Mismatched network interface performance in multi Tbit converged Ethernet SDS

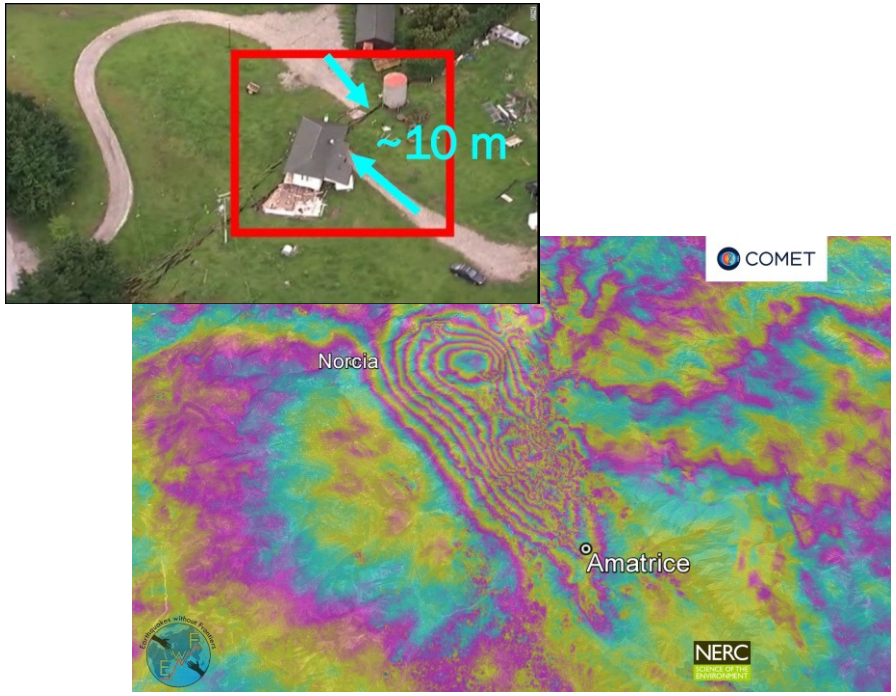
Jonathan Churchill
JASMIN Architect & Infrastructure Manager

Research Infrastructure Group
Scientific Computing Department
STFC – Rutherford Appleton Labs. UK

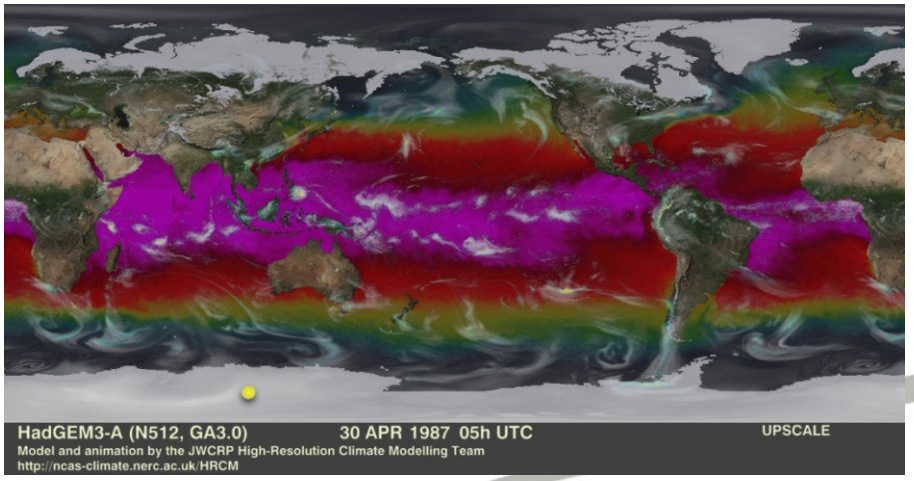
Outline

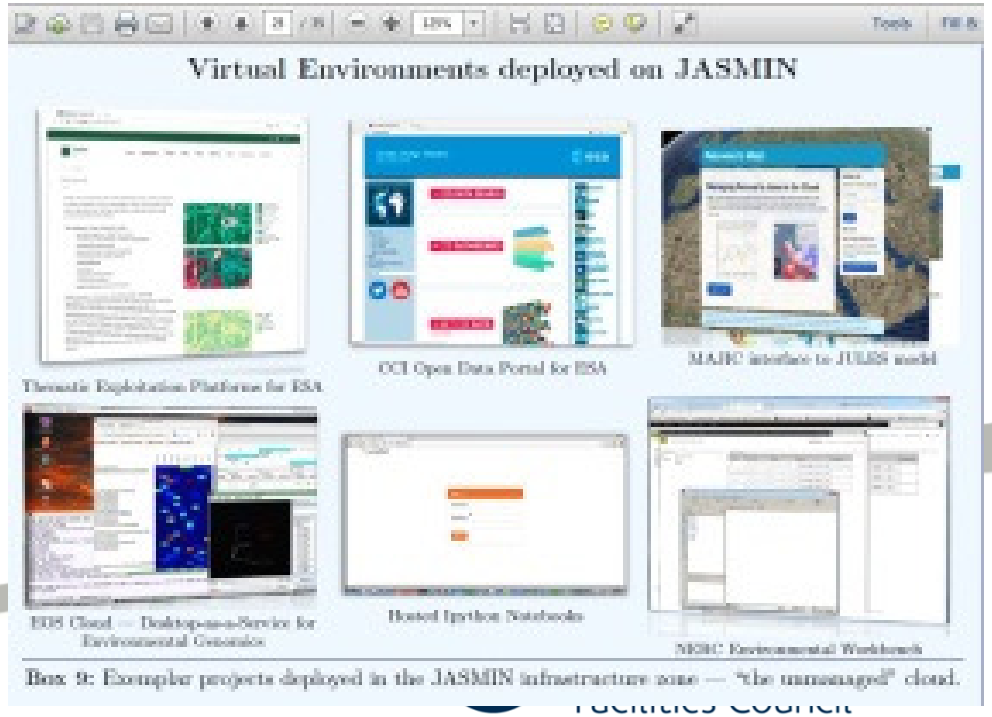
- Overview of JASMIN
- JASMIN4 Requirements
- File/Object Storage PoC.
- Implementing a Data Centre Network
- Network congestion in a “non-blocking” network

Environmental Data Analysis

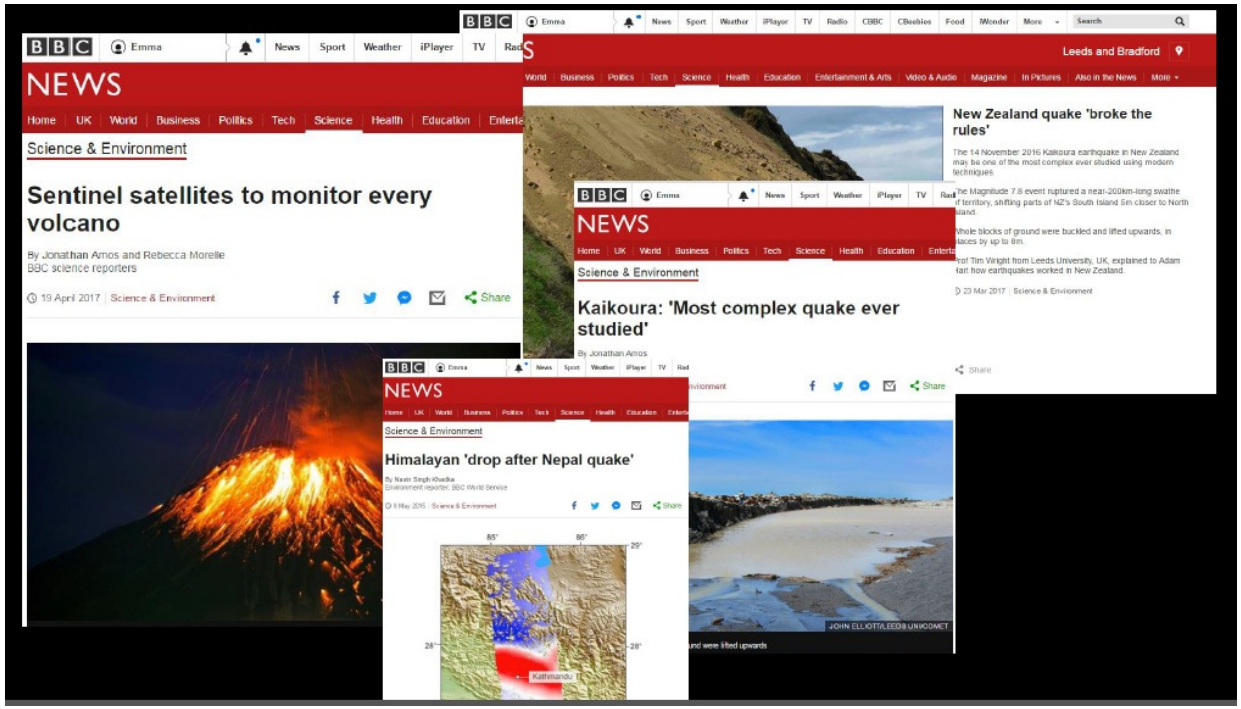


Biases in *ad-hoc* data





Jonathan.Churchill@stfc.ac.uk STFC RAL



Department for Environment Food & Rural Affairs
Agriculture, Environment and Rural Affairs
The Scottish Government

- Centre for Environment and Hydrology
- Trends for 1000's of species
- Analysis unprecedented in complexity and scope within the UK.

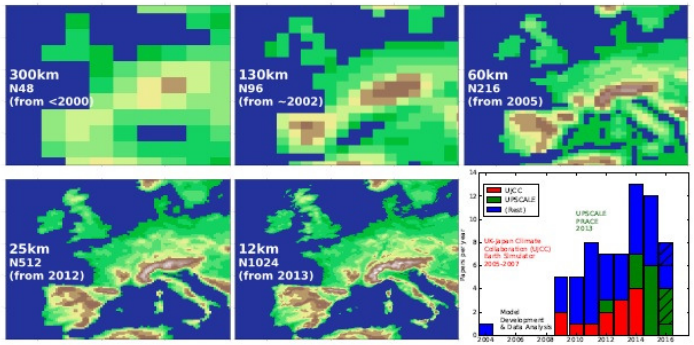
- COMET-CPOM UoLeeds
- Near real time monitoring of all active earthquake and volcanos.
- Relies on full ESA Sentinel data, Managed and unmanaged tenancies, LOTUS batch

Science & Technology Facilities Council

Jonathan.Churchill@stfc.ac.uk STFC RAL

JASMIN: the missing piece

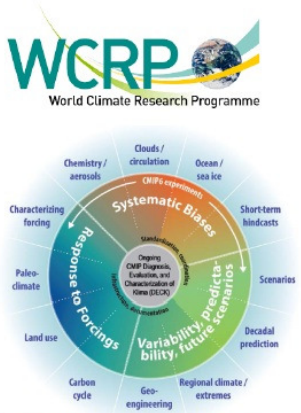
Growing Need - High Resolution Climate Programme!



Just one example, of the *many* axes of growing scientific demand in simulations and observation:

- From 7K to 3.1M points (0.05 MB to 25MB) for a single timestep of a single level of a global field.
- Multi-year data management campaigns support the data analysis (which needs to include similarly high-resolution observations).

The Organised Data Deluge



CMIP6 data volumes and data rates not yet known, but the European contribution to HiresMIP alone is expected to exceed 2 PB.

Sentinel 1A (2014), 1B (2016)
Sentinel 2A (2015) 2B (2017?)
Sentinel 3A (2016) 3B (2018?)

Data rate: o(6) PB/year

MetOffice supercomputer

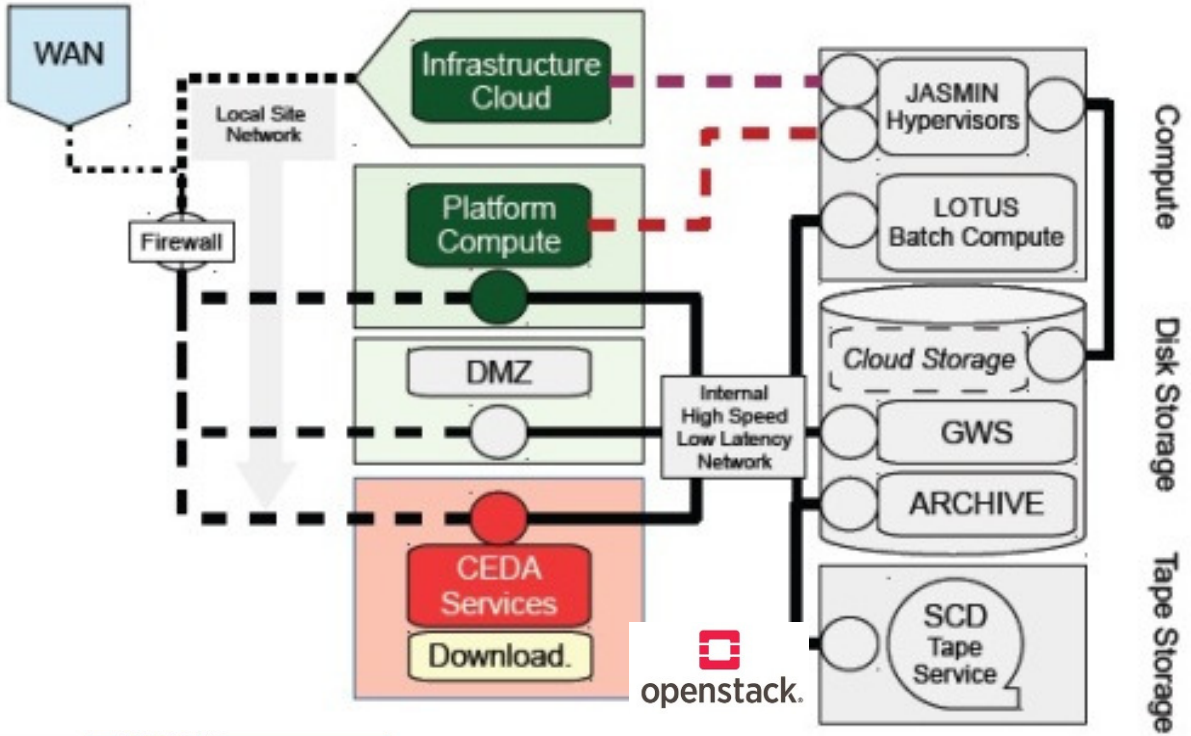
ARCHER supercomputer (EPSRC/NERC)

JAMSIN (STFC/Stephen Kill)

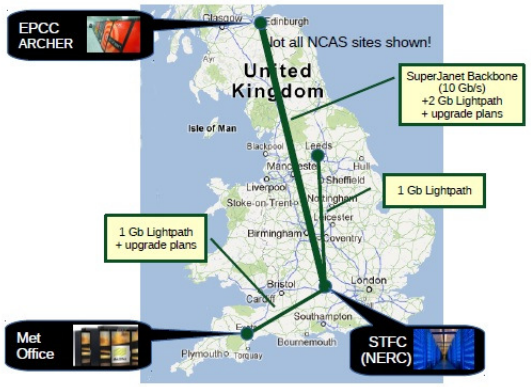
Science & Technology Facilities Council

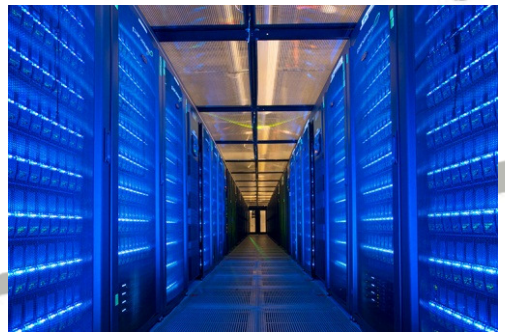
chill@stfc.ac.uk STFC RAL

Blending PB's of data, 1000's of Cloud VM's, Batch Computing & WAN Data transfer



- 24.5 PB Panasas ~ 250GByte/s
- 44 PB QuoByte SDS ~ 220GBytes/s
- 5PB Caringo Object Store
- 80PB Tape
- Batch HPC 6-10k cores
- Optical Private WAN + Science DMZ
- "Managed" VMware Cloud
- OpenStack Cloud
- Pure FlashBlade scratch
- Non-blocking ethernet > 12Tbit/sec

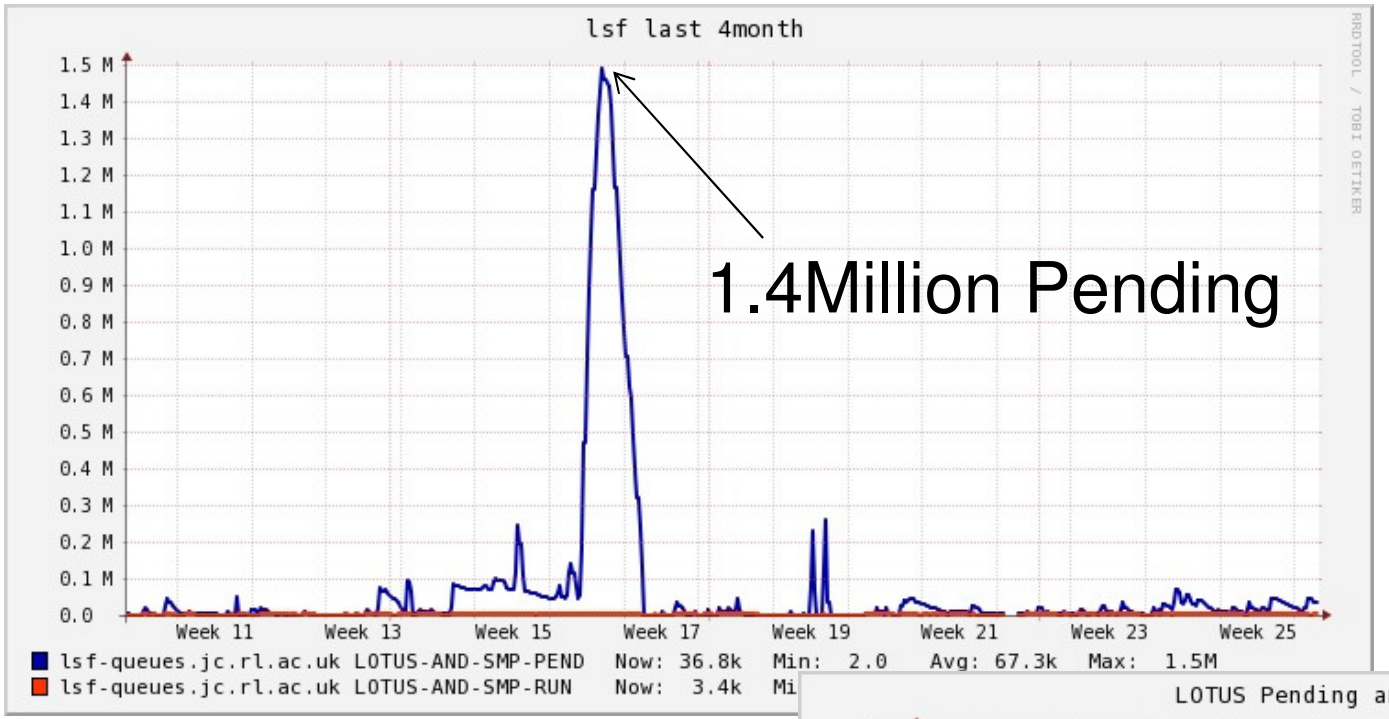


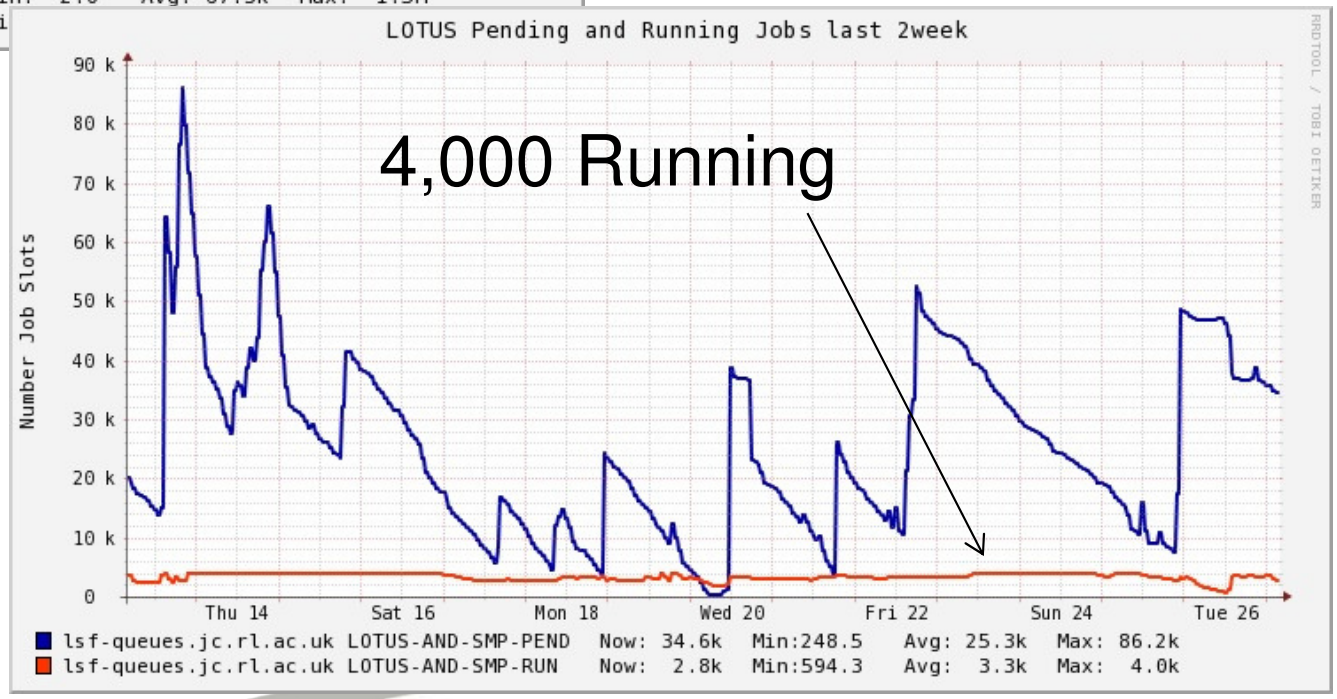


Science & Technology Facilities Council

Jonathan.Churchill@stfc.ac.uk STFC RAL

Running vs Pending LOTUS Jobs

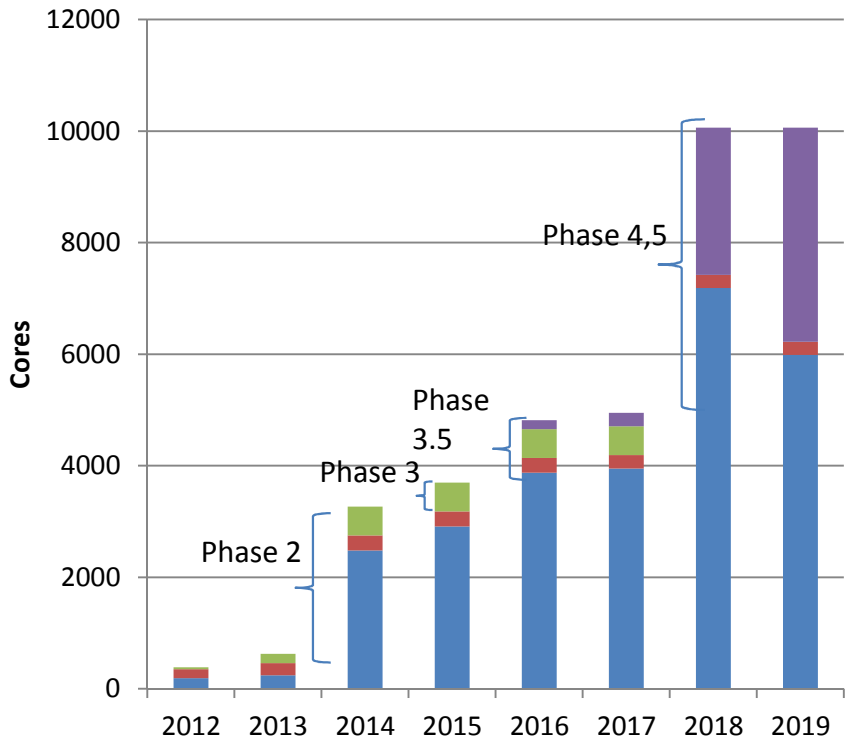


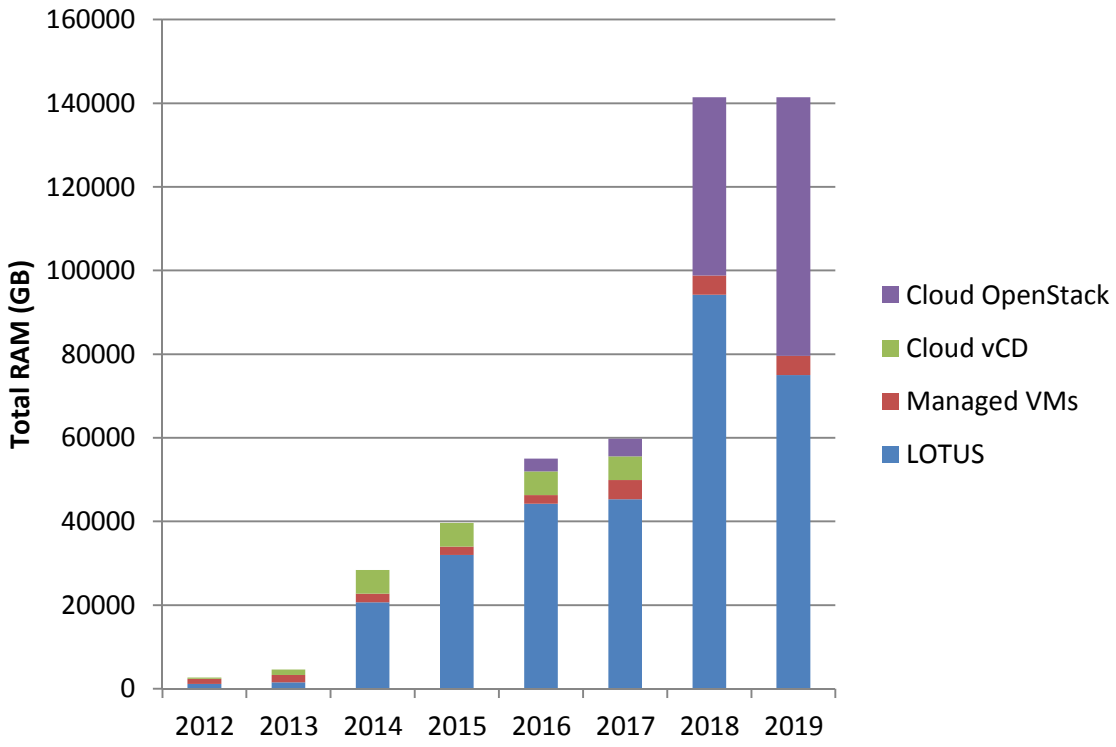


LOTUS Capacity of 10k's of Job Slots to make a noticeable difference

Science & Technology Facilities Council

JASMIN4 Compute

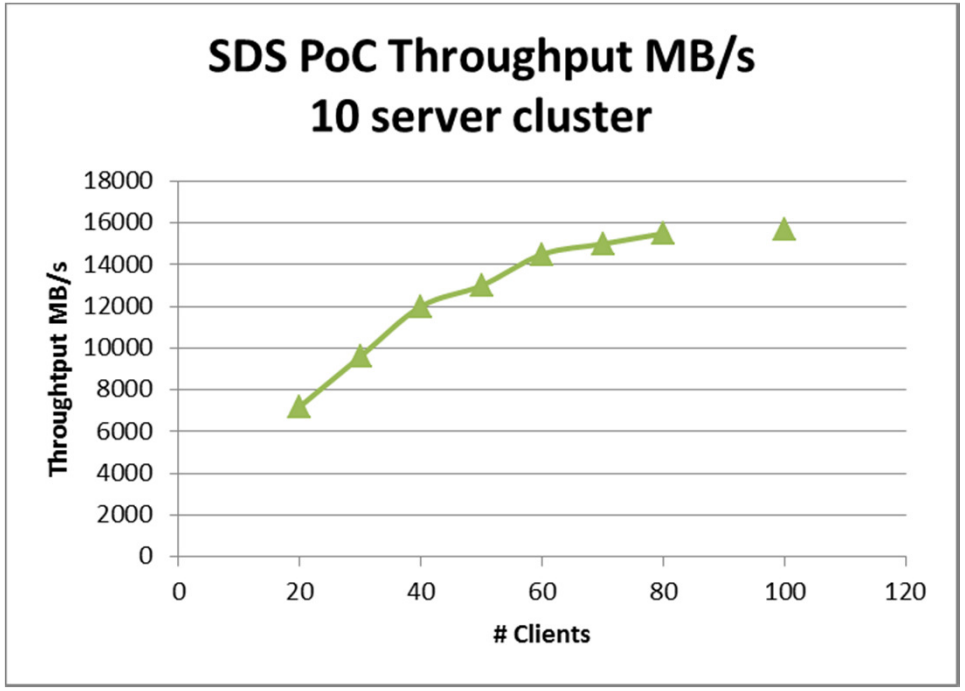


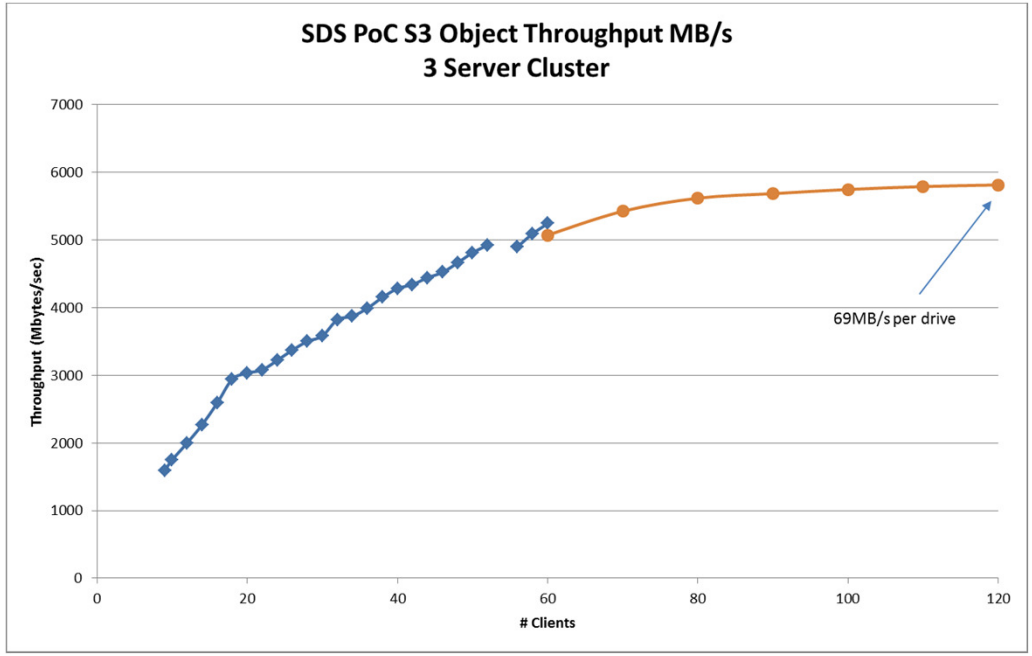


- JASMIN4 Compute
  - Targeted for Cluster as a Service (SPARK, SLURM etc) and K8S cluster Plus Additional LOTUS batch capacity interchangeably.
  - 220 nodes 2x 25Gb NICs
  - Non-blocking network to J4 spine

Science & Technology Facilities Council

Software Defined Storage PoC



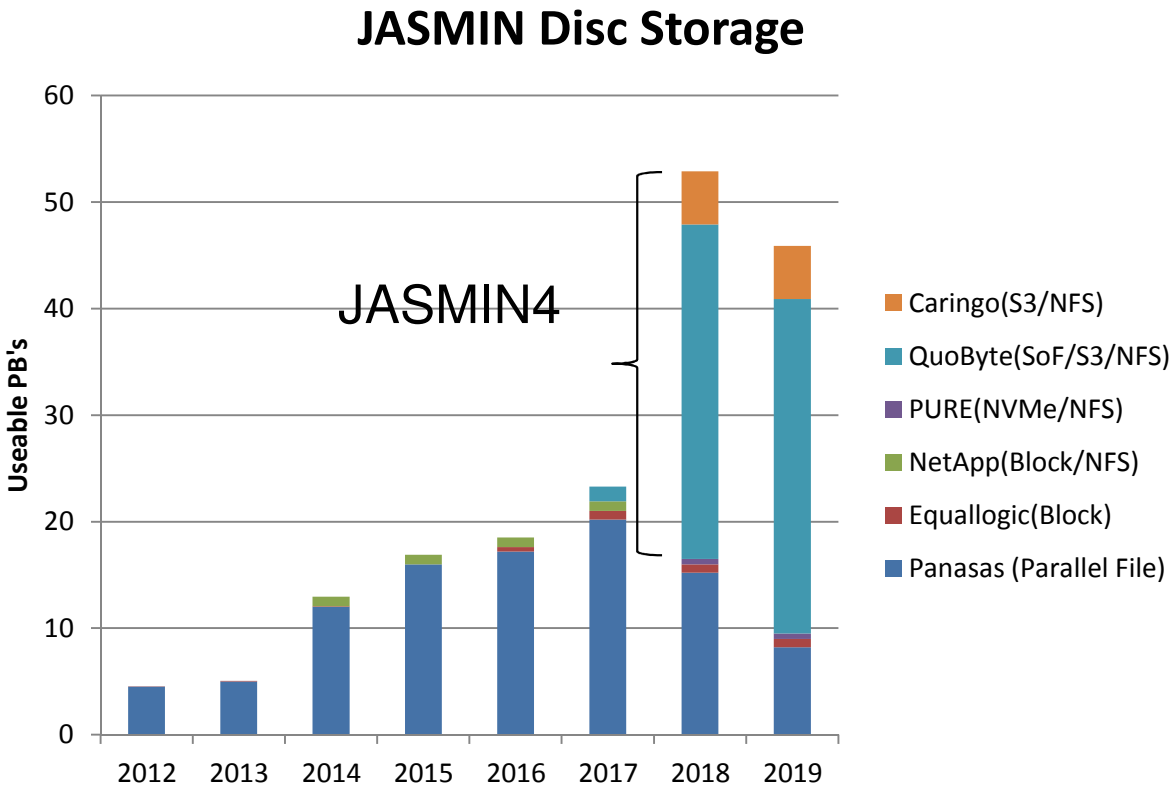


- Can we find file and object SDS comparable with PFS?
- 40Gb NIC / Chassis. No network bottlenecks.
- File 60MByte/sec/HDD
- S3 Object 60-70MByte/sec/HDD
- 27 HDD's / chassis = >>15Gbps
  - But 20-30Gbps with reconstruction/scrubs
- Clients all 10Gb.

Jonathan.Churchill@stfc.ac.uk STFC RAL

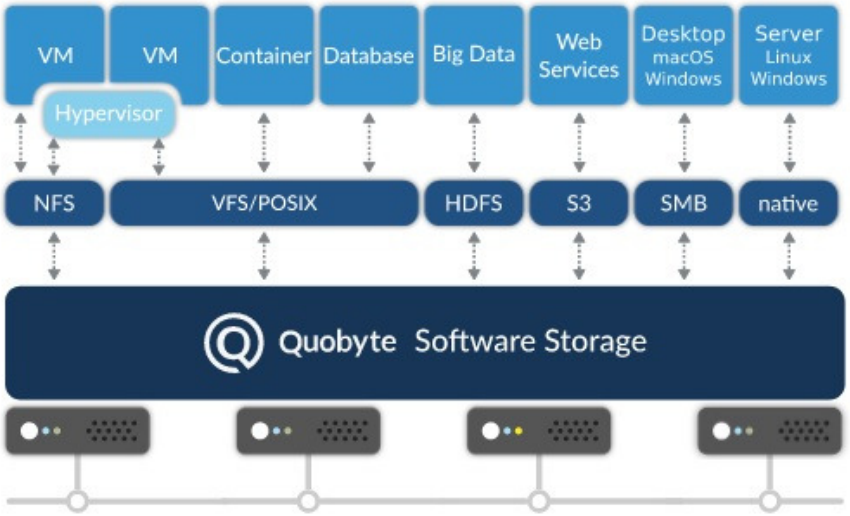
Science & Technology Facilities Council

JASMIN4 Disc Storage



- No boundaries on data growth (or network topology)
- S3 interface to file and object system. RW Both sides.
- Performance similar to Panasas PFS
- Online upgrades. Redundant networking.
- No client "call back" port.
  - Previous root /network and UMC restrictions

QuoByte



Parallel File System
HPC

Distributed File System
Video, CGI, EDA

Storage for containers
Kubernetes, Mesos, Docker

Scale-out NAS
Enterprise applications

Hadoop File System
Big Data

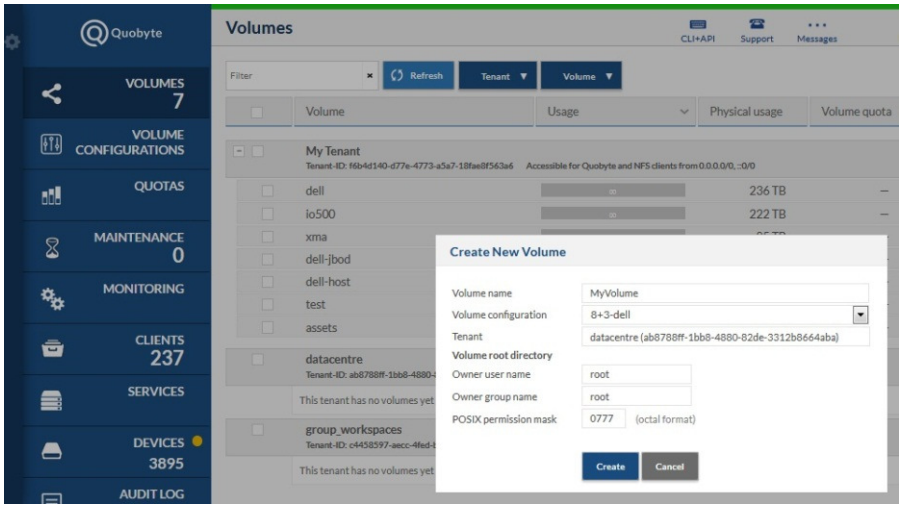
Archival storage
HPC, backup, e-Science

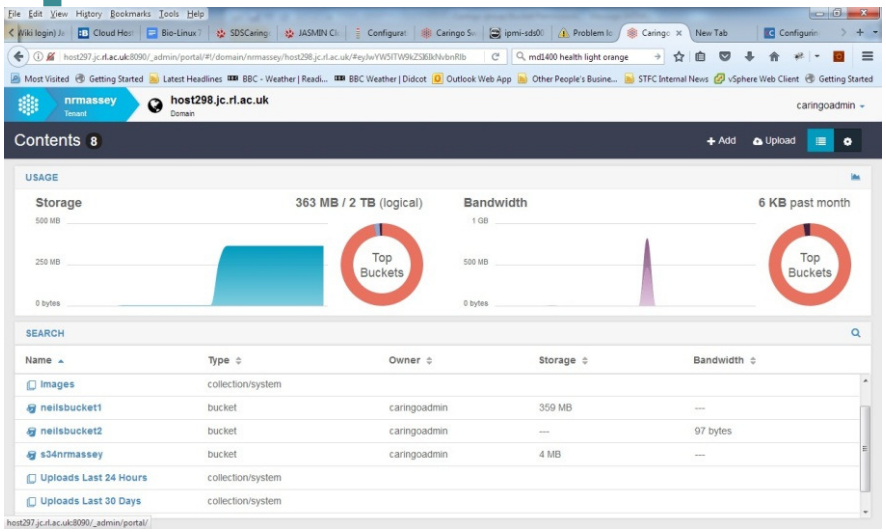
Block storage for VMs
OpenStack, hyperconverged

Object storage
Service provider-grade S3 storage

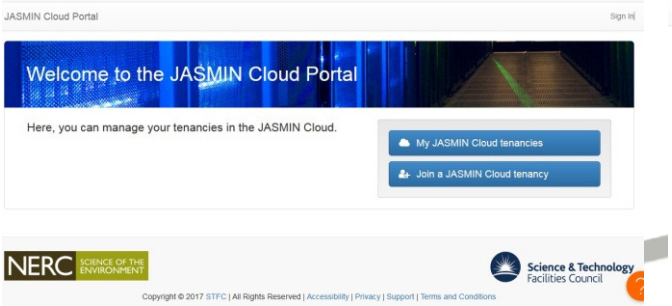
- 42PB raw, 30PB usable (EC 8+3)
- Hardware split 50:50 Dell / Supermicro
- 47x R730xd's + MD3060 arrays (1 / server pair)
  - 32 10TB drives/ server
  - Dual 40Gb NICs
- 40x Supermicro 4U "Top loader" servers
  - 44 x 12TB drives
  - Dual 50Gb NICs
- Target > 50MB/sec/HDD. Ideally 70MB/sec/HDD

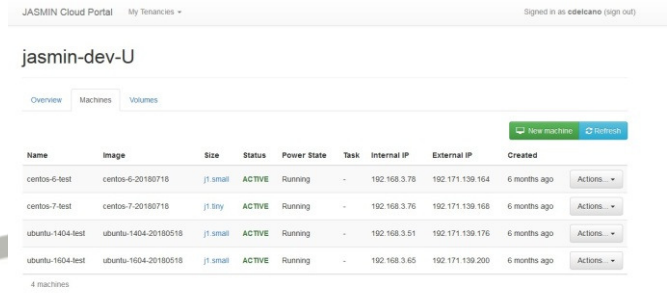
Storage and Compute Tenancies





- QuoByte File/S3 and Caringo S3/File User tenancies
  - Self provisioned, quota'ed storage.
- JASMIN OpenStack Cloud portal uses the same tenancies.
- 3 levels of root access and internet service exposure



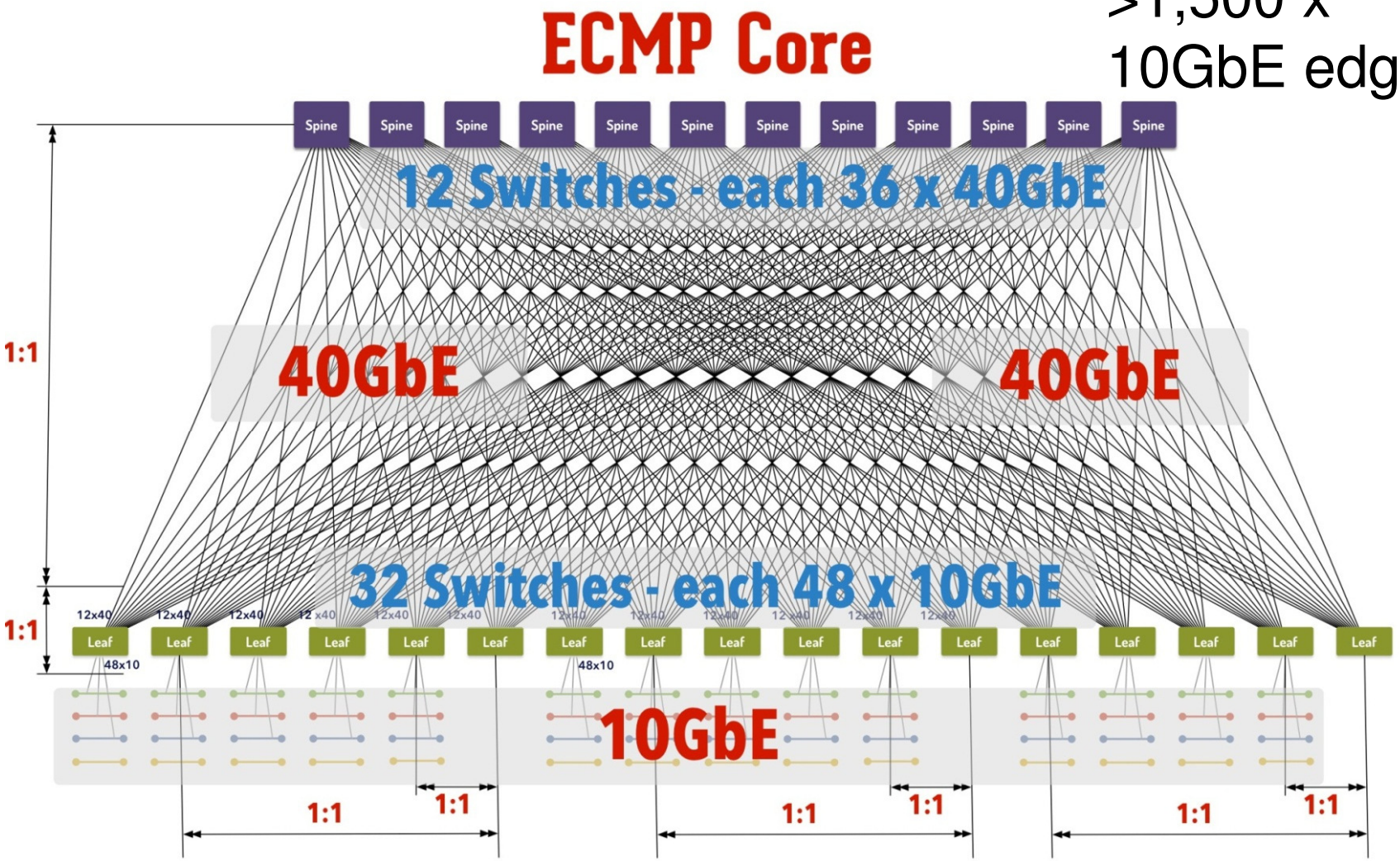


Science & Technology Facilities Council

Jonathan.Churchill@stfc.ac.uk STFC RAL

JASMIN "Fabric" Networking

>1,500 x
10GbE edge ports

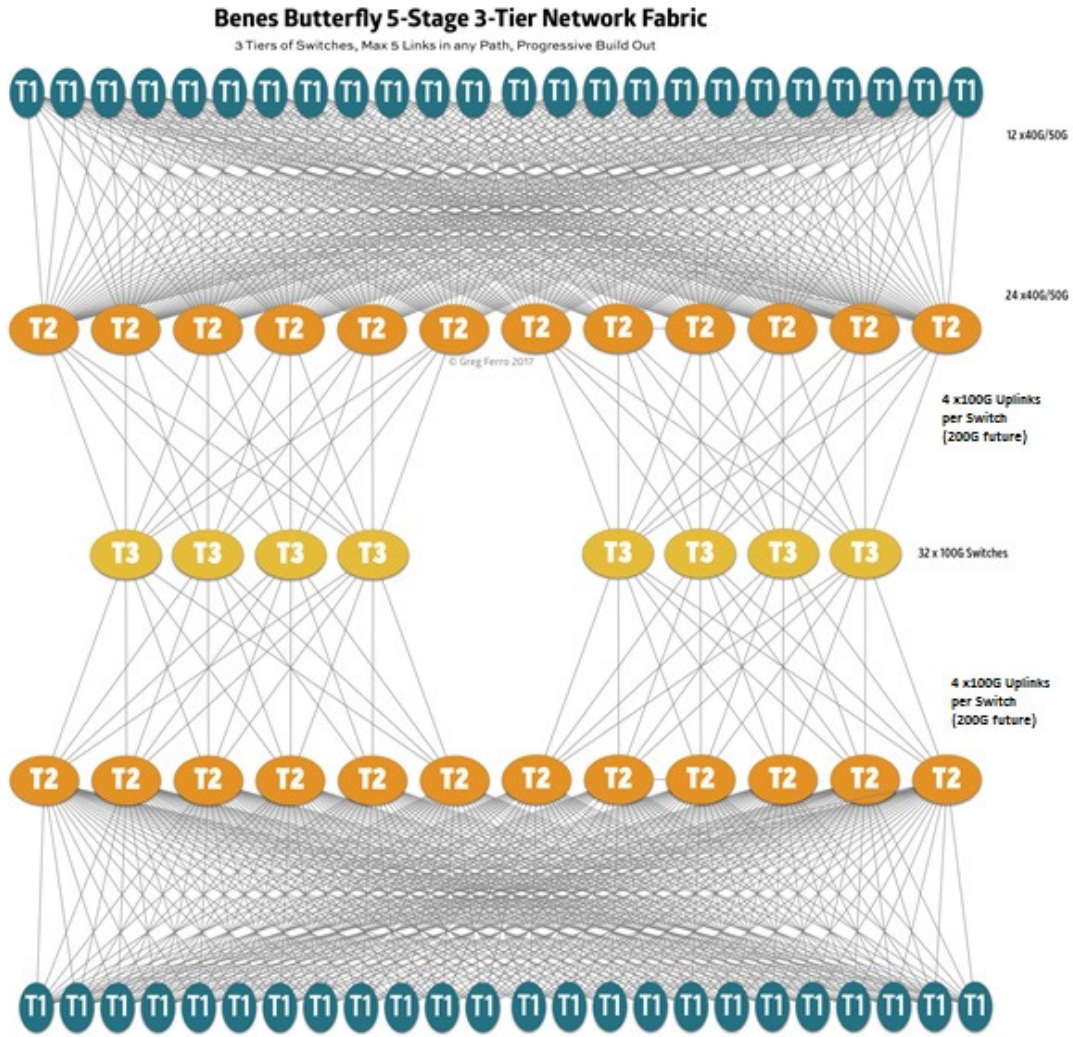


Any-any Low Latency:
< 7uS MPI ping-pong
(< 3uS with RoCEv3)

>12Terabits/sec
Non-blocking 1:1

Science & Technology Facilities Council

A Data Centre Network

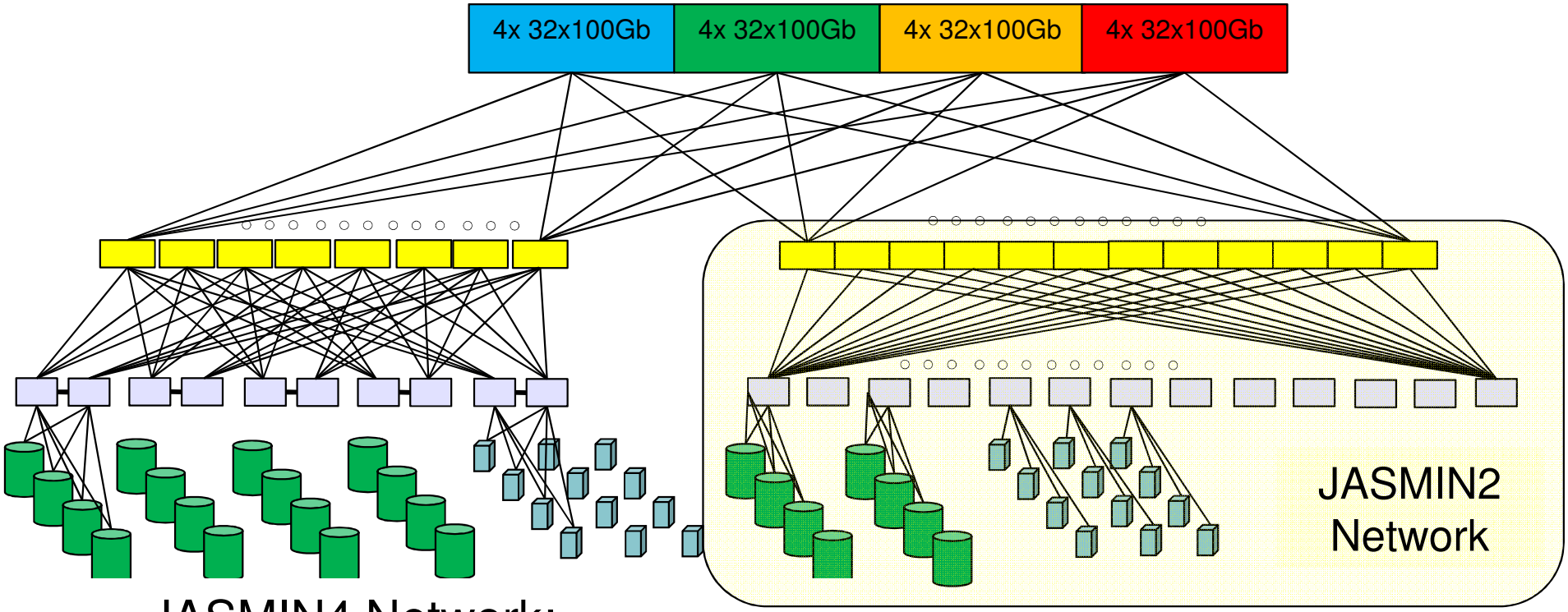


Facebook article for its three tier architecture:
https://code.facebook.com/posts/360346274145943/introducing-data-center-fabric-the-next-generation-facebook-data-center-network/

Science & Technology Facilities Council

Connecting JASMIN2 to JASMIN4

- Superspine: 16 Spines (32x 100Gb)
  - 4 Cluster/groups of 4 routers



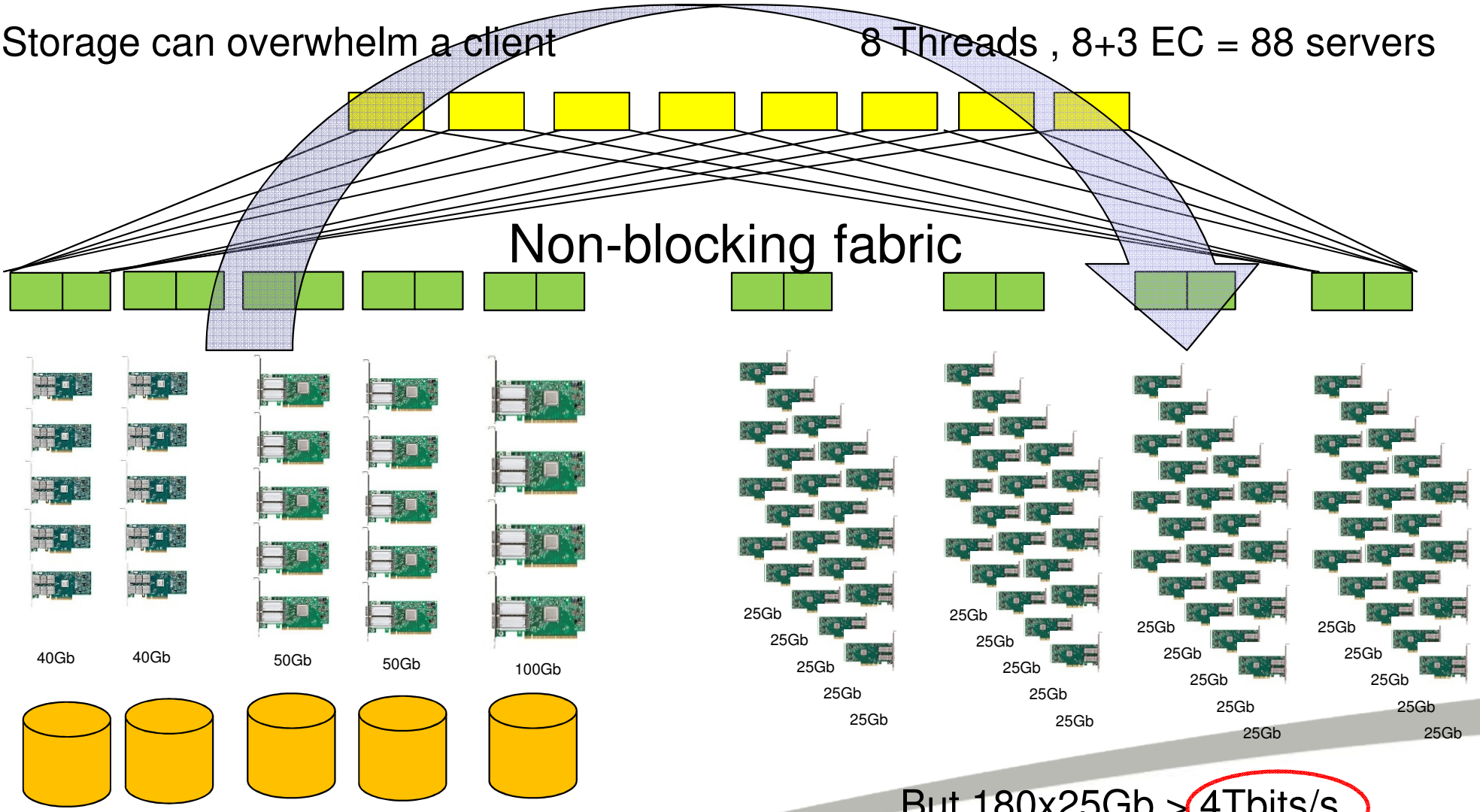
- JASMIN4 Network:
  - 8 Spines (32x 100Gb)
    - 4x 100Gb to Super-Spine
  - 17 Leaf pairs (2 of 16x 100Gb)
    - 8x 100Gb uplinks. 1 per spine
  - Storage/Compute
    - 1x 25/40/50Gb to ‘A’ and ‘B’ leaf

  - 12 Spines (36x 40Gb)
    - 4x 40Gb to Super-Spine
  - 30 Leafs (48x10Gb+12x40Gb)
    - 12x 40Gb uplinks. 1 per spine
  - Storage/Compute
    - 2x 10Gb to local leaf

Congestion in a “non-blocking” network

Storage can overwhelm a client

8 Threads , 8+3 EC = 88 servers



But 180x25Gb > 4Tbits/s

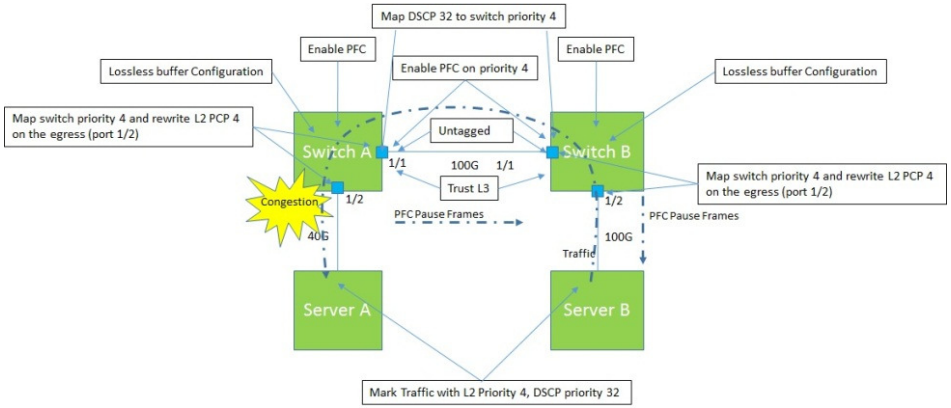
3090 HDD’s x 70MB/s > 250GBytes/sec

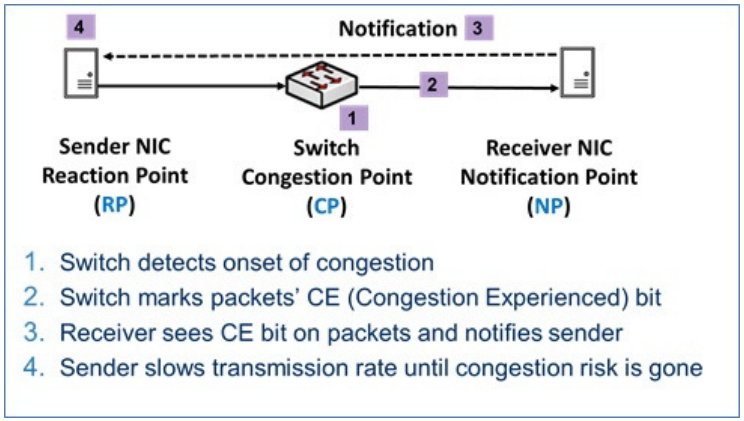
> 2Tbits/sec

~200GB/s for a few minutes

Science & Technology Facilities Council

Controlling Packet Loss





DSCP + PFC

Distributed Services Code Point +Priority Flow Control

ECN

Explicit Congestion Notification

- DSCP/PFC Recommended for lossless networks eg RCoE/FCoE
  - But no RDMA / RCoE to prioritise for PFC
  - Complex to configure
- ECN proposed over a decade ago. Simpler to configure. Slow uptake.
  - Concerns expressed for high speed networks re:
  - HoL blocking, ECN propagation times/reaction times, buffer sizes
- ECN chosen
  - Simpler to configure, applies to all traffic
- **220GB/s sustained. Virtually no packet loss**

Images: http://www.mellanox.com/blog/2016/07/resilient-roce-relaxes-rdma-requirements/

Science & Technology Facilities Council

Summary (HPC can catch up!)

- AWS / Azure say they cant do JASMIN (yet)
  - Ie The IO, networking performance and Opex costs
- "HPC Can't do my own Lustre/GPFS"
  - *QuoByte (File) and Caringo (S3) tenancies*
- "HPC cant deploy a SPARK cluster on demand"
  - *JASMIN Cloud tenants will be able to this year*
- "HPC Doesn't have SDN"
  - *JASMIN OpenStack Cloud has this now.*
- "HPC Cant make jobs or services on the internet"
  - *JASMIN UMCloud tenants can do this now.*
- "HPC cant give root to the users"
  - *JASMIN Cloud as 3 levels of root access today"*

Thank you !

Science & Technology
Facilities Council