A High performance I/O Module: the HDF5 WRF I/O module

Muqun Yang, Robert E. McGrath, Mike Folk
National Center for Supercomputing Applications
University of Illinois, Urbana-Champaign

Part of NSF-funded Alliance MEAD Expedition project

- The MEAD expedition will develop and adapt a cyberinfrastructure that will enable simulation, data mining, and visualization of atmospheric phenomena

Goals

- Provide a new IO module for WRF
- Evaluate the IO performance of parallel HDF5 with real scientific application

What is HDF?

- Format and software for scientific data
- Stores images, multidimensional arrays, tables, etc.
- Emphasis on storage and high performance I/O
- Free and commercial software support
- Emphasis on standards
- Users from many engineering and scientific fields

HDF4 vs HDF5

- HDF4 - Based on original 1988 version of HDF
  - Backwardly compatible with all earlier versions
  - 6 basic objects
    - raster image, multidimensional array (SDS), palette, group (Vgroup), table (Vdata), annotation
- HDF5
  - New format & library - not compatible with HDF4
  - 2 basic objects

HDF supporters and users

- NASA Earth Science Data & Info System
  - Migrate from HDF4 to HDF5
  - HDF-EOS library on HDF5
  - Aura and NPOESS will use HDF5

- DOE Advanced Simulation Computing(ASC)
  - Open standard exchange format and high performance I/O library
  - DOE tri-lab ASC applications
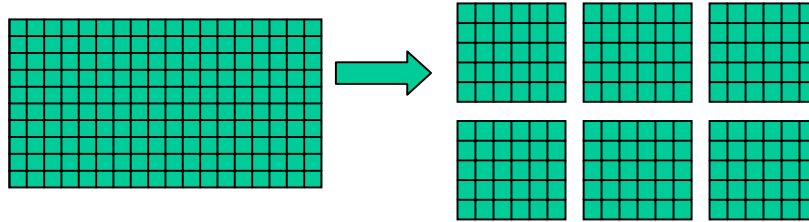
- And many other scientific applications

Check URL at http://hdf.ncsa.uiuc.edu/users5.html

HDF5 Features

- Dataset larger than 2 Giga-Byte
- Any number of Objects per file
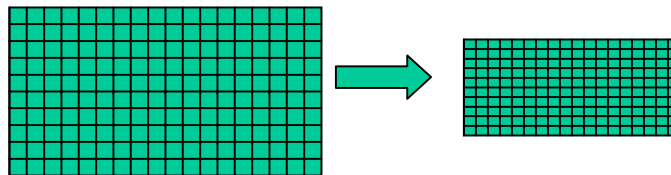- Alternative storage layout
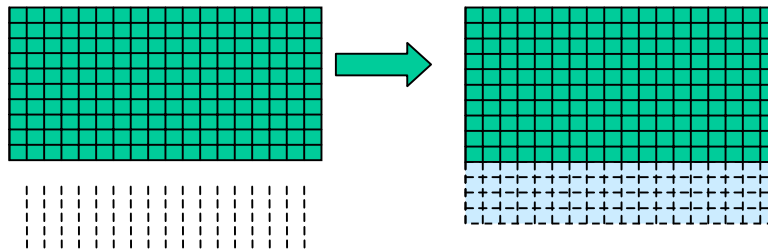- Parallel IO (MPI-IO)

Special Storage Options

chunked

Better subsetting
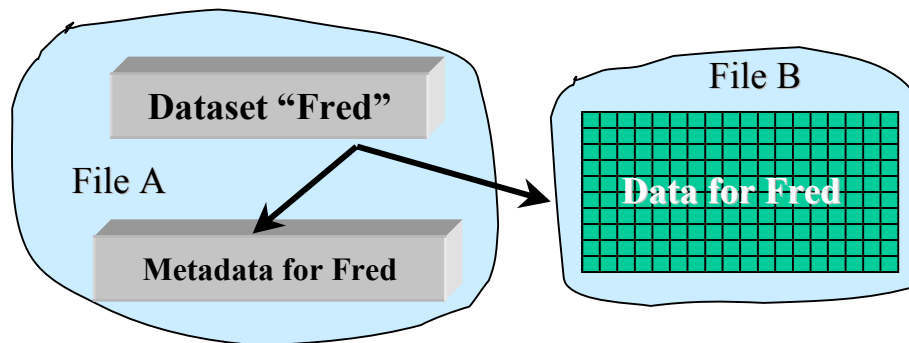Access time;
extendable

compressed

Improves storage efficiency,
Transmission speed
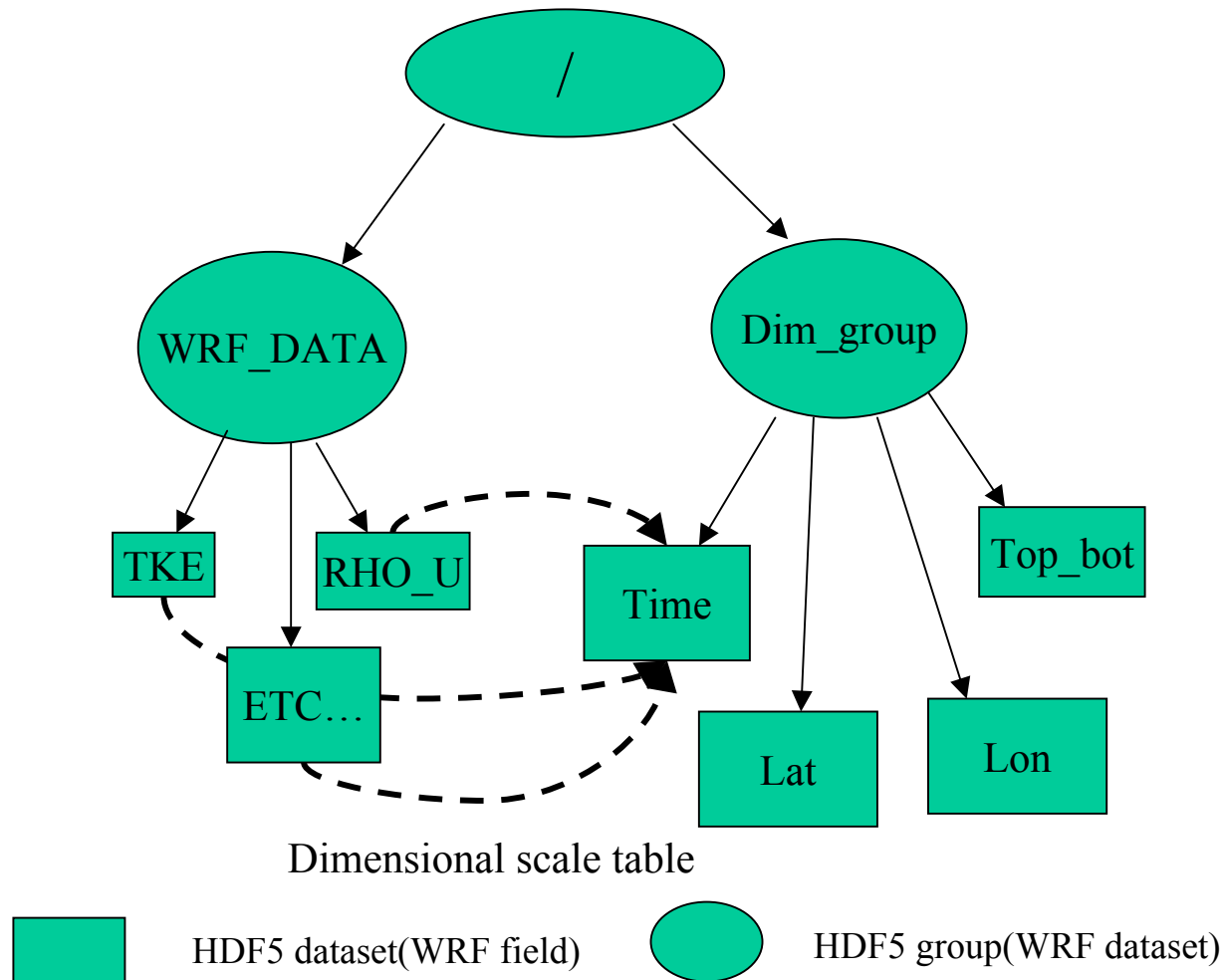
extendable

Arrays can be extended
in any direction

Split file

Dataset "Fred"

File A

Metadata for Fred

File B

Data for Fred

Metadata in one file,
raw data in another

Now WRF-HDF5 module work

Schematic HDF5 File Structure of WRF Output

Dimensional scale table

HDF5 dataset(WRF field)   HDF5 group(WRF dataset)

Solid line: HDF5 datasets or sub-groups (the arrow points to) that are members of the HDF5 parent group.
Dash line: the association of one HDF5 object to another HDF5 object;in terms of HDF5, object reference.

Facts about WRF-HDF5 module

Follow WRF Standard

- Standard WRF Configuration (Similar as NetCDF)
- Use WRF common APIs
- Application can select an IO module

A complete WRF-HDF5 sequential module

- Have both reader and writer
- Has been tested on NCSA Linux cluster, PC linux, NCAR IBM SP(blackforest), NCSA IBM P690
- Available for friendly users

Parallel HDF5 module

- Another WRF-IO module
- Read and write the same HDF5 file as the sequential module
- Use parallel IO

We are in the process of developing Parallel HDF5 module now!

Future work

As part of MEAD, WRF and the Regional Ocean Modeling System (ROMS)
are being coupled and
HDF5 I/O is being implemented in both models.

http://hdf.ncsa.uiuc.edu/apps/WRF-ROMS/
Email: ymuqun@ncsa.uiuc.edu

Acknowledgements:

Some facts related to WRF-HDF5 module

			WRF-HDF5 module
Sequential Computing	Sequential IO	Sequential HDF5
Parallel Computing	Sequential IO	Sequential HDF5
Parallel Computing	Parallel IO	Parallel HDF5