Configuring the GPFS/DCS9900 Storage System

Best Practices

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The following pages provide a very brief overview to what GPFS is and how it works via two generic configuration architectures.

1. LAN Configuration
   This is a client/server configuration. The LUNs are mounted in /dev on the servers and accessed by the clients via the LAN.

2. SAN Configuration
   GPFS is not a SAN file system but it can run in a SAN centric mode. No distinction is made between client and server. All LUNs are mounted in /dev on all nodes in the cluster. The storage controller may connect directly to the nodes or via a SAN fabric.

What is GPFS?

General Parallel File System

All of GPFS's rivals do some of these things, none of them do all of them!

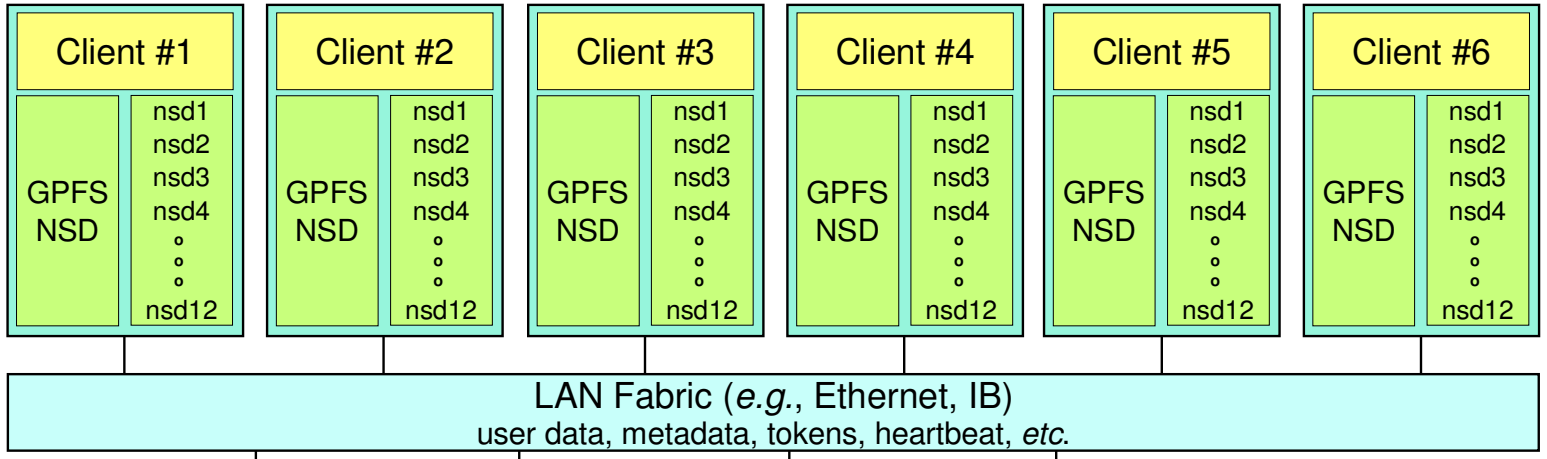
- *General*: supports wide range of applications and configurations
- *Cluster:* from large (4000+ in a multi-cluster) to small (only 1 node) clusters
- *Parallel:* user data and metadata flows between all nodes and all disks in parallel
- *HPC:* supports high performance applications
- Flexible: tuning parameters allow GPFS to be adapted to many environments
- *Capacity:* from high (4+ PB) to low capacity (only 1 disk)
- *Global*: Works across multiple nodes, clusters and labs *(i.e.,* LAN, SAN, WAN)
- *Heterogeneous:*
  - Native GPFS on AIX, Linux, Windows as well as NFS and CIFS
  - Works with almost any block storage device
- *Shared disk*: all user and meta data are accessible from any disk to any node
- *RAS*: reliability, accessibility, serviceability
- *Ease of use:* GPFS is not a black box, yet it is relatively easy to use and manage
- *Basic file system features:* POSIX API, journaling, both parallel and non-parallel access
- *Advanced features:* ILM, integrated with tape, disaster recovery, SNMP, snapshots, robust NFS support, hints

Local Area Network (LAN) Architecture

Clients Access Disks Through the Servers via the LAN

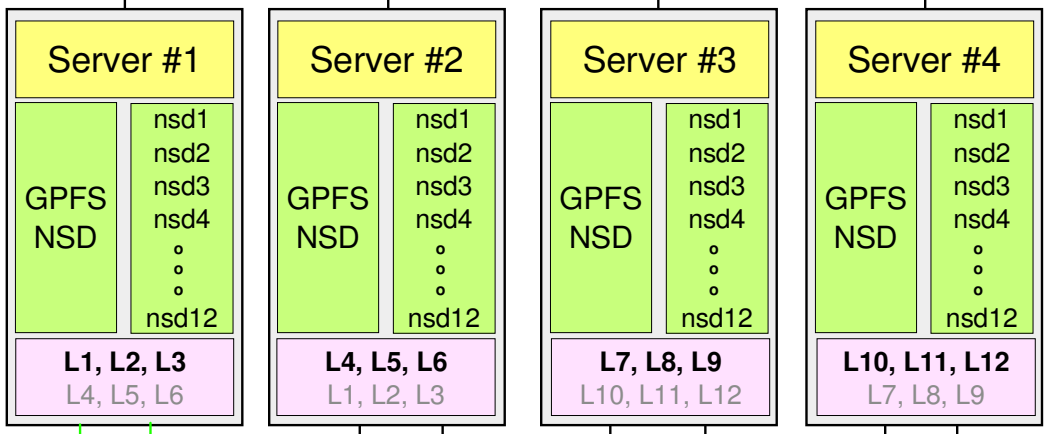
NSD

- SW layer in GPFS providing a "virtual" view of a disk
- virtual disks which correspond to LUNs in the NSD servers with a bijective mapping



LUN

- Logical Unit
- Abstraction of a disk
  - AIX - hdisk
  - Linux - SCSI device
- LUNs map to RAID arrays in a disk controller or "physical disks" in a server



Redundancy

Each server has 2 connections to the disk controller providing redundancy

Redundancy

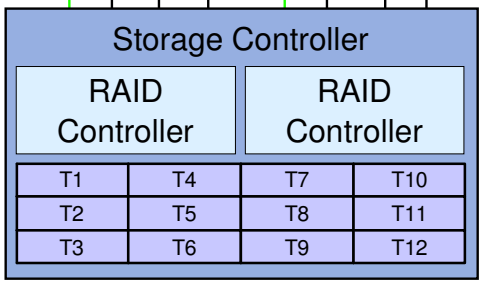
Each LUN can have upto 8 servers. If a server fails, the next one in the list takes over.

There are 2 servers per NSD, a primary and backup server.

SAN switch can be added if desired.

No single points of failure

- primary/backup servers for each LUN
- controller/host connection fail over
- Dual RAID controllers



DCS9900 RAID sets are called "tiers".

Zoning

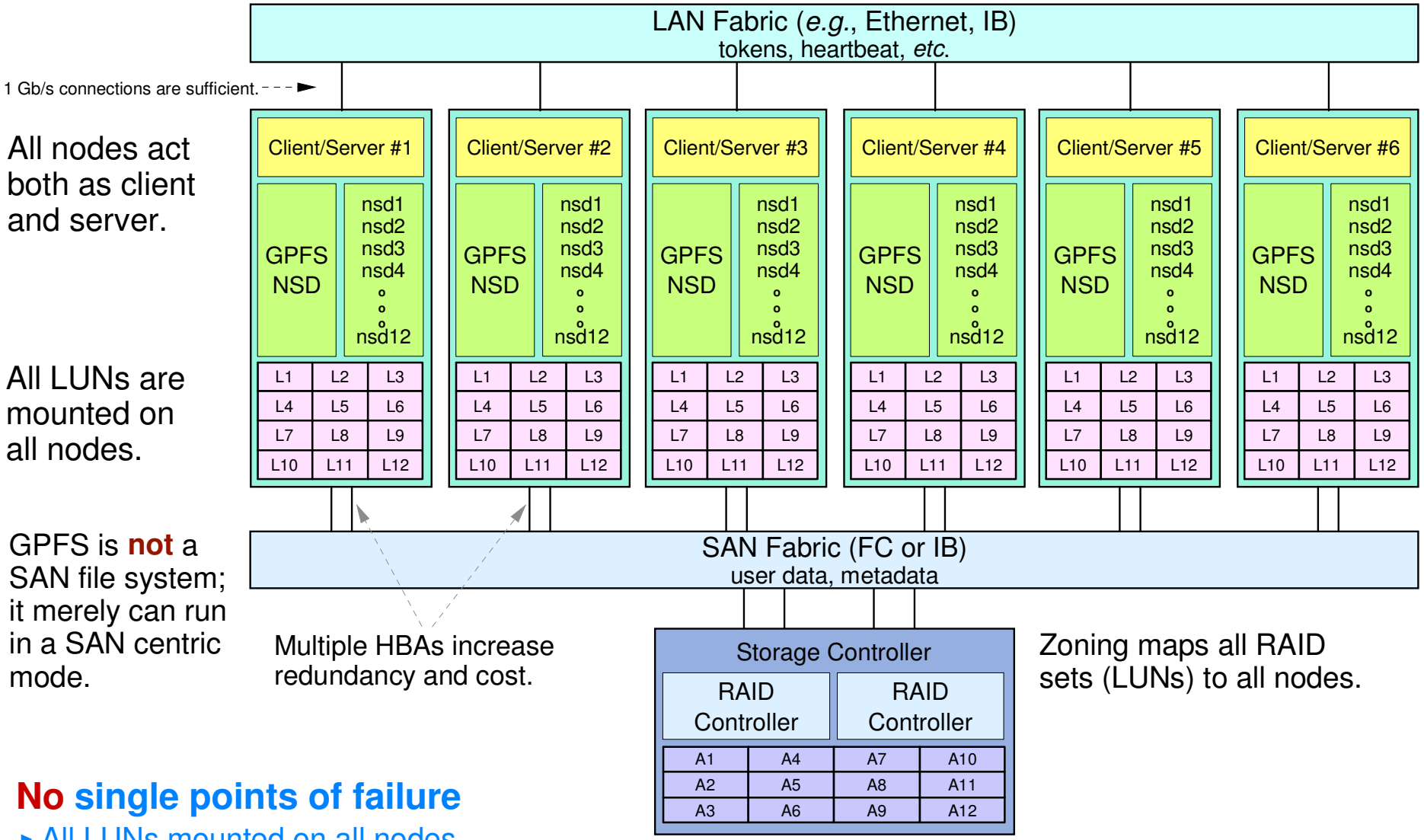
- Zoning is the process by which RAID sets are assigned to controller ports and HBAs
- GPFS achieves its best performance by mapping each RAID array to a single LUN in the host.

Twin Tailing

- For redundancy, each RAID array is zoned to appear as a LUN on 2 or more hosts.

SAN (Storage Area Network) Architecture

Client/Servers Access Disk via the SAN



All nodes act both as client and server.

All LUNs are mounted on all nodes.

GPFS is **not** a SAN file system; it merely can run in a SAN centric mode.

Multiple HBAs increase redundancy and cost.

Zoning maps all RAID sets (LUNs) to all nodes.

No single points of failure

- All LUNs mounted on all nodes
- SAN connection (FC or IB) fail over
- Dual RAID controllers

CAUTION:

Not recommended for SANs with > 32 host ports. Scaling beyond this requires special tuning (*e.g.*, set queue depth very small).

The following pages explain selected parameters and features and offer configuration guidelines of special interest for the GPFS/DCS9900 storage system.

DCS9900

Couplet Front View

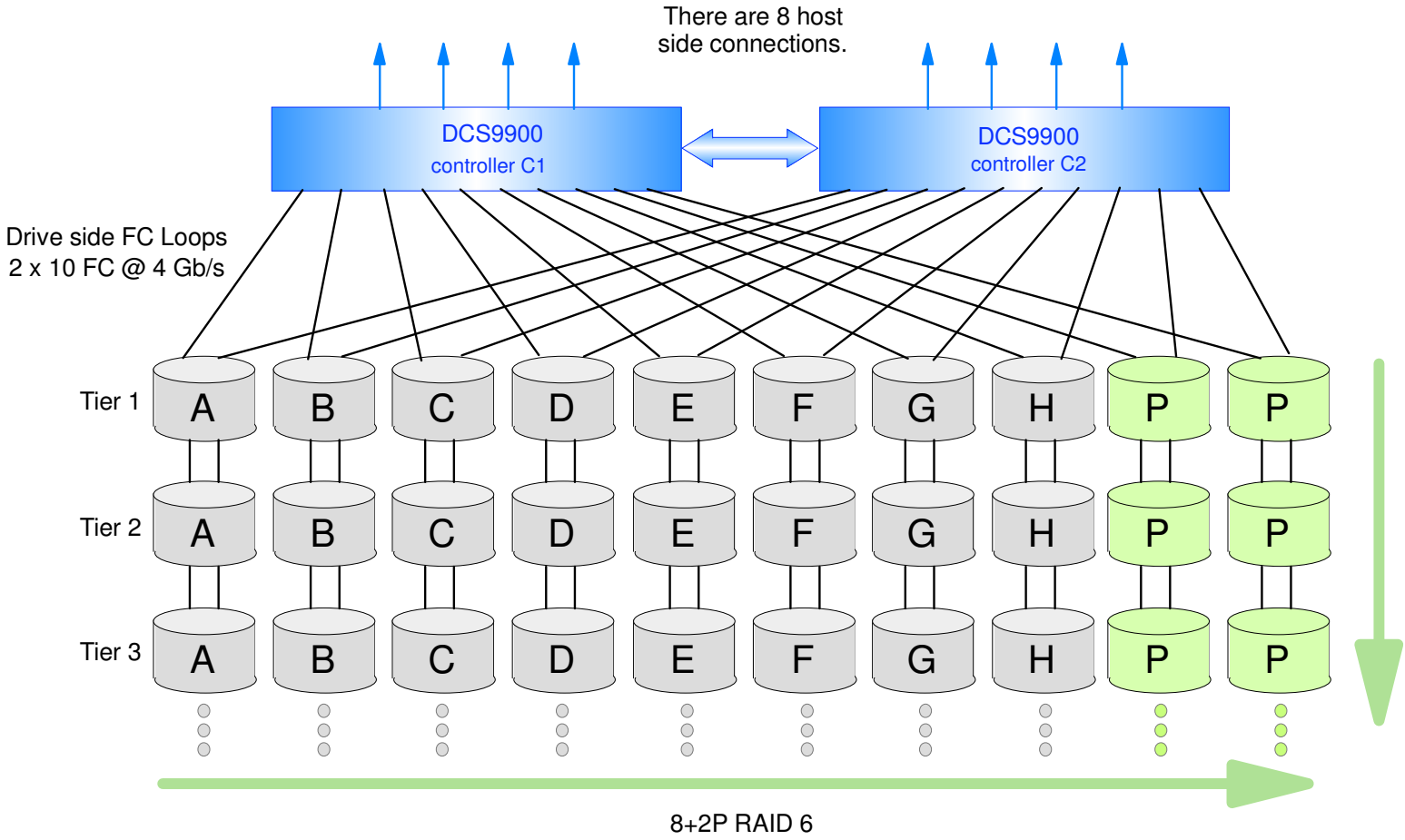
Rear View of "Half of a Couplet"

A single couplet can support up to 1200 disks (i.e., 2 frames).

10 Disk Enclosures per Frame
60 Disks per Enclosure
4u per Enclosure

Configuration and Parameter Explanation and Guidelines

- **The DCS9900 is a RAID 6 configuration using 8 data disks and 2 parity disks (*i.e.*, 8+2P)**
- **Host side connections: 2 options**
  - Infiniband (IB) - 4xDDR2
  - Fibre Channel (FC) - 8 Gb/s
- **Supported LUN block sizes**
  - 512, 1024, 2048, 4096 bytes
  - GPFS only supports 512 bytes
- **Maximum number of disks**
  - 1200 disks



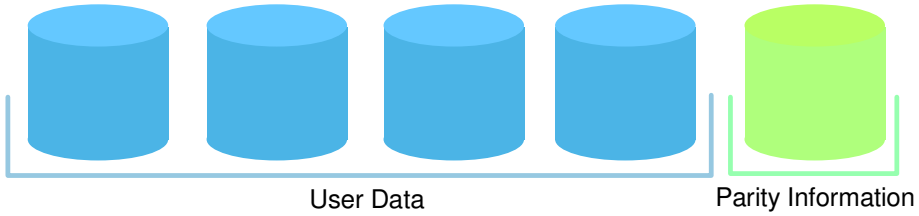
COMMENTS

- Recommend creating only 1 LUN per tier for GPFS
- Supports byte striping
- Provides dual disk failure protection
- Parity is computed for each write I/O operation
- Parity is checked for each read I/O operation

RAID 6 on a DCS9900

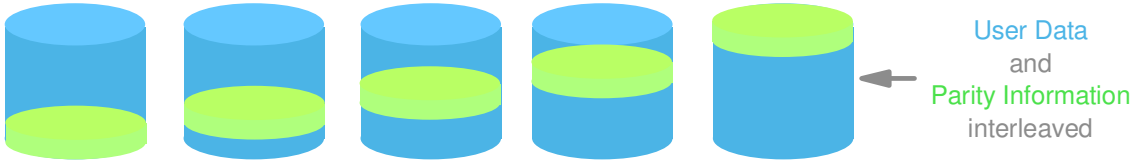
- **RAID 6 can either be an extension of RAID 3 or RAID 5**
- **The DCS9900 implements RAID 6 as a RAID 3 extension.**

- RAID 3, 4+P



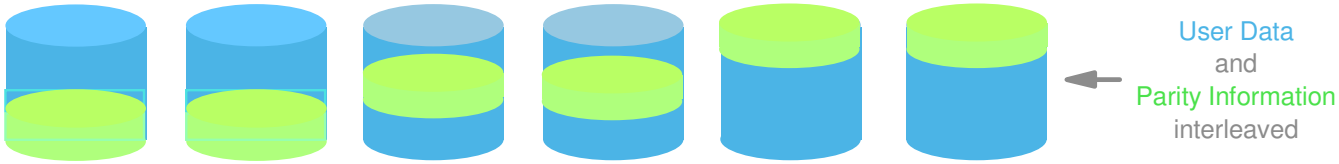
Editorial Note: Fewer disks per tier is used to simplify this drawing.

- RAID 5, 4+P



- RAID 6*, 4+2P
  RAID 3 extension

- RAID 6*, 4+2P
  RAID 5 extension



* Since RAID 6 group has 2 redundant disks, it is common to make the RAID group larger (e.g., 8+2p)

Configuration and Parameter Explanation and Guidelines

DCS9900 Cache Organization

- There is 2.5 GB of cache per RAID controller for a total of 5 GB
- The cache page size is a configurable parameter
  - set this using the command "cache size=<int>"
    - valid choices are 64, 128, 256, 512, 1024, 2048, 4096 (units are in KB)
  - **Best Practice**: set the cache size to 1024, 2048 or 4096
    - optimum streaming performance occurs for any of these values
    - if GPFS blocksize is 2M or 4M, then cache size = 1024 or 2048 or 4096 gives same performance (n.b., a cache size smaller than the GPFS blocksize is OK!)

Setting the OS transfer size

- Set cache page size >= OS transfer size
  - **Best Practice**: set them to be the same value
- AIX
  - chdev -l fcs<int> -a max_xfer_size=<hex value>
    - default = 0x100000 (i.e., 1 MB)
- Linux
  - set the max_sectors_kb parameter to the DCS9900 cache size
  - located in /sys/block/<SCSI device name>/queue/max_sectors_kb
  - typical SCSI device names are sdb, sdc, sdd, sde, ...

Configuration and Parameter Explanation and Guidelines

Write Caching: Write Back *vs.* Write Thru

- Enabling write back caching instructs the DCS9900 to write data blocks to cache and return control to the OS; data in the cache is actually written to disk later. If write thru caching is enabled, all data is written *both* to cache and disk before control is returned to the OS.
- Enable write back caching using the command "cache writeback=on"
  - warning: if a controller fails, all data in its cache will be lost, possibly before it is written to disk
    - This can corrupt the file system since metadata can be lost.
    - Adopt proper risk management procedures if write back caching is enabled.
- Enable write thru by setting "cache writeback=off"
  - **Best Practice**: disable write back caching
    - this will significantly degrade performance

Cache coherence

- The DCS9900 has the concept of "LUN ownership" or "LUN affinity". The controller in the couplet that created the LUN owns that LUN.
- Both controllers in a DCS9900 couplet can *both* see a given LUN (even though only one of them created it) iff cache coherence is enabled
- Cache coherence generally has a minimal performance degradation
- **Best Practice**: Enable cache coherence using the command "dual coherency=on"

Configuration and Parameter Explanation and Guidelines

Read Caching: Prefetch

- DCS9900 read caching uses a prefetch algorithm. The setting for this parameter is dependent on the GPFS block allocation map setting.
- **Best practice**: set GPFS block allocation map to scatter
  - assumes that number of nodes > 8 or number of LUNs > 8
  - scatter vs. cluster
    - There are 2 block allocation map types for GPFS: scatter or cluster
    - scatter: randomly distribute file blocks over the LUN
    - cluster: write file data in clusters of contiguous disk blocks
    - COMMENT: There is no guarantee that contiguous file blocks on disk will be accessed in the same order that they are mapped to disk. This problem is exacerbated by increasing "disk entropy" through repeated create/delete cycles. Scatter guarantees uniform performance for multitask jobs accessing a common file.
  - set MF bit using the command "cache mf=on"
  - disable prefetching using the command "cache prefetch=0"
    - since file blocks are randomly distributed, prefetching hurts performance

Configuration and Parameter Explanation and Guidelines

User Data *vs.* Meta Data

- **Best Practice: Segregate User Data and Meta Data**
  - DCS9900 does streaming well, but randomly distributed small transactions not as well. Since meta data transactions are small, segregating user data and meta data can improve performance for meta data intensive operations.
- Caveats and warnings
  - Most beneficial in environments with significant meta data processing
  - Must have enough dedicated metadataOnly LUNs on controllers with good enough IOP rates to keep pace with DCS9900 LUNs.

FC Drivers

- Linux
  - GPFS uses the qla2400 driver for FC access to the DCS9900
    - this driver is AVT, not RDAC
  - Supports the DCS9900 active:active access model
- AIX
  - GPFS uses the MPIO driver in failover mode
  - Only supports an active:passive access model

Linux Multipathing

- While not officially supported, customers familiar with Linux multipathing report being are able to get it work with GPFS and the DCS9900.

Configuration and Parameter Explanation and Guidelines

Summary of Selected DCS9900 Best Practice Settings

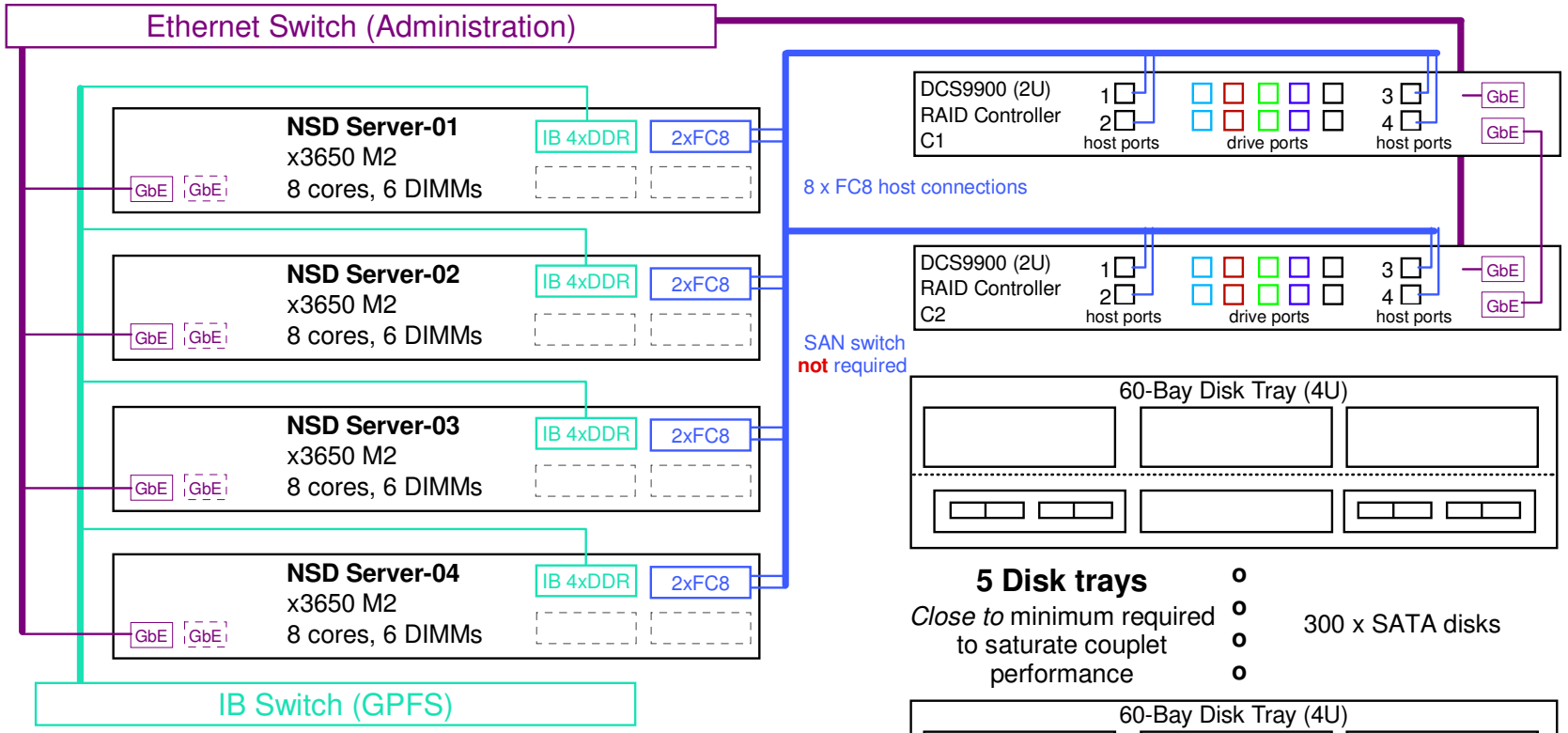
- 1 LUN per tier
- LUN block size = 512 (set interactively when the LUN is created)
- dual coherency=on
- cache size=1024 (assumes OS transfer size = 1MB)
- cache writeback=off
- cache mf=on
- cache prefetch=0
- ncq disabled

Summary of Selected GPFS Best Practice Settings

- pagepool >= 256M
- maxMBpS ~= 2X to 3X LAN connection data rate
- maxblocksize = 4096K
- blocksize = 4M (assumes objective is to optimize streaming access)
- if feasible, segregate user data and meta data
- set GPFS block allocation = scatter (i.e., mmcrfs -j scatter)

The logical configurations presented later in this report are based on the physical configuration described immediately on the following pages.

Physical Configuration



5 Disk trays

Close to minimum required to saturate couplet performance

300 x SATA disks

Performance Analysis

DCS9900 Performance

- Streaming data rate
  - write < 4.8 GB/s
  - read < 3.1 GB/s
- Noncached IOP rate
  - write < 47,000 IOP/s
  - read < 33,000 IOP/s

LAN: 4xDDR IB HCA (RDMA)

- Potential peak data rate per HCA < 1500 MB/s
- Required peak data rate per HCA < 1200 MB/s

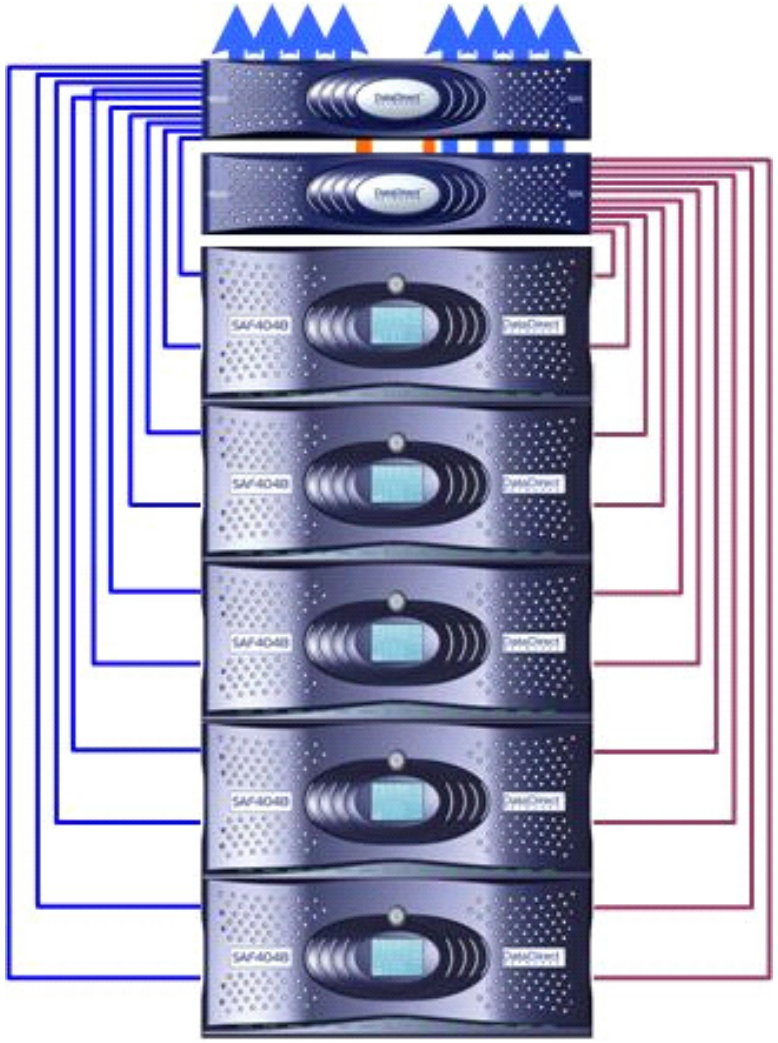
SAN: 2xFC8 (dual port 8 Gbit/s Fibre Channel)

- Potential peak data rate per 2xFC8 < 1500 MB/s
- Required peak data rate per 2xFC8 < 1200 MB/s

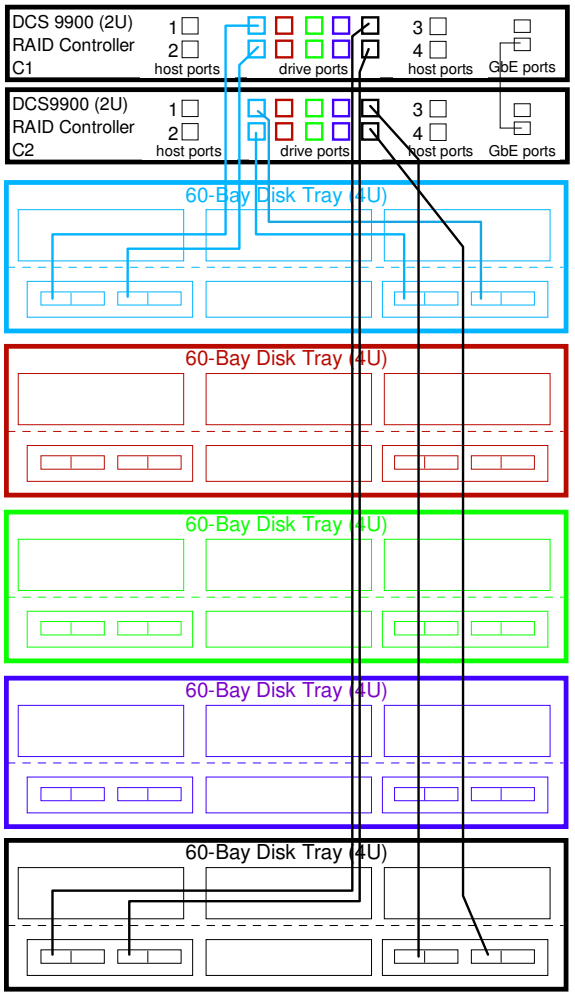
Capacity Analysis

- SATA
  - 300 disks @ 1 TB/disk
  - 30 x 8+2P RAID 6 tiers
  - raw capacity < 300 TB
  - usable capacity < 240 TB

Physical Configuration
Drive Side Cabling



Front View



Rear View

COMMENT:

In order to avoid an overly "busy" diagram, cabling is shown only to the first and last disk enclosure; the reader can easily infer the cabling to the other disk enclosures.

The following pages document several configurations using GPFS with servers and the DCS9900 to illustrate best practices and the criteria by which to judge them.

COMMENT:

In order to simplify the diagrams, they only use 24 tiers (240 disks). Remember, best practices recommend using at least 160 x 15Krpm SAS disks or 300 x SATA disks which is the minimum needed to saturate DCS9900 bandwidth.

Logical Configuration Design Criteria

LUN to Port Mapping, Primary:Backup NSD Server Mapping and Cabling

The following pages examine VARIOUS schema for

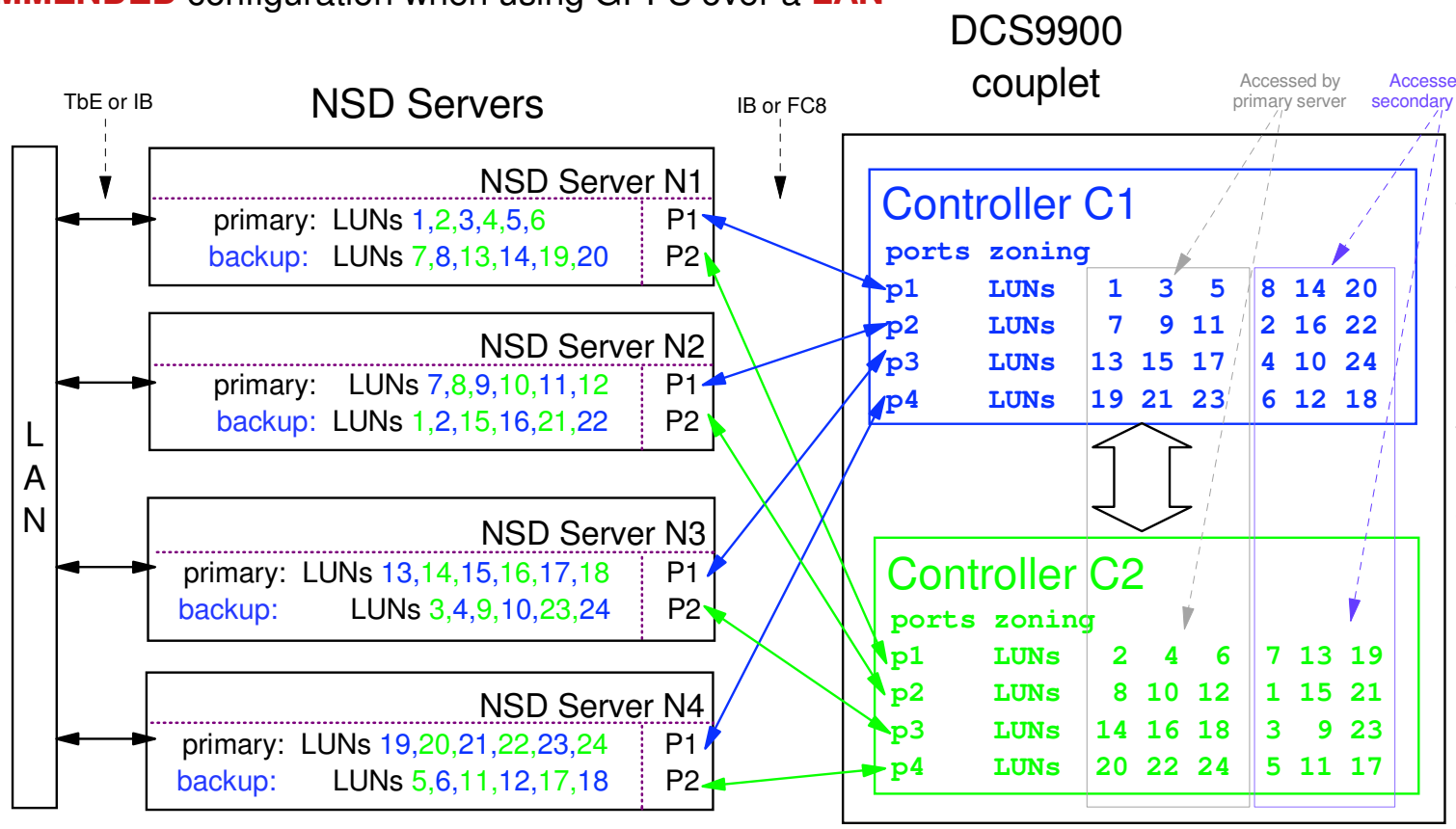
- LUN to Port Mapping (i.e., zoning) on the DCS9900 couplet
- selecting primary and backup NSD servers for each LUN
- cabling

The LAN configurations are based on the following design criteria.

1. Guarantee that all controller ports and all HBA ports are uniformly active.
   - *n.b.*, the DCS9900 supports an active:active protocol
2. If a NSD server fails, its backup server can access its LUNs.
3. Consider LUNs associated with a given HBA or controller port. If an HBA or controller port fails, GPFS failover can access the associated LUNs over alternative paths from a backup NSD server for a given LUN *in a balanced manner* (*i.e.,* do *not* access all of the affected LUNs from a single NSD server).
   - This balance condition applies to performance under degraded conditions. It results in a slightly more complex logical configuration.
4. If one of the controllers in a couplet fails, the file system remains viable using backup NSD servers to access the LUNs of the failed controller over the other controller.

Logical Configuration #1
LUN Zoning and NSD Configuration

RECOMMENDED configuration when using GPFS over a **LAN**



COMMENTS:
- The LAN provides access to GPFS clients.
- LAN connections to the NSD servers requires high speed connections (e.g., TbE or IB).

COMMENT:
Each LUN is zoned to be "twin tailed" such that the LUN can be accessed from both controllers. One access path is primary and the other is secondary; the secondary path is accessed only under adverse conditions.

COMMENTS:
- Requires TbE or other high speed LAN
- This configuration completely satisfies all 4 design criteria.
- Topologically equivalent configurations can be achieved using different cabling and zoning schema.

COMMENTS:
- C1 "owns" LUNs 1,3,5,7,9,11,13,15,17,19,21,23
- C2 "owns" LUNs 2,4,6,8,10,12,14,16,18,20,22,24
- Requires cache coherence to be enabled
  - this is a DCS9900 parameter
- Controllers and drivers support "active:active" protocol

Logical Configuration #1
Primary:Backup NSD Mapping

Suppose each NSD server has 1 internal disk; it will likely be /dev/sda. The tables below list a *likely* SCSI device name in /dev for the LUNs on each server. The LUN number is the one assigned by the DCS9550 and it is unique; the SCSI device names are not unique (e.g., LUN 1 on N1 is sdb while LUN 1 on N2 is sdh). Given this LUN to SCSI device mapping, the disk.lst file to the right can be used with the mmcrnsd command as shown. It specifies for which SCSI devices that a given NSD server is primary or backup and assigns an NSD name that corresponds to the LUN number.

Primary NSD Server | Backup NSD Server

Server	LUN	SCSI Device
N1	1	sdb
N1	3	sdc
N1	5	sdd
N1	8	sde
N1	14	sdf
N1	20	sdg
N1	2	sdh
N1	4	sdi
N1	6	sdj
N1	7	sdk
N1	13	sdl
N1	19	sdm
N2	2	sdb
N2	7	sdc
N2	9	sdd
N2	11	sde
N2	16	sdf
N2	22	sdg
N2	1	sdh
N2	8	sdi
N2	10	sdj
N2	12	sdk
N2	15	sdl
N2	21	sdm

Server	LUN	SCSI Device
N3	4	sdb
N3	10	sdc
N3	13	sdd
N3	15	sde
N3	17	sdf
N3	24	sdg
N3	3	sdh
N3	9	sdi
N3	14	sdj
N3	16	sdk
N3	18	sdl
N3	23	sdm
N4	6	sdb
N4	12	sdc
N4	18	sdd
N4	19	sde
N4	21	sdf
N4	23	sdg
N4	5	sdh
N4	11	sdi
N4	17	sdj
N4	20	sdk
N4	22	sdl
N4	24	sdm

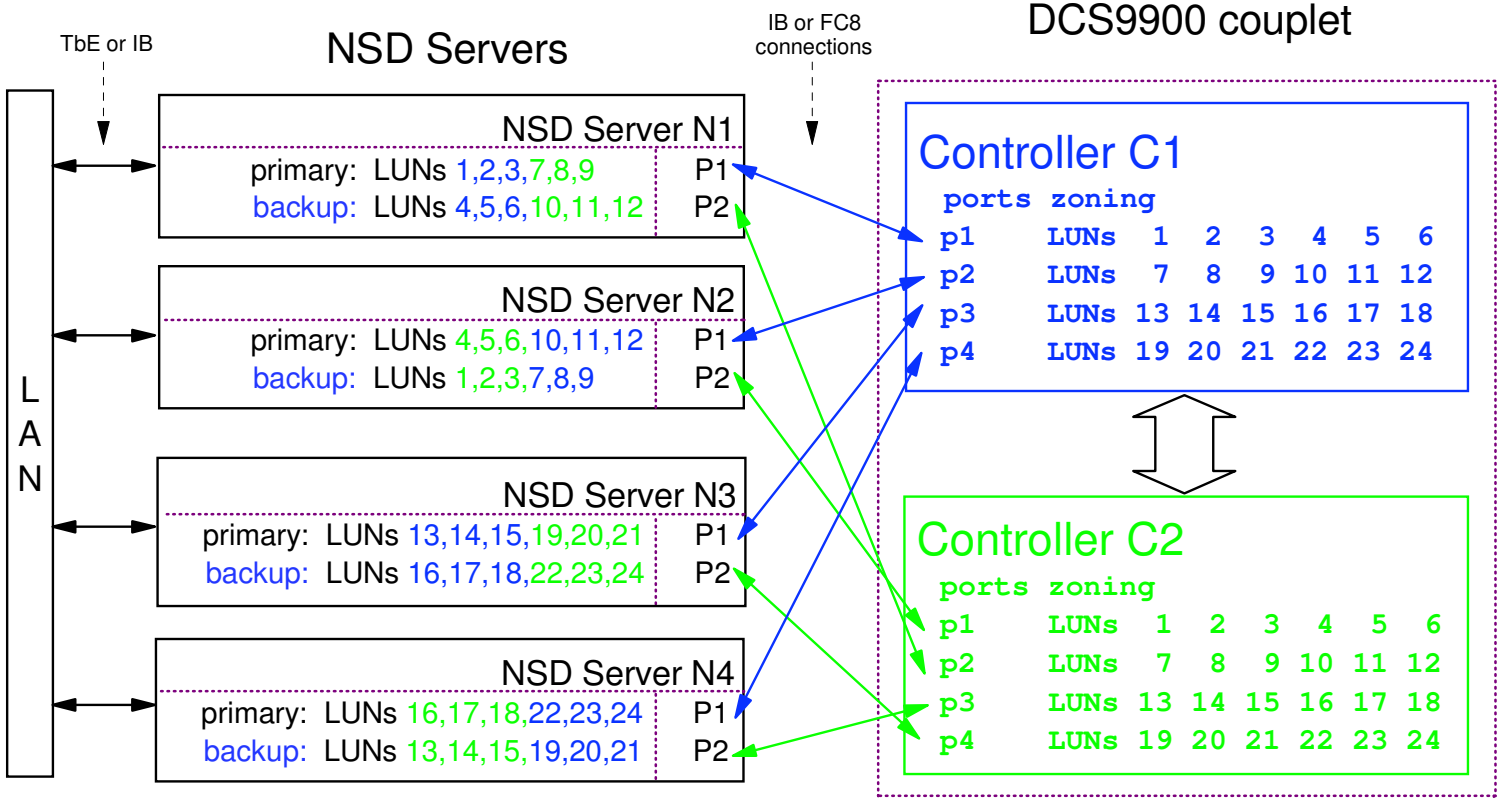
```
> cat disk.lst
/dev/sdb:N1:N2:::nsd_L1:
/dev/sdc:N1:N3:::nsd_L3:
/dev/sdd:N1:N4:::nsd_L5:
/dev/sdh:N1:N2:::nsd_L2:
/dev/sdi:N1:N3:::nsd_L4:
/dev/sdj:N1:N4:::nsd_L6:
/dev/sdc:N2:N1:::nsd_L7:
/dev/sdd:N2:N3:::nsd_L9:
/dev/sde:N2:N4:::nsd_L11:
/dev/sdi:N2:N1:::nsd_L8:
/dev/sdj:N2:N3:::nsd_L10:
/dev/sdk:N2:N4:::nsd_L12:
/dev/sdd:N3:N1:::nsd_L13:
/dev/sde:N3:N2:::nsd_L15:
/dev/sdf:N3:N4:::nsd_L17:
/dev/sdj:N3:N1:::nsd_L14:
/dev/sdk:N3:N2:::nsd_L16:
/dev/sdl:N3:N4:::nsd_L18:
/dev/sde:N4:N1:::nsd_L19:
/dev/sdf:N4:N2:::nsd_L21:
/dev/sdg:N4:N3:::nsd_L23:
/dev/sdk:N4:N1:::nsd_L20:
/dev/sdl:N4:N2:::nsd_L22:
/dev/sdm:N4:N3:::nsd_L24:
> mmcrnsd -F disk.lst -v no
```

COMMENT:
Since the SCSI device names are not unique between nodes, there can be some confusion in specifying the backup NSD server. The basic idea is to specify the backup NSD server on the same line as the primary server using the SCSI device name known to the primary server (GPFS will write unique identifiers on each LUN so that it can keep the LUN mappings straight). For example, LUN 1 is known as /dev/sdb on its primary NSD server, N1, but it is known as /dev/sdh on its backup NSD server, N2; nonetheless, the backup NSD server assignment is specified from the perspective of the primary server N1 where it is known as /dev/sdb. NSD device names are chosen to reflect the unique LUN ID.

Logical Configuration #1A

LUN Zoning and NSD Configuration: A Simpler Alternative

A **SIMPLER** alternative configuration when using GPFS over a **LAN**



COMMENTS:

- The LAN provides access to GPFS clients.
- LAN connections to the NSD servers require high speed connections (e.g., TbE or IB).

COMMENTS:

- Requires TbE or other high speed LAN
- This is configuration relaxes the balance requirement in design criterion #3 resulting in a simpler logical design. However, if a HBA or controller port fails, then all of the LUNs that are primary on that path will be serviced by the same backup node creating a bottleneck.
- Topologically equivalent configurations can be achieved using different cabling and zoning schema.

COMMENTS:

- C1 "owns" LUNs 1..12
- C2 "owns" LUNs 13..24
- Requires cache coherence to be enabled
  - this is a DCS9900 parameter
- Controllers and drivers support "active:active" protocol

Logical Configuration #1A
Primary:Backup NSD Mapping

Suppose each NSD server has 1 internal disk; it will most likely be /dev/sda.

By issuing the following commands
> modprobe -r qla2400
> modprobe -i qla2400
the LUN to SCSI device mapping in the table immediately to the right is likely.

The disk.lst file to the far right can be used as the input file to the mmcrnsd command to designate the primary and secondary NSD servers for each LUN (i.e., SCSI device)

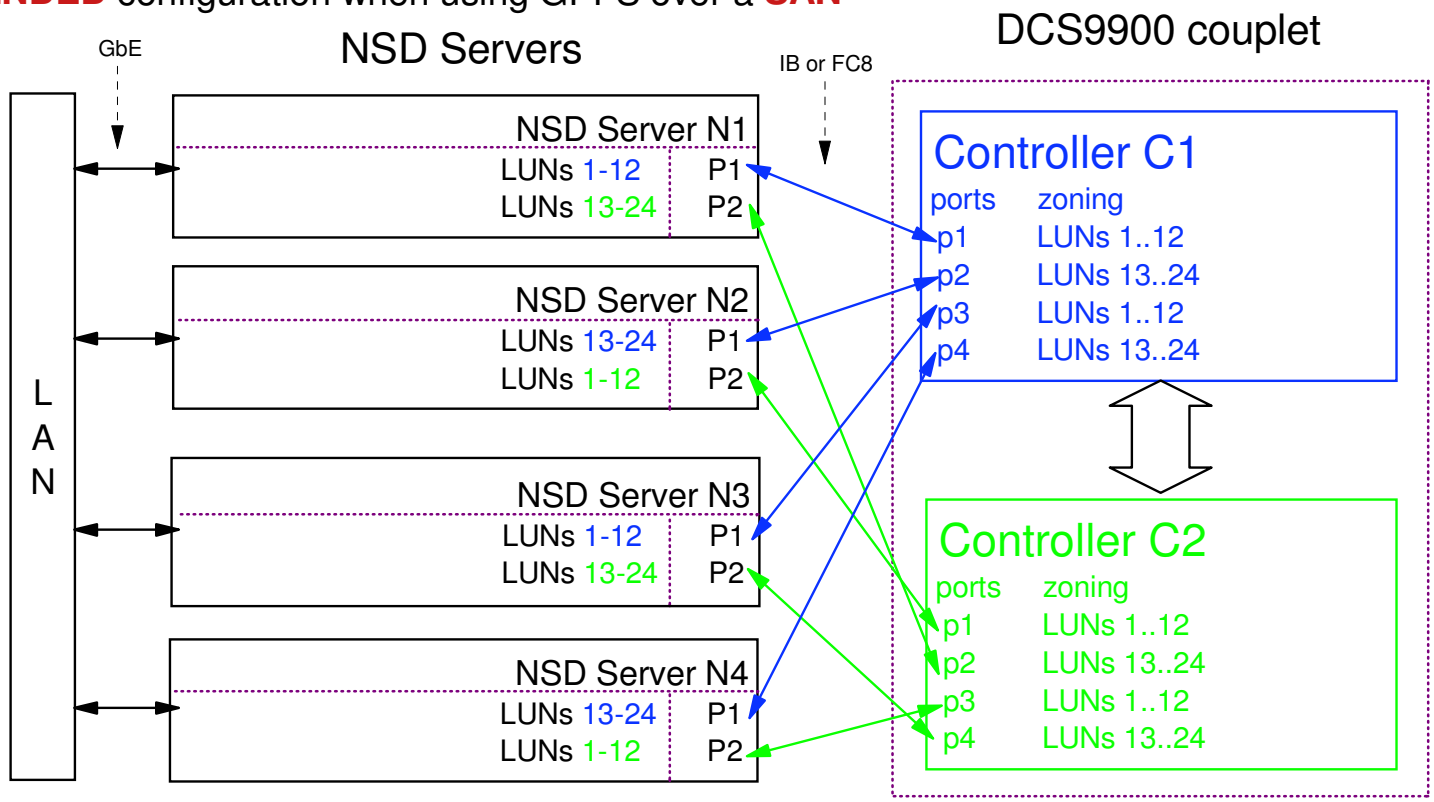
COMMENT:
In this example the SCSI device names are the same on each NSD server for a given LUN; for example, LUN 1 is known as /dev/sdb on both nodes N1 and N2. This avoids the confusion associated with the previous logical configuration, but backup NSD server assignments are not balanced under degraded conditions (e.g., a FC port fails).

LUN	SCSI Device
1	sdb
2	sdc
3	sdd
4	sde
5	sdf
6	sdg
7	sdh
8	sdi
9	sdj
10	sdk
11	sdl
12	sdm
13	sdb
14	sdc
15	sdd
16	sde
17	sdf
18	sdg
19	sdh
20	sdi
21	sdj
22	sdk
23	sdl
24	sdm

```
> cat disk.lst
/dev/sdb:N1:N2:::nsd_L1:
/dev/sdc:N1:N2:::nsd_L2:
/dev/sdd:N1:N2:::nsd_L3:
/dev/sde:N2:N1:::nsd_L4:
/dev/sdf:N2:N1:::nsd_L5:
/dev/sdg:N2:N1:::nsd_L6:
/dev/sdh:N1:N2:::nsd_L7:
/dev/sdi:N1:N2:::nsd_L8:
/dev/sdj:N1:N2:::nsd_L9:
/dev/sdk:N2:N1:::nsd_L10:
/dev/sdl:N2:N1:::nsd_L11:
/dev/sdm:N2:N1:::nsd_L12:
/dev/sdb:N3:N4:::nsd_L13:
/dev/sdc:N3:N4:::nsd_L14:
/dev/sdd:N3:N4:::nsd_L15:
/dev/sde:N4:N3:::nsd_L16:
/dev/sdf:N4:N3:::nsd_L17:
/dev/sdg:N4:N3:::nsd_L18:
/dev/sdh:N3:N4:::nsd_L19:
/dev/sdi:N3:N4:::nsd_L20:
/dev/sdj:N3:N4:::nsd_L21:
/dev/sdk:N4:N3:::nsd_L22:
/dev/sdl:N4:N3:::nsd_L23:
/dev/sdm:N4:N3:::nsd_L24:
> mmcrnsd -F disk.lst -v no
```

Logical Configuration #2
LUN Zoning and NSD Configuration

RECOMMENDED configuration when using GPFS over a **SAN**



COMMENTS:
- The LAN is only used for GPFS administration.
- There are no other GPFS clients.
- GbE is adequate.

COMMENTS:
- GbE provides adequate BW for this configuration.
- Topologically equivalent configurations can be achieved using different cabling and zoning schema.
- The design criteria for an NSD configuration do not generally apply to a SAN configuration; they are either irrelevant or naturally satisfied. The main criterion to pay attention to is to be sure that the zoning is set up so that all controller ports and all HBA ports are uniformly active.

COMMENTS:
- C1 "owns" LUNs 1..12
- C2 "owns" LUNs 13..24
- Requires cache coherence to be enabled
  - this is a DCS9900 parameter
- Controllers and drivers support "active:active" protocol

Logical Configuration #2

NSD Mapping

In a SAN configuration, since all LUNs are zoned so that they are mounted on all nodes, there is no need to specify primary and backup servers. All nodes directly access the LUNs over the FC network and do not use the IP network to access user data from disk.

Suppose each NSD server has 1 internal disk; it will most likely be /dev/sda.

By issuing the following commands

> modprobe -r qla2400

> modprobe -i qla2400

the LUN to SCSI device mapping in the table immediately to the right is likely.

The disk.lst file to the far right can be used as the input file to the mmcrnsd command to designate the primary and secondary NSD servers for each LUN (i.e., SCSI device)

LUN	SCSI Device
1	sdb
2	sdc
3	sdd
4	sde
5	sdf
6	sdg
7	sdh
8	sdi
9	sdj
10	sdk
11	sdl
12	sdm
13	sdn
14	sdo
15	sdp
16	sdq
17	sdr
18	sds
19	sdt
20	sdu
21	sdv
22	sdw
23	sdx
24	sdy

```
> cat disk.lst
/dev/sdb:::dataOnly::nsd_L1:
/dev/sdc:::dataOnly::nsd_L2:
/dev/sdd:::dataOnly::nsd_L3:
/dev/sde:::dataOnly::nsd_L4:
/dev/sdf:::dataOnly::nsd_L5:
/dev/sdg:::dataOnly::nsd_L6:
/dev/sdh:::dataOnly::nsd_L7:
/dev/sdi:::dataOnly::nsd_L8:
/dev/sdj:::dataOnly::nsd_L9:
/dev/sdk:::dataOnly::nsd_L10:
/dev/sdl:::dataOnly::nsd_L11:
/dev/sdm:::dataOnly::nsd_L12:
/dev/sdn:::dataOnly::nsd_L13:
/dev/sdo:::dataOnly::nsd_L14:
/dev/sdp:::dataOnly::nsd_L15:
/dev/sdq:::dataOnly::nsd_L16:
/dev/sdr:::dataOnly::nsd_L17:
/dev/sds:::dataOnly::nsd_L18:
/dev/sdt:::dataOnly::nsd_L19:
/dev/sdu:::dataOnly::nsd_L20:
/dev/sdv:::dataOnly::nsd_L21:
/dev/sdw:::dataOnly::nsd_L22:
/dev/sdx:::dataOnly::nsd_L23:
/dev/sdy:::dataOnly::nsd_L24:
> mmcrnsd -F disk.lst -v no
```

EXAMPLE

The following pages provide an actual example of installing and configuring GPFS under Linux using 4 x3650 NSD servers and a DCS9550 storage controller and disk enclosures. The steps for doing this under AIX are very similar; differences are explained in the annotations.

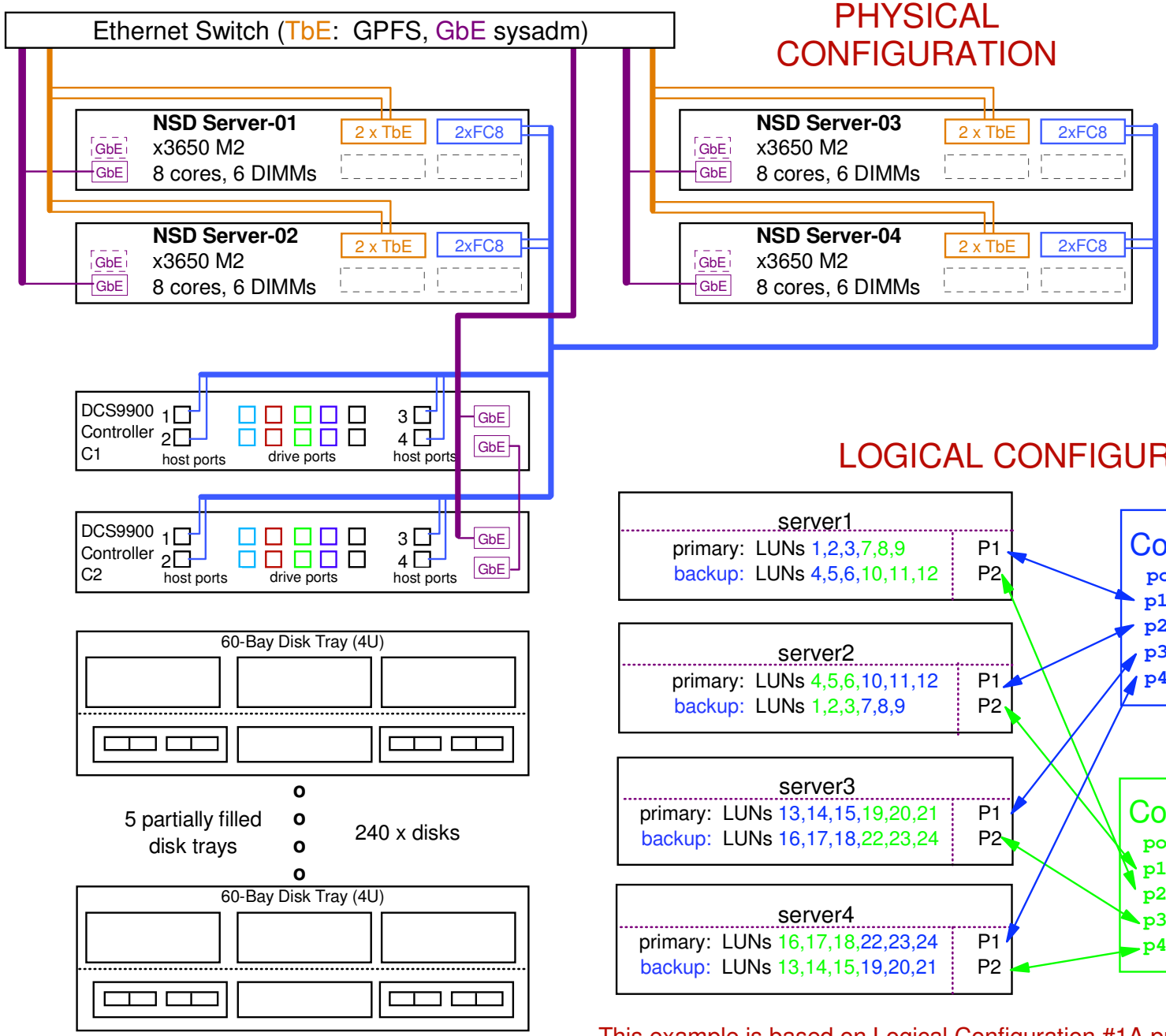
Note the following:

red arial font is used for annotations

`blue courier` font is used to highlight commands and parameters

`black courier` font is used for screen text

EXAMPLE: Installing and Configuring GPFS



The diagrams on this page illustrate the physical and logical configurations used in this example.

This example is based on Logical Configuration #1A presented earlier in this slide set.

EXAMPLE: Installing and Configuring GPFS

Outline of Steps to Install and Configure GPFS

1. Install the GPFS code
2. Build portability layer

It is only necessary to build the portability layer under Linux.

3. Configure a GPFS File System
   a. Create cluster
   b. Change global GPFS parameters and start the GPFS daemon
   c. Create the NSDs
   d. Create and Mount the file system

EXAMPLE: Installing and Configuring GPFS

Steps to Install the GPFS Code under Linux

The steps to install the GPFS code under AIX are quite different. See the note below for a reference.

1. Create an NFS mounted installation directory for extracting the RPMs
2. Copy base version RPMs to the installation directory and extract the RPMs on all nodes in the GPFS cluster.
   - gpfs.base-3.1.0-1.x86_64.rpm
   - gpfs.gpl-3.1.0-1.noarch.rpm
   - gpfs.msg.en_US-3.1.0-1.noarch.rpm
   - gpfs.docs-3.1.0-1.noarch.rpm

   It is necessary to purchase the base version. It is generally delivered via CD-ROM.
3. Download the latest update package. This comes as a tar/gzip file from
   - https://www14.software.ibm.com/webapp/set2/sas/f/gpfs/download/home.html
   - gpfs-3.1.0-12.x86_64.update.tar.gz
4. Copy this file to the installation directory, then gunzip/utar this file, and extract the RPMs on all nodes in the GPFS cluster.

The steps for doing this are more thoroughly documented in chapter 4 of the *GPFS Concepts, Planning and Installation Guide*
The steps for installing the GPFS code under AIX are documented in chapter 5 of the *GPFS Concepts, Planning and Installation Guide*
The *GPFS Concepts, Planning and Installation Guide be found* on the web at
http://publib.boulder.ibm.com/infocenter/clresctr/vxrx/index.jsp?topic=/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfs_com_faq.html

EXAMPLE: Installing and Configuring GPFS

Build and Install the GPFS Portability Layer for Linux

Building the portability layer is only necessary for Linux. This page can be skipped for AIX.

1. It is necessary to repeat the following steps for each Linux distribution and version in the GPFS cluster.
2. Select a node in the cluster and do the following…
   - cd /usr/lpp/mmfs/src
   - export SHARKCLONEROOT=/usr/lpp/mmfs/src
   - make Autoconfig
     - This step "tweaks" a make file called site.mcr for the Linux installed distribution. If this step fails, manually edit the site.mcr file as described in /usr/lpp/mmfs/src/README.
   - make World
   - make InstallImages
   - echo $?
3. Copy the following modules that were just made to all other nodes in the cluster running under the same Linux distribution and version.
   - dumpconv, lxtrace, mmfslinux, mmfs26, tracedev

The steps for doing this are more thoroughly documented in chapter 4 of the *GPFS Concepts, Planning and Installation Guide*. It can be found on the web at

http://publib.boulder.ibm.com/infocenter/clresctr/vxrx/index.jsp?topic=/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfs_com_faq.html

EXAMPLE: Installing and Configuring GPFS

Create the GPFS Cluster

```
[root@gpfs1 gpfs_install]# cat node_spec.lst
server1:quorum
server2:quorum
server3:quorum
server4:quorum
```

A small number of nodes must be declared as quorum nodes. A GPFS cluster must have ½ of the quorum nodes + 1 running for the daemon to remain in active state.

```
[root@gpfs1 gpfs_install]# mmcrcluster -n node_spec.lst -p server1 -s server2 -R
/usr/bin/scp -r /usr/bin/ssh
Thu May 31 12:26:59 CDT 2007: mmcrcluster: Processing node server1
Thu May 31 12:26:59 CDT 2007: mmcrcluster: Processing node server2
Thu May 31 12:27:00 CDT 2007: mmcrcluster: Processing node server3
Thu May 31 12:27:00 CDT 2007: mmcrcluster: Processing node server4
mmcrcluster: Command successfully completed
mmcrcluster: Propagating the cluster configuration data to all affected nodes.
This is an asynchronous process.
```

Create the GPFS cluster.

This is a common and routine message. GPFS is using ssh and scp to copy configuration information to all of the nodes asynchronously. It may be that the node on which the command is executed may complete before all of the other nodes are ready.

mmcrcluster parameters
-n: list of nodes to be included in the cluster
-p: primary GPFS cluster configuration server node
-s: secondary GPFS cluster configuration server node
-R: remote copy command (e.g., rcp or scp)
-r: remote shell command (e.g., rsh or ssh)

EXAMPLE: Installing and Configuring GPFS

Create the GPFS Cluster

```
[root@gpfs1 gpfs_install]# mmlscluster
```

"List" the cluster to verify that the cluster is created as intended

```
GPFS cluster information
========================
  GPFS cluster name:         server1
  GPFS cluster id:           9912599153855104355
  GPFS UID domain:           server1
  Remote shell command:      /usr/bin/ssh
  Remote file copy command:  /usr/bin/scp

GPFS cluster configuration servers:
-----------------------------------
  Primary server:    server1
  Secondary server:  server2

 Node  Daemon node name            IP address       Admin node name        Designation
-------------------------------------------------------------------------------------
   1   server1                     192.168.0.1      server1                quorum
   2   server2                     192.168.0.2      server2                quorum
   3   server3                     192.168.0.3      server3                quorum
   4   server4                     192.168.0.4      server4                quorum
```

EXAMPLE: Installing and Configuring GPFS

Change Global GPFS Parameters and Start the Daemon

Change selected global parameters.

```
[root@gpfs1 gpfs_install]# mmchconfig maxMBpS=2000,maxblocksize=4m,pagepool=256m,autoload=yes
mmchconfig: Command successfully completed
mmchconfig: Propagating the cluster configuration data to all affected nodes.  This is an
synchronous process.
[root@gpfs1 gpfs_install]# mmlsconfig
Configuration data for cluster server1:
-----------------------------------------------------------
clusterName server1
clusterId 9912599153855104355
clusterType lc
autoload yes
useDiskLease yes
maxFeatureLevelAllowed 913
maxMBpS 2000
maxblocksize 4m
pagepool 256m
[hofs518]
takeOverSdrServ no

File systems in cluster server1:
---------------------------------------------------------
(none)

[root@gpfs1 gpfs_install]# mmstartup -a
Thu May 31 12:29:38 CDT 2007: mmstartup: Starting GPFS ...
[root@gpfs1 gpfs_install]# mmgetstate -a

 Node number  Node name        GPFS state
------------------------------------------
       1      server1          active
       2      server2          active
       3      server3          active
       4      server4          active
```

"List" the global parameters to verify that they are set as intended.

Start the GPFS daemon (aka, mmfsd)

Be sure mmfsd is active on all nodes before proceding.

EXAMPLE: Installing and Configuring GPFS

Create the NSDs

```
[root@gpfs1 gpfs_install]# cat disk.lst
/dev/sda9:server1::metadataOnly::nsd_meta1:
/dev/sda9:server2::metadataOnly::nsd_meta2:
/dev/sda9:server3::metadataOnly::nsd_meta3:
/dev/sda9:server4::metadataOnly::nsd_meta4:
/dev/sdb:server1,server2::dataOnly::nsd_L1:
/dev/sdc:server1,server2::dataOnly::nsd_L2:
/dev/sdd:server1,server2::dataOnly::nsd_L3:
/dev/sde:server2,server1::dataOnly::nsd_L4:
/dev/sdf:server2,server1::dataOnly::nsd_L5:
/dev/sdg:server2,server1::dataOnly::nsd_L6:
/dev/sdh:server1,server2::dataOnly::nsd_L7:
/dev/sdi:server1,server2::dataOnly::nsd_L8:
/dev/sdj:server1,server2::dataOnly::nsd_L9:
/dev/sdk:server2,server1::dataOnly::nsd_L10:
/dev/sdl:server2,server1::dataOnly::nsd_L11:
/dev/sdm:server2,server1::dataOnly::nsd_L12:
/dev/sdb:server3,server4::dataOnly::nsd_L13:
/dev/sdc:server3,server4::dataOnly::nsd_L14:
/dev/sdd:server3,server4::dataOnly::nsd_L15:
/dev/sde:server4,server3::dataOnly::nsd_L16:
/dev/sdf:server4,server3::dataOnly::nsd_L17:
/dev/sdg:server4,server3::dataOnly::nsd_L18:
/dev/sdh:server3,server4::dataOnly::nsd_L19:
/dev/sdi:server3,server4::dataOnly::nsd_L20:
/dev/sdj:server3,server4::dataOnly::nsd_L21:
/dev/sdk:server4,server3::dataOnly::nsd_L22:
/dev/sdl:server4,server3::dataOnly::nsd_L23:
/dev/sdm:server4,server3::dataOnly::nsd_L24:
[root@gpfs1 gpfs_install]# cp disk.lst disk.lst.orig
```

First create a file and back up file listing the NSD specifications (*n.b.*, this is an input/output file to the mmcrnsd command).

The format for each line is as follows
f1:f2::f3:f4:f5:f6:
where
- f1 = scsi device
- f2 = comma seperate NSD server list
  there can be upto 8 NSD servers
- f3 = usage
- f4 = failure group
- f5 = NSD name
- f6 = storage pool name

Fields left blank are filled with default value

Under AIX, the mount points for the LUNs are called hdisks. For example, the line for /dev/sdf would look like this under AIX:
hdisk6:server2,server1::dataOnly::nsd_L5

NSD = Network Storage Device

In this context, you can think of an NSD as a “logical device”. In reality, it is a TCP socket allowing the GPFS clients to access the SCSI devices on the primary NSD server or the backup NSD server if the primary server is not available.

EXAMPLE: Installing and Configuring GPFS

Create the NSDs

```
[root@gpfs1 gpfs_install]# mmcrnsd -F disk.lst -v no
mmcrnsd: Processing disk sda9
mmcrnsd: Processing disk sda9
mmcrnsd: Processing disk sda9
mmcrnsd: Processing disk sda9
mmcrnsd: Processing disk sdb
mmcrnsd: Processing disk sdc
mmcrnsd: Processing disk sdd
mmcrnsd: Processing disk sde
mmcrnsd: Processing disk sdf
mmcrnsd: Processing disk sdg
mmcrnsd: Processing disk sdh
mmcrnsd: Processing disk sdi
mmcrnsd: Processing disk sdj
mmcrnsd: Processing disk sdk
mmcrnsd: Processing disk sdl
mmcrnsd: Processing disk sdm
mmcrnsd: Processing disk sdb
mmcrnsd: Processing disk sdc
mmcrnsd: Processing disk sdd
mmcrnsd: Processing disk sde
mmcrnsd: Processing disk sdf
mmcrnsd: Processing disk sdg
mmcrnsd: Processing disk sdh
mmcrnsd: Processing disk sdi
mmcrnsd: Processing disk sdj
mmcrnsd: Processing disk sdk
mmcrnsd: Processing disk sdl
mmcrnsd: Processing disk sdm
mmcrnsd: Propagating the cluster configuration data to all affected nodes.  This is an
asynchronous process.
```

The mmcrnsd parameters are

-F: name of the NSD specification file (*n.b.*, the file is changed by this command… keep a back up!)

-v: check if this disk is part of an existing GPFS file system or ever had a GPFS file system on it (*n.b.*, if it does/did and the parameter is yes, then mmcrnsd will not create it as a new NSD)

EXAMPLE: Installing and Configuring GPFS

Create the NSDs

```
[root@gpfs1 gpfs_install]# mmlsnsd
```

Verify that the NSDs were properly created.

```
 File system   Disk name    Primary node             Backup node
---------------------------------------------------------------------------
 (free disk)   nsd_lun10    server2                  server1
 (free disk)   nsd_lun11    server2                  server1
 (free disk)   nsd_lun12    server2                  server1
 (free disk)   nsd_lun13    server3                  server4
 (free disk)   nsd_lun14    server3                  server4
 (free disk)   nsd_lun15    server3                  server4
 (free disk)   nsd_lun16    server4                  server3
 (free disk)   nsd_lun17    server4                  server3
 (free disk)   nsd_lun18    server4                  server3
 (free disk)   nsd_lun19    server3                  server4
 (free disk)   nsd_lun1     server1                  server2
 (free disk)   nsd_lun20    server3                  server4
 (free disk)   nsd_lun21    server3                  server4
 (free disk)   nsd_lun22    server4                  server3
 (free disk)   nsd_lun23    server4                  server3
 (free disk)   nsd_lun24    server4                  server3
 (free disk)   nsd_lun2     server1                  server2
 (free disk)   nsd_lun3     server1                  server2
 (free disk)   nsd_lun4     server2                  server1
 (free disk)   nsd_lun5     server2                  server1
 (free disk)   nsd_lun6     server2                  server1
 (free disk)   nsd_lun7     server1                  server2
 (free disk)   nsd_lun8     server1                  server2
 (free disk)   nsd_lun9     server1                  server2
 (free disk)   nsd_meta1    server1
 (free disk)   nsd_meta2    server2
 (free disk)   nsd_meta3    server3
 (free disk)   nsd_meta4    server4
```

The internal SCSI disks on the NSD servers will be used to store GPFS metadata. The metadata is mirrored on 2 levels. First, there are 2 system disks on each NSD server which are mirrored. Second, GPFS will mirror the data on 2 different nodes. This will create 4 copies of all metadata. Note that the GPFS mirroring guarantees that a node failure will not result in a loss of access to the file system since the metadata can be accessed on 2 different nodes.

EXAMPLE: Installing and Configuring GPFS

Create and Mount the File System

```
[root@gpfs1 gpfs_install]# mmcrfs /gpfs1 gpfs1 -F disk.lst -A yes -B 2048k -M 2 -m 2 -v no
The following disks of gpfs1 will be formatted on node gpfs1:
    nsd_meta1: size 58259691 KB
    nsd_meta2: size 58259691 KB
    nsd_meta3: size 58259691 KB
    nsd_meta4: size 58259691 KB
    nsd_lun1: size 3907041280 KB
    nsd_lun2: size 3907041280 KB
    nsd_lun3: size 3907041280 KB
    nsd_lun4: size 3907041280 KB
    nsd_lun5: size 3907041280 KB
    nsd_lun6: size 3907041280 KB
    nsd_lun7: size 3907041280 KB
    nsd_lun8: size 3907041280 KB
```

*** Lines for nsd_lun9 to nsd_lun20 are omitted so that everything fits on 1 page. ***

```
    nsd_lun21: size 3907041280 KB
    nsd_lun22: size 3907041280 KB
    nsd_lun23: size 3907041280 KB
    nsd_lun24: size 3907041280 KB
Formatting file system ...
Disks up to size 149 TB can be added to storage pool 'system'.
Creating Inode File
Creating Allocation Maps
Clearing Inode Allocation Map
Clearing Block Allocation Map
  93 % complete on Thu May 31 12:32:18 2007
 100 % complete on Thu May 31 12:32:19 2007
Completed creation of file system /dev/gpfs1.
mmcrfs: Propagating the cluster configuration data to all affected nodes.  This is an
asynchronous process.
```

Parameters for mmcrfs

/gpfs1: mount point

gpfs1: device entry in /dev for the file system

-F: output file from the mmcrnsd command

-A: mount the file system automatically every time mmfsd is started

-B: actual block size for this file system; it can not be larger than the maxblocksize set by the mmchconfig command

-M: maximum number of metadata mirrors (can not be larger than 2)

-m: actual number of metadata mirrors (can not be larger than –M)

-v: check if this disk is part of an existing GPFS file system or ever had a GPFS file system on it (*n.b.*, if it does/did and the parameter is yes, then mmcrfs will not include this disk in this file system)

The optimum value for the actual block size is both application and controller dependent. Experimentation is recommended to determine the best choice for this value. The options are 16k, 64k, 256k. 512k, 1024k, 2048k, 4096k.

The /etc/fstab is automatically updated by this command.

EXAMPLE: Installing and Configuring GPFS

Create and Mount the File System

Verify disk status..

```
[root@gpfs1 gpfs_install]# mmlsdisk gpfs1
disk         driver   sector failure holds    holds                            storage
name         type       size   group metadata data  status        availability pool
------------ -------- ------ ------- -------- ----- ------------- ------------ ------------
nsd_meta1    nsd         512    4001 yes      no    ready         up           system
nsd_meta2    nsd         512    4002 yes      no    ready         up           system
nsd_meta3    nsd         512    4003 yes      no    ready         up           system
nsd_meta4    nsd         512    4004 yes      no    ready         up           system
nsd_lun1     nsd         512    4001 no       yes   ready         up           system
nsd_lun2     nsd         512    4001 no       yes   ready         up           system
nsd_lun3     nsd         512    4001 no       yes   ready         up           system
nsd_lun4     nsd         512    4002 no       yes   ready         up           system
nsd_lun5     nsd         512    4002 no       yes   ready         up           system
nsd_lun6     nsd         512    4002 no       yes   ready         up           system
nsd_lun7     nsd         512    4001 no       yes   ready         up           system
nsd_lun8     nsd         512    4001 no       yes   ready         up           system
nsd_lun9     nsd         512    4001 no       yes   ready         up           system
nsd_lun10    nsd         512    4002 no       yes   ready         up           system
nsd_lun11    nsd         512    4002 no       yes   ready         up           system
nsd_lun12    nsd         512    4002 no       yes   ready         up           system
nsd_lun13    nsd         512    4003 no       yes   ready         up           system
nsd_lun14    nsd         512    4003 no       yes   ready         up           system
nsd_lun15    nsd         512    4003 no       yes   ready         up           system
nsd_lun16    nsd         512    4004 no       yes   ready         up           system
nsd_lun17    nsd         512    4004 no       yes   ready         up           system
nsd_lun18    nsd         512    4004 no       yes   ready         up           system
nsd_lun19    nsd         512    4003 no       yes   ready         up           system
nsd_lun20    nsd         512    4003 no       yes   ready         up           system
nsd_lun21    nsd         512    4003 no       yes   ready         up           system
nsd_lun22    nsd         512    4004 no       yes   ready         up           system
nsd_lun23    nsd         512    4004 no       yes   ready         up           system
nsd_lun24    nsd         512    4004 no       yes   ready         up           system
```

EXAMPLE: Installing and Configuring GPFS

Create and Mount the File System

```
[root@gpfs1 gpfs_install]# mmmount /gpfs1 -a
Thu May 31 12:39:42 CDT 2007: mmmount: Mounting file systems ...
```

The GPFS mount command mounts the file system on multiple nodes in the cluster. The parameters are
/gpfs1: mount point
-a: mount it on all nodes in the cluster

```
[root@gpfs1 gpfs_install]# for i in `seq 1 4`
> do
> ssh server$i chmod 777 /gpfs1
> done
```

The psh command is a more elegant way to do this.

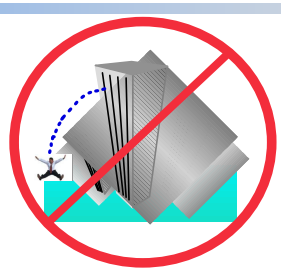
```
[root@gpfs1 gpfs_install]# touch /gpfs1/xxx
[root@gpfs1 gpfs_install]# ssh gpfs4 ls -l /gpfs1
total 0
-rw-r--r--  1 root root 0 May 31 12:36 xxx
```

"Quick and dirty" test to be sure the file system is up and mounted everywhere.

EXAMPLE: Installing and Configuring GPFS

What if I screw up?

Don't jump!



Clean up and start over again.

It's easier the second time!

Option #1 The proper way to do it.

1. Unmount the GPFS file system

```
[root@gpfs1 gpfs_install]# mmunmount /gpfs1 -a
```

2. Delete GPFS file system

```
[root@gpfs1 gpfs_install]# mmdelfs /gpfs1
```

3. Delete GPFS NSDs

```
[root@gpfs1 gpfs_install]# for i in `seq 1 24`
> do
> mmdelnsd nsd_lun$i
> done
```

4. Shutdown GPFS daemons

```
[root@gpfs1 gpfs_install]# mmshutdown -a
```

5. Delete the GPFS cluster

```
[root@gpfs1 gpfs_install]# mmdelnode -a
```

Properly deleting the file system ensures that the file system descriptors are deleted from the disks so that they will not create issues upon a subsequent file system creation attempt.

Properly deleting the NSDs ensures that the NSD descriptors are deleted so that they will not create issues upon a subsequent NSD creation attempt.

Option #2 But what if I really screw things up?

1. Unmount the GPFS file system and shutdown the GPFS daemons

```
[root@gpfs1 gpfs_install]# mmunmount /gpfs1 -a
[root@gpfs1 gpfs_install]# mmshutdown -a
```

2. Delete selected configuration files on all nodes

```
[root@gpfs1 gpfs_install]# rm -f /var/mmfs/etc/mmfs.cfg
[root@gpfs1 gpfs_install]# rm -f /var/mmfs/gen/*
[root@gpfs1 gpfs_install]# rm -f /var/mmfs/tmp/*
```

WARNING: Use with extreme caution! Once the configuration files have been deleted, the GPFS cluster no longer exists and any data on the disks will likely be lost. Use this method only when Option #1 fails.

Overview

The following pages present sample building blocks for the DCS9900. They are based on **best practice** guidelines using balanced configurations; the number of storage servers (aka, NSD servers) are sufficient to harvest all available DCS9900 BW and that increasing the number of disks will not increase the performance of the building block.

2 disk options are illustrated with the following performance results.

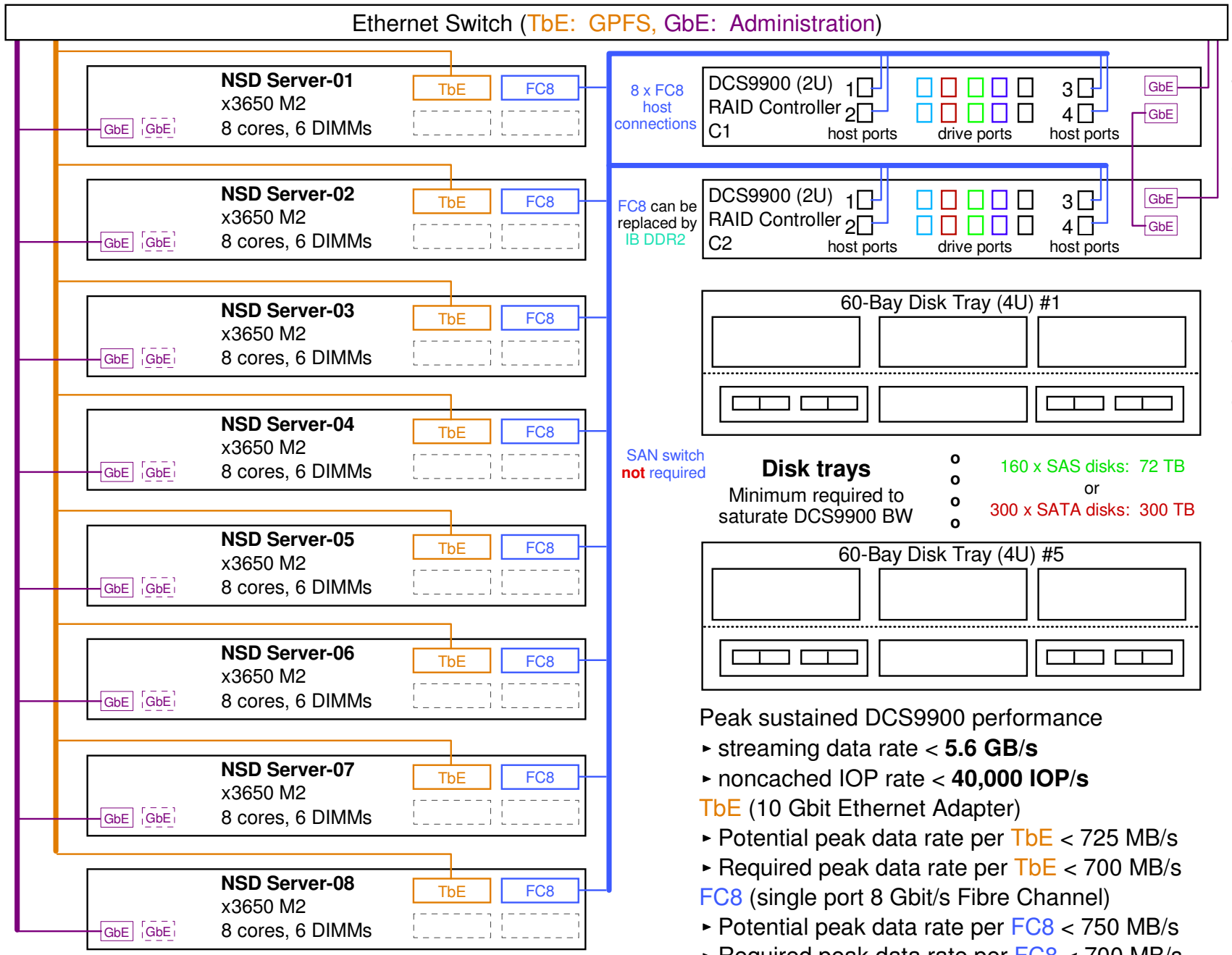
- **Best Practice**: 160 x 15 Krpm SAS disks
  - 8+2P RAID 6
  - capacity using 450 GB/disk: raw ~= 72 TB, usable ~= 56 TB
  - streaming rate: write < 5.6 GB/s, read < 4.4 GB/s
  - IOP rate < 40,000 IOP/s
- **Best Practice**: 300 x SATA disks
  - 8+2P RAID 6
  - capacity using 1 TB/disk: raw ~= 300 TB, usable ~= 240 TB
  - streaming rate: write < 5.4 GB/s, read < 3.6 GB/s
    - This read rate is based on **best practice** tuning guidelines. Significantly higher read rates (e.g., 4.4 GB/s) are possible but require tuning not generally applicable (*e.g.*, setting the allocation block map type to "cluster").
  - IOP rate < 40,000 IOP/s

Best Practice:
If you need more than 300 SAS disks to meet capacity, consider using SATA instead since 300 SATA disks will give same performance and will increase capacity.

Building Block #1 (Ethernet)

Write Rate < 5.6 GB/s, Read Rate < 4.4 GB/s*

* Based on benchmark using 160 x 15 Krpm SAS drives.



Peak sustained DCS9900 performance

- streaming data rate < **5.6 GB/s**
- noncached IOP rate < **40,000 IOP/s**

TbE (10 Gbit Ethernet Adapter)

- Potential peak data rate per TbE < 725 MB/s
- Required peak data rate per TbE < 700 MB/s

FC8 (single port 8 Gbit/s Fibre Channel)

- Potential peak data rate per FC8 < 750 MB/s
- Required peak data rate per FC8 < 700 MB/s

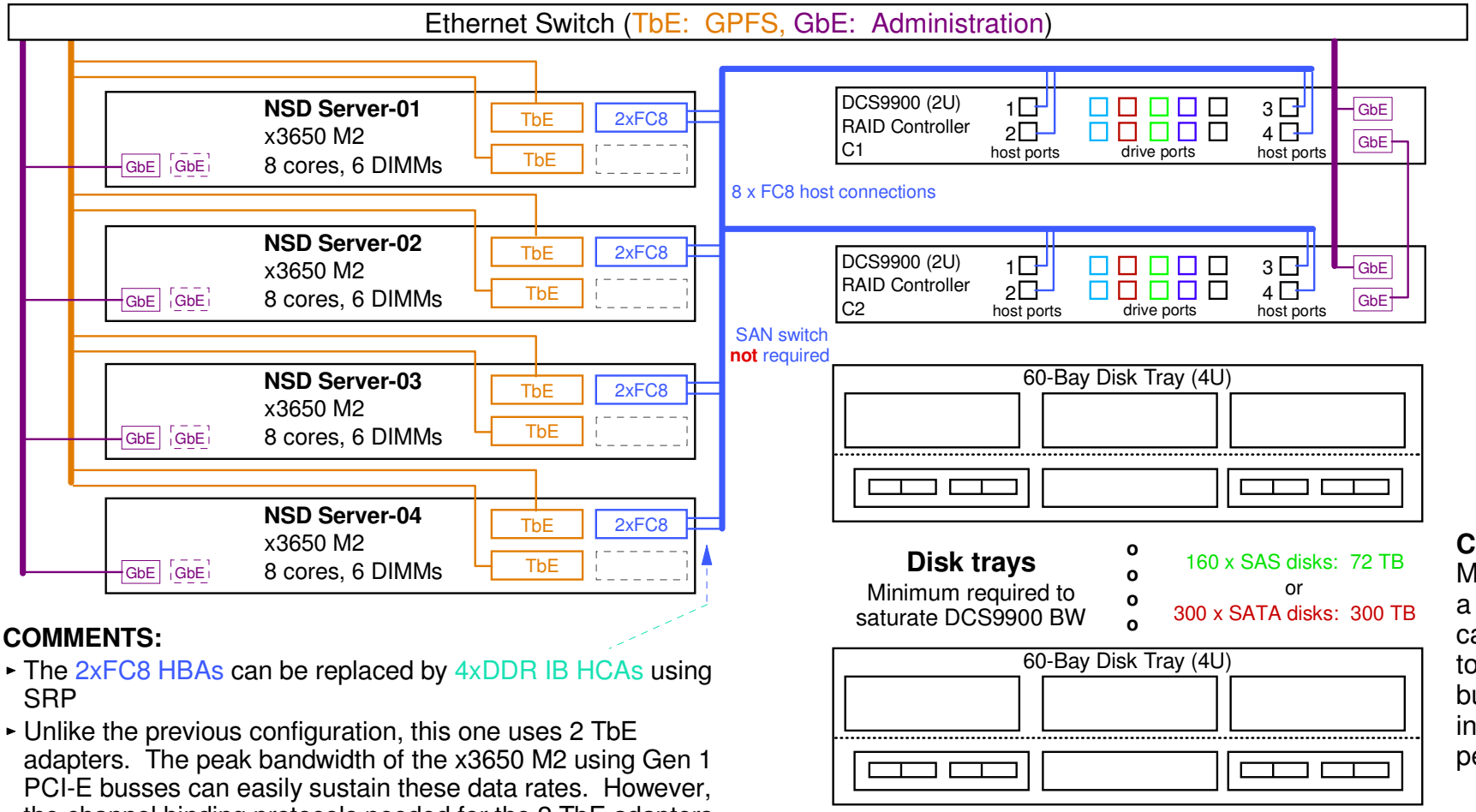
COMMENT:
The FC8 HBAs can be replaced by 4xDDR IB HCAs using SRP, but sharing the LAN based IB switch is **not** recommended.
The host ports can either be directly attached to the servers or separate IB switch can be used.

COMMENT:
More disks (for a total of 1200) can be added to this solution but it will **not** increase performance.

Alternate Building Block #1 (Ethernet)

Write Rate < 5.6 GB/s, Read Rate < 4.4 GB/s*

* Based on benchmark using 160 x 15 Krpm SAS drives.



Disk trays
Minimum required to saturate DCS9900 BW

160 x SAS disks: 72 TB
or
300 x SATA disks: 300 TB

COMMENT:
More disks (for a total of 1200) can be added to this solution but it will **not** increase performance.

COMMENTS:

- The 2xFC8 HBAs can be replaced by 4xDDR IB HCAs using SRP
- Unlike the previous configuration, this one uses 2 TbE adapters. The peak bandwidth of the x3650 M2 using Gen 1 PCI-E busses can easily sustain these data rates. However, the channel binding protocols needed for the 2 TbE adapters on each node do not always adequately balance the load. Validation testing is recommended before putting this configuration into production.

Peak sustained DCS9900 performance

- streaming data rate < **5.6 GB/s**
- noncached IOP rate < **40,000 IOP/s**

TbE (10 Gbit Ethernet Adapter)

- Potential peak data rate per 2 x TbE < 1450 MB/s
- Required peak data rate per 2 x TbE < 1400 MB/s

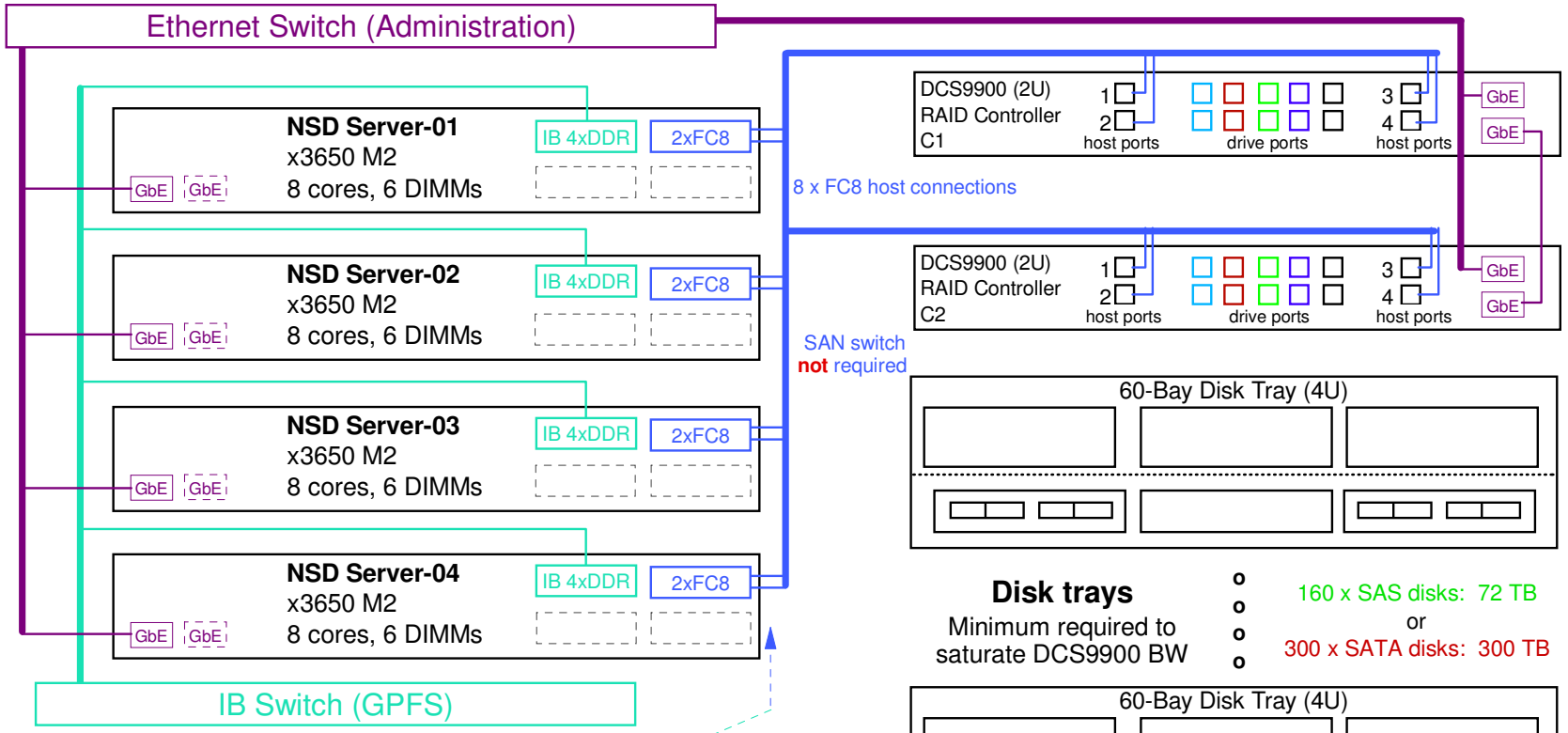
2xFC8 (dual port 8 Gbit/s Fibre Channel)

- Potential peak data rate per 2xFC8 < 1500 MB/s
- Required peak data rate per 2xFC8 < 1400 MB/s

Building Block #2 (IB-RDMA)

Write Rate < 5.6 GB/s, Read Rate < 4.4 GB/s*

* Based on benchmark using 160 x 15 Krpm SAS drives.



Disk trays
Minimum required to saturate DCS9900 BW

o
o
o
o

160 x SAS disks: 72 TB
or
300 x SATA disks: 300 TB

COMMENT:
More disks (for a total of 1200) can be added to this solution but it will **not** increase performance.

COMMENTS:

- The 2xFC8 HBAs can be replaced by 4xDDR IB HCAs using SRP

Peak sustained DCS9900 performance

- streaming data rate < **5.6 GB/s**
- noncached IOP rate < **40,000 IOP/s**

4xDDR IB HCA (Host Channel Adapter)

- Potential peak data rate per HCA < 1500 MB/s
- Required peak data rate per HCA < 1400 MB/s

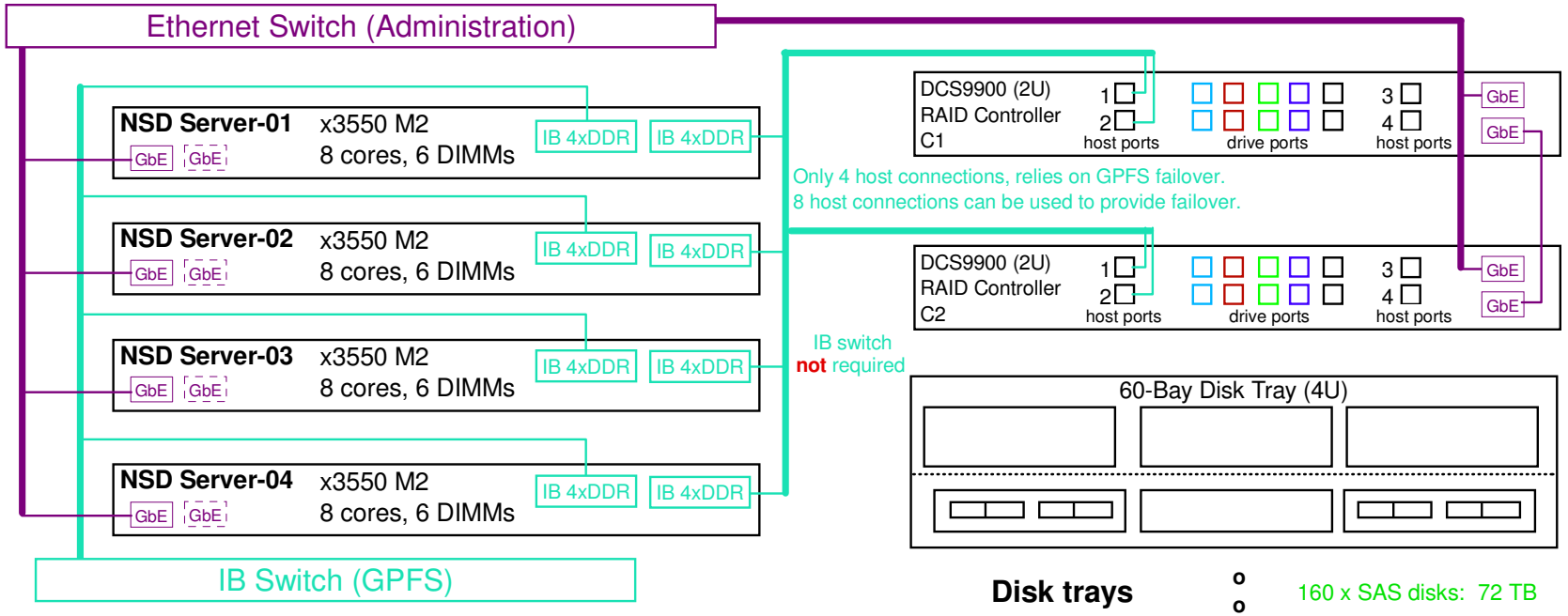
2xFC8 (dual port 8 Gbit/s Fibre Channel)

- Potential peak data rate per 2xFC8 < 1500 MB/s
- Required peak data rate per 2xFC8 < 1400 MB/s

Alternate Building Block #2 (IB-RDMA)

Write Rate < 5.6 GB/s, Read Rate < 4.4 GB/s*

* Based on benchmark using 160 x 15 Krpm SAS drives.



Disk trays
Minimum required to saturate DCS9900 BW

160 x SAS disks: 72 TB
or
300 x SATA disks: 300 TB

COMMENT:
More disks (for a total of 1200) can be added to this solution but it will **not** increase performance.

COMMENTS - DCS9900 Host Connections

- While IB 4xDDR (RDMA) can deliver rates upto 1500 MB/s over a LAN, in practice IB 4xDDR (SRP) delivers closer to 1300 MB/s over a SAN. The peak data rate for this solution may therefore be closer to 5.2 GB/s.
- Dual port IB 4xDDR HCAs may be used with all 8 host ports on the DCS9900 to provide failover redundancy. It may also provide a minor performance boost.

Peak sustained DS5300 performance
- streaming data rate < **5.6 GB/s**
- noncached IOP rate < **40,000 IOP/s**

LAN: 4xDDR IB HCA (RDMA)
- Potential peak data rate per HCA < 1500 MB/s
- Required peak data rate per HCA < 1400 MB/s

Host connections: 4xDDR IB HCA (SRP)
- Potential peak data rate per HCA < 1500 MB/s
- Required peak data rate per HCA < 1400 MB/s

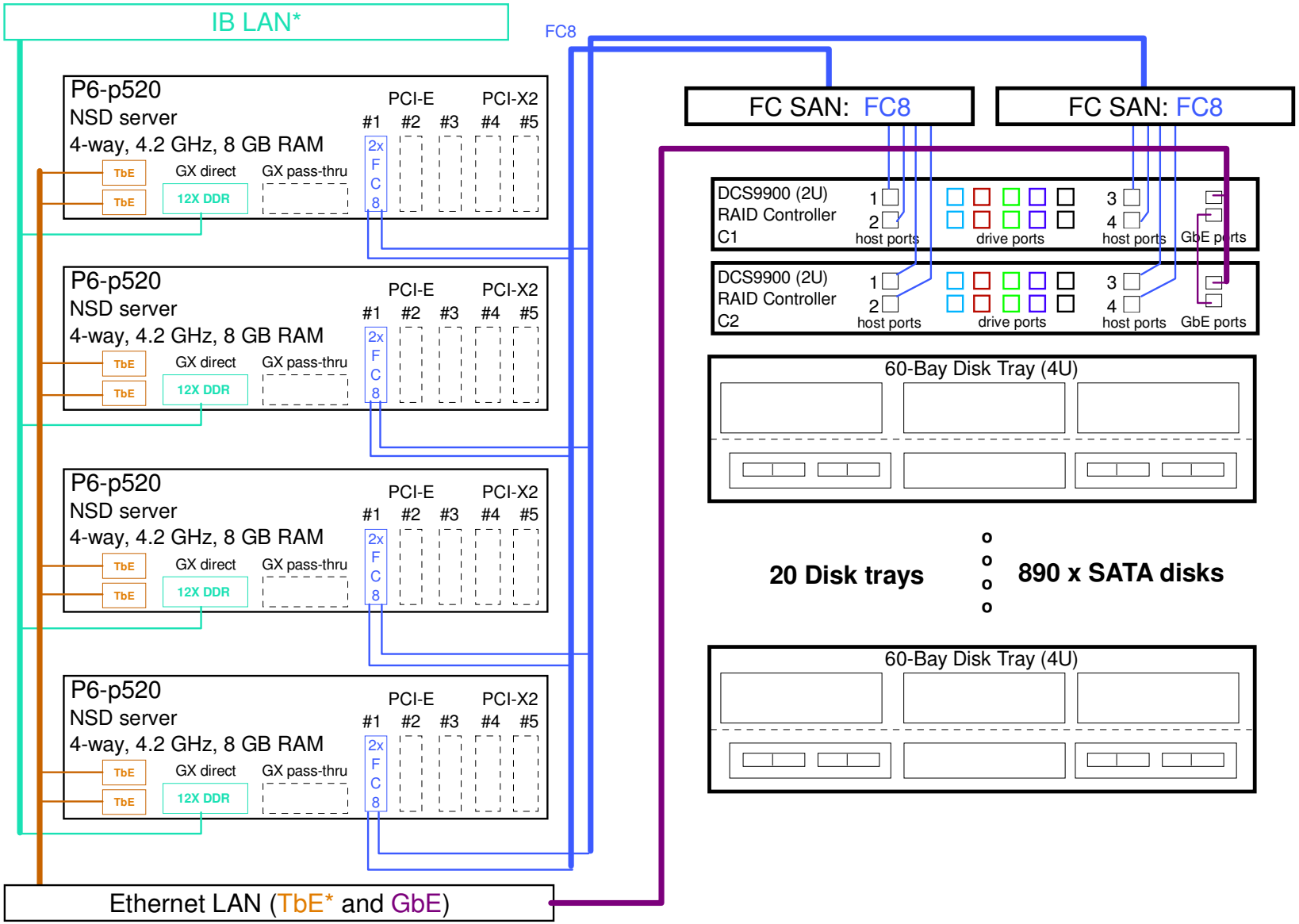
The following pages sumarize benchmark tests for 2 different DCS9900 systems, one based on SATA and one based on 15Krpm SAS.

Benchmark #1 (SATA)
System Configuration

SOFTWARE:
AIX 5.3 with GPFS 3.2

IB Protocol: IBoIP/sp3
IB HCA: 4X DDR

FC8, dual port (8 Gb/s)
2xTbE (LACP)



⋆The IB and TbE ports were not used for the results reported below.

Benchmark #1 (SATA)
Streaming Results

Common Parameter Settings

- AIX
  - transfer size = 1 MB
- DCS9900
  - FW version = 5.03, SATA, 8+2P RAID 6, dual coherency=off, cache size=1024, cache mf=on
- GPFS
  - blocksize=4M, maxblocksize=4M, maxMBpS=4000, pagepool=4G, nsdMaxWorkerThreads=128, prefetchPct=60, nsdbufspace=70, worker1Threads=128, prefetchThreads=64
  - all LUNs are dataAndMetadata
- Benchmark application (ibm.v4b)
  - record size = 4M
  - access pattern = sequential
  - direct I/O = off
  - fize size >= 16 GB * number of nodes

Tiers	nodes	tasks	write rate[1] (MB/s)	read rate[2] (MB/s)	write rate[3] (MB/s)	read rate[4] (MB/s)
1	1	1	277.2	222.3	376.5	392.3
4	4	4	791.5	709.3	1067.0	1384.0
8	4	8	1429.0	1238.0	2354.0	3237.0
16	4	16	2740.0	1607.0	3676.0	4241.0
32	4	16	4842.0	2885.0	5234.0	5194.0
64	4	16	5411.0	3581.0	5395.0	4147.0

Unique Parameter Settings for Each Column

1. DCS9900 cache writeback=off, GPFS block allocation = scatter
2. DCS9900 cache prefetch=0, GPFS block allocation = scatter
3. DCS9900 cache writeback=off, GPFS block allocation = cluster
4. DCS9900 cache prefetch=1 GPFS block allocation = cluster

Benchmark #1 (SATA)
IOP Results

Common Parameter Settings

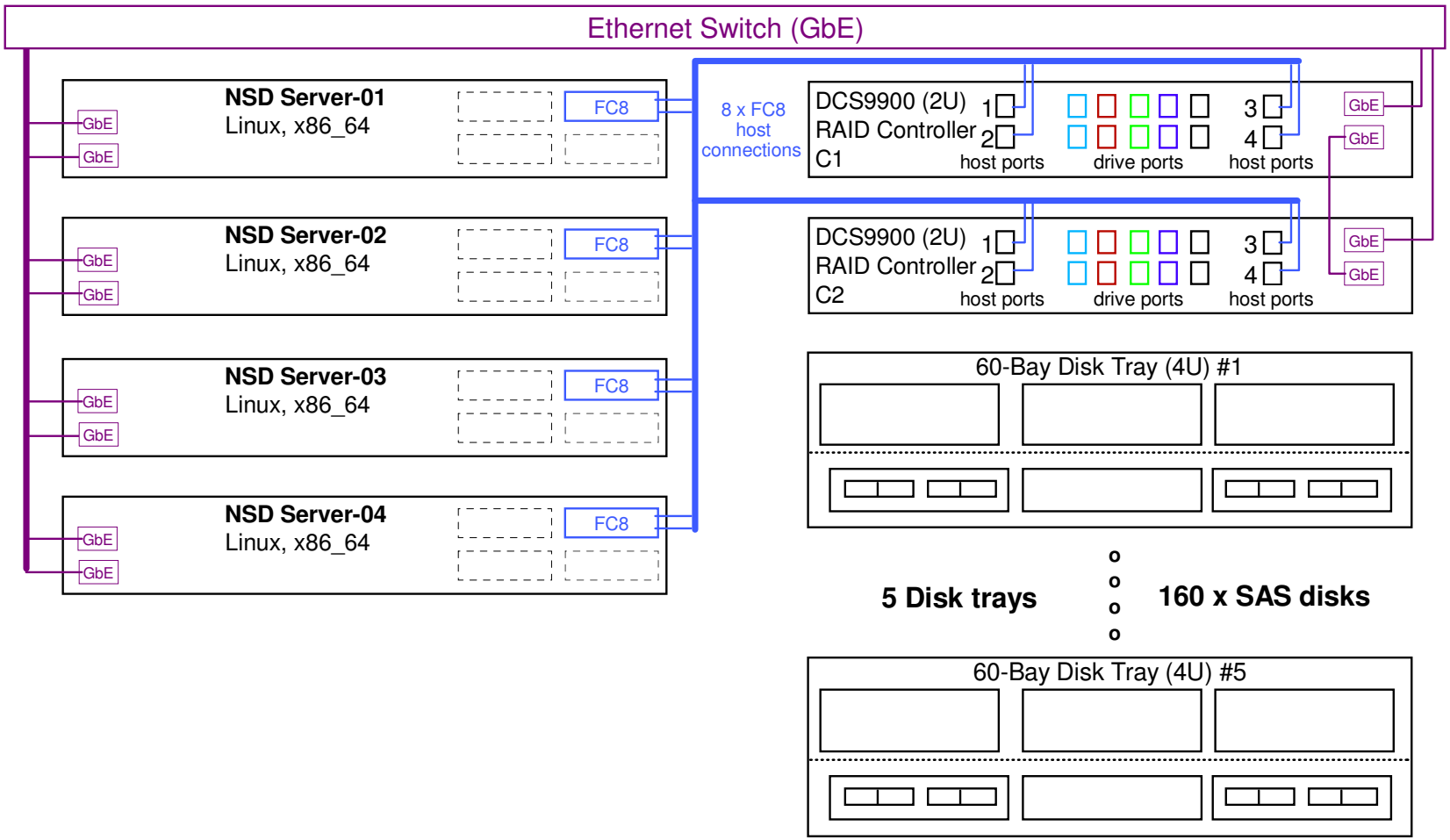
- AIX
  - transfer size = 1 MB
- DCS9900
  - FW version = 5.06, SATA, 8+2P RAID 6, dual coherency=on, cache writeback=off, cache mf=on, cache prefetch=0,
- GPFS
  - blocksize=256K, maxblocksize=4M, maxMBpS=4000, pagepool=1G, nsdMaxWorkerThreads=128, prefetchPct=60, nsdbufspace=70, worker1Threads=128, prefetchThreads=96, GPFS block allocation = scatter
  - all LUNs are dataAndMetadata
- Benchmark application (ibm.v4b)
  - record size = 4K
  - access pattern = sequential small file
    - 4 files each @ 4K, 8K, 12K, 16K per directory accessed over a binary director tree in preorder
  - direct I/O = off

Tiers	nodes	tasks	write rate[1] (IOP/s)	read rate[2] (IOP/s)	write rate[3] (IOP/s)	read rate[4] (IOP/s)
1	4	32	7522.5	3840.7		
2	4	32	13459.0	5909.7		
4	4	32	23641.0	12061.0		
8	4	32	29852.0	16301.0		
16	4	32	30381.0	27284.0	40978.0	27947.0
32	4	32	41128.0	33528.0	47658.0	32870.0

Unique Parameter Settings for Each Column

1. DCS9900 cache size=1024
2. DCS9900 cache size=1024
3. DCS9900 cache size=256
4. DCS9900 cache size=256

Benchmark #2 (SAS)
System Configuration



Benchmark #2 (SAS)
Streaming Results

Common Parameter Settings

- DCS9900
  - SAS @ 15Krpm, 8+2P RAID 6, dual coherency=on, cache writeback=on, cache mf=on, cache prefetch=0
- GPFS
  - blocksize=4M, maxblocksize=4M, maxMBpS=4000, GPFS block allocation = scatter
  - all LUNs are dataAndMetadata
- Benchmark application (xdd)
  - access pattern = sequential large file
  - direct I/O = off

Tiers	nodes	threads	record size (KB)	write rate (MB/s)	read rate (MB/s)
16	8	16	128	2506.16	4539.54
16	8	16	256	2486.71	4517.87
16	8	16	512	2485.51	4531.71
16	8	16	1024	2485.58	4512.11
16	8	16	2048	2480.43	4499.71
16	8	16	4096	5745.67	4453.76
16	8	16	8192	5749.74	4475.39
16	8	16	16384	5752.19	4487.19
16	8	16	32768	5743.40	4473.32

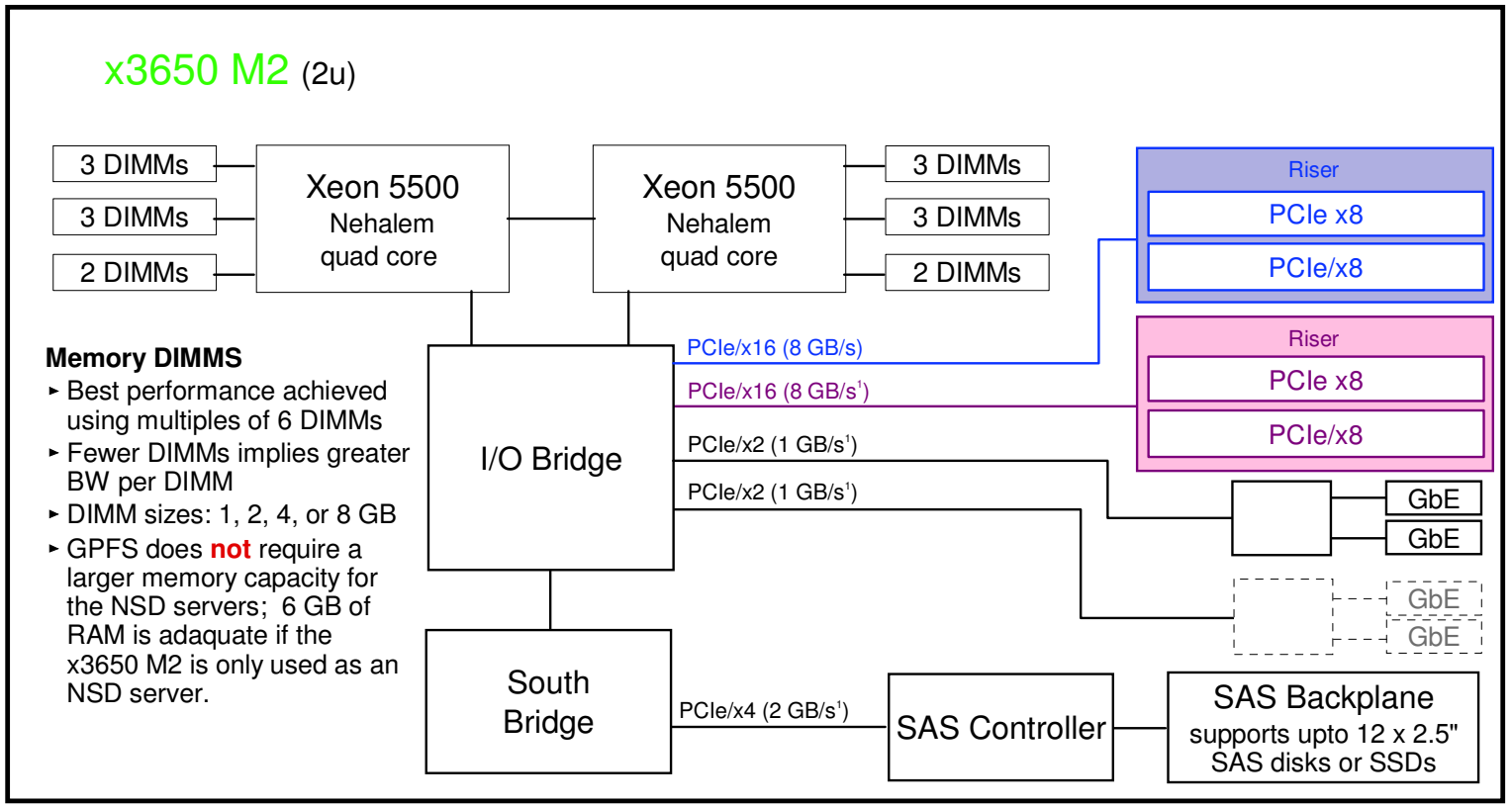
The following pages contain information on common NSD servers used with the DCS9900. These servers can generally be interchanged on a 1 to 1 basis, but there are nuanced differences.

x3650 M2
System Architecture

The work horse...

The x3650 M2 is a common and cost effective storage server for GPFS in most System X environmnets (it can even be used with System P).

This diagram illustrates those features most useful to its function as a storage server.



Data rates are based on the *Gen 1 PCIe* standard*.

1. Listed bus rates are theoretical duplex rates assuming on 512 MB/s per link. Production data will be less.
2. Actual peak duplex rates for PCIe x8 adapter < 3.2 GB/s
3. Measured aggregate over 4 x PCIe x8 adapters < 7.3 GB/s

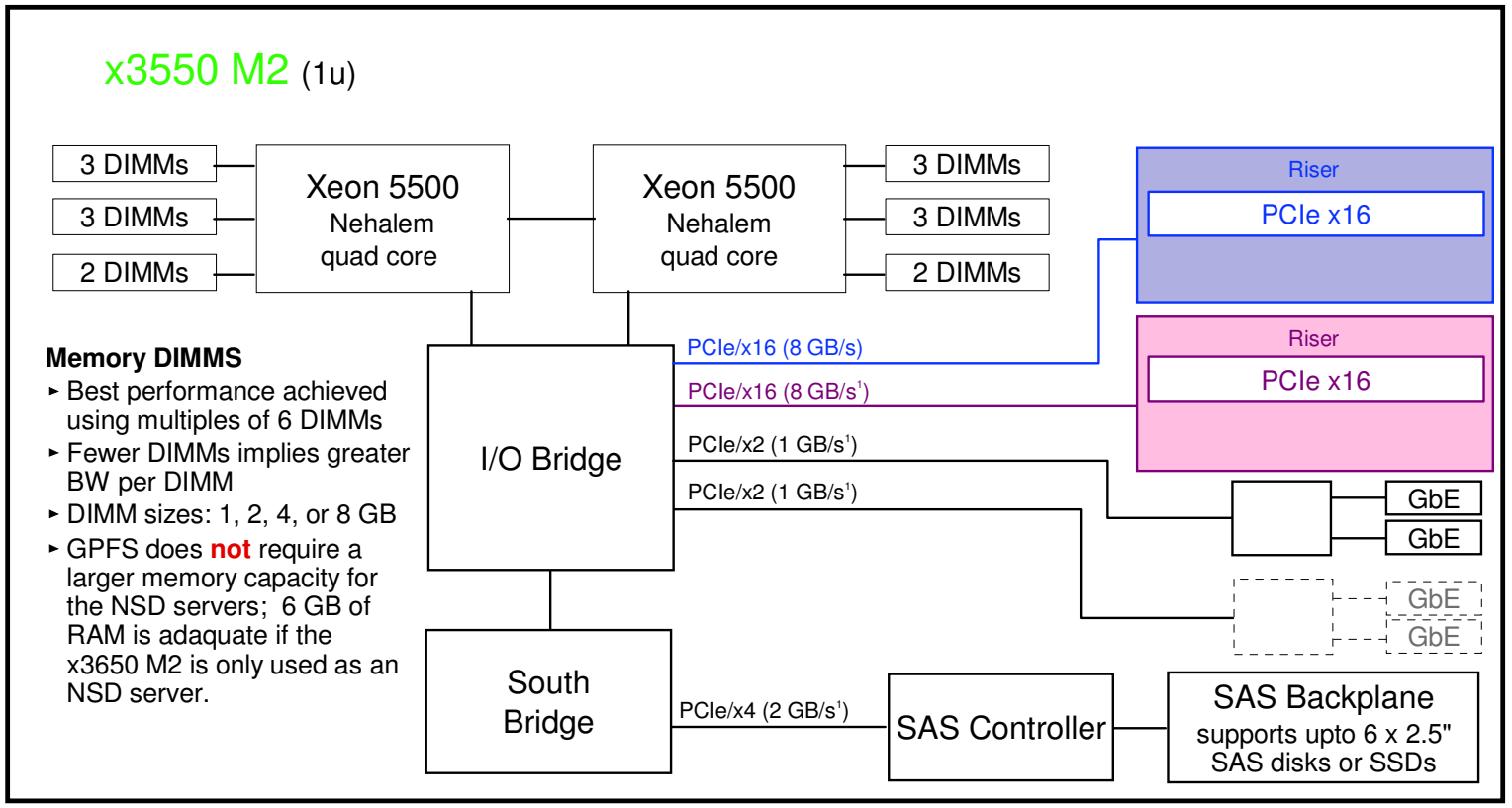
* See http://en.wikipedia.org/wiki/PCIe for details on the PCI Express standard

x3550 M2
System Architecture

A road less traveled...

The x3550 may be a cost effective storage server for GPFS in some cases. It's main limitation is a lack of PCIe slots.

This diagram illustrates those features most useful to its function as a storage server.

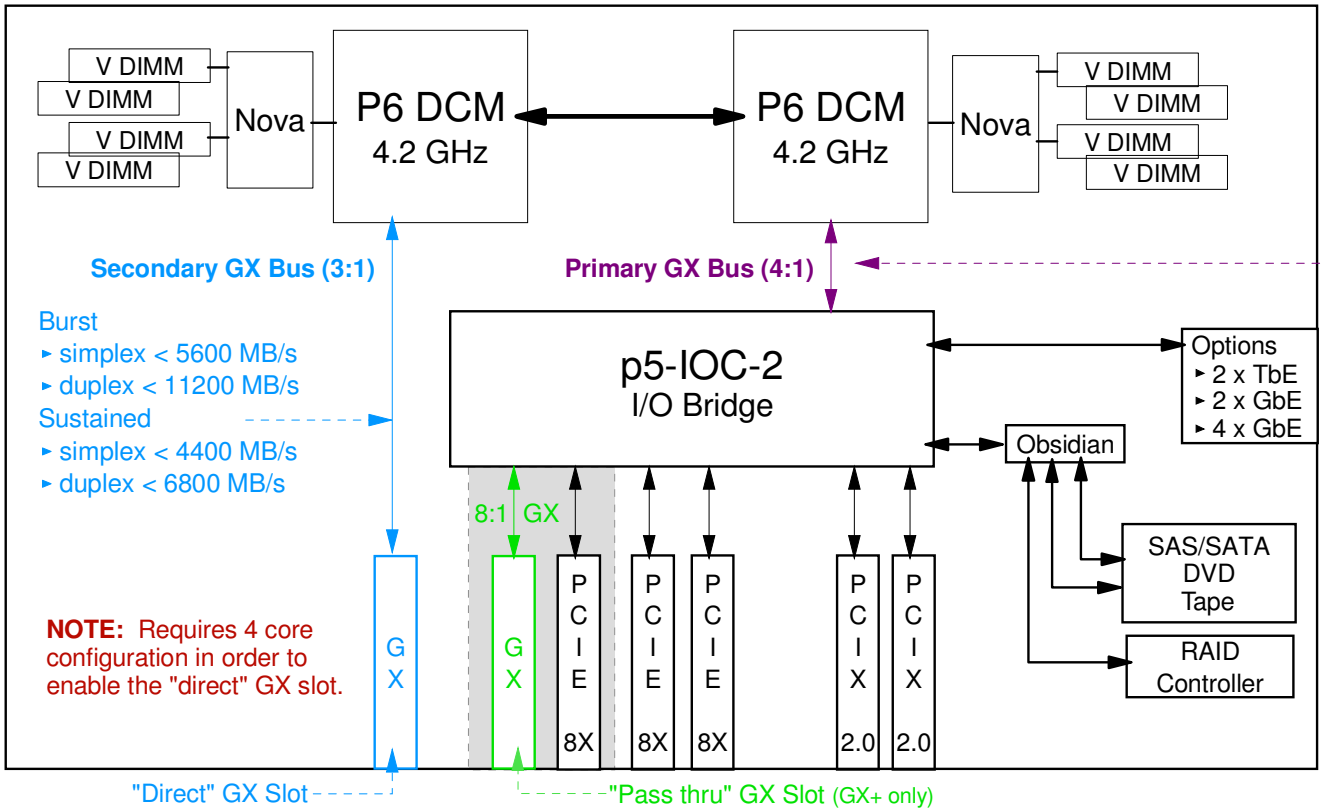


Data rates are based on the *Gen 1 PCIe* standard*.

1. Listed bus rates are theoretical duplex rates assuming on 512 MB/s per link. Production data will be less.
2. Actual peak duplex rates for PCIe x8 adapter < 3.2 GB/s
3. Measured aggregate over 4 x PCIe x8 adapters < 7.3 GB/s

* See http://en.wikipedia.org/wiki/PCIe for details on the PCI Express standard

P6-p520
System Architecture



"DIRECT" GX Slot
- IB cards are only supported in this slot.
- Card options:
  - dual port, IB 12xSDR @ 6:1 ratio (GX+)
  - dual port, IB 12xDDR @ 3:1 ratio (GX++)
  - RIO2 card @ 8:1 (GX+)
- 12x IB ports 1X and 4X cables
  - requires special "width changer" cable

- GX Bus width: 32 bits
- Rules of thumb:
  - Sustained simplex rates < 80% of simplex burst rate
  - Sustained duplex rates < 60% of duplex burst rate
  - single SDR "lane"
    burst < 250 MB/s, sustained < 185 MB/s
  - single DDR "lane"
    burst < 500 MB/s, sustained < 375 MB/s

"Pass Thru" GX Slot
- The pass thru GX slot occupies the same physical space as the 1st PCI-E slot. Therefore you can not use both of these slots.
- Supports the RIO2 card @ 8:1 (GX+). It does **not** support IB card.

Single PCI Adapter Data Rates
- PCI-E 8x:
  - Simplex: Burst < 2000 MB/s, Sustained < 1400 MB/s
  - Duplex: Burst < 4000 MB/s, Sustained < 2100 MB/s
- PCI-X 2.0
  - Burst < 2000 MB/s, Sustained < 1400 MB/s (this is not a duplex protocol)

Overiew

The P6-p520 is cost effective storage server for GPFS in most pSeries clusters using Ethernet. This diagram illustrates those features most useful to its function as a storage server.