Introduction to HDF5 Data Model, Programming Model and Library APIs

HDF and HDF-EOS Workshop VI

December 4, 2002

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- **Morning session (lecture format):**
  - Introduction to HDF5
  - Programming Model
  - Introduction to Library APIs
- **Afternoon concurrent hands-on sessions**
  - Introduction to HDF5: files, groups, datasets, attributes
  - Advanced HDF5: hyperslab selections, compound datatypes, object and region references
  - Parallel HDF5
  - High-Level APIs

Goals This Morning

- Introduce HDF5
- Provide a basic knowledge of how data can be organized in HDF5 & how it is used by applications.
- To provide some examples of how to read and write HDF5 files

Goals This Afternoon

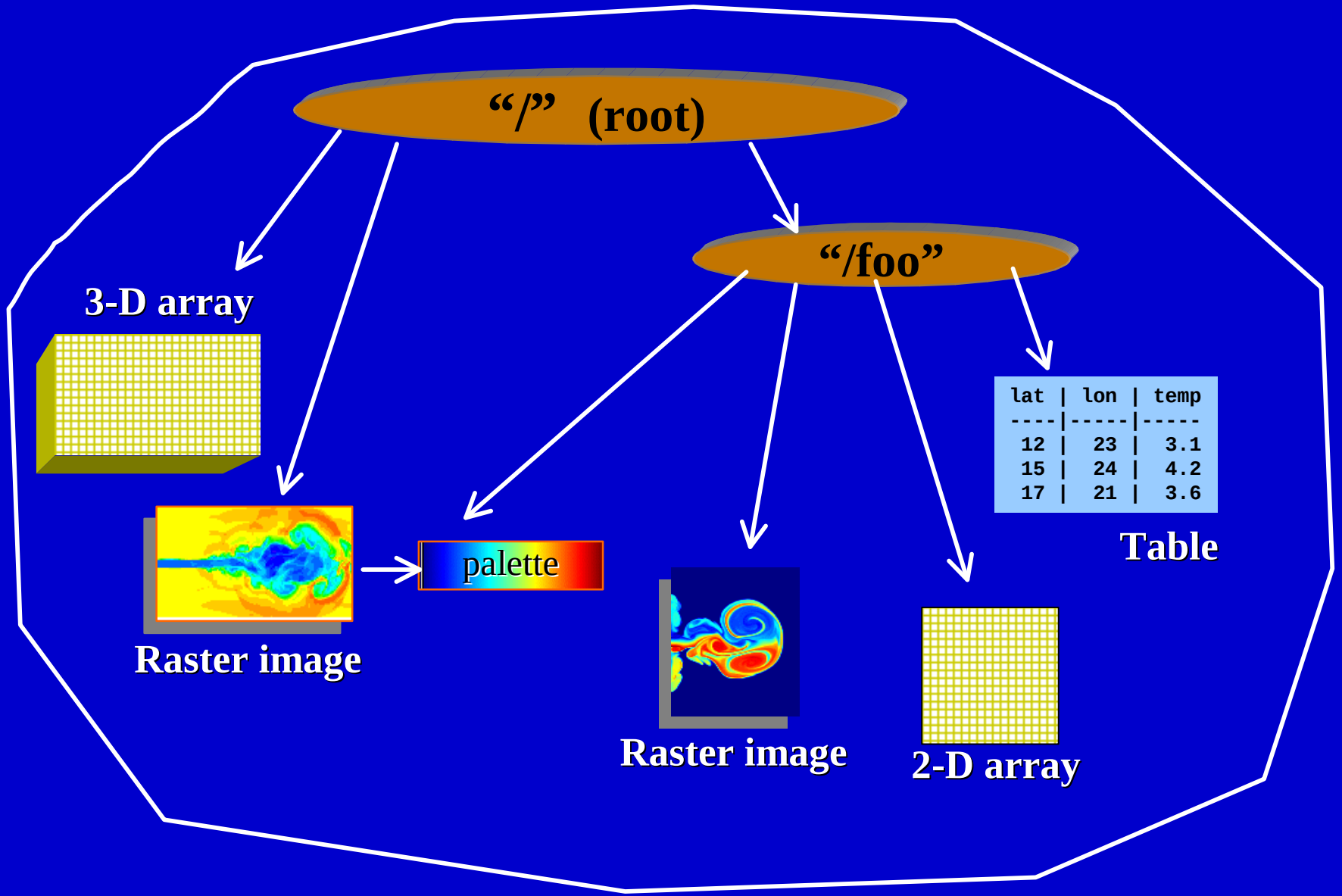
- **Help you to start working with the HDF5 Library**
  - **Login NCSA machines**
  - **Run examples**
  - **Create your own programs**

What is HDF5?

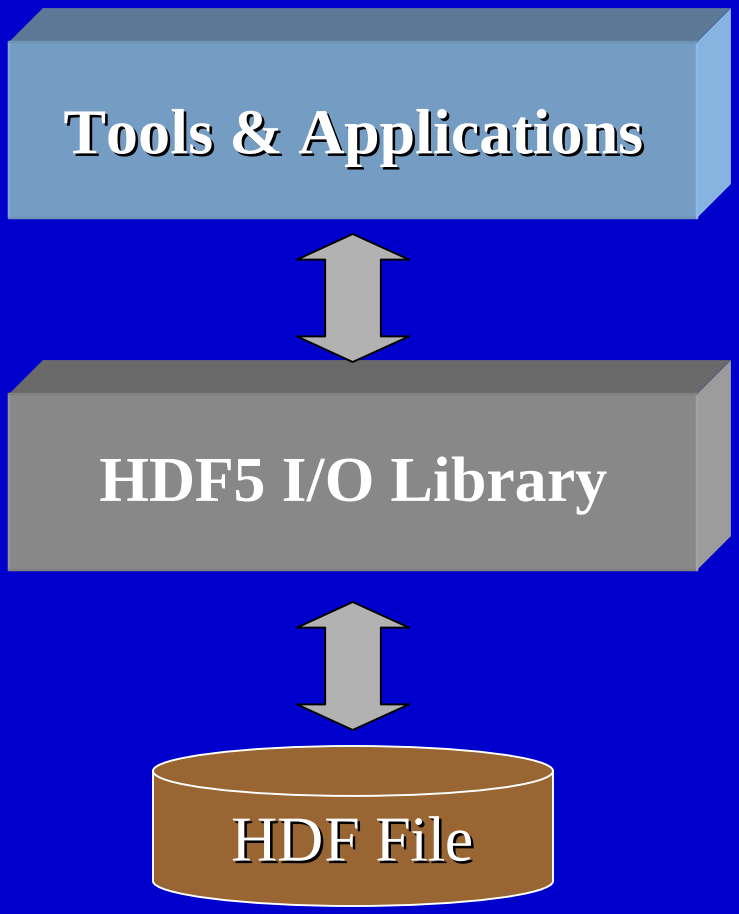
What is HDF5?

- **File format for storing scientific data**
  - To store and organize all kinds of data
  - To share data , to port files from one platform to another
  - To overcome a limit on number and size of the objects in the file
- **Software for accessing scientific data**
  - Flexible I/O library (parallel, remote, etc.)
  - Efficient storage
  - Available on almost all platforms
  - C, F90, C++ , Java APIs
  - Tools (HDFView, utilities)

Example HDF5 file



HDF5 Software



Overview
HDF5 Data Model
& I/O Library

HDF5 Data Model

HDF5 file

- **Primary Objects**
  - **Groups**
  - **Datasets**
- **Additional means to organize data**
  - **Attributes**
  - **Sharable objects**
  - **Storage and access properties**

HDF5 Dataset

- **Data array**
  - ordered collection of identically typed data items distinguished by their indices
- **Metadata**
  - Dataspace – rank, dimensions, other spatial info about dataset
  - Datatype
  - Attribute list – user-defined metadata
  - Special storage options – how array is organized

Dataset Components

Metadata

Dataspace

Rank

3

Dimensions

Dim_1 = 4

Dim_2 = 5

Dim_3 = 7

Datatype

IEEE 32-bit float

Storage info

Chunked

Compressed

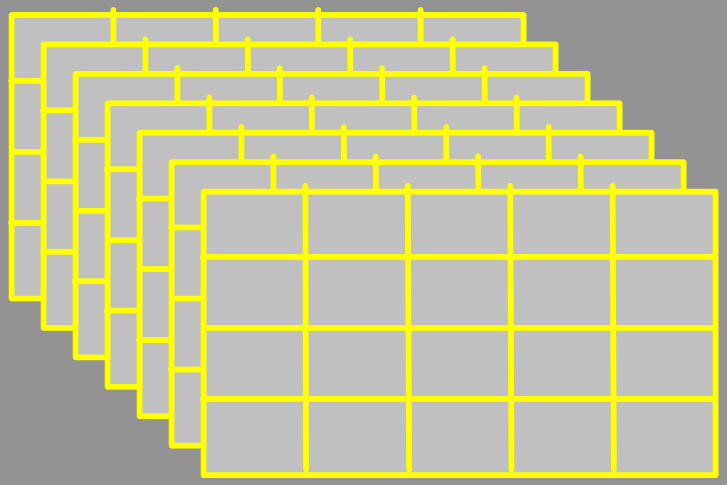
Attributes

Time = 32.4

Pressure = 987

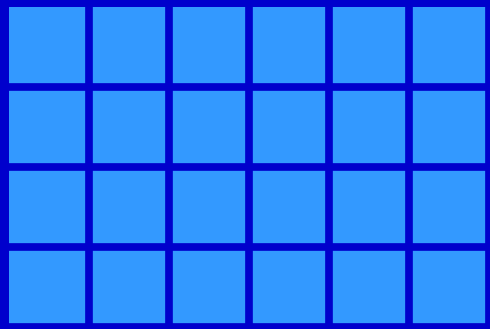
Temp = 56

Data



Dataspaces

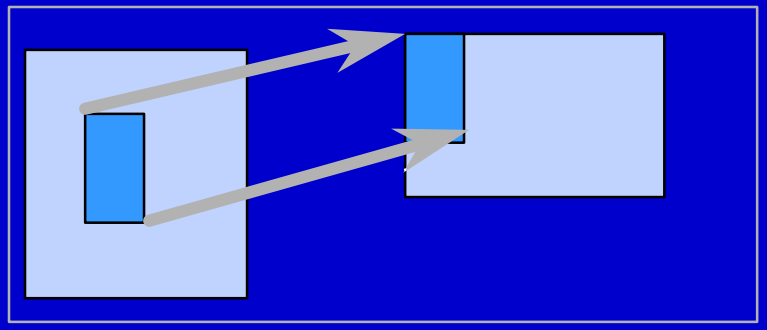
- **Dataspace – spatial info about a dataset**
  - **Rank and dimensions**
    - **Permanent part of dataset definition**
  - **Subset of points, for partial I/O**
    - **Needed only during I/O operations**
- **Apply to datasets in memory or in the file**



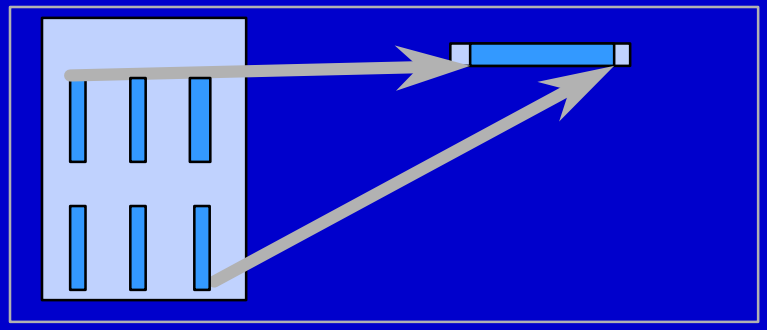
Rank = 2

Dimensions = 4x6

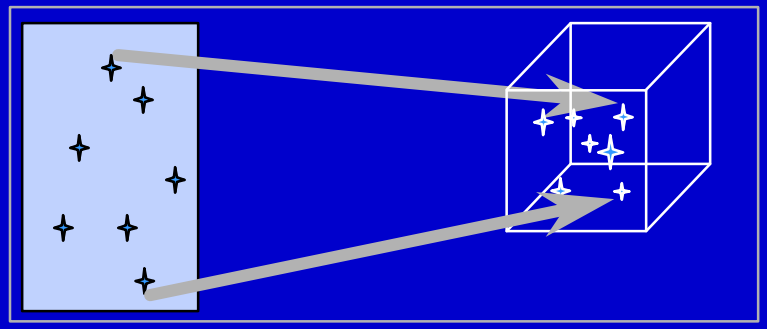
Sample Mappings between File Dataspaces and Memory Dataspaces



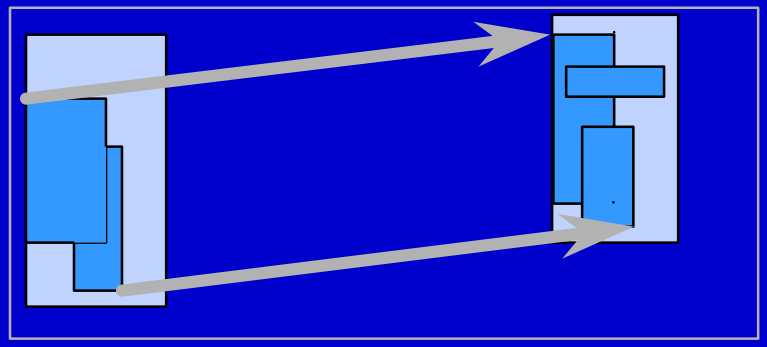
(a) Hyperslab from a 2D array to the corner of a smaller 2D array



(b) Regular series of blocks from a 2D array to a contiguous sequence at a certain offset in a 1D array



(c) A sequence of points from a 2D array to a sequence of points in a 3D array.

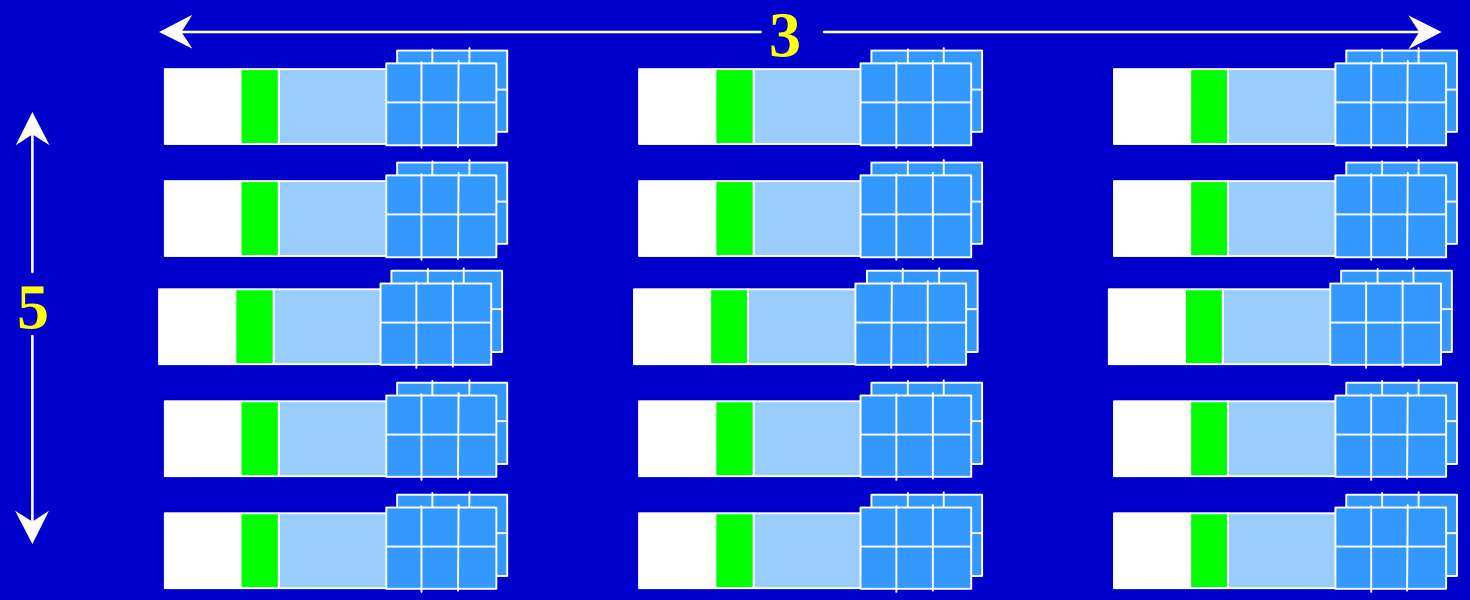


(d) Union of hyperslabs in file to union of hyperslabs in memory.

Datatypes (array elements)

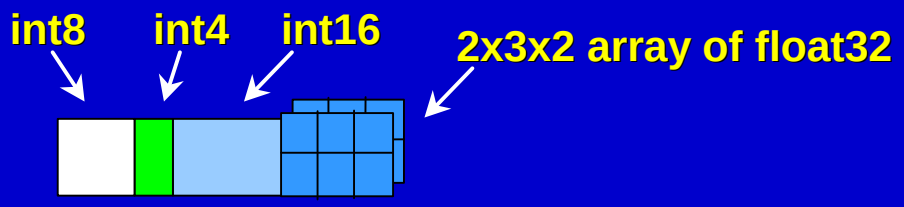
- **Datatype – how to interpret a data element**
  - Permanent part of the dataset definition
- **HDF5 atomic types**
  - normal integer & float
  - user-definable integer and float (e.g. 13-bit integer)
  - variable length types (e.g. strings)
  - pointers - references to objects/dataset regions
  - enumeration - names mapped to integers
  - array
- **HDF5 compound types**
  - Comparable to C structs
  - Members can be atomic or compound types

HDF5 dataset: array of records



Dimensionality: 5 x 3

Datatype:



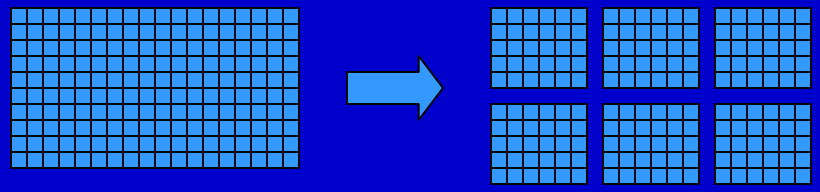
Record

Attributes

- Attribute – data of the form “name = value”, attached to an object
- Operations are scaled-down versions of the dataset operations
  - Not extendible
  - No compression
  - No partial I/O
- Optional for the dataset definition
- Can be overwritten, deleted, added during the “life” of a dataset

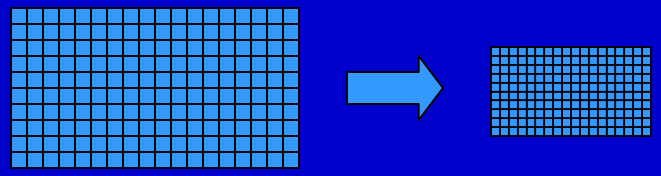
Special Storage Options

chunked



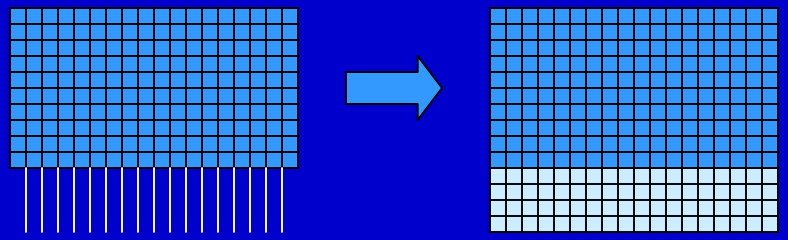
Better subsetting access time; extendable

compressed



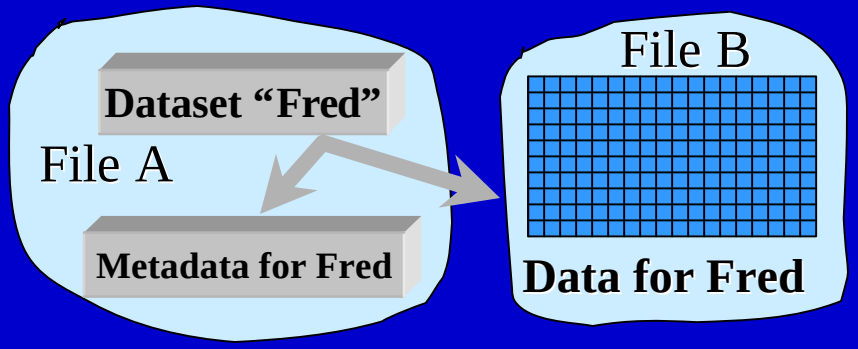
Improves storage efficiency, transmission speed

extendable



Arrays can be extended in any direction

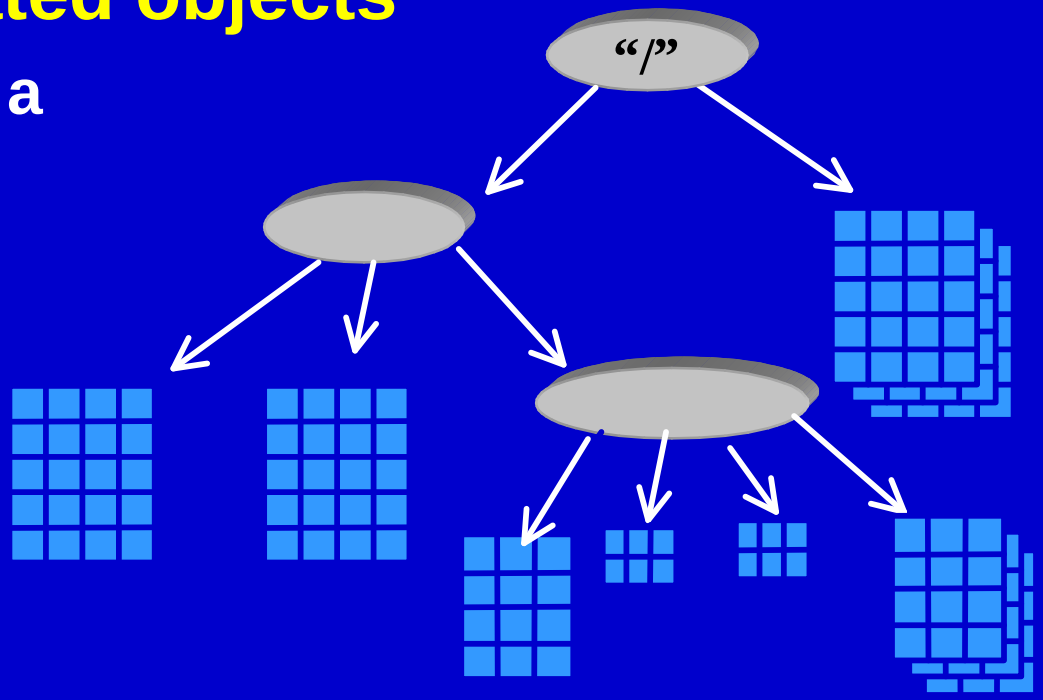
External file



Metadata in one file, raw data in another.

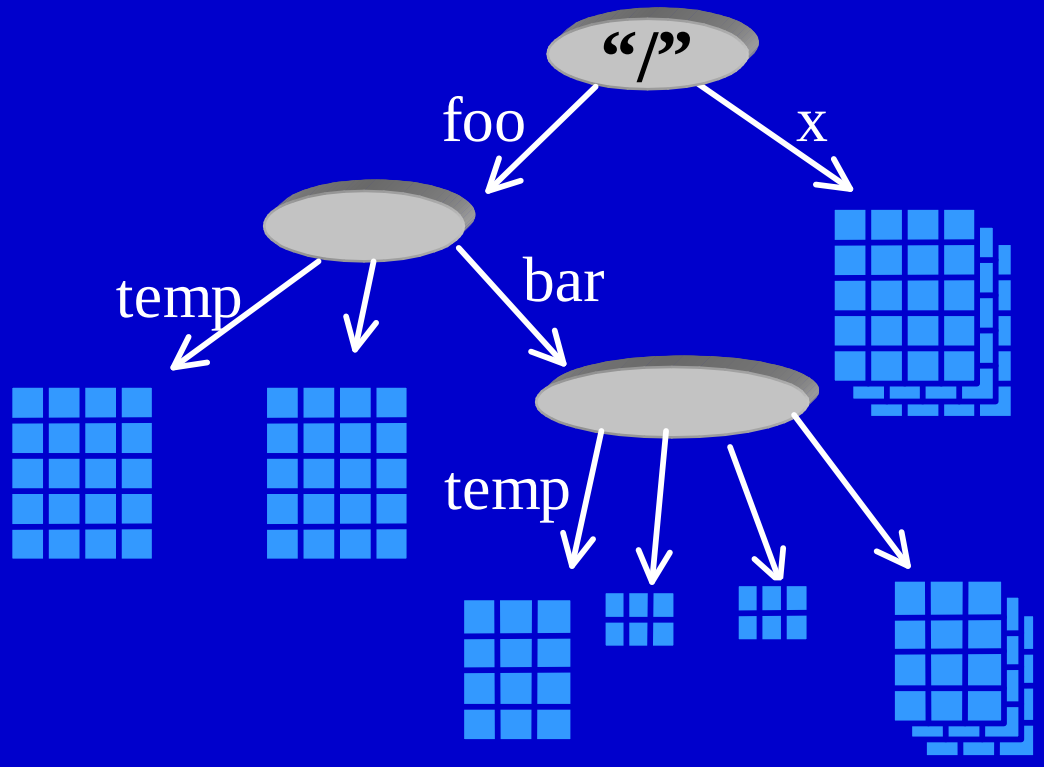
Groups

- **Group – a mechanism for describing collections of related objects**
- **Every file starts with a root group**
- **Can have attributes**
- **Similar to UNIX directories, but cycles are allowed**

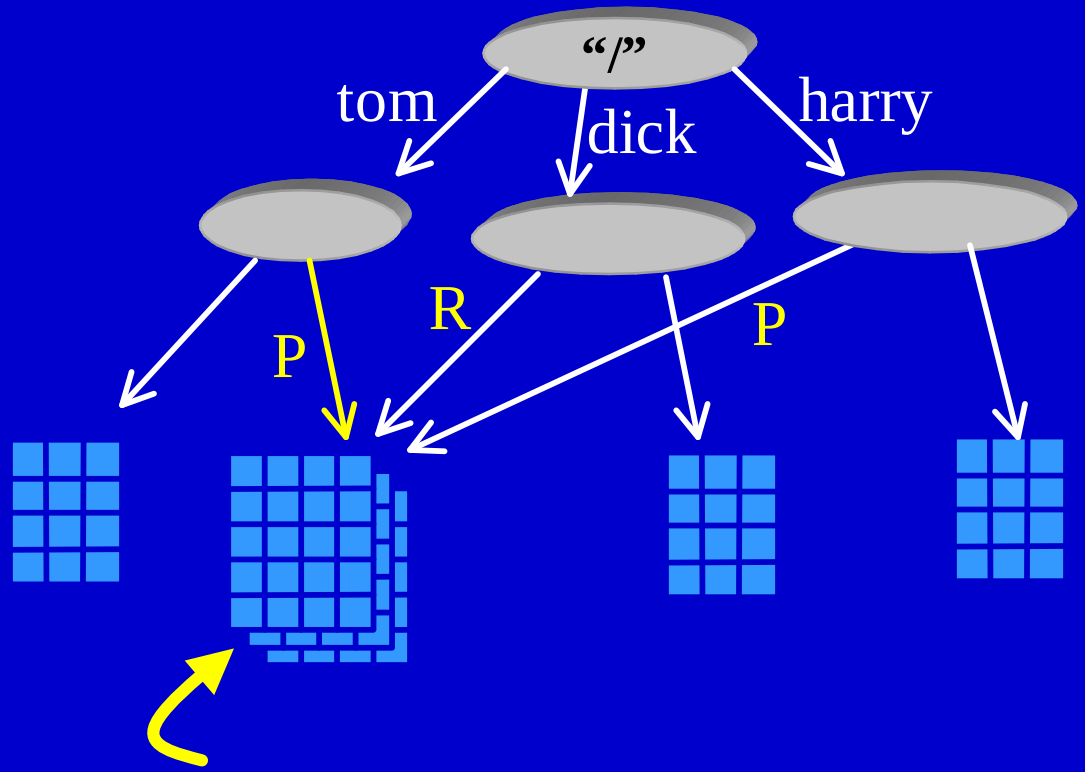


HDF5 objects are identified and located by their pathnames

/ (root)
/x
/foo
/foo/temp
/foo/bar/temp

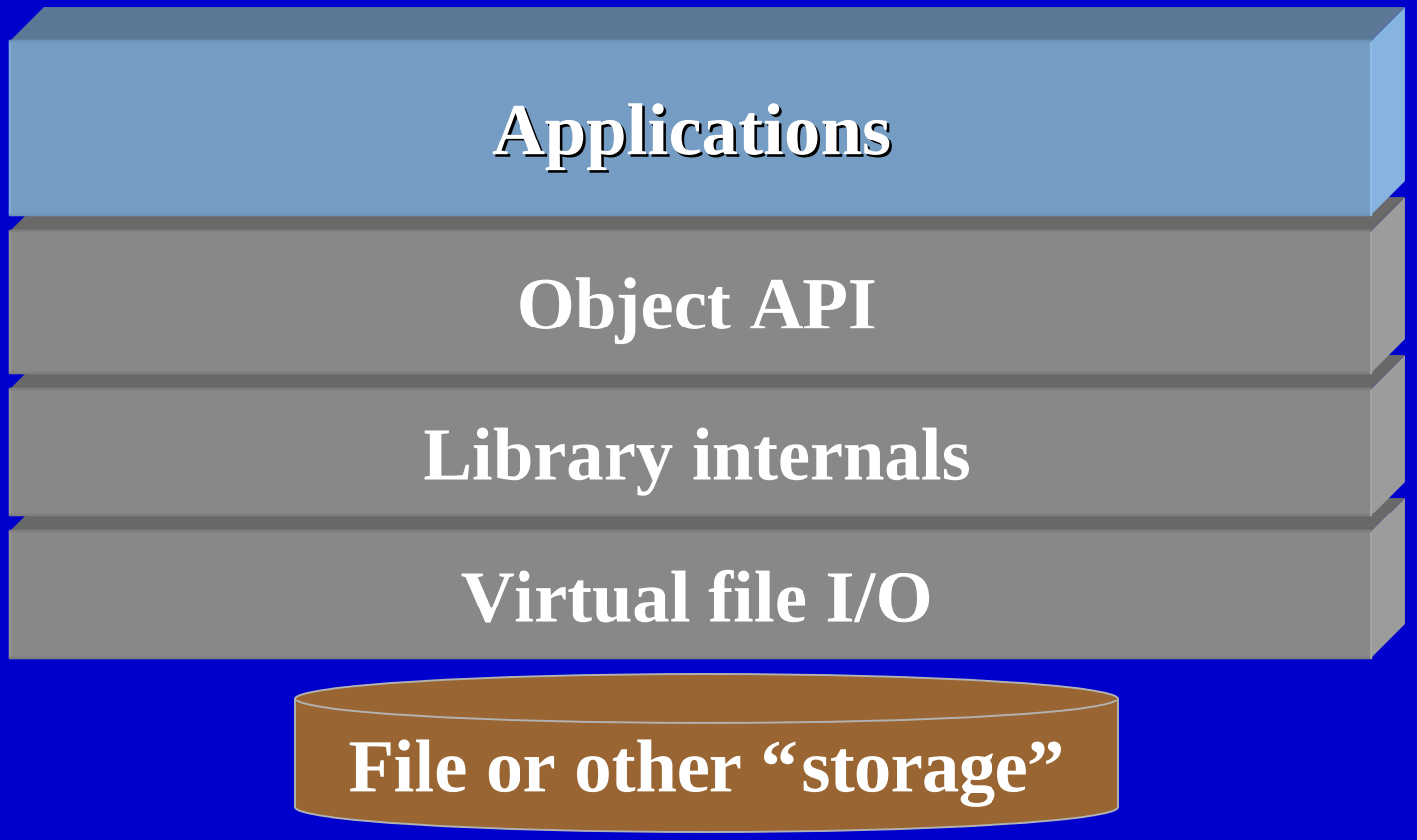


Groups & members of groups can be shared

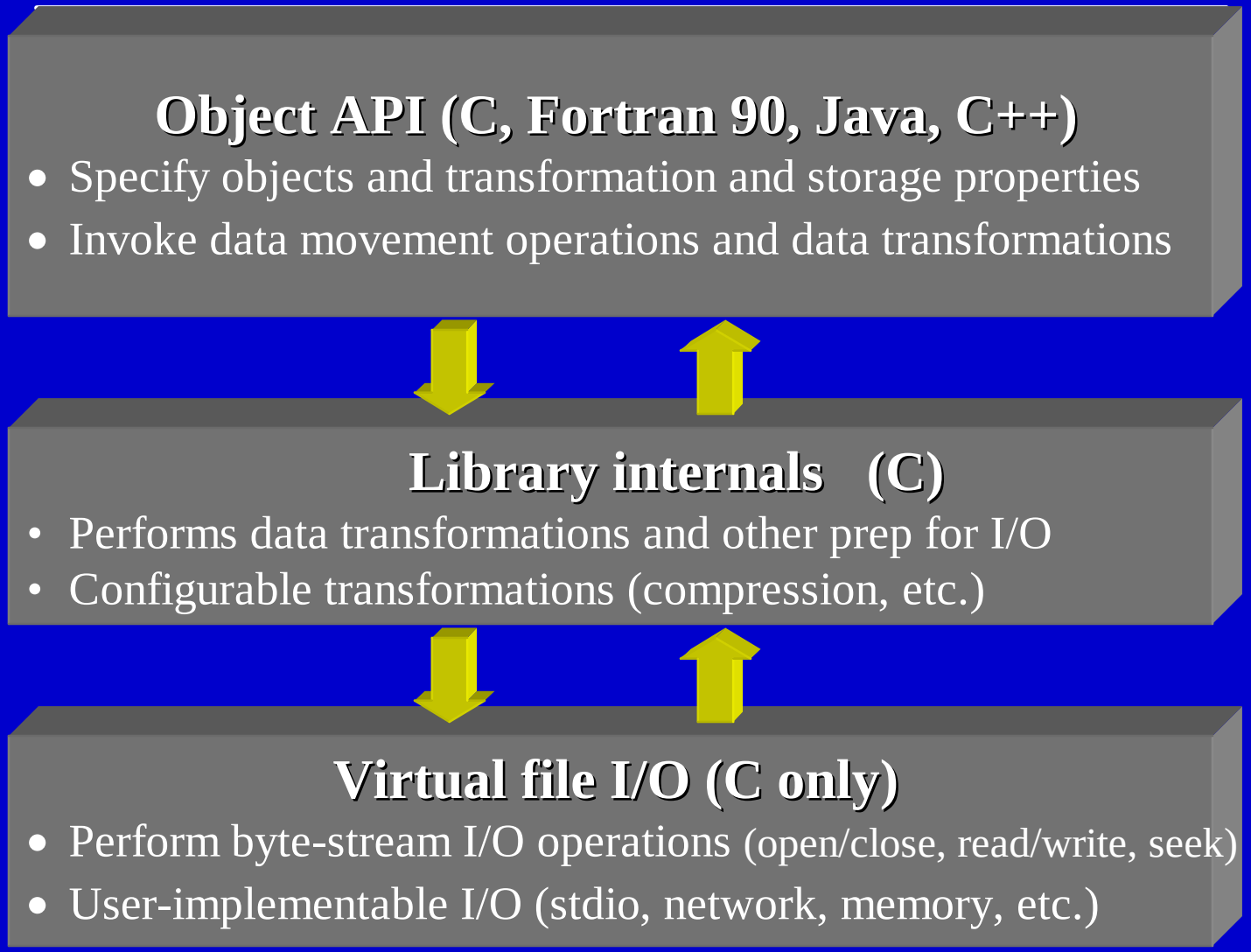


HDF5 I/O Library

Structure of HDF5 Library

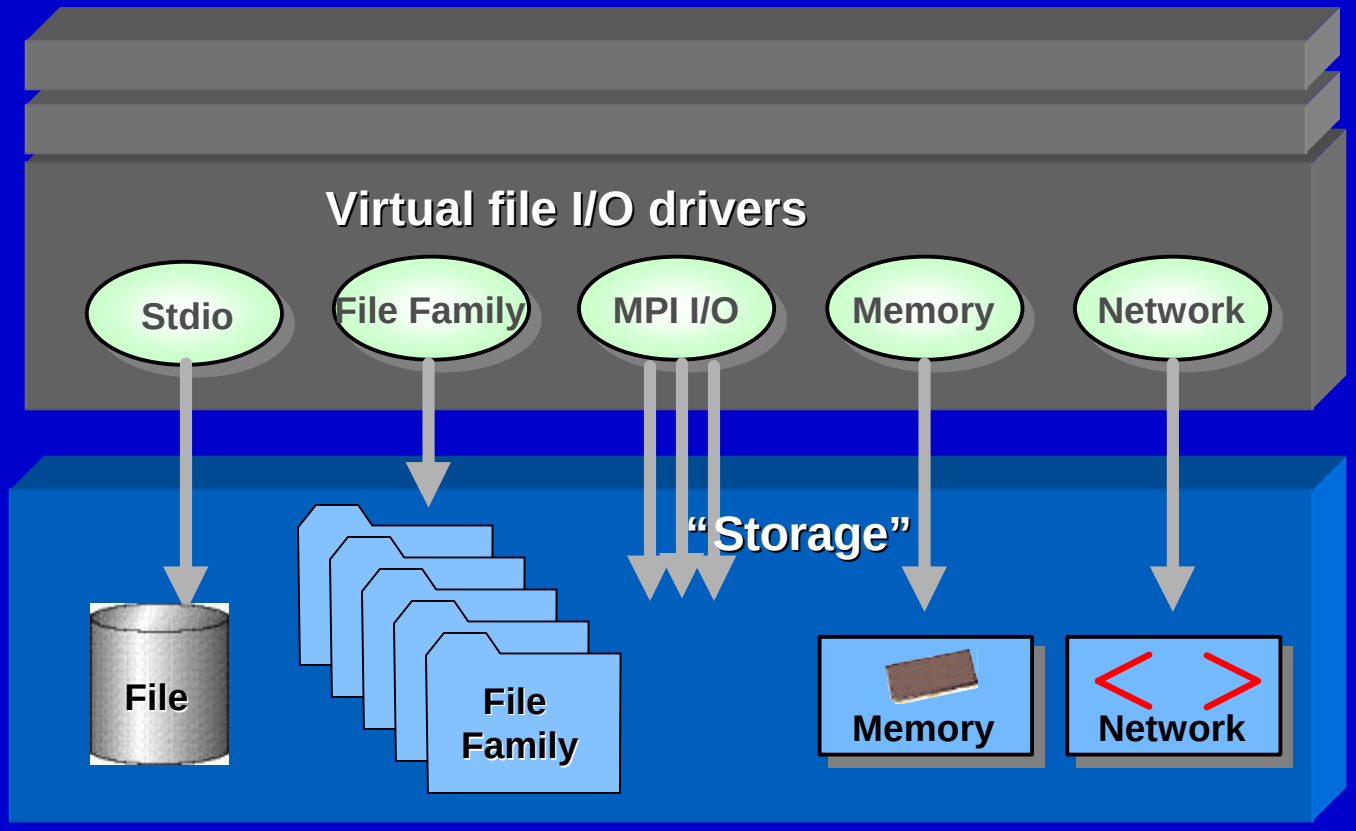


Structure of HDF5 Library



Virtual file I/O layer

- A public API for writing I/O drivers
- Allows HDF5 to interface to disk, the network, memory, or a user-defined device



Intro to HDF5 API

Programming model for sequential access

Goals

- Describe the HDF5 programming model
- Give a feel for what it's like to use the general HDF5 API
- Review some of the key concepts of HDF5

General API Topics

- General info about HDF5 programming
- Creating an HDF5 file
- Creating a dataset
- Writing and reading a dataset

The General HDF5 API

- **Currently has C, Fortran 90, Java and C++ bindings.**
- **C routines begin with prefix H5*, where * is a single letter indicating the object on which the operation is to be performed.**
- **Full functionality**

Example APIs:

H5D : **D**ataset interface *e.g..* **H5Dread**
H5F : **F**ile interface *e.g..* **H5Fopen**
H5S : data**S**pace interface *e.g..* **H5Sclose**

The General Paradigm

- ***Properties (called creation and access property lists) of objects are defined (optional)***
- **Objects are opened or created**
- **Objects then accessed**
- **Objects finally closed**

Order of Operations

- **The library imposes an order on the operations by argument dependencies**
  Example: **A file must be opened before a dataset because the dataset open call requires a file handle as an argument**

- **Objects can be closed in any order, and reusing a closed object will result in an error**

HDF5 C Programming Issues

For portability, HDF5 library has its own defined types:

hid_t:	object identifiers (native *integer*)
hsize_t:	size used for dimensions (*unsigned long* or *unsigned long long*)
hssize_t:	for specifying coordinates and sometimes for dimensions (*signed long* or *signed long long*)
herr_t:	function return value

For **C**, include *#include hdf5.h* at the top of your HDF5 application.

h5dump
Command-line Utility for Viewing HDF5 Files

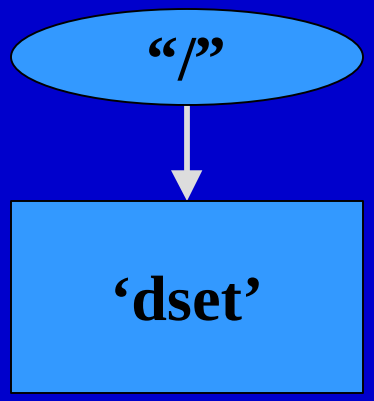
h5dump [-h] [-bb] [-header] [-a] [-d <names>] [-g <names>] [-l <names>] [-t <names>] <file>

-h	Print information on this command.
-header	Display header only; no data is displayed.
-a <names>	Display the specified attribute(s).
-d <names>	Display the specified dataset(s).
-g <names>	Display the specified group(s) and all the members.
-l <names>	Displays the value(s) of the specified soft link(s).
-t <names>	Display the specified named datatype(s).

<*names*> is one or more appropriate object names.

Example of h5dump Output

```
HDF5 "dset.h5" {
GROUP "/" {
   DATASET "dset" {
      DATATYPE { H5T_STD_I32BE }
      DATASPACE { SIMPLE ( 4, 6 ) / ( 4, 6 ) }
      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
      }
   }
}
}
```



Creating an HDF5 File

Steps to Create a File

- Specify File Creation and Access Property Lists, if necessary
- Create a file
- Close the file and the property lists, if necessary

Property Lists

- A property list is a collection of values that can be passed to HDF5 functions at lower layers of the library
- File Creation Property List
  - Controls file metadata
  - Size of the user-block, sizes of file data structures, etc.
  - Specifying H5P_DEFAULT uses the default values
- Access Property List
  - Controls different methods of performing I/O on files
  - Unbuffered I/O, parallel I/O, etc.
  - Specifying H5P_DEFAULT uses the default values.

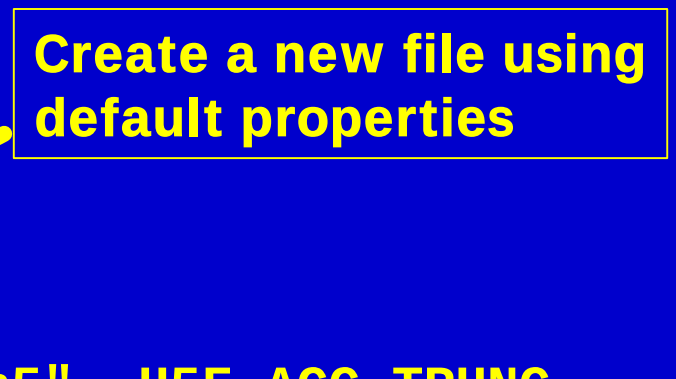
hid_t H5Fcreate (const char *name, unsigned flags, hid_t create_id, hid_t access_id)

name	**IN**:	Name of the file to access
flags	**IN**:	File access flags
create_id	**IN**:	File creation property list identifier
access_id	**IN**:	File access property list identifier

herr_t H5Fclose (hid_t file_id)

file_id **IN:** Identifier of the file to terminate access to

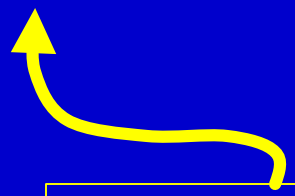
Example 1




```
1       hid_t       file_id;
2       herr_t      status;

3       file_id = H5Fcreate ("file.h5", H5F_ACC_TRUNC,
                             H5P_DEFAULT, H5P_DEFAULT);

4       status = H5Fclose (file_id);
```

Example 1

```
1       hid_t       file_id;
2       herr_t      status;

3       file_id = H5Fcreate ("file.h5", H5F_ACC_TRUNC,
                             H5P_DEFAULT, H5P_DEFAULT);

4       status = H5Fclose (file_id);
```



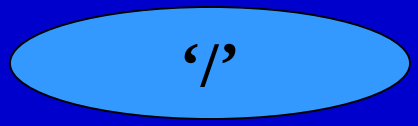
Terminate access to the File

h5_crtfile.c

```
 1   #include <hdf5.h>
 2   #define FILE "file.h5"
 3
 4   main() {
 5
 6      hid_t       file_id;   /* file identifier */
 7      herr_t      status;
 8
 9      /* Create a new file using default properties. */
10      file_id = H5Fcreate (FILE, H5F_ACC_TRUNC,
                             H5P_DEFAULT, H5P_DEFAULT);
11
12      /* Terminate access to the file. */
13      status = H5Fclose (file_id);
14   }
```

Example 1: h5dump Output

```
HDF5 "file.h5" {
GROUP "/" {
}
}
```



Create a Dataset

Dataset Components

Metadata

Dataspace

Rank

3

Dimensions

Dim_1 = 4

Dim_2 = 5

Dim_3 = 7

Datatype

IEEE 32-bit float

Storage info

Chunked

Compressed

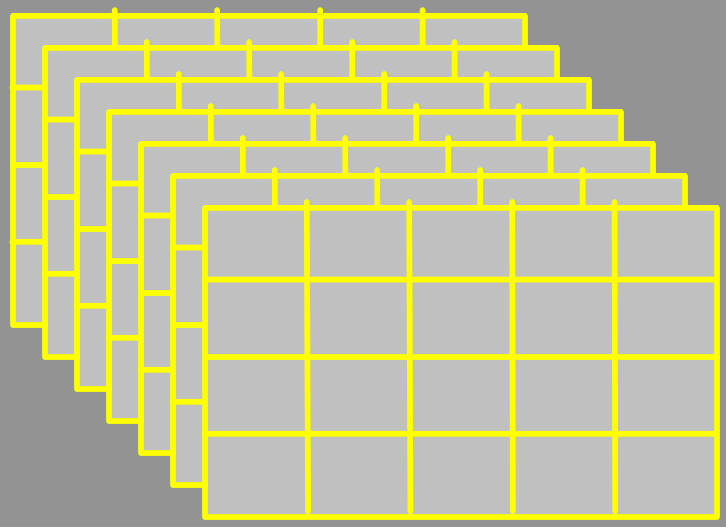
Attributes

Time = 32.4

Pressure = 987

Temp = 56

Data



Steps to Create a Dataset

- Obtain location ID where dataset is to be created
- Define dataset characteristics (datatype, dataspace, dataset creation property list, if necessary)
- Create the dataset
- Close the datatype, dataspace, and property list, if necessary
- Close the dataset

Step 1

Step 1. Obtain the *location identifier* where the *dataset* is to be created

Location Identifier: the file or group identifier in which to create a dataset

Step 2

Step 2. Define the dataset characteristics

- datatype (e.g. integer)
- dataspace (2 dimensions: 100x200)
- dataset creation properties (e.g. chunked and compressed)

Standard Predefined Datatypes

Examples:

H5T_IEEE_F64LE	Eight-byte, little-endian, IEEE floating-point
H5T_IEEE_F32BE	Four-byte, big-endian, IEEE floating point
H5T_STD_I32LE	Four-byte, little-endian, signed two's complement integer
H5T_STD_U16BE	Two-byte, big-endian, unsigned integer

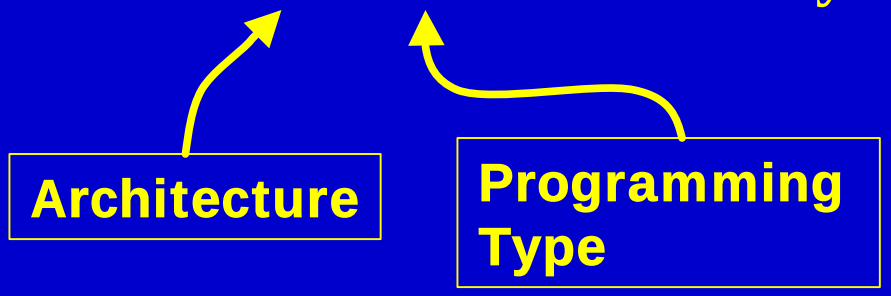
NOTE:

- **These datatypes (DT) are the same on all platforms**
- **These are DT handles generated at run-time**
- **Used to describe DT in the HDF5 calls**
- **DT are not used to describe application data buffers**

Standard Predefined Datatypes

Examples:

H5T_IEEE_F64LE	Eight-byte, little-endian, IEEE floating-point
H5T_IEEE_F32BE	Four-byte, big-endian, IEEE floating point
H5T_STD_I32LE	Four-byte, little-endian, signed two's complement integer
H5T_STD_U16BE	**Two-byte, big-endian, unsigned integer**



Native Predefined Datatypes

Examples of predefined native types in C:

H5T_NATIVE_INT	(int)
H5T_NATIVE_FLOAT	(float)
H5T_NATIVE_UINT	(unsigned int)
H5T_NATIVE_LONG	(long)
H5T_NATIVE_CHAR	(char)

NOTE:

- **These datatypes are NOT the same on all platforms**
- **These are DT handles generated at run-time**

Dataspaces

- **Dataspace: size and shape of dataset and subset**
  - **Dataset**
    - **Rank: number of dimension**
    - **Dimensions: sizes of all dimensions**
    - **Permanent – part of dataset definition**
  - **Subset**
    - **Size, shape and position of selected elements**
    - **Needed primarily during I/O operations**
    - **Not permanent**
    - **(Subsetting not covered in this tutorial)**
- **Applies to arrays in memory or in the file**

Creating a Simple Dataspace

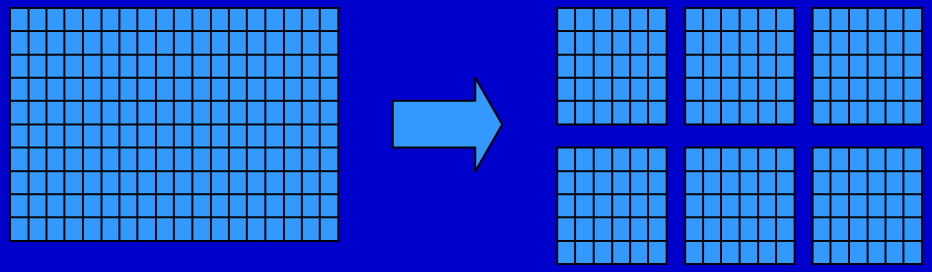
```
hid_t  H5Screate_simple (int rank,
        const hsize_t * dims,
        const hsize_t *maxdims)
```

rank	**IN**: Number of dimensions of dataspace
dims	**IN**: An array of the size of each dimension
maxdims	**IN**: An array of the maximum size of each dimension A value of **`H5S_UNLIMITED`** specifies the unlimited dimension. A value of NULL specifies that *dims* and *maxdims* are the same.

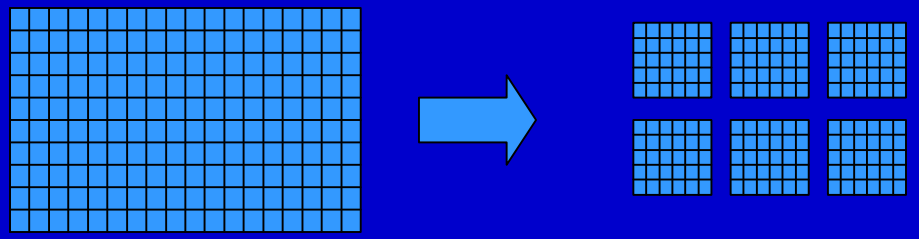
Dataset Creation Property List

The *dataset creation property list* contains information on how to organize data in storage.

Chunked



Chunked & compressed



Property List Example

- Creating a dataset with ``deflate'' compression

```
create_plist_id = H5Pcreate(H5P_DATASET_CREATE);
H5Pset_chunk(create_plist_id, ndims, chunk_dims);
H5Pset_deflate(create_plist_id, 9);
```

Remaining Steps to Create a Dataset

- Create the dataset
- Close the datatype, dataspace, and property list, if necessary
- Close the dataset

hid_t H5Dcreate (hid_t loc_id, const char *name,
hid_t type_id, hid_t space_id,
hid_t create_plist_id)

loc_id	**IN**: Identifier of file or group to create the dataset within
name	**IN**: The name of (the link to) the dataset to create
type_id	**IN**: Identifier of datatype to use when creating the dataset
space_id	**IN**: Identifier of dataspace to use when creating the dataset
create_plist_id	**IN**: Identifier of the dataset creation property list (or **H5P_DEFAULT**)

Example 2 – Create an empty 4x6 dataset

```
1  hid_t       file_id, dataset_id, dataspace_id;
2  hsize_t     dims[2];
3  herr_t      status;

   Create a new file

4  file_id = H5Fcreate ("dset.h5", H5F_ACC_TRUNC,
                        H5P_DEFAULT, H5P_DEFAULT);

5  dims[0] = 4;
6  dims[1] = 6;
7  dataspace_id = H5Screate_simple (2, dims, NULL);


8  dataset_id = H5Dcreate(file_id,"dset",H5T_STD_I32BE,
                          dataspace_id, H5P_DEFAULT);


9  status = H5Dclose (dataset_id);
10 status = H5Sclose (dataspace_id);
11 status = H5Fclose (file_id);
```

Example 2 – Create an empty 4x6 dataset

```
1  hid_t       file_id, dataset_id, dataspace_id;
2  hsize_t     dims[2];
3  herr_t      status;


4  file_id = H5Fcreate ("dset.h5", H5F_ACC_TRUNC,
                        H5P_DEFAULT, H5P_DEFAULT);
```

Create a dataspace

```
5  dims[0] = 4;
6  dims[1] = 6;
7  dataspace_id = H5Screate_simple (2, dims, NULL);


8  dataset_id = H5Dcreate(file_id,"dset",H5T_STD_I32BE,
                          dataspace_id, H5P_DEFAULT);


9  status = H5Dclose (dataset_id);
10 status = H5Sclose (dataspace_id);
11 status = H5Fclose (file_id);
```

Example 2 – Create an empty 4x6 dataset

```
1  hid_t       file_id, dataset_id, dataspace_id;
2  hsize_t     dims[2];
3  herr_t      status;


4  file_id = H5Fcreate ("dset.h5", H5F_ACC_TRUNC,
                        H5P_DEFAULT, H5P_DEFAULT);
```

Create a dataspace

```
5  dims[0] = 4;
6  dims[1] = 6;
7  dataspace_id = H5Screate_simple (2, dims, NULL);


8  dataset_id = H5Dcreate(file_id,"dset",H5T_STD_I32BE,
                          dataspace_id, H5P_DEFAULT);


9  status = H5Dclose (dataset_id);
10 status = H5Sclose (dataspace_id);
11 status = H5Fclose (file_id);
```

rank

current dims

Set maxdims to current dims

Example 2 – Create an empty 4x6 dataset

```
1  hid_t       file_id, dataset_id, dataspace_id;
2  hsize_t     dims[2];
3  herr_t      status;


4  file_id = H5Fcreate ("dset.h5", H5F_ACC_TRUNC,
                        H5P_DEFAULT, H5P_DEFAULT);

5  dims[0] = 4;
6  dims[1] = 6;
7  dataspace_id = H5Screate_simple (2, dims, NULL);
```

Create a dataset

```
8  dataset_id = H5Dcreate(file_id,"dset",H5T_STD_I32BE,
                          dataspace_id, H5P_DEFAULT);


9  status = H5Dclose (dataset_id);
10 status = H5Sclose (dataspace_id);
11 status = H5Fclose (file_id);
```

Example 2 – Create an empty 4x6 dataset

```
1  hid_t       file_id, dataset_id, dataspace_id;
2  hsize_t     dims[2];
3  herr_t      status;


4  file_id = H5Fcreate ("dset.h5", H5F_ACC_TRUNC,
                        H5P_DEFAULT, H5P_DEFAULT);

5  dims[0] = 4;
6  dims[1] = 6;
7  dataspace_id = H5Screate_simple (2, dims, NULL);
   Create a dataset
8  dataset_id = H5Dcreate(file_id,"dset",H5T_STD_I32BE,
                          dataspace_id, H5P_DEFAULT);
9  status = H5Dclose (dataset_id);
10 status = H5Sclose (dataspace_id);
11 status = H5Fclose (file_id);
```

Pathname

Datatype

Dataspace

Property list (default)

Example 2 – Create an empty 4x6 dataset

```
1  hid_t       file_id, dataset_id, dataspace_id;
2  hsize_t     dims[2];
3  herr_t      status;


4  file_id = H5Fcreate ("dset.h5", H5F_ACC_TRUNC,
                        H5P_DEFAULT, H5P_DEFAULT);

5  dims[0] = 4;
6  dims[1] = 6;
7  dataspace_id = H5Screate_simple (2, dims, NULL);


8  dataset_id = H5Dcreate(file_id,"dset",H5T_STD_I32BE,
                          dataspace_id, H5P_DEFAULT);
```

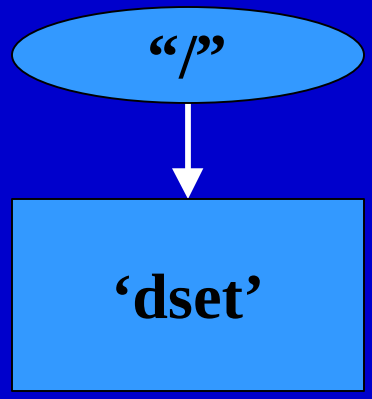
Terminate access to dataset, dataspace, & file

```
9  status = H5Dclose (dataset_id);
10 status = H5Sclose (dataspace_id);
11 status = H5Fclose (file_id);
```

Example2: h5dump Output

An empty 4x6 dataset

```
HDF5 "dset.h5" {
GROUP "/" {
      DATASET "dset" {
            DATATYPE { H5T_STD_I32BE }
            DATASPACE { SIMPLE ( 4, 6 ) / ( 4, 6 ) }
            DATA {
                        0, 0, 0, 0, 0, 0,
                        0, 0, 0, 0, 0, 0,
                        0, 0, 0, 0, 0, 0,
                        0, 0, 0, 0, 0, 0
            }
      }
 }
 }
```



Writing and Reading Datasets

Dataset I/O

- **Dataset I/O involves**
  - reading or writing
  - all or part of a dataset
  - Compressed/uncompressed
- **During I/O operations data is translated between the source & destination (file-memory, memory-file)**
  - Datatype conversion
    - data types (e.g. 16-bit integer => 32-bit integer) of the same class
  - Dataspace conversion
    - dataspace (e.g. 10x20 2d array => 200 1d array)

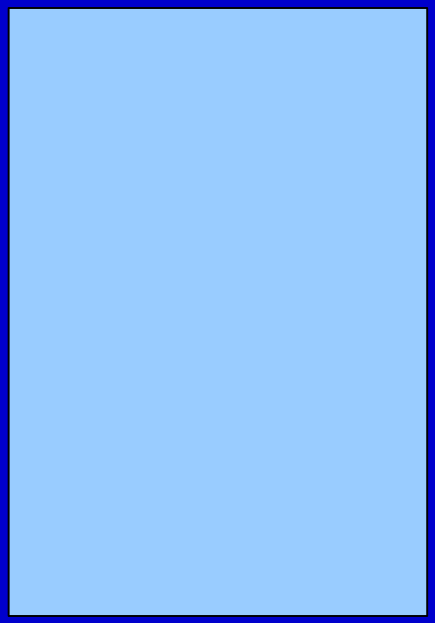
Partial I/O

- Selected elements (called selections) from source are mapped (read/written) to the selected elements in destination
- Selection
  - Selections in memory can differ from selection in file
  - Number of selected elements is always the same in source and destination
- Selection can be
  - Hyperslabs (contiguous blocks, regularly spaced blocks)
  - Points
  - Results of set operations (union, difference, etc.) on hyperslabs or points

Reading Dataset into Memory from File

File

2D array of 16-bit ints



Memory

3D array of 32-bit ints

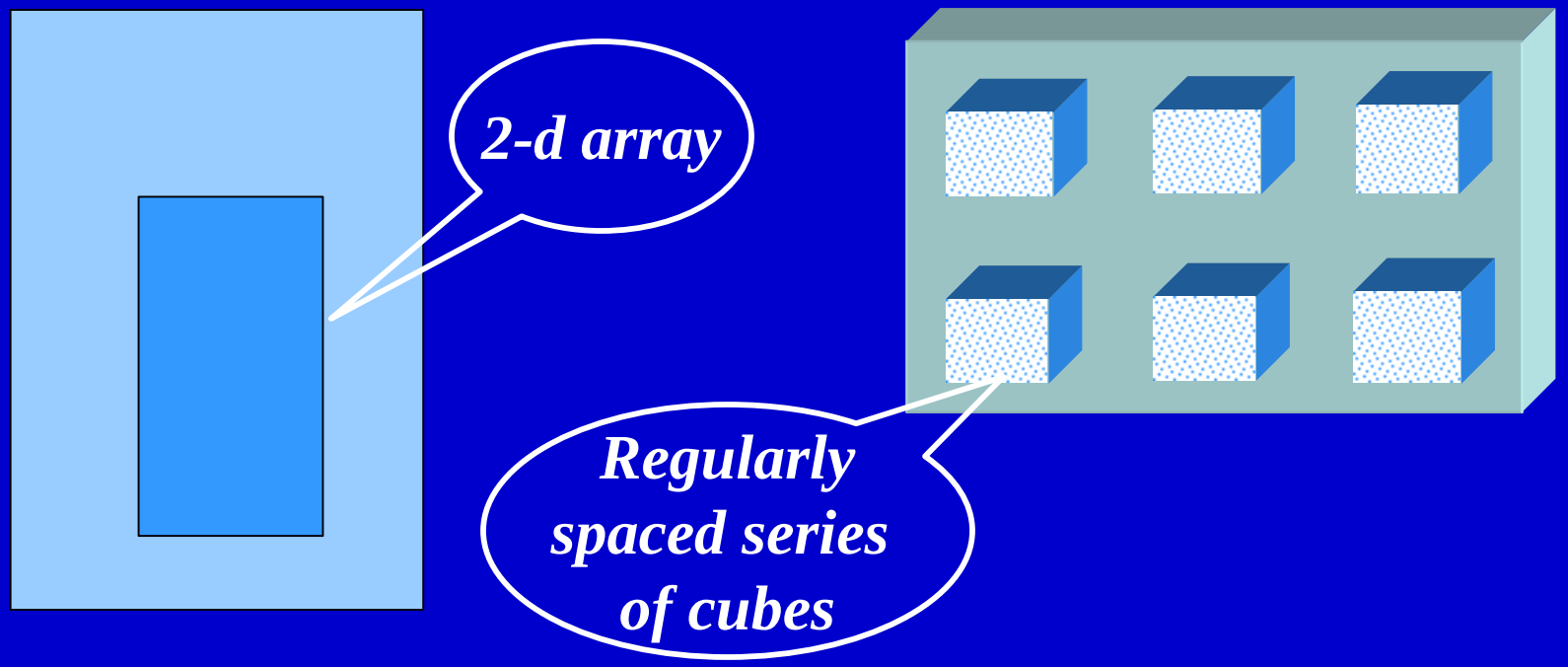
Reading Dataset into Memory from File

File

2D array of 16-bit ints

Memory

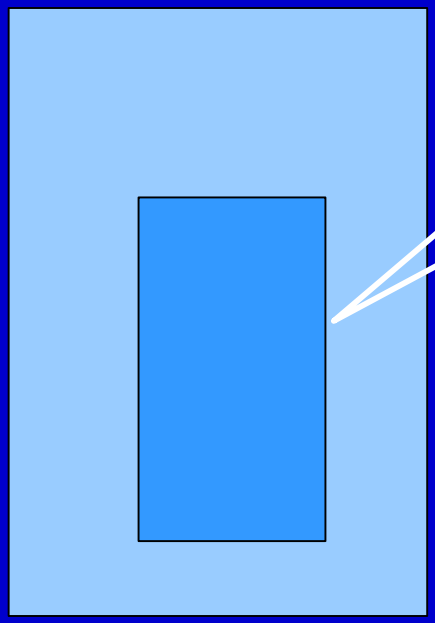
3D array of 32-bit ints



Reading Dataset into Memory from File

File

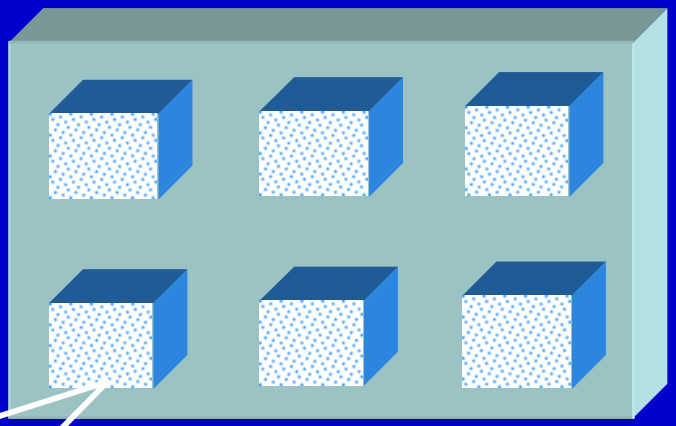
2D array of 16-bit ints



2-d array

Memory

3D array of 32-bit ints



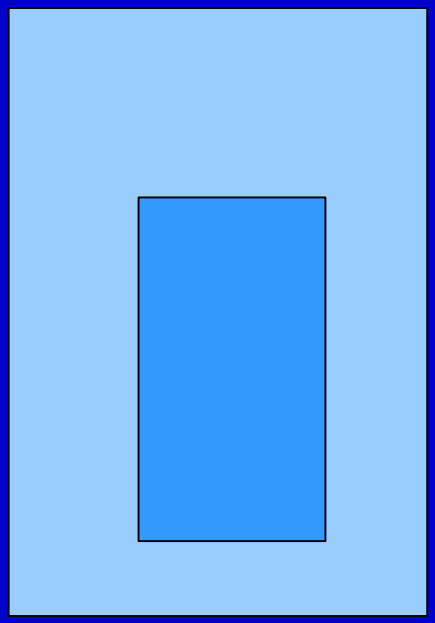
Regularly spaced series of cubes

The only restriction is that the number of selected elements on the left be the same as on the right.

Reading Dataset into Memory from File

File

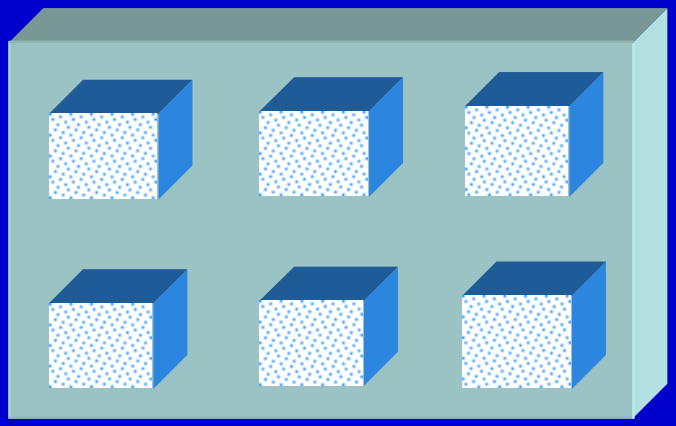
2D array of 16-bit ints



Read

Memory

3D array of 32-bit ints



Steps for Dataset Writing/Reading

- If necessary, open the file to obtain the file ID
- Open the dataset to obtain the dataset ID
- Specify
  - Memory datatype
  - ! *Library "knows" file datatype – do not need to specify* !
  - Memory dataspace
  - File dataspace
  - Transfer properties (optional)
- Perform the desired operation on the dataset
- Close dataspace, datatype and property lists

Data Transfer Property List

The data transfer property list is used to control various aspects of the I/O, such as caching hints or collective I/O information.

hid_t H5Dopen (hid_t loc_id, const char *name)

loc_id	**IN**:	Identifier of the file or group in which to open a dataset
name	**IN**:	The name of the dataset to access

NOTE: File datatype and dataspace are known when a dataset is opened

herr_t H5Dwrite (hid_t dataset_id, hid_t mem_type_id,
hid_t mem_space_id, hid_t file_space_id,
hid_t xfer_plist_id, const void * buf)

dataset_id	**IN:** Identifier of the dataset to write to
mem_type_id	**IN:** Identifier of memory datatype of the dataset
mem_space_id	**IN:** Identifier of the memory dataspace (or H5S_ALL)
file_space_id	**IN:** Identifier of the file dataspace (or H5S_ALL)
xfer_plist_id	**IN:** Identifier of the data transfer properties to use (or H5P_DEFAULT)
buf	**IN:** Buffer with data to be written to the file

Example 3 – Writing to an existing dataset

```
1  hid_t       file_id, dataset_id;
2  herr_t      status;
3  int         i, j, dset_data[4][6];


4  for (i = 0; i < 4; i++)
5    for (j = 0; j < 6; j++)
6      dset_data[i][j] = i * 6 + j + 1;


7  file_id = H5Fopen ("dset.h5", H5F_ACC_RDWR, H5P_DEFAULT);
8  dataset_id = H5Dopen (file_id, "dset");


9  status = H5Dwrite (dataset_id, H5T_NATIVE_INT,
                      H5S_ALL, H5S_ALL, H5P_DEFAULT, dset_data);
```

Example 3 – Writing to an existing dataset

```
1  hid_t       file_id, dataset_id;
2  herr_t      status;
3  int         i, j, dset_data[4][6];
```

Initialize buffer

```
4  for (i = 0; i < 4; i++)
5    for (j = 0; j < 6; j++)
6      dset_data[i][j] = i * 6 + j + 1;


7  file_id = H5Fopen ("dset.h5", H5F_ACC_RDWR, H5P_DEFAULT);
8  dataset_id = H5Dopen (file_id, "dset");


9  status = H5Dwrite (dataset_id, H5T_NATIVE_INT,
                      H5S_ALL, H5S_ALL, H5P_DEFAULT, dset_data);
```

Example 3 – Writing to an existing dataset

```
1  hid_t       file_id, dataset_id;
2  herr_t      status;
3  int         i, j, dset_data[4][6];


4  for (i = 0; i < 4; i++)
5    for (j = 0; j < 6; j++)
6      dset_data[i][j] = i * 6 + j + 1;
```

Open existing file and dataset

```
7  file_id = H5Fopen ("dset.h5", H5F_ACC_RDWR, H5P_DEFAULT);
8  dataset_id = H5Dopen (file_id, "dset");


9  status = H5Dwrite (dataset_id, H5T_NATIVE_INT,
              H5S_ALL, H5S_ALL, H5P_DEFAULT, dset_data);
```

Example 3 – Writing to an existing dataset

```
1  hid_t       file_id, dataset_id;
2  herr_t      status;
3  int         i, j, dset_data[4][6];


4  for (i = 0; i < 4; i++)
5    for (j = 0; j < 6; j++)
6      dset_data[i][j] = i * 6 + j + 1;


7  file_id = H5Fopen ("dset.h5", H5F_ACC_RDWR, H5P_DEFAULT);
8  dataset_id = H5Dopen (file_id, "dset");
```

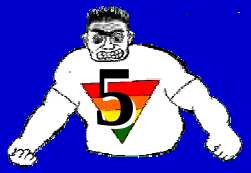
Write to dataset

```
9  status = H5Dwrite (dataset_id, H5T_NATIVE_INT,
                      H5S_ALL, H5S_ALL, H5P_DEFAULT, dset_data);
```

Example 3: h5dump Output

```
HDF5 "dset.h5" {
GROUP "/" {
   DATASET "dset" {
      DATATYPE { H5T_STD_I32BE }
      DATASPACE { SIMPLE ( 4, 6 ) / ( 4, 6 ) }
      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
      }
   }
}
}
```

For more information…



- HDF website
  - http://hdf.ncsa.uiuc.edu/

- HDF Helpdesk
  - hdfhelp@ncsa.uiuc.edu

- HDF users mailing list
  - hdfnews@ncsa.uiuc.edu

Thank you