Table 8I.
TABLE 8I

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GRsetattr</strong> [int] (mgsnatt/mgsccatt)</td>
<td>obj_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>attr_name</td>
<td>char *</td>
<td>character(*)</td>
<td>Name assigned to the attribute</td>
</tr>
<tr>
<td>data_type</td>
<td>int32</td>
<td>integer</td>
<td>Data type of the attribute</td>
</tr>
<tr>
<td>n_values</td>
<td>int32</td>
<td>integer</td>
<td>Number of values in the attribute</td>
</tr>
<tr>
<td>values</td>
<td>VOIDP</td>
<td>&lt;valid numeric data type(<em>)/character(</em>)</td>
<td>Buffer with the attribute values</td>
</tr>
<tr>
<td><strong>GRfindattr</strong> [int32] (mgfndat)</td>
<td>obj_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>attr_name</td>
<td>char *</td>
<td>character(*)</td>
<td>Name of the attribute</td>
</tr>
<tr>
<td><strong>GRattrinfo</strong> [int] (mgatinf)</td>
<td>obj_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>attr_index</td>
<td>int32</td>
<td>integer</td>
<td>Index for the attribute to be read</td>
</tr>
<tr>
<td>attr_name</td>
<td>char *</td>
<td>character(*)</td>
<td>Name of the attribute</td>
</tr>
<tr>
<td>data_type</td>
<td>int32</td>
<td>integer</td>
<td>Data type of the attribute values</td>
</tr>
<tr>
<td>n_values</td>
<td>int32</td>
<td>integer</td>
<td>Total number of values in the attribute</td>
</tr>
<tr>
<td><strong>GRgetattr</strong> [int] (mggnatt/mggcatt)</td>
<td>obj_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>attr_index</td>
<td>int32</td>
<td>integer</td>
<td>Index for the attribute to be read</td>
</tr>
<tr>
<td>values</td>
<td>VOIDP</td>
<td>&lt;valid numeric data type(<em>)/character(</em>)</td>
<td>Buffer for the attribute values</td>
</tr>
</tbody>
</table>

EXAMPLE 6.

Obtaining File and Image Attribute.

This example illustrates the use of the routines **GRattrinfo/mgatinf**, **GRfindattr/mgfndat**, and **GRgetattr/mggnatt/mggcatt** to extract information and values of file and image attributes that were set by the program in Example 5.

In this example, the program gets the information about each file attribute, then extracts its values. The program then selects the second image in the file, finds the attribute named "Image Attribute 2", obtains the data type and the number of values in the attribute, and extracts its stored values.

C:

```c
#include "hdf.h"

#define FILE_NAME "General_RImages.hdf"
#define RI_ATTR_NAME "Image Attribute 2"

intn status;  /* status for functions returning an intn */
int32 gr_id, ri_id, file_id,
    f_att_index, /* index of file attributes */
    ri_att_index, /* index of raster image attributes */
    data_type, /* image data type */
    n_values, /* number of values in an attribute */
    value_index, /* index of values in an attribute */
    n_rimages, /* number of raster images in the file */
    n_file_attrs; /* number of file attributes */
char  attr_name[MAX_GR_NAME]; /* buffer to hold the attribute name */
VOIDP data_buf; /* buffer to hold the attribute values */
int16 *int_ptr; /* int16 pointer to point to a void data buffer */
char8 *char_ptr; /* char8 pointer to point to a void data buffer */
```
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/******************** End of variable declaration **********************/

/*
 * Open the HDF file.
 */
file_id = Hopen (FILE_NAME, DFACC_READ, 0);

/*
 * Initialize the GR interface.
 */
gr_id = GRstart (file_id);

/*
 * Determine the number of attributes in the file.
 */
status = GRfileinfo (gr_id, &n_rimages, &n_file_attrs);

if (status != FAIL && n_file_attrs > 0)
{
    for (f_att_index = 0; f_att_index < n_file_attrs; f_att_index++)
    {
        /*
         * Get information about the current file attribute.
         */
        status = GRattrinfo (gr_id, f_att_index, attr_name, &data_type,
                             &n_values);

        /*
         * Allocate a buffer to hold the file attribute data. In this example,
         * knowledge about the data type is assumed to be available from
         * the previous example for simplicity. In reality, the size
         * of the type must be determined based on the machine where the
         * program resides.
         */
        if (data_type == DFNT_CHAR8)
        {
            data_buf = malloc (n_values * sizeof (char8));
            if (data_buf == NULL)
            {
                printf ("Unable to allocate space for attribute data.\n");
                exit (1);
            }
        }
        else
        {
            printf ("Unable to determine data type to allocate data buffer.\n");
            exit (1);
        }

        /*
         * Read and display the attribute values.
         */
        status = GRgetattr (gr_id, f_att_index, (VOIDP)data_buf);
        char_ptr = (char8 *) data_buf;
        printf ("Attribute %s: ", attr_name);
        for (value_index = 0; value_index < n_values; value_index++)
            printf ("%c", char_ptr[value_index]);
        printf ("\n");

        /*
         * Free the space allocated for the data buffer.
         */
free (data_buf);
} /* for */
} /* if */

/*
 * Select the second image in the file.
 */
ri_id = GRselect (gr_id, 1);

/*
 * Find the image attribute named RI_ATTR_NAME.
 */
ri_att_index = GRfindattr (ri_id, RI_ATTR_NAME);

/*
 * Get information about the attribute.
 */
status = GRattrinfo (ri_id, ri_att_index, attr_name, &data_type, &n_values);

/*
 * Allocate a buffer to hold the file attribute data. As mentioned above,
 * knowledge about the data type is assumed to be available from
 * the previous example for simplicity. In reality, the size of the
 * type must be determined based on the machine where the program resides.
 */
if (data_type == DFNT_INT16)
data_buf = malloc (n_values * sizeof (int16));

/*
 * Read and display the attribute values.
 */
status = GRgetattr (ri_id, ri_att_index, (VOIDP)data_buf);
printf ("\nAttribute %s: ", RI_ATTR_NAME);
int_ptr = (int16 *)data_buf;
for (value_index = 0; value_index < n_values; value_index++)
    printf ("%d ", int_ptr[value_index]);
printf ("\n");

/*
 * Free the space allocated for the data buffer.
 */
free (data_buf);

/*
 * Terminate access to the raster image and to the GR interface, and
 * close the file.
 */
status = GRendaccess (ri_id);
status = GRend (gr_id);
status = Hclose (file_id);
}

FORTRAN:

program get_attribute
implicit none

C Parameter declaration
C
C character*19 FILE_NAME
C character*17 RI_ATTR_NAME
C
C parameter (FILE_NAME = 'General_RImages.hdf',
C
+ RI_ATTR_NAME = 'Image Attribute 2')
integer DFACC_READ, DFNT_INT16, DFNT_CHAR8
parameter (DFACC_READ = 1,
+ DFNT_CHAR8 = 4,
+ DFNT_INT16 = 22)

C
C Function declaration
C
integer hopen, hclose
integer mgstart, mgfinfo, mgatinf, mggcatt, mggnatt, mgfndat,
+ mgselct, mgendac, mgend

C**** Variable declaration *******************************************
C
integer      status
integer      file_id, gr_id, ri_id
integer      f_att_index, ri_att_index, data_type, n_values
integer      n_rimages, n_file_attrs
integer*2    int_buf(10)
character*17 attr_name
character*80 char_buf
integer      i

C**** End of variable declaration ************************************
C
C Open the HDF file.
C
file_id = hopen(FILE_NAME, DFACC_READ, 0)
C
C Initialize the GR interface.
C
gr_id = mgstart(file_id)
C
C Determine the number of attributes in the file.
C
status = mgfinfo(gr_id, n_rimages, n_file_attrs)
if ((status .NE. -1) .AND. (n_file_attrs .GT. 0)) then
    do 10 f_att_index = 0, n_file_attrs-1

    C Get information about the current file attribute.
    C
    status = mgatinf(gr_id, f_att_index, attr_name, data_type,
+ n_values)

    C Check whether data type is DFNT_CHAR8 in order to use allocated buffer.
    C
    if(data_type .NE. DFNT_CHAR8) then
        write(*,*), 'Unable to determine data type to use allocated buffer'
    else

        C Read and display the attribute values.
        C
        status = mggcatt(gr_id, f_att_index, char_buf)
        write(*,*), 'Attribute ', attr_name, ':',
+ char_buf(1:n_values)
    endif
10 continue
endif
8.11 Reading and Writing Palette Data Using the GR Interface

The GR API library includes routines that read, write, and access information about palette data attached to GR images. Although this functionality is also provided by the HDF Palette API library, it is not a recommended practice to use the Palette API to access and manipulate palette objects created by GR interface routines.

The routines are named `GRgetlutid`, `GRluttoref`, `GRgetlutinfo`, `GRwritelut`, `GRreqlutil`, and `GRreadlut`. Note that the routine names use the term LUT to refer to palettes; LUT stands for color lookup tables.

### 8.11.1 Obtaining a Palette ID: GRgetlutid

Given a palette index, the routine `GRgetlutid` is used to get the palette identifier for the specified palette.

The `GRgetlutid` function takes two arguments, `ri_id`, the raster image identifier of the image that has the palette attached to it, and `lut_index`, the index of the palette, and returns the value of the palette identifier corresponding to the specified image. The syntax of `GRgetlutid` is as follows:

```c
C:    pal_id = GRgetlutid(ri_id, lut_index);
```

```fortran
FORTRAN:    pal_id = mggltid(ri_id, lut_index)
```

`GRgetlutid` returns the value of the palette identifier if successful and `FAIL` (or `-1`) otherwise. The `GRgetlutid` parameters are further discussed in Table 8J.
8.11.2 Obtaining the Number of Palettes Associated with an Image: GRgetnluts

Given an image identifier, GRgetnluts is used to determine the number of palettes currently associated with an image.

The GRgetnluts function takes one argument, ri_id, a raster image identifier, and returns the number of palettes associated with that image. The syntax of GRgetnluts is as follows:

C: \[ n\_luts = \text{GRgetnluts}(\text{ri}\_id); \]

FORTRAN: \[ n\_luts = \text{mggnluts}(\text{ri}\_id) \]

GRgetnluts returns the number of palettes associated with the identified image if successful and FAIL (or -1) otherwise. The GRgetnluts parameters are further discussed in Table 8J.

8.11.3 Obtaining the Reference Number of a Specified Palette: GRluttoref

Given a palette identifier, GRluttoref can be used to obtain the reference number of the specified palette.

The GRluttoref routine takes one argument, pal_id, a palette identifier, and returns the reference number of the palette. GRluttoref is commonly used to annotate the palette or to include the palette within a vgroup. The syntax of GRluttoref is as follows:

C: \[ \text{pal}\_ref = \text{GRluttoref}(\text{pal}\_id); \]

FORTRAN: \[ \text{pal}\_ref = \text{mglt2rf}(\text{pal}\_id) \]

GRluttoref returns the reference number of the palette if successful and 0 otherwise. The GRluttoref parameters are further discussed in Table 8J.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRgetnluts</td>
<td>ri_id int32</td>
<td>Raster image identifier</td>
</tr>
<tr>
<td></td>
<td>lut_index int32</td>
<td>Palette index</td>
</tr>
<tr>
<td>GRluttoref</td>
<td>pal_id int32</td>
<td>Palette identifier</td>
</tr>
<tr>
<td></td>
<td>ri_id int32</td>
<td>Raster image identifier</td>
</tr>
</tbody>
</table>

8.11.4 Obtaining Palette Information: GRgetlutinfo

Given a palette identifier, GRgetlutinfo retrieves information about the palette and its components.

The GRgetlutinfo function takes one input argument, pal_id, the identifier of the palette, and several return parameters. The return parameters are n_comps, the number of components of the palette; data_type, the data type of the palette data; interlace_mode, the interlace mode of the stored palette data; and num_entries, the number of entries in the palette. The syntax of GRgetlutinfo is as follows:
C: \[ \text{status} = \text{GRgetlutinfo}(	ext{pal_id, &n_comps, &data_type, &interlace_mode,}
\text{ &num_entries}); \]

FORTRAN: \[ \text{status} = \text{mgglinf(pal_id, n_comps, data_type, interlace_mode,}
\text{ num_entries)} \]

\text{GRgetlutinfo} returns \texttt{SUCCEED} (or 0) if successful and \texttt{FAIL} (or -1) otherwise. The \texttt{GRgetlutinfo} parameters are further discussed in Table 8J.

### 8.11.5 Writing Palette Data: \texttt{GRwritelut}

\texttt{GRwritelut} writes palette data into the palette identified by the parameter \texttt{pal_id}. The syntax of \texttt{GRwritelut} is as follows:

C: \[ \text{status} = \text{GRwritelut}(	ext{pal_id, n_comps, data_type, interlace_mode,}
\text{ num_entries, pal_data}); \]

FORTRAN: \[ \text{status} = \text{mgwrlut(pal_id, n_comps, data_type, interlace_mode,}
\text{ num_entries, pal_data)} \]

OR \[ \text{status} = \text{mgwclut(pal_id, n_comps, data_type, interlace_mode,}
\text{ num_entries, pal_data)} \]

The parameter \texttt{n_comps} specifies the number of pixel components in the palette; it must have a value of at least 1. The parameter \texttt{data_type} specifies the data type of the palette data. Refer to Table 2F on page 14 for all data types supported by HDF.

The parameter \texttt{interlace_mode} specifies the interlacing in which the palette is to be written. The valid values of \texttt{interlace_mode} are: \texttt{MFGR_INTERLACE_PIXEL} (or 0), \texttt{MFGR_INTERLACE_LINE} (or 1) and \texttt{MFGR_INTERLACE_COMPONENT} (or 2). Refer to Section 8.5.1 on page 270 for further information.

The parameter \texttt{num_entries} specifies the number of entries in the palette. The buffer \texttt{pal_data} contains the palette data.

Note that the FORTRAN-77 version of \texttt{GRwritelut} has two routines; \texttt{mgwrlut} writes buffered numeric palette data and \texttt{mgwclut} writes buffered character palette data.

\texttt{GRwritelut} returns either \texttt{SUCCEED} (or 0) or \texttt{FAIL} (or -1). The parameters of this routine are further defined in Table 8K on page 309.

### 8.11.6 Setting the Interlace Mode for a Palette: \texttt{GRreqlutil}

\texttt{GRreqlutil} sets the interlace mode for the next palette to be read. The syntax of \texttt{GRreqlutil} is as follows:

C: \[ \text{status} = \text{GRreqlutil(pal_id, interlace_mode)}; \]

FORTRAN: \[ \text{status} = \text{mgrlutil(pal_id, interlace_mode)} \]

The parameter \texttt{interlace_mode} specifies the interlacing that will be in effect for the next palette read operation. The valid values of \texttt{interlace_mode} are: \texttt{MFGR_INTERLACE_PIXEL} (or 0), \texttt{MFGR_INTERLACE_LINE} (or 1) and \texttt{MFGR_INTERLACE_COMPONENT} (or 2). Refer to Section 8.5.1 on page 270 for further information.

\texttt{GRreqlutil} may be called at anytime before the read operation of the specified palette. In addition, it may be called more than once; the interlace mode setting specified by the last call to the routine will be used for the next read operation.
GRreqlutil returns either SUCCEED (or 0) or FAIL (or -1). The parameters of this routine are further defined in Table 8K on page 309.

8.11.7 Reading Palette Data: GRreadlut

GRreadlut reads data from the palette identified by the parameter pal_id. The syntax of GRreadlut is as follows:

C:    status = GRreadlut(pal_id, pal_data);
FORTRAN: status = mgrdlut(pal_id, pal_data)
      OR status = mgrclut(pal_id, pal_data)

The read data will be stored in the buffer pal_data, which is assumed to be sufficient to store the read palette data. The sufficient amount of space needed can be determined using the routine GRgetlutinfo. The palette data is read according to the interlacing mode set by the last call to GRreqlutil.

Note that the FORTRAN-77 version of GRreadlut has two routines; mgrdlut reads numeric palette data and mgrclut reads character palette data.

GRreadlut returns either SUCCEED (or 0) or FAIL (or -1). The parameters of this routine are further defined in Table 8K.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRgetlutinfo</td>
<td>pal_id</td>
<td>int32</td>
<td>integer palette identifier</td>
</tr>
<tr>
<td>(mgglinf)</td>
<td>n_comps</td>
<td>int32*</td>
<td>integer number of components in each palette element</td>
</tr>
<tr>
<td></td>
<td>data_type</td>
<td>int32*</td>
<td>integer Data type of the palette data</td>
</tr>
<tr>
<td></td>
<td>interlace_mode</td>
<td>int32*</td>
<td>integer Interlace mode of the palette data</td>
</tr>
<tr>
<td></td>
<td>num_entries</td>
<td>int32*</td>
<td>integer Buffer for the size of the palette</td>
</tr>
<tr>
<td>GRwritelut</td>
<td>pal_id</td>
<td>int32</td>
<td>integer palette identifier</td>
</tr>
<tr>
<td>(mgwrlut/mgwclut)</td>
<td>n_comps</td>
<td>int32</td>
<td>integer number of components in each palette element</td>
</tr>
<tr>
<td></td>
<td>data_type</td>
<td>int32</td>
<td>integer Type of the palette data</td>
</tr>
<tr>
<td></td>
<td>interlace_mode</td>
<td>int32</td>
<td>integer Interlace mode of the palette data</td>
</tr>
<tr>
<td></td>
<td>num_entries</td>
<td>int32</td>
<td>integer Number of entries in the palette</td>
</tr>
<tr>
<td></td>
<td>pal_data</td>
<td>VOIDP</td>
<td>&lt;valid numeric data type&gt;<em>/character</em> Buffer for the palette data to be written</td>
</tr>
<tr>
<td>GRreqlutil</td>
<td>pal_id</td>
<td>int32</td>
<td>integer palette identifier</td>
</tr>
<tr>
<td>(mgrltil)</td>
<td>interface_mode</td>
<td>intn</td>
<td>integer Interlace mode for the next palette read operation</td>
</tr>
<tr>
<td>GRreadlut</td>
<td>pal_id</td>
<td>int32</td>
<td>integer palette identifier</td>
</tr>
<tr>
<td>(mgrdlut/mgrclut)</td>
<td>pal_data</td>
<td>VOIDP</td>
<td>&lt;valid numeric data type&gt;<em>/character</em> Buffer for the palette data to be read</td>
</tr>
</tbody>
</table>
EXAMPLE 7. Writing a Palette.

This example illustrates the use of the routines `GRgetlutid/mgglutid` and `GRwritelut/mgwclut` to attach a palette to a raster image and write data to it.

In this example, the program creates an image named "Image with Palette" in the file "Image_with_Palette.hdf". A palette is then attached to the image and data is written to it.

C:

```c
#include "hdf.h"

#define FILE_NAME "Image_with_Palette.hdf"
#define NEW_IMAGE_NAME "Image with Palette"
#define N_COMPS_IMG 2 /* number of image components */
#define X_LENGTH 5
#define Y_LENGTH 5
#define N_ENTRIES 256 /* number of entries in the palette */
#define N_COMPS_PAL 3 /* number of palette’s components */

main( )
{
    intn status, /* status for functions returning an intn */
    i, j;

    int32 file_id, gr_id, ri_id, pal_id,
        interlace_mode,
        start[2], /* holds where to start to write for each dimension */
        edges[2], /* holds how long to write for each dimension */
        dim_sizes[2]; /* sizes of the two dimensions of the image */

    uint8 image_buf[Y_LENGTH][X_LENGTH][N_COMPS_IMG]; /* data of first image */
    uint8 palette_buf[N_ENTRIES][N_COMPS_PAL];

    /************************* Variable declaration ***************************/

    /* Open the HDF file. */
    file_id = Hopen (FILE_NAME, DFACC_CREATE, 0);

    /* Initialize the GR interface. */
    gr_id = GRstart (file_id);

    /* Define the dimensions and interlace mode of the image. */
    dim_sizes[0] = X_LENGTH;
    dim_sizes[1] = Y_LENGTH;
    interlace_mode = MFGR_INTERLACE_PIXEL;

    /* Create the image named NEW_IMAGE_NAME. */
    ri_id = GRcreate (gr_id, NEW_IMAGE_NAME, N_COMPS_IMG, DFNT_UINT8,
                     interlace_mode, dim_sizes);

    /* Fill the image data buffer with values. */
    for (i = 0; i < Y_LENGTH; i++)
```
for (j = 0; j < X_LENGTH; j++)
{
    image_buf[i][j][0] = (i + j) + 1;
    image_buf[i][j][1] = (i + j) + 2;
}

/*
 * Define the size of the data to be written, i.e., start from the origin
 * and go as long as the length of each dimension.
 */
start[0] = start[1] = 0;
edges[0] = X_LENGTH;
edges[1] = Y_LENGTH;

/*
 * Write the data in the buffer into the image array.
 */
status = GRwriteimage (ri_id, start, NULL, edges, (VOIDP)image_buf);

/*
 * Initialize the palette to grayscale.
 */
for (i = 0; i < N_ENTRIES; i++) {
    palette_buf[i][0] = i;
    palette_buf[i][1] = i;
    palette_buf[i][2] = i;
}

/*
 * Define palette interlace mode.
 */
interlace_mode = MFGR_INTERLACE_PIXEL;

/*
 * Get the identifier of the palette attached to the image NEW_IMAGE_NAME.
 */
pal_id = GRgetlutid (ri_id, 0);

/*
 * Write data to the palette.
 */
status = GRwritelut (pal_id, N_COMPS_PAL, DFNT_UINT8, interlace_mode,
                      N_ENTRIES, (VOIDP)palette_buf);

/*
 * Terminate access to the image and to the GR interface, and
 * close the HDF file.
 */
status = GRendaccess (ri_id);
status = GRend (gr_id);
status = Hclose (file_id);
}

FORTRAN:
program write_palette
implicit none
C
C     Parameter declaration
C
    character*22 FILE_NAME
character*18 NEW_IMAGE_NAME
integer X_LENGTH
integer Y_LENGTH
integer N_ENTRIES
integer N_COMPS_IMG
integer N_COMPS_PAL
C
parameter (FILE_NAME = 'Image_with_Palette.hdf',
 + NEW_IMAGE_NAME = 'Image with Palette',
 + X_LENGTH = 5,
 + Y_LENGTH = 5,
 + N_ENTRIES = 256,
 + N_COMPS_IMG = 2,
 + N_COMPS_PAL = 3)
integer DFACC_CREATE, DFNT_CHAR8, DFNT_UINT8, MFGR_INTERLACE_PIXEL
parameter (DFACC_CREATE = 4,
 + DFNT_CHAR8 = 4,
 + DFNT_UINT8 = 21,
 + MFGR_INTERLACE_PIXEL = 0)
C
C     Function declaration
C
integer hopen, hclose
integer mgstart, mgcreat, mgwcimg, mggltid, mgwclut,
 + mgendac, mgend
C
C**** Variable declaration ********************************************
C
integer file_id, gr_id, ri_id, pal_id
integer interlace_mode
integer start(2), stride(2), edges(2), dim_sizes(2)
integer status
integer i, j
character image_buf(N_COMPS_IMG, X_LENGTH, Y_LENGTH)
character palette_buf(N_COMPS_PAL, N_ENTRIES)
C
C**** End of variable declaration *************************************
C
C Create and open the file.
C
file_id = hopen(FILE_NAME, DFACC_CREATE, 0)
C
C Initialize the GR interface.
C
gr_id = mgstart(file_id)
C
C Define interlace mode and dimensions of the image.
C
interlace_mode = MFGR_INTERLACE_PIXEL
dim_sizes(1) = X_LENGTH
dim_sizes(2) = Y_LENGTH
C
C Create the raster image array.
C
ri_id = mgcreat(gr_id, NEW_IMAGE_NAME, N_COMPS_IMG, DFNT_CHAR8,
 + interlace_mode, dim_sizes)
C
C Fill the image data buffer with values.
C
do 20 i = 1, Y_LENGTH
  do 10 j = 1, X_LENGTH
    image_buf(1,j,i) = char(i + j - 1 )
image_buf(2,j,i) = char(i + j)

10       continue
20    continue

C Define the size of the data to be written, i.e., start from the origin
C and go as long as the length of each dimension.

start(1) = 0
start(2) = 0
edges(1) = X_LENGTH
edges(2) = Y_LENGTH
stride(1) = 1
stride(2) = 1

C Write the data in the buffer into the image array.

status = mgwcimg(ri_id, start, stride, edges, image_buf)

C Initialize the palette buffer to grayscale.

do 40 i = 1, N_ENTRIES
   do 30 j = 1, N_COMPS_PAL
      palette_buf(j,i) = char(i)
   30    continue
40   continue

C Get the identifier of the palette attached to the image NEW_IMAGE_NAME.

pal_id = mggltid(ri_id, 0)

C Set palette interlace mode.

interlace_mode = MFGR_INTERLACE_PIXEL

C Write data to the palette.

status = mgwclut(pal_id, N_COMPS_PAL, DFNT_UINT8, interlace_mode,
                  N_ENTRIES, palette_buf)

C Terminate access to the raster image and to the GR interface,
C and close the HDF file.

status = mgendac(ri_id)
status = mgend(gr_id)
status = hclose(file_id)

end

EXAMPLE 8.

Reading a Palette.

This example illustrates the use of the routines GRgetlutinfo/mgglinf and GRreadlut/mgrclut to
obtain information about a palette and to read palette data.

In this example, the program finds and selects the image named "Image with Palette" in the file
"Image_with_Palette.hdf". Then the program obtains information about the palette and reads the
palette data.

C:

#include "hdf.h"
```
#define FILE_NAME      "Image_with_Palette.hdf"
#define IMAGE_NAME     "Image with Palette"
#define N_ENTRIES      256     /* number of elements of each color */

main( )
{
    /***************************************************************************
     * Variable declaration ***************************************************************************/

    intn status, /* status for functions returning an intn */
    i, j;
    int32 file_id, gr_id, ri_id, pal_id, ri_index;
    int32 data_type, n_comps, n_entries, interlace_mode;
    uint8 palette_data[N_ENTRIES][3];        /* static because of fixed size */

    /*************************************************************************** Variable declaration ***************************************************************************/

    /* Open the file. */
    file_id = Hopen (FILE_NAME, DFACC_READ, 0);

    /* Initiate the GR interface. */
    gr_id = GRstart (file_id);

    /* Get the index of the image IMAGE_NAME. */
    ri_index = GRnametoindex (gr_id, IMAGE_NAME);

    /* Get image identifier. */
    ri_id = GRselect (gr_id, ri_index);

    /* Get the identifier of the palette attached to the image. */
    pal_id = GRgetlutid (ri_id, ri_index);

    /* Obtain and display information about the palette. */
    status = GRgetlutinfo (pal_id, &n_comps, &data_type, &interlace_mode, &n_entries);
    printf ("Palette: %d components; %d entries\n", n_comps, n_entries);

    /* Read the palette data. */
    status = GRreadlut (pal_id, (VOIDP)palette_data);

    /* Display the palette data. Recall that HDF supports only 256 colors. */
    /* Each color is defined by its 3 components. Therefore, */
    /* verifying the value of n_entries and n_comps is not necessary and */
    /* the buffer to hold the palette data can be static. However, */
    /* if more values or colors are added to the model, these parameters */
    /* must be checked to allocate sufficient space when reading a palette. */
    */
    printf (" Palette Data: \n");
    for (i=0; i< n_entries; i++)
```
for (j = 0; j < n_comps; j++)
    printf ("%i ", palette_data[i][j]);
printf ("\n");
}
printf ("\n");

/**
 * Terminate access to the image and to the GR interface, and
 * close the HDF file.
 */
status = GRendaccess (ri_id);
status = GRend (gr_id);
status = Hclose (file_id);
}

FORTRAN:
program  read_palette
implicit none

C Parameter declaration
C
character*22 FILE_NAME
character*18 IMAGE_NAME
integer      N_ENTRIES
integer      N_COMPS_PAL
C
parameter (FILE_NAME   = 'Image_with_Palette.hdf',
+ IMAGE_NAME  = 'Image with Palette',
+ N_COMPS_PAL = 3,
+ N_ENTRIES  = 256)
integer DFACC_READ, DFNT_CHAR8, DFNT_UINT8, MFGR_INTERLACE_PIXEL
parameter (DFACC_READ  = 1,
+ DFNT_CHAR8  = 4,
+ DFNT_UINT8  = 21,
+ MFGR_INTERLACE_PIXEL = 0)
C Function declaration
C
integer hopen, hclose
integer mgstart, mgn2ndx, mgselct, mggltid, mgglinf,
+ mgrclut, mgendac, mgend
C
C**** Variable declaration **************************************************
C
integer file_id, gr_id, ri_id, ri_index, pal_id, pal_index
integer interlace_mode
integer data_type, n_comps, n_entries_out
integer status
integer i, j
character palette_data(N_COMPS_PAL, N_ENTRIES)
C
C**** End of variable declaration ******************************************
C
C Open the file.
C
file_id = hopen(FILE_NAME, DFACC_READ, 0)
C
Initialize the GR interface.
C
gr_id = mgstart(file_id)
Get the index of the image IMAGE_NAME.
ri_index = mgn2ndx(gr_id, IMAGE_NAME)

Get the image identifier.
ri_id = mgselect(gr_id, 0)

Get the identifier of the palette attached to the image.
pal_index = 0
pal_id = mggltid(ri_id, pal_index)

Obtain information about the palette.
status = mgglinf(pal_id, n_comps, data_type, interlace_mode, + n_entries_out)
write(*,*) 'Palette: ', n_comps, ' components; ', + n_entries_out, ' entries'

Read the palette.
status = mgrclut(pal_id, palette_data)
Display the palette data.
write(*,*) "Palette data"
do 10 i = 1, n_entries_out
   write(*,*) (ichar(palette_data(j,i)), j = 1, n_comps)
10    continue

Terminate access to the raster image and to the GR interface, and close the HDF file.
status = mgendac(ri_id)
status = mgend(gr_id)
status = hclose(file_id)
end

8.12 Chunked Raster Images

The GR interface also supports chunking in a manner similar to that of the SD interface. There is one restriction on a raster image: it must be created with MFGR_INTERLACE_PIXEL (or 0) in the call to GRcreate. We refer the reader to Section 3.11 of Chapter 3, Scientific Data Sets (SD API), and to Chapter 14, HDF Performance Issues, for discussions of chunking concepts and performance related topics. The GR interface provides three routines, GRsetchunk, GRsetchunkcache, and GRgetchunkinfo, to create and maintain chunked raster images. The generic functions for reading and writing GR images, GRwriteimage and GRreadimage, will write and read chunked raster images as well. However, the GR interface provides special write and read routines, GRwritechunk and GRreadchunk, which are similar to SDwritechunk and SDreadchunk. Compared to GRwriteimage and GRreadimage, GRwritechunk and GRreadchunk are low-overhead but are only suitable for writing or reading complete chunks.
8.12.1 Difference between a Chunked Raster Image and a Chunked SDS

Chunks of scientific datasets (SDSs) have the same dimensionality as the SDS itself and the chunks can divide the SDS along any dimension. While raster images under the GR interface are actually 3-dimensional arrays, 2 dimensions define the image while the third dimension (the stack of 2-dimensional image planes) provides the composite definition of the color at each pixel of the 2-dimensional image. Chunking can be applied only across the 2-dimensions of the image; chunking cannot divide the array across the third dimension. In other words, all of the elements of the raster image that define a single pixel must remain together in the same chunk.

8.12.2 Making a Raster Image a Chunked Raster Image: GRsetchunk

GRsetchunk makes the raster image, identified by the parameter ri_id, a chunked raster image according to the provided chunking and compression information. The syntax of GRsetchunk is as follows:

C:
status = GRsetchunk(ri_id, c_def, flags);

FORTRAN:
status = mgschnk(ri_id, dim_length, comp_type, comp_prm)

The parameters c_def and flags in C or the parameters comp_type and comp_prm in FORTRAN-77 provide the chunking and compression information and are discussed below.

In C:

The parameter c_def is a union of type HDF_CHUNK_DEF, which is defined as follows:

typedef union hdf_chunk_def_u
{
   int32 chunk_lengths[2]; /* chunk lengths along each dim */
   struct
   {
      int32 chunk_lengths[2];
      int32 comp_type; /* compression type */
   }
}
Valid values of the parameter `flags` are `HDF_CHUNK` for chunked and uncompressed data and `(HDF_CHUNK | HDF_COMP)` for chunked and compressed data. Data can be compressed using run-length encoding (RLE), Skipping Huffman, or GZIP compression algorithms.

If the parameter `flags` has a value of `HDF_CHUNK`, the chunk dimensions must be specified in the field `c_def.chunk_lengths[]`. If the parameter `flags` has a value of `(HDF_CHUNK | HDF_COMP)`, the chunk dimensions must be specified in the field `c_def.comp.chunk_lengths[]` and the compression type in the field `c_def.comp.comp_type`. Valid values of compression type values are:

- `COMP_CODE_NONE` (or 0) for uncompressed data
- `COMP_CODE_RLE` (or 1) for data compressed using the RLE compression algorithm
- `COMP_CODE_SKPHUFF` (or 3) for data compressed using the Skipping Huffman compression algorithm
- `COMP_CODE_DEFLATE` (or 4) for data compressed using the GZIP compression algorithm

If using Skipping Huffman compression, the skipping size is specified in the field `c_def.comp.cinfo.skphuff.skp_size`. If using GZIP compression, the deflate level is specified in the field `c_def.comp.cinfo.deflate.level`. Valid deflate level values are integers from 1 to 9 inclusive. Refer to the discussion of `SDsetcompress` routine in Section 3.5.2 on page 45 for the definition of the structure `comp_info`.

In FORTRAN-77: Chunk dimensions are specified in the array `dim_length` and the compression type in the parameter `comp_type`. Valid compression types and their values are defined in the “hdf.inc” file and are listed below:

- `COMP_CODE_NONE` (or 0) for uncompressed data
- `COMP_CODE_RLE` (or 1) for data compressed using the RLE compression algorithm
- `COMP_CODE_SKPHUFF` (or 3) for data compressed using the Skipping Huffman compression algorithm
- `COMP_CODE_DEFLATE` (or 4) for data compressed using the GZIP compression algorithm

The parameter `comp_prm` specifies the compression parameters for the Skipping Huffman and GZIP compression methods. It contains only one element which is set to the skipping size for Skipping Huffman compression or the deflate level for GZIP compression.

`GRsetchunk` returns `SUCCEED` (or 0) if successful and `FAIL` (or -1) otherwise. The `GRsetchunk` parameters are discussed further in Table 8L on page 327.

### 8.12.3 Writing a Chunked Raster Image: `GRwritechunk`

`GRwritechunk` is used to write a chunk of a chunked raster image. The syntax of the `GRwritechunk` routine is as follows:

```c
C: status = GRwritechunk(ri_id, &origin, &datap);
```
FORTRAN:

\[
\text{status} = \text{mgwchnk}(\text{ri}_\text{id}, \text{origin}, \text{datap}) \\
\text{status} = \text{mgwcchnk}(\text{ri}_\text{id}, \text{origin}, \text{datap})
\]

\text{GRwritechunk} writes the entire chunk of data stored in the buffer \text{datap} to the chunked raster image identified by the parameter \text{ri}_\text{id}. Writing starts at the location specified by the parameter \text{origin}. This function has less overhead than \text{GRwriteimage} and should be used whenever an entire chunk of data is to be written.

The raster image must be stored in pixel-interlace mode.

The parameter \text{origin} is a two-dimensional array which specifies the coordinates of the chunk according to the chunk position in the overall chunk array.

The \text{datap} buffer contains the chunk data. The data must be organized in pixel-interlace mode.

Note that the FORTRAN-77 version of \text{GRwritechunk} has two routines; \text{mgwchnk} writes buffered numeric data and \text{mgwcchnk} writes buffered character data.

\text{GRwritechunk} returns \text{SUCCEED} (or 0) if successful and \text{FAIL} (or -1) otherwise. The \text{GRwritechunk} parameters are discussed further in Table 8L.
EXAMPLE 9. Creating and Writing a Chunked Raster Image

This example illustrates the use of the routines Hopen/hopen, GRstart/mgstart, GRcreate/mgcreat, GRwritechunk/mgwichnk, GRendaccess/mgendac, GRend/mgend, and Hclose/hclose to create an HDF file and store a raster image in it.

In this example, the program creates an image of 6 rows by 10 columns in C and 10 rows by 6 columns in FORTRAN. The image is set up to be chunked with a chunk size of 3x2 in C and 2x3 in FORTRAN and compressed with the GZIP method. Three chunks are then written to the image. See Figure 8c through Figure 8d for illustrations.

FIGURE 8c

This image has 10 chunks, each 3x2 in size. This program writes data to the first, second, and last chunks, as indicated by the shading to the right.

Each chunk contains the data for all three planes of the images. The first chunk, for example would be illustrated as below.

Upon completion of the program, the three planes of the image contain the following data.

Plane 0

| 110 120 210 220 |
| 130 140 230 240 |
| 150 160 250 260 |
| 1010 1020 1030 1040 |
| 1050 1060 |

Plane 1

| 111 121 211 221 |
| 131 141 231 241 |
| 151 161 251 261 |
| 1011 1021 1031 1041 |
| 1051 1061 |

Plane 2

| 112 122 212 222 |
| 132 142 232 242 |
| 152 162 252 262 |
| 1012 1022 1032 1042 |
| 1052 1062 |
This image has 10 chunks, each 2x3 in size. This program writes data to the first, second, and last chunks, as indicated by the shading below.

Upon completion of the program, the three planes of the image contain the following data.

Plane 0

| 110 130 150 | 112 132 152 |
| 120 140 160 | 111 131 151 |
| 210 230 250 | 212 232 252 |
| 220 240 260 | 222 242 262 |

Plane 1

| 111 131 151 | 121 141 161 |
| 121 141 161 | 211 231 251 |
| 221 241 261 | 222 242 262 |

Plane 2

| 112 132 152 | 122 142 162 |
| 111 131 151 | 211 231 251 |
| 221 241 261 | 222 242 262 |

Each chunk contains the data for all three planes of the images. The first chunk, for example, would be illustrated as below.
150, 151, 152, 160, 161, 162
};
int32 chunk01[] = {210, 211, 212, 220, 221, 222,
230, 231, 232, 240, 241, 242,
250, 251, 252, 260, 261, 262
};

int32 chunk14[] = {1010, 1011, 1012, 1020, 1021, 1022,
1030, 1031, 1032, 1040, 1041, 1042,
1050, 1051, 1052, 1060, 1061, 1062
};

/******************** End of variable declaration ********************/

/* Create and open the file. */
file_id = Hopen (FILE_NAME, DFACC_CREATE, 0);

/* Initialize the GR interface. */
gr_id = GRstart (file_id);

/* Set dimensions of the image. */
dims[0] = X_LENGTH;
dims[1] = Y_LENGTH;

/* Create the raster image array. */
ri_id = GRcreate (gr_id, IMAGE_NAME, NCOMPS, DFNT_INT32,
MFGR_INTERLACE_PIXEL, dims);

/* Define chunked image. */
chunk_def.comp.comp_type = COMP_CODE_DEFLATE;
chunk_def.comp.cinfo.deflate.level = 6;
chunk_def.comp.chunk_lengths[0] = 3;
chunk_def.comp.chunk_lengths[1] = 2;
status = GRsetchunk(ri_id, chunk_def, HDF_CHUNK | HDF_COMP);

/* Write first chunk (0,0). */
start[0] = 0;
start[1] = 0;
status = GRwritechunk(ri_id, start, (VOIDP)chunk00);

/* Write second chunk (0,1). */
start[0] = 0;
start[1] = 1;
status = GRwritechunk(ri_id, start, (VOIDP)chunk01);

/* Write third chunk (1,4). */
start[0] = 1;
start[1] = 4;
status = GRwritechunk(ri_id, start, (VOIDP)chunk14);

/*
 * Terminate access to the raster image and to the GR interface and,
 * close the HDF file.
 */
status = GRendaccess (ri_id);
status = GRe nd (gr_id);
status = Hclose (file_id);
}

FORTRAN:

program gr_chunking_example
implicit none
C
C     Parameter declaration
C
character*14 FILE_NAME
character*14 DATASET_NAME
parameter (FILE_NAME = 'gr_chunked.hdf',
.           DATASET_NAME = 'gzip_comp_data')
integer   NCOMP, MFGR_INTERLACE_PIXEL
parameter(NCOMP = 3, MFGR_INTERLACE_PIXEL = 0)
integer DFACC_CREATE, DFACC_READ, DFACC_WRITE
parameter (DFACC_CREATE = 4,
.           DFACC_READ = 1,
.           DFACC_WRITE = 2)
integer DFNT_INT32
parameter (DFNT_INT32   = 24)
integer X_LENGTH, Y_LENGTH, X_CH_LENGTH, Y_CH_LENGTH
parameter (X_LENGTH     = 6,
.           Y_LENGTH     = 10,
.           X_CH_LENGTH  = 3,
.           Y_CH_LENGTH  = 2)
C
C     Compression parameters.
C
integer  COMP_CODE_DEFLATE, DEFLATE_LEVEL
parameter( COMP_CODE_DEFLATE = 4, DEFLATE_LEVEL = 6)
C
function declaration.
C
integer mgstart, mgcreat, mgendac, mgend
integer mgwchnk, mgschnk
integer hopen, hclose
C
**** Variable declaration *****************************************************
C
integer ri_id, gr_id, file_id
integer dims(2), start(2)
integer status, il
integer comp_prm(1), comp_type
C
Data buffers.
C
integer*4 chunk11(NCOMP* X_CH_LENGTH*Y_CH_LENGTH)
integer*4 chunk21(NCOMP* X_CH_LENGTH*Y_CH_LENGTH)
integer*4 chunk52(NCOMP* X_CH_LENGTH*Y_CH_LENGTH)
C
Chunking dimension arrays
integer ch_dims(2)

Data initialization

data chunk11 / 110, 111, 112, 120, 121, 122,
.   130, 131, 132, 140, 141, 142,
.   150, 151, 152, 160, 161, 162
. /,
. chunk21 /
.   210, 211, 212, 220, 221, 222,
.   230, 231, 232, 240, 241, 242,
.   250, 251, 252, 260, 261, 262
. /,
. chunk52 /
.   1010, 1011, 1012, 1020, 1021, 1022,
.   1030, 1031, 1032, 1040, 1041, 1042,
.   1050, 1051, 1052, 1060, 1061, 1062
. /

Define chunk dimensions.

ch_dims(1) = Y_CH_LENGTH
ch_dims(2) = X_CH_LENGTH

Create and open the file and initiate GR interface..

file_id = hopen(FILE_NAME, DFACC_CREATE, 0)
gr_id   = mgstart(file_id)

Define the number of components and dimensions of the image.

il      = MFGR_INTERLACE_PIXEL
dims(1) = X_LENGTH
dims(2) = Y_LENGTH

Create GR dataset.

ri_id = mgcreat(gr_id, DATASET_NAME, NCOMP, DFNT_INT32, il, dims)

Define chunked GR dataset using GZIP compression.

compprm(1) = DEFLATE_LEVEL
comp_type = COMP_CODE_DEFLATE
status = mgschnk (ri_id, ch_dims, comp_type, compprm)

Define the location of the first chunk and write the data.

start(1) = 1
start(2) = 1
status = mgwchnk(ri_id, start, chunk11)

Define the location of the second chunk and write the data.

start(1) = 2
start(2) = 1
status = mgwchnk(ri_id, start, chunk21)

Define the location of the third and write the data.
8.12.4 Reading a Chunked Raster Image: GRreadchunk

GRreadchunk is used to read an entire chunk of data from a chunked raster image. The syntax of the GRreadchunk routine is as follows:

C:
status = GRreadchunk(ri_id, &origin, datap);

FORTRAN:
status = mgrchnk(ri_id, origin, datap)

GRreadchunk reads the entire chunk of data stored from the chunked raster image identified by the parameter ri_id and stores it in the buffer datap. The chunk to be read is specified by the parameter origin. This function has less overhead than GRreadimage and should be used whenever an entire chunk of data is to be read.

The raster image must be stored in pixel-interlace mode.

The parameter origin is a two-dimensional array which specifies the coordinates of the chunk according to the chunk position in the overall chunk array.

The datap buffer contains the chunk data. The data is organized in pixel-interlace mode.

Note that the FORTRAN-77 version of GRreadchunk has two routines; mgrchnk reads numeric data and mgrcchnk reads character data to the buffer.

GRreadchunk returns SUCCEED (or 0) if successful and FAIL (or -1) otherwise. GRreadchunk will return FAIL (or -1) when an attempt is made to read from a non-chunked image. The GRreadchunk parameters are discussed further in Table 8L.

8.12.5 Obtaining Information about a Chunked Raster Image: GRgetchunkinfo

GRgetchunkinfo is used to determine whether a raster image is chunked and how chunking is defined. The syntax of the GRgetchunkinfo routine is as follows:

C:
status = GRgetchunkinfo(ri_id, &c_def, &flag);

FORTRAN:
status = mggichnk(ri_id, dim_length, flag)
GRgetchunkinfo retrieves chunking information about the raster image into the parameters c_def and flag in C and into the parameters dim_length and flag in FORTRAN-77. Note that only chunk dimensions are retrieved; compression information is not available.

The value returned in the parameter flag indicates whether the raster image is not chunked, chunked, or chunked and compressed. HDF_NONE (or -1) indicates that the raster image is not chunked. HDF_CHUNK (or 0) indicates that the raster image is chunked and not compressed. (HDF_CHUNK | HDF_COMP) (or 1) indicates that raster image is chunked and compressed with one of the allowed compression methods: RLE, Skipping Huffman, or GZIP.

In C, if the raster image is chunked and not compressed, GRgetchunkinfo fills the array chunk_lengths in the union c_def with the values of the corresponding chunk dimensions. If the raster image is chunked and compressed, GRgetchunkinfo fills the array chunk_lengths in the structure comp of the union c_def with the values of the corresponding chunk dimensions. Refer to Section 8.12.2 on page 317 on GRsetchunk for specific information on the union HDF_CHUNK_DEF. In C, if the chunk length for each dimension is not needed, NULL can be passed in as the value of the parameter c_def.

In FORTRAN-77, chunk dimensions are retrieved into the array dim_length.

GRgetchunkinfo returns SUCCEEDED (or 0) if successful and FAILED (or -1) otherwise. The GRgetchunkinfo parameters are discussed further in Table 8L.

8.12.6 Setting the Maximum Number of Chunks in the Cache:
GRsetchunkcache

GRsetchunkcache sets the maximum number of chunks to be cached for chunked raster image. GRsetchunkcache has similar behavior to SDsetchunkcache. Refer to Section 3.11.2 on page 107 for specific information. The syntax of GRsetchunkcache is as follows:

C: status = GRsetchunkcache(ri_id, maxcache, flags);

FORTRAN: status = mgscchnk(ri_id, maxcache, flags)

The maximum number of chunks is specified by the parameter maxcache. Currently, the only valid value of the parameter flags is 0.

If GRsetchunkcache is not called, the maximum number of chunks in the cache is set to the number of chunks along the fastest-changing dimension. Since GRsetchunkcache is similar to the routine SDsetchunkcache, refer to Section 3.11.2 on page 107 for more detailed discussion of the routine’s behavior.

GRsetchunkcache returns the value of the parameter maxcache if successful and FAILED (or -1) otherwise. The GRsetchunkcache parameters are discussed further in Table 8L.
<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GRsetchunk</strong></td>
<td>ri_id</td>
<td>int32</td>
<td>Raster image identifier</td>
</tr>
<tr>
<td>[intn]</td>
<td>c_def</td>
<td>HDF_CHUNK_DEF</td>
<td>Chunk definition</td>
</tr>
<tr>
<td>(mgchnk)</td>
<td>flags</td>
<td>int32*</td>
<td>Compression flags</td>
</tr>
<tr>
<td></td>
<td>dim_length</td>
<td>N/A</td>
<td>Chunk dimensions array</td>
</tr>
<tr>
<td></td>
<td>comp_type</td>
<td>N/A</td>
<td>Type of compression</td>
</tr>
<tr>
<td></td>
<td>comp_prm</td>
<td>N/A</td>
<td>Compression parameters array</td>
</tr>
<tr>
<td><strong>GRgetchunkinfo</strong></td>
<td>ri_id</td>
<td>int32</td>
<td>Raster image identifier</td>
</tr>
<tr>
<td>[intn]</td>
<td>c_def</td>
<td>HDF_CHUNK_DEF</td>
<td>Chunk definition</td>
</tr>
<tr>
<td>(mggichnk)</td>
<td>dim_length</td>
<td>N/A</td>
<td>Chunk dimensions array</td>
</tr>
<tr>
<td></td>
<td>flag</td>
<td>int32</td>
<td>Compression flag</td>
</tr>
<tr>
<td><strong>GRsetchunkcache</strong></td>
<td>ri_id</td>
<td>int32</td>
<td>Raster image identifier</td>
</tr>
<tr>
<td>[intn]</td>
<td>maxcache</td>
<td>int32</td>
<td>Maximum number of chunks to cache</td>
</tr>
<tr>
<td>(mgsechnk)</td>
<td>flags</td>
<td>int32</td>
<td>Flags determining routine behavior</td>
</tr>
<tr>
<td><strong>GRreadchunk</strong></td>
<td>ri_id</td>
<td>int32</td>
<td>Raster image identifier</td>
</tr>
<tr>
<td>(mgrchnk/ mgrcchnk)</td>
<td>origin</td>
<td>int32</td>
<td>Array specifying the coordinates of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>the chunk</td>
</tr>
<tr>
<td></td>
<td>datap</td>
<td>VOIDP</td>
<td>Buffer with chunk data in pixel</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>interlace mode</td>
</tr>
<tr>
<td><strong>GRwritechunk</strong></td>
<td>ri_id</td>
<td>int32</td>
<td>Raster image identifier</td>
</tr>
<tr>
<td>[intn]</td>
<td>origin</td>
<td>int32</td>
<td>Array specifying the coordinates of</td>
</tr>
<tr>
<td>(mgwchnk/ mgwcchnk)</td>
<td></td>
<td></td>
<td>the chunk</td>
</tr>
<tr>
<td></td>
<td>datap</td>
<td>const VOIDP</td>
<td>Buffer with chunk data in pixel</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>interlace mode</td>
</tr>
</tbody>
</table>
Chapter 9

Palettes (DFP API)

9.1 Chapter Overview

This chapter describes the routines available for storing and retrieving 8-bit palettes. An 8-bit palette is a look-up table with 256 entries, one entry for each of the 256 possible pixel values the system hardware associates with a particular color. This chapter introduces and describes the HDF palette data model and the DFP interface.

9.2 The Palette Data Model

A palette is the means by which color is applied to an image and is also referred to as a color lookup table. It is a table in which every row contains the numerical representation of a particular color. Palettes can be many different sizes, but HDF only supports palettes with 256 colors, corresponding to the 256 different possible pixel values (0 to 255) in 8-bit raster images.

For each of the 256 colors in a palette, there are three 8-bit numbers describing its appearance. (See Figure 9a.) Each 8-bit color component represents the amount of red (or "R"), green (or "G"), or blue (or "B") used to create a particular color. In HDF, 8-bit palettes are assumed to be organized as follows; each entry consists of three bytes: one each for R, G, and B value. The first group of three bytes represent the R, G, and B values of the first color in the palette; the next three the R, G, and B values of the second color; and so forth. Therefore, the 256 possible different pixel values in an image serve as an index for the 256 color entries stored in the palette.

FIGURE 9a

Color Mapping Using a Palette

<table>
<thead>
<tr>
<th>Entry</th>
<th>Red</th>
<th>Green</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>00000000</td>
<td>00000000</td>
<td>00000000</td>
</tr>
<tr>
<td>1</td>
<td>00000001</td>
<td>00000001</td>
<td>00000001</td>
</tr>
<tr>
<td>2</td>
<td>00000010</td>
<td>00000010</td>
<td>00000010</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>192</td>
<td>11000000</td>
<td>11000000</td>
<td>11000000</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
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<td>253</td>
<td>11111101</td>
<td>11111101</td>
<td>11111101</td>
</tr>
<tr>
<td>254</td>
<td>11111110</td>
<td>11111110</td>
<td>11111110</td>
</tr>
<tr>
<td>255</td>
<td>11111111</td>
<td>11111111</td>
<td>11111111</td>
</tr>
</tbody>
</table>

In the HDF library, there are four interfaces that support the reading and writing of palette data; the raster image interfaces, covered in Chapter 6, 8-Bit Raster Images (DFR8 API), Chapter 7, 24-bit Raster Images (DF24 API), Chapter 9, Palettes (DFP API), and the DFP palette interface covered in this chapter. The raster image interfaces store palettes with raster images and the palette interface reads and writes palettes outside of raster image sets. Palettes stored using the palette...
interface are stored as isolated data objects. In other words they are not included as members of any set, although they can be grouped with other objects using the Vgroup interface. For more information on the Vgroup interface, refer to Chapter 5, \textit{Vgroups (V API)}.

9.3 The Palette API

The DFP interface consists of eight routines. The routines DFPaddpal and DFPgetpal are the primary routines for palette I/O and are used for most reading and writing operations.

9.3.1 Palette Library Routines

All C functions in the palette interface are prefaced by "DFP" and the equivalent FORTRAN-77 functions are prefaced by "dp". These routines are divided into the following categories:

- \textit{Write routines} store palettes in new files or append them to existing files.
- \textit{Read routines} sequentially or randomly locate palettes to be read from a named file.

The DFP function calls are more explicitly defined in the following table and in the \textit{HDF Reference Guide}.

<table>
<thead>
<tr>
<th>TABLE 9A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DFP Library Routines</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>Routine Names</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Write</strong></td>
<td>DFPaddpal</td>
<td>Appends a palette to a file.</td>
</tr>
<tr>
<td></td>
<td>DFPputpal</td>
<td>Writes a palette to a file.</td>
</tr>
<tr>
<td></td>
<td>DFPwriteref</td>
<td>Sets the reference number for writing the next palette.</td>
</tr>
<tr>
<td><strong>Read</strong></td>
<td>DFPgetpal</td>
<td>Retrieves the next palette in a file.</td>
</tr>
<tr>
<td></td>
<td>DFPlastref</td>
<td>Returns the value of the last reference number read or written.</td>
</tr>
<tr>
<td></td>
<td>DFPn pals</td>
<td>Returns the number of palettes in a file.</td>
</tr>
<tr>
<td></td>
<td>DFPreadref</td>
<td>Sets reference number for retrieving the next palette.</td>
</tr>
<tr>
<td></td>
<td>DFPrestart</td>
<td>Specifies that the next read call will get the first palette in the file.</td>
</tr>
</tbody>
</table>

9.4 Writing Palettes

9.4.1 Writing a Palette: DFPaddpal and DFPputpal

To write a palette to an HDF file, the calling program must contain one of the following function calls:

\[
\text{C: } \quad \text{status} = \text{DFPaddpal}(\text{filename}, \text{palette});
\]

\[
\text{FORTRAN: } \quad \text{status} = \text{dapal}(\text{filename}, \text{palette})
\]

OR

\[
\text{C: } \quad \text{status} = \text{DFPputpal}(\text{filename}, \text{palette}, \text{overwrite}, \text{filemode});
\]

\[
\text{FORTRAN: } \quad \text{status} = \text{dpupal}(\text{filename}, \text{palette}, \text{overwrite}, \text{filemode})
\]

\textit{DFPaddpal} and \textit{DFPputpal} will write a palette to an HDF file named by \textit{filename}. When given a new filename, \textit{DFPputpal} and \textit{DFPaddpal} creates a new file and writes the palette as the first object in the file. When given an existing filename, \textit{DFPaddpal} appends the palette to the end of the file.
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DFPputpal provides this functionality as well with additional options for how the data is handled, providing more control over how a palette is written to file than DFPadppal. Specifically, the overwrite parameter determines whether or not to overwrite the last palette written to a file or to append a new palette onto the file. The filename parameter determines whether to create a new file or to append the data to the previous file. Note the combination to overwrite a palette in a newly created file is invalid and will generate an error. To overwrite a palette, filename must be the same filename as the last file accessed through the DFP interface. The parameters for DFPadppal and DFPputpal are more explicitly defined in the following table.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFPputpal [int] (dpppal)</td>
<td>filename</td>
<td>char *</td>
<td>Name of the HDF file.</td>
</tr>
<tr>
<td></td>
<td>palette</td>
<td>VOIDP</td>
<td>768-byte space for palette.</td>
</tr>
<tr>
<td></td>
<td>overwrite</td>
<td>int</td>
<td>Palette write specification.</td>
</tr>
<tr>
<td></td>
<td>filemode</td>
<td>char *</td>
<td>File write specification.</td>
</tr>
<tr>
<td>DFPadppal [int] (dpppal)</td>
<td>filename</td>
<td>char *</td>
<td>Name of the HDF file.</td>
</tr>
<tr>
<td></td>
<td>palette</td>
<td>VOIDP</td>
<td>768-byte space with palette.</td>
</tr>
</tbody>
</table>

Calling DFPadppal or DFPputpal immediately after writing an 8-bit raster image will not group the palette with the preceding image. Palettes written to a file sequentially can be retrieved sequentially. However, to maintain a higher level of organization between multiple palettes and images stored in the same file, it’s a good idea to explicitly group each palette with the image to which it belongs. To find out more about assigning a palette to an image, see Chapter 6, 8-Bit Raster Images (DFR8 API).

Writing a Palette

In the following code examples, DFPadppal is used to write a palette to an HDF file named "Example1.hdf".

C:

```c
#include "hdf.h"

main( )
{
  uint8 palette_data[768];
  intn i;
  int32 status;

  /* Initialize the palette to grayscale. */
  for (i = 0; i < 256; i++) {
    palette_data[i * 3] = i;
    palette_data[i * 3 + 1] = i;
    palette_data[i * 3 + 2] = i;
  }

  /* Write the palette to file. */
  status = DFPadppal("Example1.hdf", (VOIDP)palette_data);
}
```
FORTRAN:

```fortran
PROGRAM WRITE_PALETTE

  integer dpapal, status, i
  character palette_data(768)

  C Initialize the palette to greyscale.
  do 10, i = 1, 256
    palette_data((i - 1) * 3 + 1) = char(i - 1)
    palette_data((i - 1) * 3 + 2) = char(i - 1)
    palette_data((i - 1) * 3 + 3) = char(i - 1)
  10 continue

  C Write the palette to the HDF file.
  status = dpapal('Example1.hdf', palette_data)

end
```

### 9.4.2 Specifying the Reference Number of a Palette: DFPwriteref

`DFPwriteref` specifies the reference number of the palette to be written on the next call to `DFPaddpal` or `DFPputpal`:

- **C:**
  ```c
  status = DFPwriteref(filename, ref);
  status = DFPaddpal(filename, palette);
  ```

- **FORTRAN:**
  ```fortran
  status = dpwref(filename, ref)
  status = dpapal(filename, palette)
  ```

`DFPwriteref` assigns the specified reference number to the next palette written to the file `filename`. If the value of `ref` is the same as the reference number of an existing palette, the existing palette will be overwritten.

The parameters of `DFPwriteref` are further described in the following table.

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFPwriteref [intn] (dpwref)</td>
<td>filename</td>
<td>char(*)</td>
<td>Name of the HDF file containing the palette.</td>
</tr>
<tr>
<td></td>
<td>ref</td>
<td>uint16</td>
<td>Reference number for the next call to DFPaddpal or DFPputpal.</td>
</tr>
</tbody>
</table>

### 9.5 Reading a Palette

The DFP programming model for reading a palette is similar to that for writing a palette - only the palette read call is required.

#### 9.5.1 Reading a Palette: DFPgetpal

`DFPgetpal` is the only function required to read a palette. If the file is being opened for the first time, `DFPgetpal` returns the first palette in the file. Subsequent calls will return successive pal-
ettes in the file. In this way palettes are read in the same order in which they were written to the file.

To read a palette from an HDF file, the calling program must contain the following routines:

C:  
    status = DFPgetpal(filename, palette);

FORTRAN:  
    status = dpgpal(filename, palette)

DFPgetpal retrieves the next palette from the HDF file specified by filename. The space allocated for the palette is specified by palette and must be at least 768 bytes. When DFPgetpal is first called, it returns the first palette in the file. Subsequent calls to DFPgetpal will return successive palettes in the order in which they are stored in the file, including those stored via the DFR8 interface.

The parameters of DFPgetpal are defined in the following table.

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFPgetpal [intn] (dpapal)</td>
<td>filename</td>
<td>char (*)</td>
<td>Name of the HDF file.</td>
</tr>
<tr>
<td></td>
<td>palette</td>
<td>VOIDP</td>
<td>768-byte buffer for the palette.</td>
</tr>
</tbody>
</table>

### Example 2: Reading a Palette

The following examples demonstrate the method used to read a palette from the "Example1.hdf" HDF file created in Example 1.

**C:**

```c
#include "hdf.h"

main( )
{
    uint8 palette_data[768];
    intn status;

    /* Read the palette data from a file. */
    status = DFPgetpal("Example1.hdf", (VOIDP)palette_data);
}
```

**FORTRAN:**

```fortran
PROGRAM READ PALETTE
    integer dpgpal, status
    character palette_data(768)

    C Read the palette from the HDF file.
    status = dpgpal('Example1.hdf', palette_data)

end
```
9.5.2 Reading a Palette with a Given Reference Number: DFPreadref

DFPreadref is used to access specific palettes stored in files containing multiple palettes. It is the optionally called before DFPgetpal to set the next palette to be accessed to be the specified palette. DFPreadref can be used in connection with vgroups, which identify their members by tag/reference number pair.

To access a specific palette, use the following calling sequence:

\[
\begin{align*}
\text{C:} & \quad \text{true_false} = \text{DFPreadref}(\text{filename, ref}); \\
& \quad \text{status} = \text{DFPgetpal}(\text{filename, palette}); \\
\text{FORTRAN:} & \quad \text{true_false} = \text{dprref}(\text{filename, ref}) \\
& \quad \text{status} = \text{dpgpal}(\text{filename, palette})
\end{align*}
\]

DFPreadref specifies the reference number for the next read operation performed on the HDF file filename to the reference number specified by ref.

The parameters of DFPreadref are further defined in the following table.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFPreadref</td>
<td>filename</td>
<td>char*</td>
<td>Name of the HDF file.</td>
</tr>
<tr>
<td></td>
<td>ref</td>
<td>uint16</td>
<td>Reference number of the next palette to be read.</td>
</tr>
</tbody>
</table>

9.5.3 Specifying the Next Palette to be Accessed to be the First Palette: DFPrestart

DFPrestart causes the next DFPgetpal to read from the first palette in the file, rather than the palette following the one that was most recently read. DFPrestart has the following syntax:

\[
\begin{align*}
\text{C:} & \quad \text{status} = \text{DFPrestart}(); \\
\text{FORTRAN:} & \quad \text{status} = \text{dprest}()
\end{align*}
\]

9.6 Other Palette Routines

9.6.1 Querying the Number of Palettes in a File: DFPnpals

DFPnpals returns the total number palettes in a file and has the following syntax:

\[
\begin{align*}
\text{C:} & \quad \text{num_of_pals} = \text{DFPnpals}(\text{filename}); \\
\text{FORTRAN:} & \quad \text{num_of_pals} = \text{dnpals}(\text{filename})
\end{align*}
\]

The parameter of DFPnpals is further defined in the following table.
9.6.2 Obtaining the Reference Number of the Most Recently Access
ed Palette: DFPlastref

DFPlastref returns the reference number most recently used in writing or reading a palette. This
routine is used for attaching annotations to palettes and adding palettes to vgroups.

The following calling sequence uses DFPlastref to find the reference number of the palette most
recently written to an HDF file:

C:
status = DFPaddpal(filename, palette, width, height, compress);
lastref = DFPlastref();

FORTRAN:
status = dpapal(filename, palette, width, height, compress)
lastref = dplref();

DFPputpal or DFPgetpal can be used in place of DFPaddpal with similar results.

9.7 Backward Compatibility Issues

As HDF has evolved, a variety of internal structures have been used to store palettes, with differ-
ent tags used to represent them. To maintain backward compatibility with older versions of HDF,
the palette interface supported by HDF version 4.0 recognizes palettes stored using all previously-
used HDF tags. A detailed description of the tags and structures used to store palettes is in the
HDF Specifications and Developer’s Guide v3.2 which can be found from the HDF WWW home
page at http://hdf.ncsa.uiuc.edu/.
Chapter 10

Annotations (AN API)

10.1 Chapter Overview

The HDF annotation interface, the AN interface, supports the storage of labels and descriptions to HDF files and the data objects they contain. This chapter explains the methods used to read and write file and data object annotations using the AN interface.

Note that the AN interface works with multiple files and supersedes the single-file annotations interface, the DFAN interface, described in Chapter 11, Single-file Annotations (DFAN API). Further note that the AN interface can also read files written by DFAN interface routines.

10.2 The Annotation Data Model

When working with different data types, it is often convenient to identify the contents of a file by adding a short text description or annotation. An annotation serves as the explanation for a file or data object, as in "COLLECTED 12/14/90" or "BLACK HOLE SIMULATION". The annotation can be as short as a name or as long as a portion of source code. For example, if the data originated as satellite data, the annotation might include the source of the data, pertinent environmental conditions, or other relevant information. In the case of a hypothetical black hole simulation, the annotation might contain source code for the program that produced the data.

HDF annotations are designed to accommodate a wide variety of information including titles, comments, variable names, parameters, formulas, and source code. In fact, HDF annotations can encompass any textual information regarding the collection, meaning, or intended use of the data.

Annotations can be attached to files or data objects, and are themselves data objects identifiable by a tag/reference number pair. Refer to Chapter 2, HDF Fundamentals, for a description of tag/reference number pairs.

10.2.1 Labels and Descriptions

Annotations come in two forms: labels and descriptions. Labels are short annotations used for assigning things like titles or time stamps to a file or its data objects. Longer annotations are called descriptions and typically contain more extensive information, such as a source code module or mathematical formulae.

Labels are defined as a null-terminated string of characters. Descriptions may contain any sequence of ASCII characters.

In addition to the distinction made between labels and descriptions, HDF distinguishes between file annotations and object annotations.
10.2.2 File Annotations

File annotations are assigned to a file to describe the origin, meaning, or intended use of its data. Any HDF file can be annotated with a label, description, or combination of both. (See Figure 10a.) The number of labels or descriptions an HDF file may contain is limited to the maximum number of tag/reference number pairs. File annotations may be assigned in any order and at any time after a file is created.

Although it is possible to use a file annotation to describe a data object in a file, this practice is not recommended. Each data object should be described by its own data object annotation as it is added to the file.

10.2.3 Object Annotations

Object annotations are assigned to individual data objects to explain their origin, meaning, or intended use. Because object annotations are assigned to individual objects, their use requires an understanding of HDF tags and reference numbers (see Chapter 2, HDF Fundamentals).

The annotation interface takes advantage of this identification scheme by including the object’s tag/reference number pair with the text of the annotation. Consider a scientific data set identified by the tag DFTAG_NDG and the reference number 10. (See Figure 10b.) All object annotations assigned to this particular data set must be prefaced with the tag DFTAG_NDG followed by the reference number 10.
10.2.4 Terminology

The following pairs of terms are used interchangeably in the following discussions: data object annotation and data annotation; data object label and data label; data object description and data description.

10.3 The AN interface

The AN interface permits concurrent operations on a set of annotations that exist in more than one file rather than requiring the program to deal with the annotations on a file-by-file basis.

10.3.1 AN Library Routines

The C routine names of the AN interface are prefaced by the string "AN" and the FORTRAN-77 routine names are prefaced by "af". These routines are divided into the following categories:

- **Access routines** initialize and terminate access to the AN interface and the annotation.
- **Read/write routines** read and write file or object annotations.
- **General inquiry routines** return information about the annotations.

The AN routines are listed in Table 10A and are described in more detail in subsequent sections of this chapter.

<table>
<thead>
<tr>
<th>TABLE 10A AN Library Routines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
</tr>
<tr>
<td><strong>C</strong></td>
</tr>
<tr>
<td><strong>Access</strong></td>
</tr>
<tr>
<td></td>
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<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td><strong>Read/write</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>General Inquiry</strong></td>
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</tbody>
</table>
10.3.2 Type and Tag Definitions Used in the AN Interface

The AN interface uses the four general annotation types used in HDF: the data label, the data description, the file label and the file description. These annotation types correspondingly map to the AN_DATA_LABEL (or 0), the AN_DATA_DESC (or 1), the AN_FILE_LABEL (or 2) and the AN_FILE_DESC (or 3) definitions. Several routines in the AN interface require one of these type definitions to be passed in as an argument to designate the kind of annotation to be created or accessed.

10.3.3 Programming Model for the AN Interface

As with the GR and SD interfaces, the programming model for the AN interface allows several files to be open concurrently. The contents of these files can be operated on simultaneously as long as the calling program accurately keeps track of each interface. The file and object identifiers returned by the interface. Each object identifier and file identifier must be explicitly disposed of before the termination of the calling program.

The AN interface writes file labels, file descriptions, data object labels, and data object descriptions according to the following programming model:

1. Open the HDF file.
2. Initialize the AN interface.
3. Create a file annotation or a data annotation.
4. Perform the desired operations on the annotation.
5. Terminate access to the annotation.
6. Terminate access to the AN interface.
7. Close the HDF file.

To create a file or object annotation, the calling program must contain the following AN routine calls:

**C:**

```c
file_id = Hopen(filename, file_access_mode, num_dds_block);
an_id = ANstart(file_id);
ann_id = ANcreatef(an_id, annot_type);
```

**OR**

```c
ann_id = ANcreate(an_id, obj_tag, obj_ref, annot_type);
<Optional operations>
status = ANendaccess(ann_id);
status = ANend(an_id);
status = Hclose(file_id);
```

**FORTRAN:**

```fortran
file_id = hopen(filename, file_access_mode, num_dds_block)
an_id = afstart(file_id)
ann_id = affcreate(an_id, annot_type)
```

**OR**

```fortran
ann_id = afcreate(an_id, obj_tag, obj_ref, annot_type)
<Optional operations>
status = afendaccess(ann_id)
status = afend(an_id)
status = hclose(file_id)
```
10.3.4 Accessing Files and Annotations: ANstart, ANcreatef, and ANcreate

An HDF file must be opened by Hopen before it can be accessed using the AN interface. Hopen is described in Chapter 2, HDF Fundamentals.

ANstart initializes the AN interface for subsequent AN interface operations. ANstart takes one argument, the file identifier, file_id, returned by Hopen, and returns an AN interface identifier, an_id or FAIL (or -1) upon unsuccessful completion.

ANcreatef creates a file label or file description. It takes two parameters: the AN interface identifier, an_id, returned by ANstart, and the type of the file annotation to be created, annot_type. The parameter annot_type must be set to either AN_FILE_LABEL (or 2) or AN_FILE_DESC (or 3). ANcreatef returns the file annotation identifier (ann_id) if successful, and FAIL (or -1) otherwise.

ANcreate creates a data label or data description. It takes four parameters: an_id, obj_tag, obj_ref, and annot_type. The parameter an_id is the AN interface identifier, returned by ANstart. The parameters obj_tag and obj_ref are the tag/reference number pair of the object the annotation will be assigned to. The parameter annot_type specifies the type of the data annotation. It must be set to either AN_DATA_LABEL (or 0) or AN_DATA_DESC (or 1). The annotation type definitions are defined in the header file "hdf.h".

ANcreate returns the data annotation identifier (ann_id) if successful and FAIL (or -1) otherwise. The parameters of ANcreate, ANcreatef, and ANstart are further defined in Table 10B.

10.3.5 Terminating Access to Annotations and Files: ANendaccess and ANend

ANendaccess terminates access to the annotation identified by the parameter ann_id, which is returned by ANcreate or ANcreatef. Any subsequent attempts to access this annotation identifier will result in a value of FAIL being returned. One ANendaccess must be called for every ANcreate, ANcreatef, or ANattach. Each ANendaccess returns either SUCCEED (or 0) or FAIL (or -1).

ANend terminates access to the AN interface identified by the parameter an_id, which is returned by ANstart. Any subsequent attempts to access the AN interface identifier or to use AN routines will result in a value of FAIL being returned.

ANend returns either SUCCEED (or 0) or FAIL (or -1). The parameters of ANendaccess and ANend are defined in Table 10B.

The HDF file must be closed by Hclose after all calls to ANend have been properly made. Hclose is described in Chapter 2, HDF Fundamentals.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANstart</td>
<td>file_id</td>
<td>File identifier</td>
</tr>
<tr>
<td>ANcreatef</td>
<td>annot_type</td>
<td>Data annotation type</td>
</tr>
<tr>
<td>ANcreate</td>
<td>obj_tag</td>
<td>Tag of the object to be annotated</td>
</tr>
<tr>
<td>ANcreatef</td>
<td>obj_ref</td>
<td>Reference number of the object to be annotated</td>
</tr>
<tr>
<td>ANcreate</td>
<td>an_id</td>
<td>AN interface identifier</td>
</tr>
<tr>
<td>ANcreatef</td>
<td>annot_type</td>
<td>File annotation type</td>
</tr>
<tr>
<td>ANend</td>
<td>an_id</td>
<td>AN interface identifier</td>
</tr>
</tbody>
</table>

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10.4 Writing an Annotation: ANwriteann

The AN programming model for writing an annotation is as follows:

1. Create a file annotation or a data annotation.
2. Write to the annotation.
3. Terminate access to the annotation.

To write a file or data annotation, the calling program must contain the following routine calls:

**C:**

```c
file_id = Hopen(filename, file_access_mode, num_dds_block);
an_id = ANstart(file_id);
ann_id = ANcreatef(an_id, annot_type);
```

**OR**

```c
ann_id = ANcreate(an_id, obj_tag, obj_ref, annot_type);
status = ANwriteann(ann_id, ann_text, ann_length);
status = ANendaccess(ann_id);
status = ANend(an_id);
status = Hclose(file_id);
```

**FORTRAN:**

```fortran
file_id = hopen(filename, file_access_mode, num_dds_block)
an_id = afstart(file_id)
ann_id = afcreate(an_id, annot_type)
```

**OR**

```fortran
ann_id = afcreatef(an_id, annot_type)
status = afwriteann(ann_id, ann_text, ann_length)
status = afendaccess(ann_id)
status = afend(an_id)
status = hclose(file_id)
```

ANwriteann writes the annotation text given in the parameter ann_text to the annotation specified by ann_id. The parameter ann_length specifies the number of characters in the annotation text, not including the NULL character. If the annotation has already been written with text, ANwriteann will overwrite the current text.

ANwriteann returns either SUCCEED (or 0) or FAIL (or -1). The parameters of ANwriteann are further defined in Table 10C.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANwriteann</td>
<td>ann_id</td>
<td>int32</td>
<td>Annotation identifier</td>
</tr>
<tr>
<td></td>
<td>ann_text</td>
<td>char *</td>
<td>Text of the annotation</td>
</tr>
<tr>
<td></td>
<td>ann_length</td>
<td>int32</td>
<td>Number of characters in the annotation</td>
</tr>
</tbody>
</table>
EXAMPLE 1.

Creating File and Data Annotations

This example illustrates the use of ANcreatef/affcreate to create file annotations and ANcreate/afcreate to create data annotations.

In this example, the program creates an HDF file named "General_HDFobjects.hdf" then attaches to it two annotations, a file label and a file description. Within the HDF file, the program creates a vgroup named "AN Vgroup" and attaches to it two annotations, a data label and a data description. Refer to Chapter 5, Vgroups (V API), for a discussion of the V interface routines used in this example.

Note that the names AN_FILE_LABEL, AN_FILE_DESC, AN_DATA_LABEL, and AN_DATA_DESC are defined by the library to specify the type of the annotation to be accessed.

C:

```c
#include "hdf.h"
#define FILE_NAME "General_HDFobjects.hdf"
#define VG_NAME "AN Vgroup"
#define FILE_LABEL_TXT "General HDF objects"
#define FILE_DESC_TXT "This is an HDF file that contains general HDF objects"
#define DATA_LABEL_TXT "Common AN Vgroup"
#define DATA_DESC_TXT "This is a vgroup that is used to test data annotations"

main( )
{
    #************************** Variable declaration **************************/
    int status_n; /* returned status for functions returning an int */
    int32 status_32, /* returned status for functions returning an int32 */
    file_id, /* HDF file identifier */
    file_label_id, /* file label identifier */
    file_desc_id, /* file description identifier */
    data_label_id, /* data label identifier */
    data_desc_id, /* data description identifier */
    an_id, /* AN interface identifier */
    vgroup_tag, vgroup_ref;

    /* End of variable declaration **************************/
    /*
    * Create the HDF file.
    *
    * file_id = Hopen (FILE_NAME, DFACC_CREATE, 0);
    */
    /*
    * Initialize the AN interface.
    *
    * an_id = ANstart(file_id);
    */
    /*
    * Create the file label.
    *
    * file_label_id = ANcreatef(an_id, AN_FILE_LABEL);
    */
    /*
    * Write the annotations to the file label.
    *
    * status_32 = ANWriteann(file_label_id, FILE_LABEL_TXT,
```
/* Create file description. */
file_desc_id = ANcreate(an_id, AN_FILE_DESC);

/* Write the annotation to the file description. */
status_32 = ANwriteann(file_desc_id, FILE_DESC_TXT, strlen(FILE_DESC_TXT));

/* Create a vgroup in the V interface. Note that the vgroup’s ref number is set to -1 for creating and the access mode is "w" for writing. */
status_n = Vstart(file_id);
vgroup_id = Vattach(file_id, -1, "w");
status_32 = Vsetname (vgroup_id, VG_NAME);

/* Obtain the tag and ref number of the vgroup for subsequent references. */
vgroup_tag = (uint16) VQuerytag (vgroup_id);
vgroup_ref = (uint16) VQueryref (vgroup_id);

/* Create the data label for the vgroup identified by its tag and ref number. */
data_label_id = ANcreate(an_id, vgroup_tag, vgroup_ref, AN_DATA_LABEL);

/* Write the annotation text to the data label. */
status_32 = ANwriteann(data_label_id, DATA_LABEL_TXT, strlen(DATA_LABEL_TXT));

/* Create the data description for the vgroup identified by its tag and ref number. */
data_desc_id = ANcreate(an_id, vgroup_tag, vgroup_ref, AN_DATA_DESC);

/* Write the annotation text to the data description. */
status_32 = ANwriteann(data_desc_id, DATA_DESC_TXT, strlen(DATA_DESC_TXT));

/* Terminate access to the vgroup and to the V interface. */
status_32 = Vdetach(vgroup_id);
status_n = Vend(file_id);

/* Terminate access to each annotation explicitly. */
status_n = ANEndaccess(file_label_id);
status_n = ANEndaccess(file_desc_id);
status_n = ANEndaccess(data_label_id);
status_n = ANendaccess(data_desc_id);

/*
 * Terminate access to the AN interface and close the HDF file.
 */
status_32 = ANend(an_id);
status_n = Hclose(file_id);
}

FORTRAN:

program create_annotation
implicit none
C
C     Parameter declaration
C
character*22 FILE_NAME
character*9  VG_NAME
character*19 FILE_LABEL_TXT
character*53 FILE_DESC_TXT
character*16 DATA_LABEL_TXT
character*54 DATA_DESC_TXT
C
parameter (FILE_NAME      = 'General_HDFobjects.hdf',
+           VG_NAME        = 'AN Vgroup',
+           FILE_LABEL_TXT = 'General HDF objects',
+           DATA_LABEL_TXT = 'Common AN Vgroup',
+           FILE_DESC_TXT  = 'This is an HDF file that contains general HDF objects',
+           DATA_DESC_TXT  = 'This is a vgroup that is used to test data annotations')
integer DFACC_CREATE
parameter (DFACC_CREATE = 4)
integer AN_FILE_LABEL, AN_FILE_DESC, AN_DATA_LABEL, AN_DATA_DESC
parameter (AN_FILE_LABEL = 2,
+           AN_FILE_DESC  = 3,
+           AN_DATA_LABEL = 0,
+           AN_DATA_DESC  = 1)

C
C     Function declaration
C
integer hopen, hclose
integer afstart, afcreate, afwriteann, afcreate,
+     afendaccess, afend
integer vfstart, vfatch, vfsnam, vqref, vqtag, vfdtch, vfend

C
C**** Variable declaration ******************************************************
C
integer status
integer file_id, an_id
integer file_label_id, file_desc_id
integer data_label_id, data_desc_id
integer vgroup_id, vgroup_tag, vgroup_ref

C
C**** End of variable declaration **************************************************
C
C
Create the HDF file.

file_id = hopen(FILE_NAME, DFACC_CREATE, 0)
C
C Initialize the AN interface.
C
an_id = afstart(file_id)
C
Create the file label.
C
file_label_id = affcreate(an_id, AN_FILE_LABEL)
C
Write the annotation to the file label.
C
status = afwriteann(file_label_id, FILE_LABEL_TXT,
                    len(FILE_LABEL_TXT))
C
Create file description.
C
file_desc_id = affcreate(an_id, AN_FILE_DESC)
C
Write the annotation to the file description.
C
status = afwriteann(file_desc_id, FILE_DESC_TXT,
                    len(FILE_DESC_TXT))
C
Create a vgroup in the file. Note that the vgroup’s ref number is
set to -1 for creating and the access mode is ‘w’ for writing.
C
status = vfstart(file_id)
vgroup_id = vfatch(file_id, -1, ’w’)
status = vfsnam(vgroup_id, VG_NAME)
C
Obtain the tag and reference number of the vgroup for subsequent
references.
C
group_tag = vqtag(vgroup_id)
group_ref = vqref(vgroup_id)
C
Create the data label for the vgroup identified by its tag and ref
number.
C
data_label_id = afcreate(an_id, group_tag, group_ref,
                         AN_DATA_LABEL)
C
Write the annotation text to the data label.
C
status = afwriteann(data_label_id, DATA_LABEL_TXT,
                     len(DATA_LABEL_TXT))
C
Create the data description for the vgroup identified by its tag and ref.
C
status = afcreate(an_id, group_tag, group_ref,
                  AN_DATA_DESC)
C
Write the annotation text to the data description.
C
status = afwriteann(data_desc_id, DATA_DESC_TXT,
                     len(DATA_DESC_TXT))
C
Terminate access to the vgroup and to the V interface.
C
status = vfdtch(vgroup_id)
status = vfend(file_id)
C
Terminate access to each annotation explicitly.
10.5 Reading Annotations Using the AN Interface

Reading an annotation is done by first selecting the desired annotation of the appropriate type using ANselect, then reading the annotation text using ANreadann. These two routines are described in this section.

10.5.1 Selecting an Annotation: ANselect

ANselect obtains the identifier of the annotation specified by its index, index, and by its annotation type, annot_type. The syntax for ANselect is as follows:

C:     
ann_id = ANselect(an_id, index, annot_type);

FORTRAN:     
ann_id = afselect(an_id, index, annot_type)

The parameter index is a nonnegative integer and is less than the total number of annotations of type annot_type in the file. Use ANfileinfo, described in Section 10.6.1 on page 351, to obtain the total number of annotations of type annot_type in the file.

Possible valid values of annot_type are AN_DATA_LABEL (or 0) for a data label, AN_DATA_DESC (or 1) for a data description, AN_FILE_LABEL (or 2) for a file label, and AN_FILE_DESC (or 3) for a file description.

ANselect returns an annotation identifier or FAIL (or -1) upon unsuccessful completion. The parameters of ANselect are further described in Vdata.

10.5.2 Reading an Annotation: ANreadann

ANreadann reads the annotation specified by the parameter ann_id and stores the annotation text in the parameter ann_buf. The syntax for ANreadann is as follows:

C:     
status = ANreadann(ann_id, ann_buf, ann_length);

FORTRAN:     
status = afreadann(ann_id, ann_buf, ann_length)

The parameter ann_length specifies the size of the buffer ann_buf. If the length of the file or data label to be read is greater than or equal to ann_length, the label will be truncated to ann_length - 1 characters. If the length of the file or data description is greater than ann_length, the description will be truncated to ann_length characters. The HDF library adds a NULL character to the retrieved label but not to the description. The user must add a NULL character to the retrieved description if the C library string functions are to operate on this description.

ANreadann returns either SUCCEED (or 0) or FAIL (or -1). The parameters of ANreadann are further described in Table 10D.
EXAMPLE 2.

Reading File and Data Annotations

This example illustrates the use of ANfileinfo/affileinfo to get the number of data and file annotations in the file, ANSelect/afselect to get an annotation, ANAnnlen/afannlen to get the length of the annotation, and ANreadann/afreadann to read the contents of the annotation.

In this example, the program reads some of the annotations created in the file "General_HDFobjects.hdf" by Example 1. The program first gets the information on the annotations in the file so that the number of existing annotations of each kind is available prior to reading. The program then gets the length of each annotation and allocates sufficient space for the contents of the annotation to be read. For the simplicity of this example, only the data labels are read. Any other annotations can be read by adding the for loop with appropriate values as noted below.

This example uses the ANfileinfo/affileinfo routine to get annotation information. This routine is described in the Section 10.6.1

C:

```c
#include "hdf.h"
#define FILE_NAME   "General_HDFobjects.hdf"

main( )
{
    /************************* Variable declaration **************************/
    int status_n;       /* returned status for functions returning an intn */
    int32 status_32,    /* returned status for functions returning an int32 */
    file_id,           /* HDF file identifier */
    an_id,             /* AN interface identifier */
    index,             /* position of an annotation in all of the same type*/
    ann_length,        /* length of the text in an annotation */
    n_file_labels, n_file_descs, n_data_labels, n_data_descs;
    char *ann_buf;     /* buffer to hold the read annotation */

    /********************** End of variable declaration **********************/

    /* Open the HDF file. */
    file_id = Hopen (FILE_NAME, DFACC_READ, 0);

    /* Initialize the AN interface.

    TABLE 10D

    | Routine Name [Retn Type] (FORTRAN-77) | Parameter | Parameter Type | Description |
    |----------------------------------------|-----------|----------------|-------------|
    | ANselect [int32] (afselect)            | an_id     | int32          | AN interface identifier |
    |                                        | index     | int32          | Index of the annotation |
    |                                        | annot_type | ann_type       | Type of the annotation |
    | ANreadann [int32] (afreadann)          | ann_id    | int32          | Annotation identifier |
    |                                        | ann_buf   | char*          | Buffer for the returned annotation text |
    |                                        | ann_length | int32          | Number of characters to be retrieved from the annotation |
an_id = ANstart (file_id);

status_n = ANfileinfo (an_id, &n_file_labels, &n_file_descs,
                     &n_data_labels, &n_data_descs);

for (index = 0; index < n_data_labels; index++)
{
    ann_id = ANselect (an_id, index, AN_DATA_LABEL);

    ann_length = ANannlen (ann_id);

    ann_buf = malloc ((ann_length+1) * sizeof (char));

    status_32 = ANreadann (ann_id, ann_buf, ann_length+1);
    printf ("Data label index: %d\n", index);
    printf ("Data label contents: %s\n", ann_buf);

    status_n = ANendaccess (ann_id);
    free (ann_buf);
}

status_32 = ANend (an_id);
status_n = Hclose (file_id);
program read_annotation
implicit none
C
C     Parameter declaration
C
character*22 FILE_NAME
C
parameter (FILE_NAME = 'General_HDFobjects.hdf')
integer   DFACC_READ
parameter (DFACC_READ = 1)
integer   AN_DATA_LABEL
parameter (AN_DATA_LABEL = 0)
C
C     Function declaration
C
integer hopen, hclose
integer afstart, affileinfo, afselect, afannlen, afreadann,
   +   afendaccess, afend
C
C**** Variable declaration ****************************************************
C
integer status
integer file_id, an_id, ann_id
integer index, ann_length
integer n_file_labels, n_file_descs, n_data_labels, n_data_descs
character*256 ann_buf
C
C**** End of variable declaration ******************************************
C
C
C     Open the HDF file for reading.
C
file_id = hopen(FILE_NAME, DFACC_READ, 0)
C
C     Initialize the AN interface.
C
an_id = afstart(file_id)
C
C     Get the annotation information, i.e., the number of file labels,
C     file descriptions, data labels, and data descriptions.
C
status = affileinfo(an_id, n_file_labels, n_file_descs,
   +   n_data_labels, n_data_descs)
C
C     Get the data labels. Note that this DO loop can be used to obtain
C     the contents of each kind of annotation with the appropriate number
C     of annotations and the type of annotation, i.e., replace
C
n_data_labels with n_file_labels, n_file_descs, or n_data_descs, and
C
AN_DATA_LABEL with AN_FILE_LABEL, AN_FILE_DESC, or AN_DATA_DESC,
C
respectively.
C
do 10 index = 0, n_data_labels-1
C
C     Get the identifier of the current data label.
C
ann_id = afselect(an_id, index, AN_DATA_LABEL)
C
C     Get the length of the data label.
C
C
ann_length = afannlen(ann_id)

C     Read and display the data label. The data label is read into buffer
C     ann_buf. One has to make sure that ann_buf has sufficient size to hold
C     the data label. Also note, that the third argument to afreadann is
C     1 greater that the actual length of the data label (see comment to
C     C example).

C
status = afreadann(ann_id, ann_buf, ann_length+1)
write(*,*) 'Data label index: ', index
write(*,*) 'Data label contents: ', ann_buf(1:ann_length)
10    continue
C
C     Terminate access to the current data label.
C
status = afendaccess(ann_id)
C
C     Terminate access to the AN interface and close the HDF file.
C
status = afend(an_id)
status = hclose(file_id)
end

10.6 Obtaining Annotation Information Using the AN Interface

The HDF library provides various AN routines to obtain annotation information for the purpose of
locating either a particular annotation or a set of annotations that correspond to a set of search
criteria. The following sections describe these AN routines.

10.6.1 Obtaining the Number of Annotations: ANfileinfo

ANfileinfo retrieves the total number of file labels, file descriptions, data labels, and data descriptions
in the file identified by the parameter an_id. The syntax for ANfileinfo is as follows:

C:       status = ANfileinfo(an_id, &n_file_labels, &n_file_descs,
       &n_data_labels, &n_data_descs);
FORTRAN: status = affileinfo(an_id, n_file_labels, n_file_descs,
       n_data_labels, n_data_descs)

The retrieved information will be stored in the parameters n_file_labels, n_file_descs,
 n_data_labels, and n_data_descs, respectively. They can also be used as loop boundaries.

ANfileinfo returns either SUCCEED (or 0) or FAIL (or -1). The parameters of ANfileinfo are further
described in Table 10E.

10.6.2 Getting the Length of an Annotation: ANannlen

ANannlen returns either the length of the annotation, identified by the parameter ann_id, or FAIL
(or -1) upon unsuccessful completion. The syntax for ANannlen is as follows:

C:       ann_len = ANannlen(ann_id);
FORTRAN: ann_len = afannlen(ann_id)

The parameters of ANannlen are further described in Table 10E.
TABLE 10E

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANfileinfo [intn] (affileinfo)</td>
<td>an_id</td>
<td>int32</td>
<td>AN interface identifier</td>
</tr>
<tr>
<td></td>
<td>n_file_labels</td>
<td>int32 *</td>
<td>Number of file labels in the file</td>
</tr>
<tr>
<td></td>
<td>n_file_descs</td>
<td>int32 *</td>
<td>Number of file descriptions in the file</td>
</tr>
<tr>
<td></td>
<td>n_data_labels</td>
<td>int32 *</td>
<td>Number of data labels in the file</td>
</tr>
<tr>
<td></td>
<td>n_data_descs</td>
<td>int32 *</td>
<td>Number of data descriptions in the file</td>
</tr>
<tr>
<td>ANannlen [int32] (afannlen)</td>
<td>ann_id</td>
<td>int32</td>
<td>Annotation identifier</td>
</tr>
</tbody>
</table>

10.6.3 Obtaining the Number of Specifically-typed Annotations of a Data Object: ANnumann

ANnumann returns the total number of annotations that are of type annot_type and that are attached to the object identified by its tag, obj_tag, and reference number, obj_ref. The syntax for ANnumann is as follows:

C: `ann_num = ANnumann(an_id, annot_type, obj_tag, obj_ref);`

FORTRAN: `ann_num = anfnumann(an_id, annot_type, obj_tag, obj_ref)`

As this routine is implemented only to obtain the total number of data annotations and not file annotations, the valid values of annot_type are AN_DATA_LABEL (or 0) and AN_DATA_DESC (or 1). To obtain the total number of file annotations or all data annotations, use ANfileinfo.

ANnumann returns the total number of qualified annotations or FAIL (or -1). The parameters of ANnumann are further described in Table 10F.

10.6.4 Obtaining the List of Specifically-typed Annotation Identifiers of a Data Object: ANannlist

ANannlist retrieves the annotation identifiers for all of the annotations that are of type annot_type and belong to the object identified by its tag, obj_tag, and its reference number, obj_ref. The syntax for ANannlist is as follows:

C: `status = ANannlist(an_id, annot_type, obj_tag, obj_ref, ann_list);`

FORTRAN: `status = afselect(an_id, annot_type, obj_tag, obj_ref, ann_list)`

The identifiers of the retrieved annotations are stored in the parameter ann_list. The routine ANnumann can be used to obtain the number of annotations to be retrieved for dynamic memory allocation.

ANannlist returns either SUCCEED (or 0) or FAIL (or -1). The parameters of ANannlist are further described in Table 10F.
10.6.5 Obtaining the Tag/Reference Number Pair of the Specified Annotation Index and Type: ANget_tagref

ANget_tagref retrieves the tag and reference number of the annotation identified by its index, specified by the parameter index, and by the annotation type, specified by the parameter annot_type. The syntax for ANget_tagref is as follows:

C: status = ANget_tagref(an_id, index, annot_type, &ann_tag, &ann_ref);
FORTRAN: status = afgettagref(an_id, index, annot_type, ann_tag, ann_ref)

The tag is stored in the parameter ann_tag and the reference number is stored in the parameter ann_ref. The parameter index is a nonnegative value and is less than the total number of annotations of type annot_type in the file. Use ANfileinfo to obtain the total number of annotations of type annot_type in the file.

The value of annot_type can be either AN_DATA_LABEL (or 0), AN_DATA_DESC (or 1), AN_FILE_LABEL (or 2), or AN_FILE_DESC (or 3).

ANget_tagref returns either SUCCEED (or 0) or FAIL (or -1). The parameters of ANget_tagref are further described in Table 10G on page 355.

10.6.6 Obtaining the Tag/Reference Number Pair from a Specified Annotation Identifier: ANid2tagref

ANid2tagref retrieves the tag/reference number pair of the annotation identified by the parameter ann_id. The syntax for ANid2tagref is as follows:

C: status = ANid2tagref(ann_id, &ann_tag, &ann_ref);
FORTRAN: status = afidtagref(ann_id, ann_tag, ann_ref)

ANid2tagref stores the retrieved tag and reference number into the parameters ann_tag and ann_ref. Possible values returned in ann_tag are DFTAG_DIL (or 104) for a data label, DFTAG_DIA (or 105) for a data description, DFTAG_FID (or 100) for a file label, and DFTAG_FD (or 101) for a file description.
**ANid2tagref** returns either **SUCCEED** (or 0) or **FAIL** (or −1). The parameters of **ANid2tagref** are further described in Table 10G on page 355.

### 10.6.7 Obtaining the Annotation Identifier from a Specified Tag/Reference Number Pair: **ANtagref2id**

**ANtagref2id** routine returns the identifier of the annotation that is specified by its tag/reference number pair or **FAIL** (or −1). The syntax for **ANtagref2id** is as follows:

**C:**
```c
ann_id = ANtagref2id(an_id, ann_tag, ann_ref);
```

**FORTRAN:**
```fortran
ann_id = aftagrefid(an_id, ann_tag, ann_ref)
```

The parameters of **ANtagref2id** are further described in Table 10G on page 355.

### 10.6.8 Obtaining an Annotation Tag from a Specified Annotation Type: **ANatype2tag**

**ANatype2tag** returns the tag that corresponds to the annotation type specified by the parameter **annot_type** if successful, or **DFTAG_NULL** (or 0) otherwise. The syntax for **ANatype2tag** is as follows:

**C:**
```c
ann_tag = ANatype2tag(annot_type);
```

**FORTRAN:**
```fortran
ann_tag = afatypetag(annot_type)
```

The following table lists the valid values of **annot_type** in the left column and the corresponding values for the returned annotation tag on the right.

<table>
<thead>
<tr>
<th>Annotation Type</th>
<th>Annotation Tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>AN_DATA_LABEL (or 0)</td>
<td>DFTAG_DIL (or 104)</td>
</tr>
<tr>
<td>AN_DATA_DESC (or 1)</td>
<td>DFTAG_DIA (or 105)</td>
</tr>
<tr>
<td>AN_FILE_LABEL (or 2)</td>
<td>DFTAG_FID (or 100)</td>
</tr>
<tr>
<td>AN_FILE_DESC (or 3)</td>
<td>DFTAG_FD (or 101)</td>
</tr>
</tbody>
</table>

The parameters of **ANatype2tag** are further described in Table 10G.

### 10.6.9 Obtaining an Annotation Type from a Specified Object Tag: **ANtag2atype**

**ANtag2atype** returns the annotation type corresponding to the annotation tag **ann_tag** if successful, or **AN_UNDEF** (or −1) otherwise. The syntax for **ANtag2atype** is as follows:

**C:**
```c
annot_type = ANtag2atype(ann_tag);
```

**FORTRAN:**
```fortran
annot_type = aftagatype(ann_tag)
```

The following table lists the valid values of **ann_tag** in the left column and the corresponding values of the returned annotation type in the right column.
The parameters of \texttt{ANtag2atype} are further described in Table 10G.

### Table 10G

**ANget\_tagref, ANid2tagref, ANtagref2id, ANtype2tag, and ANtag2atype Parameter Lists**

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Parameter Type</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{ANget_tagref} [\texttt{int32}] [\texttt{afgettagref}]</td>
<td>\texttt{an_id}</td>
<td>\texttt{int32}</td>
<td>\texttt{integer}</td>
</tr>
<tr>
<td></td>
<td>\texttt{ann_index}</td>
<td>\texttt{int32}</td>
<td>\texttt{integer}</td>
</tr>
<tr>
<td></td>
<td>\texttt{annot_type}</td>
<td>\texttt{ann_type}</td>
<td>\texttt{integer}</td>
</tr>
<tr>
<td></td>
<td>\texttt{ann_tag}</td>
<td>\texttt{uint16 *}</td>
<td>\texttt{integer}</td>
</tr>
<tr>
<td></td>
<td>\texttt{ann_ref}</td>
<td>\texttt{uint16 *}</td>
<td>\texttt{integer}</td>
</tr>
<tr>
<td>\texttt{ANid2tagref} [\texttt{int32}] [\texttt{afidtagref}]</td>
<td>\texttt{ann_id}</td>
<td>\texttt{int32}</td>
<td>\texttt{integer}</td>
</tr>
<tr>
<td></td>
<td>\texttt{ann_tag}</td>
<td>\texttt{uint16 *}</td>
<td>\texttt{integer}</td>
</tr>
<tr>
<td></td>
<td>\texttt{ann_ref}</td>
<td>\texttt{uint16 *}</td>
<td>\texttt{integer}</td>
</tr>
<tr>
<td>\texttt{ANtagref2id} [\texttt{int32}] [\texttt{aftagrefid}]</td>
<td>\texttt{ann_id}</td>
<td>\texttt{int32}</td>
<td>\texttt{integer}</td>
</tr>
<tr>
<td></td>
<td>\texttt{ann_tag}</td>
<td>\texttt{uint16}</td>
<td>\texttt{integer}</td>
</tr>
<tr>
<td></td>
<td>\texttt{ann_ref}</td>
<td>\texttt{uint16}</td>
<td>\texttt{integer}</td>
</tr>
<tr>
<td>\texttt{ANtype2tag} [\texttt{uint16}] [\texttt{afatypetag}]</td>
<td>\texttt{annot_type}</td>
<td>\texttt{ann_type}</td>
<td>\texttt{integer}</td>
</tr>
<tr>
<td>\texttt{ANtag2atype} [\texttt{ann_type}] [\texttt{afatagtype}]</td>
<td>\texttt{ann_tag}</td>
<td>\texttt{uint16}</td>
<td>\texttt{integer}</td>
</tr>
</tbody>
</table>

**Obtaining Annotation Information**

This example illustrates the use of \texttt{ANnumann/afnumann} to obtain the number of annotations of an object, \texttt{ANannlist/afannlist} to obtain the list of annotation identifiers, and \texttt{ANid2tagref/afidtagref}, \texttt{ANtype2tag/afatypetag}, and \texttt{ANtag2atype/afatagtype} to perform some identifier conversions.

In this example, the program locates the vgroup named "AN Vgroup" that was created in the file "General_HDFobjects.hdf" by Example 1. The program then gets the number of data descriptions that this vgroup has and the list of their identifiers. If there are any identifiers in the list, the program displays the corresponding reference numbers. Finally, the program makes two simple conversions, from an annotation type to a tag and from a tag to an annotation type, and displays the results.

```c
#include "hdf.h"

#define FILE_NAME   "General_HDFobjects.hdf"
#define VG_NAME     "AN Vgroup"

main( )
{
```

December 30, 2003
```c
/************************* Variable declaration ***************************/
int n_status;  /* returned status for functions returning an int */
int32 status_32,     /* returned status for functions returning an int32*/
file_id, an_id, ann_id,
  n_annots,      /* number of annotations */
*ann_list,      /* list of annotation identifiers */
  vgroup_ref,    /* reference number of the vgroup */
index;         /* index of an annotation in the annotation list */
  ann_type annot_type = AN_DATA_DESC;   /* annotation to be obtained*/
uint16 ann_tag, ann_ref,              /* tag/ref number of an annotation */
  vgroup_tag = DFTAG_VG;         /* tag of the vgroup */

/************************* End of variable declaration ***************************/

/*
* Create the HDF file.
*/
file_id = Hopen (FILE_NAME, DFACC_READ, 0);

/*
* Initialize the V interface.
*/
status_n = Vstart (file_id);

/*
* Get the vgroup named VG_NAME.
*/
vgroup_ref = Vfind  (file_id, VG_NAME);

/*
* Initialize the AN interface and obtain an interface id.
*/
an_id = ANstart (file_id);

/*
* Get the number of object descriptions. Note that, since ANnumann takes
* the tag and reference number as being of type unit16, vgroup_ref must be
* safely cast to uint16 by checking for FAIL value first.
*/
if (vgroup_ref != FAIL)
{
  n_annots = ANnumann (an_id, annot_type, vgroup_tag, (uint16)vgroup_ref);

  /*
   * Allocate space to hold the annotation identifiers.
   */
  ann_list = malloc (n_annots * sizeof (int32));

  /*
   * Get the list of identifiers of the annotations attached to the
   * vgroup and of type annot_type.
   */
  n_annots = ANannlist (an_id, annot_type, vgroup_tag, (uint16)vgroup_ref,
                      ann_list);

  /*
   * Get each annotation identifier from the list then display the
   * tag/ref number pair of the corresponding annotation.
   */
  printf ("List of annotations of type AN_DATA_DESC:n");
  for (index = 0; index < n_annots; index++)
  {
```

National Center for Supercomputing Applications
/*
  * Get and display the ref number of the annotation from
  * its identifier.
  */
  status_32 = ANid2tagref (ann_list[index], &ann_tag, &ann_ref);
  printf ("Annotation index %d: tag = %s\nreference number= %d\n", index, ann_tag == DFTAG_DIA ? "DFTAG_DIA (data description)" : "Incorrect", ann_ref);
} /* for */
} /* for */

/*
  * Get and display an annotation type from an annotation tag.
  */
  annot_type = ANtag2atype (DFTAG_FID);
  printf ("\nAnnotation type of DFTAG_FID (file label) is %s\n", annot_type == AN_FILE_LABEL ? "AN_FILE_LABEL" : "Incorrect");

/*
  * Get and display an annotation tag from an annotation type.
  */
  ann_tag = ANatype2tag (AN_DATA_LABEL);
  printf ("\nAnnotation tag of AN_DATA_LABEL is %s\n", ann_tag == DFTAG_DIL ? "DFTAG_DIL (data label)" : "Incorrect");

/*
  * Terminate access to the AN interface and close the HDF file.
  */
  status_32 = ANend (an_id);
  status_n = Hclose (file_id);

/*
  * Free the space allocated for the annotation identifier list.
  */
  free (ann_list);
}

FORTRAN:

program annotation_info
implicit none
C
C     Parameter declaration
C
character*22 FILE_NAME
character*9  VG_NAME
C
parameter (FILE_NAME      = 'General_HDFobjects.hdf',
           VG_NAME        = 'AN Vgroup')
integer    DFACC_READ
parameter (DFACC_READ = 1)
integer AN_FILE_LABEL, AN_DATA_LABEL, AN_DATA_DESC
parameter (AN_FILE_LABEL      = 2,
              AN_DATA_LABEL = 0,
              AN_DATA_DESC  = 1)
integer DFTAG_DIA, DFTAG_FID, DFTAG_DIL
parameter (DFTAG_DIA = 105,
              DFTAG_FID = 100,
              DFTAG_DIL = 104)
integer DFTAG_VG
parameter (DFTAG_VG = 1965)
C
C     Function declaration
C
integer hopen, hclose
integer afstart, afnumann, afidtagref, aftypeatag, afatypetag, afend
integer vfstart, vfind

C**** Variable declaration ****************************
C
integer status
integer file_id, an_id
integer n_annots, ann_index, annot_type, ann_tag, ann_ref
integer ann_list(10)
in integer vgroup_tag, vgroup_ref
C
C**** End of variable declaration ****************************
C
annot_type = AN_DATA_DESC
vgroup_tag = DFTAG_VG

C Open the HDF file for reading.
C
file_id = hopen(FILE_NAME, DFACC_READ, 0)

C Initialize the V interface.
C
status = vfstart(file_id)

C Get the group named VG_NAME.
C
vgroup_ref = vfind(file_id, VG_NAME)

C Initialize the AN interface.
C
an_id = afstart(file_id)

C Get the number of object descriptions.
C
if (vgroup_ref .eq. -1) goto 100
n_annots = afnumann(an_id, annot_type, vgroup_tag, vgroup_ref)

C Get the list of identifiers of the annotations attached to the
C vgroup and of type annot_type. Identifiers are read into ann_list
C buffer. One has to make sure that ann_list has the size big enough
C to hold the list of identifiers.
C
n_annots = afannlist(an_id, annot_type, vgroup_tag, vgroup_ref,
                     + ann_list)

C Get each annotation identifier from the list then display the
tag/ref number pair of the corresponding annotation.
C
write(*,*) 'List of annotations of type AN_DATA_DESC'
do 10 ann_index = 0, n_annots - 1
C
C Get and display the ref number of the annotation from its
C identifier.
C
status = afidtagref(ann_list(ann_index+1), ann_tag, ann_ref)
write(*,*) 'Annotation index: ', ann_index
if (ann_tag .eq. DFTAG_DIA) then
    write(*,*) 'tag - DFTAG_DIA (data description)'
else
  write(*,*) ' tag = Incorrect'
endif
write(*,*) 'reference number = ', ann_ref
continue

C     Get and display an annotation type from an annotation tag.
C
  annot_type = aitagtype(DFTAG_FID)
  if (annot_type .eq. AN_FILE_LABEL) then
    write(*,*) 'Annotation type of DFTAG_FID (file label) is ',
                'AN_FILE_LABEL'
  else
    write(*,*) 'Annotation type of DFTAG_FID (file label) is ',
                'Incorrect'
  endif

C     Get and display an annotation tag from an annotation type.
C
  ann_tag = afatypetag(AN_DATA_LABEL)
  if (ann_tag .eq. DFTAG_DIL) then
    write(*,*) 'Annotation tag of AN_DATA_LABEL is ',
                'DFTAG_DIL (data label)'
  else
    write(*,*) 'Annotation type of DFTAG_FID (file label) is ',
                'Incorrect'
  endif

C     Terminate access to the AN interface and close the HDF file.
C
100   continue
  status = afend(an_id)
  status = hclose(file_id)
eend
11.1 Chapter Overview

The original HDF annotation tools were the single-file tools that constitute the DFAN interface. These tools, which are used to read and write file and data object annotations, are described in this chapter.

Note that there is a multi-file annotations interface, called the AN interface, for dealing with annotations. The AN interface supersedes the DFAN interface and is described in Chapter 10, Annotations (AN API).

11.2 The Single-file Annotation Interface

The functions and routines that comprise the single-file annotation interface have names that begin with the string "DFAN" in C; the equivalent FORTRAN-77 routine names are prefaced by "da". This interface is the older annotation interface and only supports annotation access within one particular HDF file. It doesn’t support the concept of an annotation identifier used in the newer multi-file interface. Therefore, annotations created with the multi-file interface cannot be accessed or manipulated with DFAN interface functions.

11.2.1 DFAN Library Routines

These functions are divided into the following categories:

- **Write routines** assign a file or object annotation.
- **Read routines** retrieve a file or object annotation.
- **General inquiry routines** return a list of all labels and reference numbers.
- **Maintenance routine** performs cleanup services.

The DFAN interface routines are listed in the following table and are discussed in the subsequent sections of this document.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Functions</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write</td>
<td>DFANaddfds</td>
<td>daafds Assigns a file description to a specific file</td>
</tr>
<tr>
<td></td>
<td>DFANaddfid</td>
<td>daafid Assigns a file label to a specific file</td>
</tr>
<tr>
<td></td>
<td>DFANputdesc</td>
<td>dapdesc Assigns an object description to a specific data object</td>
</tr>
<tr>
<td></td>
<td>DFANputlabel</td>
<td>daplalb Assigns an object label to a specific data object</td>
</tr>
</tbody>
</table>
11.2.2 Tags in the Annotation Interface

Table 11B lists the annotation tags defined in HDF versions 2.0, 3.0, and 4.0. Newly-defined tag names in each version are bolded. For a more complete list of tags, refer to the *HDF Specifications and Developer’s Guide* v3.2 from the HDF WWW home page at [http://hdf.ncsa.uiuc.edu/](http://hdf.ncsa.uiuc.edu/).

**TABLE 11B**

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Functions</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Read</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFANgetdesc</td>
<td>dagdesc</td>
<td>Reads the text of an object description</td>
</tr>
<tr>
<td>DFANgetdesclen</td>
<td>dagdlen</td>
<td>Returns the length of an object description</td>
</tr>
<tr>
<td>DFANgetfds</td>
<td>dagfds</td>
<td>Reads the text of a file description</td>
</tr>
<tr>
<td>DFANgetfslen</td>
<td>dagfsl</td>
<td>Returns the length of a file description</td>
</tr>
<tr>
<td>DFANgetfid</td>
<td>dagfid</td>
<td>Reads the text of a file label</td>
</tr>
<tr>
<td>DFANgetfidlen</td>
<td>dagfidl</td>
<td>Returns the length of a file label</td>
</tr>
<tr>
<td>DFANgetlabel</td>
<td>daglab</td>
<td>Reads the text of an object label</td>
</tr>
<tr>
<td>DFANgetlablen</td>
<td>daglablen</td>
<td>Returns the length of an object label</td>
</tr>
<tr>
<td><strong>General Inquiry</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFANlablist</td>
<td>dallist</td>
<td>Gets a list of all the labels in a file for a particular tag</td>
</tr>
<tr>
<td>DFANlastref</td>
<td>dalref</td>
<td>Returns the reference number of the last annotation accessed</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFANclear</td>
<td>None</td>
<td>Clears the internal tables and structures used by the DFAN interface</td>
</tr>
</tbody>
</table>

**List of Annotation Interface Tags in HDF Versions 2.0, 3.0 and 4.0**

<table>
<thead>
<tr>
<th>Interface</th>
<th>Data Object</th>
<th>Tag Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>v2.0</td>
</tr>
<tr>
<td><strong>DFR8</strong></td>
<td>Raster Image: 8-bit (uncompressed)</td>
<td>DFTAG_RI8</td>
</tr>
<tr>
<td></td>
<td>Compressed Image: 8-bit</td>
<td>DFTAG_CI8</td>
</tr>
<tr>
<td></td>
<td>Image Dimension: 8-bit</td>
<td>DFTAG_ID8</td>
</tr>
<tr>
<td></td>
<td>Image Palette: 8-bit</td>
<td>DFTAG_IP8</td>
</tr>
<tr>
<td><strong>DF24</strong></td>
<td>Raster Image Group</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Raster Image (uncompressed)</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Compressed Image</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Image Dimension</td>
<td>None</td>
</tr>
<tr>
<td><strong>DFP</strong></td>
<td>Color Look-up Table</td>
<td>DFTAG_LUT</td>
</tr>
<tr>
<td><strong>DFSD</strong></td>
<td>Scientific Data Group</td>
<td>DFTAG_SDG</td>
</tr>
<tr>
<td></td>
<td>Scientific Data</td>
<td>DFTAG_SD</td>
</tr>
<tr>
<td></td>
<td>Scientific Data Dimension</td>
<td>DFTAG_SDD</td>
</tr>
<tr>
<td></td>
<td>Scientific Data Scale Attribute</td>
<td>DFTAG_SDS</td>
</tr>
<tr>
<td></td>
<td>Scientific Data Label Attribute</td>
<td>DFTAG(SDL)</td>
</tr>
<tr>
<td></td>
<td>Scientific Data Unit Attribute</td>
<td>DFTAG_SDU</td>
</tr>
<tr>
<td></td>
<td>Scientific Data Format Attribute</td>
<td>DFTAG_SDF</td>
</tr>
<tr>
<td></td>
<td>Scientific Data Max/Min Attribute</td>
<td>DFTAG_SDM</td>
</tr>
<tr>
<td></td>
<td>Scientific Data Coordinates Attribute</td>
<td>DFTAG_SDC</td>
</tr>
<tr>
<td><strong>DFAN</strong></td>
<td>File Identifier</td>
<td>DFTAG_FID</td>
</tr>
<tr>
<td></td>
<td>File Descriptor</td>
<td>DFTAG_FD</td>
</tr>
<tr>
<td></td>
<td>Data Identifier Label</td>
<td>DFTAG_DIL</td>
</tr>
<tr>
<td></td>
<td>Data Identifier Annotation</td>
<td>DFTAG_DIA</td>
</tr>
</tbody>
</table>
11.3 Programming Model for the DFAN Interface

There are two general programming models for the DFAN interface; the first programming model addresses file annotation while the second addresses object annotation. In the case of file annotations, the DFAN interface relies on the calling program to initiate and terminate access to files. This approach necessitates the following programming model:

1. Open the file.
2. Perform the desired file annotation operation.
3. Close the file.

The object annotation programming model is a simplified version of the file annotation programming model:

1. Perform the desired object annotation operation.

Essentially, the difference between the two models is that file annotations require Hopen and Hclose to open and close the target files whereas object annotations do not.

11.4 Writing Annotations

The DFAN interface supports writes to file labels, file descriptions, object labels, and object descriptions.

11.4.1 Assigning a File Label: DFANaddfid

To write a file label, the calling program must call DFANaddfid:

C: status = DFANaddfid(file_id, label);

FORTRAN: status = daafid(file_id, label)

DFANaddfid has two parameters: file_id and label. The file_id parameter contains the file identifier for the file to be annotated and the label parameter contains the annotation string. The label array must be null-terminated. In the FORTRAN-77 version, the length of the label should be the length of the label array as in FORTRAN-77 string lengths are assumed to be the declared length of the array that holds the string.

The parameters of DFANaddfid are further defined in Table 11C on page 364.

11.4.2 Assigning a File Description: DFANaddfds

To write a file description, the calling program must call DFANaddfds:

C: status = DFANaddfds(file_id, description, desc_length);

FORTRAN: status = daafds(file_id, description, desc_length)

DFANaddfds has three parameters: file_id, description, and desc_length. The file_id parameter contains the file identifier. The parameter description can contain any sequence of ASCII characters and is not limited to a single string (e.g., a carriage return may appear anywhere in the description). The desc_length parameter specifies the length of the description.

The parameters of DFANaddfds are defined in Table 11C.
TABLE 11C

<table>
<thead>
<tr>
<th>Routine Name [Return Type] [FORTRAN-77]</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFANadd [intn] (daafid)</td>
<td>file_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>label</td>
<td>char *</td>
<td>File identifier</td>
</tr>
<tr>
<td>DFANaddfds [intn] (daafdfs)</td>
<td>file_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>description</td>
<td>char *</td>
<td>File description string</td>
</tr>
<tr>
<td></td>
<td>desc_length</td>
<td>int32</td>
<td>Length of the description in bytes</td>
</tr>
</tbody>
</table>

EXAMPLE 1.

Writing a File Label and a File Description

The following examples add a file label and description to the file named "Example1.hdf". Notice that after the file is opened, the file_id may be used to add any combination of file annotations before the file is closed.

C:

```c
#include "hdf.h"

int32 file_id;
intn status;
static char file_label[] = "This is a file label."
static char file_desc[] = "This is a file description."

/* Open the HDF file to write the annotations. */
file_id = Hopen("Example1.hdf", DFACC_CREATE, 0);

/* Write the label to the file. */
status = DFANaddfid(file_id, file_label);

/* Write the description to the file. */
status = DFANaddfds(file_id, file_desc, strlen(file_desc));

/* Close the file. */
status = Hclose(file_id);
```

FORTRAN:

```fortran
PROGRAM CREATE ANNOTATION

character*50 file_label, file_desc
integer daafid, daafdfs, status, file_id, hopen, hclose
integer*4 DFACC_CREATE
parameter (DFACC_CREATE = 4)

file_label = "This is a file label."
file_desc = "This is a file description."

C Open the HDF file to write the annotations.
file_id = hopen('Example1.hdf', DFACC_CREATE, 0)

C Write the label to the file.
```
status = daafid(file_id, file_label)

C     Write the description to the file.
status = daafds(file_id, file_desc, 26)

C     Close the file.
status = hclose(file_id)

end

11.4.3 Assigning an Object Label: DFANputlabel

To write a file label, the calling program must contain a call to DFANputlabel:

C:       status = DFANputlabel(filename, tag, ref, label);
FORTRAN: status = daplab(filename, tag, ref, label)

DFANputlabel has four parameters: filename, tag, ref, and label. The label parameter contains a single null-terminated string that defines the annotation.

The parameters of DFANputlabel are further defined in Table 11D.

11.4.4 Assigning an Object Description: DFANputdesc

To write an object description, the calling program must contain a call to DFANputdesc:

C:       status = DFANputdesc(filename, tag, ref, description, desc_len);
FORTRAN: status = dapdesc(filename, tag, ref, description, desc_len)

DFANputdesc has five parameters: filename, tag, ref, description, and desc_len. The filename parameter is the name of the HDF file containing the object to be annotated. The tag and ref parameters are the tag/reference number pair of the object to be annotated. The description parameter contains a buffer for the annotation text and the desc_len parameter specifies the length of the buffer.

The parameters of DFANputdesc are further defined in Table 11D.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>[Return Type] [FORTRAN-77]</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFANputlabel</td>
<td>[int] (daplab)</td>
<td>filename</td>
<td>char *</td>
<td>character(*)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tag</td>
<td>uint16</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ref</td>
<td>uint16</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>label</td>
<td>char *</td>
<td>character(*)</td>
</tr>
<tr>
<td>DFANputdesc</td>
<td>[int] (dapdesc)</td>
<td>filename</td>
<td>char *</td>
<td>character(*)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>tag</td>
<td>uint16</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ref</td>
<td>uint16</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>description</td>
<td>char *</td>
<td>character(*)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>desc_len</td>
<td>int32</td>
<td>integer</td>
</tr>
</tbody>
</table>
EXAMPLE 2.

Writing an Object Label and Description to a Scientific Data Set

These examples illustrate the use of `DFANputlabel` and `DFANputdesc` to assign both an object label and an object description to a scientific data set immediately after it is written to file. The tag for scientific data sets is `DFTAG_NDG`.

C:

```c
#include "hdf.h"

#define X_LENGTH 3
#define Y_LENGTH 2
#define Z_LENGTH 5

main()
{

    /* Create the data array. */
    static float32 sds_data[X_LENGTH][Y_LENGTH][Z_LENGTH] =
        {  1,  2,  3,  4,  5,
            6,  7,  8,  9, 10,
            11, 12, 13, 14, 15,
            16, 17, 18, 19, 20,
            21, 22, 23, 24, 25,
            26, 27, 28, 29, 30);

    /* Create the array that will hold the dimensions of the data array. */
    int32 dims[3] = {X_LENGTH, Y_LENGTH, Z_LENGTH};
    intn refnum, status;
    static char object_desc[] = "This is an object description."
    static char object_label[] = "This is an object label."

    /* Write the data to the HDF file. */
    status = DFSDadddata("Example1.hdf", 3, dims, (VOIDP)sds_data);

    /* Get the reference number for the newly written data set. */
    refnum = DFSDlastref();

    /* Assign the object label to the scientific data set. */
    status = DFANputlabel("Example1.hdf", DFTAG_NDG, refnum, object_label);

    /* Assign the object description to the scientific data set. */
    status = DFANputdesc("Example1.hdf", DFTAG_NDG, refnum, object_desc, strlen(object_desc));
}
```

FORTRAN:

```fortran
PROGRAM ANNOTATE_OBJECT

    integer dsadata, dims(3), status, refnum
    integer daplab, dapdesc, dslref

    integer*4 DFTAG_NDG, X_LENGTH, Y_LENGTH, Z_LENGTH
    parameter(DFTAG_NDG = 720,
        +      X_LENGTH = 5,
        +      Y_LENGTH = 2,
        +      Z_LENGTH = 3)
```
C Create the data array.
real*4 sds_data(X_LENGTH, Y_LENGTH, Z_LENGTH)
data sds_data /
+  1,  2,  3,  4,  5,
+  6,  7,  8,  9, 10,
+ 11, 12, 13, 14, 15,
+ 16, 17, 18, 19, 20,
+ 21, 22, 23, 24, 25,
+ 26, 27, 28, 29, 30 /

C Create the array the will hold the dimensions of the data array.
data dims /X_LENGTH, Y_LENGTH, Z_LENGTH/

C Write the data to the HDF file.
ref = dsadata('Example1.hdf', 3, dims, sds_data)

C Get the reference number for the newly written data set.
refnum = dalref( )

C Assign the object label to the scientific data set.
status = daplab('Example1.hdf', DFTAG_NDG, refnum,
+ 'This is an object label. ')

C Assign an object description to the scientific data set.
status = dapdesc('Example1.hdf', DFTAG_NDG, refnum,
+ 'This is an object description.', 30)

end

11.5 Reading Annotations

The DFAN interface provides several functions for reading file and data object annotations, which are described below.

11.5.1 Reading a File Label: DFANgetfidlen and DFANgetfid

The DFAN programming model for reading a file label is as follows:
1. Get the length of the label.
2. Read the file label.

To read the first file label in a file, the calling program must contain the following function calls:

C: isfirst = 1;
   label_length = DFANgetfidlen(file_id, isfirst);
   label_buffer = HDgetspace(label_length);
   fid_len = DFANgetfid(file_id, label_buffer, label_length, isfirst);

FORTRAN: isfirst = 1
   label_length = dag fidl(file_id, isfirst)
   fid_len = dagfid(file_id, label_buffer, label_length, isfirst)

DFANgetfidlen has two parameters: file_id and isfirst. The isfirst parameter specifies whether the first or subsequent file annotations are to be read. To read the first file label length, isfirst should be set to the value 1; to sequentially step through all the remaining file labels assigned to a file isfirst should be set to 0.
When **DFANgetfdlen** is first called for a given file, it returns the length of the first file label. To get the lengths of subsequent file labels, you must call **DFANgetfid** between calls to **DFANgetfdlen**. Otherwise, additional calls to **DFANgetfdlen** will return the length of the same file label.

**DFANgetfid** has four parameters: `file_id`, `label_buffer`, `label_length`, and `isfirst`. The `label_buffer` parameter is a pointer to a buffer for the label text. The `label_length` parameter is the length of the buffer in memory, which can be shorter than the full length of the label in the file. If the `label_length` is not large enough, the label is truncated to `label_length - 1` characters in the buffer `label_buffer`. The `isfirst` parameter is used to determine whether to read the first or subsequent file annotations. To read the first file label, `isfirst` should be set to 1; to sequentially step through all the remaining file labels assigned to a file, `isfirst` should be set to 0.

**HDgetspace** is described in Chapter 2, *HDF Fundamentals*.

The parameters of **DFANgetfdlen** and **DFANgetfid** are described in Table 11E.

### 11.5.2 Reading a File Description: **DFANgetfdslen** and **DFANgetfds**

The DFAN programming model for reading a file description is as follows:

1. Get the length of the description.
2. Read the file description.

To read the first file description in a file, the calling program must contain the following calls:

**C:**

```c
isfirst = 1;
desc_length = DFANgetfdslen(file_id, isfirst);
desc_buffer = HDgetspace(desc_length);
fds_len = DFANgetfd(file_id, desc_buf, desc_length, isfirst);
```

**FORTRAN:**

```fortran
isfirst = 1
desc_length = dagfdsl(file_id, isfirst)
fds_len = dagfds(file_id, desc_buf, desc_length, isfirst)
```

**DFANgetfdslen** has two parameters: `file_id` and `isfirst`. The `isfirst` parameter specifies whether the first or subsequent file annotations are to be read. To read the first file description length, `isfirst` should be set to the value 1; to sequentially step through all the remaining file descriptions assigned to a file, `isfirst` should be set to 0.

When **DFANgetfdslen** is first called for a given file, it returns the length of the first file description. As with **DFANgetfdslen**, you must call **DFANgetfdsl** between calls to **DFANgetfdslen** to get the lengths of successive file descriptions.

**DFANgetfds** has four parameters: `file_id`, `desc_buf`, `desc_length`, and `isfirst`. The `desc_buffer` parameter is a pointer to a buffer for the description text. The `desc_length` parameter is the length of the buffer in memory, which can be shorter than the full length of the description in the file. If `desc_length` is not large enough, the description is truncated to `desc_length` characters in the buffer `desc_buf`. The `isfirst` parameter specifies whether the first or subsequent file annotations are to be read. To read the first file description, `isfirst` should be set to the value 1; to sequentially step through all the remaining file descriptions assigned to a file, `isfirst` should be set to 0.

The parameters of these routines are described further in the following table.
EXAMPLE 3.

Reading a File Label and a File Description

The following examples read a file label from the HDF file named "Example1.hdf". The DFANgetfidlen routine is used to verify the length of the label before the read operation is performed. The argument "1" in both routines indicate the first description in the HDF file is the target. DFANgetfdslen and DFANgetfds can be directly substituted for DFANgetfidlen and DFANgetfid in order to read a file description instead of a file label.

```
C:

#include "hdf.h"

int32 file_id, file_label_len;
char *file_label;
intn status;

/* Open the HDF file containing the annotation. */
file_id = Hopen("Example1.hdf", DFACC_READ, 0);

/* Determine the length of the file label. */
file_label_len = DFANgetfidlen(file_id, 1);

/* Allocated memory for the file label buffer. */
file_label = HDgetspace(file_label_len);

/* Read the file label. */
file_label_len = DFANgetfid(file_id, file_label, file_label_len, 1);

/* Close the file */
status = Hclose(file_id);
```
FORTRAN:

```fortran
PROGRAM GET_ANNOTATION

  integer status, file_id, label_length
  integer hopen, hclose, dagfidl, dagfid
  character file_label(50)

  integer*4 DFACC_READ
  parameter(DFACC_READ = 1)

  C Open the HDF file containing the file label.
  file_id = hopen("Example1.hdf", DFACC_READ, 0)

  C Determine the length of the file label.
  label_length = dagfidl(file_id, 1)

  C Read the file label.
  status = dagfid(file_id, file_label, label_length, 1)

  C Close the HDF file.
  status = hclose(file_id)
end
```

11.5.3 Reading an Object Label: DFANgetlablen and DFANgetlabel

The DFAN programming model for reading a data object label is as follows:

1. Get the length of the label.
2. Read the file label.

To read the first object label in a file, the calling program must contain the following routines:

```
C: label_length = DFANgetlablen(filename, tag, ref);
    label_buf = HDgetspace(label_length);
    status = DFANgetlabel(filename, tag, ref, label_buf, label_length);

FORTRAN: label_length = daglabl(filename, tag, ref)
          status = daglab(filename, tag, ref, label_buf, label_length)
```

DFANgetlablen returns the length of the label assigned to the object identified by the given tag/reference number pair. DFANgetlabel must be called between calls to DFANgetlablen. DFANgetlabel is the routine that actually returns the label and prepares the API to read the next label.

DFANgetlabel has five parameters: filename, tag, ref, label_buf, and label_length. The label_buf parameter is a pointer to a buffer that stores the label text. The label_length parameter is the length of the buffer in memory. label_length can be shorter than the full length of the label in the file, but if so, the label is truncated to label_length characters in the buffer label_buf. The length of label_buf must be at least one greater than the anticipated length of the label to account for the null termination appended to the label text.

The parameters of DFANgetlablen and DFANgetlabel are defined below.
11.5.4 Reading an Object Description: DFANgetdesclen and DFANgetdesc

The DFAN programming model for reading a data object description is as follows:

1. Get the length of the description.
2. Read the file description.

To read the first object description in a file, the calling program must contain the following routines:

**C:**
```
desc_length = DFANgetdesclen(filename, tag, ref);
desc_buf = HDgetspace(desc_length);
status = DFANgetdesc(filename, tag, ref, desc_buf, desc_length);
```

**FORTRAN:**
```
label_length = dagdlen(filename, tag, ref)
status = dagdesc(filename, tag, ref, desc_buf, desc_length)
```

**DFANgetdesclen** returns the length of the description assigned to the object identified by the specified tag/reference number pair. **DFANgetdesc** must be called between calls to **DFANgetdesclen** to reset the current object description to the next in the file.

**DFANgetdesc** takes five parameters: filename, tag, ref, desc_buf, and desc_length. The desc_buf parameter is a pointer to the buffer that stores the description text. The desc_length parameter is the length of the buffer in memory, which can be shorter than the full length of the description in the file. If the desc_length is not large enough, the description is truncated to desc_length characters in the buffer desc_buf.

The parameters of **DFANgetdesclen** and **DFANgetdesc** are defined in the following table.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFANgetlablen</td>
<td>filename</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td></td>
<td>tag</td>
<td>uint16</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>ref</td>
<td>uint16</td>
<td>integer</td>
</tr>
<tr>
<td>DFANgetlabel</td>
<td>filename</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td></td>
<td>tag</td>
<td>uint16</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>ref</td>
<td>uint16</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>label_buf</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td></td>
<td>label_length</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>DFANgetdesclen</td>
<td>filename</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td></td>
<td>tag</td>
<td>uint16</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>ref</td>
<td>uint16</td>
<td>integer</td>
</tr>
<tr>
<td>DFANgetdesc</td>
<td>filename</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td></td>
<td>tag</td>
<td>uint16</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>ref</td>
<td>uint16</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>desc_buf</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td></td>
<td>desc_length</td>
<td>int32</td>
<td>integer</td>
</tr>
</tbody>
</table>
Reading an Object Label and Description

The following examples demonstrate the use of `DFANgetdesclen` and `DFANgetdesc` to read an object description assigned to a scientific data set. These examples assume that, in addition to other data objects, the "Example1.hdf" HDF file also contains multiple scientific data sets, some of which may not be annotated. `Hfind` is used to determine the reference number for the first annotated scientific data object in the file.

C:

```c
#include "hdf.h"

main( )
{
    int32 desc_length = -1, status;
    char desc[50];
    int32 file_id;
    uint16 tag = 0, ref = 0;
    uint32 find_offset, find_length;

    /* Open the file and initialize the searching parameters to 0. */
    file_id = Hopen("Example1.hdf", DFACC_READ, 0);

    /*
     * Start a sequential forward search for the first reference
     * number assigned to a scientific data set.
     *
     * while (Hfind(file_id, DFTAG_NDG, DFREF_WILDCARD, &tag, &ref, \
     *       &find_offset, &find_length, DF_FORWARD) != FAIL) {
     */

    /*
     * After discovering a valid reference number, check for an
     * object description by returning the length of the description.
     * If the inquiry fails, continue searching for the next valid
     * reference number assigned to a scientific data set.
     *
     * if ((desc_length = DFANgetdesclen("Example1.hdf", tag, ref)) \
     *     == FAIL)
     *    break;
     */

    /*
     * If a description exists and it will fit in the description buffer,
     * print it.
     *
     * if (desc_length != FAIL && desc_length <= 50) {
     *    status = DFANgetdesc("Example1.hdf", tag, ref, desc, desc_length);
     *    printf("Description: \%s\n", desc);
     * }
     */

    /* Close the file. */
    status = Hclose(file_id);
}
```

FORTRAN:

There is no FORTRAN-77 version of the Example 4 C code for this version of the documentation as there is no FORTRAN-77 equivalent of `Hfind`.
11.6 Maintenance Routines

The DFAN interface provides one function for interface maintenance, **DFANclear**.

11.6.1 Clearing the DFAN Interface Internal Structures and Settings: **DFANclear**

**DFANclear** clears all internal library structures and parameters of the DFAN annotation interface.

When a file is regenerated in a single run by a library routine of another interface (such as **DFSDput-data**), **DFANclear** should be called to reset the interface.

**DFANclear** returns **SUCCEED** (or 0) if successful and **FAIL** (or -1) otherwise. **DFANclear** takes no parameters, as described in the following table.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFANclear</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

11.7 Determining Reference Numbers

It is advisable to check the reference number before attempting to assign an object annotation, as the overwriting of reference numbers is not prevented by the HDF library routines.

There are three ways to check a reference number for an object:

- Access the object with a read or write operation followed by **DF*lastref**.
- Call **DFANlablist** to return a list of all assigned reference numbers for a given tag.
- Call **Hfind** to locate an object with a given tag/reference number pair.

11.7.1 Determining a Reference Number for the Last Object Accessed: **DF*lastref** and **DF*writeref**

There are two methods of obtaining a reference number through the use of a **DF*lastref** call. The first approach is to obtain and store the reference number of an object immediately after the object is created:

1. Create the data object.
2. Call **DF*lastref** to determine its reference number.
3. Read or write an object annotation.

The second approach is to determine the reference number at some time after the data object is created. This approach requires repeated **DF*read** calls until the appropriate object is accessed, followed by a call to **DF*lastref**:

1. Read the appropriate data object.
2. Call **DF*lastref** to determine its reference number.
3. Read or write and object annotation.

Most HDF interfaces provide one routine that assigns a specified reference number to a data object and another routine that returns the reference number for the last data object accessed. (See
Table 11H.) However, the SD interface doesn’t. Also, the DFAN annotation doesn’t include a DF*lastref routine.

Although DF*writerref calls are designed to assign specific reference numbers, they are not recommended for general use because there is no protection against reassigning an existing reference number and overwriting data. In general, it is better to determine a reference number for a data object by calling DF*lastref immediately after reading or writing a data object.

The DF*lastref routines have no parameters. The DF*writerref routines have two: filename, which is the name of the file that contains the data object, and ref, which is the reference number for the next data object read operation.

The DF*lastref and DF*writerref routines are further described in the following table.

<table>
<thead>
<tr>
<th>HDF Data Object</th>
<th>Routine Name (FORTRAN-77)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-bit Raster Image</td>
<td>DFR8writeref (d8wref)</td>
<td>Assigns the specified number as the reference number for the next 8-bit raster write operation and updates the write counter to reflect highest reference number</td>
</tr>
<tr>
<td></td>
<td>DFR8lastref (d8lref)</td>
<td>Returns the reference number for the last 8-bit raster image set accessed</td>
</tr>
<tr>
<td>24-bit Raster Image</td>
<td>DF24writeref (d2wref)</td>
<td>Assigns the specified number as the reference number for the next 24-bit raster write operation and updates the write counter to reflect the highest reference number</td>
</tr>
<tr>
<td></td>
<td>DF24lastref (d2lref)</td>
<td>Returns the reference number for the last 24-bit raster image set accessed</td>
</tr>
<tr>
<td>Palette</td>
<td>DFPwriteref (dpwref)</td>
<td>Assigns the specified number as the reference number for the next palette write operation and updates the write counter to reflect the highest reference number</td>
</tr>
<tr>
<td></td>
<td>DFPlastref (dp1ref)</td>
<td>Returns the reference number for the last palette accessed</td>
</tr>
<tr>
<td>DFSD Scientific Data</td>
<td>DFSDwriteref (ds1ref)</td>
<td>Assigns the specified number as the reference number for the next SDS write operation and updates the write counter to reflect the highest reference number</td>
</tr>
<tr>
<td></td>
<td>DFSDlastref (ds1ref)</td>
<td>Returns the reference number for the last scientific data set accessed</td>
</tr>
<tr>
<td>Annotation</td>
<td>DFANlastref (d1ref)</td>
<td>Returns the reference number for the last annotation accessed</td>
</tr>
</tbody>
</table>

11.7.2 Querying a List of Reference Numbers for a Given Tag: DFANlablist

Given a tag and two buffers, DFANlablist will fill one buffer with all reference numbers for the given tag and the other with all labels assigned to the given tag. The programming model for determining a list of reference numbers is as follows:

1. Determine the number of reference numbers that exist for a given tag.
2. Allocate a buffer to store the reference numbers.
3. Specify the maximum label length.
4. Allocate a buffer to store the labels.
5. Store the list of reference numbers and their labels.

To create a list of reference numbers and their labels for a given tag, the following routines should be called:

```c
num_refs = Hnumber(file_id, tag);
ref_buf = HDmalloc(sizeof(uint16*)*num_refs);
max_lab_len = 16;
label_buf = HDmalloc(max_lab_len * num_refs);
start_pos = 0;
```
num_of_refs = DFANlablist(filename, tag, ref_buf, label_buf,
num_refs, max_lab_len,
start_pos);

FORTRAN: num_refs = hnumber(file_id, tag)
max_lab_len = 16
start_pos = 0
num_of_refs = dallist(filename, tag, ref_buf, label_buf,
num_refs, max_lab_len, start_pos)

Hnumber determines how many objects with the specified tag are in a file. It is described in Chapter 2, *HDF Fundamentals*.

DFANlablist has seven parameters: filename, tag, ref_list, label_buf, num_refs, max_lab_len, and start_pos. The filename parameter specifies the name of the file to search and tag specifies the search tag to use when creating the reference and label list. The ref_buf and label_buf parameters are buffers used to store the reference numbers and labels associated with tag. The num_ref parameter specifies the length of the reference number list and the max_lab_len parameter specifies the maximum length of a label. The start_pos parameter specifies the first label to read. For instance, if start_pos has a value of 1 all labels will be read; if it has a value of 4, all but the first three labels will be read.

Taken together, the contents of ref_list and label_list constitute a directory of all objects and their labels for a given tag. The contents of label_list can be displayed to show all of the labels for a given tag or it can be searched to find the reference number of a data object with a certain label. Once the reference number for a given label is found, the corresponding data object can be accessed by invoking other HDF routines. Therefore, this routine provides a mechanism for direct access to data objects in HDF files.

### TABLE 11

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFANlablist</td>
<td>filename</td>
<td>char *</td>
<td>Name of the file to be accessed.</td>
</tr>
<tr>
<td></td>
<td>tag</td>
<td>uint16</td>
<td>Tag assigned to the annotated object.</td>
</tr>
<tr>
<td></td>
<td>ref_list</td>
<td>uint16 [ ]</td>
<td>Reference number for the annotated object.</td>
</tr>
<tr>
<td></td>
<td>label_list</td>
<td>char *</td>
<td>Buffer for the labels.</td>
</tr>
<tr>
<td></td>
<td>list_len</td>
<td>int</td>
<td>Size of the reference number and label lists.</td>
</tr>
<tr>
<td></td>
<td>label_len</td>
<td>uintn</td>
<td>Maximum label length.</td>
</tr>
<tr>
<td></td>
<td>start_pos</td>
<td>intn</td>
<td>First entry in the reference number and label lists to be returned.</td>
</tr>
</tbody>
</table>

### EXAMPLE 5.

**Getting a List of Labels for All Scientific Data Sets**

These examples illustrate the method used to get a list of all labels used in scientific data sets in an HDF file using DFANlablist. The DFS_MAXLEN definition is located in the "hlimits.h" include file.

**C:**

```c
#include "hdf.h"
#define LISTSIZE 20

main( )
```
```c
{
    int i, num_of_labels, start_position = 1, list_length = 10;
    uint16 ref_list[LISTSIZE];
    char label_list[DFS_MAXLEN*LISTSIZE-1];

    /* Get the total number of labels in the "Example1.hdf" file. */
    num_of_labels = DFANlablist("Example1.hdf", DFTAG_NDG, ref_list, \
            label_list, list_length, DFS_MAXLEN,  \n            start_position);

    /* Print the reference numbers and label names for each label
    * in the list.
    */
    for (i = 0; i < num_of_labels; i++)
        printf("\n	%d	Ref number: %d	Label: %s", i+1, ref_list[i], \
            label_list - (i * 13));

    printf("\n");
}
```

**FORTRAN:**

```fortran
PROGRAM GET LABEL LIST

    integer dallist
    integer*4 DFTAG_NDG, LISTSIZE, DFS_MAXLEN

    parameter (DFTAG_NDG = 720, 
                LISTSIZE = 20, 
                DFS_MAXLEN = 255)

    character*60 label_list(DFS_MAXLEN*LISTSIZE)
    integer i, num_of_labels, start_position, ref_list(DFS_MAXLEN)

    start_position = 1

    num_of_labels = dallist('Example1.hdf', DFTAG_NDG, ref_list, \n                        label_list, 10, DFS_MAXLEN,  \n                        start_position)

    do 10 i = 1, num_of_labels
         print *, Ref number: ',ref_list(i), \n            Label: ',label_list(i)
    10    continue

end
```

11.7.3 Locate an Object by Its Tag and Reference Number: Hfind

Instead of using DFANlablist to create a list of reference numbers to search, HDF provides a general search routine called Hfind. Hfind is described in Chapter 2, *HDF Fundamentals*. 
Single-File Scientific Data Sets
(DFSD API)

12.1 Chapter Overview
The DFSD interface is one of two interfaces in the HDF library that support the scientific data model. With the release of HDF version 3.3, the multi-file SD interface described in Chapter 3, *Scientific Data Sets (SD API)*, was made available. Generally, the SD interface should be used instead of the DFSD interface.

12.2 The DFSD Scientific Data Set Data Model
The scientific data set, or SDS, data model supports four primary data objects: arrays, dimensions, dimension scales, and dimension attributes. As in the multi-file SD SDS model, the fundamental object of the data model is the SDS array. Unlike the SD multi-file SDS model the DFSD SDS model has, in addition to dimension attributes, attributes that refer to the SDS array itself.

![The Contents of a Three-Dimensional DFSD Scientific Data Set](image)

12.2.1 Required DFSD SDS Objects
The only required objects in the DFSD SDS model are the *array* and the *data type* of the array data. Without this information, the data set is inaccessible. Required objects are created by the library using the information supplied at the time the SDS is defined.

Descriptions of these objects are in Chapter 3, *Scientific Data Sets (SD API)*.
12.2.1.1 Dimensions

Unlimited dimensions, supported in the multifile SD SDS model, aren’t supported in the single-file DFSD SDS model.

12.2.2 Optional DFSD SDS Objects

There are two types of optional objects available for inclusion in an SDS: dimension scales and attributes. Optional objects are only created when specified by the calling program.

12.2.2.1 Dimension Scales

Conceptually, a dimension *scale* is a series of numbers placed along a dimension to demarcate intervals in a data set. They are assigned one per dimension. Structurally, each dimension scale is a one-dimensional array with size and name equal to its assigned dimension name and size.

12.2.2.2 Predefined Attributes

*Predefined attributes* are attributes that have reserved labels and in some cases predefined number types. They are described in Chapter 3, *Scientific Data Sets (SD API)*.

12.3 The Single-File Scientific Data Set Interface

The HDF library currently contains several routines for storing scientific data sets in the HDF format. *DFSDadddata*, *DFSDputdata*, and *DFSDgetdata* perform data I/O and by default assume that all scientific data is uncompressed 32-bit floating-point data stored in row-major order. DFSD library routines also read and write subsets and slabs of data, set defaults, determine the number of data sets in a file, and inquire about or assigning reference numbers before reading or writing data.

12.3.1 DFSD Library Routines

The names of the C routines in the DFSD library are prefaced by "DFSD" and the names of the equivalent FORTRAN-77 functions are prefaced by "ds". They are categorized as follows:

- **Write routines** create new data sets and add slabs to existing data sets.
- **Read routines** read whole scientific data sets.
- **Slab routines** read and write subsets and slabs of scientific data.
- **Data set attribute routines** read and write the predefined string and value attributes assigned to data sets.
- **Dimension attribute routines** read and write the predefined string and value attributes assigned to dimensions.

DFSD library routines are more explicitly defined in Table A and on their respective pages in the *HDF Reference Manual*.
### TABLE 12A DFSD Library Routines

<table>
<thead>
<tr>
<th>Category</th>
<th>Routine Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write</td>
<td>DFSDadddata</td>
<td>Appends a data set to a file.</td>
</tr>
<tr>
<td></td>
<td>DFEclear</td>
<td>Clears all possible set values.</td>
</tr>
<tr>
<td></td>
<td>DFSDputdata</td>
<td>Overwrites new data to a file.</td>
</tr>
<tr>
<td></td>
<td>DFSDsetdims</td>
<td>Sets the rank and dimension for succeeding data sets.</td>
</tr>
<tr>
<td></td>
<td>DFSDsetNT</td>
<td>Sets the number type for the data set.</td>
</tr>
<tr>
<td></td>
<td>DFSDwriterref</td>
<td>Assigns a reference number to the next data set written.</td>
</tr>
<tr>
<td>Read</td>
<td>DFSDgetdata</td>
<td>Retrieves the next data set in the file.</td>
</tr>
<tr>
<td></td>
<td>DFSDgetdims</td>
<td>Returns the number and dimensions for the next data set.</td>
</tr>
<tr>
<td></td>
<td>DFSDgetNT</td>
<td>Determines the number type for the data in the data set.</td>
</tr>
<tr>
<td></td>
<td>DFSDlastref</td>
<td>Returns the reference number of last data set accessed.</td>
</tr>
<tr>
<td></td>
<td>DFSDnumdatasets</td>
<td>Returns the number of data sets in a file.</td>
</tr>
<tr>
<td></td>
<td>DFSDpre32s</td>
<td>Determines if the data set was created before HDF version 3.2.</td>
</tr>
<tr>
<td></td>
<td>DFSDreadref</td>
<td>Locates a data set with the specified reference number.</td>
</tr>
<tr>
<td></td>
<td>DFSDreset</td>
<td>Sets the location of the next access operation to be the first data set in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the file.</td>
</tr>
<tr>
<td>Slabs</td>
<td>DFSDendslab</td>
<td>Terminates a read or write slab operation.</td>
</tr>
<tr>
<td></td>
<td>DFSDreadslab</td>
<td>Reads a slab of data from a data set.</td>
</tr>
<tr>
<td></td>
<td>DFSDstartslab</td>
<td>Begins a read or write slab operation.</td>
</tr>
<tr>
<td></td>
<td>DFSDwriteslab</td>
<td>Writes a slab of data to a data set.</td>
</tr>
<tr>
<td>Data Set</td>
<td>DFSDgetcal</td>
<td>Retrieves the calibration information for the data set.</td>
</tr>
<tr>
<td>Attribute</td>
<td>DFSDgetdalen</td>
<td>Retrieves the length of the attributes assigned to the data.</td>
</tr>
<tr>
<td></td>
<td>DFSDgetdatastr</td>
<td>Returns the label, unit, format and coordinate system for data.</td>
</tr>
<tr>
<td></td>
<td>DFSDgetfillvalue</td>
<td>Retrieves the fill value used to complete the data set.</td>
</tr>
<tr>
<td></td>
<td>DFSDgetrange</td>
<td>Retrieves the range of values for the data set.</td>
</tr>
<tr>
<td></td>
<td>DFSDsetcal</td>
<td>Sets the calibration information for the data set.</td>
</tr>
<tr>
<td></td>
<td>DFSDsetdalen</td>
<td>Sets label, unit, format and coordinate system for data.</td>
</tr>
<tr>
<td></td>
<td>DFSDsetdatastr</td>
<td>Sets the fill value to use when completing a data set.</td>
</tr>
<tr>
<td></td>
<td>DFSDsetfillvalue</td>
<td>Sets the length for the data set and dimension attributes.</td>
</tr>
<tr>
<td></td>
<td>DFSDsetlengths</td>
<td>Sets the range of values for the data set.</td>
</tr>
<tr>
<td>Dimension</td>
<td>DFSDgetdimlen</td>
<td>Retrieves the length of the attributes assigned to the dimension.</td>
</tr>
<tr>
<td>Attribute</td>
<td>DFSDgetdimscale</td>
<td>Returns the scale for a dimension.</td>
</tr>
<tr>
<td></td>
<td>DFSDgetdimstrs</td>
<td>Sets the label, unit, and format for a dimension.</td>
</tr>
</tbody>
</table>

#### 12.3.2 File Identifiers in the DFSD Interface

File identifiers are handled internally by each routine and access to a file is granted simply by providing a filename. As the file identifier is handled by the function call, the calling program need not keep track of how to open and close files.
12.4 Writing DFSD Scientific Data Sets

The DFSD programming model for writing an SDS to an HDF file involves the following steps:
1. Define data set options. (optional)
2. Write all or part of the data set.

These steps are performed for every data set written to a file. However, it is not always necessary to define data set options for every write operation as setting an option places information about the data set in a structure in primary memory. This information is retained until explicitly altered by another set call.

12.4.1 Creating a DFSD Scientific Data Set: DFSDadddata and DFSDputdata

To define and write a single SDS, the calling program must contain one of the following routines:

C:
status = DFSDadddata(filename, rank, dim_sizes, data);

FORTRAN:
status = dsadata(filename, rank, dim_sizes, data)

OR

C:
status = DFSDputdata(filename, rank, dim_sizes, data);

FORTRAN:
status = dspdata(filename, rank, dim_sizes, data)

DFSDadddata appends data to a file when given an existing file name and creates a new file when given a unique file name. DFSDputdata replaces the contents of a file when given an existing file name and creates a new file when given a unique file name. To avoid accidentally overwriting data in a file, the use of DFSDadddata is recommended.

DFSDadddata and DFSDputdata have four parameters: filename, rank, dim_sizes, and data. In both routines, the data set is written to the file specified by the filename parameter. The total number of dimensions in the array and the size of each dimension are passed in the rank and dim_sizes parameters. A pointer to the data or slab of data written to the named file is passed in the data parameter.

The parameters of DFSDadddata and DFSDputdata are further described in the following table.

<table>
<thead>
<tr>
<th>routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDadddata</td>
<td>filename</td>
<td>char *</td>
<td>Name of the file containing the data set.</td>
</tr>
<tr>
<td></td>
<td>rank</td>
<td>int32</td>
<td>Number of dimensions in the array.</td>
</tr>
<tr>
<td></td>
<td>dim_sizes</td>
<td>int32 *</td>
<td>Size of each dimension in the data array.</td>
</tr>
<tr>
<td></td>
<td>data</td>
<td>VOIDP</td>
<td>Array containing the data.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFSDputdata</td>
<td>filename</td>
<td>char *</td>
<td>Name of file containing the data set.</td>
</tr>
<tr>
<td></td>
<td>rank</td>
<td>int32</td>
<td>Number of dimensions in the array.</td>
</tr>
<tr>
<td></td>
<td>dim_sizes</td>
<td>int32 *</td>
<td>Size of each dimension in the data array.</td>
</tr>
<tr>
<td></td>
<td>data</td>
<td>VOIDP</td>
<td>Array containing the data.</td>
</tr>
</tbody>
</table>
12.4.2 Specifying the Data Type of a DFSD SDS: DFSDsetNT

The default data type for scientific data is `DFNT_FLOAT32`. To change the default setting, the calling program must contain calls to the following routines:

```c
C:
status = DFSDsetNT(number_type);
status = DFSDadddata(filename, rank, dim_sizes, data);
```

```fortran
FORTRAN:
status = dsnt(number_type)
status = dsadata(filename, rank, dim_sizes, data)
```

`DFSDsetNT` defines the data type for all subsequent `DFSDadddata` and `DFSDputdata` calls until it is changed by a subsequent call to `DFSDsetNT` or reset to the default by `DFSDclear`. `DFSDsetNT`'s only parameter is the data type.

---

**EXAMPLE 1. Creating and Writing to a DFSD Scientific Data Set**

In the following code examples, `DFSDadddata` is used to write an array of 64-bit floating-point numbers to a file named "Example1.hdf". Although the `DFSDsetNT` function call is optional, it is included here to demonstrate how to override the float32 default.

```c
C:
#include "hdf.h"

#define LENGTH 3
#define HEIGHT 2
#define WIDTH 5

main( )
{
    /* Create data array - store dimensions in array 'dims' */
    static float64 scien_data[LENGTH][HEIGHT][WIDTH] =
        { 1., 2., 3., 4., 5.,
          6., 7., 8., 9.,10.,
          11.,12.,13.,14.,15.,
          16.,17.,18.,19.,20.,
          21.,22.,23.,24.,25.,
          26.,27.,28.,29.,30. };

    intn status;
    int32 dims[3] = {LENGTH, HEIGHT, WIDTH};

    /* Set number type to 64-bit float */
    status = DFSDsetNT(DFNT_FLOAT64);

    /* Write the data to file */
    status = DFSDadddata("Example1.hdf", 3, dims, scien_data);
}
```

```fortran
FORTRAN:
PROGRAM WRITE SDS

integer  dsadata, dssnt, dims(3), status
real*8   sci_data(5,2,3)

C     Create array called 'sci_data'; store dimensions in array 'dims'.
```
data     sci_data/ 1., 2., 3., 4., 5.,
$                   6., 7., 8., 9.,10.,
$                   11.,12.,13.,14.,15.,
$                   16.,17.,18.,19.,20.,
$                   21.,22.,23.,24.,25.,
$                   26.,27.,28.,29.,30./
data dims /3,2,5/
C     Set number type to 64-bit float
status = dssnt(6)
C     Write the data to file
status = dsadata('Example1.hdf', 3, dims, sci_data)
end

12.4.3 Overwriting Data for a Given Reference Number: DFSDwriteref

DFSDwriteref is a highly specialized function call that overwrites data referred to by the specified reference number.

If DFSDwriteref is called with a reference number that doesn’t exist, an error return value of -1 will be returned.

The following series of function calls should appear in your program:

C: 
  status = DFSDwriteref(filename, ref_number);
  status = DFSDadddata(filename, rank, dim_sizes, data);

FORTRAN: 
  status = dswref(filename, ref_number)
  status = dsadata(filename, rank, dim_sizes, data)

If the filename passed to DFSDwriteref is different from the filename in the DFSDadddata or DFSDputdata routine calls, it will be ignored. The next scientific data set written, regardless of the filename, is assigned the reference number ref_number.

Care should be taken when using DFSDwriteref, as once the new data has been written the old data cannot be retrieved.

The parameters of DFSDwriteref are described in the following table.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDsetNT</td>
<td>number_type</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td>DFSDwriteref</td>
<td>filename</td>
<td>char *</td>
<td>character*(*)</td>
</tr>
<tr>
<td></td>
<td>ref_number</td>
<td>int16</td>
<td>integer</td>
</tr>
</tbody>
</table>

12.4.4 Writing Several Data Sets: DFSDsetdims and DFSDclear

The DFSD programming model for writing multiple data sets to an HDF file is identical to that for writing individual data sets. (Refer to Section 12.4 on page 380). To understand how multiple data
sets are written to file, it is first necessary to take a closer look at each step of the programming model. First and most importantly, all DFSD routines that set a write option except DFSDsetNT and DFSDsetfillvalue add information to a special structure in primary memory. This information is used to determine how data is written to file for all subsequent write operations.

Information stored in primary memory is retained by the HDF library until explicitly changed by a call to DFSDsetdims or reset to NULL by calling DFSDclear. DFSDsetdims and DFSDclear are used to prevent assignments of attributes created for a group of data sets to data sets outside the group. For more information on assigning attributes see Section 12.7.1 on page 390 and Section 12.7.3 on page 397.

### 12.4.5 Preventing the Reassignment of DFSD Data Set Attributes: DFSDsetdims

Information stored in primary memory is retained by the HDF library until explicitly changed by a call to DFSDsetdims or reset to NULL by calling DFSDclear. DFSDsetdims and DFSDclear are used to prevent assignments of attributes created for a group of data sets to data sets outside the group.

The syntax of DFSDsetdims is the following:

**C:**
```c
status = DFSDsetdims(rank, dim_size);
```

**FORTRAN:**
```fortran
status = dssdims(rank, dim_sizes)
```

DFSDsetdims is not used here to define the rank and dimension sizes to be used in the next operation, but to alert the DFSD interface to stop the automatic assignment of attributes to the data sets to be written to file. DFSDsetdims has two parameters: `rank` and `dim_sizes`. The rank of an array is the total number of dimensions in the array and the dimension sizes are the length of each individual dimension.

As a rule of thumb, DFSDsetdims should be called if any DFSDset* routine (DFSDsetNT, for example) has been called. This insures that all attribute values that have been reset will be assigned in future data set operations.

The parameters of DFSDsetdims are further defined in the following table.

#### TABLE 12D

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDsetdims</td>
<td>rank</td>
<td>intn</td>
<td>Number of dimensions in the array.</td>
</tr>
<tr>
<td></td>
<td>dim_sizes</td>
<td>int32*</td>
<td>Size of each dimension in the array.</td>
</tr>
</tbody>
</table>

### 12.4.6 Resetting the Default DFSD Interface Settings: DFSDclear

The syntax for DFSDclear is as follows:

**C:**
```c
status = DFSDclear( );
```

**FORTRAN:**
```fortran
status = dsclear( )
```

The DFSDclear routine clears all interface settings defined by any of the DFSDset* routines (DFSDsetNT, DFSDsetfillvalue, DFSDsetdims, DFSDsetdatastrs, DFSDsetdatalengths, DFSDsetrange, DFSDsetcal, DFSDsetdimscale and DFSDsetdimstrs). After the DFSDclear has
been called, calls to any of the DFSDset® routines will result in the corresponding value not being written. To write new values, call the appropriate DFSDset routine again.

**TABLE 12E DFSDclear Parameter List**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDclear</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clear all DFSD interface settings.</td>
<td></td>
</tr>
</tbody>
</table>

### 12.5 Reading DFSD Scientific Data Sets

The DFSD programming model for reading an SDS is also a two-step operation:

1. Obtain information about the data set if necessary.
2. Read all or part of the data set.

These steps are performed for every data set read. In some cases, calls to determine the data set definition may be reduced or avoided completely. For example, if the data set dimensions are known, the call that returns the data set dimensions may be eliminated.

#### 12.5.1 Reading a DFSD SDS: DFSDgetdata

If the dimensions of the data set are known, **DFSDgetdata** is the only function call required to read an SDS. If the file is being opened for the first time, **DFSDgetdata** returns the first data set in the file. Any subsequent calls will return successive data sets in the file - data sets are read in the same order they were written. Normally, **DFSDgetdims** is called before **DFSDgetdata** so that space allocations for the array can be checked if necessary and the dimensions verified. If this information is already known, **DFSDgetdims** may be omitted.

To read an SDS of known dimension and number type, the calling program should include the following routine:

```c
status = DFSDgetdata(filename, rank, dim_sizes, data);
```

```fortran
status = dsgdata(filename, rank, dim_sizes, data)
```

**DFSDgetdata** has four parameters: `filename`, `rank`, `dim_sizes`, and `data`. **DFSDgetdata** returns a data set specified by the parameter `filename`. The total number of dimensions is specified in `rank` and the size of each dimension is specified in `dim_sizes`. **DFSDgetdata** returns the array in `data`.

The parameters of **DFSDgetdata** are further defined in the following table.

**TABLE 12F DFSDgetdata Parameter List**

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>filename</td>
<td>char</td>
<td>character*(*) Name of the file containing the data.</td>
</tr>
<tr>
<td></td>
<td>rank</td>
<td>int32</td>
<td>integer     Number of dimensions.</td>
</tr>
<tr>
<td></td>
<td>dim_sizes</td>
<td>int32 *</td>
<td>integer     Buffer for the dimension sizes.</td>
</tr>
<tr>
<td></td>
<td>data</td>
<td>VOIDP</td>
<td>&lt;valid numeric data type&gt; Buffer for the stored scientific data.</td>
</tr>
</tbody>
</table>
12.5.2 Specifying the Dimensions and Data Type of an SDS: DFSDgetdims and DFSDgetNT

When DFSDgetdims is first called, it returns dimension information of the first data set. Subsequent calls will return this information for successive data sets. If you need to determine the dimensions or the data type of an array before reading it, call DFSDgetdims and DFSDgetNT. DFSDgetNT gets the data type (or, in HDF parlance, number type) of the data retrieved in the next read operation.

To determine the dimensions and data type of an array before attempting to read it, the calling program must include the following:

```c
status = DFSDgetdims(filename, rank, dimsizes, max_rank);
status = DFSDgetNT(number_type);
status = DFSDgetdata(filename, rank, dimsizes, data);
```

```fortran
status = dsgnt(filename, rank, dimsizes, max_rank)
status = dsgdims(number_type)
status = dsgdata(filename, rank, dimsizes, data)
```

DFSDgetdims has four parameters: filename, rank, dim_sizes, and maxrank. The number of dimensions is returned in rank, the size of each dimension in the array dim_sizes, and the size of the array containing the dimensions sizes in max_rank. DFSDgetNT has only one parameter: number_type. As there is no way to specify the file or data set through the use of DFSDgetNT, it is only valid if it is called after DFSDgetdims.

The parameters of DFSDgetdims and DFSDgetNT are further defined in the following table.

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDgetdims [int] (dsgdims)</td>
<td>filename</td>
<td>char *</td>
<td>Name of file containing the data.</td>
</tr>
<tr>
<td></td>
<td>rank</td>
<td>intn *</td>
<td>Number of dimensions.</td>
</tr>
<tr>
<td></td>
<td>dim_sizes</td>
<td>int32 *</td>
<td>Buffer for the dimension sizes.</td>
</tr>
<tr>
<td></td>
<td>max_rank</td>
<td>intn</td>
<td>Size of the dimension size buffer.</td>
</tr>
<tr>
<td>DFSDgetNT [int] (dsgnt)</td>
<td>number_type</td>
<td>int32 *</td>
<td>Data type of the data to be read.</td>
</tr>
</tbody>
</table>

**EXAMPLE 2.**

**Reading from a DFSD Scientific Data Set**

The following examples search the file named "Example1.hdf" for the dimensions and data type of a DFSD array. Although use of DFSDgetdims and DFSDgetNT is optional, they are included here as a demonstration of how to verify the array dimensions and number type before reading any data. If the dimensions and type are known, only a call to DFSDgetdata is required.

```c
#include "hdf.h"

#define LENGTH 3
#define HEIGHT 2
#define WIDTH 5

main( )
```

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FORTRAN:

```fortran
PROGRAM READ SDS
    integer  dsgdata, dsgdims, dsngnt, dims(3), status
    integer rank, num_type
    real*8   sci_data(5, 2, 3)
C     Get the dimensions and number type of the array.
    status = dsgdims('Example1.hdf', rank, dims, 3)
    status = dsngnt(num_type)
C     Read the array if the dimensions are correct.
    if ((dims(1) .eq. 3) .and. (dims(2) .eq. 2) .and.
       +   (dims(3) .eq. 5)) then
       status = dsgdata('Example1.hdf', rank, dims, sci_data)
    endif
end
```

12.5.3 Determining the Number of DFSD Data Sets: DFSDndatasets and DFSDrestart

DFSDgetdims and DFSDgetdata sequentially access DFSD data sets. By repeatedly calling either function, a program can step through an entire file by reading one data set at a time. However, before attempting to sequentially access all of the data sets in a file the total number of data sets in the file should be determined. To do so, the calling program must call the following routine:

```
C:       num_of_datasets = DFSDndatasets(filename);
```
```
FORTRAN: num_of_datasets = dsnum(filename)
```

Once the total number of data sets is known, a calling program can at any time, reset the current data set to the first data set in the file by calling the following routine:

```
C:       status = DFSDrestart( );
```
```
FORTRAN: status = dsfirst( )
```

Use of DFSDndatasets and DFSDrestart is optional, it is usually more convenient than cycling through the entire file one SDS at a time.
12.5.4 Obtaining Reference Numbers of DFSD Data Sets: DFSDreadref and DFSDlastref

As the HDF library handles the assignment and tracking of reference numbers, reference numbers must be explicitly returned. Obtaining the reference number is an operation best performed immediately after data set creation.

The DFSD interface uses the function DFSDreadref to initiate access to individual scientific data sets. DFSDreadref specifies the reference number of the next SDS to be read.

To access a specific SDS, the calling program must contain the following routines:

C:
```c
status = DFSDreadref(filename, ref);
status = DFSDgetdata(filename, rank, dim_sizes, data);
```

FORTRAN:
```fortran
status = dsrref(filename, ref)
status = dsgdata(filename, rank, dim_sizes, data)
```

DFSDreadref has two parameters: filename and ref. DFSDreadref specifies the reference number of the object to be next operated on in the HDF file filename as ref. Determining the correct reference number is the most difficult part of this operation. As a result, DFSDreadref is often used in conjunction with DFSDlastref, which determines the reference number of the last data set accessed.

To syntax of DFSDadddata and DFSDlastref is:

C:
```c
status = DFSDadddata(filename, rank, dim_sizes, data);
ref_num = DFSDlastref();
```

FORTRAN:
```fortran
status = dsadata(filename, rank, dim_sizes, data)
ref_num = dslref()
```

DFSDputdata can also be used with DFSDlastref to obtain similar results. In any case, DFSDlastref can be used before any operation that requires identifying a scientific data set by reference number, as in the assignment of annotations and inserting data sets into vgroups. For more information about annotations and vgroups refer to Chapter 10, Annotations (AN API), and Chapter 5, Vgroups (V API).

<table>
<thead>
<tr>
<th>TABLE 12H</th>
<th>DFSDreadref Parameter List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine Name</td>
<td>Parameter</td>
</tr>
<tr>
<td>DFSDreadref</td>
<td>filename</td>
</tr>
<tr>
<td></td>
<td>ref_number</td>
</tr>
</tbody>
</table>

12.6 Slabs in the DFSD Interface

To review, a slab is an n-dimensional array whose dimensions are smaller than those of the SDS array into which it is written or from which it is read.

12.6.1 Accessing Slabs: DFSDstartslab and DFSEDendslab

There are two routines required for every DFSD slab operation - DFSDstartslab and DFSEDendslab. DFSDstartslab is used to initialize the slab interface and to initiate access to new or existing data sets. DFSEDendslab is used to terminate access to open data sets. DFSDstartslab must be
called before any read or write slab operation and \texttt{DFSDendslab} must be called after the slab operation is completed. Both routines are required when reading and writing slabs.

Given a new filename, \texttt{DFSDstartslab} will create a new HDF file with the specified name. Given an existing filename, it will open the named file and append the new data set to the end of the file. Its only parameter is \texttt{filename}. \texttt{DFSDendslab} has no parameters and need only be called once per file. \texttt{DFSDendslab} will write any attributes defined immediately before the data set is created.

For more information on assigning attributes, see Section 12.7.3 on page 397.

### TABLE 12I

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{DFSDstartslab}</td>
<td>\texttt{filename}</td>
<td>char *</td>
<td>Name of the file containing the data set.</td>
</tr>
</tbody>
</table>

#### 12.6.2 Writing Slabs: \texttt{DFSDwriteslab}

In the DFSD interface, writing an entire data set array and writing slabs follow the same programming model. The difference between the two is that calls to three routines is needed to write slabs, while a call to one routine is needed to write whole data sets.

More specifically, the DFSD programming model for writing slabs to an SDS is as follows:

1. Set the appropriate options to define the new SDS or select an existing SDS.
2. Write the data set using three specialized slab routines.

In addition to writing slabs to both new and existing data sets, \texttt{DFSDwriteslab} can also perform the following sequential write operations:

- Write slabs to a single data set when called repeatedly.
- Write slabs to sequential data sets when repeatedly called between calls to \texttt{DFSDgetdims}.
- Write slabs to selected data sets when repeatedly called between calls to \texttt{DFSDwriteref}.

Although not specifically defined as a slab routine, in practice, the \texttt{DFSDsetfillvalue} routine is used to initialize array elements between non-contiguous slab write operations. Setting a fill value places the same value in every array location before the first slab is written. Any hole created by non-contiguous writes can then be recognized by identifying the known fill value. The fill value must have the same number type as the values in the data set. For more information on fill values refer to Section 12.7.1.2 on page 391.

To write a slab to a new data set, the calling program must include the following routine calls:

**C:**

```c
status = DFSDsetdims(rank, dimsizes);
status = DFSDsetNT(num_type);
status = DFSDstartslab(filename);
status = DFSDwriteslab(start, stride, count, data);
status = DFSDendslab( );
```

**FORTRAN:**

```fortran
status = dssnt(num_type)
status = dssdims(rank, dim_sizes)
status = dssslab(filename)
status = dswslab(start, stride, edge, data)
status = dseslab( )
```
When writing slabs to an existing data set, it is impossible to change the number type, array boundaries, fill value, or calibration information. Consequently DFSDsetNT, DFSDsetdims, DFSDsetcal, and DFSDsetfillvalue will generate errors if called for an existing data set.

To write a slab to an existing data set, your program should include the following calls:

C:
status = DFSDwriteref(filename, ref);
status = DFSDstartslab(filename);
status = DFSDwriteslab(start, stride, count, data);
status = DFSDendslab( );

FORTRAN:
status = dswref(filename, ref)
status = dssslab(filename)
status = dswslab(start, stride, edge, data)
status = dseslab( )

Because DFSDwriteslab offers no overwrite protection, the calling program is responsible for eliminating overlap when arranging slabs within the newly defined data set.

DFSDwriteslab has four arguments: start, stride, edge, and data. The arguments start, stride, and edge are defined as they are in the corresponding SD routines.

The DFSD SDS model does not support strides. Pass the start array as the stride parameter as a place holder. Whatever is passed as the stride parameter will be ignored by the DFSD interface.

Although DFSDendslab need only be called once per file, it is required to write data to the file. It will also write any attributes defined immediately before the data set is created.

**TABLE 12J** DFSDwriteslab Parameter List

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDwriteslab</td>
<td>start</td>
<td>int32 * integer (*)</td>
<td>Array containing the starting coordinate the write.</td>
</tr>
<tr>
<td></td>
<td>stride</td>
<td>int32 * integer (*)</td>
<td>Ignored parameter.</td>
</tr>
<tr>
<td></td>
<td>count</td>
<td>int32 * integer (*)</td>
<td>Array defining the boundaries of the slab.</td>
</tr>
<tr>
<td></td>
<td>data</td>
<td>VOIDP &lt;valid numeric data type&gt;</td>
<td>Buffer for the data to be written.</td>
</tr>
</tbody>
</table>

### 12.6.3 Reading Slabs: DFSDreadslab

The programming model for reading one or more slabs involves the following steps:

1. Select an existing SDS.
2. Read the data set using three specialized slab routines.

In addition to reading single slabs of data, DFSDreadslab can perform the following sequential access operations:

- Read multiple slabs from the first data set in a file when called repeatedly.
- Read multiple slabs from a specified data set when repeatedly called after DFSDreadref.
- Read multiple slabs from sequential data sets when repeatedly called between calls to DFS-Dgetdims.
To read a slab, the calling program must include the following routine calls:

**C:**
```
status = DFSDreadref(filename, ref);
status = DFSDstartslab(filename);
status = DFSDreadslab(start, stride, edge, data);
status = DFSDendslab( );
```

**FORTRAN:**
```
status = dsrref(filename, ref)
status = dssslab(filename)
status = dslabref(filename, ref)
status = dseslab( )
```

In addition to **DFSDreadref**, **DFSDgetdims** may also be used to position the read pointer to the appropriate data set. When **DFSDreadslab** is used to read slabs, the coordinates of the **start** array must begin at 0 for each dimension (**start**=(0,0, ... 0)) and the size of each dimension must equal the size of the array itself (**edge**=(dim size 1, dim size 2, dim size n)). As with **DFSDwriteslab**, whatever is passed in as the **stride** parameter is ignored. Finally, the data buffer must allocate enough space to hold the data: excess data is truncated.

All parameters of the **DFSDreadslab** routine assume FORTRAN-77-style one-based arrays - the starting coordinates of the slab must be given as an offset from the origin of the data set where the origin is defined as (dim 1 = 1, dim 2 = 1, ... dim n-1 = 1, dim n = 1). The first element of the slab will be the coordinates specified by the contents of the **start** array. **DFSDreadslab** will extract elements in increasing order until the until the dimensional offset specified by the contents of the **edge** array are encountered.

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDreadslab [intn] (dwslab)</td>
<td>filename</td>
<td>char *</td>
<td>Name of the HDF file.</td>
</tr>
<tr>
<td></td>
<td>start</td>
<td>int32 *</td>
<td>Array containing the coordinates for start of the slab.</td>
</tr>
<tr>
<td></td>
<td>slab_size</td>
<td>int32</td>
<td>Array of rank containing the size of each dimension of the slab.</td>
</tr>
<tr>
<td></td>
<td>stride</td>
<td>int32 *</td>
<td>Place holder array.</td>
</tr>
<tr>
<td></td>
<td>buffer</td>
<td>VOIDP</td>
<td>Array the will used to store the extracted slab.</td>
</tr>
<tr>
<td></td>
<td>buffer_size</td>
<td>int32 *</td>
<td>Array containing the dimensions of the buffer parameter.</td>
</tr>
</tbody>
</table>

### 12.7 Predefined Attributes and the DFSD Interface

Although they often contain important information, attributes are optional to the data set array and the dimension record. Although both types of attributes use similar names, they are read and written using different sets of routines. All attributes are predefined by the DFSD library.

#### 12.7.1 Writing Data Set Attributes

*Data set attributes* are described in Chapter 3, *Scientific Data Sets (SD API)*. There is a limit of one string attribute per data set.
12.7.1.1 Assigning String Attributes to an SDS: DFSDsetlengths and DFSDsetdatastrs

The DFSD interface provides two function calls for creating data set string attributes: DFSD-setlengths and DFSDsetdatastrs. DFSDsetlengths overrides the default string length and DFSDsetdatastrs writes the string. DFSDsetlengths and DFSDsetdatastrs are optional and may be called individually, or in any order as long as they precede calls to DFSDadddata or DFSDput-data.

Predefined string attributes are defined as follows:

- **Coordinate system attributes** specify the coordinate system used to generate the original data.
- **Format attributes** specify the format to use when displaying values for the data.
- **Label attributes** contains data array names.
- **Unit attributes** identifies the units of measurement associated with the data.

To assign a predefined attribute to an HDF file, the program must contain the following routine calls:

**C:**
```
status = DFSDsetlengths(label_len, unit_len, format_len, coords_len);
status = DFSDsetdatastrs(label, unit, format, coordsys);
status = DFSDadddata(filename, rank, dimsizes, data);
```

**FORTRAN:**
```
status = dsslens(label_len, unit_len, format_len, coords_len)
status = dssdast(label, unit, format, coordsys)
status = dsadata(filename, rank, dimsizes, data)
```

DFSDsetlengths has four arguments: `label_len`, `unit_len`, `format_len`, and `coords_len`. Each parameter reflects the maximum length for the string that will hold the label, unit, format, and coordinate system. Use of DFSDsetlengths is optional and usually not necessary.

DFSDsetdatastrs writes null-terminated strings to an HDF file. It has the same four arguments: `label`, `unit`, `format`, and `coordsys`. To avoid the assignment of a string, pass `NULL` as the appropriate argument.

### TABLE 12L DFSDsetlengths and DFSDsetdatastrs Parameter List

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDsetlengths</td>
<td><code>label_len</code></td>
<td>intn integer</td>
<td>Maximum length for any label string.</td>
</tr>
<tr>
<td></td>
<td><code>unit_len</code></td>
<td>intn integer</td>
<td>Maximum length for any unit string.</td>
</tr>
<tr>
<td></td>
<td><code>format_len</code></td>
<td>intn integer</td>
<td>Maximum length for any format string.</td>
</tr>
<tr>
<td></td>
<td><code>coords_len</code></td>
<td>intn integer</td>
<td>Maximum length for any coordinate system string.</td>
</tr>
<tr>
<td>DFSDsetdatastrs</td>
<td><code>label</code></td>
<td>char* character*($)</td>
<td>Label describing the data.</td>
</tr>
<tr>
<td></td>
<td><code>unit</code></td>
<td>char* character*($)</td>
<td>Unit to be applied to the data.</td>
</tr>
<tr>
<td></td>
<td><code>format</code></td>
<td>char* character*($)</td>
<td>Format to be applied in displaying the data.</td>
</tr>
<tr>
<td></td>
<td><code>coordsys</code></td>
<td>char* character*($)</td>
<td>Coordinate system of the data set.</td>
</tr>
</tbody>
</table>

12.7.1.2 Assigning Value Attributes to a DFSD SDS: DFSDsetfillvalue, DFSDsetrange, and DFSDsetcal

The DFSD interface provides the following routines for defining value attributes. All three function calls are optional and may be called in any order provided they precede a call to DFSDadddata or DFSDputdata.
To assign a value attribute to a data set, the following routines must be called:

C:
status = DFSDsetfillvalue(fill_val);
status = DFSDsetcal(scale, scale_err, offset, offset_err, num_type);
status = DFSDsetrange(max, min);
status = DFSDadddata(filename, rank, dimsizes, data);

FORTRAN:
status = dssfill(fill_val)
status = dsscal(scale, scale_err, offset, offset_err, num_type)
status = dssrang(max, min)
status = dsadata(filename, rank, dimsizes, data)

DFSDsetrange sets a new range attribute for the current DFSD SDS. DFSDsetrange has two arguments: max and min. The HDF library will not check or update the range attributes as new data are added to the file, therefore max and min will always reflect the values supplied by the last DFSDsetrange call. The parameters for DFSDsetrange is defined in Table K below.

DFSDsetfillvalue specifies a new value to the default fill value attribute for an SDS array. It’s only argument is fill_val, which specifies the new fill value. The fill value must be of the same number type as the array it’s written to. To avoid conversion errors, use data-specific fill values instead of special architecture-specific values, such as infinity or Not-a-Number (or NaN). Setting the fill value after data is written to the SDS will not update the fill values already written to the data set - it will only change the attribute.

The parameters for DFSDsetfillvalue are further defined in Table K below.

The DFSDsetcal routine creates a calibration record for a specified array and by doing so adds five attributes to the current data set. As the HDF library does not specifically apply calibration information to the data, SDsetcal can be called anytime before or after the data is written. DFSDsetcal has five arguments; scale, scale_error, offset, off_err, and num_type. The arguments scale and offset are defined as they are for the multi-file SD API routines.

In addition to the scale and offset, DFSDsetcal also includes both a scale and offset error. The argument scale_error contains the potential error of the calibrated data due to scaling and offset_err contains the potential error for the calibrated data due to the offset. The num_type parameter specifies the number type of the uncalibrated data.

The parameters of DFSDsetcal are defined in the following table.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDsetfillvalue</td>
<td>label</td>
<td>char*</td>
<td>character*(*)</td>
</tr>
<tr>
<td></td>
<td>unit</td>
<td>char*</td>
<td>character*(*)</td>
</tr>
<tr>
<td></td>
<td>format</td>
<td>char*</td>
<td>character*(*)</td>
</tr>
<tr>
<td></td>
<td>coordsys</td>
<td>char*</td>
<td>character*(*)</td>
</tr>
<tr>
<td>DFSDsetrange</td>
<td>max</td>
<td>VOIDP</td>
<td>&lt;valid numeric data type&gt;</td>
</tr>
<tr>
<td></td>
<td>min</td>
<td>VOIDP</td>
<td>&lt;valid numeric data type&gt;</td>
</tr>
</tbody>
</table>
EXAMPLE 3. Assigning Predefined String Attributes to a File

The following examples demonstrate the steps necessary to assign predefined string attributes to the data set and stores the data set in the file "Example1.hdf". They create a string attribute using DFSDsetdatastrs and a value attribute using DFSDsetrange. It also demonstrates the use of DFSDsetlengths in altering the maximum string length from 255 characters to 50. It then writes the SDS array by calling DFSDadddata.

C:

```c
#include "hdf.h"

/*
 * Write an array of floating point values representing
 * pressure in a 3x2x5 array.
 */

main( )
{

float32 data[3][2][5];
int32 dimsizes[3];
float32 max, min;
intn status, rank;
int i, j, k;

/* Set the rank and dimension sizes. */
rank = 3;
dimsizes[0] = 3;
dimsizes[1] = 2;
dimsizes[2] = 5;

/* Set the dimensions, to define the beginning of a data set. */
status = DFSDsetdims(rank, dimsizes);

/* Set the maximum string length to 50. */
status = DFSDsetlengths(50, 50, 50, 50);

/* Define the attribute strings and values. */
status = DFSDsetdatastrs("Pressure Data", "Millibars", "F5.5", "None");
max = 1500.0;
min = 0.0;
status = DFSDsetrange(&max, &min);

/* Set the rank to 3. */
rank = 3;

/* Calculate the data values. */
for (i = 0; i < 3; i++)
    for (j = 0; j < 2; j++)
        for (k = 0; k < 5; k++)
            data[i][j][k] = i*100.0 + j*10.0 + k;
```

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Format</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cal</td>
<td>float64</td>
<td>real*8</td>
<td>Calibration scale.</td>
</tr>
<tr>
<td>cal_error</td>
<td>float64</td>
<td>real*8</td>
<td>Calibration scale error.</td>
</tr>
<tr>
<td>off</td>
<td>float64</td>
<td>real*8</td>
<td>Uncalibrated offset.</td>
</tr>
<tr>
<td>off_err</td>
<td>float64</td>
<td>real*8</td>
<td>Uncalibrated offset error.</td>
</tr>
<tr>
<td>num_type</td>
<td>int32</td>
<td>integer</td>
<td>Number type of uncalibrated data.</td>
</tr>
</tbody>
</table>
FORTRAN:

```fortran
PROGRAM SET ATTRIBS

real*8 data(5, 2, 3), max, min, i, j, k
integer*4 dimsizes(3)
integer status, rank

integer dsslens, dssdast, dsrang, dsadata
integer dssdims

character*13 label /"Pressure Data"/
character*9 unit /"Millibars"/
character*4 format /"F5.5"/
character*4 coordsys /"None"/

C     Set the dimensions, to define the beginning of a data set.
rank = 3
   dimsizes(1) = 5
   dimsizes(2) = 2
   dimsizes(3) = 3
   status = dssdims(rank, dimsizes)

C     Set the maximum string lengths to 50.
status = dsslens(50, 50, 50, 50)

C     Define the attribute strings and values.
status = dssdast(label, unit, format, coordsys)
max = 1500.0
min = 0.0
status = dsrang(max, min)

C     Fill the data array with values.
do 30 k = 1, 3
   do 20 j = 1, 2
      do 10 i = 1, 5
         data(i, j, k) = i*100.0 + j*10.0 + k
   10 continue
   20 continue
30 continue

C     Write the data set and its attributes to file.
status = dsadata("Example3.hdf", rank, dimsizes, data)

end
```

12.7.2 Reading DFSD Data Set Attributes

The DFSD interface provides two function calls for reading predefined data set attribute strings.

12.7.2.1 Reading Data Set Attributes: DFSDgetdatalen and DFSDgetdatastrs

`DFSDgetdatalen` returns the length of each string in the attribute. It is useful for determining the length of an attribute before reading it. `DFSDgetdatastrs` reads the label, unit, format, and coordinate system strings.
Attribute data is not read by **DFSDgetdatastrs** until the appropriate routine is called to read the array and its dimension record. If **DFSDgetdatastrs** and **DFSDgetrange** are not called, the array and its dimension record can be read without reading its associated data set attributes. It is also possible to read string and value attributes individually. As attribute data is not actually read by **DFSDgetdatastrs** or **DFSDgetrange**, these calls must be made before calling **DFSDgetdata**.

Reading the attributes of a data set involves the following steps:
1. Determine the length of each attribute string.
2. Read the attribute strings.
3. Read the maximum and minimum values.
4. Read the remainder of the data set.

To assign a predefined attribute to an HDF file, the following routines should be called:

**C:**
```
status = DFSDgetdatalen(label_len, unit_len, format_len, coords_len);
status = DFSDgetdatastrs(label, unit, format, coordsys);
status = DFSDgetrange(max, min);
status = DFSDgetdata(filename, rank, dimsizes, data);
```

**FORTRAN:**
```
status = dsgdghaln(label_len, unit_len, format_len, coords_len)
status = dsgdast(label, unit, format, coordsys)
status = dsgrang(max, min)
status = dsgdata(filename, rank, dimsizes, data)
```

The parameters of **DFSDgetdatalen** and **DFSDgetdatastrs** are described in the following table.

<table>
<thead>
<tr>
<th>Routine Name [Return Type] (FORTRAN-77)</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDgetdatalen [int] (dsgdaln)</td>
<td>label_len</td>
<td>intn * integer</td>
<td>Length of any label string.</td>
</tr>
<tr>
<td></td>
<td>unit_len</td>
<td>intn * integer</td>
<td>Length of any unit string.</td>
</tr>
<tr>
<td></td>
<td>format_len</td>
<td>intn * integer</td>
<td>Length of any format string.</td>
</tr>
<tr>
<td></td>
<td>coords_len</td>
<td>intn * integer</td>
<td>Length of any coordinate system string.</td>
</tr>
<tr>
<td>DFSDgetdatastrs [int] (dsgdast)</td>
<td>label</td>
<td>char * character*(*</td>
<td>Label describing the data.</td>
</tr>
<tr>
<td></td>
<td>unit</td>
<td>char * character*(*</td>
<td>Unit applied to the data.</td>
</tr>
<tr>
<td></td>
<td>format</td>
<td>char * character*(*</td>
<td>Format applied to the data.</td>
</tr>
<tr>
<td></td>
<td>coordsys</td>
<td>char * character*(*</td>
<td>Coordinate system of the data set.</td>
</tr>
</tbody>
</table>

**EXAMPLE 4.**

**Reading a Data Set and its Attribute Record**

These examples read the pressure data set and the dimension attribute record stored in the "Example1.hdf" file into the arrays pointed to by the `data`, `datalabel`, `dataunit`, `datafmt` and `coordsys` pointer variables. It assumes the dimension sizes and rank are correct and data strings are less than 10 characters long, with one additional character for the null termination.

**C:**
```c
#include "hdf.h"

main( )
{
    intn rank, maxrank, status;
```
int32 dimsizes[3];
char datalabel[50], dataunit[50], datafmt[50], coordsys[50];
float64 data[3][2][5];

maxrank = 3;
status = DFSDgetdims("Example3.hdf", &rank, dimsizes,
  maxrank);
status = DFSDgetdatastrs(datalabel, dataunit, datafmt,
  coordsys);
status = DFSDgetdata("Example3.hdf", rank, dimsizes, data);
}

FORTRAN:
PROGRAM READ SD INFO

  integer dsdadata, dsgdata, dsgdast, dsgdims
  integer*4 dimsizes(3)
  integer status, rank, maxrank
  character*50 datalabel, dataunit, datafmt
  character*10 coordsys
  real*8 data(5, 2, 3)

  maxrank = 3
  status = dsgdims('Example3.hdf', rank, dimsizes, maxrank)
  status = dsgdast(datalabel, dataunit, datafmt, coordsys)
  status = dsgdata('Example3.hdf', rank, dimsizes, data)

end

12.7.2.2 Reading the Value Attributes of a DFSD Data Set: DFSDgetfillvalue and DFSDgetcal

There are three routines in the DFSD interface that retrieve the fill value, range and calibration information of a data set array: DFSDgetfillvalue, DFSDgetrange, and DFSDgetcal.

The syntax of these routines are as follows:

C:

  status = DFSDgetfillvalue(sds_id, fill_val);
  status = DFSDgetrange(max, min);
  status = DFSDgetcal(cal, cal_err, offset, offset_err, num_type);

FORTRAN:

  status = dsgfill(fill_value)
  status = dsgrang(max, min)
  status = dsadata(cal, cal_err, offset, offset_err, num_type)

DFSDgetfillvalue has two arguments; sds_id and fill_val. The sds_id is the data set identifier and fill_val is the space allocated to store the fill value.

The maximum range of values in the data set isn’t automatically stored with the data set data; it is explicitly stored through a call to DFSDgetrange. The defined range of values can be less than the actual range of values stored in the data set. The value of the max parameter is the maximum value of the defined range and the value of the min parameter is the minimum value. These values must be of the same number type as the values stored in the data array. In C, the max and min parameters are indirect pointers specifying the range values, while in FORTRAN-77 they are variables set to the range values.

DFSDgetcal reads the calibration record of the current data set, if one exists. Each of the parameters of DFSDgetcal correspond to the five elements of the calibration record; - four 64-bit float-
ing-point integers followed by a 32-bit integer. The cal, offset, offset_err and cal_err parameters are defined as they are in the multilfile SD API. This calibration record exists for information only.

The parameters for DFSDgetfillvalue, DFSDgetcal, and DFSDgetrange are defined in the following table.

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDgetfillvalue</td>
<td>sds_id</td>
<td>int32</td>
<td>integer</td>
</tr>
<tr>
<td></td>
<td>fill_val</td>
<td>VOIDP</td>
<td>&lt;valid numeric data type&gt;</td>
</tr>
<tr>
<td>DFSDgetcal</td>
<td>cal</td>
<td>float64 *</td>
<td>real*8</td>
</tr>
<tr>
<td></td>
<td>offset</td>
<td>float64 *</td>
<td>real*8</td>
</tr>
<tr>
<td></td>
<td>offset_err</td>
<td>float64 *</td>
<td>real*8</td>
</tr>
<tr>
<td></td>
<td>num_type</td>
<td>int32 *</td>
<td>integer</td>
</tr>
<tr>
<td>DFSDgetrange</td>
<td>max</td>
<td>VOIDP</td>
<td>&lt;valid numeric data type&gt;</td>
</tr>
<tr>
<td></td>
<td>min</td>
<td>VOIDP</td>
<td>&lt;valid numeric data type&gt;</td>
</tr>
</tbody>
</table>

12.7.3 Writing the Dimension Attributes of a DFSD SDS

Dimension attributes are described in Chapter 3, Scientific Data Sets (SD API).

12.7.3.1 Writing the String Attributes of a Dimension: DFSDsetlengths and DFSDsetdimstrs

The DFSD interface provides two routines for creating dimension string attributes: DFSDsetlengths and DFSDsetdimstrs. DFSDsetlengths overwrites the default string length and DFSDsetdimstrs is defines the string text. DFSDsetdatalengths and DFSDsetdimstrs are optional and must precede calls to DFSDadddata or DFSDputdata.

Predefined dimension string attributes are limited to one per dimension and contain the following:

- **Format attributes** specify the format to use when displaying values for the dimension.
- **Label attributes** contain dimension names.
- **Unit attributes** identify the unit of measurement associated with the dimension.

To assign a predefined attribute to a dimension, the following routines should be called:

C:  
status = DFSDsetlengths(label_len, unit_len, format_len, coords_len);  
status = DFSDsetdimstrs(label, unit, format);  
status = DFSDadddata(filename, rank, dimsizes, data);

FORTRAN:  
status = dsslens(label_len, unit_len, format_len, coords_len)  
status = dssdist(label, unit, format)  
status = dsadata(filename, rank, dimsizes, data)

DFSDsetlengths has four arguments: label_len, unit_len, format_len, and coords_len. Each parameter specifies the maximum length of the string that defines the label, unit, format, and coordinate system. As mentioned earlier in this chapter, attribute lengths seldom need to be reset.

DFSDsetdimstrs also has four arguments; dim, label, unit, and format. The parameter dim = 1 for the first dimension, dim = 2 for the second dimension, etc. To avoid assigning a string to the
coordinate length, pass **null** in the appropriate parameter. **DFSDsetdimstrs** writes null-terminated strings to a file.

The parameters for **DFSDsetlengths** and **DFSDsetdimstrs** are further defined in the following table.

### TABLE 12P  DFSDsetlengths and DFSDsetdimstrs Parameter List

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDsetlengths</td>
<td>label_len</td>
<td>intn integer</td>
<td>Maximum length of any label string.</td>
</tr>
<tr>
<td></td>
<td>unit_len</td>
<td>intn integer</td>
<td>Maximum length of any unit string.</td>
</tr>
<tr>
<td></td>
<td>format_len</td>
<td>intn integer</td>
<td>Maximum length of any format string.</td>
</tr>
<tr>
<td></td>
<td>coords_len</td>
<td>intn integer</td>
<td>Maximum length of any coordinate system string.</td>
</tr>
<tr>
<td>DFSDsetdimstrs</td>
<td>dim</td>
<td>intn integer</td>
<td>Dimension of the attribute strings specified by the remaining three parameters</td>
</tr>
<tr>
<td></td>
<td>label</td>
<td>char * character(*)</td>
<td>Label describing the data.</td>
</tr>
<tr>
<td></td>
<td>unit</td>
<td>char * character(*)</td>
<td>Unit to be applied to the data.</td>
</tr>
<tr>
<td></td>
<td>format</td>
<td>char * character(*)</td>
<td>Format to be applied in displaying the data.</td>
</tr>
</tbody>
</table>

#### 12.7.3.2 Writing a Dimension Scale of a DFSD SDS: **DFSDsetdimscale**

The syntax of the two routines needed to write a dimension scale is the following:

**C:**

```c
status = DFSDsetdimscale(dim, dimsize, scale);
status = DFSDadddata(filename, rank, dimsizes, data);
```

**FORTRAN:**

```fortran
status = dssdisc(dim, dimsize, scale)
status = dsadata(filename, rank, dimsizes, data)
```

**DFSDsetdimscale** has three arguments; `dim`, `dimsize`, and `scale`. These arguments identify the dimension, specify its size, and assign a value to each of its grid points. The parameter `dim = 1` for the first dimension, and `dim = 2` for the second dimension. The `dimsize` argument must contain a value equal to the dimension it describes in order for the scale to be applied correctly.

The parameters of **DFSDsetdimscale** are further described in the following table.

### TABLE 12Q  DFSDsetdimscale Parameter List

<table>
<thead>
<tr>
<th>Routine Name</th>
<th>Parameter</th>
<th>Parameter Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFSDsetdimscale</td>
<td>dim</td>
<td>intn integer</td>
<td>Dimension of the current scale.</td>
</tr>
<tr>
<td></td>
<td>dim_size</td>
<td>int32 integer</td>
<td>Size of the current scale.</td>
</tr>
<tr>
<td></td>
<td>scale</td>
<td>VOIDP &lt;valid numeric data type&gt;</td>
<td>Values of the current scale.</td>
</tr>
</tbody>
</table>

#### 12.7.4 Reading the Dimension Attributes of a DFSD SDS

The DFSD interface provides three routines for reading dimension attributes: **DFSDgetdimlen**, **DFSDgetdimstrs** and **DFSDgetdimscale**. **DFSDgetdimlen** returns the string length for each string in the attribute record. It is a useful routine to call before reading an attribute. **DFSDgetdimstrs** and **DFSDgetdimscale** are used as instructions for reading the dimension attributes. **DFSDgetdimstrs** reads the dimension strings and **DFSDgetdimscale** reads the dimension scale. By avoiding calls to **DFSDgetdimstrs** and **DFSDgetdimscale**, it is possible to read an array and
its dimension record without reading the data set attributes associated with it. It is also possible to omit one function call in order to read one attribute without the other. **DFSDgetdimstrs** and **DFSDgetdimscale** must be called before **DFSDgetdata**.

Reading data set attributes involves the following steps:

1. Determine the length of each attribute string.
2. Read the attribute strings.
3. Read the scale values.
4. Read the remainder of the data set.

To assign a predefined attribute to an HDF file, the following routines must be called:

```
C:       status = DFSDgetdimlen(label_len, unit_len, format_len, coords_len);
         status = DFSDgetdimstrs(label, unit, format);
         status = DFSDgetdimscale(dim, dim_size, scale);
         status = DFSDgetdata(filename, rank, dimsizes, data);

FORTRAN: status = dsgdiln(label_len, unit_len, format_len, coords_len)
         status = dsgdist(label, unit, format)
         status = dsgdisc(dim, dim_size, scale)
         status = dsgdata(filename, rank, dimsizes, data)
```

The parameters for **DFSDgetdimlen**, **DFSDgetdimstrs** and **DFSDgetdimscale** are described in the following table.

<table>
<thead>
<tr>
<th>TABLE 12R</th>
<th>DFSDgetdimlen, DFSDgetdimstrs and DFSDgetdimscale Parameter List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine Name (Return Type)</td>
<td>Parameter</td>
</tr>
<tr>
<td><strong>DFSDgetdimlen</strong></td>
<td>dim</td>
</tr>
<tr>
<td>[intn] (dsgdiln)</td>
<td>label_len</td>
</tr>
<tr>
<td></td>
<td>unit_len</td>
</tr>
<tr>
<td></td>
<td>format_len</td>
</tr>
<tr>
<td><strong>DFSDgetdimstrs</strong></td>
<td>dim</td>
</tr>
<tr>
<td>[intn] (dsgdist)</td>
<td>label</td>
</tr>
<tr>
<td></td>
<td>unit</td>
</tr>
<tr>
<td></td>
<td>format</td>
</tr>
<tr>
<td><strong>DFSDgetdimscale</strong></td>
<td>dim</td>
</tr>
<tr>
<td>[intn] (dsgdisc)</td>
<td>dim_size</td>
</tr>
<tr>
<td></td>
<td>scale</td>
</tr>
</tbody>
</table>
Chapter 13

Error Reporting

8.1 Chapter Overview

This chapter describes the main error reporting routines designed for general HDF use and the types of errors handled by the error reporting API and the general structure of the API.

8.2 The HDF Error Reporting API

The HDF error reporting API consists of routines that query error stack information, the names of which are prefaced by “HE”. They are described briefly in Table 8A. Some are primarily for use by HDF developers while others are available to HDF users. In this chapter, three error reporting functions are covered: HEprint, HEvalue and HEstring. Note that only one C error reporting routine has a FORTRAN-77 counterpart: heprnt/heprntf (heprntf is the newer function, supported on all platforms; heprnt is the original function, supported on non-Microsoft Windows platforms).

<table>
<thead>
<tr>
<th>Category</th>
<th>Routine Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error Reporting</td>
<td>HEprint</td>
<td>Prints the errors on the error stack to a specified file.</td>
</tr>
<tr>
<td></td>
<td>HEstring</td>
<td>Returns the error message associated with an error code.</td>
</tr>
<tr>
<td></td>
<td>HEvalue</td>
<td>Returns the nth most recent error reported.</td>
</tr>
</tbody>
</table>

8.3 Error Reporting in HDF

Most HDF error reporting routines return FAIL (or -1) if the operation is successful and SUCCEEDED (or 0) otherwise. Each time a FAIL code is returned one or more error codes are pushed onto the error code stack. The following pseudo-code will demonstrate the two methods commonly used to access and print the contents of this stack.

```c
if (<general HDF function() >= FAIL) {
    <HDF error reporting API routines>
}
```

OR

```c
status = <general HDF function( );
if (status == FAIL) {
    <HDF error reporting API routines>
}
8.3.1 Writing Errors to a File: HEprint

HEprint writes the errors on the stack to the specified file. There are four sections of an HEprint error report:

1. A description of the error.
2. The routine in which the error was detected.
3. The source file in which the error was detected.
4. The line number in which the error was detected.

The syntax for HEprint is as follows:

C:        HEprint(stream, level);

FORTRAN:  status = heprnt(level)

The stream parameter is a UNIX file handle indicating the output stream the error information will be written to. The level parameter specifies the amount of error information to report. In FORTRAN-77, heprnt (supported on non-Microsoft Windows platforms) always writes to the standard error stream, or stderr; therefore the only parameter is level. To facilitate Microsoft Windows support, a newer function heprntf (supported on all platforms) requires two parameters, filename to identify the file to which the error information is to be written and level.

Errors are written in sequential order starting from the bottom of the stack. Consequently, specifying a level parameter value of 1 will write the first error that occurred, or the first error pushed onto the stack. Specifying a level parameter of value 0 will write all errors on the stack to the specified file. For example, the following C code will write all errors on the stack to the file named “errors”.

```c
f = fopen("errors", "w");
HEprint(f, 0);
```

As an example of the output of HEprint, suppose an attempt is made to open an nonexistent file with Hopen. Calling HEprint(stdout, 0) or heprnt(0) will produce the following output:

```
HDF error: <error opening file>
Detected in Hopen() [hfile.c line 305]
```

8.3.2 Returning the Code of the Nth Most Recent Error: HEvalue

HEvalue returns the error code for the nth most recent error and is only available as a C routine. The error_stack_offset parameter specifies the number of errors to regress from the top of the error stack.

The syntax for HEvalue is as follows:

```c
status = HEvalue(error_stack_offset);
```

Note that several HDF functions, upon successful completion, assume that all important errors have been processed; these functions then call HEclear, clearing the error stack. This has the side effect of sometimes making it difficult to predict the contents of the error stack. HEclear is documented in the advanced H functions section at the back of the HDF Reference Manual.
8.3.3 Returning the Description of an Error Code: HEstring/hestringf

**HEstring** returns the error description associated with the error code specified by the `error_code` parameter as a character string.

The syntax for **HEstring** is as follows:

```c
C:     error_message = HEstring(error_code);
```

```fortran
FORTRAN: status = hestringf(error_code, error_message)
```

### Writing Errors to a Console Window

The following C code fragment will copy errors from the stack to a console window.

```c
C:
#include "hdf.h"

main( )
{
    int32 i, e;
    const char *str;
    ...
    i = 0;
    while ((e = HEvalue(i)) != DFE_NONE) {
        str = HEstring(e);
        <device-specific code to print the string to a console>
        i++
    }
```

---

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Code Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFE_NONE</td>
<td>No error.</td>
</tr>
<tr>
<td>DFE_FNF</td>
<td>File not found.</td>
</tr>
<tr>
<td>DFE_DENIED</td>
<td>Access to file denied.</td>
</tr>
<tr>
<td>DFE_ALROPN</td>
<td>File already open.</td>
</tr>
<tr>
<td>DFE_TOMANY</td>
<td>Too many AID's or files open.</td>
</tr>
<tr>
<td>DFE_BADNAME</td>
<td>Bad file name on open.</td>
</tr>
<tr>
<td>DFE_BADACC</td>
<td>Bad file access mode.</td>
</tr>
<tr>
<td>DFE_BADOPEN</td>
<td>Miscellaneous open error.</td>
</tr>
<tr>
<td>DFE_NOTOPEN</td>
<td>File can't be closed because it hasn't been opened.</td>
</tr>
<tr>
<td>DFE_CANTCLOSE</td>
<td>fclose error</td>
</tr>
<tr>
<td>DFE_READERE</td>
<td>Read error.</td>
</tr>
<tr>
<td>DFE_WRITEERROR</td>
<td>Write error.</td>
</tr>
<tr>
<td>DFE_SEEKERROR</td>
<td>Seek error.</td>
</tr>
<tr>
<td>DFE_RDONLY</td>
<td>File is read only.</td>
</tr>
<tr>
<td>DFE_BADSEEK</td>
<td>Attempt to seek past end of element.</td>
</tr>
<tr>
<td>DFE_PUTELEM</td>
<td>Hputelement error.</td>
</tr>
<tr>
<td>DFE_GETELEM</td>
<td>Hgetelement error.</td>
</tr>
<tr>
<td>DFE_CANTLINK</td>
<td>Cannot initialize link information.</td>
</tr>
<tr>
<td>DFE_CANTSYNC</td>
<td>Cannot synchronize memory with file.</td>
</tr>
<tr>
<td>Error Code</td>
<td>Code Definition</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>DFE_BADGROUP</td>
<td>Error from DFiread in opening a group.</td>
</tr>
<tr>
<td>DFE_GROUPSETUP</td>
<td>Error from DFisetup in opening a group.</td>
</tr>
<tr>
<td>DFE_PUTGROUP</td>
<td>Error on putting a tag/reference number pair into a group.</td>
</tr>
<tr>
<td>DFE_GROUPWRITE</td>
<td>Error when writing group contents.</td>
</tr>
<tr>
<td>DFE_DFNULL</td>
<td>Data file reference is a null pointer.</td>
</tr>
<tr>
<td>DFE_ILTTYPE</td>
<td>Data file contains an illegal type: internal error.</td>
</tr>
<tr>
<td>DFE_BADDLIST</td>
<td>The DD list is non-existent: internal error.</td>
</tr>
<tr>
<td>DFE_NOTDPFILE</td>
<td>The current file is not an HDF file and it is not zero length.</td>
</tr>
<tr>
<td>DFE_SEEDTWICE</td>
<td>The DD list already seeded: internal error.</td>
</tr>
<tr>
<td>DFE_NOSUCHTAG</td>
<td>No such tag in the file: search failed.</td>
</tr>
<tr>
<td>DFE_NOFREEDD</td>
<td>There are no free DDs left: internal error.</td>
</tr>
<tr>
<td>DFE_BADTAG</td>
<td>Illegal WILDCARD tag.</td>
</tr>
<tr>
<td>DFE_BADREF</td>
<td>Illegal WILDCARD reference number.</td>
</tr>
<tr>
<td>DFE_NOMATCH</td>
<td>No DDs (or no more DDs) that match the specified tag/reference number pair.</td>
</tr>
<tr>
<td>DFE_NOTINSET</td>
<td>Warning: Set contained unknown tag. Ignored.</td>
</tr>
<tr>
<td>DFE_BADOFFSET</td>
<td>Illegal offset specified.</td>
</tr>
<tr>
<td>DFE_CORRUPT</td>
<td>File is corrupted.</td>
</tr>
<tr>
<td>DFE_NOREF</td>
<td>No more reference numbers are available.</td>
</tr>
<tr>
<td>DFE_DUPDD</td>
<td>The new tag/reference number pair has been allocated.</td>
</tr>
<tr>
<td>DFE_CANTMOD</td>
<td>Old element doesn’t exist. Cannot modify.</td>
</tr>
<tr>
<td>DFE_DIFFFILES</td>
<td>Attempt to merge objects in different files.</td>
</tr>
<tr>
<td>DFE_BADAID</td>
<td>An invalid AID was received.</td>
</tr>
<tr>
<td>DFE_OPENAID</td>
<td>Active AIDs still exist.</td>
</tr>
<tr>
<td>DFE_CANTFLUSH</td>
<td>Cannot flush DD back to file.</td>
</tr>
<tr>
<td>DFE_CANTUPDATE</td>
<td>Cannot update the DD block.</td>
</tr>
<tr>
<td>DFE_CANTHASH</td>
<td>Cannot add a DD to the hash table.</td>
</tr>
<tr>
<td>DFE_CANTDELDD</td>
<td>Cannot delete a DD in the file.</td>
</tr>
<tr>
<td>DFE_CANTDELHASH</td>
<td>Cannot delete a DD from the hash table.</td>
</tr>
<tr>
<td>DFE_CANTACCESS</td>
<td>Cannot access specified tag/reference number pair.</td>
</tr>
<tr>
<td>DFE_CANTENDACCESS</td>
<td>Cannot end access to data element.</td>
</tr>
<tr>
<td>DFE_TABLEFULL</td>
<td>Access table is full.</td>
</tr>
<tr>
<td>DFE_NOTINTABLE</td>
<td>Cannot find element in table.</td>
</tr>
<tr>
<td>DFE_UNSUPPORTED</td>
<td>Feature not currently supported.</td>
</tr>
<tr>
<td>DFE_NOSPACE</td>
<td>malloc failed.</td>
</tr>
<tr>
<td>DFE_BADCALL</td>
<td>Routine calls were in the wrong order.</td>
</tr>
<tr>
<td>DFE_BADPTR</td>
<td><strong>NULL</strong> pointer argument was specified.</td>
</tr>
<tr>
<td>DFE_BADLEN</td>
<td>Invalid length was specified.</td>
</tr>
<tr>
<td>DFE_NOTENOUGH</td>
<td>Not enough space for the data.</td>
</tr>
<tr>
<td>DFE_NOVALS</td>
<td>Values were not available.</td>
</tr>
<tr>
<td>DFE_ARGS</td>
<td>Invalid arguments passed to the routine.</td>
</tr>
<tr>
<td>DFE_INTERNAL</td>
<td>Serious internal error.</td>
</tr>
<tr>
<td>DFE_NORESET</td>
<td>Too late to modify this value.</td>
</tr>
<tr>
<td>DFE_GENAPP</td>
<td>Generic application level error.</td>
</tr>
<tr>
<td>DFE_UNINIT</td>
<td>Interface was not initialized correctly.</td>
</tr>
<tr>
<td>DFE_CANTINIT</td>
<td>Cannot initialize the interface the operation requires.</td>
</tr>
<tr>
<td>DFE_CANTSHUTDOWN</td>
<td>Cannot shut down the interface the operation requires.</td>
</tr>
<tr>
<td>DFE_BADDIM</td>
<td>Negative number of dimensions, or zero dimensions, was specified.</td>
</tr>
<tr>
<td>Error Code</td>
<td>Code Definition</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>DFE_BADFP</td>
<td>File contained an illegal floating point number.</td>
</tr>
<tr>
<td>DFE_BADDATATYPE</td>
<td>Unknown or unavailable data type was specified.</td>
</tr>
<tr>
<td>DFE_BADMCTYPE</td>
<td>Unknown or unavailable machine type was specified.</td>
</tr>
<tr>
<td>DFE_BADNUMTYPE</td>
<td>Unknown or unavailable number type was specified.</td>
</tr>
<tr>
<td>DFE_BADORDER</td>
<td>Unknown or illegal array order was specified.</td>
</tr>
<tr>
<td>DFE_RANGE</td>
<td>Improper range for attempted access.</td>
</tr>
<tr>
<td>DFE_BADCOMP</td>
<td>Invalid data type conversion was specified.</td>
</tr>
<tr>
<td>DFE_BADTYPE</td>
<td>Incompatible types were specified.</td>
</tr>
<tr>
<td>DFE_BADSCHEME</td>
<td>Unknown compression scheme was specified.</td>
</tr>
<tr>
<td>DFE_BADMODEL</td>
<td>Invalid compression model was specified.</td>
</tr>
<tr>
<td>DFE_BADCODER</td>
<td>Invalid compression encoder was specified.</td>
</tr>
<tr>
<td>DFE_MODEL</td>
<td>Error in the modeling layer of the compression operation.</td>
</tr>
<tr>
<td>DFE_CODER</td>
<td>Error in the encoding layer of the compression operation.</td>
</tr>
<tr>
<td>DFE_CINIT</td>
<td>Error in encoding initialization.</td>
</tr>
<tr>
<td>DFE_CXECODE</td>
<td>Error in decoding compressed data.</td>
</tr>
<tr>
<td>DFE_CECCODE</td>
<td>Error in encoding compressed data.</td>
</tr>
<tr>
<td>DFE_CTERM</td>
<td>Error in encoding termination.</td>
</tr>
<tr>
<td>DFE_CSEEK</td>
<td>Error seeking in an encoded data set.</td>
</tr>
<tr>
<td>DFE_MINIT</td>
<td>Error in modeling initialization.</td>
</tr>
<tr>
<td>DFE_COMPINFO</td>
<td>Invalid compression header.</td>
</tr>
<tr>
<td>DFE_CANTCOMP</td>
<td>Cannot compress an object.</td>
</tr>
<tr>
<td>DFE_CANTDECOMP</td>
<td>Cannot decompress an object.</td>
</tr>
<tr>
<td>DFE_RDFDIM</td>
<td>A dimension record was not associated with the image.</td>
</tr>
<tr>
<td>DFE_BADRIG</td>
<td>Error processing a RIG.</td>
</tr>
<tr>
<td>DFE_RINOFOUND</td>
<td>Cannot find raster image.</td>
</tr>
<tr>
<td>DFE_BADATTR</td>
<td>Invalid attribute.</td>
</tr>
<tr>
<td>DFE_BADTABLE</td>
<td>The nsdg table has incorrect information.</td>
</tr>
<tr>
<td>DFE_BADSDG</td>
<td>Error in processing an SDG.</td>
</tr>
<tr>
<td>DFE_BADNDG</td>
<td>Error in processing an NDG.</td>
</tr>
<tr>
<td>DFE_VGSIZE</td>
<td>Too many elements in the vgroup.</td>
</tr>
<tr>
<td>DFE_VTABLE</td>
<td>Element not in vtab[].</td>
</tr>
<tr>
<td>DFE_CANTADDLELEM</td>
<td>Cannot add the tag/reference number pair to the vgroup.</td>
</tr>
<tr>
<td>DFE_BADVNAME</td>
<td>Cannot set the vgroup name.</td>
</tr>
<tr>
<td>DFE_BADVCLASS</td>
<td>Cannot set the vgroup class.</td>
</tr>
<tr>
<td>DFE_BADFIELDS</td>
<td>Invalid fields string passed to vset routine.</td>
</tr>
<tr>
<td>DFE_NOVS</td>
<td>Cannot find the vset in the file.</td>
</tr>
<tr>
<td>DFE_SYMSIZE</td>
<td>Too many symbols in the users table.</td>
</tr>
<tr>
<td>DFE_BADATTACH</td>
<td>Cannot write to a previously attached vdata.</td>
</tr>
<tr>
<td>DFE_BADVNAME</td>
<td>Cannot set the vdata name.</td>
</tr>
<tr>
<td>DFE_BADVCLASS</td>
<td>Cannot set the vdata class.</td>
</tr>
<tr>
<td>DFE_VSCANTCREATE</td>
<td>Cannot create the vdata.</td>
</tr>
<tr>
<td>DFE_VGCANTCREATE</td>
<td>Cannot create the vgroup.</td>
</tr>
<tr>
<td>DFE_CANTATTACH</td>
<td>Cannot attach to a vdata or vset.</td>
</tr>
<tr>
<td>DFE_CANTDETACH</td>
<td>Cannot detach a vdata or vset with write access.</td>
</tr>
<tr>
<td>Error Code</td>
<td>Code Definition</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>DFE_BITREAD</td>
<td>A bit read error occurred.</td>
</tr>
<tr>
<td>DFE_BITWRITE</td>
<td>A bit write error occurred.</td>
</tr>
<tr>
<td>DFE_BITSEEK</td>
<td>A bit seek error occurred.</td>
</tr>
<tr>
<td>DFE_TBPRTNS</td>
<td>Failed to insert the element into tree.</td>
</tr>
<tr>
<td>DFE_BVNEW</td>
<td>Failed to create a bit vector.</td>
</tr>
<tr>
<td>DFE_BVSET</td>
<td>Failed when setting a bit in a bit vector.</td>
</tr>
<tr>
<td>DFE_BVGET</td>
<td>Failed when getting a bit in a bit vector.</td>
</tr>
<tr>
<td>DFE_BVFIND</td>
<td>Failed when finding a bit in a bit vector.</td>
</tr>
</tbody>
</table>
Chapter 14

HDF Performance Issues

14.1 Chapter Overview and Introduction

This chapter describes many of the concepts the HDF user should understand to gain better performance from their applications that use the HDF library. It also covers many of the ways in which HDF can be used to cause impaired performance and methods for correcting these problems.

As stated earlier in this manual, HDF has been designed to be very general-purpose, and it has been used in many different applications involving scientific data. Each application has its own set of software and hardware resource constraints that will affect performance in a different way, and to a different extent, from the resource constraints in other applications.

Therefore, it is impossible to outline all of the performance issues that may relate to a particular application of HDF. However, this chapter should give the reader sufficient knowledge of the most common performance issues encountered by the HDF Group. This knowledge should enable the reader to explore different ways of storing data on the platforms they use for the purpose of increasing library performance.

14.2 Examples of HDF Performance Enhancement

In this section, four pairs of HDF object models along with their C implementations will be presented. Each pair will illustrate a specific aspect of HDF library performance as it relates to scientific data sets. They will be employed here as general pointers on how to model scientific data sets for optimized performance.

In developing and testing these examples, the Sun Solaris OS version supported by HDF version 4.1 release 1 was used. Version 2.0 of the Quantify performance profiler was used to measure the relative differences in library performance between the SDS models in each pair. It should be noted that, while the examples reliably reflect which SDS configurations result in better performance, the specifics of how much performance will be improved depend on many factors such as OS configuration, compiler used and profiler used. Therefore, any specific measurements of performance mentioned in the chapter should be interpreted only as general indicators.

The reader should keep in mind that the following examples have been designed for illustrative purposes only, and should not be considered as real-world examples. It is expected that the reader will apply the library performance concepts covered by these examples to their specific usage of the HDF library.
14.2.1 One Large SDS versus Several Smaller SDSs

The scientific data set is an example of what in HDF parlance is referred to as a primary object. The primary objects accessed and manipulated by the HDF library include, beside scientific data sets, raster images, annotations, vdatas and vgroups. Each primary object has metadata, or data describing the data, associated with it. Refer to the HDF Specifications Manual for a description of the components of this metadata and how to calculate its size on disk.

An opportunity for performance enhancement can exist when the size of the metadata far exceeds the size of the data described by the metadata. In this situation, more CPU time and disk space will be used to maintain the metadata than the data contained in the SDS. Consolidating the data into fewer, or even one, SDS can increase performance.

To illustrate this, consider 1,000 1 x 1 x 1 element scientific data sets of 32-bit floating-point numbers. No user-defined dimension, dimension scales or fill values have been defined or created.

In this example, 1,000 32-bit floating-point numbers are first buffered in-core, then written as 1,000 SDSs.

In Table 14A, the results of this operation are reflected in two metrics: the total number of CPU cycles used by the example program, and the size of the HDF file after the write operation.

Now the 1,000 32-bit floating point numbers that were split into 1,000 SDSs are combined into one 10 x 10 x 10 element SDS. This is illustrated in the following figure.

FIGURE 14a

1,000 1 x 1 x 1 Element Scientific Data Sets

<table>
<thead>
<tr>
<th>SDS 1</th>
<th>SDS 2</th>
<th>SDS 3</th>
<th>SDS 4</th>
<th>SDS 5</th>
<th>SDS 6</th>
<th>SDS 7</th>
<th>...</th>
<th>SDS 1000</th>
</tr>
</thead>
</table>

In Table 14A, the results of this operation are reflected in two metrics: the total number of CPU cycles used by the example program, and the size of the HDF file after the write operation.

<table>
<thead>
<tr>
<th>Total Number of CPU Cycles</th>
<th>Size of the HDF File (in bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>136,680,037</td>
<td>896,803</td>
</tr>
</tbody>
</table>

Now the 1,000 32-bit floating point numbers that were split into 1,000 SDSs are combined into one 10 x 10 x 10 element SDS. This is illustrated in the following figure.
As with the last example, 1,000 32-bit floating-point numbers are first buffered in-core, then written to a single SDS. The following table contains the performance metrics of this operation.

<table>
<thead>
<tr>
<th>Total Number of CPU Cycles</th>
<th>Size of the HDF File (in bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>205,201</td>
<td>7,258</td>
</tr>
</tbody>
</table>

It is apparent from these results that merging the data into one scientific data set results in a substantial increase in I/O efficiency - in this case, a 99.9% reduction in total CPU load. In addition, the size of the HDF file is dramatically reduced by a factor of more than 100, even through the amount of SDS data stored is the same.

The extent to which the data consolidation described in this section should be done is dependent on the specific I/O requirements of the HDF user application.

14.2.2 Sharing Dimensions between Scientific Data Sets

When several scientific data sets have dimensions of the same length, name and data type, they can share these dimensions to reduce storage overhead and CPU cycles in writing out data.

To illustrate this, again consider the example of 1,000 1 x 1 x 1 scientific data sets of 32-bit floating point numbers. Three dimensions are attached by default to each scientific data set by the HDF library. The HDF library assigns each of these dimensions a default name prefaced by the string _fakeDim_. See Chapter 3, *Scientific Data Sets (SD API)*, for a specific explanation of default dimension naming conventions.
One 32-bit floating point number is written to each scientific data set. The following table lists the performance metrics of this operation.

<table>
<thead>
<tr>
<th>SDS 1</th>
<th>SDS 2</th>
<th>SDS 3</th>
<th>SDS 1,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Default Dimensions</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dimension Named X_Axis</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dimension Named Y_Axis</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dimension Named Z_Axis</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Total Number of CPU Cycles</th>
<th>Size of the HDF File (in bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>136,680,037</td>
<td>896,803</td>
</tr>
</tbody>
</table>

Now consider the 1,000 SDSs described previously in this section. In this case, the 1,000 SDSs share the program-defined X_Axis, Y_Axis and Z_Axis dimensions as illustrated in the following figure.

The performance metrics that result from writing one 32-bit floating-point number to each dataset are in the following table.
An 82% performance improvement in this example program can be seen from the information in this table, due to the fewer write operations involved in writing dimension data to shared dimensions. Also, the HDF file is significantly smaller in this case, due to the smaller amount of dimension data that is written.

### 14.2.3 Setting the Fill Mode

When a scientific data set is created, the default action of the HDF library is to fill every element with the default fill value. This action can be disabled, and reenabled once it has been disabled, by a call to the `SDsetfillmode` routine.

The library’s default writing of fill values can degrade performance when, after the fill values have been written, every element in the dataset is written to again. This operation involves writing every element in the SDS twice. This section will demonstrate that disabling the initial fill value write operation by calling `SDsetfillmode` can improve library performance.

Consider 50 10 x 10 x 10 scientific data sets of 32-bit floating-point numbers.

By default, the fill value is written to every element in all 50 SDSs. The contents of a two-dimensional buffer containing 32-bit floating-point numbers is then written to these datasets. The way these two-dimensional slices are written to the three-dimensional SDSs is illustrated in the following figure. Each slice (represented by each shaded area in the figure) is written along the third dimension of each SDS, or if the dimensions are related to a Cartesian grid, the z-dimension, until the entire SDS is filled.
Writing to the 50 10 x 10 x 10 Element Scientific Data Sets

It should be noted that the reason each SDS is not rewritten to in one write operation is because the HDF library will detect this and automatically disable the initial write of the fill values as a performance-saving measure. Hence, the partial writes in two-dimensional slabs.

The following table shows the number of CPU cycles needed in our tests to perform this write operation with the fill value write enabled. The "Size of the HDF File" metric has been left out of this table, because it will not change substantially regardless of whether the default fill value write operation is enabled.

<table>
<thead>
<tr>
<th>Total Number of CPU Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>584,956,078</td>
</tr>
</tbody>
</table>

The following table shows the number of CPU cycles needed to perform the same write operation with the fill value write disabled.

<table>
<thead>
<tr>
<th>Total Number of CPU Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>390,015,933</td>
</tr>
</tbody>
</table>

The information in these tables demonstrate that eliminating the I/O overhead of the default fill value write operation when an entire SDS is rewritten to results in a substantial reduction of the CPU cycles needed to perform the operation -- in this case, a reduction of 33%.

14.2.4 Disabling Fake Dimension Scale Values in Large One-dimensional Scientific Data Sets

In versions 4.0 and earlier of the HDF library, dimension scales were represented by a vgroup containing a vdata. This vdata consisted of as many records as there are elements along the dimension. Each record contained one number which represented each value along the dimension scale, and these values are referred to as fake dimension scale values.

In HDF version 4.0 a new representation of the dimension scale was implemented alongside the old one -- a vdata containing only one value representing the total number of values in the dimension scale. In version 4.1 release 2, this representation was made the default. A compatible mode is also supported where both the older and newer representations of the dimension scale are written to file.
In the earlier representation, a substantial amount of I/O overhead is involved in writing the fake dimension scale values into the vdata. When one of the dimensions of the SDS array is very large, performance can be improved, and the size of the HDF file can be reduced, if the old representation of dimension scales is disabled by a call to the `SDsetdimval_comp` routine. The examples in this section will illustrate this.

First, consider one 10,000 element array of 32-bit floating point numbers, as shown in the following figure. Both the new and old dimension scale representations are enabled by the library.

**FIGURE 14g**

One 10,000 Element Scientific Data Set with Old- and New-Style Dimension Scales

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000 element array</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vdata Containing 1 Dimension Scale Value (New-style)

Vdata Containing 10,000 Fake Dimension Scale Values (Old-style)

10,000 32-bit floating-point numbers are buffered in-core, then written to the scientific data set. In addition, 10,000 integers are written to the SDS as dimension scale values. The following table contains the results of this operation from our tests.

**TABLE 14G**

Results of the SDS Write Operation with the New and Old Dimension Scales

<table>
<thead>
<tr>
<th>Total Number of CPU Cycles</th>
<th>Size of the HDF File (in bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>439,428</td>
<td>82,784</td>
</tr>
</tbody>
</table>

Now consider the same SDS with the fake dimension scale values disabled. The following figure illustrates this.

**FIGURE 14h**

One 10,000 Element Scientific Data Set with the Old-Style Dimension Scale Disabled

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000 element array</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vdata Containing One Dimension Scale Value (New-style)

The following table contains the performance metrics of this write operation.
TABLE 14H

Results of the SDS Write Operation with Only the New Dimension Scale

<table>
<thead>
<tr>
<th>Total Number of CPU Cycles</th>
<th>Size of the HDF File</th>
</tr>
</thead>
<tbody>
<tr>
<td>318,696</td>
<td>42,720</td>
</tr>
</tbody>
</table>

The old-style dimension scale is not written to the HDF file, which results in the size of the file being reduced by nearly 50%. There is also a marginal reduction in the total number of CPU cycles.

14.3 Data Chunking

14.3.1 What Is Data Chunking?

Data chunking is a method of organizing data within an SDS where data is stored in chunks of a predefined size, rather than contiguously by array element. Its two-dimensional instance is sometimes referred to as data tiling. Data chunking is generally beneficial to I/O performance in very large arrays, e.g., arrays with thousands of rows and columns.

If correctly applied, data chunking may reduce the number of seeks through the SDS data array to find the data to be read or written, thereby improving I/O performance. However, it should be remembered that data chunking, if incorrectly applied, can significantly reduce the performance of reading and/or writing to an SDS. Knowledge of how chunked SDSs are created and accessed and application-specific knowledge of how data is to be read from the chunked SDSs are necessary in avoiding situations where data chunking works against the goal of I/O performance optimization.

The following figure illustrates the difference between a non-chunked SDS and a chunked SDS.

FIGURE 14i

Comparison between Chunked and Non-chunked Scientific Data Sets

While the data in a non-chunked SDS is written to, and organized in, a contiguous fashion, a chunked SDS is written to, and organized in, equally-sized regions of data -- or chunks.
14.3.2 Writing Concerns and Reading Concerns in Chunking

There are issues in working with chunks that are related to the reading process and others that are related to the writing process.

Specifically, the issues that affect the process of reading from chunked SDSs are
- Compression
- Subsetting
- Chunk sizing
- Chunk cache sizing

The issues that affect the process of writing to chunked SDSs are
- Compression
- Chunk cache sizing

14.3.3 Chunking without Compression

Accessing Subsets According to Storage Order

The main consideration to keep in mind when subsetting from chunked and non-chunked SDSs is that if the subset can be accessed in the same order as it was stored, subsetting will be efficient. If not, subsetting may result in less-than-optimal performance considering the number of elements to be accessed.

To illustrate this, the instance of subsetting in non-chunked SDSs will first be described. Consider the example of a non-chunked, two-dimensional, 2,000 x 1,600 SDS array of integer data. The following figure shows how this array is filled with data in a row-wise fashion. (Each square in the array shown represents 100 x 100 integers.)

FIGURE 14j
Filling a Two-dimensional Array with Data Using Row-major Ordering

In C, a two dimensional array is filled row-wise.

The most efficient way an application can read a row of data, or a portion of a row, from this array, is a contiguous, row-wise read of array elements. This is because this is the way the data was originally written to the array. Only one seek is needed to perform this. (See Figure 14k.)
If the subset of data to be read from this array is one 2,000 integer column, then 2,000 seeks will be required to complete the operation. This is the most inefficient method of reading this subset as nearly all of the array locations will be accessed in the process of seeking to a relatively small number of target locations.

Now suppose this SDS is chunked, and the chunk size is 400 x 400 integers. A read of the aforementioned row is performed. In this case, four seeks are needed to read all of the chunks that contain the target locations. This is less efficient than the one seek needed in the non-chunked SDS.
To read the aforementioned column of data, five chunks must be read into memory in order to access the 2,000 locations of the subset. Therefore, five seeks to the starting location of each of these chunks are necessary to complete the read operation, far fewer than the 2,000 needed in the non-chunked SDS.

These examples show that, in many cases, chunking can be used to reduce the I/O overhead of subsetting, but in certain cases, chunking can impair I/O performance.

The efficiency of subsetting from chunked SDSs is partly determined by the size of the chunk: the smaller the chunk size, the more seeks will be necessary. Chunking can substantially improve I/O performance when data is read along the slowest-varying dimension. It can substantially degrade performance when data is read along the fastest-varying dimension.
14.3.4 Chunking with Compression

Chunking can be particularly effective when used in conjunction with compression. It allows subsets to be read (or written) without having to uncompress (or compress) the entire array.

Consider the example of a tiled, two-dimensional SDS containing one million bytes of image data. Each tile of image data has been compressed as illustrated in the following figure.

When it becomes necessary to read a subset of the image data, the application passes in the location of a tile, reads the entire tile into a buffer, and extracts the data-of-interest from that buffer.

In a compressed and non-tiled SDS, retrieving a subset of the compressed image data necessitates reading the entire contents of the SDS array into a memory buffer and uncompressing it in-core. (See Figure 14q.) The subset is then extracted from this buffer. (Keep in mind that, even though
the illustrations show two-dimensional data tiles for clarity, this process can be extended to data chunks of any number of dimensions.)

FIGURE 14q

Extracting a Subset from a Compressed Non-tiled SDS

As compressed image files can be as large as hundreds of megabytes in size, and a gigabyte or more uncompressed, it is clear that the I/O requirements of reading to and writing from non-tiled, compressed SDSs can be immense, if not prohibitive. Add to this the additional I/O burden inherent in situations where portions of several image files must be read at the same time for comparison, and the benefits of tiling become even more apparent.

NOTE: It is recommended that the SDwritechunk routine be used to write to a compressed and chunked SDS. SDwritechunk can perform this operation more efficiently than the combination of SDsetcompress and SDwritedata. This is because the chunk information provided by the user to the SDwritechunk routine must be retrieved from the file by SDwritedata, and therefore involves more computational overhead.

14.3.5 Effect of Chunk Size on Performance

The main concern in modelling data for chunking is that the chunk size be approximately equal to the average expected size of the data block needed by the application.

If the chunk size is substantially larger than this, increased I/O overhead will be involved in reading the chunk and increased performance overhead will be involved in the decompression of the data if it is compressed. If the chunk size is substantially smaller than this, increased performance and memory/disk storage overhead will be involved in the HDF library’s operations of accessing and keeping track of more chunks, as well as the danger of exceeding the maximum number of chunks per file. (64K)

It is recommended that the chunk size be at least 8K bytes.

14.3.6 Insufficient Chunk Cache Space Can Impair Chunking Performance

The HDF library provides caching chunks. This can substantially improve I/O performance when a particular chunk must be accessed more than once.
There is a potential performance problem when subsets are read from chunked datasets and insufficient chunk cache space has been allocated. The cause of this problem is the fact that two separate levels of the library are working to read the subset into memory and these two levels have a different perspective on how the data in the dataset is organized.

Specifically, higher-level routines like \texttt{SDreaddata} access the data in a strictly row-wise fashion, not according to the chunked layout. However, the lower-level code that directly performs the read operation accesses the data according to the chunked layout.

As an illustration of this, consider the 4\times12 dataset depicted in the following figure.

\begin{figure}[h]
\centering
\caption{Example 4 x 12 Element Scientific Data Set}
\begin{tabular}{cccccccccccc}
1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 \\
41 & 42 & 43 & 44 & 45 & 46 & 47 & 48 & 49 & 50 & 51 & 52 \\
61 & 62 & 63 & 64 & 65 & 66 & 67 & 68 & 69 & 70 & 71 & 72 \\
\end{tabular}
\end{figure}

Suppose this dataset is untiled, and the subset shown in the following figure must be read.

\begin{figure}[h]
\centering
\caption{2 x 8 Element Subset of the 4 x 12 Scientific Data Set}
\begin{tabular}{cccccccccccc}
1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 \\
41 & 42 & 43 & 44 & 45 & 46 & 47 & 48 & 49 & 50 & 51 & 52 \\
61 & 62 & 63 & 64 & 65 & 66 & 67 & 68 & 69 & 70 & 71 & 72 \\
\end{tabular}
\end{figure}

As this dataset is untiled, the numbers are stored in linear order. \texttt{SDreaddata} finds the longest contiguous stream of numbers, and requests the lower level of the library code to read it into memory. First, the first row of numbers will be read:

\[3 \ 4 \ 5 \ 6 \ 7 \ 8 \ 9 \ 10\]

Then the second row:

\[23 \ 24 \ 25 \ 26 \ 27 \ 28 \ 29 \ 30\]

This involves two reads, two disk accesses and sixteen numbers.

Now suppose that this dataset is tiled with 2\times2 element tiles. On the disk, the data in this dataset is stored as twelve separate tiles, which for the purposes of this example will be labelled A through L.
Also, the chunk cache size is set to 2.

A request is made to read the aforementioned subset of numbers into memory. As before, **SDreaddata** will determine the order the numbers will be read in. The routine has no information about the tiled layout. The higher-level code will again request the values in the first rows of tiles B through E from the lower level code on the first read operation.

In order to access those numbers the lower level code must read in four tiles: B, C, D, E. It reads in tiles B and C, retrieving the values 3, 4, 5, and 6. However, as the cache space is now completely filled, it must overwrite tile B in the cache to access the values 7 and 8, which are in tile D. It then has to overwrite tile C to access the values 9 and 10, which are in tile E. Note that, in each case, half of the values from the tiles that are read in are unused, even though those values will be needed later.

Next, the higher-level code requests the second row of the subset. The lower-level code must reread tile B to access the values 23 and 24. But tile B is no longer in the chunk cache. In order to access tile B, the lower-level code must overwrite tile D, and so on. By the time the subset read operation is complete, it has had to read in each of the tiles twice. Also, it has had to perform 8 disk accesses and has read 32 values.

Now consider a more practical example with the following parameters:

- A scientific data set has 3,000 rows and 8,400 columns.
- The target subset is 300 rows by 1,000 columns, and contains 300,000 numbers.

If the dataset is untiled the numbers are read into memory row-by-row. This involves 300 disk accesses for 300 rows, with each disk access reading in 1,000 numbers. The total number of numbers that will be read is 300,000.

Suppose the dataset is tiled as follows:

- The tile size is 300 rows by 200 columns, or 60,000 numbers.
- The size of the chunk cache is 2.

Each square in the following figure represents one 100 x 100 element region of the dataset. Five tiles span the 300 x 1,000 target subset. For the purposes of this example, they will be labelled A, B, C, D and E.
First, the higher-level code instructs the lower-level code to read in the first row of subset numbers. The lower-level code must read all five tiles (A through E) into memory, as they all contain numbers in the first row. Tiles A and B are read into the cache without problem, then the following set of cache overwrites occurs.

1. Tile A is overwritten when tile C is read.
2. Tile B is overwritten when tile D is read.
3. Tile C is overwritten when tile E is read.

When the first row has been read, the cache contains tiles D and E.

The second row is then read. The higher-level code first requests tile A, however the cache is full, so it must overwrite tile D to read tile A. Then the following set of cache overwrites occur.

1. Tile E is overwritten when tile B is read.
2. Tile A is overwritten when tile C is read.
3. Tile B is overwritten when tile D is read.
4. Tile C is overwritten when tile E is read.

For each row, five tiles must be read in. No actual caching results from this overwriting. When the subset read operation is complete, $300 \times 5 = 1,500$ tiles have been read, or $60,000 \times 1,500 = 90,000,000$ numbers.

Essentially, five times more disk accesses are being performed and 900 times more data is being read than with the untiled $3,000 \times 8,400$ dataset. The severity of the performance degradation increases in a non-linear fashion as the size of the dataset increases.
From this example it should be apparent that, to prevent this kind of chunk cache "thrashing" from occurring, the size of the chunk cache should be made equal to, or greater than, the number of chunks along the fastest-varying dimension of the dataset. In this case, the chunk cache size should be set to 4.

When a chunked SDS is opened for reading or writing, the default cache size is set to the number of chunks along the fastest-varying dimension of the SDS. This will prevent cache thrashing from occurring in situations where the user does not set the size of the chunk cache. Caution should be exercised by the user when altering this default chunk cache size.

### 14.4 Block Size Tuning Issues

A key to I/O performance in HDF is the number of disk accesses that must be made during any I/O operation. If you can decrease significantly the number of disk accesses required, you may be able to improve performance correspondingly. In this section we examine two such strategies for improving HDF I/O performance.

#### 14.4.1 Tuning Data Descriptor Block Size to Enhance Performance

HDF objects are identified in HDF files by 12-byte headers called data descriptors (DDs). Most composite HDF objects, such as SDSs, are made up of many small HDF objects, so it is not unusual to have a large number of DDs in an HDF file. DDs are stored in blocks called data descriptor blocks (DD blocks).

When an HDF file is created, the file’s DD block size is specified. The default size is 16 DDs per DD block. When you start putting objects into an HDF file, their DDs are inserted into the first DD block. When the DD block gets filled up, a new DD block is created, stored at some other location in the file, and linked with the previous DD block. If a large number of objects are stored in an HDF file whose DD block size is small, a large number of DD blocks will be needed, and each DD block is likely to be stored on a different disk page.

Consider, for example, an HDF file with 1,000 SDSs and a DD block size of 16. Each SDS could easily require 10 DDs to describe all the objects comprising the SDS, so the entire file might contain 10,000 DDs. This would require 625 (10,000/16) DD blocks, each stored on a different disk page.

Whenever an HDF file is opened, all of the DDs are read into memory. Hence, in our example, 625 disk accesses might be required just to open the file.

Fortunately, there is a way we can use this kind of information to improve performance. When we create an HDF file, we can specify the DD block size. If we know that the file will have many objects stored in it, we should choose a large DD block size so that each disk access will read in a large number of DDs, and hence there will be fewer disk accesses. In our example, we might have chosen the DD block size to be 10,000, resulting in only one disk access. (Of course, this example goes deliberately to a logical extreme. For a variety of reasons, a more common approach would be to set the DD block size to something between 1,000 and 5,000 DDs.)

From this discussion we can derive the following rules of thumb for achieving good performance by altering the DD block size.

- Increasing the size of the data descriptor block may improve performance when opening a file, especially when working with large HDF files with lots of objects. It will reduce the number of times that HDF has to go out and read another DD block. This will be particularly valuable in code that does large numbers of HDF file opens.
- The same principle applies when closing an HDF file that has been written to. Since all DDs are flushed to an HDF file when it is written to and then closed, the DD block size can similarly impact performance.

- Notice that these actions only affect the opening and closing of a file. Once a file is opened, DDs are accessed in memory; no further disk accesses are required.

- Large DD blocks can negatively affect storage efficiency, particularly if very large DD blocks are used. Since the last DD block may only be partially filled up, you probably should not use large DD blocks for very small HDF files.

### 14.4.2 Tuning Linked Block Size to Enhance Performance

Linked blocks get created whenever compression, chunking, external files, or appendable datasets are used. They provide a means of linking new data blocks to a pre-existing data element. If you have ever looked at an HDF file and seen Special Scientific Data or Linked Block Indicator tags with strange tag values, these are used in specifying linked blocks. As with DD blocks, linked block size can affect both storage efficiency and I/O performance.

You can change the linked block size for SDSs by use of the function `SDsetblocksize`. To change the linked block size for Vdatas, you must edit the `hlimts.h` file, change the value of `HDF_APPENDABLE_BLOCK_LEN`, and re-build the HDF library. Changing the linked block size only affects the size of the linked blocks used after the change is made; it does not affect the size of blocks that have already been written.

There is a certain amount of overhead when creating linked blocks. For every linked block that is added there will be a specified number of block accesses, disk space used, and reference numbers added to the file. If you increase the size of the linked block, it will decrease the number of block accesses, disk space used, and reference numbers added to the file. Making the linked block size larger will decrease the number of reference numbers required; this is sometimes necessary because there are a limited number of available reference numbers.

Linked block size can also affect I/O performance, depending on how the data is accessed. If the data will typically be accessed in large chunks, then making the linked block size large could improve performance. If the data is accessed in small chunks, then making the linked block size small could improve performance.

If data will be randomly accessed in small amounts, then it is better to have small linked blocks.

Ideally one might say that making the linked block size equal to the size of the dataset that will typically be accessed, is the best solution. However, there are other things that will affect performance, such as the operating system being used, the sector size on the disk being accessed, the amount of memory available, and access patterns.

Here are some rules of thumb for specifying linked block size:

- Linked block size should be at least as large as the smallest number of bytes accessed in a single disk access. This amount varies from one system to another, but 4K bytes is probably a safe minimum.

- Linked block size should be a power of 2.

- Linked blocks should be approximately equal to the number of bytes accessed in a typical access. This rule should be mitigated by the amount of locality from one disk access to another, however, as the next rule indicates.

- If memory is large, it may be possible to take advantage of caching that your operating system does by using a large block size. If successive accesses are close to one another, blocks may be cached by the OS, so that actual physical disk accesses are not always required. If successive accesses are not close to one another, this strategy could backfire, however.
• Although very large blocks can result in efficient access, they can also result in inefficient storage. For instance if the block size is 100K bytes, and 101K bytes of data are stored per SDS in an HDF file, the file will be twice as large as necessary.

Unfortunately, there are so many factors affected by block size that there is no simple formula that you can follow for deciding what the linked block size should be. A little experimentation on the target platform can help a great deal in determining the ideal block size for your situation.

14.4.3 Unlimited Dimension Data Sets (SDSs and Vdatas) and Performance

In some circumstances, repeatedly appending to unlimited dimension data sets can lead to significant performance problems.

Each time data is appended to a Vdata or an unlimited dimension SDS, a new linked block may be created. Eventually, the linked block list may become so large that data seeking performance deteriorates substantially. In the worst case, one can exceed the allowable number of reference numbers, corrupting the HDF file.

In many such instances, increasing the linked block size (see Section 14.4.2 in this User’s Guide or, for SDSs only, SDsetblocksize/sfsblsz in the HDF Reference Manual) or DD block size (see Section 14.4.1) will alleviate the reference number problems and improve performance.

14.5 Use of the Pablo Instrumentation of HDF

Pablo HDF Trace software provides a means of measuring the performance of programs using HDF. The Pablo software consists of an instrumented copy of the HDF library (libdf-inst.a and libmfhdf-inst.a), the Pablo Trace and Trace Extensions libraries, and some utilities for processing the output. The instrumented version of the HDF library has hooks inserted into the HDF code which call routines in the Pablo Trace library just after entry to each instrumented HDF routine and just prior to exit from the routine. The Pablo Trace Extension library has programs that track the I/O activity between the entry and exit of the HDF routine during execution. A few lines of code must be inserted in the user’s main program to enable tracing and to specify which HDF procedures are to be traced. The program is linked with the special HDF and Pablo libraries to produce an executable. Running this executable on a single processor produces an output file called the trace file which contains records, called Pablo Self-Defining Data Format (SDDF) records, which can later be analyzed using the HDF Analysis Utilities. The HDF Analysis Utilities can be used to interpret the SDDF records in the trace files to produce a report describing the HDF IO activity that occurred during execution. A User’s Guide for this software can be found in the $(toplevel)/hdf/pablo/ subdirectory of the HDF distribution in the files Pablo.doc (Microsoft Word format), Pablo.pdf (PDF format), and Pablo.ps (PostScript format). Also see the file README.Pablo in that directory. For further information about Pablo and the Self-Defining Data Format, visit the Pablo website at http://www-pablo.cs.uiuc.edu.

To enable the creation of an instrumented library, the following section in the makefile fragment $(toplevel)/config/mh-os) must be uncommented and set.

```
# ------------ Macros for Pablo Instrumentation ---------------
# Uncomment the following lines to create a Pablo Instrumentation
# version of the HDF core library called 'libdf-inst.a'
# See the documentation in the directory 'hdf/pablo' for further
# information about Pablo and what platforms it is supported on
# before enabling.
# You need to set 'PABLO_INCLUDE' to the Pablo distribution
# include directory to get the files 'IOTrace.h' and 'IOTrace_SD.h'.
```
After setting these values you must re-run the top-level configure script. Make sure that your start from a clean re-build (i.e. make clean) after re-running the toplevel configure script and then run make. Details on running configure can be found in the section "General Configuration/Installation - Unix" section of the top-level installation file $(toplevel)/INSTALL.
15.1 Chapter Overview

This chapter describes a number of command-line utilities that are available for working with HDF files.

The HDF command-line utilities are application programs that are executed from the UNIX shell prompt. These utilities serve the following needs of the HDF developer.

- They make it possible to perform, at the command line level, common operations on HDF files without having to resort to custom-programmed utilities to do these operations.
- They provide the capability for performing operations on HDF files that would be very difficult to do with custom-programmed utilities.

Table 15A lists the names and descriptions of the utilities described in this chapter.

<table>
<thead>
<tr>
<th>Utility Type</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>File content display tools</td>
<td>hdp</td>
<td>Also known as HDF dumper. Displays general information about the contents of an HDF file (Section 15.2 on page 428)</td>
</tr>
<tr>
<td></td>
<td>hdiff</td>
<td>Displays the differences between the contents of two HDF files (Section 15.3 on page 432)</td>
</tr>
<tr>
<td></td>
<td>vshow</td>
<td>Displays vset information (Section 15.4 on page 433)</td>
</tr>
<tr>
<td>Raw data to HDF conversions</td>
<td>hdfimport</td>
<td>Converts floating-point and/or integer data to HDF scientific data sets (SDS) and/or HDF 8-bit raster image sets (RIS8) format, storing the results in an HDF file (Section 15.5 on page 433) [This utility replaces fp2hdf.]</td>
</tr>
<tr>
<td></td>
<td>r8tohdf</td>
<td>Converts one or more 8-bit raster images in raw format to the HDF RIS8 format and writes them to a file, optionally with palettes (Section 15.6 on page 437)</td>
</tr>
<tr>
<td></td>
<td>r24hdf8</td>
<td>Converts raw RGB 24-bit images to an RIS8 with a palette (Section 15.7 on page 438)</td>
</tr>
<tr>
<td></td>
<td>paltohdf</td>
<td>Converts a raw palette to the HDF format (Section 15.8 on page 439)</td>
</tr>
<tr>
<td>HDF to raw data conversions</td>
<td>hdtorr8</td>
<td>Converts raster images and/or palettes from the HDF format to the raw format and stores them in two sets of files - one for images and the other for palettes (Section 15.9 on page 439)</td>
</tr>
<tr>
<td></td>
<td>hdtopaal</td>
<td>Converts a palette in an HDF file to a raw palette format (Section 15.10 on page 440)</td>
</tr>
<tr>
<td>Raster 8 and 24 image operations</td>
<td>ristosds</td>
<td>Converts a set of RIS8 HDF files into a single three-dimensional SDS HDF file (Section 15.11 on page 440)</td>
</tr>
<tr>
<td></td>
<td>hdf24hdf8</td>
<td>Converting an RIS24 HDF image to an RIS8 HDF image with a 256-color palette (Section 15.12 on page 441)</td>
</tr>
<tr>
<td></td>
<td>hdfcomp</td>
<td>Compresses 8-bit raster images from an HDF file, storing them in a new HDF file (Section 15.13 on page 441)</td>
</tr>
</tbody>
</table>
15.2 Displaying Data Contained in and General Information About the Contents of an HDF File: \textit{hdp} (or HDF Dumper)

15.2.1 General Description

The \textit{hdp} utility, also known as the HDF dumper, provides quick and general information about all objects in the specified HDF file. It can list the contents of HDF files at various levels with different details. It can also dump the data of one or more specific objects in the file.

15.2.2 Command-line Syntax

\begin{verbatim}
  hdp [ [-H \texttt{command}] | \texttt{command} ] filelist
\end{verbatim}

The \textit{hdp} option flags are described in Table 15B:

\begin{table}[h]
\centering
\begin{tabular}{|c|c|}
\hline
\textbf{Utility Type} & \textbf{Name} & \textbf{Description} \\
\hline
\multicolumn{3}{|c|}{HDF file maintenance operations} \\
\hline
 & \texttt{hdpack} & Compresses an HDF file, reading all of the objects in the file and writing them to a new HDF file (Section 15.14 on page 442) \\
 & \texttt{hrpack} & Performs a logical copy of an input HDF4 file to an output HDF4 file, copying all high level objects while optionally rewriting the objects with or without compression and/or with or without chunking (Section 15.15 on page 442) \\
 & \texttt{vmake} & Creates vsets (Section 15.16 on page 444) \\
\hline
\multicolumn{3}{|c|}{Miscellaneous utilities} \\
\hline
 & \texttt{hdfls} & Displays information about HDF data objects (Section 15.17 on page 445) \\
 & \texttt{hdfed} & Displays the contents of an HDF file and allows limited manipulation of the data (Section 15.18 on page 447) \\
\hline
\multicolumn{3}{|c|}{HDF5 / HDF4 file conversion} \\
\hline
 & \texttt{h4toh5, h5toh4, etc} & Tools to assist HDF5 users working with HDF4 files and HDF4 users working with HDF5 files (Section 15.19 on page 447) (These tools are not included in this HDF4 distribution) \\
\hline
\multicolumn{3}{|c|}{HDF4-to-GIF and GIF-to-HDF conversion} \\
\hline
 & \texttt{hdf2gif} & Converts an HDF file to a GIF file (Section 15.20 on page 457) \\
 & \texttt{gif2hdf} & Converts a GIF file to an HDF file (Section 15.21 on page 458) \\
\hline
\multicolumn{3}{|c|}{HDF4 Library configuration and management} \\
\hline
 & \texttt{h4cc} & Simplifies the compilation of HDF4 programs written in C (Section 15.22 on page 460) \\
 & \texttt{h4fc} & Simplifies the compilation of HDF5 programs written in Fortran90 (Section 15.23 on page 461) \\
 & \texttt{h4redploy} & Updates HDF4 compiler tools after an HDF4 software installation in a new location (Section 15.24 on page 462) \\
\hline
\multicolumn{3}{|c|}{User-contributed utilities} \\
\hline
 & & Dozens of user-contributed utilities (Section 15.25 on page 463) \\
\hline
\end{tabular}
\caption{hdp Option Flags}
\end{table}

\texttt{-H} \hspace{1cm} \textbf{Help:} Displays usage information about the specified command. If no command is listed, information about all commands are displayed.

Like \texttt{hdfed}, \texttt{hdp} provides a set of commands that allow the user to determine what kind of information is to be displayed.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|}
\hline
\textbf{Name} & \textbf{Description} \\
\hline
\texttt{list} & Displays the contents of the HDF files in the specified format. \\
\texttt{dumpds} & Displays the contents of the SDSs in the listed files. \\
\texttt{dumpgr} & Displays the contents of the raster images in the listed files. \\
\texttt{dumpvd} & Displays the contents of the vdata objects in the listed files. \\
\hline
\end{tabular}
\caption{The hdp Command Set}
\end{table}
The **list** command

**Syntax:**

```
list [-acensldg] [-o<f|g|t|n>] [-t tag] filelist
```

**Flags:**

- `-a` Print annotations of selected items. (Sets long output.)
- `-c` Print classes of selected items. (Sets long output.)
- `-n` Print names or labels of selected items. (Sets long output.)
- `-e` Print special element information for selected items. (Sets long output.)
- `-s` Set output to short format.
- `-l` Set output to long format.
- `-d` Set output to debugging format.
- `-g` Display information for groups only.
- `-t number` Display information for objects with the given tag number.
- `-t name` Display information for objects with the given name.
- `-of` Print items in the order found in the file.
- `-og` Print items in group order.
- `-ot` Print items in tag order. (default)
- `-on` Print items in name or label order.

**filelist** Names of HDF input files, separated by spaces.

**Description:** Displays the contents of the HDF files in the specified format. As with the **hdfed info** command, the listing for special elements will contain a special tag value (for DFTAG_VS, it is 18347) and the text **Unknown Tag**.

The **dumpsds** command

**Syntax:**

```
hdf dumpsds [-a | -i indices | -r refs | -n names ] [-v | -h | -d] [-o filename] [-bx] filelist
```

**Flags:**

- `-a` Dump all SDSs in the file(s). (default)
- `-i indices` Dump the SDSs at the positions listed in `indices`.
- `-r refs` Dump the SDSs with reference numbers listed in `refs`.
- `-n names` Dump the SDSs with names listed in `names`.
- `-v` Dump all SDS contents, including annotations. (default)
- `-h` Dump SDS header information only, no data or element annotations.
- `-d` Dump SDS data only, no tag/ref or header information. Output is formatted for input to `fp2hdf`.
The **dumpgr** command

**Syntax:**
```
hdp dumpgr [-a | -i indices | -r refs | -n names ]
     [-v | -h | -d | -p] [-o filename] [-bx] filelist
```

**Flags:**
- `-a` Dump all raster images (RIs) in the file(s). (default)
- `-i indices` Dump the RIs indicated in `indices`.
- `-r refs` Dump the RIs with reference numbers listed in `refs`.
- `-n names` Dump the RIs with names listed in `names`.
- `-v` Dump all RI contents, including all annotations. (default)
- `-h` Dump RI header information only, no data or element annotations.
- `-d` Dump RI data only, no tag/ref or header information. Output is formatted for input to `fp2hdf`.
- `-p` Dump palette information for the requested images or for all images if no specific image is requested. With `-h`, dump only palette header information and no data; with `-d`, dump palette data and no header information; with `-v` or without any of `-h`, `-d`, or `-v`, dump palette data and header information.

**Description:** Displays SDS information in the specified format. The `-r`, `-i`, and `-n` flags can be selected together.

The **dumpvd** command

**Syntax:**
```
hdp dumpvd [-a | -i indices | -r refs | -n names | -c classes ]
     [-f f1, f2, ...] [-v | -h | -d] [-o filename] [-bx] filelist
```

**Flags:**
- `-a` Dump all vdatas in the file(s). (default)
- `-i indices` Dump the vdatas at positions listed in `indices`.
- `-r refs` Dump the vdatas with the reference numbers listed in `refs`.
- `-n names` Dump all the vdatas with names listed in `names`.
- `-c classes` Dump all the vdatas with the classes listed listed in `classes`.
- `-f f1, f2, ...`

**Description:** Displays GR raster image information in the specified format. The `-r`, `-i`, and `-n` flags can be selected together. GR images are always stored in pixel interlace mode (see Section 8.5.1 on page 270).
Dump data based on the indicated fields in the vdata header.

-\(v\)  Dump everything, including annotations. (default)
-\(h\)  Dump vdata header information only, no data or element annotations.
-\(d\)  Dump vdata data only, no tag/ref or header information. Output is formatted for input to \texttt{fp2hdf}.

-\(o\) \texttt{filename}  Print output to file \texttt{filename}.
-\(b\)  Output in binary format.
-\(x\)  Output in ASCII format. (default)
\texttt{filelist}  Names of HDF input files, separated by spaces.

**Description:** Displays vdata information in the specified format. The -\(x\), -\(i\), -\(n\), and -\(c\) flags can be selected together.

The \texttt{dumpvg} command

**Syntax:**
\[
\texttt{dumpvg} \ [-a \mid -i \textit{indices} \mid -r \textit{refs} \mid -n \textit{names} \mid -c \textit{classes}] \\
\[-v \mid -h \] \[-o \texttt{filename}] \texttt{filelist}
\]

**Flags:**
-\(a\)  Dump all vgroups in the file(s). (default)
-\(i\) \textit{indices}  Dump the vgroups at positions listed in \textit{indices}.
-\(r\) \textit{refs}  Dump the vgroups with the reference numbers listed in \textit{refs}.
-\(n\) \textit{names}  Dump all the vgroups with names listed in \textit{names}.
-\(c\) \textit{classes}  Dump all the vgroups with classes listed in \textit{classes}.

-\(v\)  Dump everything, including annotations. (default)
-\(h\)  Dump vgroup header information only, no data or element annotations.

-\(o\) \texttt{filename}  Print output to file \texttt{filename}.
\texttt{filelist}  Names of HDF input files, separated by spaces.

**Description:** Displays vgroup information in the specified format. The -\(x\), -\(i\), -\(n\), and -\(c\) flags can be selected together. This command has no binary output option; it produces only ASCII text output.

The \texttt{dumprig} command

**Syntax:**
\[
\texttt{dumprig} \ [-a \mid -i \textit{indices} \mid -m \textit{n} \mid -r \textit{refs}] \ [-dhv] \\
\[-o \texttt{filename} \mid -b \mid -x\] \texttt{filelist}
\]

**Flags:**
-\(a\)  Dump all RIGs in the specified file(s). (default)
-\(i\) \textit{indices}  Dump the RIGs with the positions listed in \textit{indices}.
-\(m\) \textit{n}  Dump only RIGs with the specified data length. \textit{n} can have a value of 8 or 24, for 8- or 24-bit raster images, respectively.
-\(r\) \textit{refs}  Dump the RIGs with the reference numbers listed in \textit{refs}.
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-\(d\)  Dump RIG data only, no tag/ref or header information. Output is formatted for input to \texttt{fp2hdf}.
-\(h\)  Dump RIG header information only, no data or element annotations.
-\(v\)  Dump everything, including annotations. (default)

\(-o \) \texttt{filename}  Print output to \texttt{filename}.
\(-b\)  Output in binary format.
\(-x\)  Output in ASCII format. (default)
\(filelist\)  Names of HDF input files, separated by spaces.

Description: Displays RIG information in the specified format. The \(-r\), \(-i\), and \(-m\) flags can be selected together.

15.3 Displaying Data Contained in and General Information About the Contents of an HDF File: \texttt{hdp} (or HDF Dumper)

15.3.1 General Description

The \texttt{hdiff} utility compares two HDF files and reports differences between them. Only datasets, attributes, and vdata objects are compared.

This section presents the basic usage of the program and examples.

15.3.2 Command-line Syntax

The \texttt{hdiff} command line syntax is as follows:

\[
\texttt{hdiff [-g] [-s] [-d] [-D] [-v \texttt{var1}, \texttt{var2}...]} [-u \texttt{var1}, \texttt{var2}...]]
\[-S\] [-e \texttt{count}] [-t \texttt{limit}] \texttt{file1 file2}
\]

The \texttt{hdiff} command line options and usage are described in Table 15D:

<table>
<thead>
<tr>
<th>\texttt{hdiff Option Flags}</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-g)</td>
<td>Attributes: Compare global attributes only.</td>
</tr>
<tr>
<td>(-s)</td>
<td>Compare SD local attributes only.</td>
</tr>
<tr>
<td>(-d)</td>
<td>Data: Compare SD data only.</td>
</tr>
<tr>
<td>(-D)</td>
<td>Compare Vdata data only.</td>
</tr>
<tr>
<td>(-v \texttt{var1}, \texttt{var2}...)</td>
<td>Variables: Compare SD data only on the variable(s) \texttt{var1}, \texttt{var2}, etc.</td>
</tr>
<tr>
<td>(-u \texttt{var1}, \texttt{var2}...)</td>
<td>Compare Vdata data only on the variable(s) \texttt{var1}, \texttt{var2}, etc.</td>
</tr>
<tr>
<td>(-S)</td>
<td>Output: Print statistics.</td>
</tr>
<tr>
<td>(-e \texttt{count})</td>
<td>Print difference up to \texttt{count} instances for each variable. \texttt{count} is a positive integer.</td>
</tr>
<tr>
<td>(-t \texttt{limit})</td>
<td>Print difference when it is greater than \texttt{limit}. \texttt{limit} is a positive floating point value.</td>
</tr>
<tr>
<td>\texttt{file1} \texttt{file2}</td>
<td>Filenames: First and second HDF input files to be compared.</td>
</tr>
</tbody>
</table>
15.3.3 Examples

Examples of **hdiff** usage can be found at the following URL:

http://hdf.ncsa.uiuc.edu/RFC/hdiff/hdiff_examples.html

---

15.4 Displaying Vdata Information: **vshow**

15.4.1 General Description

Displays information about either one vdata object in an HDF file, or all Vdata objects in the file.

15.4.2 Command-line Syntax

```
   vshow input HDF filename [+|+vdata id]
```

The **vshow** option flags are described in Table 15E.

<table>
<thead>
<tr>
<th>Option Flag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>All Vdatas: The utility will display information about all Vdata objects in the HDF file.</td>
</tr>
<tr>
<td>+vdata id</td>
<td>One Vdata: The utility will display information about the Vdata object corresponding to the specified vdata id.</td>
</tr>
</tbody>
</table>

15.4.3 Examples

Information about all of the Vdata objects in the HDF file named `image012.hdf` must be examined. The following command will display this information.

```
vshow image012.hdf +
```

---

15.5 Converting Floating-point or Integer Data to SDS or RIS8: **hdfimport**

Note that **hdfimport** replaces the **fp2hdf** utility that was distributed with earlier HDF releases.

15.5.1 General Description

The **hdfimport** utility converts data from ASCII text files, 32-bit or 64-bit native floating point data files, 8-bit, 16-bit or 32-bit integer files, or HDF floating-point scientific data sets to either HDF floating-point scientific data sets or 8-bit HDF raster image datasets, or both, and stores the results in an HDF file. (See Figure 15a.) The images can be scaled on a user-specified mean value.
15.5.2 Command-line Syntax

The syntax of `hdfimport` is as follows.

```
hdfimport -h[elp]
hdfimport input-file [-t[ype] output-type | -n ] [input-file-t[ype] output-type | -n ] [-o[utfile] output-file [-r[aster] raster-options ...] [-f[loat]]]
```

The `input-file` parameter specifies the name of the file containing the unconverted data set. The file may contain a single two-dimensional or three-dimensional array in ASCII text, native floating point, native integer, or HDF SDS format. If an HDF file is used for input, it must contain an SDS. The SDS need only contain a dimension record and the data, but if it also contains maximum and minimum values and/or scales for each axis, these will be used. If the format is ASCII text, native floating point, or native integer, see Table 15G and the accompanying discussion regarding the required structure of the data.
Data from one or more input files will be stored as datasets and/or images in a single output file, the HDF file specified in the parameter `output-file`. The output file will contain one SDS and/or one image for each input file.

The `hdfimport` options and parameters are described in Table 15F.

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-h</code></td>
<td>Help: Prints a usage summary, then exits.</td>
</tr>
<tr>
<td><code>-t output-type</code></td>
<td>Output datatype: Optionally used with each ASCII input file to specify the data type of the data set to be written. Can be any of the following values: FP32 (default), FP64, INT8, INT16, or INT32. If not specified, the default value of FP32 is assumed.</td>
</tr>
<tr>
<td><code>-n</code></td>
<td>64-bit output: Used only if a binary input file contains 64-bit floating point data and the default behavior of writing the output as a 32-bit dataset should be overridden to write it as a 64-bit dataset.</td>
</tr>
<tr>
<td><code>-r raster-options</code></td>
<td>Raster: Stores the data as a raster image set in the output file. The available <code>raster-options</code> are described below.</td>
</tr>
<tr>
<td><code>-f</code></td>
<td>Float: Stores the data as a scientific data set, an SDS, in the output file. (Default if the <code>-r</code> option is not specified.) 32-bit binary input data will be stored to a 32-bit SDS. 64-bit binary input data will be stored to a 64-bit SDS.</td>
</tr>
</tbody>
</table>

**Raster options**

Additional options that accompany the `-r` (or `-raster`) option are as follows:

- `expand horiz vert [depth]` Expand: Expands the floating point data via pixel replication to produce the output image(s). `horiz` and `vert` specify the horizontal and vertical resolutions of the image(s) to be produced. The optional parameter `depth` is used only with 3-dimensional input data and specifies the number of images or depth planes.

If `max` the maximum value, and `min` the minimum value, are supplied in the input file, this option clips values that are greater than `max` or less than `min`, setting them to the `max` and `min`, respectively. Cannot be used with the `-i` option.
Interpolation: Applies bilinear or trilinear interpolation when expanding floating-point data. The values of the \texttt{horiz}, \texttt{vert}, and \texttt{depth} parameters specify the horizontal, vertical, and depth resolutions of the dataset(s) to be produced and must be greater than or equal to the dimensions of the original dataset. If a maximum value, \texttt{max}, and/or a minimum value, \texttt{min}, are supplied in the input file, this option clips values that are greater than \texttt{max} or less than \texttt{min}, setting them to the \texttt{max} and \texttt{min}, respectively.

Cannot be used with the \texttt{-e} option.

Palette: Stores the palette with the image. The \texttt{palette} parameter names the file containing the palette data. This may be an HDF file containing a palette or a file containing a raw palette.

Mean: Causes the data to be scaled around a user-specified \texttt{mean} when generating the image. The new maximum and minimum values, \texttt{newmax} and \texttt{newmin}, will be equidistant from \texttt{mean} and determined by the following formulae:

\[
\begin{align*}
\text{newmax} &= \text{mean} + \max(\text{abs}(\text{max} - \text{mean}), \text{abs}(\text{mean} - \text{min})) \\
\text{newmin} &= \text{mean} - \max(\text{abs}(\text{max} - \text{mean}), \text{abs}(\text{mean} - \text{min}))
\end{align*}
\]

If no mean value is specified, then the mean will be \(0.5 \times (\text{max} + \text{min})\).

The \texttt{-e} and the \texttt{-i} flags cannot be used simultaneously. Either pixel interpolation or bilinear interpolation can be chosen for image expansion, but not both.

Data from several input files (with one data set per input file) are stored as several data sets and/or images in one output HDF file. Alternatively, a shell script can be used to call \texttt{hdimport} repeatedly to convert data from multiple input files to corresponding output HDF files.

### 15.5.3 Structure of Data in non-HDF Input Files

If the format of \texttt{input-file} is ASCII text, native floating point, or native integer (i.e., \texttt{input-file} is not an HDF file), the data must be structured in fields as described below.

<table>
<thead>
<tr>
<th>TABLE 15G</th>
<th>hdfimport ASCII Text, Native Floating Point, or Native Integer Input Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{format}</td>
<td>Must contain exactly one format designator: \texttt{TEXT}, \texttt{FP32}, \texttt{FP64}, \texttt{IN32}, \texttt{IN16}, or \texttt{IN08}</td>
</tr>
<tr>
<td>\texttt{number_of_columns}</td>
<td>Rank of the fastest-changing dimension, the horizontal axis, or X-axis, in a 3-dimensional scale</td>
</tr>
</tbody>
</table>
format, number_of_columns, number_of_rows, and number_of_planes are native integers. format is the integer representation of the appropriate 4-character string (0x46503332 for FP32, 0x46503634 for FP64).

If the data input format is FP32 or FP64, the remaining input fields are composed of native 32-bit floating point values for FP32 input format, or native 64-bit floating point values for FP64 input format data.

If the data input format is IN08, IN16, or IN32, the remaining input fields are composed of native 8-bit integer values for IN08 input format, native 16-bit integer values for IN16 input format, or native 32-bit integer values for IN32 input format data.

The term scale refers to the spacing between points on the axes. If the spacing is uniform, i.e., the gaps are of equal size, a uniform scale is specified -- for example, 1.0, 2.0, 3.0, .... Scales may be omitted in an HDF file; they must be included in a text file.

The arrays containing the plane, row, and column scales must have a size equal to the values specified in the number_of_rows, number_of_columns, and number_of_planes positions, respectively.

15.6 Converting 8-Bit Raster Images to the HDF Format: r8tohdf

15.6.1 General Description

The r8tohdf utility converts a set of raw raster images to the HDF RIS8 format and writes them to a file.

15.6.2 Command-line Syntax

```
   r8tohdf [number-of-rows number-of-columns] output-filename [-p palette-filename]
   [-c|-r|-i] raw-raster-image-filename-1, raw-raster-image-filename-2,
   ... raw-raster-image-filename-n
```

The option flags are described in Table 15H.
TABLE 15H

<table>
<thead>
<tr>
<th>Option Flags</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-p</td>
<td>Palette File</td>
</tr>
<tr>
<td>-c</td>
<td>Run-length Encoding</td>
</tr>
<tr>
<td>-i</td>
<td>IMCOMP Compression</td>
</tr>
<tr>
<td>-r</td>
<td>No Compression</td>
</tr>
</tbody>
</table>

**15.6.3 Examples**

A file named `rawras` contains a 256 x 512-byte raw raster image, and its palette is stored in a file named `mypal`. To convert the information in these files to an RIS8 without compression and store the RIS8 in a file named `ras.hdf`, enter the following `r8tohdf` command:

```
r8tohdf 256 512 ras.hdf -p mypal rawras
```

A 800 x 1000-byte raw raster image is stored in a file named `bigpic`. This data must be converted to a RIS8 without a palette, compressing it using run-length encoding, then stored in a file named `bigpic.hdf`. The following command will do this:

```
r8tohdf 800 1000 bigpic.hdf -c bigpic
```

A 300 x 400 raw raster image is contained in each of the files named `pic1`, `pic2`, and `pic3`. To convert all three files to RIS8s, compress them using the IMCOMP method, and store them in a file named `pic.hdf`, enter:

```
r8tohdf 300 400 pic.hdf -i pic1 pic2 pic3
```

Different types of raster image data are to be stored in a file named `ras.hdf`. The image data in the file `rawras1` will be stored without a palette. The image data sets from the file named `rawras2` are to be stored with a palette extracted from a file named `mypal`. The images from the `rawras1` and `rawras2` files are to be compressed using run-length encoding, and the image in the `rawras3` file is not to be compressed. The size of all images are 256 x 512 bytes. The following command is used to do this:

```
r8tohdf 256 512 ras.hdf -c rawras1 -p mypal rawras2 -r rawras3
```

**15.7 Converting 24-Bit Raw Raster Images to RIS8 Images: r24hdf8**

**15.7.1 General Description**

The `r24hdf8` utility quantizes a raw RGB 24-bit raster image, creating an 8-bit image with a 256-color palette, then it stores the palette and raster image data in an HDF file.

**15.7.2 Command-line Syntax**

```
r24hdf8 [x-dimension-length y-dimension-length] raw-24-bit-image-filename-hdf ris8-image-filename
```

The pixel order in the raw 24-bit image file is left-to-right and top-to-bottom. Each pixel data element consists of three contiguous bytes, the first representing the red intensity value, the second the green intensity value, and the third the blue intensity value. Use the `ptox` filter to convert the raster image data from a pixel-interlaced format to scan-plane interlaced.
15.7.3 Examples

A file named `rawraster` containing 24-bit raw raster images with x and y-dimensions of 480 x 640, respectively, must be converted to the HDF RIS8 format and stored in a file named `hdfraster`. The following command is used to do this:

```
r24hdf8 480 640 rawraster hdfraster
```

15.8 Converting Raw Palette Data to the HDF Palette Format: `paltohdf`

15.8.1 General Description

The `paltohdf` utility converts raw palette data to the HDF palette format. The raw palette data must have 768 bytes organized in the following order: first, 256 contiguous red intensity values, then 256 contiguous green intensity values, then 256 contiguous blue intensity values. The palette in the HDF file will have the RGB values pixel-interlaced, as follows.

```
red-value green-value blue-value red-value green-value blue-value ...
```

This is the standard HDF format for 8-bit palettes.

15.8.2 Command-line Syntax

```
paltohdf raw-format-palette-filename HDF-format-palette-filename
```

If an HDF palette format file is specified that does not exist, it is created before the converted data is stored. If an HDF palette format file is specified that already exists, the converted data is appended to the file.

15.9 Extracting 8-Bit Raster Images and Palettes from HDF Files: `hdftor8`

15.9.1 General Description

The `hdftor8` utility extracts the raster images and/or palettes from an HDF file and stores them in one file that contains the raster image data and another that contains the palette data.

15.9.2 Command-line Syntax

```
hdftor8 input-HDF-filename [-i] [-v] [-r raster-image-filename] [-p palette-filename]
```

The option flags are described in Table 151.

<table>
<thead>
<tr>
<th>hdftor8 Option Flags:</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-i</code></td>
<td>Interactive Mode: Program is executed in interactive mode.</td>
</tr>
<tr>
<td><code>-v</code></td>
<td>Verbose Mode: Program is executed in verbose mode. Diagnostic messages are displayed during the session.</td>
</tr>
<tr>
<td><code>-r</code></td>
<td>Raster Image File Name: The raster image file name immediately follows this flag.</td>
</tr>
<tr>
<td><code>-p</code></td>
<td>Palette File Name: The palette file name immediately follows this flag.</td>
</tr>
</tbody>
</table>
The names given as the HDF format file, raster image file, and palette file are interpreted by `hdfror8` as follows: For each raster image file, the file name is given the extension .#.@.%

where # represents the raster image number from the HDF file, @ represents the x-dimension of the raster image and % represents the y-dimension of the raster image. For each palette file, the file name is given the extensions .#, where # represents the palette number from the HDF format file.

If no name is given for the raster image file, the default name `img.#.@.%` is assigned, where #, @, and % are defined as in the preceding paragraph. The default name for a palette file, if no name is specifically given in the command, is `pal.#`.

### 15.9.3 Examples

A file named `denm.hdf` contains three 512 x 256 raster images and three palettes. To store these images and palettes in separate raster image and palette files, use the following `hdfror8` command:

```
hdftor8 denm.hdf
```

Six files are created, named `img1.512.256`, `img2.512.256`, `img3.512.256`, `pal.1`, `pal.2`, and `pal.3`.

### 15.10 Extracting Palette Data from an HDF File: hdftopal

#### 15.10.1 General Description

The `hdftopal` utility converts a palette in an HDF file to a raw palette in an non-HDF file. The raw palette will have 768 bytes with the first 256 bytes representing red intensity values, the second 256 bytes representing green intensity values, and the third 256 bytes representing blue intensity values. The utility performs the converse operation of the `paltohdf` utility.

#### 15.10.2 Command-line Syntax

```
hdftopal HDF-format-palette-filename raw-format-palette-filename
```

### 15.11 Converting Several RIS8 Images to One 3D SDS: ristosds

#### 15.11.1 General Description

The `ristosds` utility creates a single HDF file consisting of a three-dimensional SDS from a set of HDF files containing one or more raster images. All images in the input HDF files must have the same dimensions. If a palette is to be included with the images, it should be in the first HDF input file. Only one palette can be associated with the images; any additional palette data encountered by the utility after the first palette has been processed will be ignored.

#### 15.11.2 Command-line Syntax

```
ristosds input-filename-1, input-filename-2, ... input-filename-n [ -o output-filename ]
```

#### 15.11.3 Examples

The contents of a directory consists of 20 files named `storm001.hdf`, `storm002.hdf`, ..., `storm020.hdf`. Each file contains a single RIS8 with a 100 x 200 raster image. A file that combines these 20 raster
images into a 32-bit floating-point SDS with the dimensions 100 x 200 x 20 can be created with the following `ristosds` command:

```
ristosds storm*.hdf -o storm.hdf
```

### 15.12 Converting an HDF RIS24 Image to an HDF RIS8 Image: hdf24hdf8

#### 15.12.1 General Description

The `hdf24hdf8` utility quantizes an HDF RGB RIS24 pixel-interlaced image, producing an HDF RIS8 image with a 256-color palette and stores the palette and raster image data in an HDF file.

#### 15.12.2 Command-line Syntax

```
hdf24hdf8 ris24-image-filename ris8-image-filename
```

### 15.13 Compressing RIS8 Images in an HDF File: hdfcomp

#### 15.13.1 General Description

The `hdfcomp` utility reads RIS8 images from a set of HDF files, compresses them and stores the compressed data in a second HDF file. If the output HDF file exists, the compressed images will be appended to it.

#### 15.13.2 Command-line Syntax

```
hdfcomp output-filename [-c|-r|-i] input-filename-1, [-c|-r|-i] input-filename-2, ... [-c|-r|-i] input-filename-n
```

The option flags are described in Table 15J

<table>
<thead>
<tr>
<th>hdfcomp Option Flags</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-r</code></td>
<td>No compression: The raster image data is not compressed. (the default)</td>
</tr>
<tr>
<td><code>-c</code></td>
<td>Run-length Encoding: The raster image data is compressed using run-length encoding.</td>
</tr>
<tr>
<td><code>-i</code></td>
<td>IMCOMP Compression: The raster image data is compressed using the IMCOMP algorithm.</td>
</tr>
</tbody>
</table>

#### 15.13.3 Examples

A directory contains twenty files named `storm001`, `storm002`, ... `storm020`. Each of these files contains a single RIS8 image. To compress these images using run-length encoding and store them in a file named `allcomp.hdf`, use the following `hdfcomp` command:

```
hdfcomp allcomp.hdf -c storm*.hdf
```
15.14 Compressing an HDF File: hdfpack

15.14.1 General Description
The hdfpack utility compresses all of the data in an HDF file and writes the compressed data to a second HDF file.

15.14.2 Command-line Syntax

```
```

The hdfpack option flags are described in Table 15K.

<table>
<thead>
<tr>
<th>hdfpack Option Flags</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-b</td>
<td>Non-coalesced blocks: The utility will not coalesce linked-block elements.</td>
</tr>
<tr>
<td>-i</td>
<td>Interactive mode: The utility will prompt for each linked-block element.</td>
</tr>
<tr>
<td>-d</td>
<td>Data descriptors per block: The output file will be created with the specified number of data descriptors per block of data descriptors.</td>
</tr>
<tr>
<td>-t</td>
<td>Linked-blocks per table entry: The output file will be created with the specified number of linked blocks per table entry.</td>
</tr>
</tbody>
</table>

15.14.3 Examples
To compress the data in the file named aa.hdf and store the compressed data in the file named aa.cmp, use the following hdfpack command:

```
hdfpack aa.hdf aa.cmp
```

Suppose a file named bb.hdf contains data elements stored as sequences of linked blocks. The following hdfpack command compresses the file while leaving the linked-block elements intact, and writes the compressed data to a file named bb.blk:

```
hdfpack -b bb.hdf bb.blk
```

15.15 Reformatting an HDF File: hrepack

15.15.1 General Description
hrepack is a command line utility that performs a logical copy of an input HDF4 file to an output HDF4 file, copying all the high level objects while optionally rewriting the objects with or without compression and/or with or without chunking. (Note that compression is supported only for data sets and images in HDF4.)

Further information is available at the following URL:

http://hdf.ncsa.uiuc.edu/doc_resource/h4_doc/util/hrepack/hrepack.html
15.15.2 Command-line Syntax

The **hrepack** syntax is as follows:

```
  trepack -i input -o output [-h] [-v] [-t "comp_info"]
          [-c "chunk_info"] [-m number]
```

The **hrepack** options and usage are as follows:

- `-i input` The input HDF file.
- `-o output` The output HDF file.
- `-h` Print usage, or help, message.
- `-t "comp_info"` Specifies the compression type.
  "comp_info" is a string with the format
  "list_of_objects : type_of_compression compression_parameters"
  `list_of_objects` is a comma-separated list of object names, indicating to apply the specified type of compression only to those objects.
  "*" means to apply the specified type of compression to all objects.
  `type_of_compression` should be one of the following values:
  - RLE for RLE compression
  - HUFF for Huffman compression
  - GZIP for gzip compression
  - JPEG for JPEG compression
  - SZIP for Szip compression
  - NONE to uncompress the object
  `compression_parameters` contains optional compression information as follows:
  - for RLE, no additional information
  - for HUFF, the skip-size
  - for GZIP, the deflation level
  - for JPEG, the quality factor
  - for SZIP, no additional information

In the case of Szip compression, the utility uses the Szip parameter values initially employed for the dataset and preset default values for parameters that were not originally explicitly defined.

- `-c "chunk_info"` Specifies the objects to which to apply chunking.
  "chunk_info" is a string with the format
  "list_of_objects : chunk_information"
  `list_of_objects` is a comma-separated list of object names, indicating to apply chunking only to those objects.
  "*" means to apply chunking to all objects.
  `chunk_information` specifies the chunk size of each dimension and is of the format `dim_1 x dim_2 x ... dim_n` The value NONE indicates that the object is not to be chunked, i.e., stored as a contiguous data set, even it was stored as a chunked data set in the original file.
15.16 Creating Vgroups and Vdatas: vmake

15.16.1 General Description

The **vmake** utility creates Vgroup and Vdata objects in the specified HDF file.

15.16.2 Command-line Syntax

To create a new Vgroup:

```bash
vmake <output_HDF_filename> "Vgroup_name"
```

To create a new Vdata object:

```bash
vmake <output_HDF_filename> <Vdata_object_name> <Vdata_field_data_type>
```

The **Vdata_field_data_type** argument consists of a Vdata field name followed by an equal sign and one of the following characters:
- c for character data (char in the HDF file)
- b for byte data (int8 in the HDF file)
- s for short integer data (int16 in the HDF file)
- l for long integer data (int32 in the HDF file)
- f for floating point data (float32 in the HDF file)

Any of these characters may be preceded by a decimal number specifying an element size other than one.

To create links from one or more Vdatas to a specified Vgroup:

```bash
vmake <output_HDF_filename> [-1] "Vgroup_ref_number" "Vdata1_ref_number" "Vdata2_ref_number" ... "Vdatan_ref_number"
```

**Vgroup_ref_number** is the reference number of the Vgroup to which the Vdatas are to be linked. **Vdata1_ref_number** through **Vdatan_ref_number** are the reference numbers of the Vdatas being linked to the Vgroup.

Note that all **vmake** arguments, except the output HDF filename, are surrounded by double quotes.

15.16.3 Examples

Assume the following. A file containing storm data is named **storm.dat**. A Vdata object named Storm Data B must be created in an HDF file named **sdata.hdf** using **vmake**. The new Vdata object is to contain a field named PLIST with an element size of three long integers. And finally, the data in **storm.dat** is to be loaded into the Vdata object Storm Data B.

This can be accomplished with the following command:

```bash
vmake sdata.hdf "Storm Data B" "PLIST=3l" < storm.dat
```
15.17 Listing Basic Information about Data Objects in an HDF File: 

hdfls

15.17.1 General Description

The hdfls utility provides general information about the tags, reference numbers, and if requested, lengths of the data elements.

The hdfls utility provides general information about the HDF data objects in a file. This information includes the tags and reference numbers of the data objects, the lengths and offsets of the HDF object's data elements, the contents of DD blocks, and information regarding special elements. In situations where the DD block information is not needed, we recommend the hdp utility with the list command and its options.

15.17.2 Command-line Syntax

hdfls [-o][-l][-d][-v][-g][-s][-h][-t #] filename

When no flags are used, hdfls displays data objects ordered by the tags and reference numbers. Contents of the DD blocks and lengths and offsets of the data elements are not displayed.

The option flags are described in Table 15L.

<table>
<thead>
<tr>
<th>hdfls Option Flags</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-o</code> Order off:</td>
</tr>
<tr>
<td><code>-l</code> Long format:</td>
</tr>
<tr>
<td><code>-d</code> Offset/length:</td>
</tr>
<tr>
<td><code>-v</code> Verbose:</td>
</tr>
<tr>
<td><code>-g</code> Group contents:</td>
</tr>
<tr>
<td><code>-s</code> Special elements:</td>
</tr>
<tr>
<td><code>-h</code> DD block:</td>
</tr>
<tr>
<td><code>-t</code> Tag:</td>
</tr>
</tbody>
</table>
15.17.3 Examples

The file \texttt{SDSchunked.hdf}, created by the example... in Chapter 3, contains one chunked data set. \texttt{hdfls -s} can be used to display information about the data objects and special elements in this file. Note that data objects are listed in tag and reference number ascending order.

For example, the command

\begin{verbatim}
hdfls -s SDSchunked.hdf
\end{verbatim}

would display the following output:

\begin{verbatim}
SDSchunked.hdf:
File library version: Major= 4, Minor=1, Release=2
String=NCSA HDF post Version 4.1 Release 2, March 1998

Linked Blocks Indicator : (tag 20)
Ref no  1         12 bytes
Ref no  2         34 bytes
Ref no  3       4096 bytes

Version Descriptor : (tag 30)
Ref no  1         92 bytes

Data Chunk : (tag 61)
Ref no  1         12 bytes
Ref no  2         12 bytes
Ref no  3         12 bytes
Ref no  4         12 bytes
Ref no  5         12 bytes
Ref no  6         12 bytes

Number type : (tag 106)
Ref no 12          4 bytes

SciData dimension record : (tag 701)
Ref no 12         22 bytes

Numeric Data Group : (tag 720)
Ref no  2         16 bytes

Vdata : (tag 1962)
Ref no  4        116 bytes
Ref no  7         60 bytes
Ref no  9         60 bytes
Ref no 11        60 bytes

Vdata Storage : (tag 1963)
Ref no  7          4 bytes
Ref no  9          4 bytes
Ref no 11          2 bytes

Vgroup : (tag 1965)
Ref no  8          33 bytes
Ref no 10          33 bytes
Ref no 13          60 bytes
Ref no 14          47 bytes

Special Scientific Data : (tag 17086)
Ref no  3         72 bytes

Chunked Element: logical size: 12
\end{verbatim}
15.18.1 General Description

The hdfed utility allows experienced HDF users to manipulate the elements of an HDF file. These manipulations include

- Selecting groups and showing information about them.
- Dumping group information to output files.
- Writing group data to output files.
- Deleting groups from HDF files.
- Inserting groups in HDF files.
- Replacing elements of HDF files.
- Editing the labels and descriptions of any element in an HDF file.

It is designed primarily for users who need to know about HDF files at the level of individual data elements. It is not designed to provide a comprehensive high-level view of the contents of an HDF file -- other tools and utilities should be used for that purpose. To use hdfed one should be familiar with the components of an HDF file covered in the HDF Specifications manual.

The hdfed utility is loosely modeled on ed, the UNIX line editor. When hdfed is invoked, it prompts the user for commands, as does ed. Also, basic command syntax and description information is available to the user through hdfed. The most common hdfed commands are used to control the position in the HDF file and the format of the information provided.

The initial view of the file under hdfed consists of a set of tag-reference number pairs. Although hdfed allows modification of tags and reference numbers within strict constraints, it will not allow the user to arbitrarily modify binary data in the file.

The following terms and concepts must be understood in order to use hdfed correctly and will be used in the following discussion about hdfed.

- The **data object or object** refers to an HDF data object and the data descriptor of that object. (i.e., tags, reference numbers, offsets, or lengths.)
- The **data or data element** refers to the record that the data descriptor points to. For a precise definition of the data that is associated with a given tag consult the HDF Specifications and Developer’s Guide v3.2 from the HDF WWW home page at http://hdf.ncsa.uiuc.edu/.
- The **group** refers to a predefined collection of data objects that correspond to a particular application. For example, a raster image group refers to the collection of objects that are used to store all of the information in a raster image set.

Once an HDF file has been opened by hdfed, the following operations can be performed on the data file, among others:

- Select an HDF object to examine more closely.
- Move forward or backward within the HDF file.
- Get information about an object. (tag, reference number, size, label)
- Display a raster image using the ICR protocol.
• Display the contents of any object.
• Delete an object.
• Annotate an object with a label or description.
• Write an object to a second HDF file.
• Write data elements in binary form to a non-HDF file.
• Close the file and exit, or open a new file.

15.18.2 Command-line Syntax

The syntax of hdfed is

```
hdfed [-nobackup][-batch] filename
```

If a file named `filename` exists, it is opened and a backup is made of the file. Files may also be opened from within the editor.

The option flags are described in Table 15M.

<table>
<thead>
<tr>
<th>Option Flags</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-nobackup</code></td>
<td>Specifies that no backup file is to be made. If this option is omitted, a backup file is automatically created.</td>
</tr>
<tr>
<td><code>-batch</code></td>
<td>Specifies that input to <code>hdfed</code> is to be input via a stream of <code>hdfed</code> commands, rather than interactively.</td>
</tr>
</tbody>
</table>

The `-batch` flag is useful when a group of commonly-used commands are included in a UNIX shell script. The following is an example of such a script, using the C-shell, that lists information about the groups in a specified HDF file.

```
#!/bin/csh
set file=$1
shift
hdfed -batch $file -nobackup << EOF
info -all group $*
close
quit
EOF
echo ""
```

To receive usage information, as well as a quick list of the `hdfed` commands, type the command `hdfed -help`.

While in `hdfed`, the standard command prompt is displayed.

```
hdfed>
```

Many `hdfed` commands have qualifiers, or flags. For example, the command `info` may be followed by the `-all`, `-long`, `-group`, or `-label` flags.

All of the commands and flags can be abbreviated to the extent that their abbreviations are unique. For example, `-he` is ambiguous as it could stand for either the `-hexadecimal` or the `-help` flags, but `-hel` is not ambiguous.
TABLE 15N

The hdfed Command Set

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>help</td>
<td>Displays general hdfed help information.</td>
</tr>
<tr>
<td>open</td>
<td>Opens an HDF file.</td>
</tr>
<tr>
<td>close</td>
<td>Closes an HDF file.</td>
</tr>
<tr>
<td>revert</td>
<td>Reverts to the original HDF file.</td>
</tr>
<tr>
<td>next</td>
<td>Goes to the next object or group that satisfies the predicate.</td>
</tr>
<tr>
<td>prev</td>
<td>Goes to the previous object or group that satisfies the predicate.</td>
</tr>
<tr>
<td>info</td>
<td>Displays information about the current data object.</td>
</tr>
<tr>
<td>dump</td>
<td>Displays information about the current data object in non-default formats.</td>
</tr>
<tr>
<td></td>
<td>(i.e., binary, ASCII, etc.). The default is octal.</td>
</tr>
<tr>
<td>display</td>
<td>Displays a raster image using ICR.</td>
</tr>
<tr>
<td>put</td>
<td>Writes the current data element in a non-HDF file with the specified filename in binary format.</td>
</tr>
<tr>
<td>putr8</td>
<td>Writes the current RIS8 group into a non-HDF file with the specified filename.</td>
</tr>
<tr>
<td>getr8</td>
<td>Reads a RIS8 group from a non-HDF file with the specified filename.</td>
</tr>
<tr>
<td>delete</td>
<td>Deletes an object or group.</td>
</tr>
<tr>
<td>write</td>
<td>Writes an object or group to an HDF file.</td>
</tr>
<tr>
<td>annotate</td>
<td>Annotates an object.</td>
</tr>
<tr>
<td>if</td>
<td>Conditional statement.</td>
</tr>
<tr>
<td>select</td>
<td>Loop for each object.</td>
</tr>
<tr>
<td>alias</td>
<td>Defines an alias or display the alias list.</td>
</tr>
<tr>
<td>unalias</td>
<td>Deletes an alias.</td>
</tr>
<tr>
<td>wait</td>
<td>Prints a message and wait for a carriage return.</td>
</tr>
</tbody>
</table>

To obtain information about the usage of any hdfed command, type the following at the hdfed prompt.

```
any-hdfed-command -help
```

Note that usage information cannot be obtained by typing only the command, with no flags. There are other hdfed commands, such as delete, that do not require an argument, so watch out for this kind of error.

There is a subset of hdfed commands where predicates, items, and comparators are used. Items are used to denote an HDF object type and can be any of the following identifiers: tag, ref, image_size, or label. A comparator is an expression used to compare an item with a user-defined value, and can be any of the following:

<table>
<thead>
<tr>
<th>Comparator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>=</td>
<td>equal</td>
</tr>
<tr>
<td>!=</td>
<td>not equal</td>
</tr>
<tr>
<td>&lt;</td>
<td>less than</td>
</tr>
<tr>
<td>&lt;=</td>
<td>less than or equal</td>
</tr>
<tr>
<td>&gt;</td>
<td>greater than</td>
</tr>
<tr>
<td>&gt;=</td>
<td>greater than or equal</td>
</tr>
</tbody>
</table>

User-defined values can be either a number (with or without a decimal point) or a string of characters delimited by double-quotes. Predicates consist of items, comparators and user-defined values and are of the syntax:

```
item comparator-value
```

Or they may consist of the identifier group, as in the next group command. Some examples of predicates are:
The following is a more inclusive description of the **hdfed** commands.

**The help command**

Syntax:  
```plaintext
help
```

Flags:  
None

Description: Prints a help screen describing the basic purpose and functionality of the hdfed utility.

Usage Example:

```
hfed> help
```

hfed allows sophisticated HDF users the ability to manipulate the elements in an HDF file. These manipulations include selecting groups...

**The open command**

Syntax:  
```plaintext
open [-nobackup] filename
```

Flags:  
- nobackup The specified file name is not backed up.

Description: Opens the specified HDF file.

Usage Example:

```
hfed> open -help
open <file> [-nobackup]
nobackup Don't make a backup for this file.
hfed>
hfed> open h1
```

**The info command**

Syntax:  
```plaintext
info [-all] [-long] [-group] [-label]
```

Flags:  
- all Displays information for all of the objects in the current file.
- long Displays the long form of the information.
- group Organizes the information into groups.
- label Shows any labels.

Description: Displays information for a data object. The listing for special elements will contain a special tag value (in Item 13 below it’s 18347, which corresponds to DPTAG_VS) and the text “Unknown Tag”.

Usage Example:

```
hfed> info -all -label -long
(1) Version Descriptor: (Tag 30)
   Ref: 1, Offset: 202, Length:92 (bytes)
(2) Scientific Data: (Tag 702)
   Ref: 2, Offset: 294, Length : 200 (bytes)
(3) Number type: (Tag 106)
   Ref: 2, Offset: 494, Length: 4 (bytes)
```

(4) SciData description: (Tag 701)
Ref: 2, Offset: 498, Length: 2 (bytes)
(5) SciData max/min: (Tag 707)
Ref: 2, Offset: 520, Length: 4 (bytes)
*(6) Numeric Data Group: (Tag 720)
Ref: 2, Offset: 524, Length: 12 (bytes)
Label: Experiment #1
(7) Data Id Label: (Tag 104)
Ref: 3, Offset: 536, Length: 17 (bytes)
(8) Scientific Data: (Tag 702)
Ref: 4, Offset: 553, Length: 400 (bytes)
(9) Number type: (Tag 106)
Ref: 4, Offset: 953, Length: 4 (bytes)
(10) SciData description: (Tag 701)
Ref: 4, Offset: 957, Length: 22 (bytes)
(11) Numeric Data Group: (Tag 720)
Ref: 4, Offset: 979, Length: 8 (bytes)
Label: Experiment #2
(12) Data Id Label: (Tag 104)
Ref: 5, Offset: 987, Length: 17 (bytes)
(13) Unknown Tag: (Tag 18347)
Ref: 8, Offset: 0, Length: 40 (bytes)

hdfed> info -group -all

**Group 1:
- Numeric Data Group: (Tag 720) Ref 2
- Scientific Data: (Tag 702) Ref 2
- SciData description: (Tag 701) Ref 2
- SciData max/min: (Tag 707) Ref 2

**Group 2:
- Numeric Data Group: (Tag 720) Ref 4
- Scientific Data: (Tag 702) Ref 4
- SciData description: (Tag 701) Ref 4

**These do not belong to any group:
- Version Descriptor: (Tag 30) Ref 1
- Number Type: (Tag 106) Ref 2
- Data Id Label: (Tag 104) Ref 3
- Number Type: (Tag 106) Ref 4
- Data Id Label: (Tag 104) Ref 5

hdfed>

The `prev` command

**Syntax:**
```
prev predicate-list
```

**Flags:**
None.

**Description:**
Moves to the next object that satisfies the predicate list.

**Usage Example:**

hdfed> info -all

```
(1) Version Descriptor: (Tag 30) Ref 1
(2) Scientific Data: (Tag 702) Ref 2
(3) Number type: (Tag 106) Ref 2
(4) SciData description: (Tag 701) Ref 2
(5) SciData max/min: (Tag 707) Ref 2
*(6) Numeric Data Group: (Tag 720) Ref 2
(7) Data Id Label: (Tag 104) Ref 3
(8) Scientific Data: (Tag 702) Ref 4
(9) Number type: (Tag 106) Ref 4
(10) SciData description: (Tag 701) Ref 4
(11) Numeric Data Group: (Tag 720) Ref 4
(12) Data Id Label: (Tag 104) Ref 5
```
The `next` command

**Syntax:**
```
next predicate-list
```

**Flags:** None.

**Description:** Moves to the next object that satisfies the predicate.

**Usage Example:**
```
hdfed> ! Move in the file using next and prev
hdfed> ! The move direction depends on the relative positions.
hdfed> ! so it is often necessary to do an 'info -all' first.
hdfed> info -all
(1) Version Descriptor: (Tag 30) Ref 1
(2) Scientific Data : (Tag 702) Ref 2
(3) Number type : (Tag 106) Ref 2
(4) SciData description : (Tag 701) Ref 2
 *(5) SciData max/min : (Tag 707) Ref 2
(6) Numeric Data Group : (Tag 720) Ref 2
(7) Data Id Label: (Tag 104) Ref 3
(8) Scientific Data : (Tag 702) Ref 4
(9) Number type : (Tag 106) Ref 4
(10)SciData description: (Tag 701) Ref 4
(11)Numeric Data Group: (Tag 720) Ref 4
(12)Data Id Label : (Tag 104) Ref 5
```
```
hdfed> ! This predicate persists for the next and prev
hdfed> ! commands. That means if I now type another 'next'
hdfed> ! command, it will look for a tag that equals 707.
hdfed> hdfed> next
Reached end of file. Not moved.
hdfed> info
(5) SciData max.min (SciData): (Tag 707) Ref: 2
```
```
hdfed> hdfed> next group
hdfed> next group
```

The `dump` command

**Syntax:**
```
dump [-offset offset] [-length length] [-decimal|-short|-byte|-octal|-hexadecimal|-float|-double|-ascii]
```

**Flags:**
- `-offset` Starting offset
- `-length` Length of the object to dump.
- `-decimal` Decimal format (32-bit integers)
- `-short` Decimal format (16-bit integers)
- `-byte` Decimal format (8-bit integers)
- `-octal` Octal format (the default)
-hexadecimal  Hexadecimal format
-float       Single-precision floating-point format (32-bit floats)
-double      Double-precision floating-point format (16-bit floats)
-ascii       ASCII format

**Description:** Displays the contents of the current object in the specified format.

**Usage Example:**

```bash
hdfed> ! to see the binary representation of this element
hdfed> dump
0: 257400004 257200004
hdfed> dump -short
0: 702 4 701 4
```

The **delete** command

**Syntax:**   delete
**Flags:**   None.

**Description:** Deletes the current object or group.

**Usage Example:**

```bash
hdfed> ! deleting groups
hdfed> ! If an element is required by other group it is alone.
hdfed> ! However, this is not perfect as the method by which group
hdfed> ! membership is determined can be pretty ad hoc.
hdfed> delete
hdfed> ! This deletes the Scientific Data Group
hdfed> info -all
   (1) Version Descriptor: (Tag 30) Ref 1
   (2) Scientific Data: (Tag 702) Ref 2
   (3) Number type: (Tag 106) Ref 2
   (4) SciData description : (Tag 701) Ref 2
   (5) SciData max/min: (Tag 707) Ref 2
   (6) Numeric Data Group : (Tag 720) Ref 2
   (7) Data Id Label : (Tag 104) Ref 3
   (8) Number type : (Tag 106) Ref 4
   (9) Data Id Label : (Tag 104) Ref 5
hdfed> ! Notice that the Numeric Data Group with reference
hdfed> ! number 4 is missing, and now there are only 9
hdfed> ! objects in the file.
```

The **annotate** command

**Syntax:**   annotate [-label] [-descriptor] [-editor editor]
**Flags:**   -label    Edit a label (the default)
             -descriptor Edit a descriptor.
             -editor    Use an editor. (Default is the editor referred to by the
                          EDITOR environment variable.)

**Description:** Edits an annotation.

**Usage Example:**
hdfed> ! Annotations are labels and descriptors
hdfed> prev -group
hdfed> info -label
   (6) Numeric Data Group: (Tag 720) Ref 2
       Label: Experiment #1
hdfed> annotate -editor /usr/ucb/ex
"/tmp/he5091.1" 1 line, 14 characters
:p
Experiment #1
:s/$/ <more stuff>/
Experiment #1<more stuff>
wq
"/tmp/he5091.1" 1 line 27 characters
hdfed> info -label
   (6) Numeric Data Group: (Tag 720) Ref 2
       Label: Experiment #1 <more stuff>
hdfed>

The **write** command

**Syntax:** write [-attachto tag-reference-number] filename

**Flags:**
- attachto Which element the annotation will be attached to. (only for writing annotations)

**Description:** Writes an element or group into another HDF file.

**Usage Example:**

hdfed> ! Write object or group to another HDF file.
hdfed> write test

hdfed> ! Let’s take a look at the file ‘test’
hdfed> close; open test; info -all
   (1) Version Descriptor(Tag 30) Ref 1
   (2) Scientific Data(Tag 702) Ref 2
   (3) Number type (Tag 106) Ref 2
   (4) SciData description(Tag 701) Ref 2
   (5) SciData max/min(Tag 707) Ref 2
      *(6) Numeric Data Group (Tag 720) Ref 2
hdfed> hdfed> close;
hdfed>

The **display** command

**Syntax:** display [-position x-position y-position] [-expansion expansion] [-large]

**Flags:**
- position Image position on console screen
- expansion Image expansion factor
- large Make image as large as possible

**Description:** Displays image on screen.

**Usage Example:**

hdfed> ! We will open a file with some RIS8 images.
hdfed> open demn,HDF
hdfed> display
hdfed> ! The ‘display’ command displays the current RIS8
The putr8 command

Syntax: putr8 [-image image_filename palette_filename -verbose]

Flags:
-image Image file name template (Default is "img#.0.%")
-palette Palette file name template (Default is "pal#")
-verbose To give output of steps taken.

Description: Writes a RIS8 group into raw image and palette files.

Usage Example:

hdfed> ! putr8 puts an RIS8 group into raw files
hdfed> hdfed> putr8 -image my_image#.0.% -palette testPalettes# -verbose
Writing to file: my_image8.10.10
Writing to file: my_palette
hdfed>

The close command

Syntax: close [-keep]

Flags:
-keep The backup file is not deleted.

Description: Closes the HDF file opened by the last open command.

Usage Example:

hdfed> close
hdfed>

The select command

Syntax: select predicate_list command_list

Flags: None.

Description: Step through all the elements in the HDF file that satisfies the predicates, and execute the command list.

Usage Example:

hdfed> To step through a file and, for example, putr8 on all HDF groups we can use the select command.

hdfed> select tag=306
>> putr8 -image testImages# -palette testPalettes# -verbose
>> end
Writing to file: testImages8
Writing to file: testPalettes8
Writing to file: testImages14
Writing to file: testPalettes14
Writing to file: testImages21
Writing to file: testPalettes21
hdfed>

hdfed> The 'select' and 'if' commands take the same predicates as 'next' and 'pref'. There are also hdfed> 'the predicates 'succeed" and "fail" that test the hdfed> return status of the 'last' command.

hdfed>
The **put** command

**Syntax:**
```
put [-file filename] [-verbose]
```

**Flags:**
- `-file` Output file name (Default is "elt#.0")
- `-verbose` Output diagnostic information.

**Description:** Writes the raw binary image of the current object to a file.

**Usage Example:**
```
hdfed> ! The 'put' command writes an element into a binary file.
hdfed> ! This is a dumb routine and does not know about the
hdfed> ! formats of an element.
hdfed> 
```
```
hdfed> put -file binary#
hdfed> put -file myBinary -verbose
```
```
Writing to file: myBinary
```

The **revert** command

**Syntax:**
```
revert
```

**Flags:**
None.

**Description:** Discards all changes made in the current hdfed session.

**Usage Example:**
```
hdfed> revert
```

The **getr8** command

**Syntax:**
```
getr8 image-file-name [x-dimension y-dimension] [-palette palette-file-
name] [-raster|-rle|-imcomp]
```

**Flags:**
- `-palette` Palette will be read from a binary file.
- `-raster` No compression will be performed during the write. (the
default)
- `-rle` Run-length compression will be performed during the write.
- `-imcomp` IMCOMP compression will be performed during the write.

**Description:** Reads a RIS8 group from binary files.

The **if** conditional

**Syntax:**
```
if predicate-list command-list end
```

**Flags:**
None.

**Description:** Executes commands in a loop if predicates are satisfied for each element
processed.

The **select** loop command

**Syntax:**
```
select predicate-list command-list end
```

**Flags:**
None.

**Description:** Executes the list of commands for each element that satisfies the predi-
cates.

The **wait** command

**Syntax:**
```
wait message
```

**Flags:**
None.
Description: Prints a message, then waits for a carriage return to be typed.

15.19 Working with Both HDF4 and HDF5 File Formats


This mapping is implemented by the H4toH5 Conversion Library and the h4toh5 and h5toh4 conversion utilities. These tools and further information regarding download, installation, and use are available at [http://hdf.ncsa.uiuc.edu/h4toh5/](http://hdf.ncsa.uiuc.edu/h4toh5/).

The H4toH5 Conversion Library is a C library providing APIs for customized conversion of individual objects from an HDF4 file to equivalent objects in an HDF5 file. The conversion follows the default mapping defined in the specification document, *Mapping HDF4 Objects to HDF5 Objects*. The library uses both the HDF4 and HDF5 libraries. Further information is available at [http://hdf.ncsa.uiuc.edu/h4toh5/libh4toh5.html](http://hdf.ncsa.uiuc.edu/h4toh5/libh4toh5.html).

The h4toh5 and h5toh4 utilities are special-purpose tools developed for users who must convert files created with either an HDF4 or an HDF5 library to files that can be opened and manipulated by applications built on the other library. These utilities convert all supported objects in entire files and do not require the user to write any additional software. These utilities are documented in the Tools section of the *HDF5 Reference Manual*, which is available at [http://hdf.ncsa.uiuc.edu/HDF5/doc/Tools.html](http://hdf.ncsa.uiuc.edu/HDF5/doc/Tools.html).

15.20 Converting an HDF File to a GIF File: hdf2gif

15.20.1 General Description

hdf2gif is a command line utility to convert files from the Hierarchical Data Format (HDF) ([http://hdf.ncsa.uiuc.edu](http://hdf.ncsa.uiuc.edu)) to the Compuserve Graphics Interchange Format (GIF) ([http://www.w3.org/Graphics/GIF/spec-gif89a.txt](http://www.w3.org/Graphics/GIF/spec-gif89a.txt)).

15.20.2 Command-line Syntax and Requirements:

hdf2gif takes two arguments: the name of the GIF file to read and the name of the HDF file to write.

```
hdf2gif <HDF file> <GIF file>
```

Inputs: HDF file Name of the HDF file

Outputs: GIF file Name of the GIF file

Requirements:

This utility requires the HDF 4 library.

The HDF 4 file is expected to contain 8-bit raster images which are consecutively converted to GIF images. At this time, this utility cannot be used to convert higher resolution images (16-bit, 24-bit, or 32-bit) to GIF images, which have a maximum resolution of 8-bit.

15.20.3 Structure of the GIF File

The GIF file may be of either GIF 87a or 89a formats. The choice between the two formats depends on the number of images stored in the HDF file. If there is only one image in the HDF
file, then a GIF 87a file is written. If there are multiple images, a GIF89a file is written and it is animated with a time delay of 15ms between two consecutive images. The animation is set to loop indefinitely. The only exception occurs in case the HDF file was generated from a previous GIF file using the gif2hdf utility. In this case the original GIF file's values for animation and time out are taken into account instead of the preset defaults.

Depending on the version of the GIF file generated, the structure of the output file is as follows:
- **GIF87a**: The GIF file consists of a header, logical screen descriptor, image descriptor, local color table, image data, and the trailer. There is no global color table.
- **GIF89a**: The GIF file consists of a header, logical screen descriptor, and the Netscape 2.0 application extension. This is followed by graphic control extension, image descriptor, local color table, and raw image data, in that order and repeated for every image present in the HDF file. The trailer follows and signifies the end of the GIF file. As in the GIF87a format, there is no global color table.

The Netscape 2.0 application extension is present to inform the GIF renderer the number of times the GIF animation should loop.

### 15.20.4 Building the Utility

**hdf2gif** is made when the utilities in the HDF 4 libraries are made.

Please refer to the instructions on how to make the HDF 4 libraries in order to make these utilities.

### 15.21 Converting a GIF File to an HDF File: gif2hdf

#### 15.21.1 General Description

**gif2hdf** is a command line utility to convert files from the Compuserve Graphics Interchange Format (GIF) ([http://www.w3.org/Graphics/GIF/spec-gif89a.txt](http://www.w3.org/Graphics/GIF/spec-gif89a.txt)) to the Hierarchical Data Format (HDF) ([http://hdf.ncsa.uiuc.edu](http://hdf.ncsa.uiuc.edu)).

#### 15.21.2 Command-line Syntax and Requirements

**gif2hdf** takes two arguments: the name of the GIF file to read and the name of the HDF file to write.

```
gif2hdf <GIF file> <HDF file>
```

**Inputs:**
- **GIF file**: Name of the GIF file

**Outputs:**
- **HDF file**: Name of the HDF file

**Requirements:**

This utility requires the HDF 4 library.

The amount of memory used by the program depends on the size of the GIF file and to some extent the type and quality of the image stored.

The GIF file being used as input must be a valid GIF87a or GIF89a file. If the file has multiple images (e.g., animated GIF), then the corresponding HDF file will contain all the images in a single *Vgroup*. Since HDF was not intended to be a format for animation, some information, such as the time between two consecutive images of an animation which is present in the GIF file, cannot be used by HDF tools. That information is, however, stored in the HDF file as an attribute.
15.21.3 Structure of the GIF and HDF Files and the Mapping between Them

**FIGURE 15b**

Structure of the GIF and HDF files

### GIF File

- **Header**
- **Logical Screen Descriptor**
  - **Global Color Table**
  - **Graphic Control Extension**
  - **Image Descriptor**
  - **Local Color Table**
  - **Image Data (Data Sub Blocks)**
- **Comment Extension**
  - **Comment Data (Data Sub Blocks)**
- **Application Extension**
  - **Application Data (Data Sub Blocks)**
- **Plain Text Extension**
  - **Plain Text Data (Data Sub Blocks)**
- **Trailer**

### HDF File

- **Vgroup**
  - **GR Image**
    - **Global / Local Palette**
    - **GR Attributes:**
      - **Image Descriptor**
      - **Graphic Control Extension**
  - **Vgroup Attributes:**
    - **Global Palette**
    - **Header**
    - **Logical Screen Desc.**
    - **Comment Extension**
    - **Comment Data**
    - **Plain Text Extension**
    - **Plain Text Data**
    - **Application Extension**
    - **Application Data**

The GIF file structure consists of a compulsory header followed by a logical screen descriptor. If the GIF file has a global color table, it follows the logical screen descriptor. The image descriptor precedes the raw image data. If the file is a GIF89a file, a graphic control extension may precede the image descriptor.

The comment extension, application extension, and plain text extension blocks are not compulsory and may appear any number of times within the GIF file. There is no preset order in which they must appear. These blocks are restricted to GIF89a files.

The final block is the trailer that consists only of one byte and signifies the end of the file. This block is compulsory.

For further information on the structure of a GIF file, refer to the GIF format specification at [http://www.w3.org/Graphics/GIF/spec-gif89a.txt](http://www.w3.org/Graphics/GIF/spec-gif89a.txt).

The GIF images are stored in the HDF file in a Vgroup with `class="GIF"` and `Name` being the name of the original GIF file. The name is restricted to 64 characters, as set by `VSNAMELENMAX`. 
The GIF file contains a number of extensions that are all stored as attributes to the Vgroup, with the exception of the graphic control extension which is stored as an attribute to the individual image. In the case of comment extension, application extension, and plain text extension, there are two Vgroup attributes for every extension block: the extension dump attribute and the extension data attribute.

Each image in the GIF file is stored as a compressed GR image, using gzip compression, under the Vgroup in the HDF file. A palette is stored with each image in the HDF file. If the original GIF image contained a local color table, this table is stored as a palette. If the images contained only a global color table, each GR image in the HDF file has the global color table associated with it. This association of color tables enables an HDF viewer (such as JHV, available from ftp.ncsa.uiuc.edu) to correctly render the corresponding image. The image descriptor and the graphic control extension, if present, of the GIF file are attached to the GR image as attributes. If this HDF file is reconverted to the GIF format, the graphic control extension contains important information regarding the animation of those images.

15.21.4 Building the Utility

gif2hdf is made when the utilities in the HDF 4 libraries are made.

Please refer to the instructions on how to make the HDF 4 libraries.

15.22 Compiling C applications that Use HDF4: h4cc

15.22.1 General Description

Compiling the HDF4 library and HDF4 applications is a complex task, encompassing environment settings, particular use of compiler flags, many include files, etc. h4cc is a helper script, or wrapper, designed to assist in the task of compiling C applications that use HDF4 by providing several default settings and required flags and listing all of the required include files. Using h4cc, the user can take advantage of these defaults while retaining the options of setting environment variables to override the default compiler and linker and overriding the HDF4 include file and library locations on the command line.

h4cc subsumes all other compiler commands in that if a certain command has been used to compile the HDF4 library, then h4cc also uses that command. For example, if HDF4 was built using gcc, then h4cc will use gcc in compiling the new program.

Some programs use HDF4 in only a few modules. It is not necessary to use h4cc to compile those modules which do not use HDF4. In fact, since h4cc is only a convenience script, HDF4 modules can still be compiled in the normal way, taking care to properly specify the HDF4 libraries and include paths.

15.22.2 Command-line Syntax

The h4cc command-line syntax is as follows:

    h4cc [-help]
    h4cc [-echo] [-prefix=dir] [-show] compile_line

<table>
<thead>
<tr>
<th>h4cc Options and Compiler Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>-help</td>
</tr>
<tr>
<td>-echo</td>
</tr>
</tbody>
</table>
Several environment variables, listed in the following table, are available that provide another level of control over \texttt{h4cc}. When set, they override some of the built-in \texttt{h4cc} defaults.

| TABLE 15P |
| Environment Variables |
| HDF4\_CC | Use a different C compiler. |
| HDF4\_CLINKER | Use a different linker. |

15.22.3 Examples

The following example illustrates the use of \texttt{h4cc} to compile the program \texttt{hdf\_prog}, which consists of modules \texttt{prog1.c} and \texttt{prog2.c}:

\begin{verbatim}
# h4cc -c prog1.c
# h4cc -c prog2.c
# h4cc -o hdf\_prog prog1.o prog2.o
\end{verbatim}

15.23 Compiling Fortran applications that Use HDF4: \texttt{h4fc}

15.23.1 General Description

Compiling the HDF4 library and HDF4 applications is a complex task, encompassing environment settings, particular use of compiler flags, many include files, etc. \texttt{h4fc} is a helper script, or wrapper, designed to assist in the task of compiling Fortran applications that use HDF4 by providing several default settings and required flags and listing all of the required include files. Using \texttt{h4fc}, the user can take advantage of these defaults while retaining the options of setting environment variables to override the default compiler and linker and overriding the HDF4 include file and library locations on the command line.

\texttt{h4cc} subsumes all other compiler commands in that if a certain command has been used to compile the HDF4 library, then \texttt{h4fc} also uses that command. For example, if HDF4 was built using \texttt{f77}, then \texttt{h4cc} will use \texttt{f77} in compiling the new program.

Some programs use HDF4 in only a few modules. It is not necessary to use \texttt{h4fc} to compile those modules which do not use HDF4. In fact, since \texttt{h4fc} is only a convenience script, HDF4 modules can still be compiled in the normal way, taking care to properly specify the HDF4 libraries and include paths.

15.23.2 Command-line Syntax

The \texttt{h4fc} command-line syntax is as follows:

\texttt{h4fc [ -help ]}
Several environment variables, listed in the following table, are available that provide another level of control over h4fc. When set, they override some of the built-in h4fc defaults.

### Table 15R Environment Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDF4_FC</td>
<td>Use a different Fortran compiler.</td>
</tr>
<tr>
<td>HDF4_FLINKER</td>
<td>Use a different linker.</td>
</tr>
</tbody>
</table>

### 15.23.3 Example

The following example illustrates the use of h4fc to compile the program `hdf_prog`, which consists of modules `prog1.f` and `prog2.f` and uses the HDF4 Fortran library:

```bash
# h4fc -c prog1.f
# h4fc -c prog2.f
# h4fc -o hdf_prog prog1.o prog2.o
```

### 15.24 Updating HDF4 Compiler Tools after an Installation in a New Location: h4redeploy

#### 15.24.1 General Description

h4redeploy updates the HDF4 compiler tools after the HDF4 software has been installed in a new location.

#### 15.24.2 Command-line Syntax

The h4redeploy command-line syntax is as follows:

```bash
h4redeploy [ help | -help ]
```

```bash
h4redeploy [ -echo ] [ -force ] [ -prefix=dir ] [ -tool=tool ] [ -show ] compile_line
```
In addition to the command-line utilities supported by NCSA, a number of utilities have been created by HDF users.

Over two dozen tools have been contributed by HDF users and are distributed from NCSA’s anonymous FTP server at hdf.ncsa.uiuc.edu in the directory /pub/dist/HDF/contrib. These utilities are not supported by NCSA. An updated list of all of the user-contributed HDF utilities is available in the README file in that directory.

Other users have developed and maintain tools that they distribute from their own web and FTP servers. The web page What Software Uses HDF? at http://hdf.ncsa.uiuc.edu/tools.html contains links to all such tools of which the HDF team is aware.

---

**TABLE 15S**

<table>
<thead>
<tr>
<th>Option Flags</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-help</td>
<td>Prints a help message.</td>
</tr>
<tr>
<td>help</td>
<td>Print a help message.</td>
</tr>
<tr>
<td>-echo</td>
<td>Shows all the shell commands executed.</td>
</tr>
<tr>
<td>show</td>
<td>Shows the shell commands to be executed without actually executing them.</td>
</tr>
<tr>
<td>-force</td>
<td>Performs the requested actions without offering any prompt requesting confirmation.</td>
</tr>
<tr>
<td>-prefix=dir</td>
<td>The directory <code>dir</code> specifies the location of the HDF4 <code>lib/</code> and <code>include/</code> subdirectories. Default: the current working directory.</td>
</tr>
<tr>
<td>-tool=tool</td>
<td>Specifies the tool to update. <code>tool</code> must be in the current working directory and must be writeable. Default: h4fc</td>
</tr>
</tbody>
</table>
Appendices

Appendix A  NCSA HDF Tags

A.1 Overview

This appendix includes tables containing brief descriptions of most of the tags that have been assigned at NCSA for general use. This list will be expanded in future editions to include new tags as they are assigned. A more detailed description of the tags can be found in the *HDF Specification and Developer’s Guide*. Also see the *HDF Specification and Developer’s Guide* for a description of extended tags, which are not discussed in this appendix.

Each table contains a list of tags within one category. The titles of the tables, with a functional description of each table, are:

- **Table A: The HDF Utility Tags.** Used by the HDF utilities.
- **Table B: The HDF General Raster Image Tags.** Used to describe aspects of raster image data.
- **Table C: The HDF Composite Image Tags.** Used to describe aspects of composite image data.
- **Table D: The HDF Scientific Data Set Tags:** Used to describe aspects of scientific data set (SDS) data.
- **Table E: The HDF Vset Tags.** Used to describe aspects of HDF Vset data.
- **Table F: The Obsolete HDF Tags:** Used to describe aspects of HDF data elements that have been replaced by newer tags or discontinued.

A.2 Tag Types and Descriptions

The following tables have five columns:

- **Tag Name** contains the abbreviated symbolic names of tags that are often used in an augmented form in HDF programs.
- **Short Description** contains a brief (four word maximum) description of the tag that is commonly used to describe the tag in HDF manuals and in-line code documentation.
- **Data Size** describes the type of data that is associated with the tag and, where possible, lists the data size.
- **Tag Value** lists the numeric value of the tag symbol in the `hdf.h` header file.
- **Long Description** contains a general description of the tag.

In the tables, the term *String* refers to a sequence of ASCII characters with the null byte possibly occurring at the end, but nowhere else. The term *Text* also refers to a sequence of ASCII characters, but it may contain null characters anywhere in the sequence. An *n* in the Data Size column
describes a data unit of variable-length. For more detailed descriptions of these units of data, refer to the appropriate tag entry in the *HDF Specification and Developer’s Guide*.

**TABLE 0A**

<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Short Description</th>
<th>Data Size</th>
<th>Tag Value</th>
<th>Long Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFTAG_NULL</td>
<td>No Data</td>
<td>None</td>
<td>001</td>
<td>Used for place holding and filling up empty portions of the Data Descriptor Block.</td>
</tr>
<tr>
<td>DFTAG_VERSION</td>
<td>Library Version Number</td>
<td>4 bytes + string</td>
<td>030</td>
<td>Specifies the latest version of the HDF library used to write to the file.</td>
</tr>
<tr>
<td>DFTAG_NT</td>
<td>Number Type</td>
<td>4 bytes</td>
<td>106</td>
<td>Used by any other element in the file to specifically indicate what a numeric value looks like.</td>
</tr>
<tr>
<td>DFTAG_MT</td>
<td>Machine Type</td>
<td>0 bytes</td>
<td>107</td>
<td>Specifies that all unconstrained or partially constrained values in this HDF file are of the default type for that hardware.</td>
</tr>
<tr>
<td>DFTAG_FID</td>
<td>File Identifier</td>
<td>String</td>
<td>100</td>
<td>Points to a string that the user wants to associate with this file. This supports the inclusion of a user-supplied title for the file.</td>
</tr>
<tr>
<td>DFTAG_FD</td>
<td>File Descriptor</td>
<td>Text</td>
<td>101</td>
<td>Points to a block of text describing the overall file contents. It is intended to be user-supplied comments about the file.</td>
</tr>
<tr>
<td>DFTAG_TID</td>
<td>Tag Identifier</td>
<td>String</td>
<td>102</td>
<td>Provides a way to determine the meaning of a tag stored in the file.</td>
</tr>
<tr>
<td>DFTAG_TD</td>
<td>Tag Descriptor</td>
<td>Text</td>
<td>103</td>
<td>Similar to DFTAG_TD, but allows more text to be included.</td>
</tr>
<tr>
<td>DFTAG_DIL</td>
<td>Data Identifier Label</td>
<td>String</td>
<td>104</td>
<td>Associates the string with the Data Identifier as a label for whatever the identifier points to. By including DILs, any data element can be given a label for future reference. For example, this tag is often used to give titles to raster image data sets.</td>
</tr>
<tr>
<td>DFTAG_DIA</td>
<td>Data Identifier Annota-</td>
<td>Text</td>
<td>105</td>
<td>Associates the text block with the Data Identifier as an annotation for whatever that Data Identifier points to. With DIAs, and Data Identifier can have a lengthy, user-provided description of why that particular data element is in the file.</td>
</tr>
<tr>
<td>DFTAG_RLE</td>
<td>Run-length Encoding</td>
<td>0 bytes</td>
<td>011</td>
<td>Specifies that run-length encoding (RLE) is used to compress a raster image.</td>
</tr>
<tr>
<td>DFTAG_IMC</td>
<td>IMCOMP Compression</td>
<td>0 bytes</td>
<td>012</td>
<td>Specifies that IMCOMP compression is used to compress a raster image.</td>
</tr>
<tr>
<td>DFTAG_JPEG</td>
<td>24-bit JPEG Compression</td>
<td>n bytes</td>
<td>013</td>
<td>Provides header information for 24-bit JPEG-compressed raster images.</td>
</tr>
<tr>
<td>DFTAG_GREYPEG</td>
<td>8-bit JPEG Compression</td>
<td>n bytes</td>
<td>014</td>
<td>Provides header information for 8-bit JPEG-compressed raster images.</td>
</tr>
</tbody>
</table>

**TABLE 0B**

<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Short Description</th>
<th>Data Size</th>
<th>Tag Value</th>
<th>Long Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFTAG_RIG</td>
<td>Raster Image Group</td>
<td>n*4 bytes</td>
<td>306</td>
<td>Lists the Data Identifiers (tag/reference number pairs) that uniquely describe a raster image set.</td>
</tr>
<tr>
<td>DFTAG_ID</td>
<td>Image Dimension</td>
<td>20 bytes</td>
<td>300</td>
<td>Defines the dimensions of the two-dimensional array the corresponding RI tag refers to.</td>
</tr>
</tbody>
</table>
### TABLE 0C

<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Short Description</th>
<th>Data Size</th>
<th>Tag Value</th>
<th>Long Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFTAG_LD</td>
<td>LUT Dimension</td>
<td>20 bytes</td>
<td>307</td>
<td>Defines the dimensions of the two-dimensional array the corresponding LUT tag refers to.</td>
</tr>
<tr>
<td>DFTAG_MD</td>
<td>Matte Dimension</td>
<td>20 bytes</td>
<td>308</td>
<td>Defines the dimensions of the two-dimensional array the corresponding MA tag refers to.</td>
</tr>
<tr>
<td>DFTAG_CI</td>
<td>Raster Image</td>
<td>x*y bytes</td>
<td>302</td>
<td>Points to a raster image data set.</td>
</tr>
<tr>
<td>DFTAG_CI</td>
<td>Compressed Image</td>
<td>n bytes</td>
<td>303</td>
<td>Points to a compressed raster image data set.</td>
</tr>
<tr>
<td>DFTAG_LUT</td>
<td>Lookup Table</td>
<td>n bytes</td>
<td>301</td>
<td>Table to be used by the hardware for the purpose of assigning RGB or HSV colors to data values.</td>
</tr>
<tr>
<td>DFTAG_MA</td>
<td>Matte Data</td>
<td>n bytes</td>
<td>309</td>
<td>Points to matte data.</td>
</tr>
<tr>
<td>DFTAG_CCN</td>
<td>Color Correction</td>
<td>n bytes</td>
<td>310</td>
<td>Specifies the gamma correction for the raster image and color primaries used in the generation of the image.</td>
</tr>
<tr>
<td>DFTAG_CFM</td>
<td>Color Format</td>
<td>String</td>
<td>311</td>
<td>Indicates the interpretation to be given to each element of each pixel in a raster image.</td>
</tr>
<tr>
<td>DFTAG_AR</td>
<td>Aspect Ratio</td>
<td>4 bytes</td>
<td>312</td>
<td>Indicates the aspect ratio of the image.</td>
</tr>
<tr>
<td>DFTAG_XYP</td>
<td>XY Position</td>
<td>8 bytes</td>
<td>500</td>
<td>Specifies the screen X-Y coordinate for raster image sets. (Also used for composite image sets - See the entry for DFTAG_XYP in Table 12.6)</td>
</tr>
</tbody>
</table>

### The HDF Composite Image Tags

<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Short Description</th>
<th>Data Size</th>
<th>Tag Value</th>
<th>Long Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFTAG_DRAO</td>
<td>Draw</td>
<td>n*4 bytes</td>
<td>400</td>
<td>Specifies a list of Data Identifiers (tag/reference number pairs) which define a composite image.</td>
</tr>
<tr>
<td>DFTAG_XYP</td>
<td>XY Position</td>
<td>8 bytes</td>
<td>500</td>
<td>Identifies code that is to be executes as a program or script.</td>
</tr>
<tr>
<td>DFTAG_RUN</td>
<td>Run</td>
<td>n bytes</td>
<td>401</td>
<td>Used as a vector image tag. Points to a Tektronix 4014 data. The bytes in the data field, when read and sent to a Tektronix 4014 terminal, will be displayed as a vector image.</td>
</tr>
<tr>
<td>DFTAG_T14</td>
<td>Tektronix 4014</td>
<td>n bytes</td>
<td>602</td>
<td>Used as a vector image tag. Points to a Tektronix 4014 data. The bytes in the data field, when read and sent to a Tektronix 4014 terminal, will be displayed as a vector image.</td>
</tr>
<tr>
<td>DFTAG_T10S</td>
<td>Tektronix 4015</td>
<td>n bytes</td>
<td>603</td>
<td>Used as a vector image tag. Points to a Tektronix 4015 data. The bytes in the data field, when read and sent to a Tektronix 4015 terminal, will be displayed as a vector image.</td>
</tr>
</tbody>
</table>

### The HDF Scientific Data Set Tags

<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Short Description</th>
<th>Data Size</th>
<th>Tag Value</th>
<th>Long Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFTAG_SDG</td>
<td>Numeric Data Group</td>
<td>n*4 bytes</td>
<td>720</td>
<td>Lists the Data Identifiers (tag/reference number pairs) that describe a scientific data set. Supersedes DFTAG_SDG.</td>
</tr>
<tr>
<td>DFTAG_SDD</td>
<td>SDS Dimension Record</td>
<td>n bytes</td>
<td>701</td>
<td>Defines the rank and dimensions of the array the corresponding SD refers to.</td>
</tr>
</tbody>
</table>
### TABLE OE

<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Short Description</th>
<th>Data Size</th>
<th>Tag Value</th>
<th>Long Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFTAG_SD</td>
<td>Scientific Data</td>
<td>Real Number</td>
<td>702</td>
<td>Points to scientific data.</td>
</tr>
<tr>
<td>DFTAG_SDS</td>
<td>Scales</td>
<td>Real Number</td>
<td>703</td>
<td>Identifies the scales to be used when interpreting and displaying data.</td>
</tr>
<tr>
<td>DFTAG_SSL</td>
<td>Labels</td>
<td>String</td>
<td>704</td>
<td>Labels all dimensions and data.</td>
</tr>
<tr>
<td>DFTAG_SSG</td>
<td>Units</td>
<td>String</td>
<td>705</td>
<td>Displays units for all dimensions and data.</td>
</tr>
<tr>
<td>DFTAG_SSF</td>
<td>Formats</td>
<td>String</td>
<td>706</td>
<td>Displays formats for axes and data.</td>
</tr>
<tr>
<td>DFTAG_SSM</td>
<td>Maximum/minimum</td>
<td>2 Real Numbers</td>
<td>707</td>
<td>Displays the maximum and minimum values for the data.</td>
</tr>
<tr>
<td>DFTAG_SSC</td>
<td>Coordinate system</td>
<td>String</td>
<td>708</td>
<td>Displays the coordinate system to be used in interpreting data.</td>
</tr>
<tr>
<td>DFTAG_SDLK</td>
<td>SDS Link</td>
<td>8 bytes</td>
<td>710</td>
<td>Links and old-style DFTAG_SDG and a DFTAG_NDG in cases where the DFTAG_NDG meets all criteria for a DFTAG_SDG.</td>
</tr>
<tr>
<td>DFTAG_CAL</td>
<td>Calibration Information</td>
<td>36 bytes</td>
<td>731</td>
<td>The calibration record for the corresponding DFTAG_SD.</td>
</tr>
<tr>
<td>DFTAG_FV</td>
<td>Fill Value</td>
<td>n bytes</td>
<td>732</td>
<td>The value which has been used to indicate unset values in the corresponding DFTAG_SD.</td>
</tr>
</tbody>
</table>

### The HDF Vset Tags

<table>
<thead>
<tr>
<th>Tag Name</th>
<th>Short Description</th>
<th>Data Size</th>
<th>Tag Value</th>
<th>Long Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFTAG_VG</td>
<td>Vgroup</td>
<td>14+n bytes</td>
<td>1965</td>
<td>Provides a general-purpose grouping structure.</td>
</tr>
<tr>
<td>DFTAG_VH</td>
<td>Vdata Description</td>
<td>22+n bytes</td>
<td>1962</td>
<td>Provides information necessary to process a DFTAG_VS.</td>
</tr>
<tr>
<td>DFTAG_VS</td>
<td>Vdata</td>
<td>n bytes</td>
<td>1963</td>
<td>Contains a block a data that is to be interpreted according to the information in the corresponding DFTAG_VH.</td>
</tr>
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</table>

### THE OBSOLETE HDF TAGS

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<tr>
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<th>Short Description</th>
<th>Data Size</th>
<th>Tag Value</th>
<th>Long Description</th>
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<tr>
<td>DFTAG_IDS</td>
<td>Image Dimension-8</td>
<td>4 bytes</td>
<td>200</td>
<td>Two 16-bit integers that represent the width and height of an 8-bit raster image in bytes.</td>
</tr>
<tr>
<td>DFTAG_IP8</td>
<td>Image Palette-8</td>
<td>768 bytes</td>
<td>201</td>
<td>A 256 x 3 byte array representing the red, green and blue elements of the 256-color palette respectively.</td>
</tr>
<tr>
<td>DFTAG_RI8</td>
<td>Raster Image-8</td>
<td>x*y bytes</td>
<td>202</td>
<td>A row-oriented representation of the elementary 8-bit image data.</td>
</tr>
<tr>
<td>DFTAG_CI8</td>
<td>Compressed Image-8</td>
<td>n bytes</td>
<td>203</td>
<td>A row-oriented representation of the elementary 8-bit raster image data, with each row compressed using a form of run-length encoding.</td>
</tr>
<tr>
<td>DFTAG_UI8</td>
<td>IMCOMP Image-8</td>
<td>n bytes</td>
<td>204</td>
<td>A 4:1 8-bit raster image, compressed using the IMCOMP algorithm.</td>
</tr>
<tr>
<td>DFTAG_SDG</td>
<td>Scientific Data Group</td>
<td>n*4 bytes</td>
<td>700</td>
<td>List the Data Identifiers (tag/reference number pairs) that uniquely describe a scientific data set.</td>
</tr>
<tr>
<td>DFTAG_SDT</td>
<td>Transpose</td>
<td>0 bytes</td>
<td>709</td>
<td>Indicates that data is transposed in the file.</td>
</tr>
</tbody>
</table>
Appendix B  HDF Installation Overview

B.1  General HDF Installation Overview

B.1.1  Acquiring the HDF Library Source

You may obtain HDF source code and/or selected binaries at no charge from NCSA's anonymous FTP server. The Internet address of the server is:

ftp.ncsa.uiuc.edu

Log in by entering anonymous for the name and your full e-mail address (login@host) for the password.

After logging in, change directory to HDF/HDF_Current/. Precompiled binaries will be found in the subdirectory bin/, source code in the subdirectory to src/. Note that any compressed or binary files in these directories must be transferred using binary mode.

For reference, the unpacked HDF source code can be found in the subdirectory src/unpacked/.

If you have any questions regarding this procedure or whether you are connected to the Internet, consult your local system administration or network expert.

B.1.2  Building the HDF Library Source

For instructions on building HDF from the source code, please refer to the INSTALL file in the top directory of the unpacked HDF source tree.
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