Implementation, evaluation and analysis of Block index for ADIOS

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Introduction

- Scientific datasets are commonly stored and managed by parallel file systems and I/O libraries
  - E.g. Lustre, HDF5, NetCDF, ADIOS
  - optimized for reading/writing large chunks of data
  - Data layout and file organization impact query performance
- The characteristics and behaviors of I/O systems should be considered into the design of indexing methods

The idea of "Block index"

- Indexing blocks (consecutive data records) instead of individual data records
    - Reduce index size
    - Reduce number of I/O requests
    - Reading an individual record has similar I/O latency as reading a data block

Implement block index into ADIOS

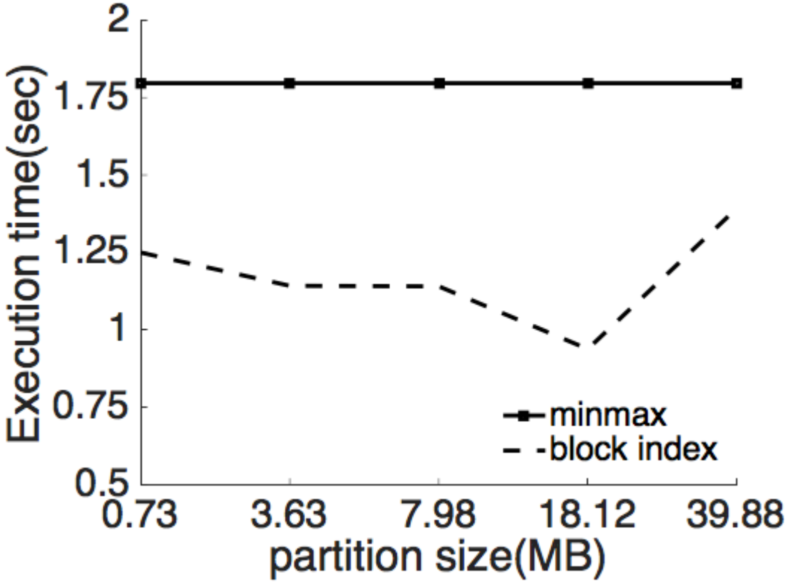
- Minmax method in ADIOS
  - Records the min, max value from each writeblock
  - The size of writeblock => the size of data of each process (can be extremely big)
- Block index method in ADIOS
  - Logically divides a writeblock into smaller partitions
  - Records the min, max values of each partition
  - Using logical partition can maintain the same number of writeblock
  - The I/O requests on the same writeblock can be merged by ADIOS to minimize I/O contention

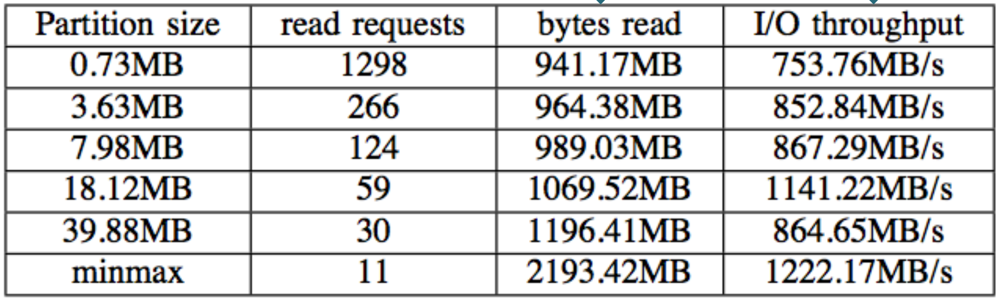
Experiment Setup

- Edison Cray XC30 at NERSC
  - 5576 compute nodes, with 12-core Intel Ivy Bridge 2.4GHz CPU and 64GB memory per node
  - Lustre parallel file system with 72GB peak performance
- S3D dataset
  - Each variable contains 1100*1080*1408 double precision records
  - Each variable is written to file using 64 writeblocks of size 275*270*352 (~200MB)

Performance evaluation

- Varied partition size
  - The performance is a tradeoff between read size and I/O throughput
  - Minmax's read bytes is more than twice the block index

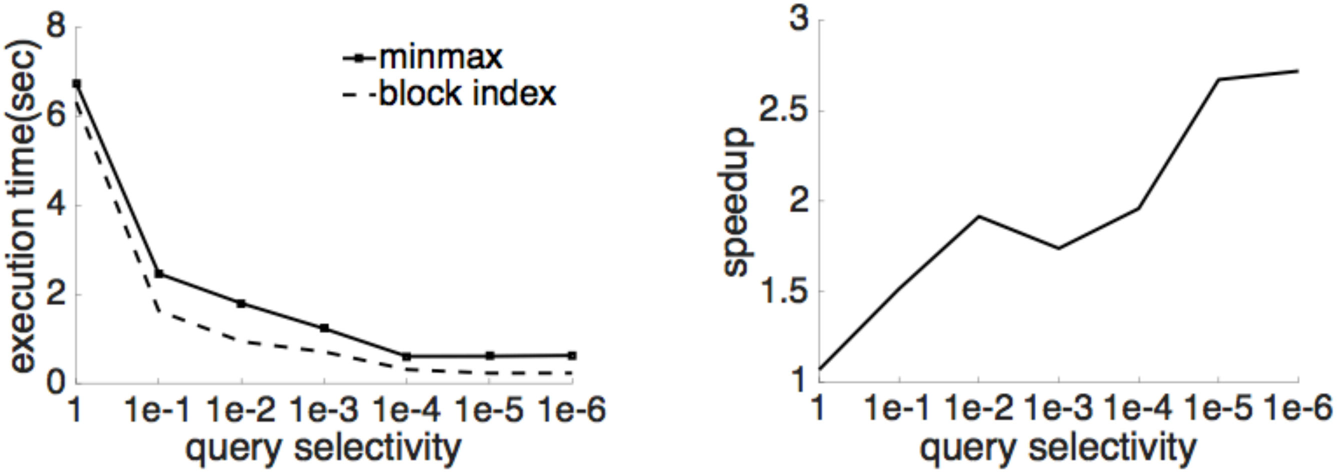




Partition size	read requests	bytes read	I/O throughput
0.73MB	1298	941.17MB	753.76MB/s
3.63MB	266	964.38MB	852.84MB/s
7.98MB	124	989.03MB	867.29MB/s
18.12MB	59	1069.52MB	1141.22MB/s
39.88MB	30	1196.41MB	864.65MB/s
minmax	11	2193.42MB	1222.17MB/s

Performance evaluation

- Varied query selectivity
  - Block index reads less data when query selectivity is smaller => speedup is higher
  - Similar performance under 100% query selectivity



(a) Execution time.

(b) speedup of block index.

Conclusion

- Query performance of minmax is limited by the size of writeblock
- Query performance of Block index that logically partitions a writeblock improves due to less data reading, and more flexible read size
- Future work
  - Performance analysis and modeling of I/O systems
  - Design the algorithm to select the proper block size and request merging condition

THANK YOU