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View-based collective I/O for MPI-IO

View-based I/O

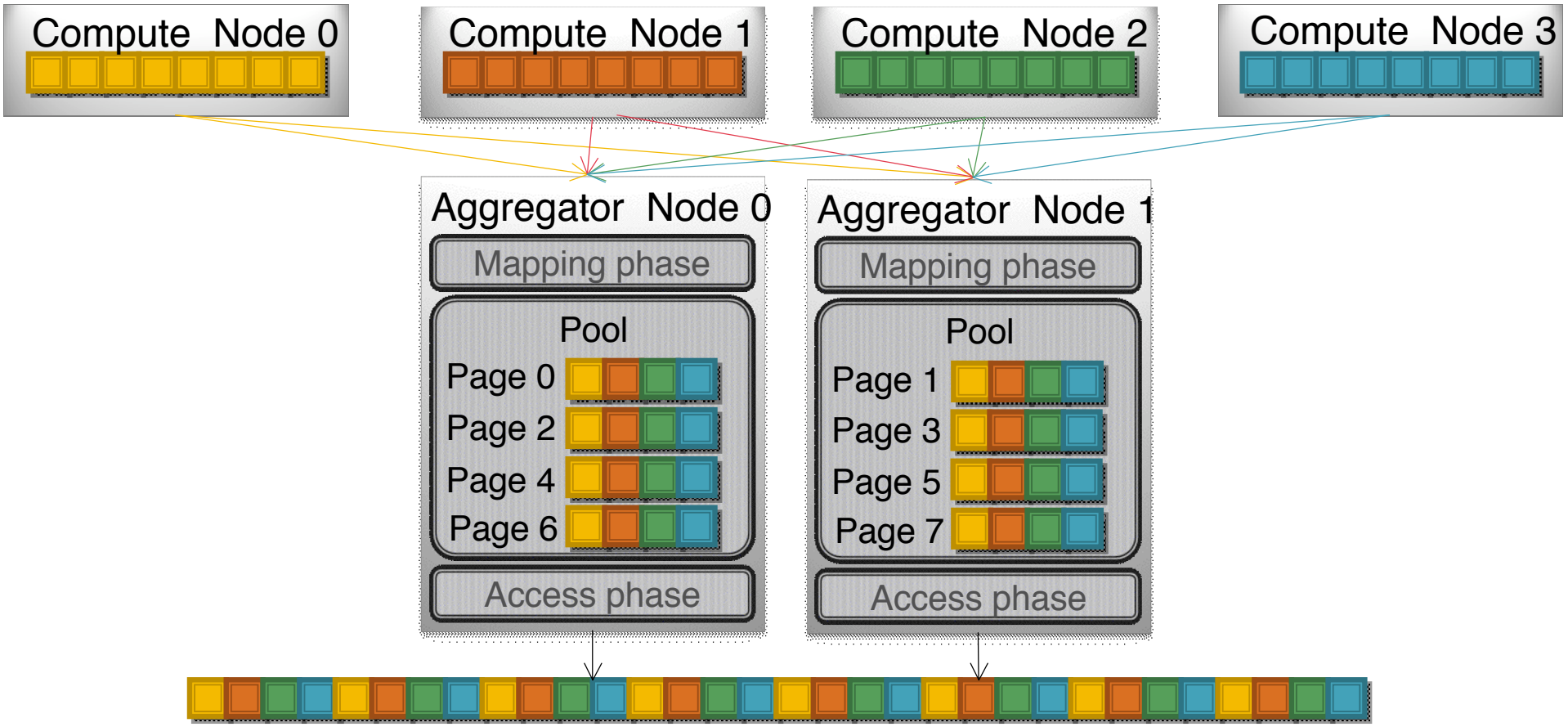
- We propose and evaluate an alternative to the two-phase collective I/O (TP I/O) implementation of ROMIO called view-based collective I/O (VB I/O).

- View based I/O targets the following goals:
  - **Reducing** the cost of data scatter-gather operations,
  - **Minimizing** the overhead of file metadata transfer,
  - **Decreasing** the number of conservative collective communication and synchronization operations.

View-based I/O

- Differences between two-phase I/O and view-based I/O :
  - At view declaration, **VB I/O** sends the view data type to aggregators, while **TP I/O** stores it locally at the application nodes.
  - **VB I/O** assigns statically the file domain to aggregators, while TP I/O dynamically.
  - At access time, **TP I/O** sends the offset-lists to the aggregators, while **view I/O** transfers only the view access interval extremities.
  - The collective buffers of **VB I/O** are cached across collective operations. A collective read following a write, may find the data already at the aggregator.
  - The collective buffers of **VB I/O** are written to the file system when the collective buffer pool is full or when the file is closed. For **TP I/O**, the collective buffers are flushed to the file system when they are full or at the end of each write operation.

Overview


Compute Node 0
Compute Node 1
Compute Node 2
Compute Node 3
Aggregator Node 0
Mapping phase
Pool
Page 0
Page 2
Page 4
Page 6
Access phase
Aggregator Node 1
Mapping phase
Pool
Page 1
Page 3
Page 5
Page 7
Access phase

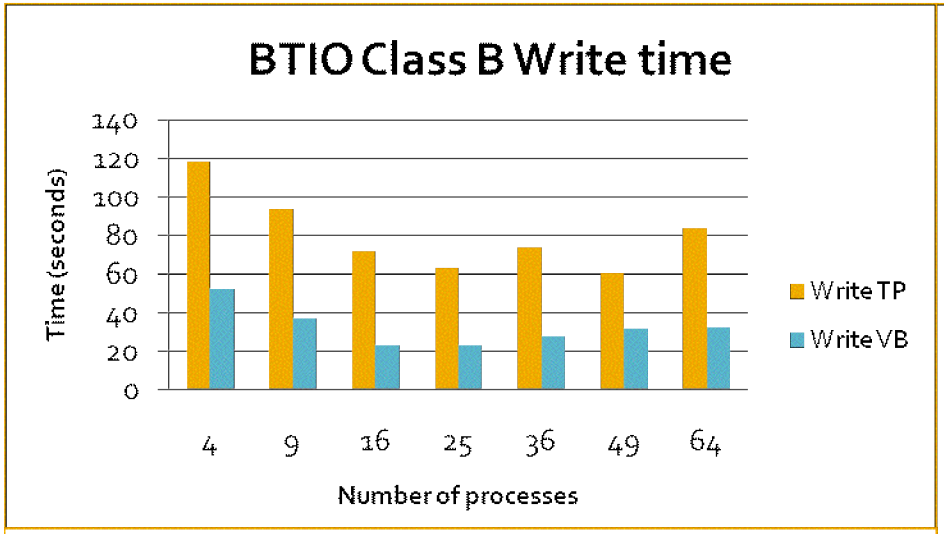
Evaluation

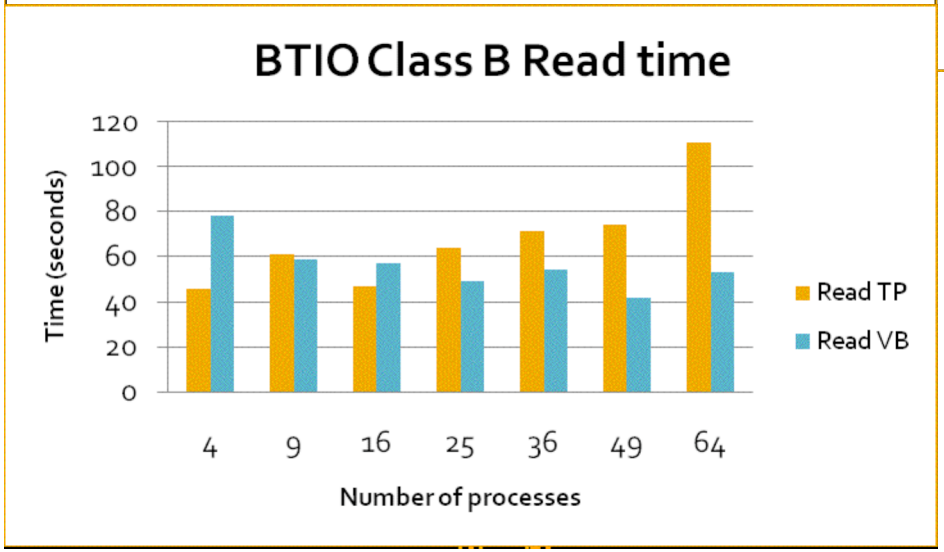
- Evaluated on CACAU (HLRS Stuttgart)
- MPICH2
- File system tested: PVFS 2.6.3 with 8 I/O servers
- The communication protocol of PVFS2 and MPICH2 was TCP/IP on top of the native Infiniband communication library
- 1 process per node
- View-based I/O had a collective buffer pool of maximum 64 Mbytes
- BTIO, coll perf and MPI_TILE_IO

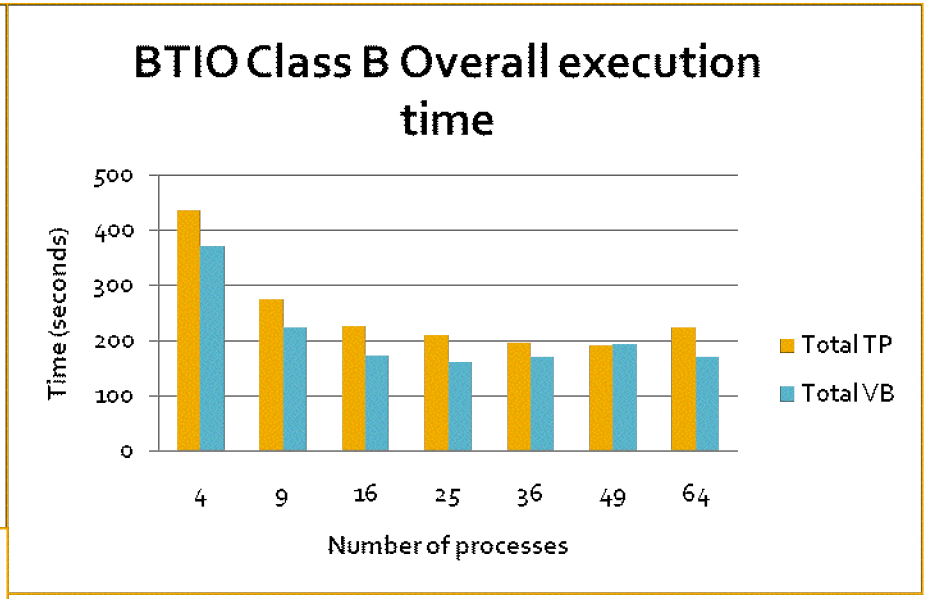
BTIO benchmark

- Use 4 to 64 processes and two classes of data set sizes: B (1697.93 Mbytes) and C (6802.44 MBytes).
- BTIO explicitly sets the size of write collective buffer to 1 Mbytes
- The benchmark reports the total time including the time spent to write the solution to the file.
- However, the verification phase time containing the reading of data from files is not included in the reported total time

BTIO benchmark



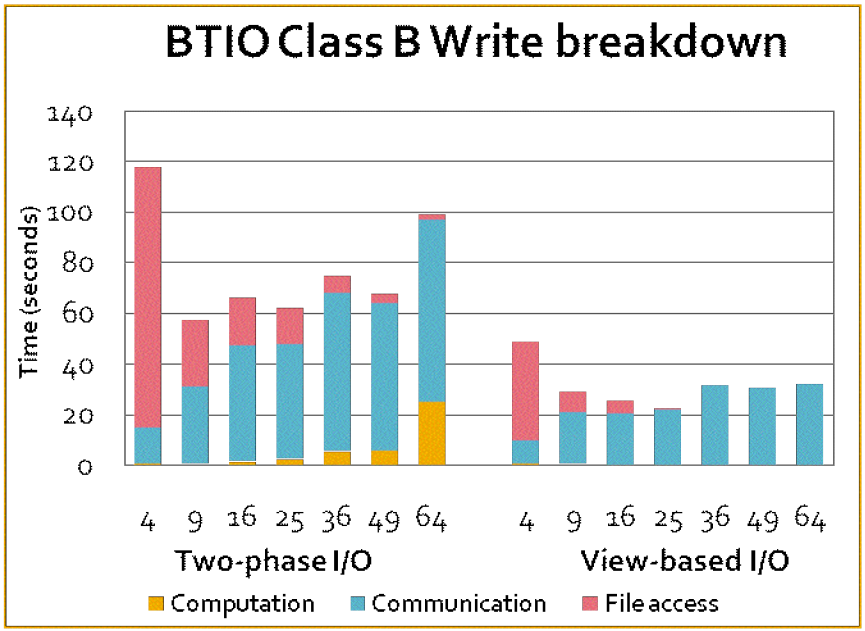


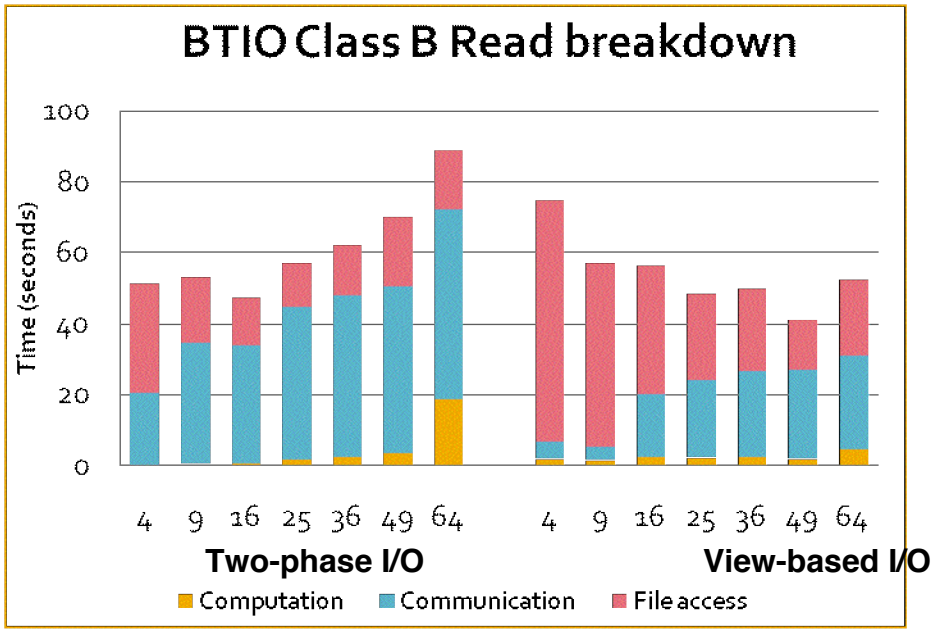


- Writes were between 89% and 121%
- Reads were between 3% to 109%
- Overral time was between 8% to 50%

BTIO breakdown

- Breakdowns: total time spent in computation, communication and file access of collective write and read operations, for class B from 4 to 64 processes.





Conclusions

- Avoids the necessity of transferring large lists of offset-length pairs at file access time as the present implementation of two-phase I/O.
- Reduces the total run time of a data intensive parallel application, by reducing both I/O cost and implicit synchronization cost.
- The write-on-close approach brings satisfactory results in all cases.

Future work

- Adding lazy view I/O
  - Views and data are sent together in write/read primitives
  - Views are sent if the aggregators do not have the data view
- Including two data staging strategies for **prefetching** and **flushing** the collective I/O buffer cache:
  - The prefetch is done in coordinate manner, by aggregating the view information of several processes and reading ahead whole blocks. Based on MPI-IO views.
  - The flushing strategy allows for overlapping the computation and I/O. Reduces also the rates at which the buffer cache becomes full with dirty file blocks, which may clog the computation to go on.
- Currently:
  - We have already implemented the mechanisms for enforcing these two strategies and are estimating the efficiency of this approach for large scale scientific parallel application.
  - We are investigating the trade-off between the contradictory goals of promoting data by prefetching, demoting the data by flushing and temporal locality.

Thanks for all