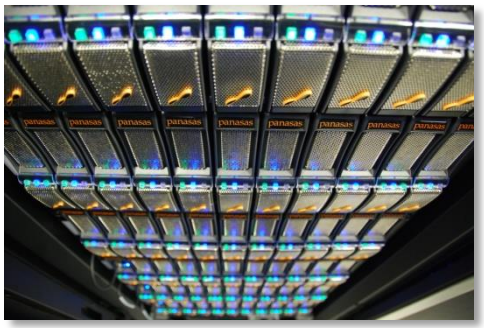
Big Data and the Earth Observation and Climate Modelling Communities: JASMIN and CEMS



Workshop on the Future of Big Data Management
27-28 June 2013

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RAL Space, STFC Rutherford Appleton Laboratory

Some Challenges

- Velocity – a data deluge
  - Earth Observation e.g. new generation of ESA Sentinel satellite missions, S-3 ~1PB/year
- Volume
  - Climate modelling e.g. the CMIP3 generated 35TB in one central archive, CMIP5 > 2PB in a federated archive.
- Variety
  - Not a new factor to our community (a topic for another talk)
- We run a number of active data archives
  - the data lifetime is an important factor, we need to keep the data – in the case of CMIP5 *indefinitely*
  - The availability of the data: we have a responsibility to a much wider and set of communities than merely those who created the data
- How do we analyse the data?
  - How responsive can we be with the hardware and software we use to address the needs?

Presentation Structure

- Introduce CEDA
- Tell a story starting with,
- What life was like before JASMIN and CEMS
- System description
- Initial application of the infrastructure for:
  - Archive management
  - Data handling and analysis for Climate model data
  - Earth Observation data reprocessing
- How patterns of usage have emerged from these experiences
- How these patterns are influencing our future plans

CEDA – The Centre for Environmental Data Archival

- Our mission:
  - to curate data and
  - **facilitate science**
- We run 3 NERC data centres
- 20 projects underway currently covering
  - Data modelling, preservation, publishing
  - Web applications and services
  - Cloud computing
- http://www.ceda.ac.uk

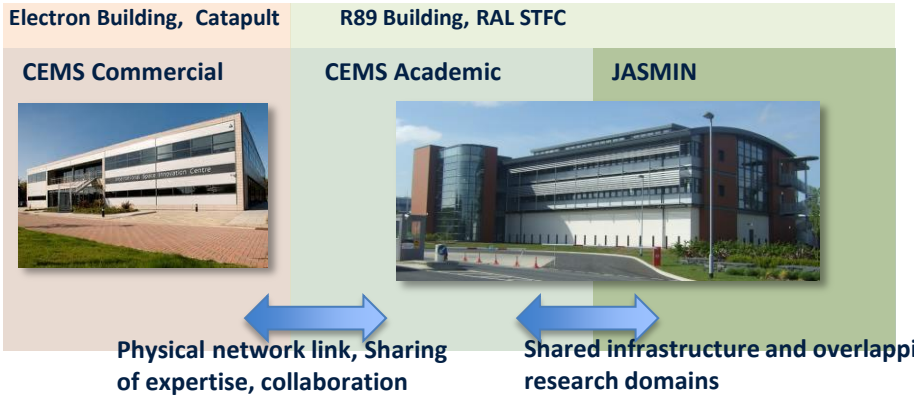
Life before JASMIN and CEMS

- Snapshot at the beginning of 2012, infrastructure hosted within RAL Space:
  - 200 million files
  - ~1.5PB of NAS disk on
  - ~150 disk partitions, split into 600 datasets
  - ~300 different computers, incl. VMs
  - ~30 hypervisors (Xen)
  - Lots of tapes in STFC Atlas data store
- This was not a designed environment, it was organic, it grew over a decade
- CEDA was straining under this legacy:
  - inexplicable network problems.
  - lots of time spent moving data as machine lifetimes expired
  - user services suffered.
- It has taken us a year to migrate our data to JASMIN, it'll probably take nearly as long to retire all the services on legacy hardware

Introducing JASMIN and CEMS

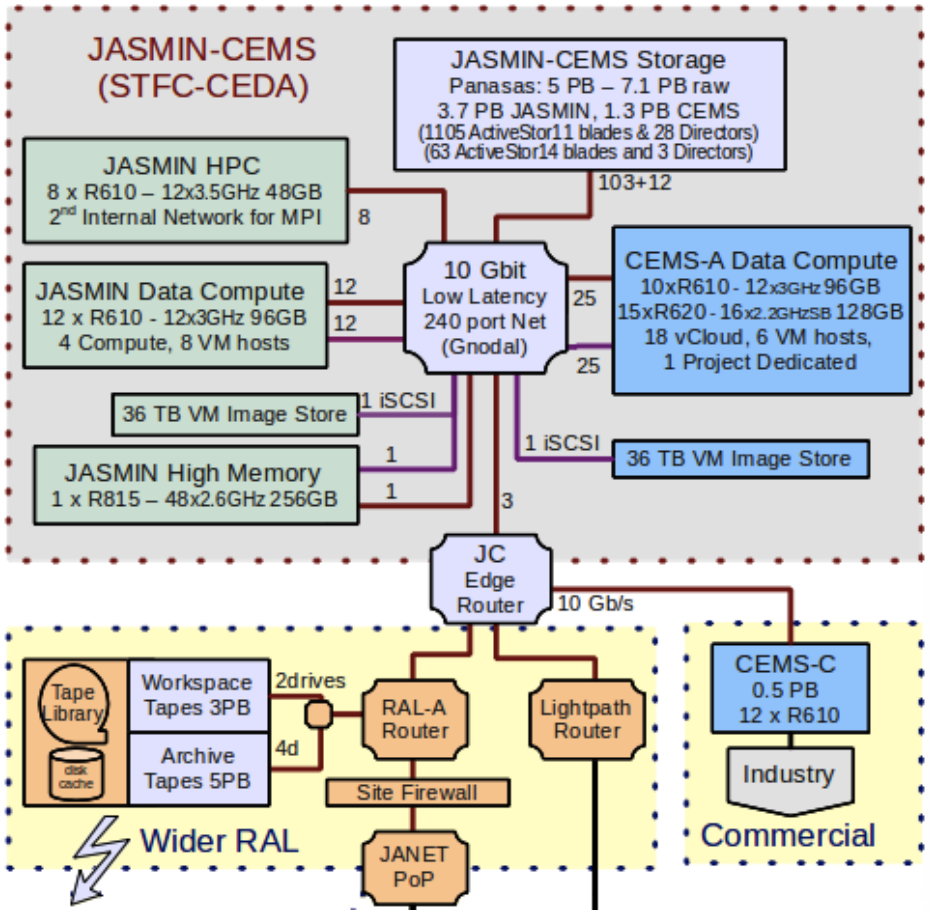
Panasas storage in RAL R89 server room

JASMIN and CEMS



- Petascale fast disk via low latency networks
- Supports batch processing, hosting environments and Cloud
- Supports two communities atmospheric science and earth observation (CEMS)
- Initially funded through e-Infrastructure capital investment in 2011 through BIS
- CEMS – the facility for Climate and Environmental Monitoring from Space
- CEMS consists of two components:
  - the academic CEMS infrastructure, running on JASMIN
  - commercial CEMS infrastructure part of the new UK Satellite Applications Catapult centre

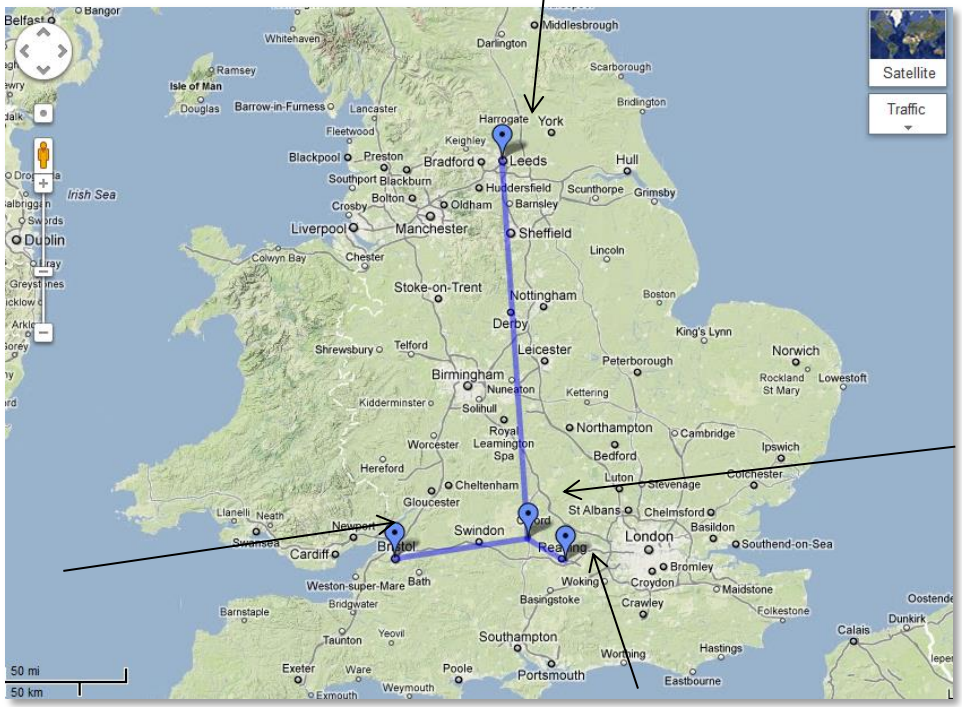
JASMIN-CEMS topology



- 6 major components to the system:
  1. The low latency core network (based on Gnodal switches);
  2. The Panasas parallel storage
  3. The batch compute system (Lotus);
  4. bare metal compute and hypervisors for virtual machines (VMs);
  5. A High Memory System and
  6. Two image stores to support the private disks of VMs.

Distributed JASMIN Infrastructure

JASMIN-North
University of Leeds
150 TB



JASMIN-West
University of Bristol
150 TB

JASMIN-Core
STFC RAL
3.5 PB + compute

JASMIN-South
University of Reading
500 TB + compute

Links to HPC Facilities

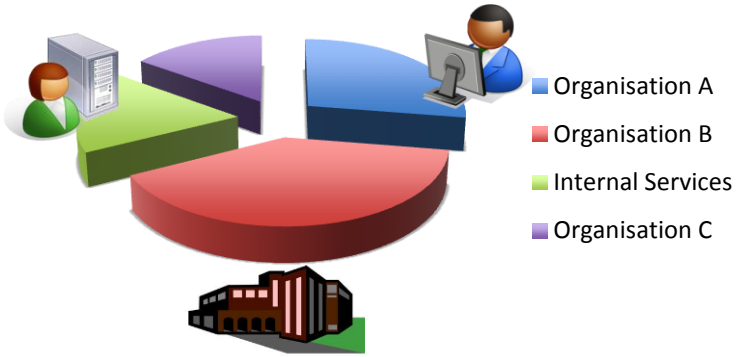
HECToR Cray XE6, 90k cores (to be replaced with ARCHER)

MONSooN 5000 core
IBM P7

- For the modelling community - provide dedicated links to HPC facilities
- JASMIN – provide one place to analyse outputs
- But also combine outputs from multiple sources

Virtualisation and Cloud

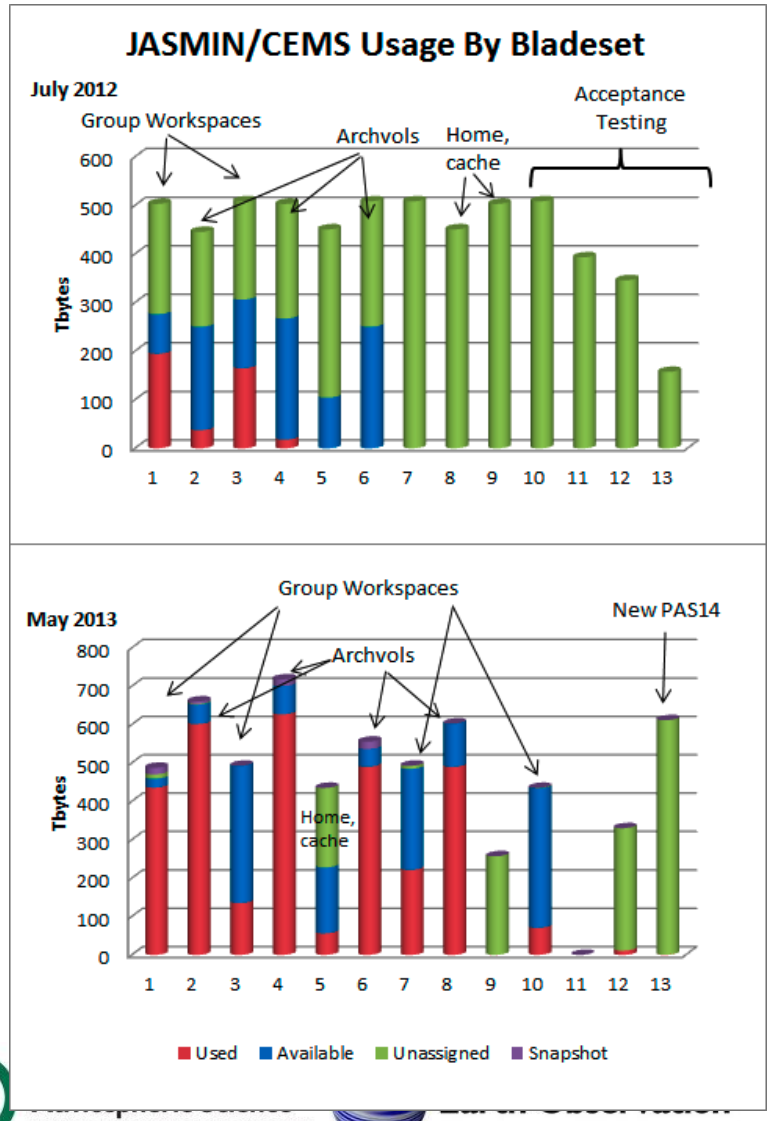
Virtualised share of overall network, storage and compute




```
from libcloud.compute.types import Provider
from libcloud.compute.providers import get_driver

vcloud_driver = get_driver(Provider.VCLOUD)
self.conn = vcloud_driver('pjkershaw', passwd,
                          host="cemscloud.jc.rl.ac.uk",
                                  api_version='1.5')

# Query VM images available
images = self.conn.list_images()

log.info('Creating vApp ...')
node = self.conn.create_node(name='Phil-Test-Node01',
                             image=images[0])
```

- VMware and vCloud chosen
- Why not Open Source?
  - Capital expenditure project + short time scales
  - Assessment of maturity of Open Source solutions at the time
- Organised into two vSphere pools
- JASMIN using virtualisation only
- CEMS full vCloud
  - RHEL, CentOS, Fedora14 vApps
  - 6 Virtual Data Centres (vDC)
  - Web interface available to Plymouth Marine Laboratory
- Interest in larger VMs with batch queues
- vCloud REST API very promising but still to be fully exploited
- Issues:
  - Remote root console access
  - Panasas file system integration

Disk usage



- 4.6PB deployed in 6 Hours!

```
$ df –h
Filesystem            Size  Used Avail Use% Mounted on
nfs01.jc.rl.ac.uk:/   4.9P  3.0P  2.0P  61% /mnt/nfs01
```

- Migrating the archive from the legacy NAS storage was a whole project in itself – 6 months
- Reaching capacity in under a year!
- Filling both the archive volumes and Group workspaces (user caches)

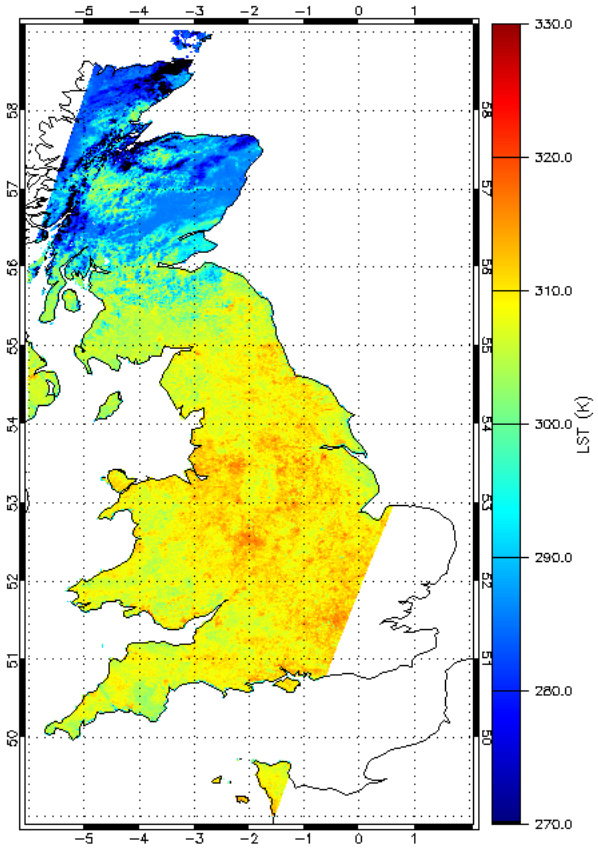
Data Archive: CMIP5

- CMIP5 (5th Coupled Model Intercomparison Project) has so far produced over 2 PB of *requested* data from over
  - 100 different numerical experiments run by 29 different modelling centres
  - using 61 different climate models.
- Stored in a globally distributed archive currently using 23 geographically distinct data nodes (the Earth System Grid Federation)
- Three centres have agreed to manage replicates of as much of the requested data as possible including
  - British Atmospheric Data Centre (a core component of CEDA).

Climate Modelling: UPSCALE

- A high resolution climate modelling experiment, run under the UK Joint Weather and Climate Research Programme (JWCRP, joint between NERC and the UK Met Office)
- 144 million core hours on the German supercomputer HERMIT, producing 330TB.
- The data retrieved to JASMIN over GridFTP at 1-10 TB/day.
- At JASMIN, a second copy was kept until the data had also been copied to the Met Office tape
- At its peak, the UPSCALE archive online at JASMIN approached 600TB - and it is now around 380TB (including post-processed products).
- These data are expected to provide a hugely valuable resource for the study of current and future climate, => feed into ESGF and the CEDA archive.
- Benefit of single analysis environment:
  - post-processing involves comparisons with CMIP5 and earth observation data held within JASMIN.

Earth Observation: ATSR Processing

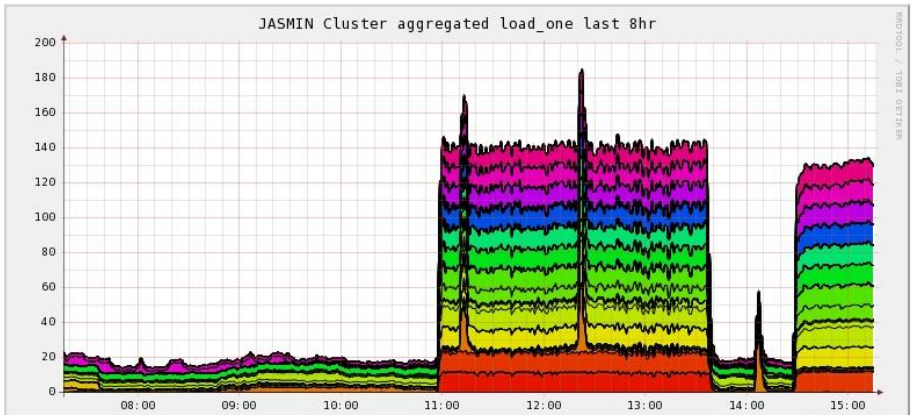


LST plot for the UK [John Remedios and Darren Ghent, University of Leicester].

- Examples (re)processing for whole satellite missions, a job that hitherto was done rarely.
- A number of different groups generated products from (the Along Track Scanning Radiometer) using brightness temperature data held in the CEDA archive:
  - Cloud detection and sea surface temperature
  - Land surface temperature
  - Cloud ECV (Essential Climate Variable)
- Trivial to parallelise
- They had prior evidence of being i/o bound on previous hosting environments

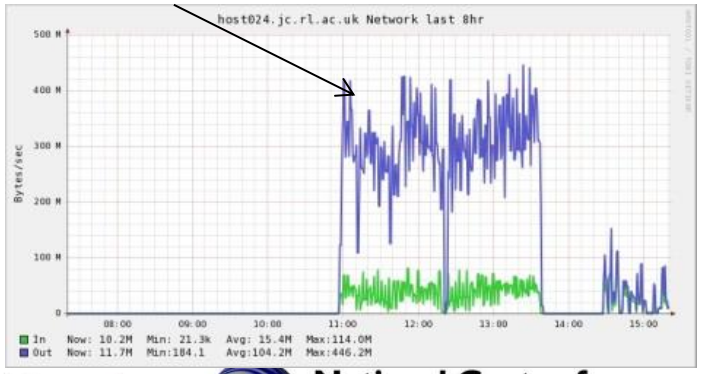
ATSR1 and 2 Reprocessing Project

140-185 jobs in parallel with no IO issues.



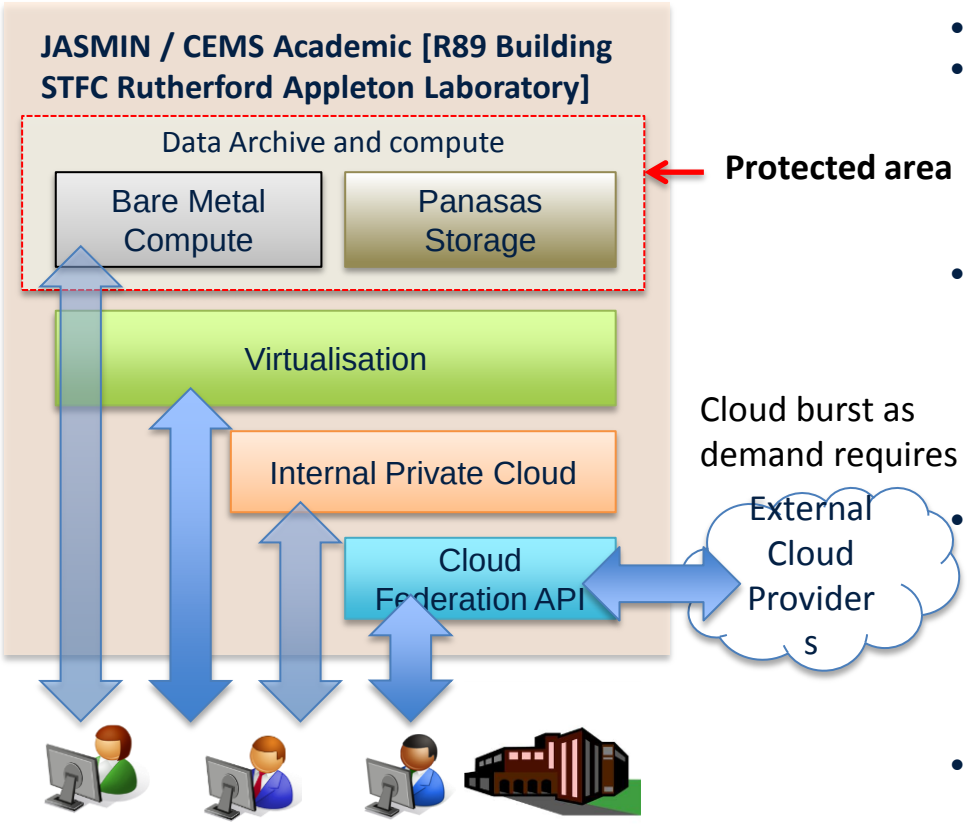
Each colour represents a node, 12 cores / node

3.0GB/s x 8 = 24Gb/s (would swamp a NAS/NFS server)



- Virtualised environment for initial trials:
  - cores/VM, memory, operating system
- This showed that standard CEMS Redhat distro was fine => suitable for bursting to JASMIN's Lotus compute cluster
- **One month's L1B data processing in 12 minutes where on previous system it took 3 days**
  - Impact of parallisation and fast i/o
- LSF was used for job scheduler so that adding Lotus to the processing was simple.
- A hybrid approach: compute cluster + VMs
- Importance of documentation and direct support to orient users and enable them to avoid pitfalls

Future Plans

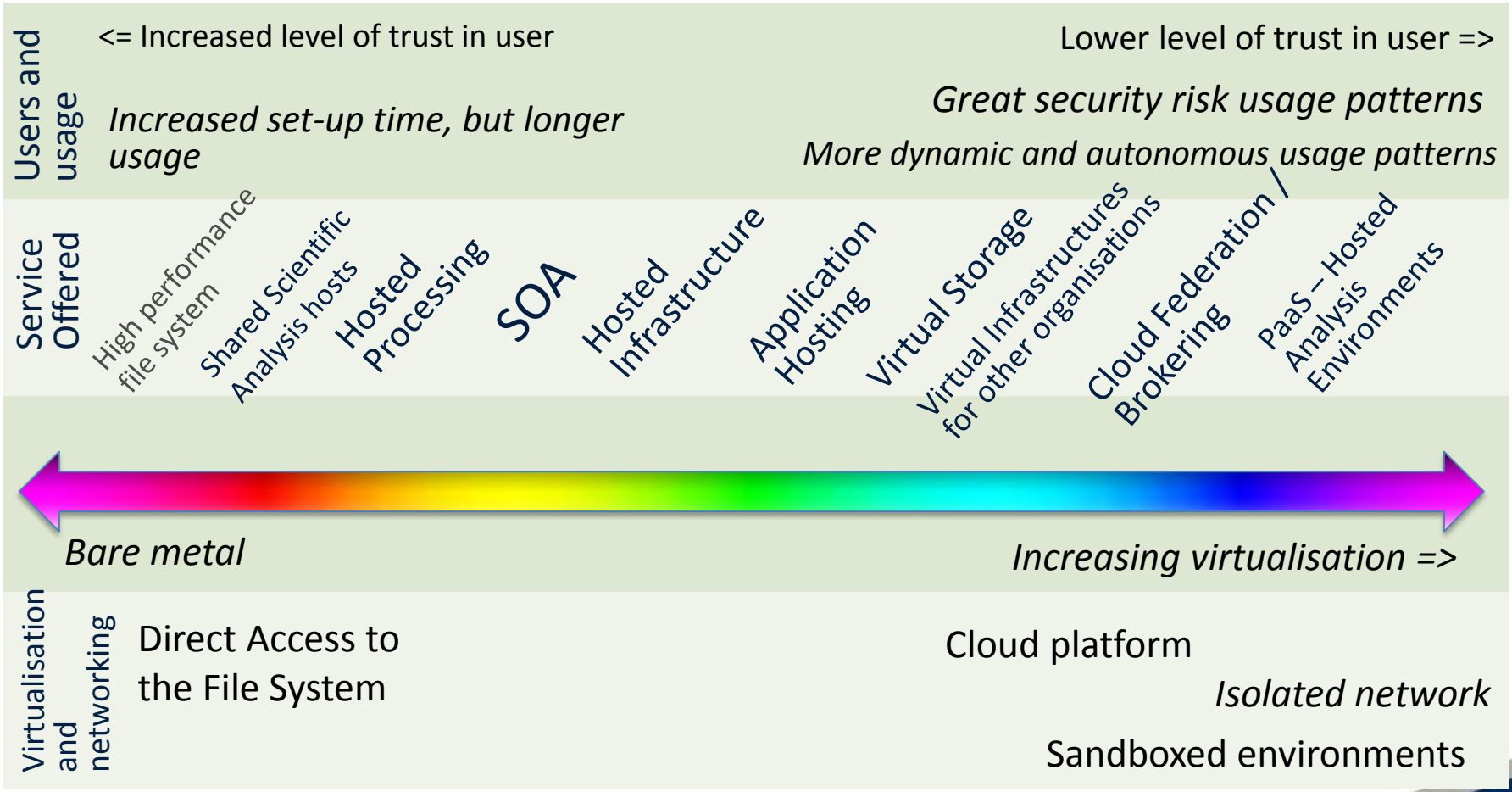


Direct access to the data archive - Hosted processing and analysis environments

- Provided a range of service models
- Direct access to the data archive and compute
  - Performance
  - Great level of trust with user
  - Set-up time and training
- Virtualisation
  - Flexibility for management of system
  - Greater autonomy for user
  - Performance overhead (and expense VMware)
- Private Cloud
  - hosted on an independent internal network for greater security but also autonomy
  - Less privileged access to the archive
- Possibility of moving storage and compute between environments dynamically
  - Nodes can be run as hypervisors or bare metal compute

Conclusions

- The role of a dedicated data analysis environment integral to our support for Big Data for EO and atmospheric science for the forseeable future
- The first projects have show the impact such an infrastructure can make on the science
- Data curation – we could not have gone as we had before
- A lot to handle in a very short space of time
  - Scratching surface about data analysis issues
- Looking to the future, use a flexible combination of processing clusters, virtualisation and public and private Cloud to best support the usage patterns


Users and usage
<= Increased level of trust in user
Lower level of trust in user =>
Increased set-up time, but longer usage
Great security risk usage patterns
More dynamic and autonomous usage patterns
Service Offered
High performance file system
Shared Scientific Analysis hosts
Hosted Processing
SOA
Hosted Infrastructure
Application Hosting
Virtual Storage
Virtual Infrastructures for other organisations
Cloud Federation / Brokering
PaaS – Hosted Analysis Environments
Bare metal
Increasing virtualisation =>
Virtualisation and networking
Direct Access to the File System
Cloud platform
Isolated network
Sandboxed environments