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Experiences with IO Performance Analysis on Red Storm

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http://www.cs.sandia.gov/RSIOPA

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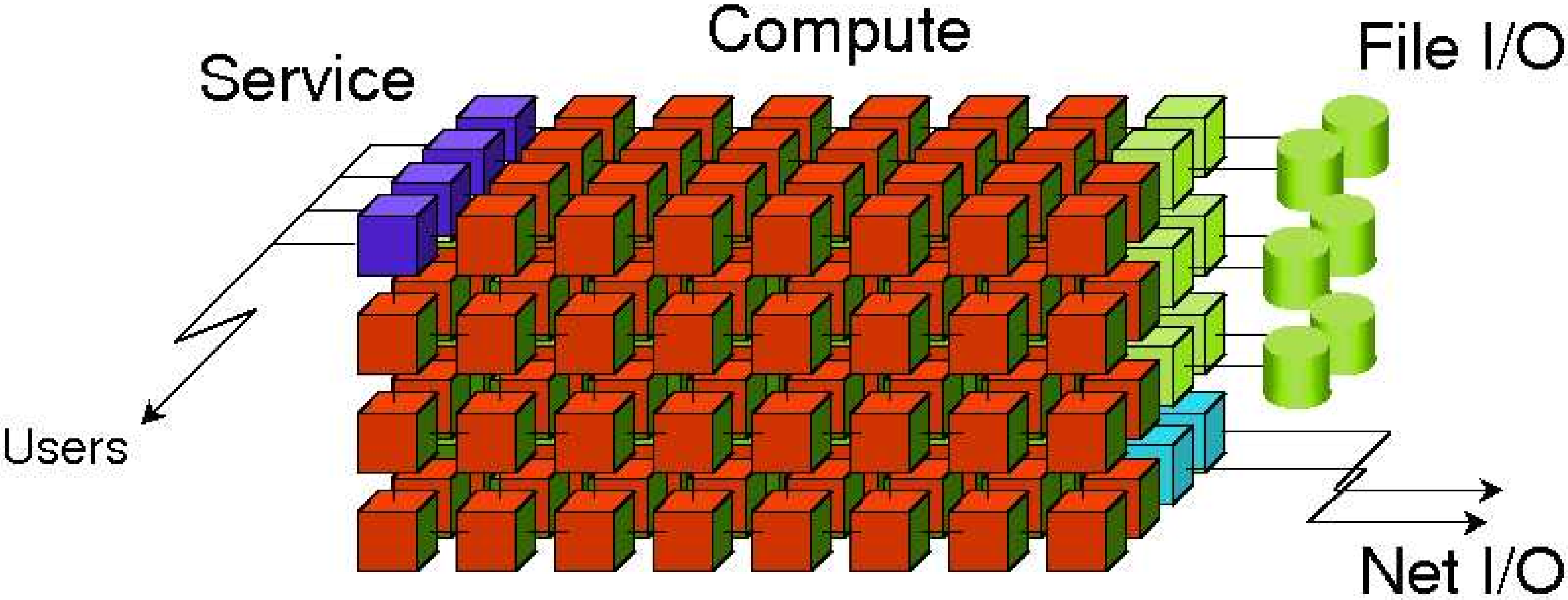
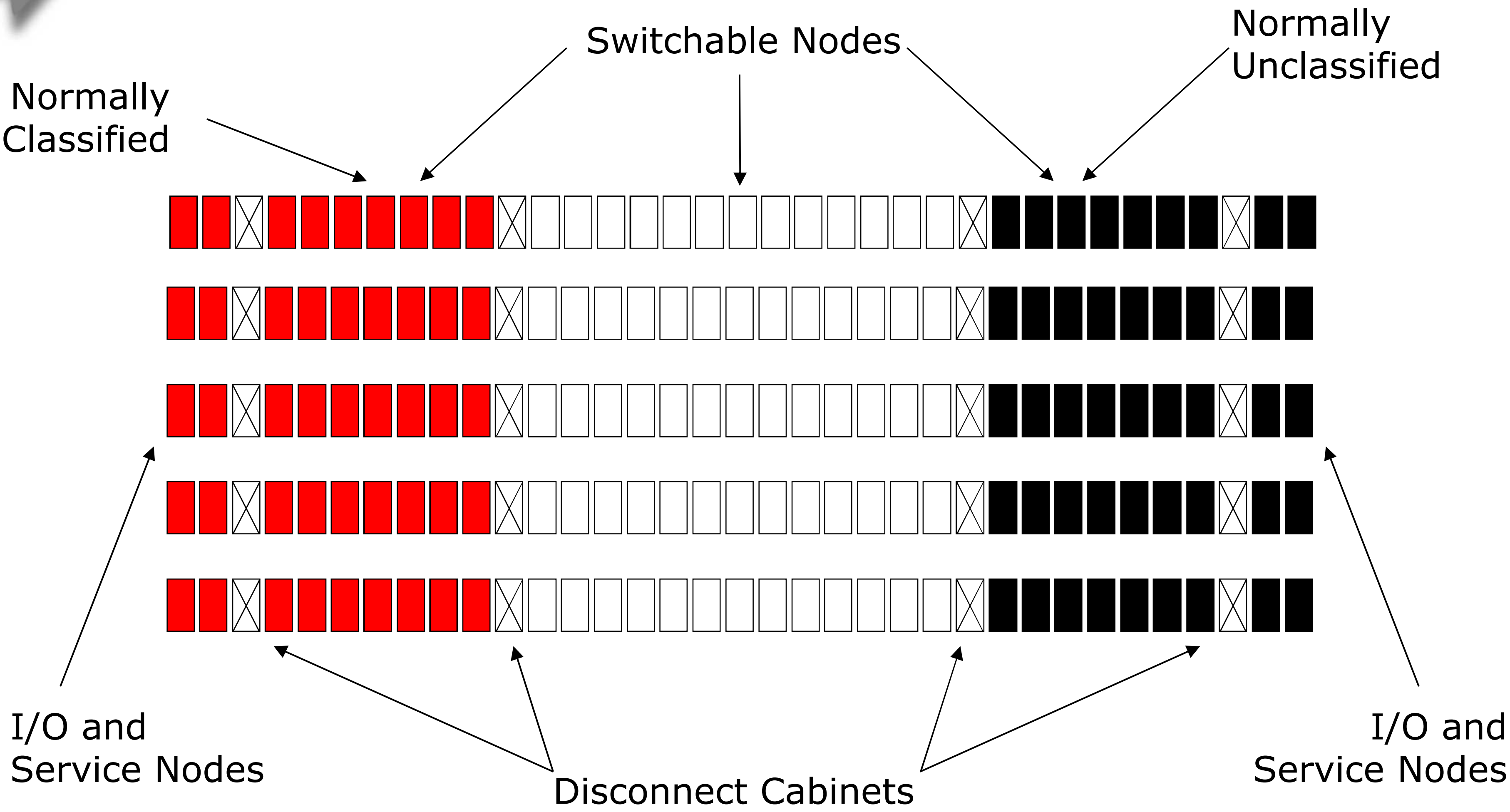
Red Storm Architecture (Logical View)



View From the Cheap Seats



Normally Classified

Switchable Nodes

Normally Unclassified

I/O and Service Nodes

Disconnect Cabinets

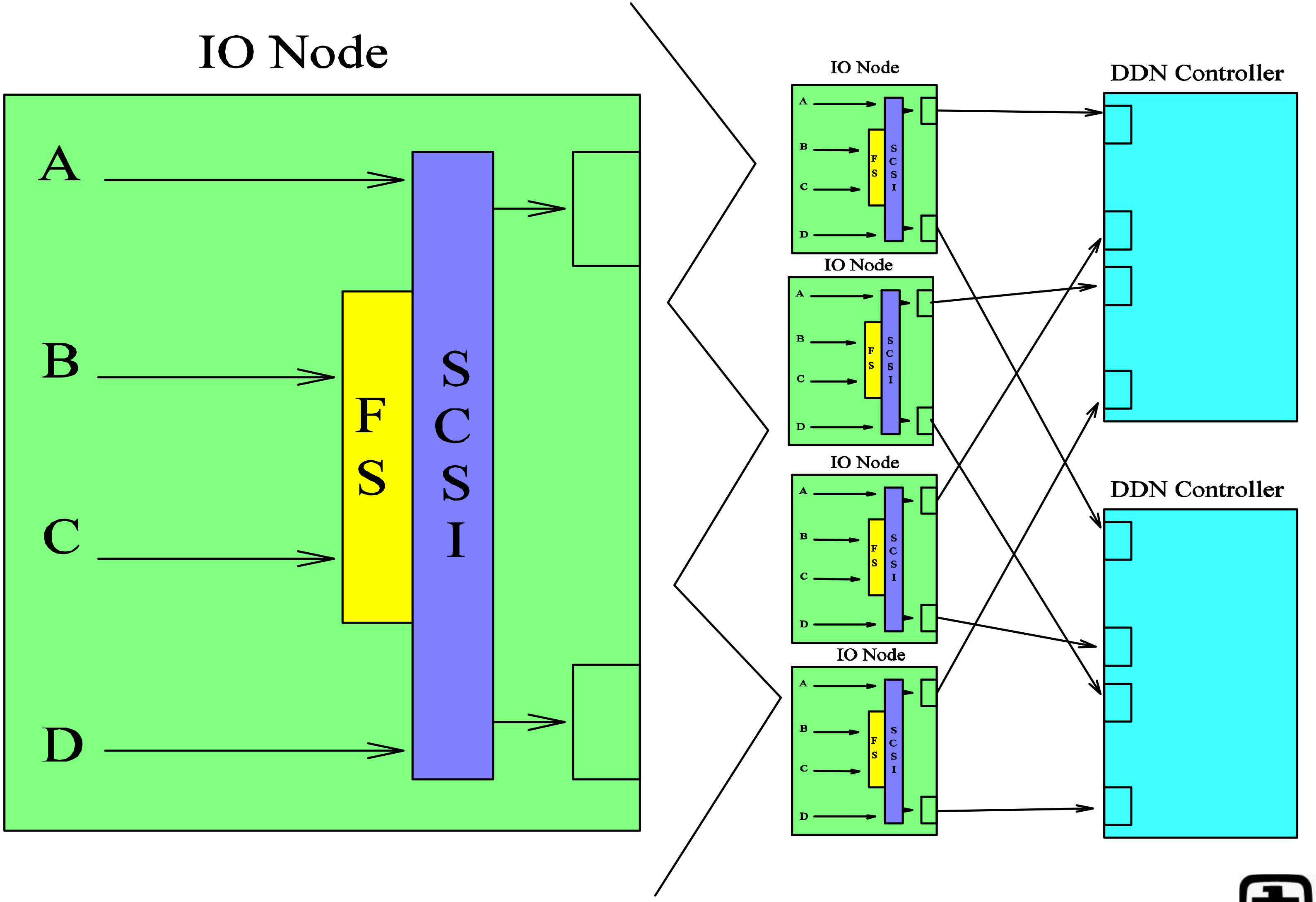
I/O and Service Nodes

Disk storage system not shown

Some Important Numbers

- 12960 nodes (2.4Ghz Opteron dual core)
- 3D Mesh Topology
- 3.6 TB/sec Bisection Bandwidth
- 2.1 GB/sec Individual Link Speed (unidirectional)
- Light Weight Kernel (Catamount) – Compute
- Cray Modified SUSE Linux – IO
- Qlogics 2300 2Gb dual port HBA
- Data Direct Networks S2A 8500 controllers
  - 4, 2Gb ports per controller

IO Node/Controller Configuration



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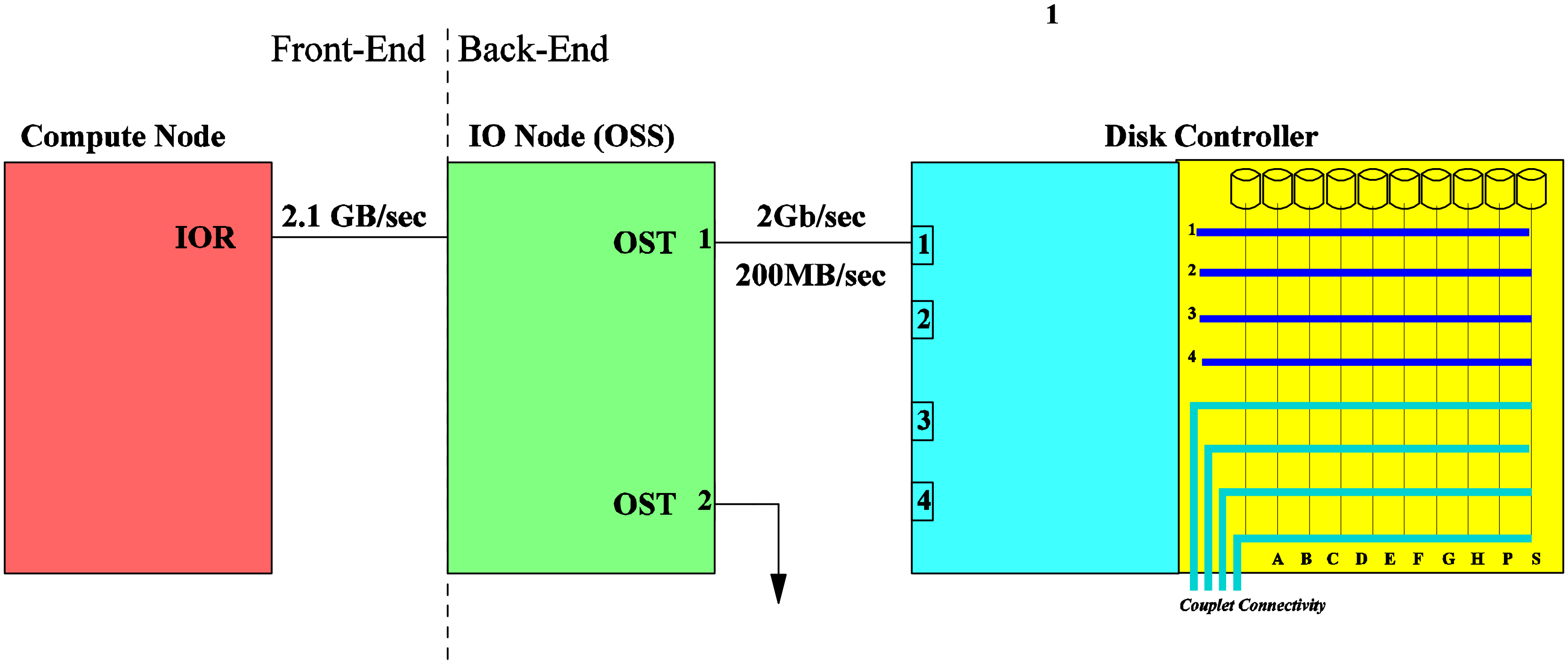
End to End IO Path



1

Front-End

Back-End

Compute Node

IOR

2.1 GB/sec

IO Node (OSS)

OST 1

OST 2

2Gb/sec

200MB/sec

Disk Controller

1

2

3

4

1

2

3

4

A B C D E F G H P S

Couplet Connectivity

Goal?

- 50000MB/sec from application to parallel file-system
  - Read or write
  - File-per-process or Shared-file
- Lustre is the parallel file-system
- File-system configuration
  - 160 OSSs (IO nodes)
  - 2 OSTs per OSS (320 OSTs)

Back End Testing
(Single path Theoretical)

- What is the limiting factor using a single port of controller?
- Internel disk channels (A-H,P,S) 1Gb/sec (100MB/sec)
- Disk 43MB/sec (min) – 78MB/sec (max)
- Controller port 2Gb/sec (200MB/sec)
- HBA 2Gb/sec (200MB/sec)

8 DDN data channels (A-H) → 800MB/sec

43MB/sec × 1 disk/channel × 8 channels = 344MB/sec (min)

78MB/sec × 1 disk/channel × 8 channels = 624MB/sec (max)

- Inside the controller disk limits the rate - BUT
- Still limited by 200MB/sec controller port/HBA port

Back End Testing (Aggregate Theoretical)

- What is the limiting factor Using all four ports of controller?

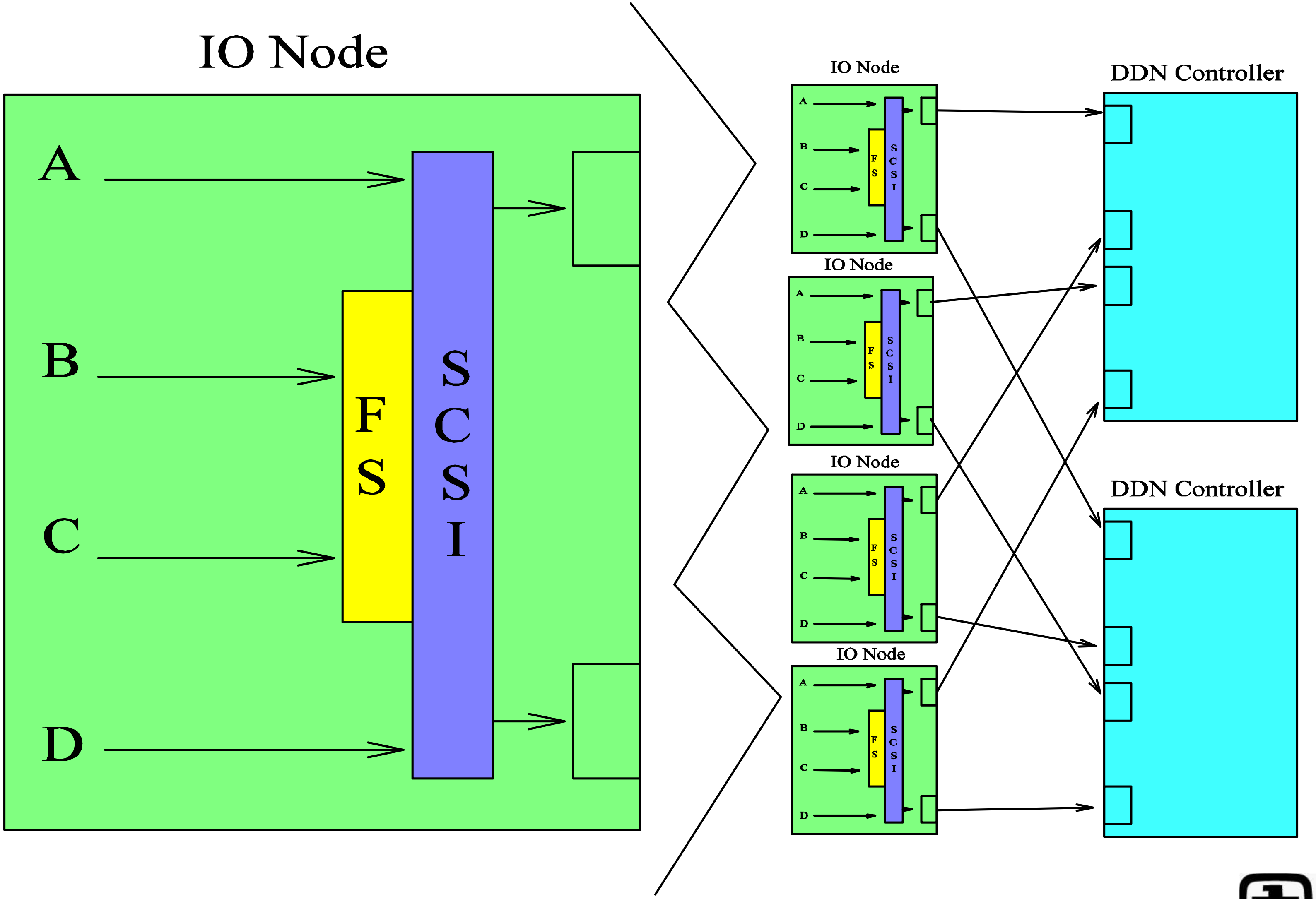
8 DDN data channels (A-H) → 800MB/sec
800MB/sec ÷ 4 ports/controller = 200MB/sec/port/controller

- Each port on controller gets ¼ of each data channel

100MB/sec/channel ÷ 4 ports = 25MB/sec/channel/port

- Minimum per disk rate is 43MB/sec
  - Exceeds shared per data channel rate
- Still limited by controller port/HBA/data channel rate (200MB/sec)

IO Node/Controller Configuration (AGAIN)



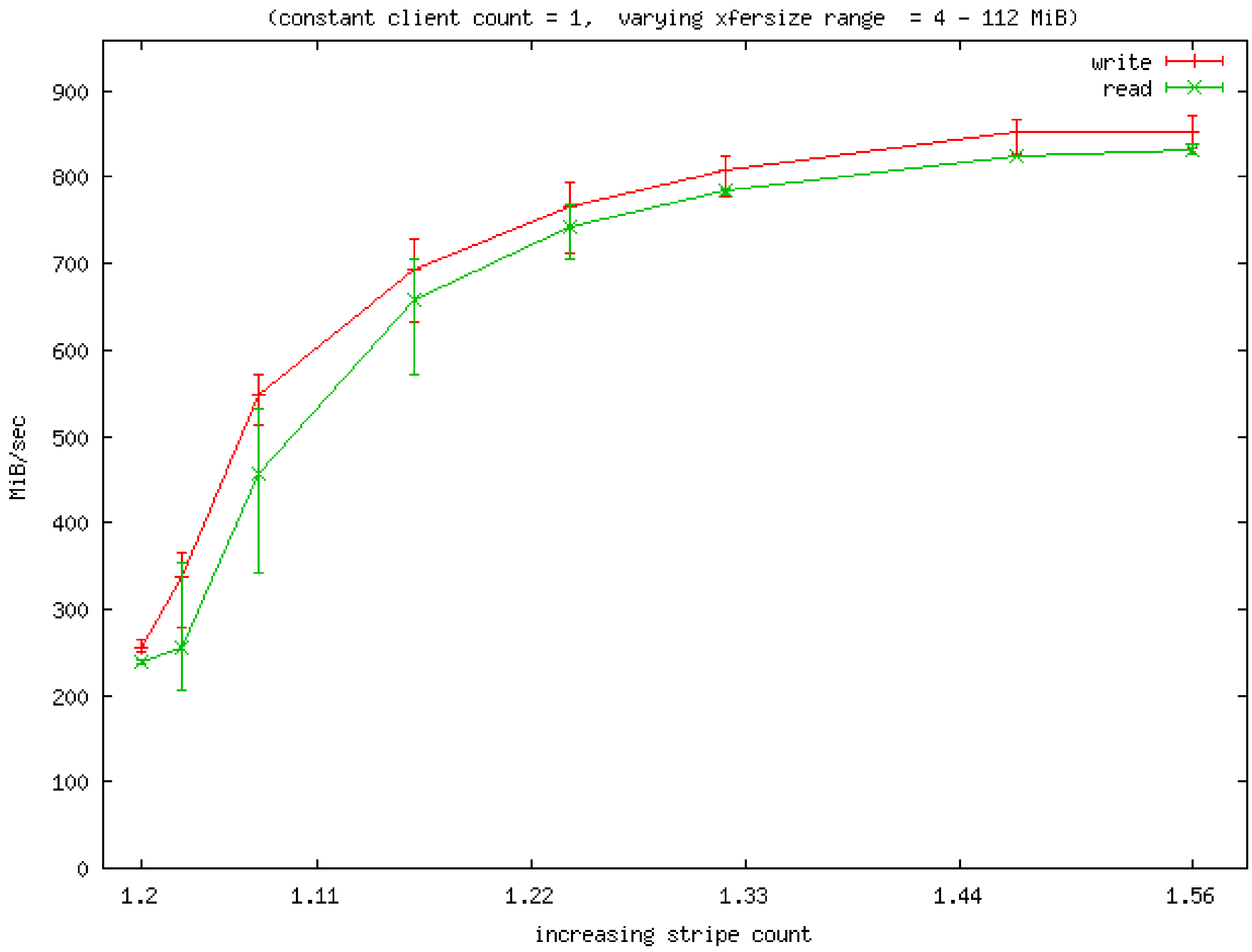
Back End Testing (Demonstrable)

- Single port on IO node, Single port Controller
  - SCSI layer 196.23MB/sec (A)
  - File-system layer 179.84MB/sec (B)
- Both ports on IO node, one port each on separate controllers
  - SCSI layer same (196MB/sec) (A and D)
  - File-system layer 102.35MB/sec (B and C)
- One port each on four IO nodes, all four ports on a single controller
  - SCSI layer 195.13MB/sec (Ax4)
  - File-system layer 140.82MB/sec (Bx4)

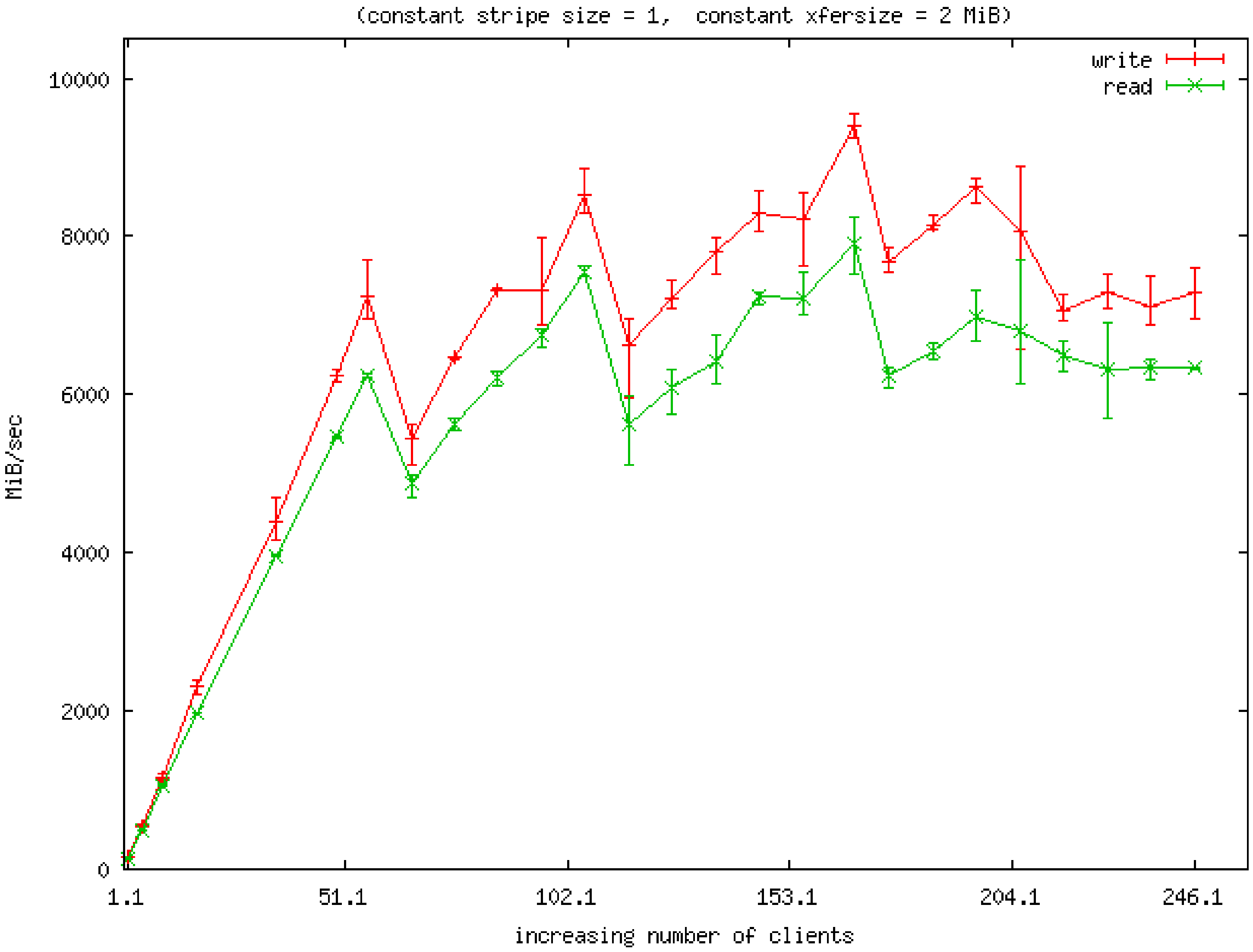
Parallel File-System Tests

- IOR – parallel application
  - File-per-process
  - Shared-file
- Lustre
  - OSS/OST assignment carefully controlled
- Testing Oversubscription
  - 60:1, ratio of compute to IO nodes in initial configuration
  - Achieve this by limiting OSS/OSTs used

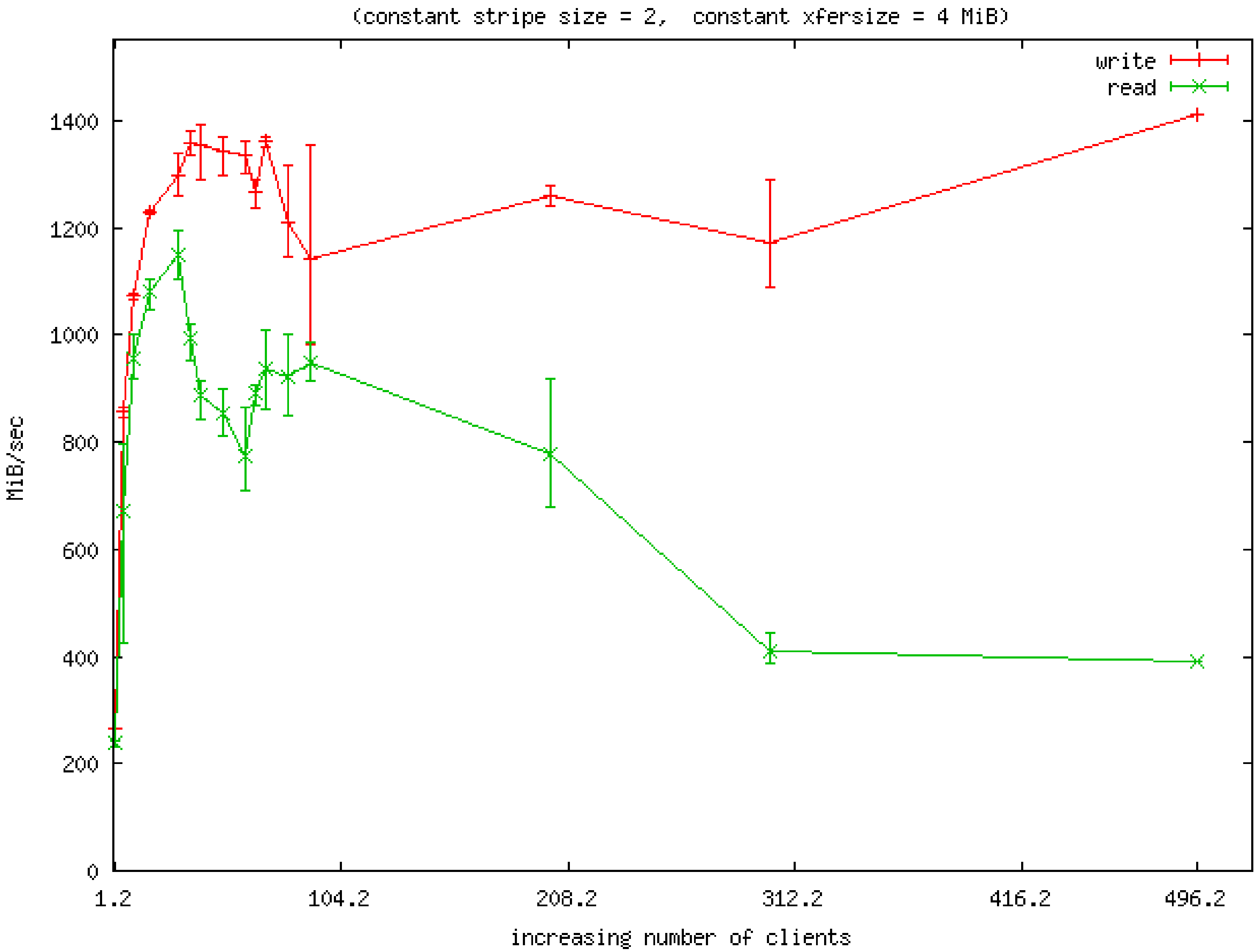
Front End Test



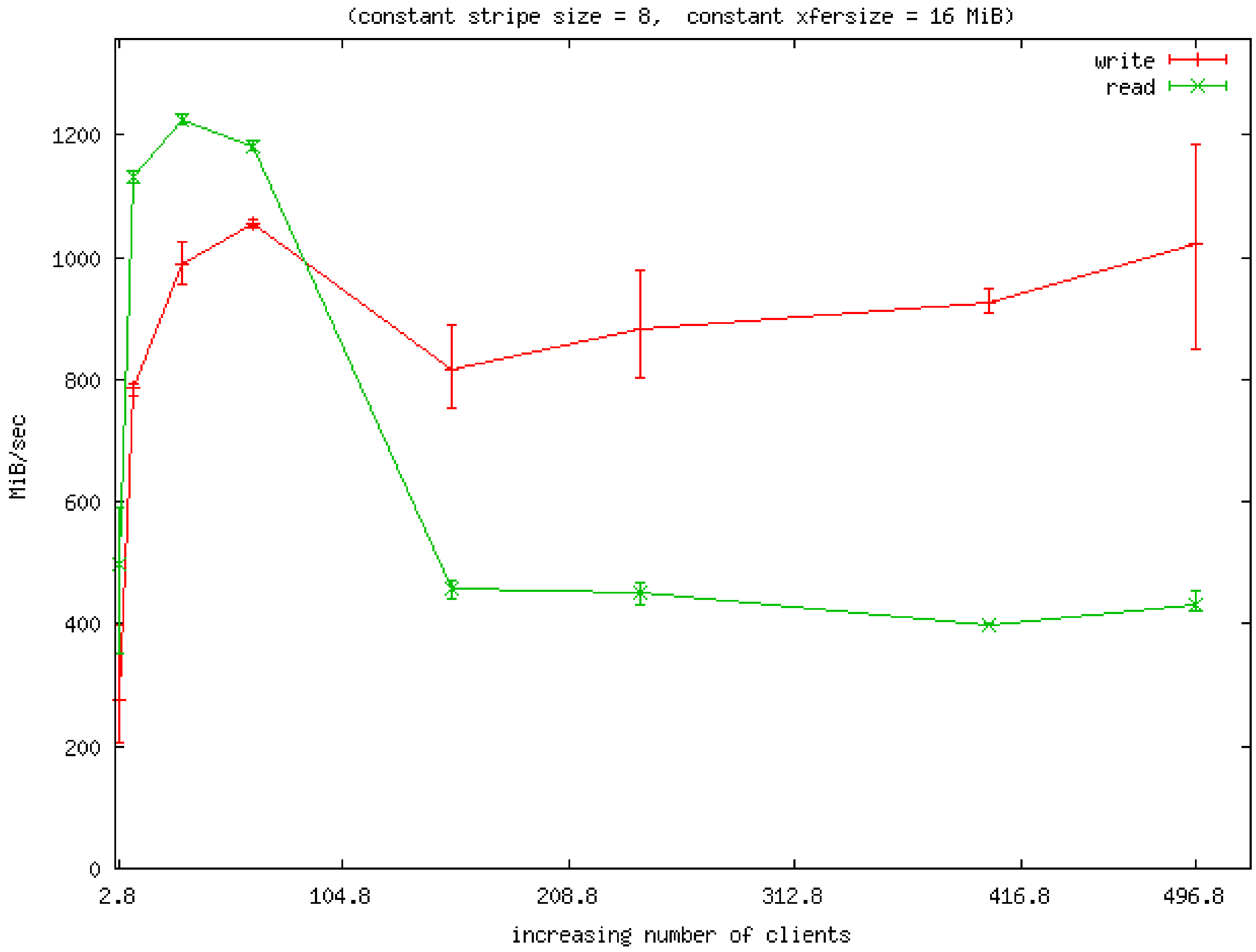
File-Per-Process



File-Per-Process (Oversubscribed)



Shared-File (Oversubscribed)



Conclusions

- **Physical configuration sufficient to achieve goals**

195MB/sec per port using 320 ports yields 62400MB/sec

- **Initial non-Lustre file-system testing not good**
- **Lustre results more promising**
  - **154.15MB/sec (avg) × 320 OSTs = 49280MB/sec (from file-per-process oversubscribed)**
  - **176.31MB/sec (max) × 320 OSTs = 56419.2MB/sec (from file-per-process oversubscribed)**
  - **Unfortunately only for writing**
  - **Only for file-per-process**
- **Read performance suffered in all cases**
- **Write performance for shared-file also insufficient**
- **Results shared with Cray and CFS**

Future

- Testing will continue after software or hardware upgrades
- Large scale testing
  - Demonstrated 54104MB/sec (writing)
    - 86% of theoretical!
    - 320 OSTs
    - 640 clients
    - File-per-process
    - Not reliably repeatable ☹
  - Demonstrated > 50000MB/sec (writing)
    - Client counts up to 3200
    - Indicates rates can be maintained at larger scale
    - Not reliably repeatable ☹
  - Little good to say about read rates

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Acknowledgements

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