Using the Direct Chunk Write Function

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# Using the Direct Chunk Write Function

When a user application has a chunked dataset and is trying to write a single chunk of data with H5Dwrite, the data goes through several steps inside the HDF5 library. The library first examines the hyperslab selection. Then it converts the data from the datatype in memory to the datatype in the file if they are different. Finally, the library processes the data in the filter pipeline. Starting with the 1.8.11 release, a new high-level C function called H5DOwrite\_chunk becomes available. It writes a data chunk directly to the file bypassing the library’s hyperslab selection, data conversion, and filter pipeline processes. In other words, if an application can pre-process the data, then the application can use H5DOwrite\_chunk to write the data much faster.

H5DOwrite\_chunk was developed in response to a client request. The client builds X-ray pixel detectors for use at synchrotron light sources. These detectors can produce data at the rate of tens of gigabytes per second. Before transferring the data over their network, the detectors compress the data by a factor of 10 or more. The modular architecture of the detectors can scale up its data stream in parallel and maps well to current parallel computing and storage systems.

## Using the H5DOwrite\_chunk Function

Basically, the H5DOwrite\_chunk function takes a pre-processed data chunk (buf) and its size (data\_size) and writes to the chunk location (offset) in the dataset (dset\_id).

The function prototype is shown below:

*herr\_t* H5DOwrite\_chunk(

*hid\_t* dset\_id, /\*the dataset \*/

*hid\_t* dxpl\_id, /\*data transfer property list \*/

*uint32\_t* filter\_mask, /\*indicates which filters are used \*/

*hsize\_t* \* offset, /\*position of the chunk \*/

*size\_t* data\_size, /\*size of the actual data \*/

*const void* \* buf /\*buffer with data to be written \*/

)

Below is a simple example showing how to use the function:

|  |
| --- |
| hsize\_t offset[2] = {4, 4};  uint32\_t filter\_mask = 0;  size\_t nbytes = 40;  if(H5DOwrite\_chunk(dset\_id, dxpl, filter\_mask,  offset, nbytes, data\_buf) < 0)  goto error; |
| Example 1. Using H5DOwrite\_chunk |

In the example above, the dataset is 8x8 elements of int. Each chunk is 4x4. The offset of the first element of the chunk to be written is 4 and 4. In the diagram below, the shaded chunk is the data to be written. The function is writing a pre-compressed data chunk of 40 bytes (assumed) to the dataset. The zero value of the filter mask means that all filters have been applied to the pre-processed data.

|  |
| --- |
|  |
| Figure 1. Illustration of the chunk to be written in the example code above |

The complete code example at the end of this topic shows how to set the value of the filter mask to indicate a filter being skipped. The corresponding bit in the filter mask is turned on when a filter is skipped. For example, if the second filter is skipped, the second bit of the filter mask should be turned on. For more information, see the H5DOwrite\_chunk entry in the *HDF5 Reference Manual*.

## The Design

The following diagram shows how the function H5DOwrite\_chunk bypasses hyperslab selection, data conversion, and filter pipeline inside the HDF5 library.

|  |
| --- |
|  |
| Figure 2. Diagram for H5DOwrite\_chunk in the HDF5 Library |

## Performance

The table below describes the results of performance benchmark tests run by HDF developers. It shows that using the new function H5DOwrite\_chunk to write pre-compressed data is much faster than using the H5Dwrite function to compress and write the same data with the filter pipeline. Measurements involving H5Dwrite include compression time in the filter pipeline. Since the data is already compressed before H5DOwrite\_chunk is called, use of H5DOwrite\_chunk to write compressed data avoids the performance bottleneck in the HDF5 filter pipeline.

The test was run on a Linux 2.6.18 / 64-bit Intel x86\_64 machine. The dataset contained 100 chunks. Only one chunk was written to the file per write call. The number of writes was 100. The time measurement was for the entire dataset with the Unix system function gettimeofday. Writing the entire dataset with one write call took almost the same amount of time as writing chunk by chunk. In order to force the system to flush the data to the file, the O\_SYNC flag was used to open the file.

| Table 1. Performance result for H5DOwrite\_chunk in the high-level library | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Dataset size (MB)  Size after compression (MB)  Dataset dimensionality  Chunk dimensionality  Datatype | 95.37  64.14  100x1000x250  1000x250  4-byte integer | | 762.94  512.94  100x2000x1000  2000x1000  4-byte integer | | 2288.82  1538.81  100x2000x3000  2000x3000  4-byte integer | |
|  | speed1 | time2 | speed | time | speed | time |
| H5Dwrite writes without compression filter | 77.27 | 1.23 | 97.02 | 7.86 | 91.77 | 24.94 |
| H5DOwrite\_chunk writes uncompressed data | 79 | 1.21 | 95.71 | 7.97 | 89.17 | 25.67 |
| **H5Dwrite writes with compression filter** | **2.68** | **35.59** | **2.67** | **285.75** | **2.67** | **857.24** |
| **H5DOwrite\_chunk writes compressed data** | **77.19** | **0.83** | **78.56** | **6.53** | **96.28** | **15.98** |
| Unix writes compressed data to Unix file | 76.49 | 0.84 | 95 | 5.4 | 98.59 | 15.61 |

1 IO speed is in MB/s.

2 Time is in second (s).

## A Word of Caution

Since H5DOwrite\_chunk writes data chunks directly in a file, developers must be careful when using it. The function bypasses hyperslab selection, the conversion of data from one datatype to another, and the filter pipeline to write the chunk. Developers should have experience with these processes before they use this function.

## A Complete Code Example

The following is an example of using H5DOwrite\_chunk to write an entire dataset by chunk.

|  |
| --- |
| #include <zlib.h>  #include <math.h>  #define DEFLATE\_SIZE\_ADJUST(s) (ceil(((double)(s))\*1.001)+12)  :  size\_t buf\_size = CHUNK\_NX\*CHUNK\_NY\*sizeof(int);  const Bytef \*z\_src = (const Bytef\*)(direct\_buf);  Bytef \*z\_dst; /\*destination buffer \*/  uLongf z\_dst\_nbytes = (uLongf)DEFLATE\_SIZE\_ADJUST(buf\_size);  uLong z\_src\_nbytes = (uLong)buf\_size;  int aggression = 9; /\* Compression aggression setting \*/  uint32\_t filter\_mask = 0;  size\_t buf\_size = CHUNK\_NX\*CHUNK\_NY\*sizeof(int);  /\* Create the data space \*/  if((dataspace = H5Screate\_simple(RANK, dims, maxdims)) < 0)  goto error;    /\* Create a new file \*/  if((file = H5Fcreate(FILE\_NAME5, H5F\_ACC\_TRUNC, H5P\_DEFAULT,  H5P\_DEFAULT)) < 0)  goto error;    /\* Modify dataset creation properties, i.e. enable chunking  and compression \*/  if((cparms = H5Pcreate(H5P\_DATASET\_CREATE)) < 0)  goto error;    if((status = H5Pset\_chunk( cparms, RANK, chunk\_dims)) < 0)  goto error;    if((status = H5Pset\_deflate( cparms, aggression)) < 0)  goto error;    /\* Create a new dataset within the file using cparms creation  properties \*/  if((dset\_id = H5Dcreate2(file, DATASETNAME, H5T\_NATIVE\_INT, dataspace,  H5P\_DEFAULT,cparms, H5P\_DEFAULT)) < 0)  goto error;  /\* Initialize data for one chunk \*/  for(i = n = 0; i < CHUNK\_NX; i++)  for(j = 0; j < CHUNK\_NY; j++)  direct\_buf[i][j] = n++;  /\* Allocate output (compressed) buffer \*/  outbuf = malloc(z\_dst\_nbytes);  z\_dst = (Bytef \*)outbuf;  /\* Perform compression from the source to the destination buffer \*/  ret = compress2(z\_dst, &z\_dst\_nbytes, z\_src, z\_src\_nbytes, aggression);  /\* Check for various zlib errors \*/  if(Z\_BUF\_ERROR == ret) {  fprintf(stderr, "overflow");  goto error;  } else if(Z\_MEM\_ERROR == ret) {  fprintf(stderr, "deflate memory error");  goto error;  } else if(Z\_OK != ret) {  fprintf(stderr, "other deflate error");  goto error;  }  /\* Write the compressed chunk data repeatedly to cover all the chunks in  \* the dataset, using the direct write function. \*/  for(i=0; i<NX/CHUNK\_NX; i++) {  for(j=0; j<NY/CHUNK\_NY; j++) {  status = H5DOwrite\_chunk(dset\_id, H5P\_DEFAULT,  filter\_mask, offset, z\_dst\_nbytes, outbuf);  offset[1] += CHUNK\_NY;  }  offset[0] += CHUNK\_NX;  offset[1] = 0;  }  /\* Overwrite the first chunk with uncompressed data. Set the filter  \* mask to indicate the compression filter is skipped \*/  filter\_mask = 0x00000001;  offset[0] = offset[1] = 0;  if(H5DOwrite\_chunk(dset\_id, H5P\_DEFAULT, filter\_mask, offset, buf\_size,  direct\_buf) < 0)  goto error;  /\* Read the entire dataset back for data verification converting ints  \* to longs\*/  if(H5Dread(dataset, H5T\_NATIVE\_LONG, H5S\_ALL, H5S\_ALL, H5P\_DEFAULT,  outbuf\_long) < 0)  goto error;  /\* Data verification here \*/  :  : |
| Example 2. A complete code example for H5DOwrite chunk |