Silo/HDF5 Modifications for Dawn

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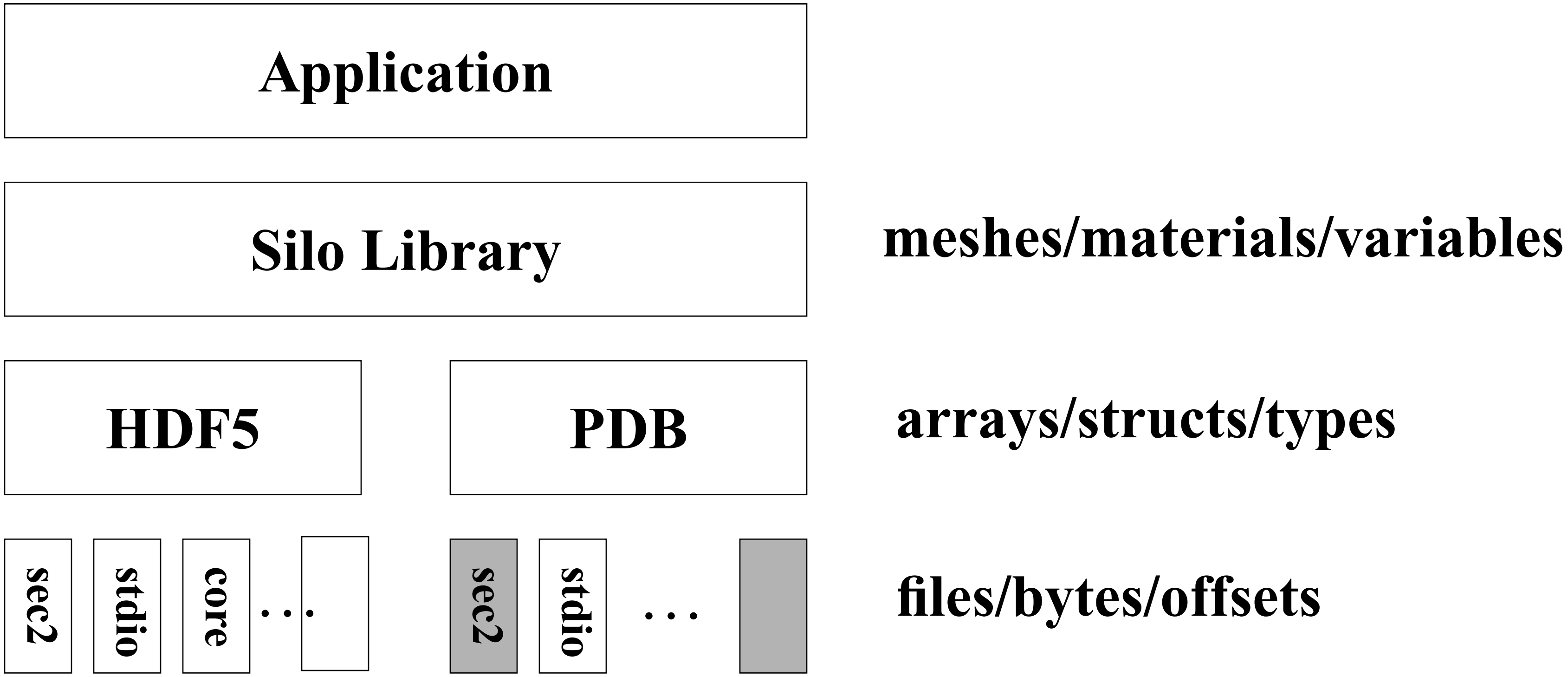
Silo Background



Application

Silo Library

HDF5

PDB

sec2

stdio

core

. . .

sec2

stdio

. . .

meshes/materials/variables

arrays/structs/types

files/bytes/offsets

Benefits (= flexibility)

- *platform independent, self-describing, archiveable data*
- *random access (more true of post-processors than simulation codes)*

Drawbacks (= performance degradation)

- *metadata (data a lib writes on behalf of its caller)*
- *caller is far removed from actual disk I/O behavior/control*

Poor Man’s Parallel I/O

Concurrent, parallel writes work ONLY FOR simple I/O patterns

- *Size, shape, distribution of data across MPI tasks is ‘simple’ to describe*
- *The global monolithic “whole” object is decomposed on read, re-composed on write*
- *Example: 1D table of particle types, positions, velocities ==> good candidate*

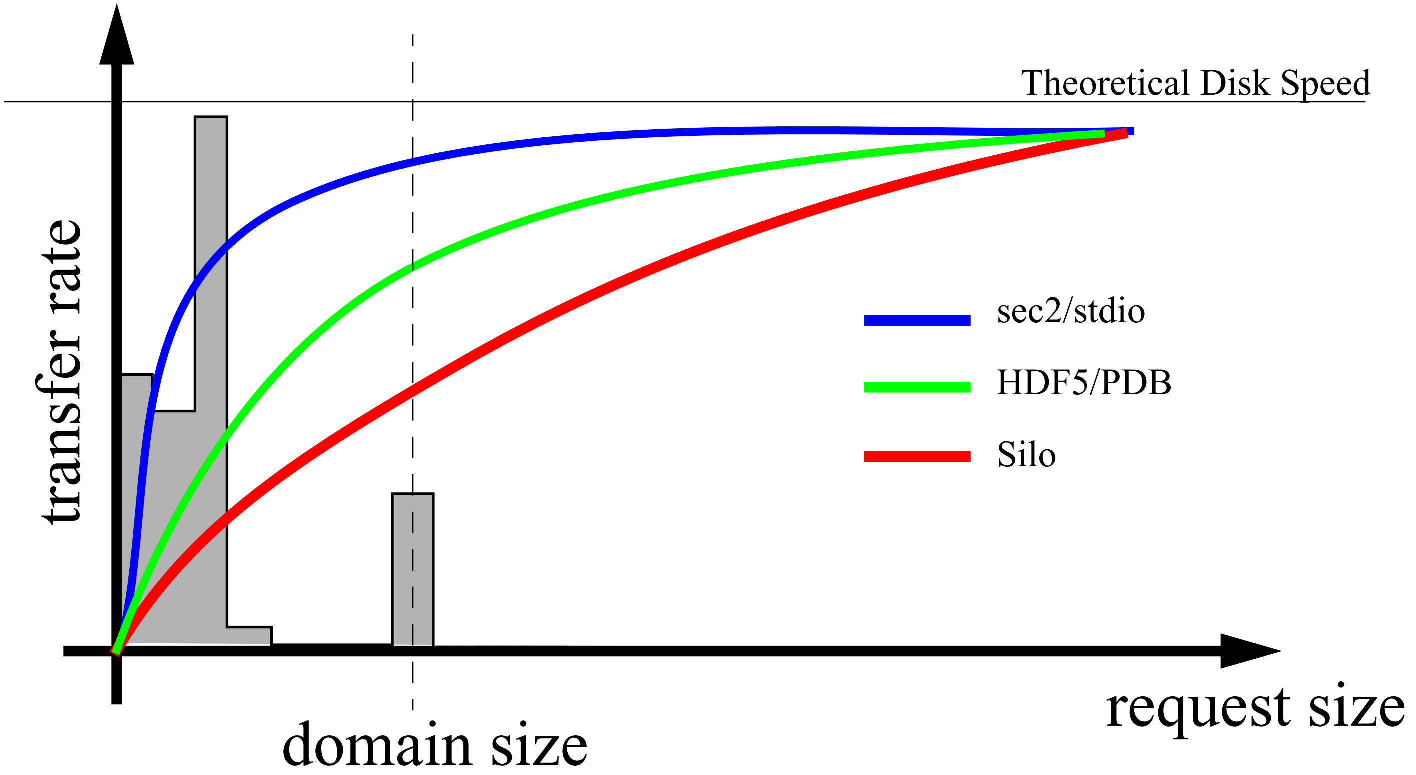
Large, multi-physics simulations are more complex

- *size, shape, distribution and existence of data from task to task varies significantly*
- *All tasks have piece of (main) mesh...*
- *but some tasks have only some variables, materials, particles, tracers, time histories*

Solution: Poor Man’s Parallel I/O

- *Decompose into N GROUPS -- N totally independent of MPI_Comm_size()*
- *Only one MPI-task in each group has write access at any one time*
- *Serial I/O to multiple files, simultaneously*
- *Very flexible with what each MPI-task needs to do in the way of I/O*
- *Do not pay cost of “decomposing on read” and “recomposing on write”*
- *When N==1, get completely serial I/O (doesn’t scale too well!!!)*
- *When N==MPI_Comm_size() (Ares), get a file per MPI-task*
- *Ale3d typically chooses N==# I/O channels*
- *Note: Looking up from Lustre, you can’t tell the difference between this and MPI-IO*

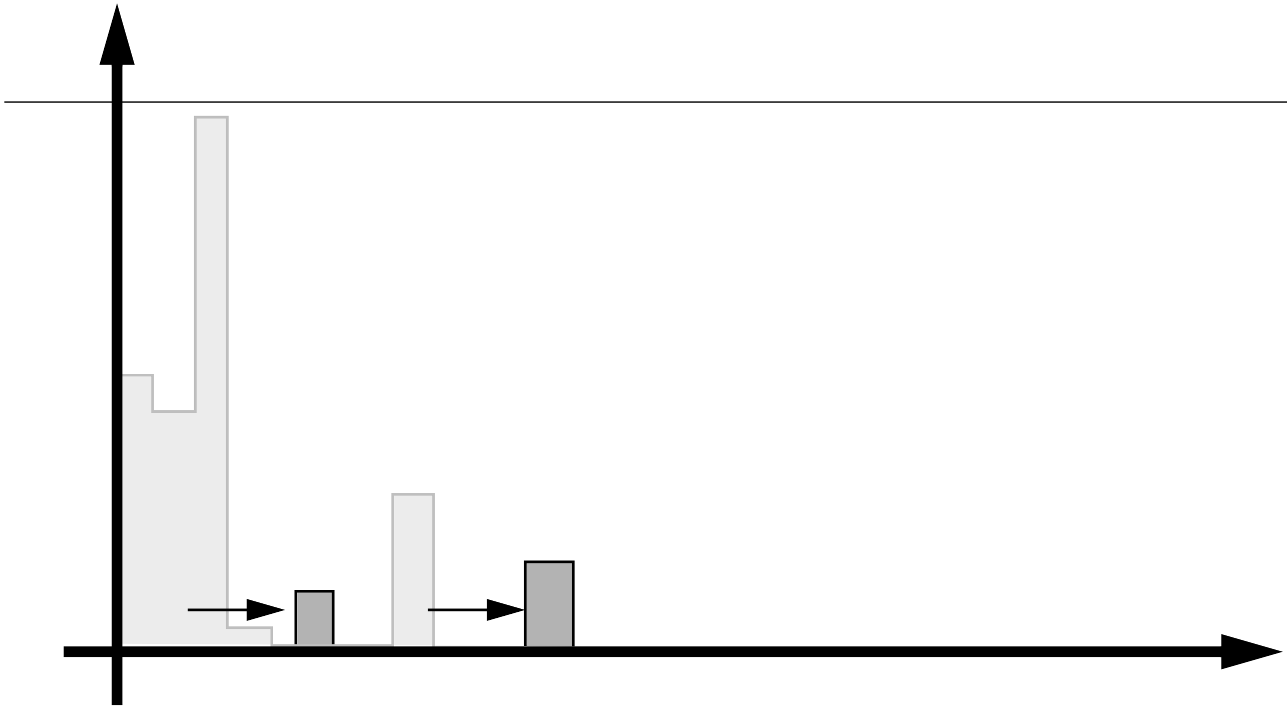
I/O Performance



Histogram

```
               writes          bytes           %writes         cum.%writes      %bytes
<10^1 bytes:    48              217             20.1680         20.1680         .0001
<10^2 bytes:    41              1485            17.2268         37.3949         .0009
<10^3 bytes:    116             22474           48.7394         86.1344         .0136
<10^4 bytes:    8               30540           3.3613          89.4957         .0186
<10^5 bytes:    0               0               0               89.4957         0
<10^6 bytes:    3               1092492         1.2605          90.7563          .6655
<10^7 bytes:    22              162989412       9.2436          100.0000      99.3010
```

Strategies for Improving Performance?



Aggregation

- *Gather many smaller requests into fewer larger ones*
- *Need memory (buffer) to do this.*
- *Try aggregating as much as possible WITHIN one MPI-task first.*
- *Failing that, start aggregating ACROSS MPI-tasks.*

Simplest Aggregation Strategy: Ram Disk

HDF5's "Core" Virtual File Driver (VFD):

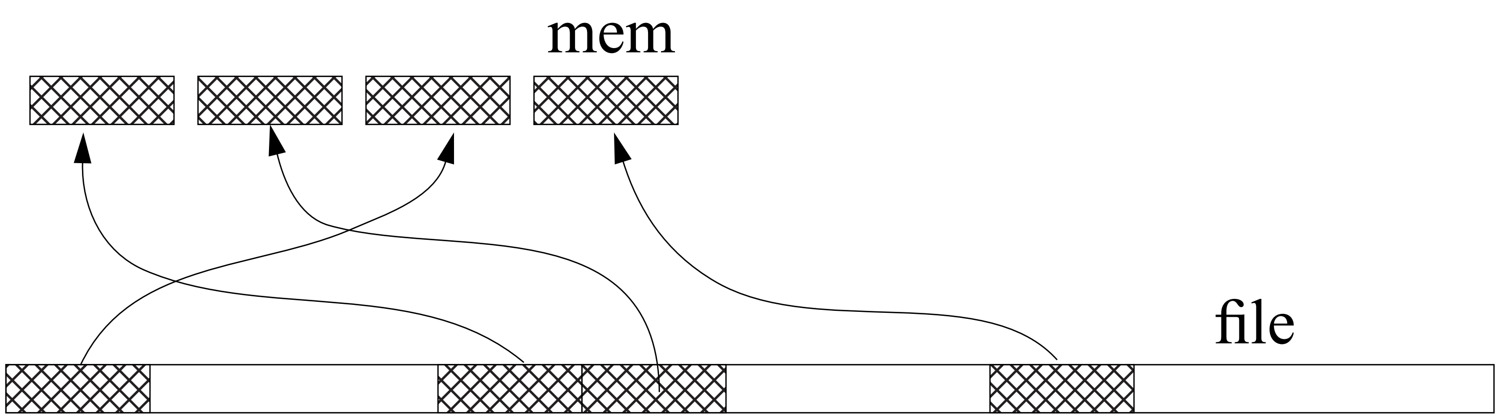
- *Stores everything to a growing buffer in memory.*
- *Writes buffer to file on close.*
- *Reads ENTIRE file to memory buffer on open.*
- *Represents upper-bound of what is possible at expense of (a lot) of memory.*
- *Only works if when code does I/O, it is dumping less than 50% of available memory.*
- *Not a good long term solution*

HDF5's "Split" VFD:

- *Splits data into two classes; raw and meta, writing each to its own file.*
- *Keep all metadata in memory using core vfd*
- *Write raw data using sec2 vfd.*
- *This results in good performance too.*
- *But, you wind up with two files for every one "file" that application creates.*

New HDF5 Virtual File Driver for Silo

Breaks file's address space into blocks



Does I/O only in blocks

- *Allocates enough memory to keep N blocks in memory*

Two Parameters set by code

- *SILO_BLOCK_SIZE*
- *SILO_BLOCK_COUNT*

Good Values for Dawn

- *SILO_BLOCK_SIZE = (1<<20)*
- *SILO_BLOCK_COUNT=16 (16 Megabytes total)*

Other VFDs We May Write

Aggregate blocks across MPI-tasks

- *Wind up with a SINGLE file at the bottom even though application thought it was writing many.*
- *But the file will still be a valid, HDF5 file*

Remote-Core VFD

- *Use extra MPI-tasks just for I/O*
- *Code "writes" to memory in these extra MPI tasks just like core VFD does now.*
- *Code goes back to compute while data drains to files from the extra MPI-tasks*
- *This could be fastest as code would NOT have to wait for I/O to complete before returning to compute.*

Smart-Split VFD:

- *Only one file is produced*
- *Raw data is block buffered as in new Silo VFD*
- *Metadata is kept in memory until file close, then tacked onto end of file.*