DataDirect™ NETWORKS

Storage Architectures for Petaflops Computing

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Karlsruhe, GridKA Summerschool, 06.09.2011

Agenda

- **Who's DDN ?**
- **S2A Architecture**
- **SFA Architecture**
- **WOS: Web Object Storage**

The Worldwide Scalability Leader

The DDN Mission	Enable Organizations to Maximize the Value of All Information Everywhere
Established	1998
Ownership	Privately-Held, Self-Funded
Revenue	Over $200M Annually
Profitability	Consistently Profitable Since 2002
Growth	30% Annual Growth (’09-’10), about 400 employees
Presence	4 Continents, Located in 18 Countries
Markets	Content & Cloud, HPC, BioTech, Intelligence, Surveillance
Recognition	Frost & Sullivan Best Storage for Digital Media World’s Largest Private Storage Company (IDC ‘11) Deloitte Fast500 Technology Company (‘10) Inc. Magazine 500|5000 Winner (‘10) Frost & Sullivan Best Practice for Video Surveillance HPCWire Best HPC Storage Product (6 Yrs. Running)

DDN = HPC

2	DOE/SC/Oak Ridge National Laboratory	Lustre	Cray XT5-HE Opteron 6-core 2.6 GHz
4	GSIC Center, Tokyo Institute of Technology	Lustre	HP ProLiant SL390s G7 Xeon 6C X5670, Nvidia GPU, Linux/Windows
5	DOE/SC/LBNL/NERSC	GPFS	Cray XE6 12-core 2.1 GHz
6	Commissariat a l'Energie Atomique (CEA)	Lustre	Bull bullx super-node S6010/S6030
8	National Institute for Computational Sciences/University of Ter	Lustre	Cray XT5-HE Opteron 6-core 2.6 GHz
9	Forschungszentrum Juelich (FZJ)	Lustre	Blue Gene/P Solution

- 6 out of Top10
- 15 out of Top20
- 56 out of Top100
- 122 out of Top500
- **13 Petaflops computing powered**
- **5 systems over 120 GB/s**
- DDN provides more bandwidth (> 2TB/s) to the top500 list than all other vendors combined!

Accelerating Accelerators

DDN is the leading provider of affordable, high-availability storage for the next generation of particle physics research.

DDN Supplied Over 30PB of LHC Storage in the last 3 years

The Worldwide Scalability Leader

140,000	**# of Supercomputer CPUs** World's Fastest File System
23,000,000	**Online Users Served** Xbox Live Community
5,000,000,000	**Individual Photos** ~35 PBs of Storage

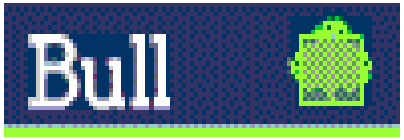
cea

Microsoft

shutterfly

Drawing From Leadership Development Experience To Scale Business Drivers

Sample HPC Partners & Customers



The Rich Media Leader

600+

DDN has delivered solutions to over 600 of the world's largest media organizations.

S2A & SFA Architecture

Product Portfolio

NASScaler

ExaScaler

GridScaler

xStreamScaler

xStream VTL

File Storage

Supporting SATA, SAS and SSD Disks

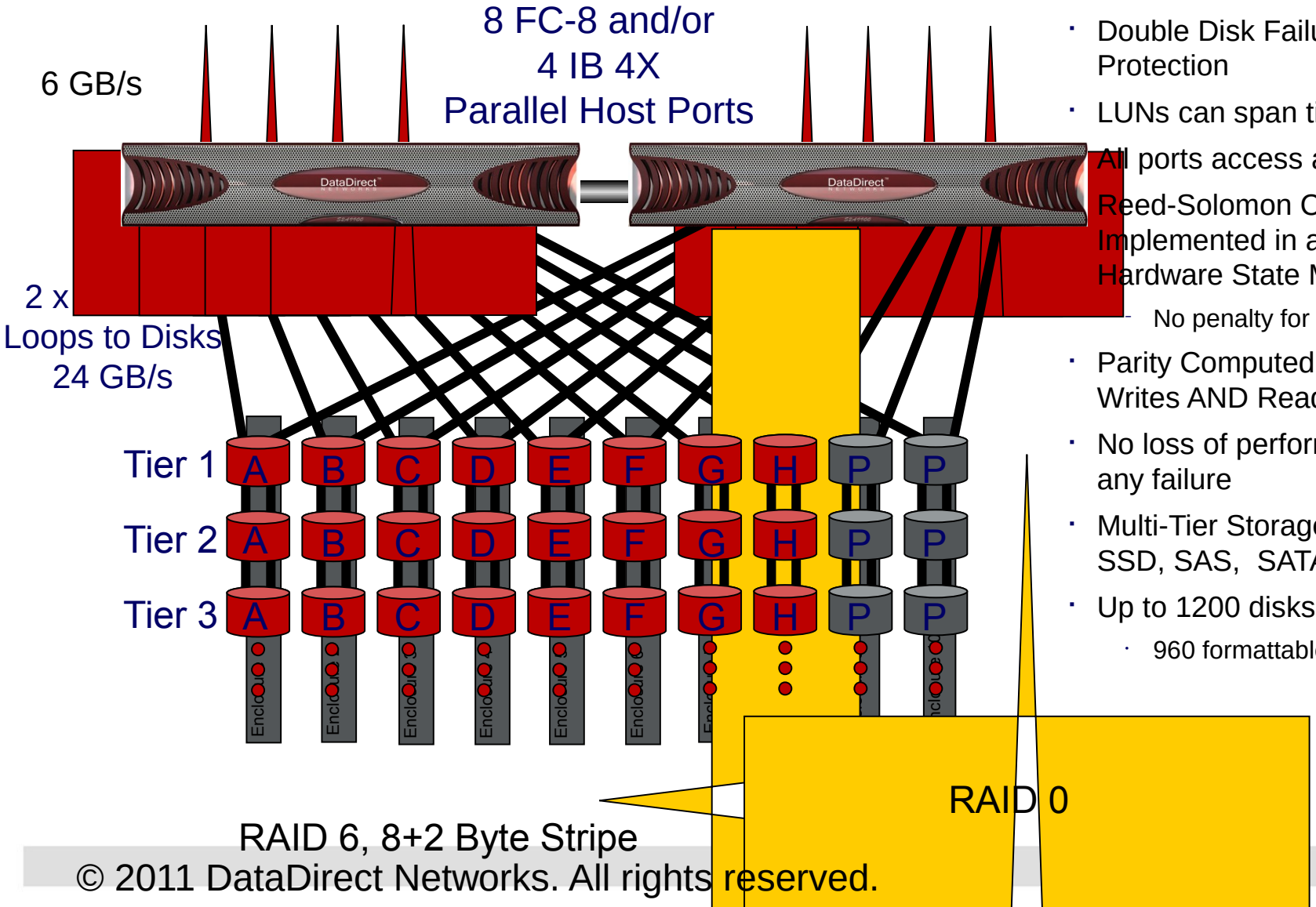
Featuring:

Leading Scalability • Highest Efficiency • Fastest ROI

DataDirect™ NETWORKS

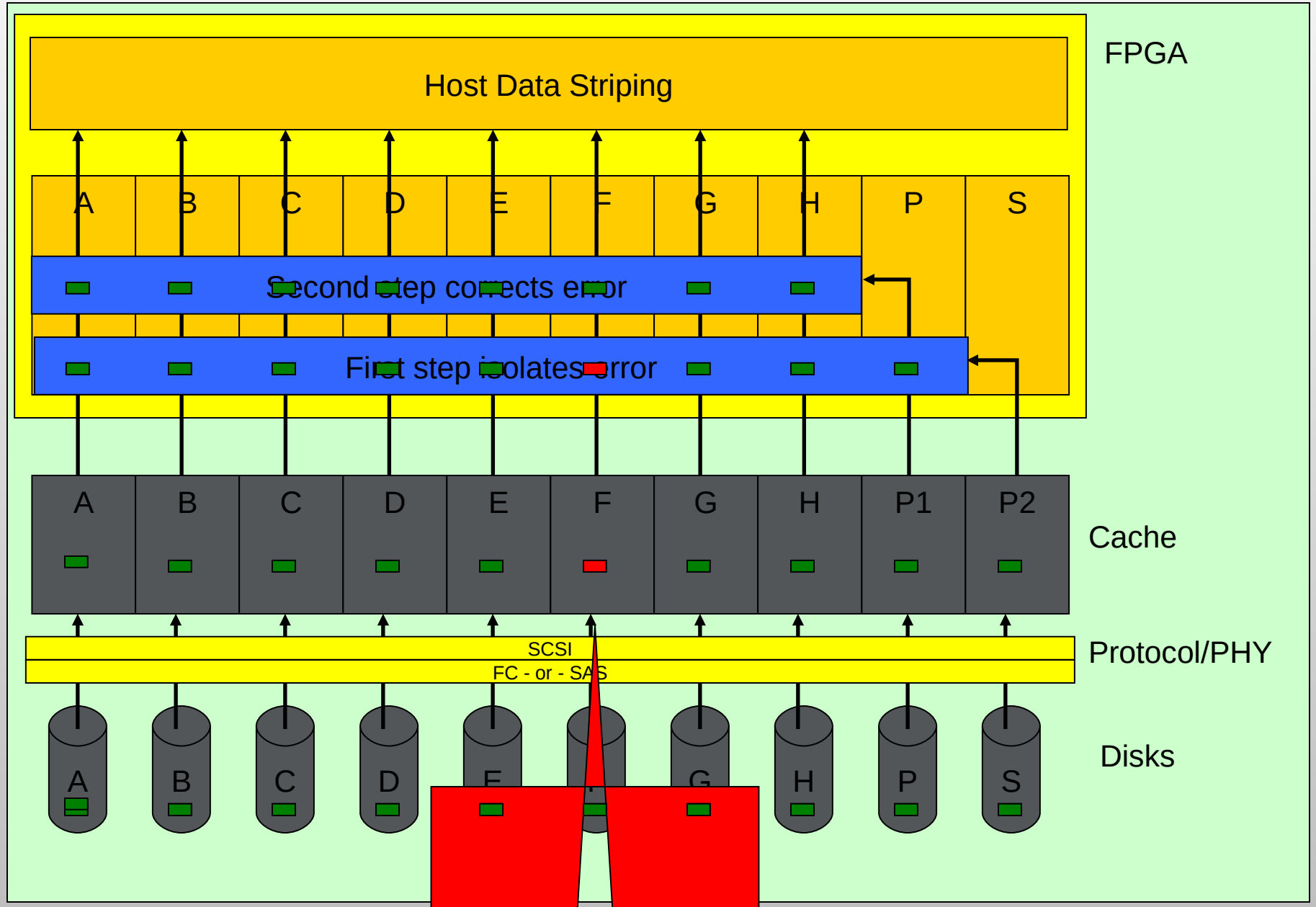
S2A9900
Real-Time Content Storage

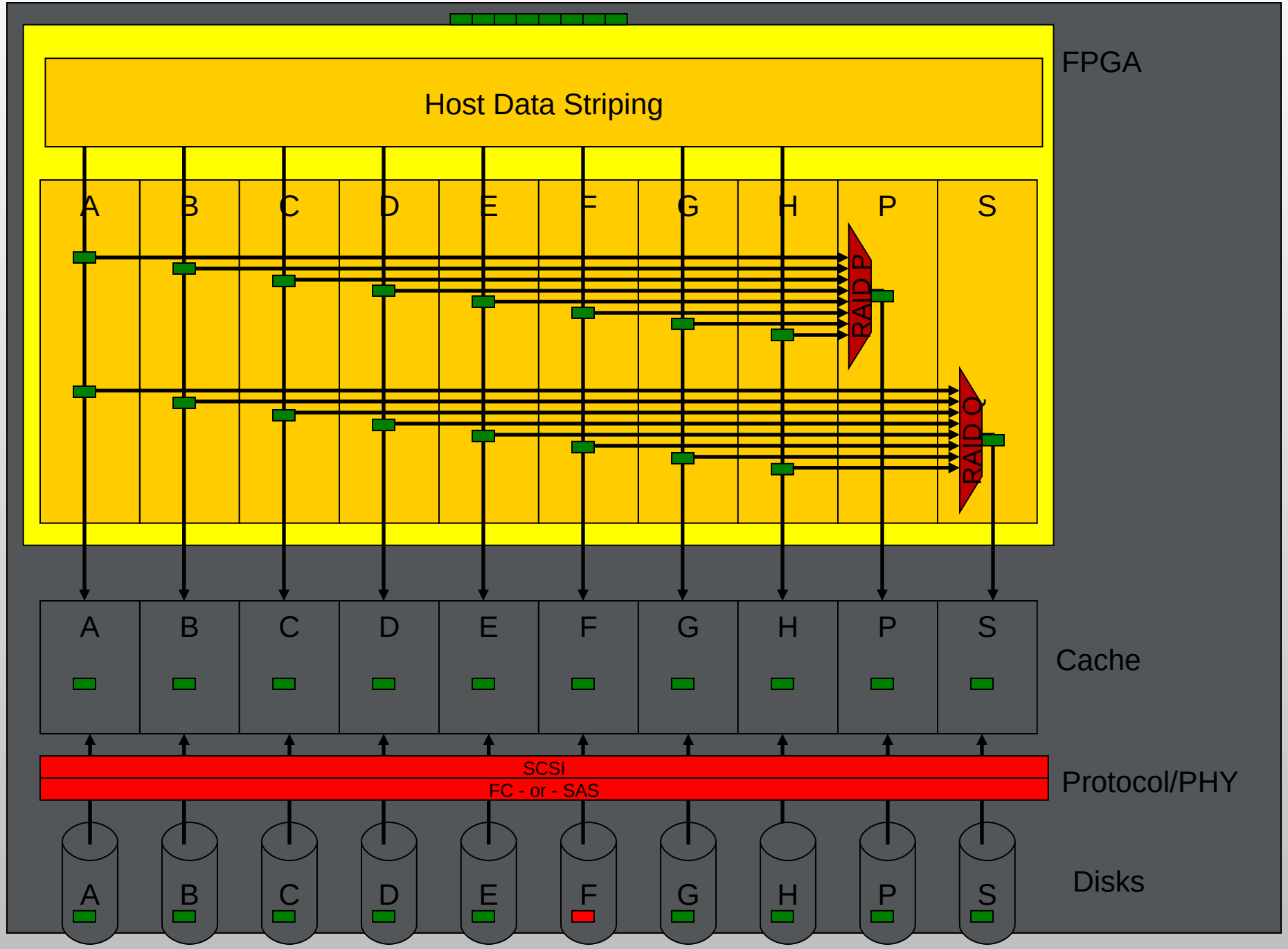
An Implementation of Parallelism w/ Double Parity RAID Protection



- Double Disk Failure Protection
- LUNs can span tiers
- All ports access all storage
- Reed-Solomon Code Implemented in a Hardware State Machine
  - No penalty for RAID 6!
- Parity Computed On Writes AND Reads
- No loss of performance on any failure
- Multi-Tier Storage Support, SSD, SAS, SATA Disks
- Up to 1200 disks total
  - 960 formattable disks

Data Corruption Error Handling




FPGA
Host Data Striping
A
B
C
D
E
F
G
H
P
S
RAID P
RAID Q
Cache
SCSI
FC - or - SAS
Protocol/PHY
Disks

Supported Enclosures

60 x 3.5” drives in 4U
SSD, SAS, SATA

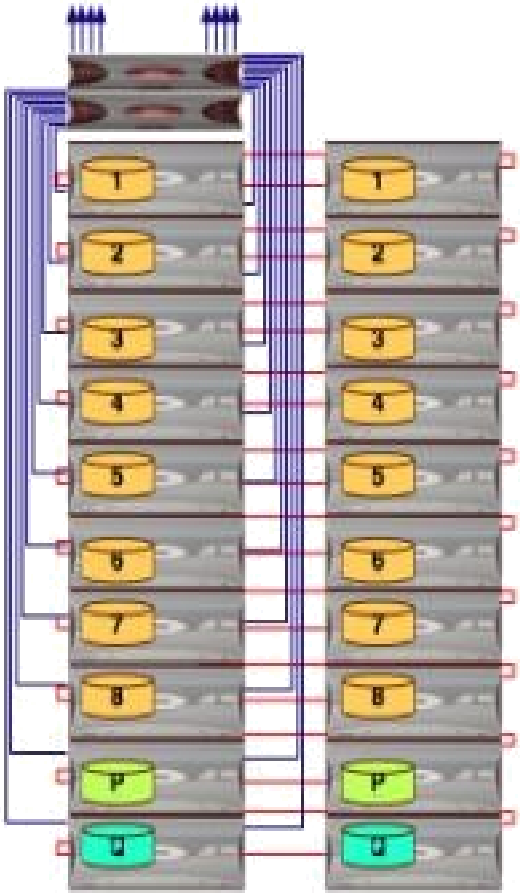
16 x 2.5” drives in 3U
SSD, SAS

Simple, Reliable Configuration

Direct Connection and RAID Striping Provides Maximum Data Availability

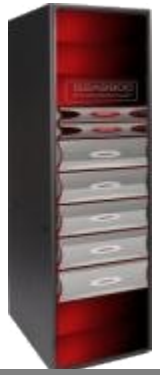
- Direct cabling avoids daisy chaining
- Data is striped across channels/enclosures
- Drive Channels are RAIDed 8+2
- Drive Enclosures are RAIDed 8+2

Only DDN Enclosure RAIDing can withstand the loss of 20% of system enclosures & drives while delivering full data availability!!



Scalability & Density

The World Scalability & Density Leader



5 Enclosures	10 Enclosures	20 Enclosures
24U: 1/2 Rack	44U: 1 Rack	84U: 2 Racks
Up to 300 Drives	Up to 600 Drives	Up to 1,200 Drives
Up to 900TB	Up to 1.8PB	Up to 3.6PB

- Simple Cabling: All Enclosures are direct connected (up to 10 enclosures) to the S2A Appliances for easy configuration and maximum reliability.
- Maximum Availability: S2A Storage Systems can lose up to 20% of the available drive enclosures without impacting host performance or data availability.

SFA
Storage Fusion Architecture

Transition To SW Platforms: Complete

Previous Design
36-24 mos. spin

Custom HW for Accelerated Storage Processing

The New DDN
< 9 mos. product spin

Full Storage SW Portfolio = Maximum Design Flexibility
Embedded Virtualization to Natively Host Storage Apps

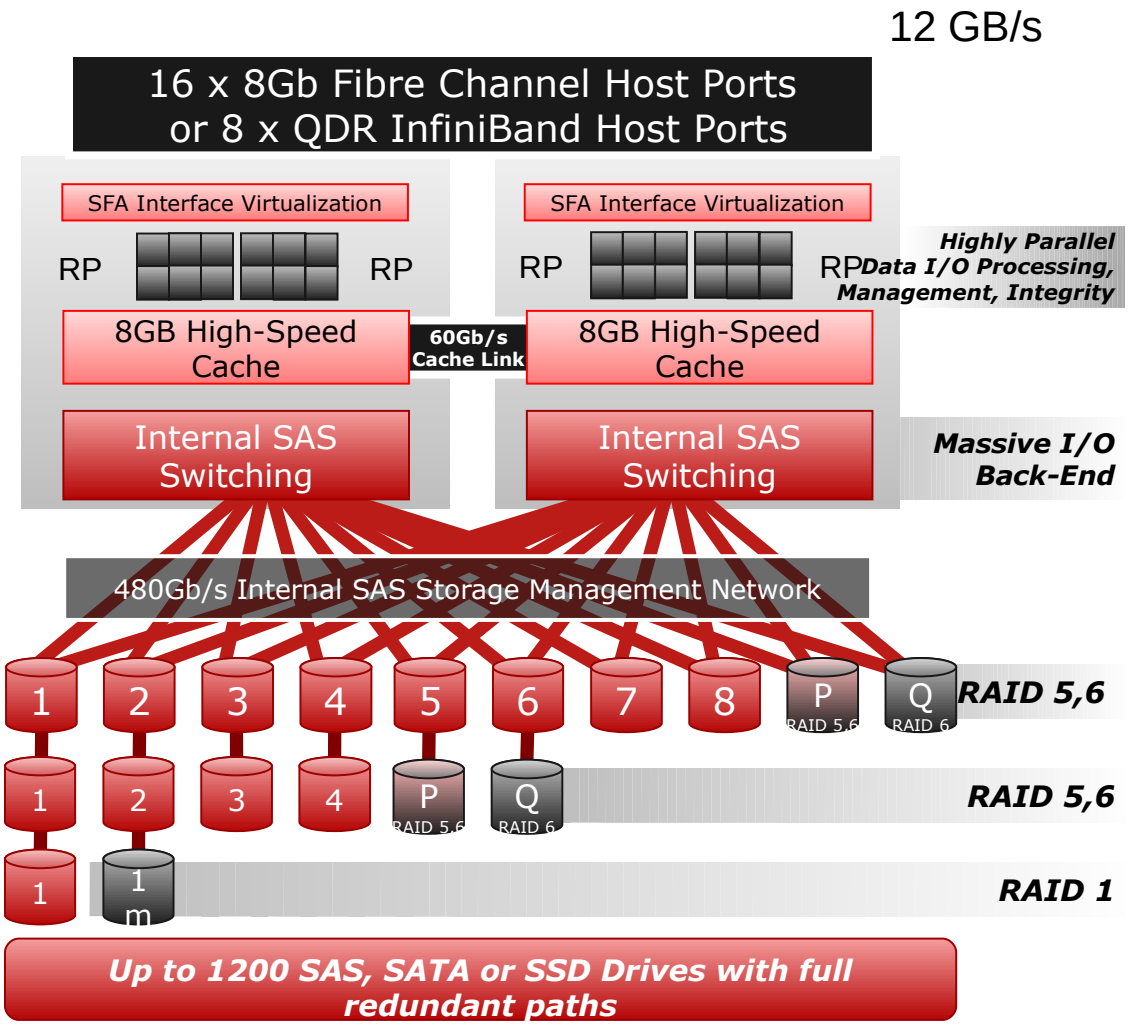
2010+ Petaflop Systems

- LLNL
  - 1TB/sec and 30PB (Lustre)
- Argonne
  - 500GB/sec and 60PB (GPFS, PVFS)
- ORNL
  - 800GB/sec and 30PB (Lustre)
- CEA
  - 500GB/sec (Lustre)
- HLRS
  - 150-300GB/sec
- LRZ
  - 200-400GB/sec

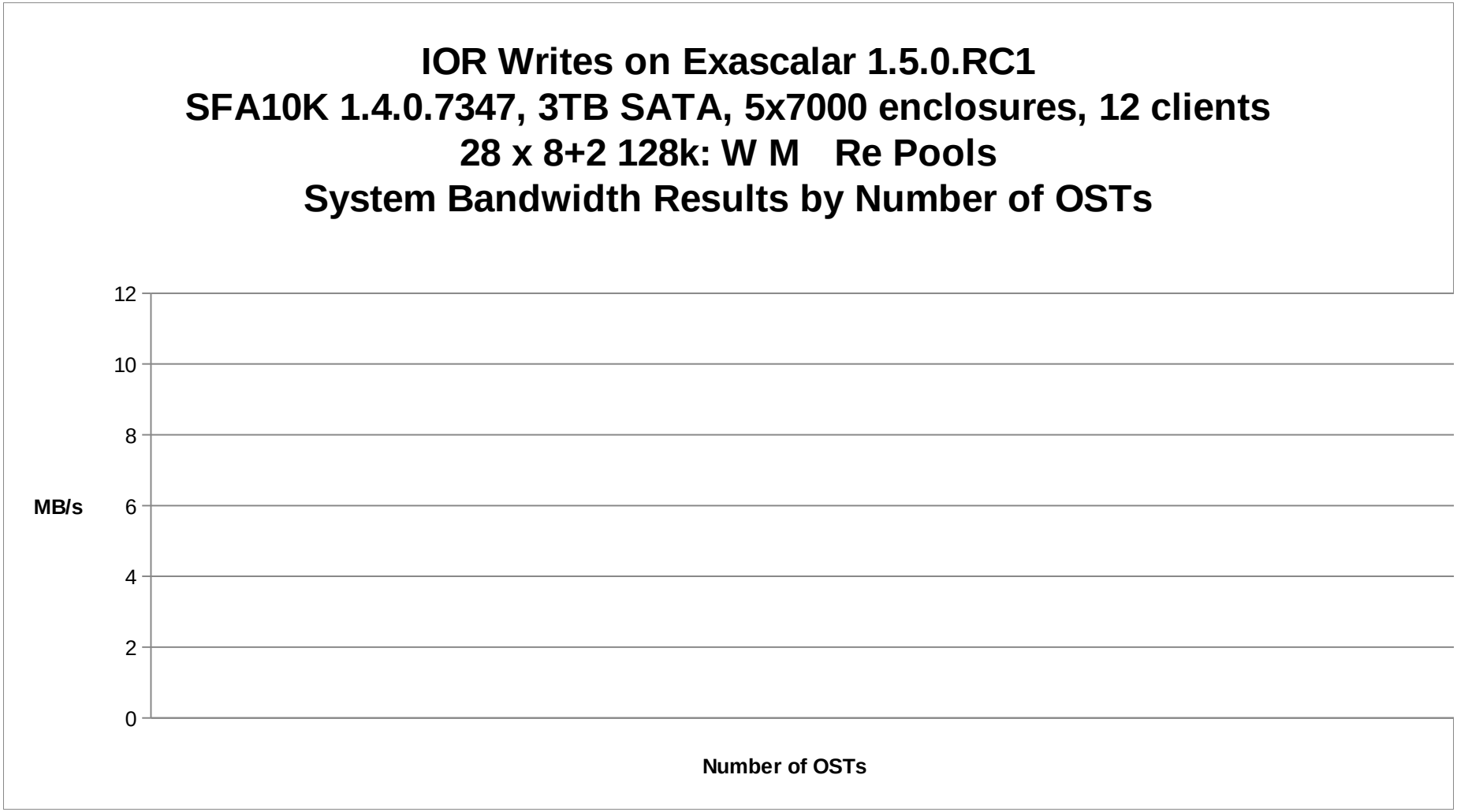
SFA10000

Highly Parallelized SFA Storage Processing Engine

- Active/Active Design
- 1 Million Burst IOPS from 16GB Mirrored, Non-Volatile Cache
- Up to 300K Sustained Random Read Disk IOPS with 1200 SAS 15K Drives
- Up to 600K Sustained Random Read IOPS from SSDs
- 13GB/s Raw Sequential Read & Write Speed
- RAID Levels 1, 5 and 6
- Intelligent Write-Through Striping
- SATAssure Data Protection
- GUI, SNMP, CLI
- 16 x FC-8 ports or 8 x QDR-IB ports

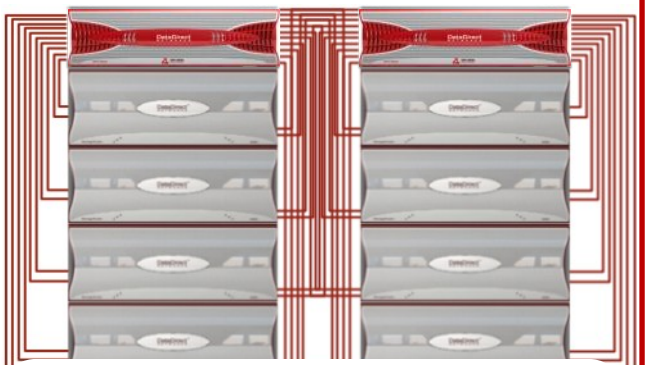


Sustained Bandwidth

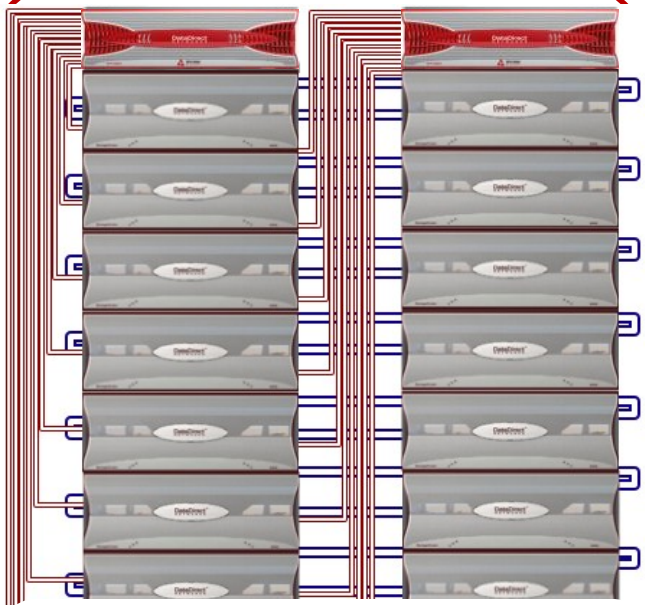


SFA10000 Configurations

5 Enclosure System
Up to 300 Drives
2 BBUs, 28U



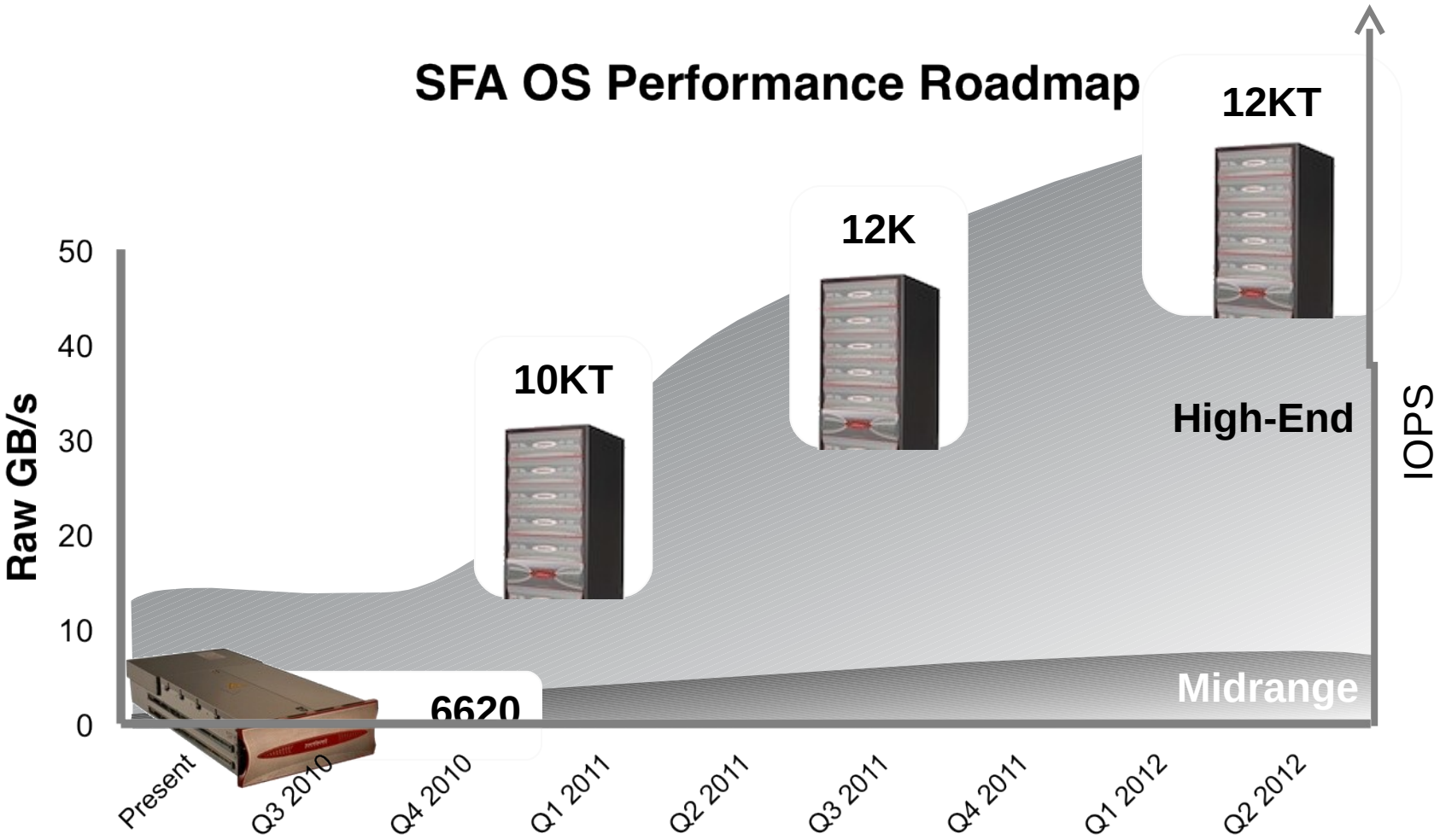
10 Enclosure System
Up to 600 Drives
2 BBUs, 48U



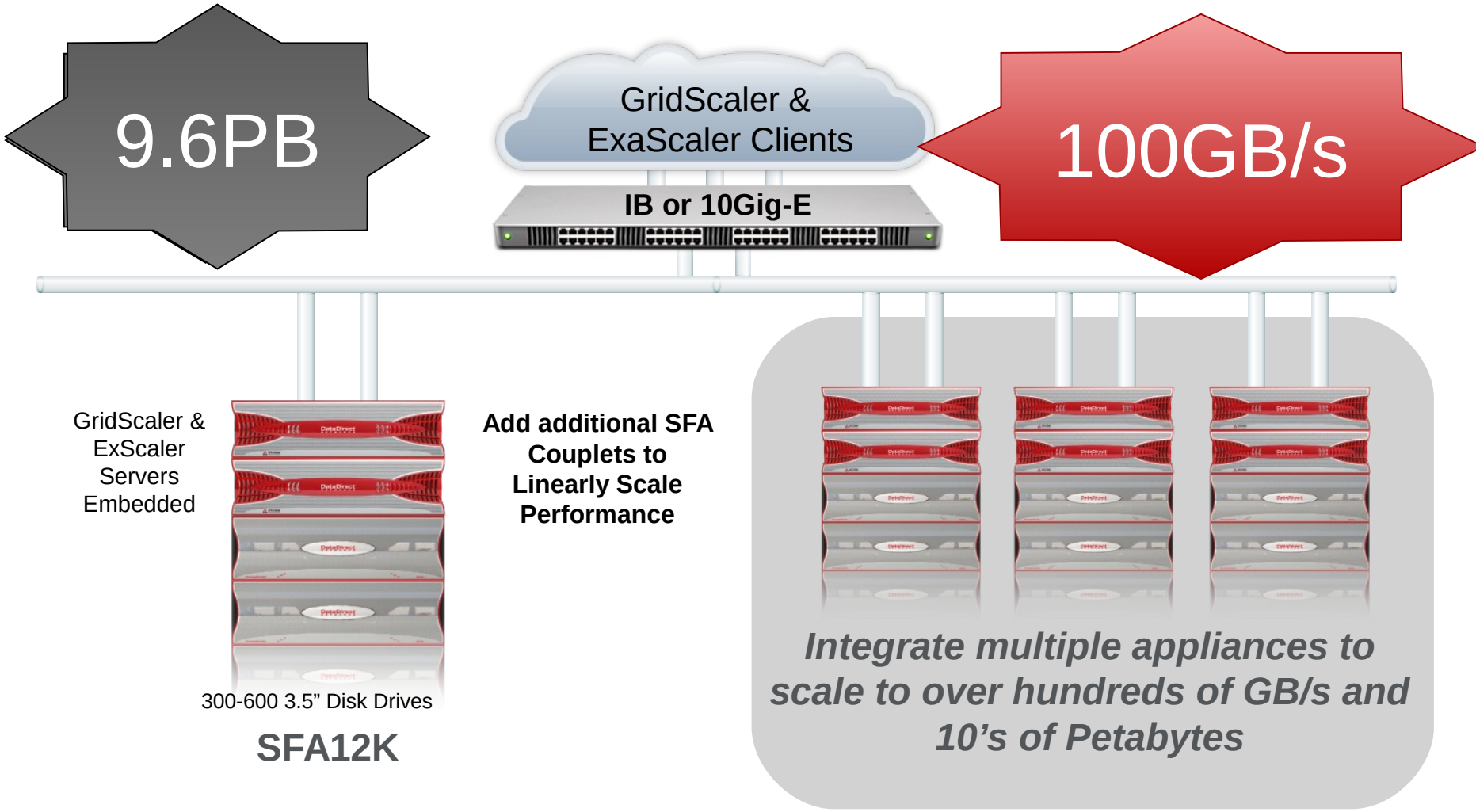
20 Enclosure System
Up to 1,200 Drives
2 BBUs, 88U

High Availability Drive Channel & Enclosure RAIDing

Dynamic Workload Arrays: Roadmap

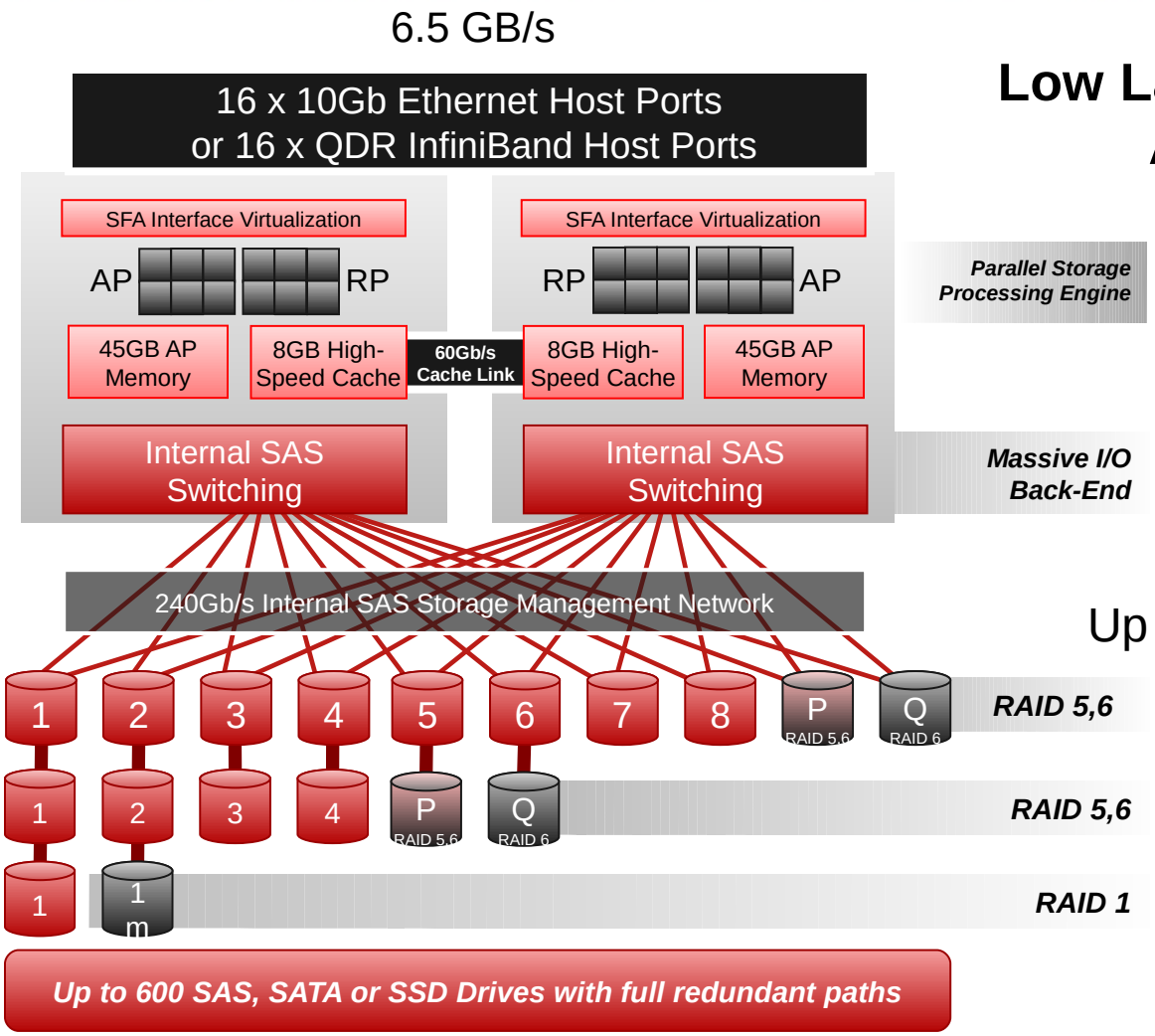


Scaling Performance with the SFA12K



SFA10000E
Embedded Applications

SFA10000E Features



Low Latency Embedded Storage Application Platform

Active/Active Design

8 Application CPU Cores

90GB of Application RAM

16 x 10Gb Ethernet or

16 x QDR InfiniBand Ports

Up to 6.5 GB/s Read & Write Speed

500,000+ Burst IOPS

150K Random Disk IOPS

16GB Mirrored Cache

RAID Levels 1, 5 and 6

Intelligent Block Striping

Up to 600 SAS, SATA or SSD Drives

Eliminating Application Overhead

Embedded Services Eliminate Communication Overhead

6KB

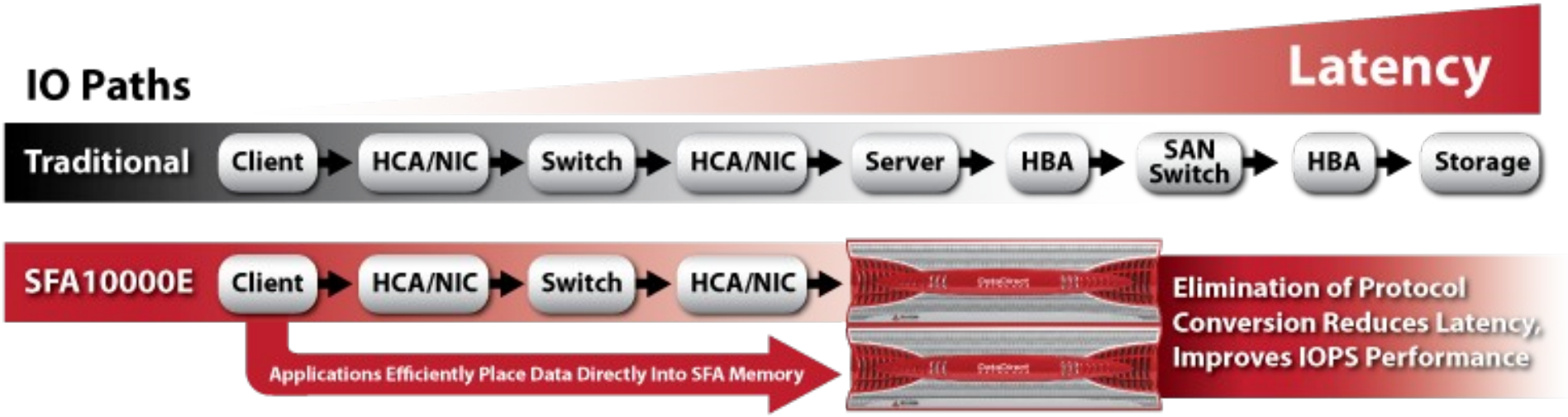
Communication per traditional SCSI Transfer

4KB I/Os = 10KB of Communication

32KB I/Os Become 20% Less Efficient

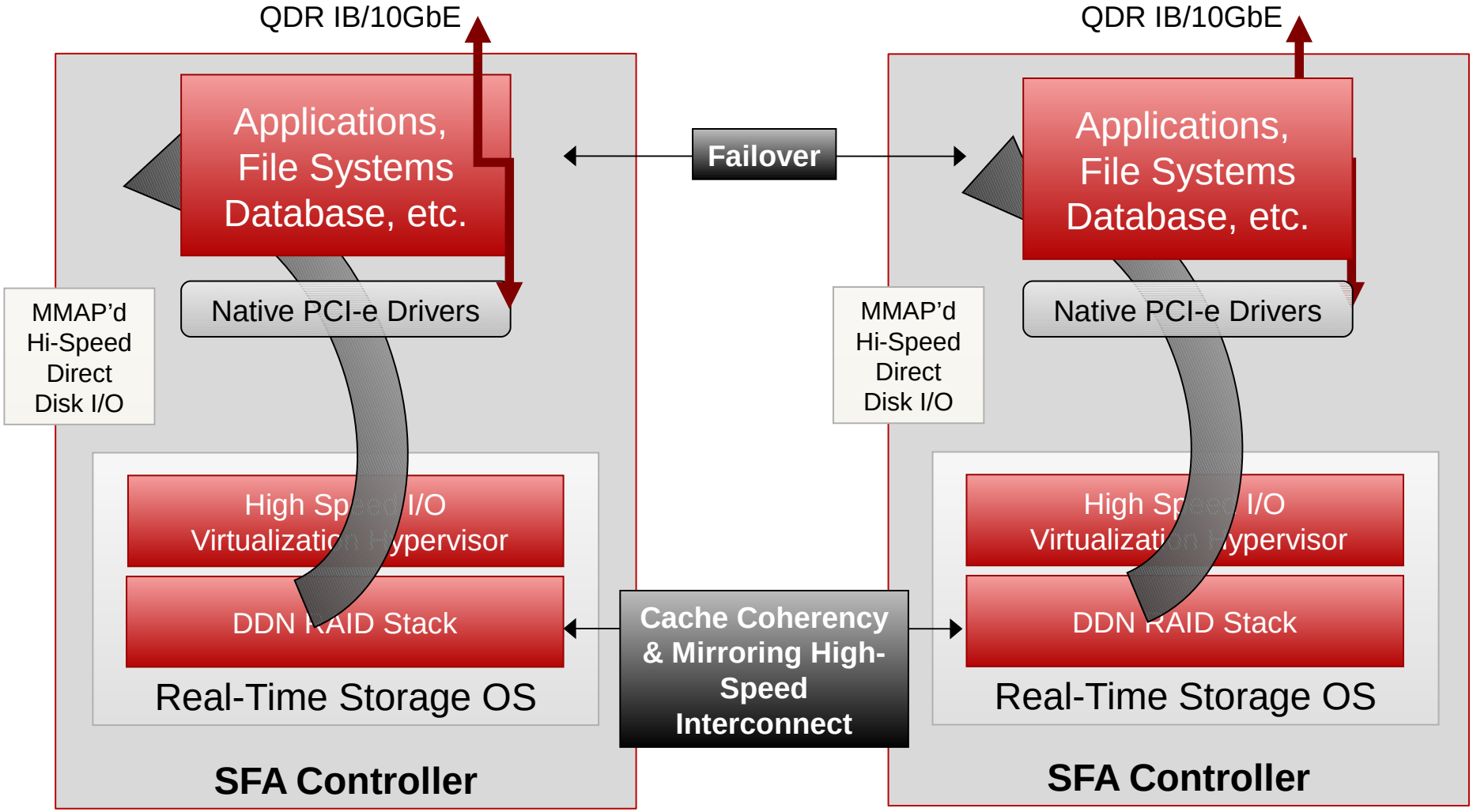
Accelerated Through Memory Copy, Eliminating SCSI Transfer

IO Path Acceleration



Storage Fusion Architecture shortens the IO path from the application to storage, reducing latency and increasing IOPS performance.

Embedded Applications



SFA10000E Appliances

- Reduce complexity and Cost
- Increase performance for latency sensitive applications
- SFA10000E initially available with DataDirect Networks' parallel clustered file system solutions

ExaScaler SFA10000E

6.5GB/s
Up To 900TB

GridScaler SFA10000E

6.5GB/s
Up To 1.8PB

Multi-Platform Architecture

Block Storage Array	Clustered Filer	Open Appliance
SFA10K Block Storage Target	**SFA10KE** DDN File Storage EXAScaler GridScaler	**SFA10KE** Customer Applications
	SFA10K Block Storage Target	**SFA10KE** Embedded Storage Server
		SFA10K Block Storage Target

Product Evolution

Flexible Deployment Options: 3 System Modalities

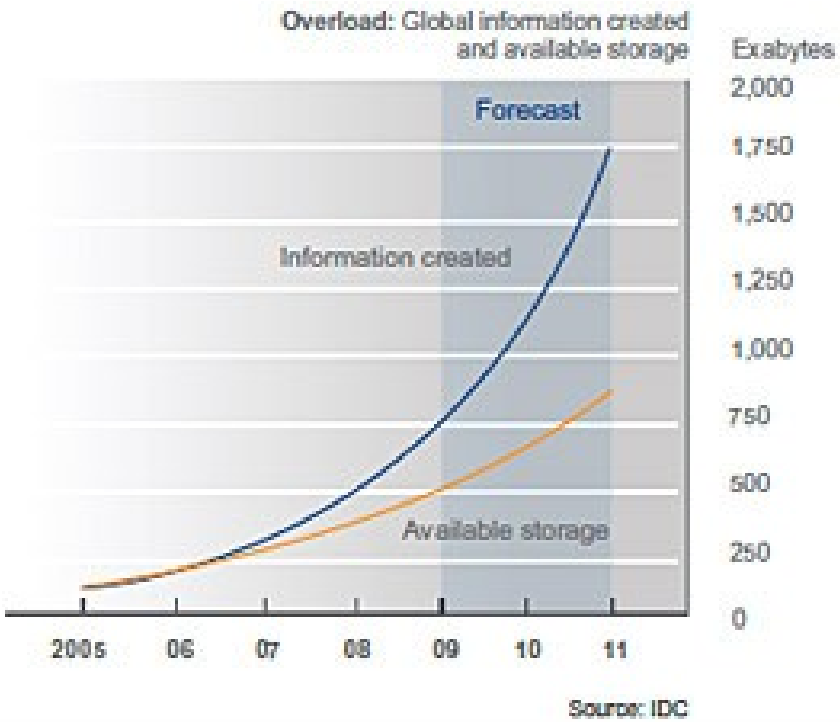
DataDirect™
NETWORKS

WOS

Distributed Hyperscale
Collaborative Storage

Web Object Storage

The Big Data Reality



Information universe in 2009:
- 800 Exabytes

In 2020's:
- 35 Zettabytes

A new type of data is driving this growth

- Structured data – Relational tables or arrays
- Unstructured data — All other human generated data
- **Machine-Generated Data – growing as fast as Moore's Law**

A Paradigm Shift is Needed

Vs.

File storage		Object Storage
Millions of Files	**Scalability**	100's of Billions of Objects
Point to Point, Local	**Access**	Peer to Peer, Global
Fault-Tolerant	**Management**	Self-Healing, Autonomous
Files, Extent Lists	**Information**	Objects w/ Metadata
75% on average	**Space Utilization**	Near 100%

What Big Data Needs

- Hyper-scale
  - World-wide single & simple namespace
  - Dense, efficient & green
  - High performance versatile on-ramp and off-ramp
- Geographically distributed
  - Process the data close to where its generated vs. copying vast amount of data to processing
  - Cloud enabling
  - World-wide single & simple namespace
- Resiliency with extremely low TCO
  - No complexity
  - Near zero administration
- Ubiquitous Access
  - Legacy protocols
  - Web Access

Storage should improve collaboration

- … ***Not make it harder***

- Minutes to install, not hours
- Milliseconds to retrieve data, not seconds
- Replication built in, not added on
- Instantaneous recovery from disk failure, not days
- Built in data integrity, not silent data corruption

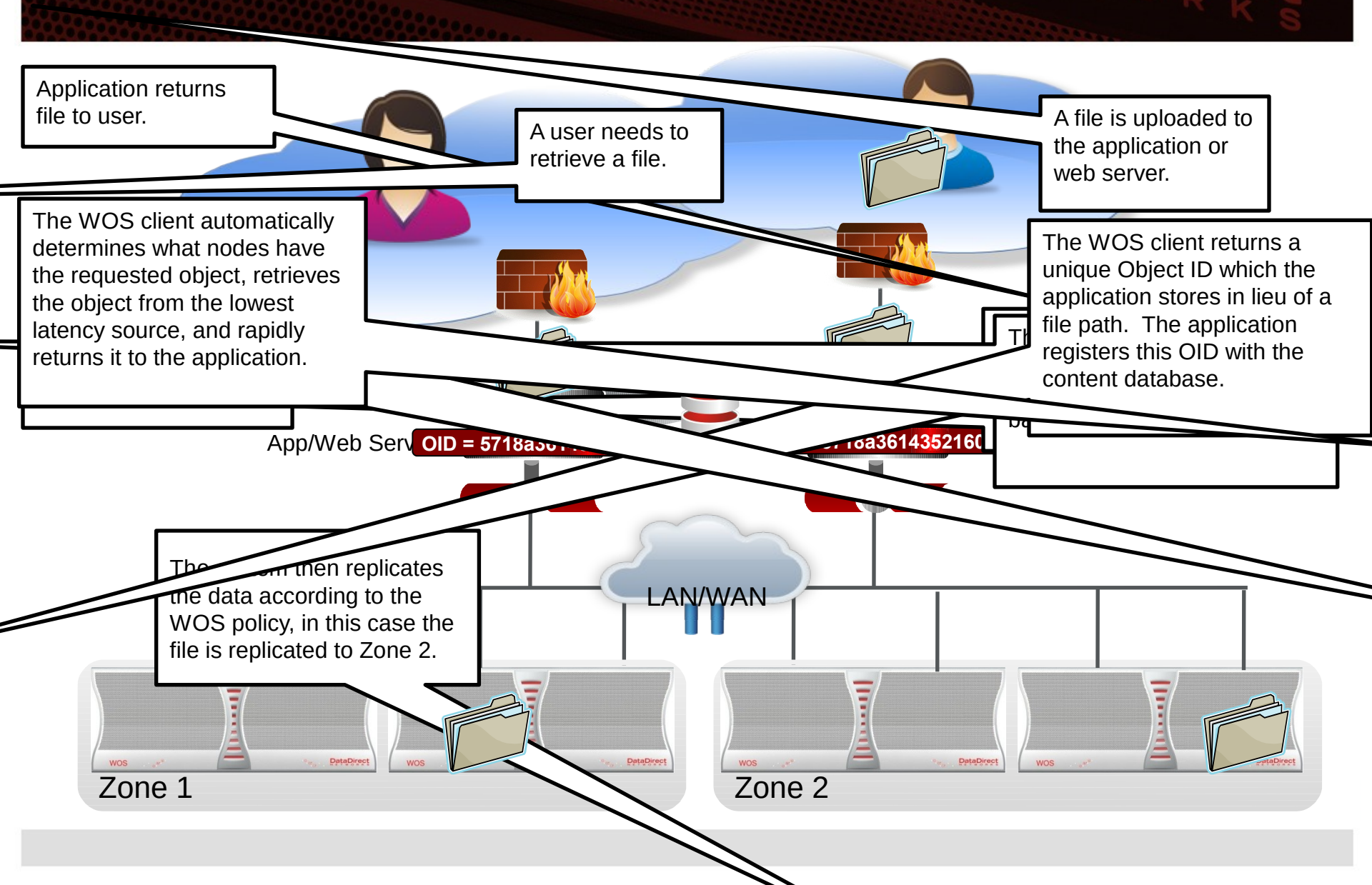
The WOS initiative

- Understand the data usage model in a collaborative environment where immutable data is shared and studied.
- A simplified data access system with minimal layers.
- Eliminate the concept of FAT and extent lists.
- Reduce the instruction set to PUT, GET, & DELETE.
- Add the concept of locality based on latency to data.

WOS Fundamentals

- **No central metadata storage**, distributed management
- **Self-managed**, online growth & balancing, replication
- **Self-tuning**, zero-intervention storage
- **Self-healing** to resolve all problems & failures with rapid recovery
- **Single-Pane-of-Glass** global, petabyte storage management

WOS: Distributed Data Mgmt.



Intelligent WOS Objects

Sample Object ID (OID): `ACuoBKmWW3Uw1W2TmVYthA`

WOS Signature

A random 64-bit key to prevent unauthorized access to WOS objects

WOS Policy

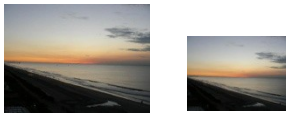
`Eg. Replicate Twice; Zone 1 & 3`

WOS Checksum

Robust 64 bit checksum to verify data integrity during every read.

User Metadata
Key Value or Binary

```
Object = Photo
Tag = Beach
```

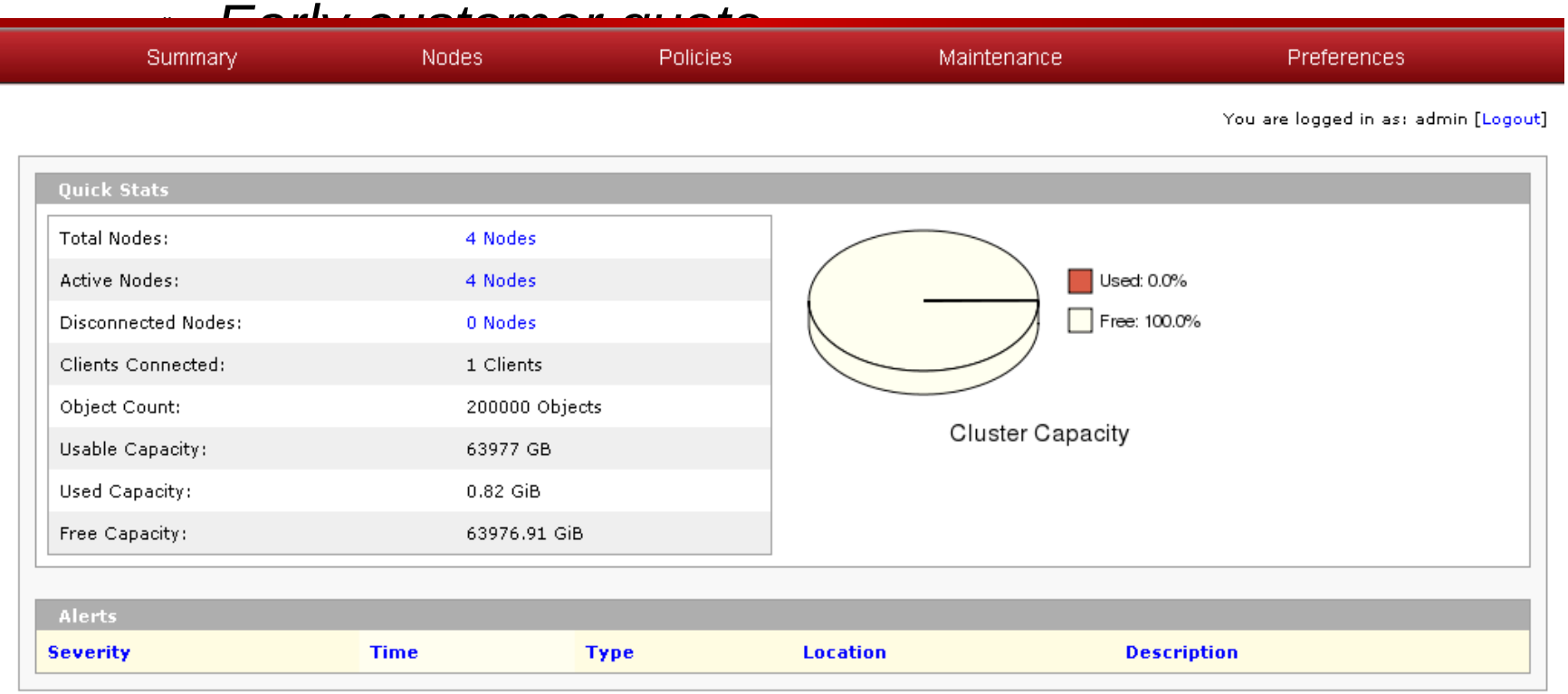


thumbnails

Full File or
Sub-Object

WOS Advantages
Simple Administration

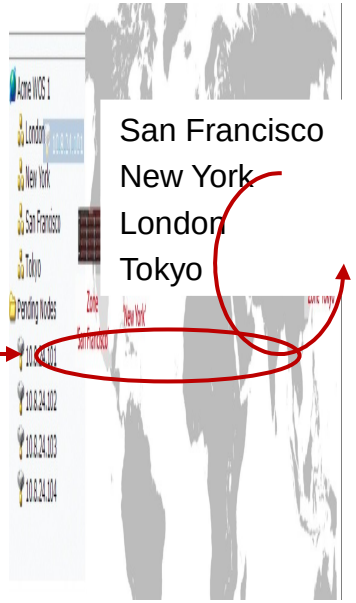
- Designed with a simple, easy-to-use GUI
- **“This feels like an Apple product”**
  - *Early customer quote*



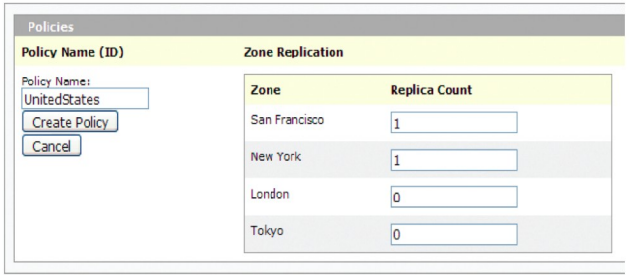
WOS Deployment & Provisioning

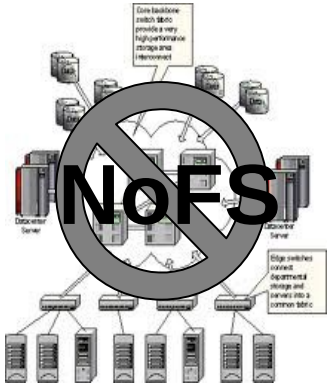
WOS building blocks are easy to deploy & provision – in 10 minutes or less

- Provide power & network for the WOS Node
- Assign IP address to WOS Node & specify cluster name (“Acme WOS 1”)
- Go to WOS Admin UI. WOS Node appears in “Pending Nodes” List for that cluster
- Drag & Drop the node into the desired zone
- Assign replication policy (if needed)



Simply drag new nodes to any zone to extend storage





Congratulations! You have just added 180TB to your WOS cluster!

Data Protection: Drive and Node Failure Handling

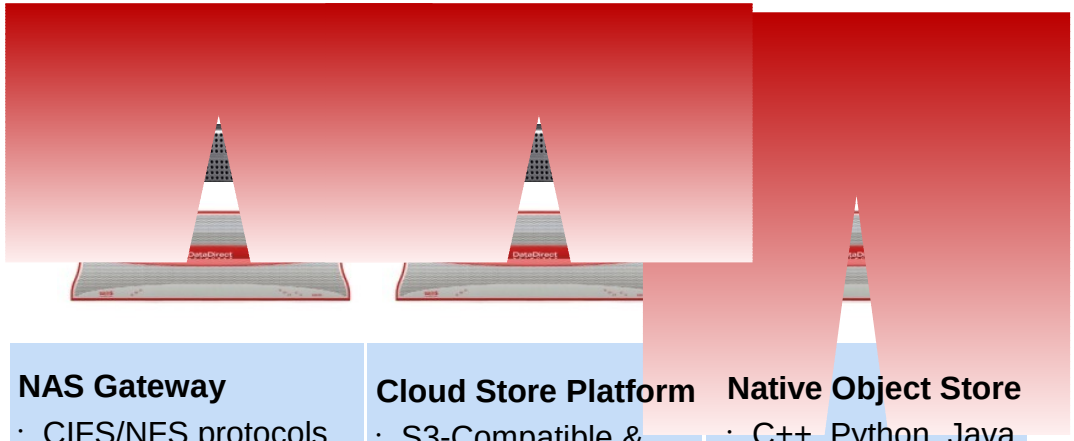
This slide needs to be viewed in PowerPoint presentation mode. Static display such as editing mode or printed slides will not convey anything meaningful due to the interactive nature of this slide.

WOS Accessibility

NAS Protocols (CIFS, NFS, etc)

Cloud Platform S3 compatibility

Native Object Store interface



NAS Gateway
- CIFS/NFS protocols
- LDAP/AD Support
- Scalable
- HA & DR Protected
- Migration from existing NAS

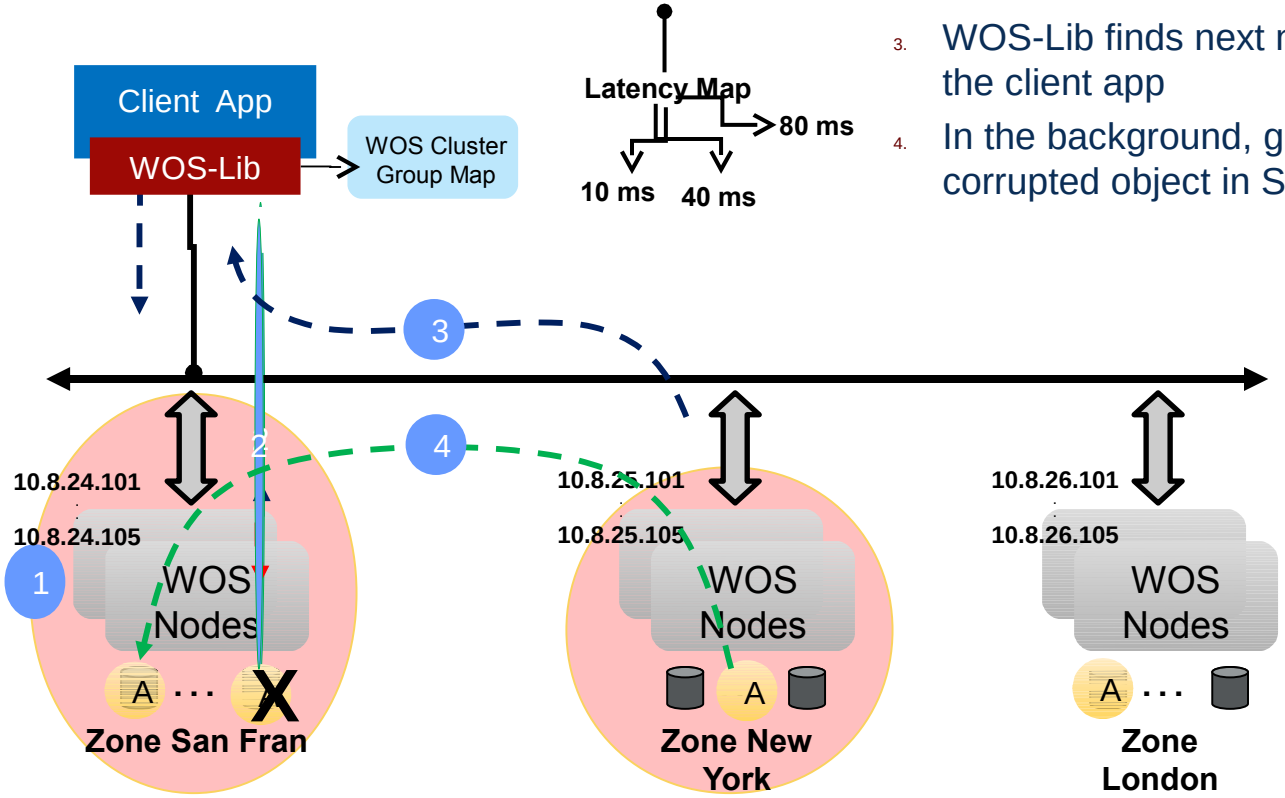
Cloud Store Platform
- S3-Compatible & WebDAV APIs
- Multi-tenancy
- Reporting & Billing
- Remote storage, file sharing, and backup agents

Native Object Store
- C++, Python, Java, PHP, HTTP REST interfaces
- PUT, GET, DELETE object, RESERVE ObjectID, etc

- NAS Gateway
  - Scalable to multiple gateways
  - DR protected & HA Failover
  - Synchronized database across remote sites
  - Local read & write cache
  - LAN or WAN access to WOS
  - Federates across WOS & NAS
- Cloud Storage Platform
  - Targeted at cloud service providers or private clouds
  - Enables S3-enabled apps to use WOS storage at a fraction of the price
  - Supports full multi-tenancy, bill-back, and per-tenant reporting

Failure recovery - Data, Disk or Net

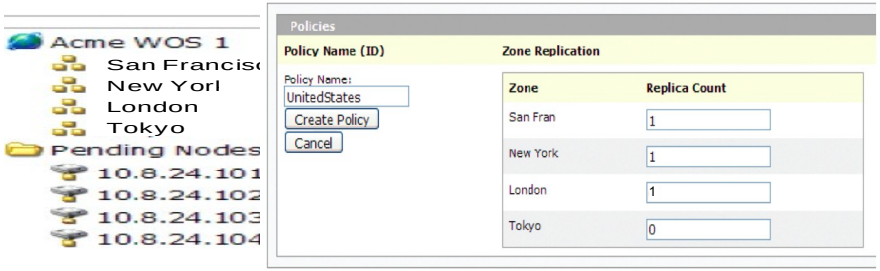
Operation:
GET "A"



Get Operation – Corrupted with Repair

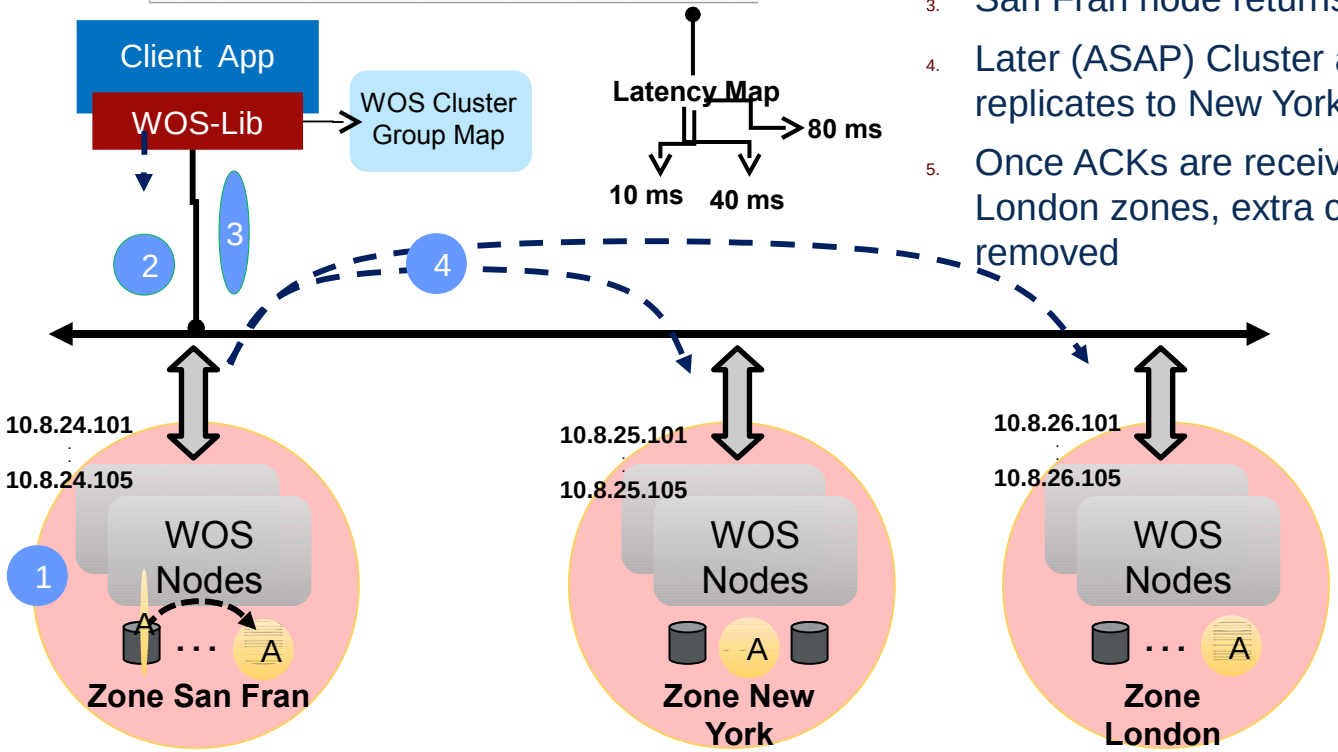
1. WOS-Lib selects replica with least latency & sends GET request
2. Node in Zone "San Fran" detects object corruption
3. WOS-Lib finds next nearest copy & retrieves it to the client app
4. In the background, good copy is used to replace corrupted object in San Fran zone

Geographic Replica Distribution



PUT with Asynchronous Replication

1. WOSLib selects “shortest-path” node
2. Node in Zone “San Fran” stores 2 copies of object to different disks (nodes)
3. San Fran node returns OID to application
4. Later (ASAP) Cluster asynchronously replicates to New York & London zones
5. Once ACKs are received from New York & London zones, extra copy in San Fran zone is removed



WOS + IRODS is a simple solution for Cloud Collaboration

- iRODS, a rules oriented distributed data management application meets WOS, an object oriented content scale-out and global distribution system
- WOS is a flat, addressable, low latency data structure.
- WOS creates a “trusted” environment with automated replication.
- WOS is not an extents based file system with layers of V-nodes and I-nodes.
- IRODS is the ideal complement to WOS allowing multiple client access and an incorporation of an efficient DB for metadata search activities.

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Thank You

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