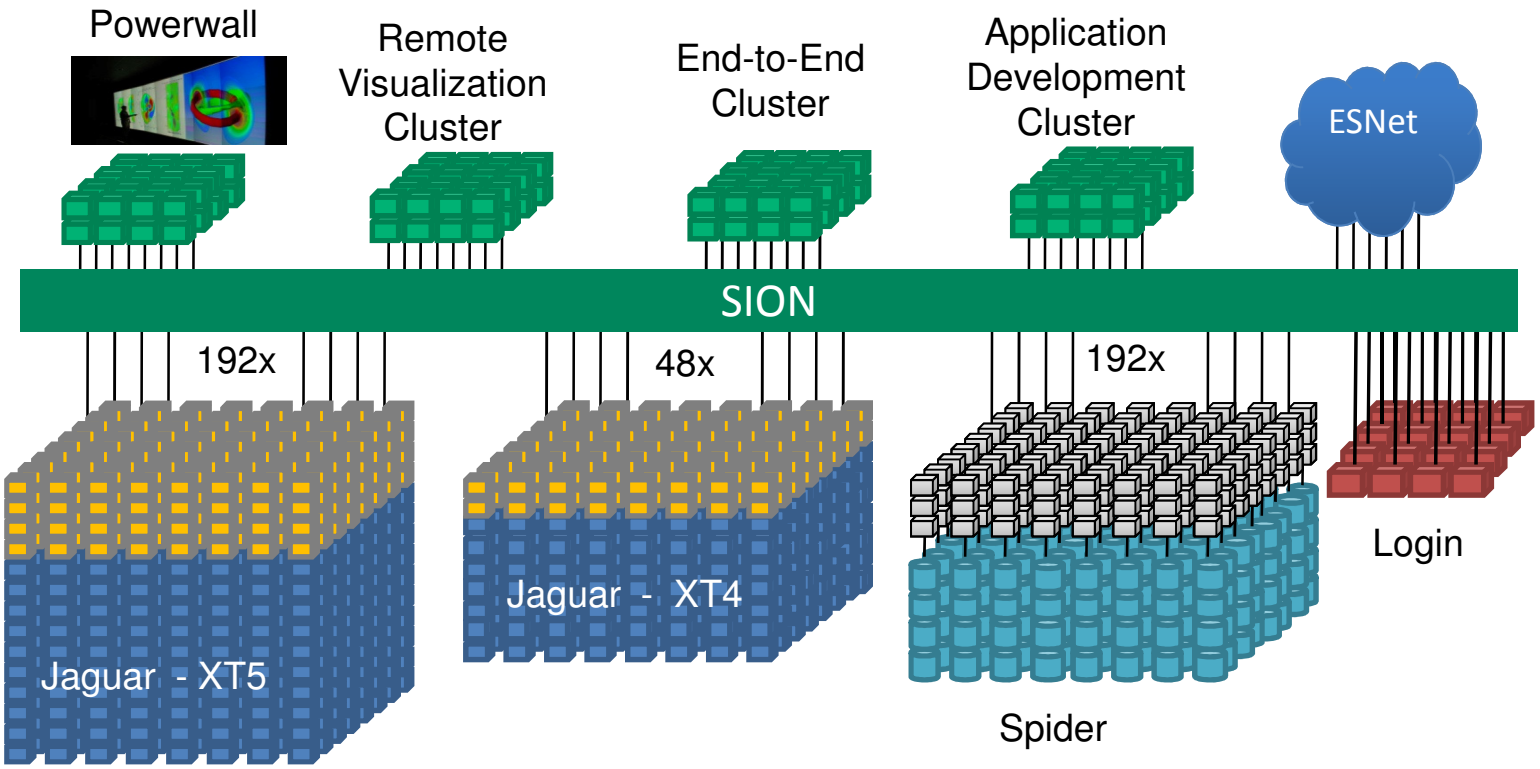
Administering Lustre at Scale

Lessons learned at ORNL

Outline

- Overview/Diagram of “Spider”
- “must haves” for any Lustre FS
- Some Uptime/Outage information
- User Experience
- Administrative Experience
- Where we’re heading from here
- Wrapup/Questions

Spider


Powerwall
Remote Visualization Cluster
End-to-End Cluster
Application Development Cluster
ESNet
SION
192x
48x
192x
Jaguar - XT5
Jaguar - XT4
Login
Spider

“Must Haves”

- Budget is the final driver
- RAID + dm-multipath
- Redundant SAN (As much bandwidth as you can buy)
- Lustre Failover node
- High Availability Solution
- Diskless Boot Environment
  - If not available, use Centralized Configuration Management
  - Probably good to use even with Diskless Env.
- Policy for deleting data
  - Sweep for files that are older than 14 days (daily)

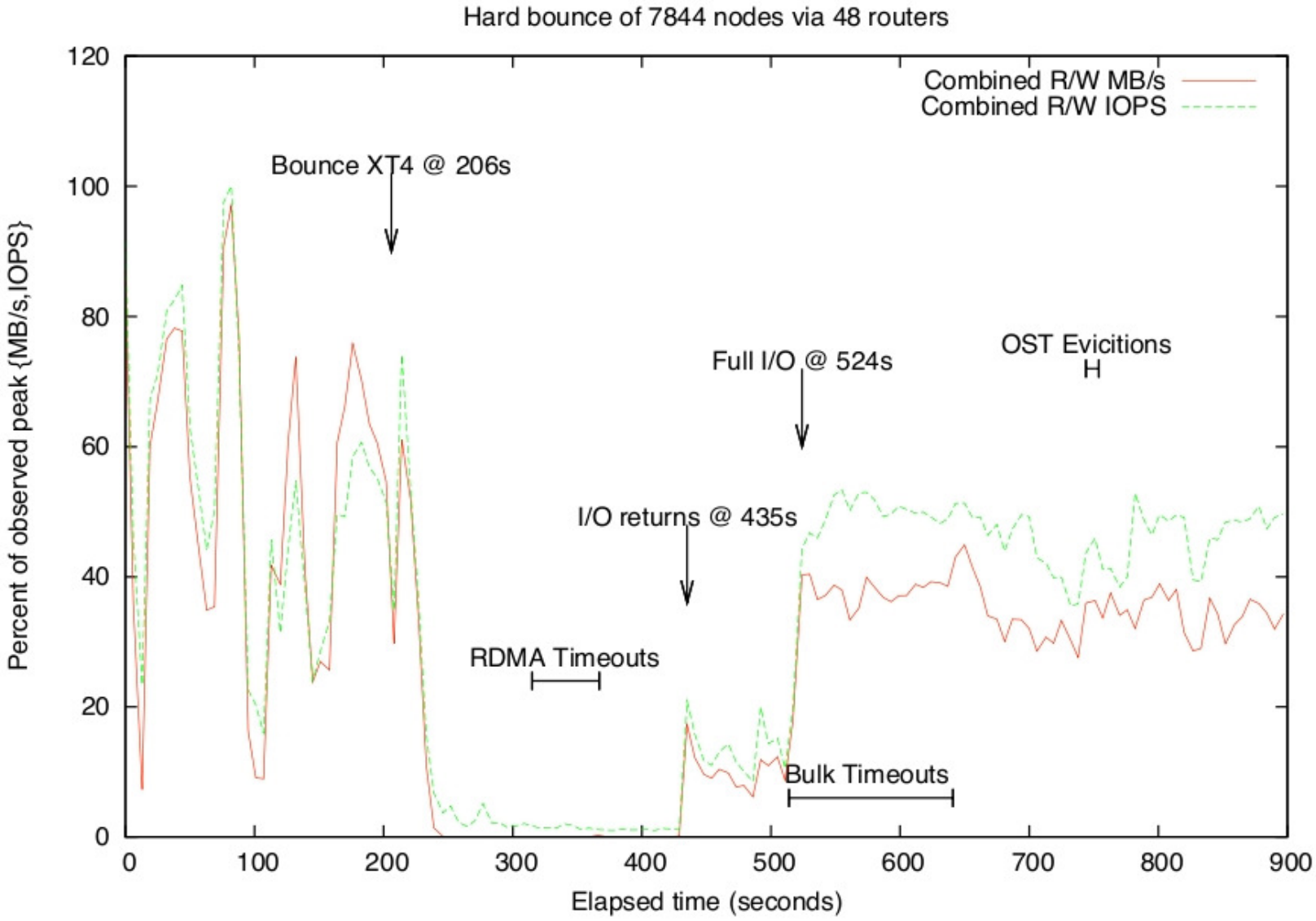
Uptime

- Hard to measure
  - MDS/MGS/OSS uptime?
  - Currently MDS up short time
    - Downtime to add threads
  - Some OSSes have over 130 days of uptime
    - Ones that don't have had backend storage problems
- MTTI – ex. OST/OSS unavailable
- MTTF – MDS or filesystem unavailable

Hiccups?

- We see some IO “hiccups”
  - Run MDS out of servicing threads
- XT dies, large IO job holding locks
  - Spend odb_timeout trying to talk to the clients

IO Shadow


Hard bounce of 7844 nodes via 48 routers
Combined R/W MB/s
Combined R/W IOPS
Bounce XT4 @ 206s
Full I/O @ 524s
OST Evicitions
H
I/O returns @ 435s
RDMA Timeouts
Bulk Timeouts
Percent of observed peak {MB/s,IOPS}
Elapsed time (seconds)
0
20
40
60
80
100
120
0
100
200
300
400
500
600
700
800
900

Outages/Saved Outages

- dm-multipath saves the day
  - Since 07/13/2009, 25 controller failures resulted in 6 service interrupts
- Other outages for LBUG's (panic on lbug set)
- Testing time (center wide, rare)
- Issues with ib_srp
- Backend storage problems

Feb 25th 2010

- Backend storage problem caused us some grief
- Complicated by bug in e2fsck
  - Freeing inodes that were note used, but are part of a valid stripe
- What did we learn?
  - Verify connectivity to disks on both controllers before rebooting, check status of all disks
  - e2fsck –n
  - We need better tools

Tools

- Need better way to get what files are on an OST
  - Have ne2scan output, but that's not current as of time of failure
  - Recommendation from Oracle folks was lfs getstripe –obd=
    - Took 5 days on OST with ~1M objects
- Need way to map inode on MDS to a filename/path
- Lustre error message marking OST as read only could use a note about the path it's using
  - Very hard to determine what OST was marked read only because of IO errors from backend storage

Admin Experience

- At this scale “Lustre” can be difficult to work with
  - Log parsing from 210 servers with differing filesystems
  - Log correlation between 27k clients and 210 servers more difficult
  - Host Monitoring
    - We killed our existing Nagios Infrastructure by putting ~1500 more checks into it just for Lustre (more coming)
  - Storage monitoring (not Lustre’s job)
  - Maintenance windows
    - We’re at the center of everything. When the FS is down we stop processing.

Admin Experience

- Developed some tools to help
  - DDN monitoring tool (Ross Miller)
  - MDS/OSS RPC Tracing application (David Dillow)
- Still need to develop some more tools
  - IB Fabric monitoring
  - Log parsing/Event notification
- Never sure of an applied patch until you try it against 27k Lustre clients

Admin Experience

- Some key admin tools
  - Syslog-ng
  - SEC
  - Nagios
  - DDNTool
  - Tail, grep, etc.
  - LCTL
  - Routerstat
  - MDS/OSS trace
  - Ne2scan/genhit/purge/fsfind
- DDNtool is working its way to being released

Admin Tools

- DDNTool
  - Use DDN API to get information
  - Classes of information
    - Performance Stats (fast polling – every 2 seconds)
    - Failure Data (medium polling – every 60 seconds)
    - Environmental Data (slow pollign – every 30 minutes)
  - Can write application to query this data in anything
  - Each update erases the data from the previous run
  - If you want to track it, slurp the data into your own database
    - It gets large **very** quickly

Admin Tools

- Syslog-ng
  - Use rules here to put types of messages into the same logfile
    - Weekly run of all kernel messages from the oss nodes for an example
    - Lots of possibilities here
- SEC
  - Simple Event Correlator
  - Write rules to alert if you see a specific syslog message
  - We trigger on OSS reboot
  - Have some rules for non-contigious memory for IB page allocation
  - Need to continue to dig deeper into error messages to send more
  - Can have issues after long uptimes with the message suppression algorithm in Lustre (don't see messages in a timely fashion because lots are suppressed).

Admin Tools

- Nagios
  - Make sure it's robust for large filesystems
  - We check for server health
    - Ping, SSH, Environmentals, Voltage
    - Multipath health
    - Load\
  - Probably more to check for, and we'll add that as the Nagios infrastructure allows
  - Also monitor ping for DDN controllers
  - Haven't investigated snmp traps from DDN yet, the API is working well for us

Admin Tools

- lctl
  - Disable OST's, remove OST's completely
  - Manage routes
  - All the normal stuff
- Routerstat
  - Locally modified to put in date and time to the ouput
  - Use on the MDS to see :
    - Messages in flight (and max messages)
    - Errors
    - MB Sent/Received
    - LNET information

Admin Tools

- MDS/OSS trace
  - Lctl dk >> /dev/null
  - Echo + rpctrace >> /proc/sys/lnet/debug
  - Wait
  - Echo – rpctrace >> /proc/sys/lnet/debug
  - Lctl dk >> /tmp/myfile
- Use this data to correlate information back to nodes (LNET nids)
- Gather apstat information from XT5 and XT4 and do further correlation
- Generate report and e-mail if the average LDLM_ENQUEUE time is longer than 1 second
- Do this every 10 minutes; We get ~50 emails a day
- Run by hand on OSS currently

Admin Tools

- Ne2scan
  - Get all information off the mdt (modified e2scan by Nick Cardo @ NERSC)
- GenHit
  - Generate list of files that are older than a specified date from the ne2scan output
- Purge
  - Stat the file, make sure mtime/ctime allow for deletion
  - Unlink
- Fsfind
  - Find files for a specific user
  - Find files on a specific OST
  - Find files that are setuid/setgid
- Talk to Nick – should be going through tech transfer here soon

Addressing Scalability Challenges

- Periodic user reports that the filesystem is slow
  - Very helpful!
- Mainly interactive performance is poor
  - ls –l /tmp/work/user
- Our observations are that we're running out of locks when large jobs spin up or do checkpoint
  - Ex. Single shared file with 48k cores
- Some things we've done to help
  - Turn off color ls
    - Doesn't help if user is doing ls –l
  - Changed mds_num_threads from 128 (default) to 2048
    - Is a local modification/patch, not generally advised
    - Had tried up to 16k
    - At that scale saw 1.6 Million context switches per second during MDT unmount
    - MDT unmount took over 20 minutes

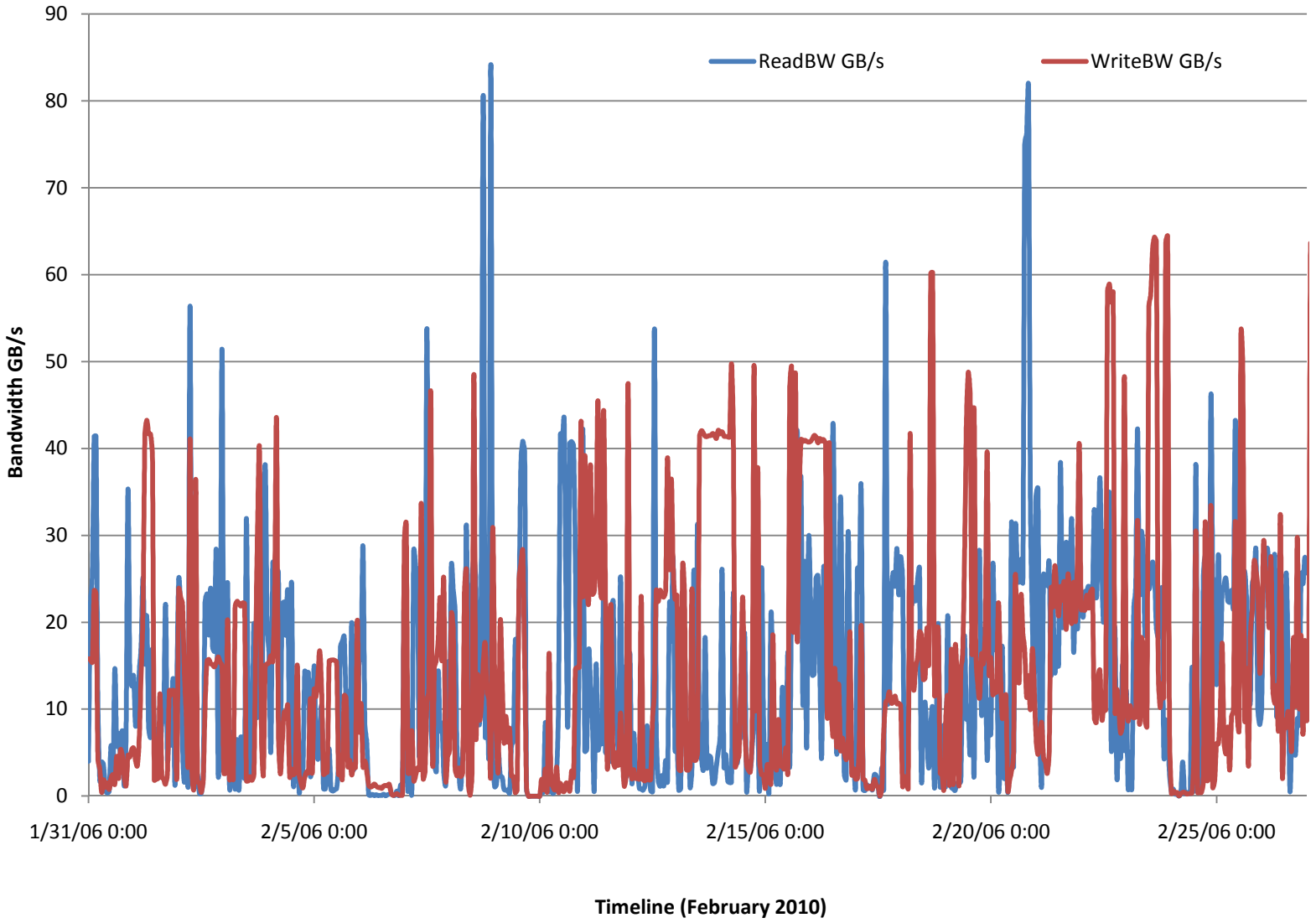
Addressing Scalability Challenges

- Things to think about moving forward
  - Give users information about changing their .vimrc to move the swap file (or turn it off)
  - Potentially recommend alternate workflows that have less impact on the MDS
  - Deploying multiple (order 2-3) shared filesystems
    - Allows better segregation of users and use cases
    - Gives smaller collision domain if one project/code has a pathalogical IO behavior
- All of these are band-aids to the thread model on the MDS
  - Fixing thread sleeping model is not easy

Moving Forward

- Administratively we have a lot of work to do
  - Deploying HA/Failover
  - Nagios checks
    - Mounted OST's, memory utilization, IB Health
  - Deploying Lustre 1.8
  - With that a focus on getting better MDS performance for interactive use
    - This is a question, not a solution
    - Is there a way to get part of the namespace assigned to a particular MDS?
    - Could be bridge to clustered metadata

Performance Numbers



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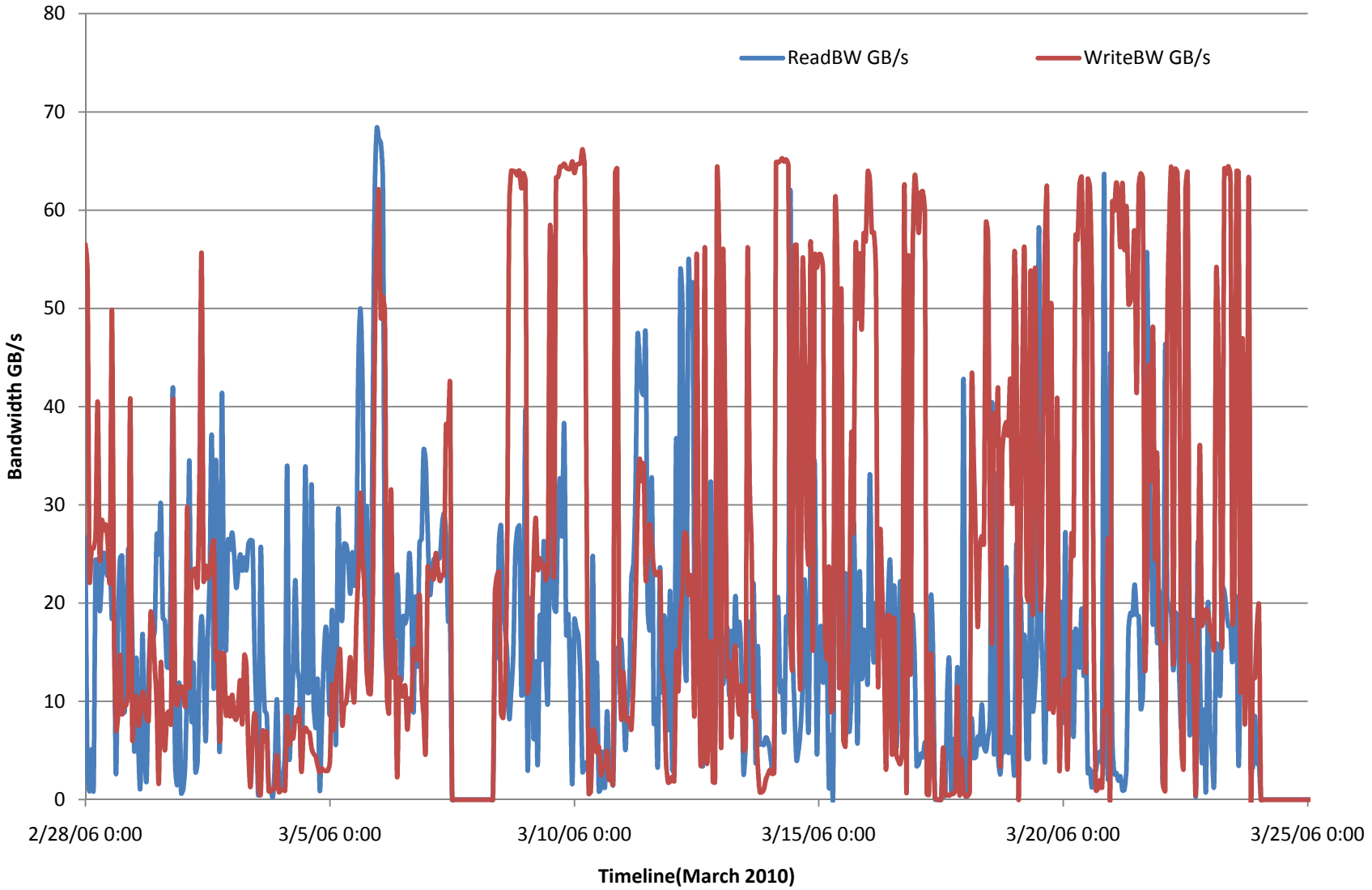

Wrapup

- Always plan for failure
- Develop procedures for scenarios
- We've had pretty good luck, but Murphy strikes all
- Lots of tools to develop
- More bugs to squash

Questions

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