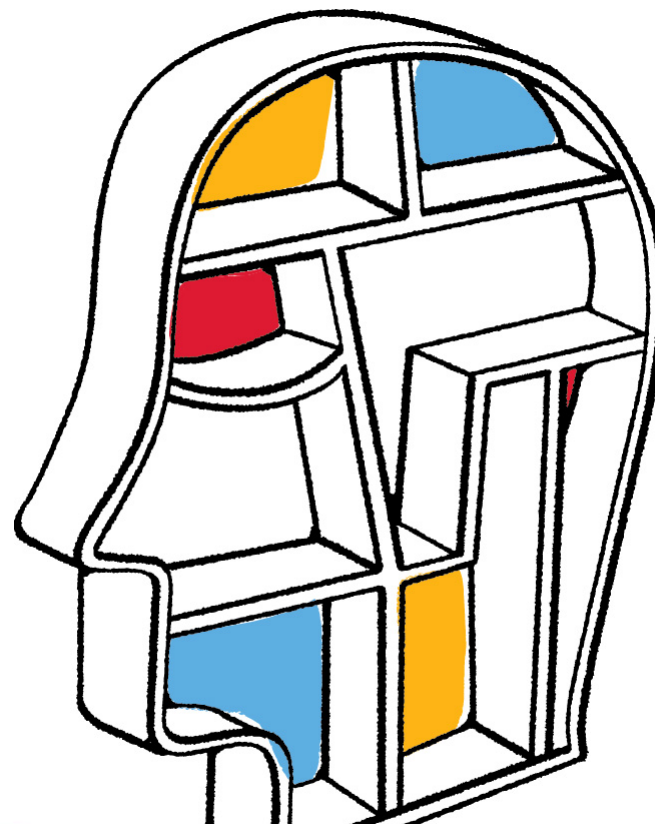




Go further, faster®

The Lego® Approach to HPC Storage

Dr. Didier Gava
EMEA HPC Storage Architect
CUG 2012





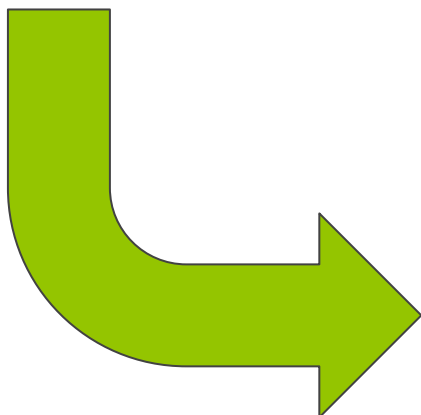
Our HPC Challenges

Get the job done...

As fast as possible

As reliably as possible

At lowest cost possible



Storage Contribution

■ Performance

- Get bigger jobs done in a shorter amount of time
- Get more jobs done in the same amount of time
- Address widening gap between compute & storage

■ Reliability

- Minimize system downtime
- Ensure data integrity and availability

■ Efficiency

- Optimize storage performance density, capacity density and power density
- Ease of design and deployment and management

■ Cost

- Competitive acquisition cost
- Minimize operating expense



E5400 and E2600

Industry leading IOPS per drive
Industry leading Bandwidth per drive





RAID Controllers & ESMs

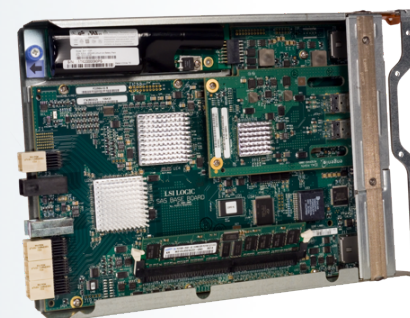
■ E5400 RAID Controller

- FC or IB host attach
- 24GB cache memory per dual controller system
- Rich RAID feature set
- Use for highest bandwidth and highest IOPS per array
- Up to 384 drives per system
- Dual E5400 RAID Controllers in any enclosure = an E5400 Array



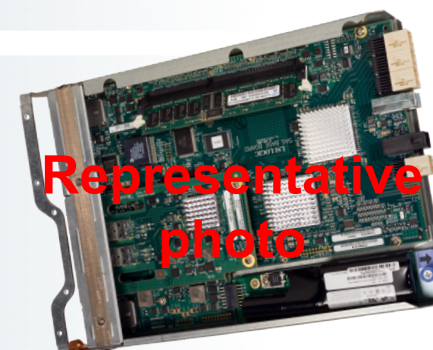
■ E2600 RAID Controller

- SAS, FC or iSCSi host attach
- 8GB memory per dual controller system
- Rich RAID feature set
- Use for balanced price, performance and capacity per array
- Up to 192 drives per system
- Dual E2600 RAID Controllers in any enclosure = an E2600 Array



■ ESM – Enclosure Services Module

- Non-RAID, Enclosure Services Module – dual ESMs are installed in drive enclosures for array expansion
- SAS 2.0 for connectivity
- Use to add additional enclosures and drives for performance and capacity





Drive Enclosures



■ Ebbets

- 2U12 with 12 - 3.5" drives
- SAS and NL-SAS drives
- Fully redundant
- Use for moderate bandwidth, high IOPs, moderate capacity



■ Camden

- 2U enclosure with 24 - 2.5" drives
- SAS, NL-SAS and SSD drives
- Fully redundant
- Use for high bandwidth, highest IOPs, moderate capacity



■ Wembley

- 4U enclosure with 60 - 3.5" and/or 2.5" drives
- SAS, NL-SAS and SSD drives
- Fully redundant
- Use for highest bandwidth, high IOPs, highest capacity



E5400 Storage Building Blocks

Great IOPS



Maximum IOPS



Huge Capacity

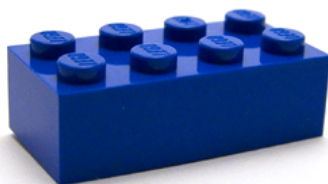


Excellent Bandwidth



Ebbets 12 Drive Enclosure

Storage Tier	Drive type	Raw Capacity	Configuration (typical)
1	SAS 15k	600, 300 & 450GB	R5 (8+1+1)
2	SAS 7.2k	3, 2 & 1TB	R6 (8+2+0)





Ebbets 12 Drive Enclosure – 15k SAS

Drive type	Raw Capacity	Usable Capacity	Read IOPS	Write IOPS	Write Bandwidth
300GB SAS 15k	3.6TB	13.4TB	4320	931	600MB/s
146GB SAS 15k	1.8TB	6.5TB	4320	931	600MB/s





Ebbets 12 Drive Enclosure – 7.2k SAS

Drive type	Raw Capacity	Usable Capacity	Read IOPS	Write IOPS	Write Bandwidth
3TB SAS 7.2k	36TB	26.8TB	1315	326	600MB/s
2TB SAS 7.2k	24TB	17.8TB	1315	326	600MB/s
1TB SAS 7.2k	12TB	8.9TB	1315	326	600MB/s





Camden 24 Drive Enclosure

Storage Tier	Drive type	Raw Capacity	Configuration (typical)
0	SAS SSD (SLC)	800 & 200GB	R5, R1, R10, R0 variants
1	SAS 15k	300 & 146GB	R5 (8+1+1)
1	SAS 10k	900, 600, 450 & 300GB	R5 (8+1+1)
2	SAS 7.2k	1TB & 500GB	R6 (8+2+0)





Camden 24 Drive Enclosure – **SAS SSD**

Drive type	Raw Capacity	Usable Capacity	Read IOPS	Write IOPS	Write Bandwidth
800GB SAS SSD (MLC)	16TB	11.9TB	350,000	80,000	3 GB/s
200GB SAS SSD (MLC)	4TB	2.9TB	350,000	80,000	3 GB/s
100GB SAS SSD (SLC)	2TB	1.5TB	350,000	80,000	3 GB/s
200GB SAS SSD (SLC)	4TB	2.9TB	350,000	80,000	3 GB/s
400GB SAS SSD (SLC)	8TB	5.9TB	350,000	80,000	3 GB/s

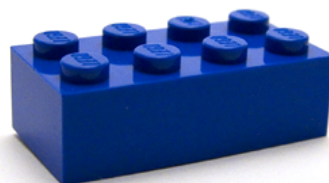
- **20 drives**





Camden 24 Drive Enclosure – 15k SAS

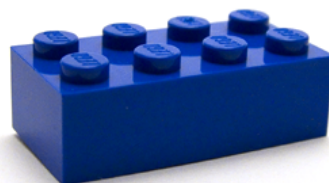
Drive type	Raw Capacity	Usable Capacity	Read IOPS	Write IOPS	Write Bandwidth
300GB SAS 15k	18TB	13.4TB	22560	5280	1.2 GB/s
146GB SAS 15k	8.7TB	6.5TB	22560	5280	1.2 GB/s





Camden 24 Drive Enclosure – 10k SAS

Drive type	Raw Capacity	Usable Capacity	Read IOPS	Write IOPS	Write Bandwidth
900GB SAS 10k	54TB	40.2TB	18672	4320	1.2GB/s
600GB SAS 10k	36TB	26.8TB	18672	4320	1.2GB/s
450GB SAS 10k	27TB	20.1TB	18672	4320	1.2GB/s
300GB SAS 10k	18TB	13.4TB	18672	4320	1.2GB/s





Camden 24 Drive Enclosure – 7.2k SAS

Drive type	Raw Capacity	Usable Capacity	Read IOPS	Write IOPS	Write Bandwidth
1TB SAS 7.2k	24TB	17.9TB	2630	653	1.25 GB/s
500GB SAS 7.2k	12TB	8.9TB	2630	653	1.25 GB/s





Wembley 60 Drive Enclosure

Storage Tier	Drive type	Raw Capacity	Configuration (typical)
0	SAS SSD (MLC)	800 & 200GB	R5, R1, R10, R0 variants
1	SAS 15k	300 & 146GB	R5 (8+1+1)
1	SAS 10k	900, 600, 450 & 300GB	R5 (8+1+1)
2	SAS 7.2k	3, 2 & 1TB	R6 (8+2+0)





Wembley 60 Drive Enclosure – SAS SSD

Drive type	Raw Capacity	Usable Capacity	Read IOPS	Write IOPS	Write Bandwidth
800GB SAS SSD	16TB	11.9TB	350,000	80,000	3 GB/s
200GB SAS SSD	4TB	2.9TB	350,000	80,000	3 GB/s

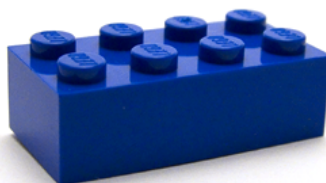
- 20 drives





Wembley 60 Drive Enclosure – 15k SAS

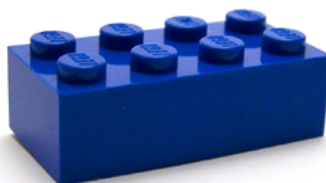
Drive type	Raw Capacity	Usable Capacity	Read IOPS	Write IOPS	Write Bandwidth
300GB SAS 15k	18TB	13.4TB	22560	5280	3 GB/s
146GB SAS 15k	8.7TB	6.5TB	22560	5280	3 GB/s





Wembley 60 Drive Enclosure – 10k SAS

Drive type	Raw Capacity	Usable Capacity	Read IOPS	Write IOPS	Write Bandwidth
900GB SAS 10k	54TB	40.2TB	18672	4320	3 GB/s
600GB SAS 10k	36TB	26.8TB	18672	4320	3 GB/s
450GB SAS 10k	27TB	20.1TB	18672	4320	3 GB/s
300GB SAS 10k	18TB	13.4TB	18672	4320	3 GB/s





Wembley 60 Drive Enclosure – 7.2k SAS

Drive type	Raw Capacity	Usable Capacity	Read IOPS	Write IOPS	Write Bandwidth
3TB SAS 7.2k	180TB	133.9TB	6576	1632	3 GB/s
2TB SAS 7.2k	120TB	89.3TB	6576	1632	3 GB/s
1TB SAS 7.2k	60TB	44.6TB	6576	1632	3 GB/s





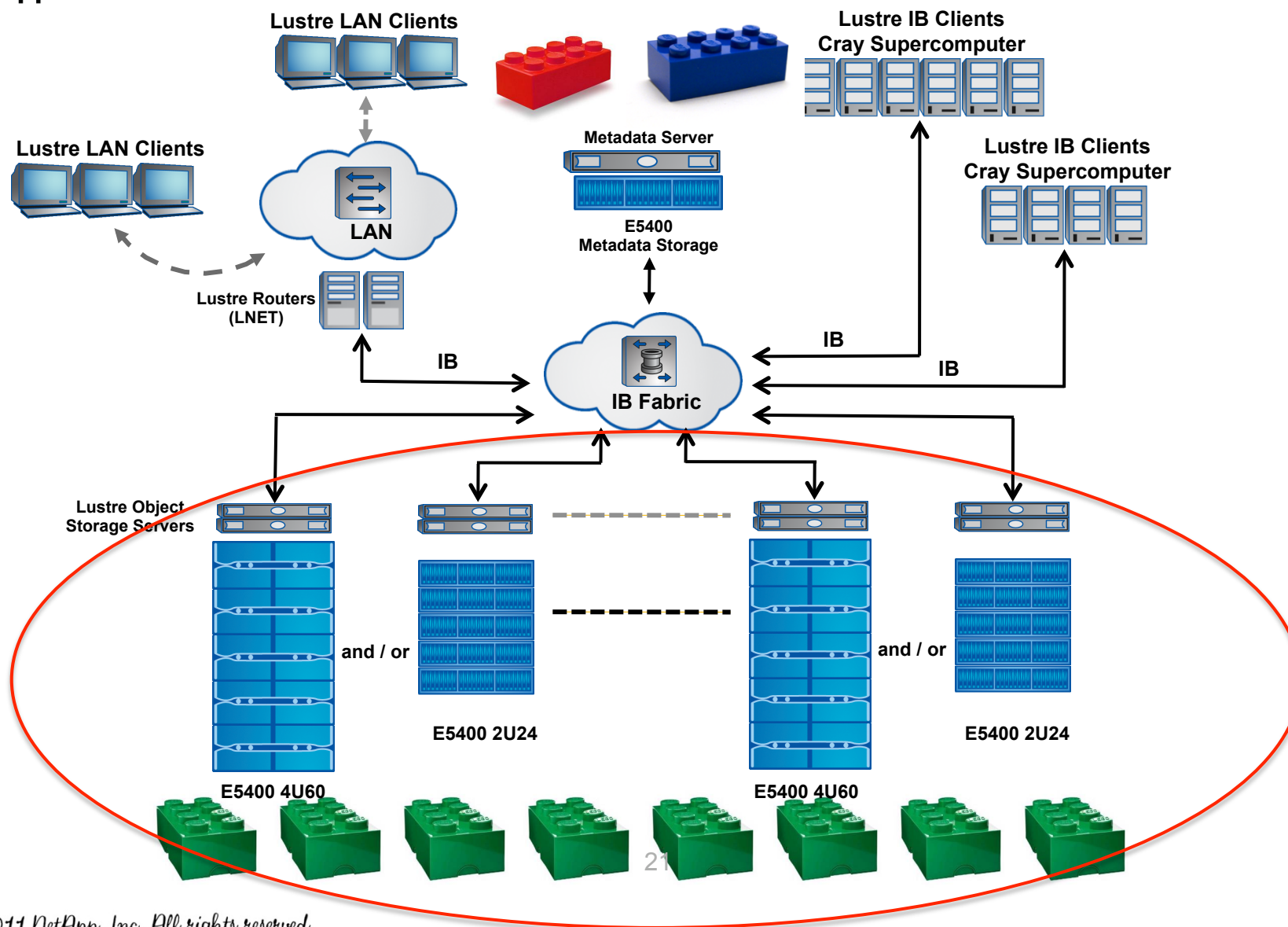
E5400 Building Blocks: Lustre OST example





NetApp®

E5400 HPC Solution For Lustre





HPC Solution for Lustre OST

- High bandwidth
 - 3GB/s writes per E5400
- High density
 - 60 drives per 4U
 - 6 OSTs per 4U
- High availability
 - No single points of failure
 - Extensive RAS features



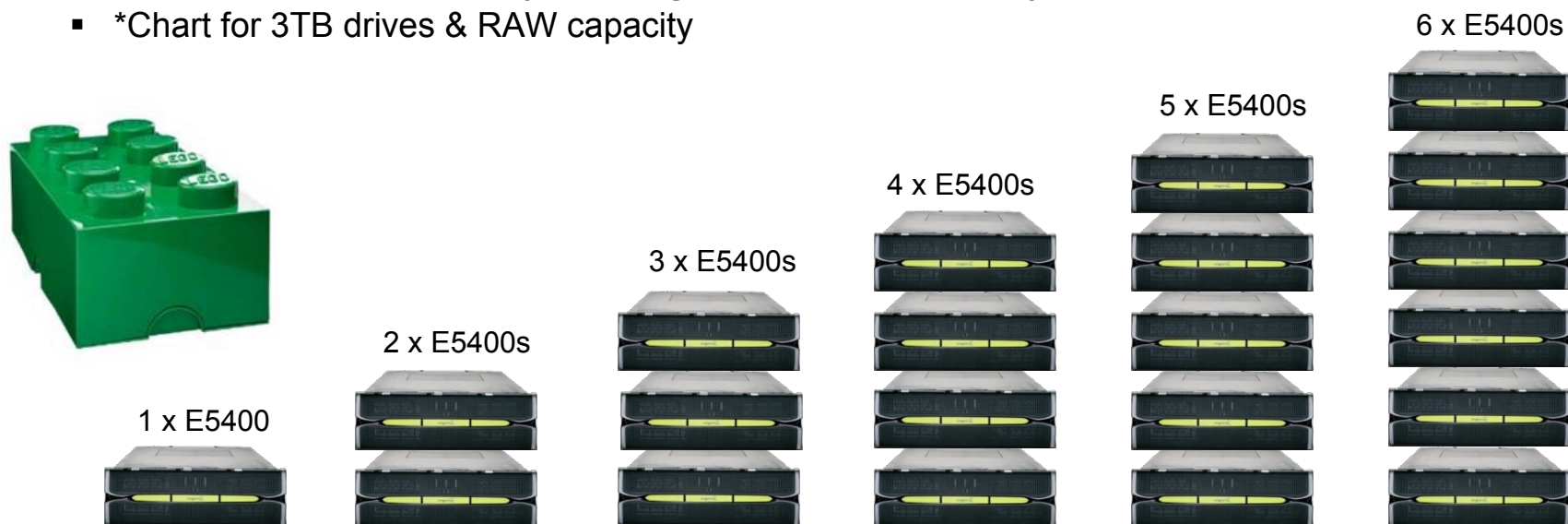
- 2 x E5400 RAID controllers
 - FC or IB
 - 12GB cache memory
- Wembley (4U60) drive enclosure
- 60 x 3TB, 3.5", 7.2k NL-SAS drives
- SANtricity Storage Management



NetApp®

Lustre Scaling – Bandwidth **First**

- Scale Lustre bandwidth by adding E5400 OSS arrays with 60 drives
 - *Chart for 3TB drives & RAW capacity



60 drives	120 drives	180 drives	240 drives	300 drives	360 drives
180TB*	360TB*	540TB*	720TB*	900TB*	1080TB*
3.0GB/s writes	6.0GB/s writes	9.0GB/s writes	12.0GB/s writes	15.0GB/s writes	18.0GB/s writes
3.0GB/s reads	6.0GB/s reads	9.0GB/s reads	12.0GB/s reads	15.0GB/s reads	18.0GB/s reads

Bandwidth Formula:

The Specified Lustre File System Aggregate Performance

----- = the required # of
E5400 OSS

3 GB/s (per E5400)



NetApp®

Lustre Scaling – Capacity **Second**

- Scale Lustre capacity by adding Wembley drive expansion enclosures with 60 drives to each E5400 OSS array

- *Chart for 3TB drives & RAW capacity



60 drives	120 drives	180 drives	240 drives	300 drives	360 drives
180TB*	360TB*	540TB*	720TB*	900TB*	1080TB*
3.0GB/s writes	3.0GB/s writes	3.0GB/s writes	3.0GB/s writes	3.0GB/s writes	3.0GB/s writes
3.0GB/s reads	3.0GB/s reads	3.0GB/s reads	3.0GB/s reads	3.0GB/s reads	3.0GB/s reads

Capacity Formula:

The Specified Lustre File System Aggregate Capacity

E5400 OSS

The required # of Lustre E5400 OSS

= the Capacity required for each



Single Rack Example - Lustre

- Complete Lustre File System in a single 40U rack
- Dual MDS servers
- 1 MDT array
- Six OSS servers
- Six OST arrays delivering **36 OSTs**
- Usable* capacity with 3TB drives = **803TB @ 18GB/s**

* Usable Capacity as delivered to Linux OS





Summary

- The NetApp E5400 provides simple building blocks to solve all your HPC Storage needs.
 - The E5400 provides dense storage that easily scales to solve HPC Capacity requirements.
 - The E5400 provides both bandwidth and IOPS storage building blocks that easily scale to solve HPC Performance and Capacity requirements.
 - Flexibility to start small and easily grow bigger





Thank you

