Tier 3 Plan and Architecture

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THE UNIVERSITY OF CHICAGO

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Tier 3 or Small Sites

- The name Tier 3 originates from the computing hierarchy of the LHC experiments
- Sometimes referred as small sites. Definitely not connected to the importance. Actually they are or will be soon the majority of the sites.
- Site or cluster: something bigger than a single workstation used by one scientist
- Sites that often do not have a lot of dedicated IT personnel and satisfy mainly the needs of local scientific groups. Usually not hosting vital resources for the VO.
- OSG saw commonalities: standardization and partnership can help

Tier 3

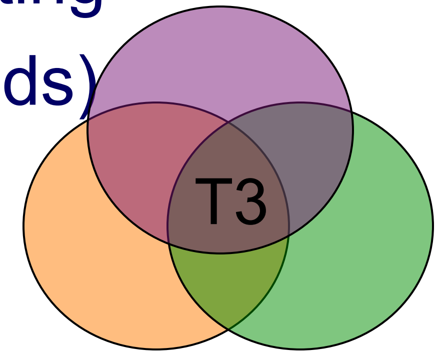
- In ATLAS and CMS Tier 3 systems typically provide one or more of the following capabilities:
  - access to local computational resources using a batch queue
  - interactive access to local computational resources
  - storage of large amounts of data using a distributed file system
  - access to external computing resources on the Grid
  - the ability to transfer large datasets to and from the Grid
- Tier 3s can also offer computing resources and data to fellow grid users

Summary

- Definition, Communities
- Plan, example
- Some ideas
  - System administrator
  - Who to talk
  - Infrastructure
- Components
- Options for the cluster, topologies
- Batch system, Storage systems
- Grid services

Many communities

- Campus
  - Local resources and support
- Virtual Organization (science experiment)
  - Direction and requirements
- OSG
  - Tools and solutions for Grid computing
  - Specific components (common needs)
  - Ideas from a wider community
  - Support



Plan

- Start with requirements from local community and scientific collaboration (VO)
- Define what you need
- See what you can leverage
- Consider the infrastructure
- Plan for expansion
- Have experts checking your plans
- Purchase needed resources
- Install and maintain

Example of Tier 3 definition - ATLAS

- Classify Tier 3s depending on the level of interaction with the Grid and the VO
- Example of activities for a T3g:
  - Run Athena jobs interactively on small data samples.
  - Submit jobs to Grid using pathena (or prun) and retrieve the output
  - Get substantial amount (several TB) ATLAS data to a local storage and keep them.
  - Analyze, using athena or root, a large (TB) data sets in a short time (~1day) in an local batch system
  - Generate and reconstruct Monte Carlo samples locally.
  - Run root jobs interactively for final steps of the analysis.

Example of Tier 3 definition -CMS

- University cluster, not Tier 1-2, unique site design depending on local needs, resources and capabilities
- CMS prefers Tier 3s with full grid access: you can run CRAB jobs on it in exactly the same way as on a Tier 2 or 1
  - Easier to verify a proper setup, e.g. by running identical jobs on the same datasets at Tier 3 vs Tier 2
  - Will provide confidence to physics analysis groups when approving official results
- The USCMS Tier 3 hypernews is an excellent resource for asking questions about what to do in your special situation.

Select a Tier 3 manager

- A T3 requires an initial setup effort and a smaller continuous maintenance effort
- If you can get experienced help at your institute, you should do so.
- A person with a clear responsibilities for the T3 cluster is needed. It cannot be a group responsibility.
- Assign one person from your group and a backup, to the T3 setup effort. If at all possible, the same persons should be responsible for T3 administration when T3 is operational.
- Having a backup person will be important. Although the maintenance tasks is envisioned to be light, some of these will have to be done daily or weekly, or it may not be able to wait until the admin returns. Think about rotation of responsibilities after a while.

People you need to know

- **Department** or university **system administrator** who manages computers in your environment already; bring him/her into the discussion from the beginning. He/she may be able to actively participate in the setup; or take a part of the responsibility for running the cluster. Effort has been made to separate the "root" type tasks from the non-privileged "VO-admin" tasks to make this easier. In any case he/she needs to stay informed.
- **Space, Power and Cooling**; depending on the size of your installation, you will need to take into consideration space, power and cooling needs for your cluster. Probably your department sys. admin will be able to help you on these issues. Typically there is another set of people to contact about **infrastructure**; the contact needs to happen after the initial decision about the size of the cluster is made.

People you need to know (cont)

- University person who is **responsible for networking**. After you have an initial decision about the size and scope of your cluster. You will need to obtain IP addresses for your cluster as well as discuss with this person any connectivity issues that might come up.
- **Campus** computer **security officer**: responsible for the local computer security. He/she needs to be contacted early on in the cluster set up process.
- **VO collaborators**: e.g. “nearest” Tier 2 and Tier 1 that may provide services to you.
- **Hardware representative**: most likely it will be convenient to use group agreements from your campus or your VO that will provide you the right contact.
- **VO support and coordination** (e.g. US CMS or US ATLAS T3 coordination).

OSG role in initial contacts

- Help you to identify your needs
- Provide with vocabulary and examples that make it easier to interact with local experts
- Put you in touch with experts
- Provide intermediaries that can act on your behalf or on your side specially for the initial contact
- Share experiences and solutions

Some notes about infrastructure

- Critical to a well functioning cluster
- Examples of Infrastructure include:
  - Networking
  - Physical space and associated hardware (Racks)
  - Electrical Power and Cooling
  - Computer security / data security
  - System administration and maintenance

Physical space

- Prior to making your computer purchases determine where you will put your hardware
- Keep in mind:
  - 1 Rack of computers is heavy > 1000 lbs
  - Rack of computers is noisy and generates a lot of heat
- Does your University department have a computer room that you can use part of?
- Do you have space for eventual expansion?
- Do you have easy access to machines for repairs?
- Are there costs involved?

Electrical power

- What type of electrical power is available? (110 or 220 V) How much current? (number of circuits)
- Each Dell R710 (used by LHC T3) draws 300W (max) 200W (nominal). i.e. 10 servers in a rack will draw 3000W
- Consider other equipment as well. E.g. UPS.
- Check the load with local safety. Usually 50-70% of the total circuit capacity can be assigned
- Will you have to pay for electricity?

Cooling

- Sufficient cooling important to operation of your cluster
- Some AC systems require a steady load
- Some reference cluster used by LHC T3:
  1. 23U, 927lbs (837 HEPSPEC, 72 cores, 48 TB) - storage on worker nodes – 4745 W (@220V) ~ 16000 BTU/hr ~ 1.4 tons AC (1 ton AC = 12000 BTU/hr; 1 W ~ 3.4 BTU/hr)
  2. 27U, 1279lbs- (837 HEPSPEC, 72 cores, 96 TB) - storage on worker node + extra centralized storage – 5245 W ~17800 BTU/hr ~ 1.5 tons of AC
- Will you have to pay for cooling?

Networking

- How far are you from the edge of campus?
- Determine the available bandwidth between your computers and campus backbone?
- Determine the available bandwidth across the campus backbone?
- Determine the available campus bandwidth to Internet 2?
- Is the amount of available bandwidth sufficient for your needs? (100 MB/s ~ 1 TB /day)
- Determine how much networking infrastructure you will have to purchase? Can you use a specific brand of switches? Does your campus require Cisco or another vendor?
- Will you have to pay for bandwidth used?

Networking (cont)

- How many public IP address can you get?
- What is the campus firewall policy?
- Some places have several networks
  - Public/restricted to the campus or department
  - Open/limited, e.g. behind a firewall or a traffic shaper
- Do you need a private network for your cluster?
  - Tier 3 examples have public and private networks
  - Added complexity with advantages
  - “No” firewall on private network.

Security

- Who is the department computer security contact? Meet with them.
- Secure computers are vital to our ability to produce science results.
- What are your campus/department computer security policies?
- What will be your role for your cluster?
- We do not want to be the weak link in the computer security chain. - Computer security should not be ignored
- You will hear more in Igor's talk later

System administration

- How centralized is your campus?
- Who is responsible for machine installation? And for up keep (hardware and software)?
- Does you department have system administrators who can help you?
- Can they administer the machines (OS/ accounts etc)?
- Will you have to do it all but they provide expert guidance?
- What is your data preservation plan? What is your backup strategy

Hardware has compromises

- Hardware selection and tuning is difficult
- Using known configuration or tapping into other people experience may simplify the task
- Some VO, e.g. US-ATLAS, provide hardware recommendations and standard setups aiming to reduce maintenance (e.g. aiming to 1 FTE-week setup and .25 FTE maintenance)
- It's always possible to spend effort instead of money and obtain a more powerful cluster or vice versa.
- It is difficult to estimate the manpower cost of such an effort. Depends largely on the expertise and the commitment of the person doing it.

Classes of machines

- Service nodes (as needed):
  - NFS, Cluster Monitoring, Cluster Management
  - Batch Management, User Management, User authentication, CE
  - Data Gateway/buffer, Web data buffer, Data Management, SE
- Interactive nodes (one or more):
  - User login, interactive analysis, submission to local batch and Grid.
  - local user storage area.
- Batch nodes (one or more—two or more for a meaningful batch system):
  - Parallel batch processing queues
  - Storage space for data
- Dedicated storage nodes
- For a very light installation, you can consider an interactive only cluster (nodes may run services and store data)

E.g. US-ATLAS T3g machines

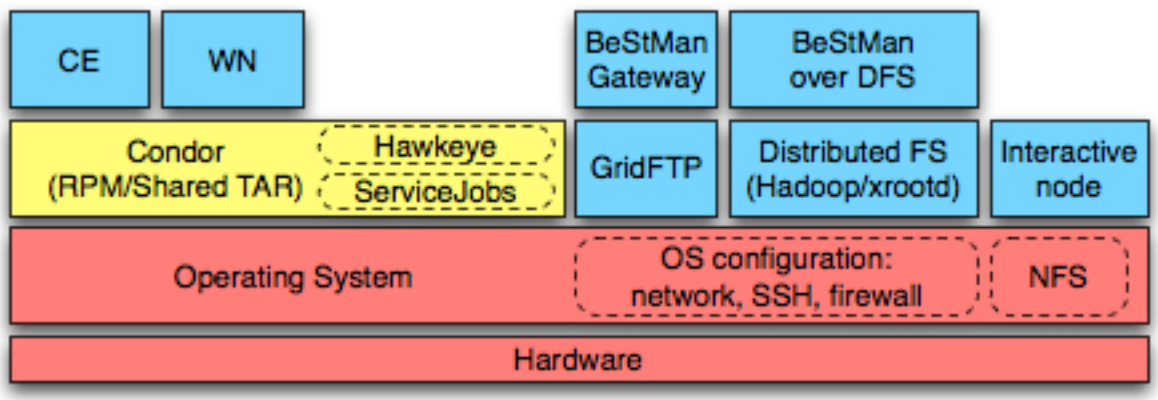
- 2 Service nodes:
  - 1 server for: NFS, Data Gateway/buffer, Cluster Monitoring, Cluster Management
  - 1 server for: Batch Management, Data Management, User Management, Web data buffer
- Interactive nodes (one or more):
  - User login, interactive analysis, submission to local batch and Grid.
  - local user storage area.
- Batch nodes (one or more—two or more for a meaningful batch system):
  - Parallel batch processing queues.
  - Storage space for data.
- Depending on you needs you might add
- Storage nodes for data.
- For a very light installation, you can consider an interactive only cluster.
- Service nodes, in this case will most likely only 1 server (not all services will be needed) or even be a part of an interactive node.

E.g. CMS $100k Tier 3

- Assumptions: (Rob Snihur, Ian Fisk 2009)
  - 6 physicists, (1.4 + 1) TB each
  - Process sample in 24 hrs → 16 nodes w/ 8 cores each
  - Flush & update sample in 12 hrs → 600 Mb/s networking
- Upgradeable RAID chassis ($33k)
- 16 worker nodes ($41k)
- 24-port Gigabit switch ($12k)
- 3 server nodes ($9k)
- Racks and infrastructure ($5k)

OSG documentation

- Reference documents on the TWiki in ReleaseDocumentstion
- Tier3 Web on the TWiki
- Covers mainly Grid services
- Some suggestions on other components of a Tier 3
- User contributions



Some notes about the OS

- VDT supported platforms (for the services) http://vdt.cs.wisc.edu/releases/2.0.0/requirements.html
- RHEL 5 (and variants) most common platform
- Don't forget time synchronization (NTP) https://twiki.grid.iu.edu/bin/view/Tier3/ClusterTimeSetup
- More notes in the Tier 3 documentation (phase 1) https://twiki.grid.iu.edu/bin/view/Tier3/ModulesIntro

Cluster components

- Shared File System (general purpose)
  - Usually NFSv3/NFSv4 (safer) Server. Using NFS to create a shared file system is the easiest way to set up and maintain a Tier 3. NFS is likely to cause performance issues. Read about NFS tuning/setup. Lustre or other commercial solutions (GPFS) can be an alternative.
- Condor Batch Queue
  - A batch queue system is strongly recommended for Tier 3s. Tier 3 documents only provide the installation of Condor (selected because it is one of the most familiar internally to the OSG and hence easily supported by the OSG), but other systems can be used and may be preferable, for example if there is local expertise available in another batch queuing system. The general OSG documentation provides some help for different systems.
- Distributed File System (for data)
  - An optional capability that can be helpful for moving efficiently VO data and other files across the worker nodes. It may also provide data-locality performance improvements to scientific applications. This document covers the installation of Xrootd, a DFS optimized for ROOT files used in the HEP community, although other systems may be used. Tomorrow you will see Hadoop.

Cluster components (cont)

- Cluster deployment and configuration management
  - Provides automatic deployment and some management operations.
  - Some CMS sites use Rocks, a free cluster management solution based on a 'clean reinstall' model. Modifications to the default distribution are done by editing xml files in an admin-friendly way, creating a new distribution, then reinstalling the compute/worker nodes. Rocks has one head node which serves the distribution and numerous other services and which does not require regular reinstall. Nodes can be broken into groups of Rocks appliances, where each group is served a different distribution according to your directions. The 'clean reinstall' model can be convenient for guaranteeing system integrity as compute nodes are working on a very clean and well-defined system. It can pose difficulties when compute nodes are used as interactive nodes or when a particular appliance requires frequent updates, necessitating frequent reinstalls.
  - Some ATLAS sites use Puppet, Ruby-based, is a declarative language for expressing system configuration, a client and server for distributing it, and a library for realizing the configuration. It is more a configuration management tool and allows changes without reinstalling the system.
  - Bcfg2, Cfengine, Cobbler, Modules, Perceus/Warewulf and Quattor are other alternative systems.
- Monitoring
  - Ganglia, Cacti and Nagios are useful monitoring and alarm tools.
- http://www.linuxjournal.com/magazine/taming-beast?page=0,0

Site services

- Authentication Service
  - enables grid users to authenticate with your site using their grid or voms proxies
- Compute Element
  - enables grid users to run jobs on your site
- Worker Node Client
  - enables grid jobs running on worker nodes to access grid tools
- Storage Element
  - enables grid users to store large amounts of data at your site
- VO Management Service
  - provides functionality for VO Managers to manage the membership information of their users

Authentication Service

- enables grid users to authenticate with your site using their grid or VOMS proxies
- Alternatives:
  - grid-mapfile (edg-mkgridmap)
    - a simple program that contacts VOMS servers and creates a grid-map file
    - easy to install and maintain
    - does not support voms proxies
  - GUMS
    - a web service providing sophisticated controls of how users authenticate
    - supports voms proxies (groups, roles)
    - requires Tomcat to be run as a web service

Compute Element

- enables grid users to run jobs on your site
- Services
  - GRAM: Globus service for job submission
  - GridFTP: grid authenticated file transfer
- Optional services
  - GRAM-WS: web service implementation of GRAM
  - Squid: caching Web proxy
- Managed-fork jobmanager

Worker Node Client

- enables grid jobs running on worker nodes to access grid tools
- Options
  - Shared or local installation
- On worker nodes and compute element
- Required?

Storage Element

- enables grid users to store or access large amounts of data at your site
- Interfaces
  - Storage Resource Manager (SRM)
    - Dynamic Space Management Support (dyn)
    - No or Static Space Management Support (st)
  - GridFTP
- Tanya's talk tomorrow and https://twiki.grid.iu.edu/bin/view/ReleaseDocumentation/StorageInfrastructureSoftware
- Several options

Storage Requirements	Min Hardware Requirements	OSG SE Solution
SRM interface, Dynamic Space Management Support	Server with local disk	BeStMan-fullmode
SRM interface, No or Static Space Management Support	Server with local disk or NFS	BeStMan-gateway
SRM interface, No or Static Space Management Support, jobs need root protocol to access data	Multiple servers(>3)	BeStMan-gateway/Xrood
SRM interface, No or Static Space Management Support, file replication	Multiple servers(>4)	BeStMan-gateway/HDFS
SRM interface, Dynamic Space Management Support, file replication, interface to tape backend	Multiple servers (>5)	dcache

VO Management Service

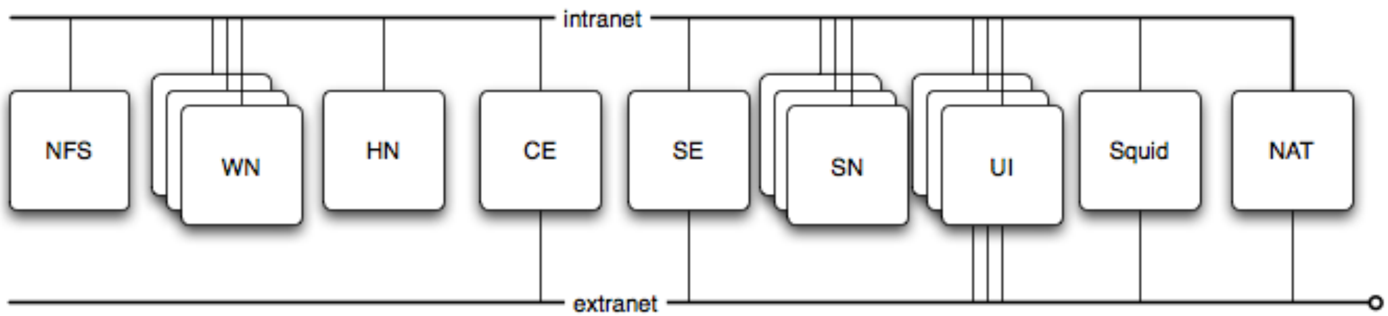
- provides functionality for VO Managers to manage the membership information of their users
- Each VO needs to provide one VOMS
- You need it only if you manage a VO
- If you need groups you can request them to your VO

Server names

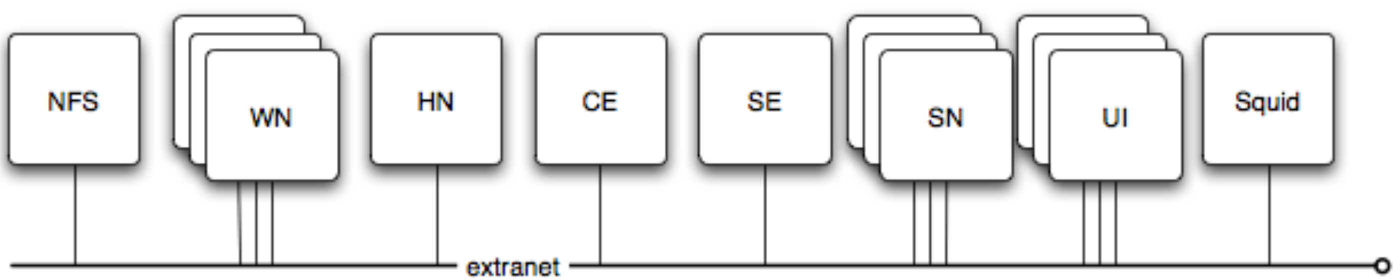
- NFS – shared file system (general purpose)
- WN-nn – batch system worker nodes
- HN – batch system head node
- CE – compute element
- SE – storage element
- SN-nn – storage node
- UI-nn – user interface (interactive node)
- Squid – Web proxy
- NAT - firewall
- GUMS – user management

Network topologies

- Intranet (private) + Extranet (public)
  - More independent (IP addresses)
  - Manage dual homed hosts

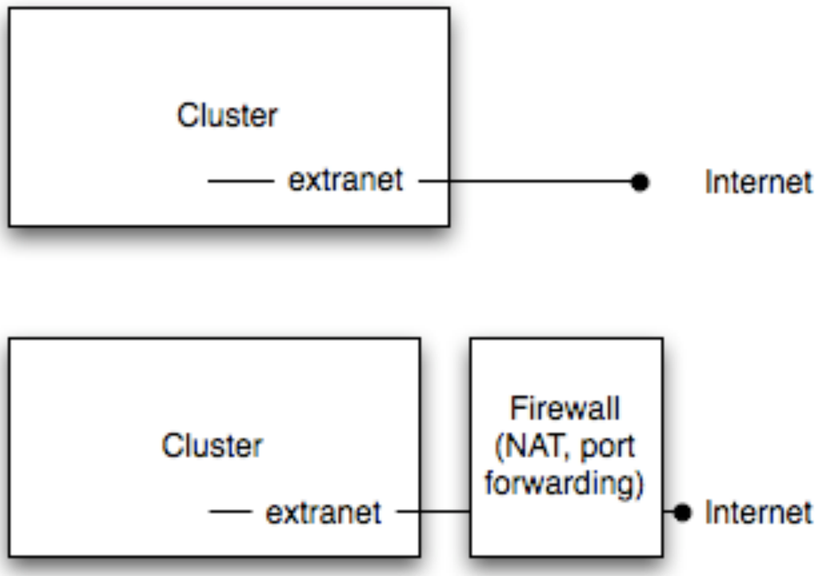


- All on one network



Connection to the public internet

- Connected directly to the internet
- Behind a firewall
  - Cluster more protected
  - Requests to open ports for outgoing or incoming connections
  - May have bandwidth limitations



Virtual machines

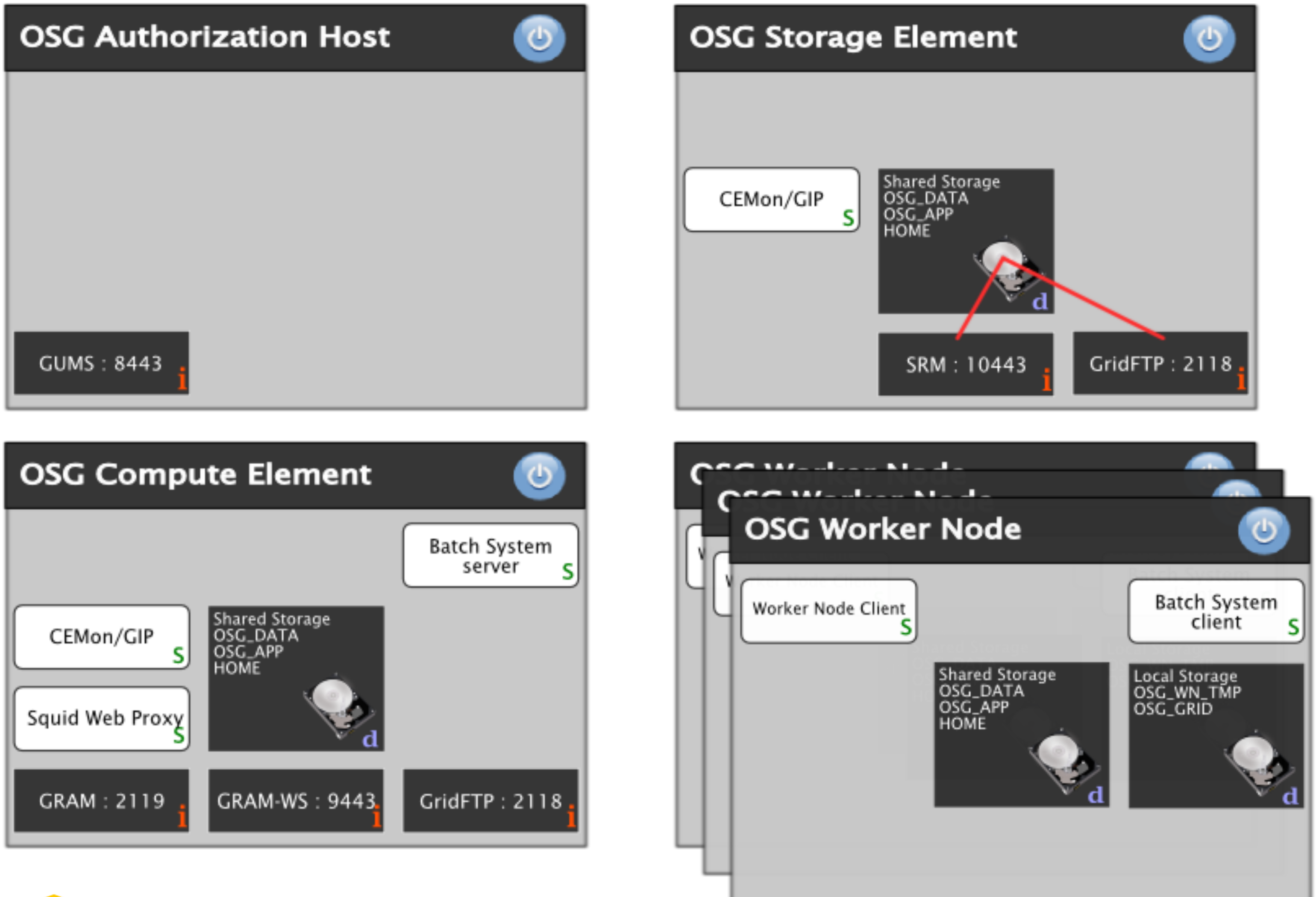
- Allow to install services on their own machine
- Isolation and easy load balancing
- No conflicts for ports or other resources
- Standard configuration

- Some penalties
  - Installation and management
  - IO penalty
  - Slower response time (e.g. Xrootd redirector)

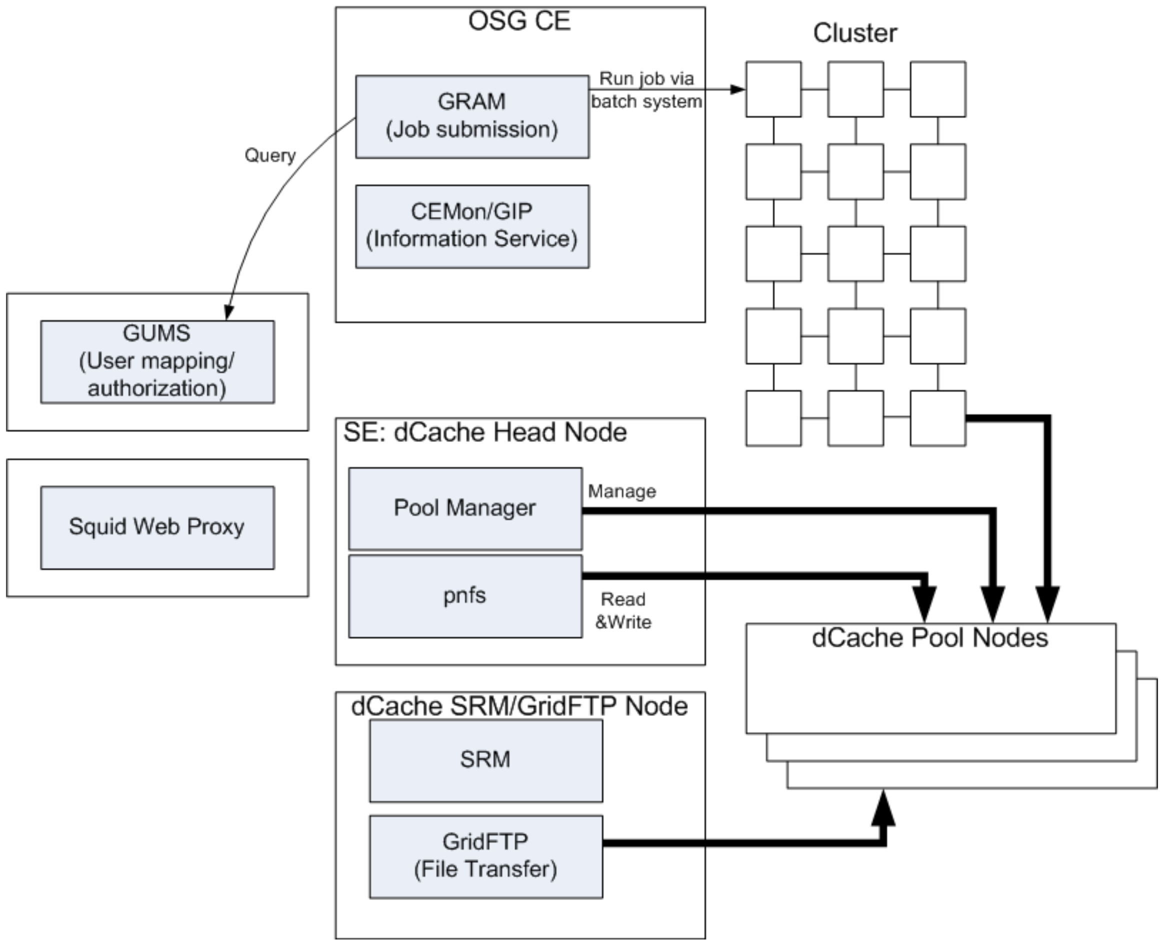
Compute and Storage Element

- provide dedicated hardware for the Compute and the Storage Element
- use as many CPUcores and main memory as possible
- avoid running other grid services such as GUMS on the Compute and the Storage Element
- avoid running a file server on the Compute and the Storage Element

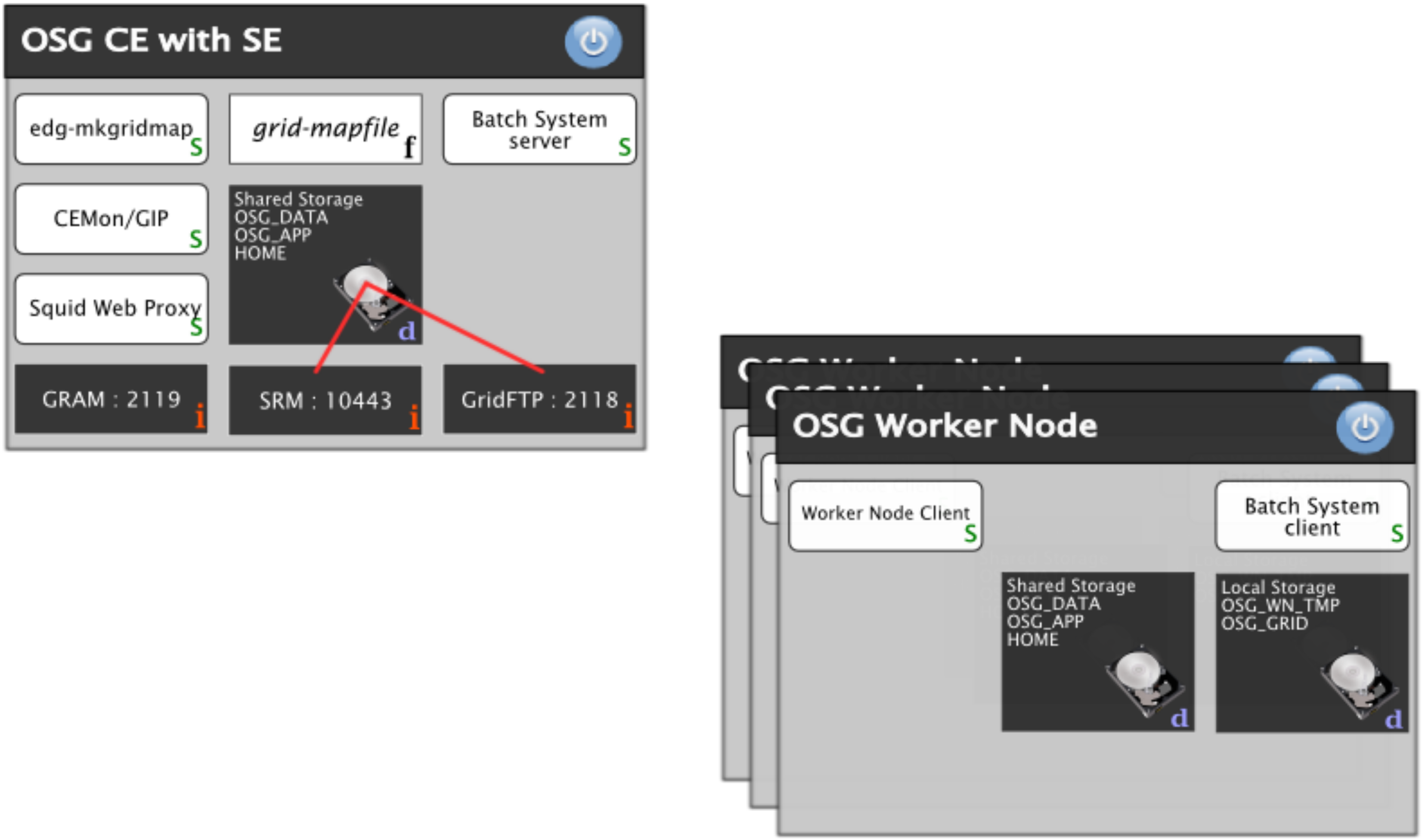
An OSG site


OSG Authorization Host
GUMS : 8443
OSG Storage Element
CEMon/GIP
Shared Storage
OSG_DATA
OSG_APP
HOME
SRM : 10443
GridFTP : 2118
OSG Compute Element
Batch System server
CEMon/GIP
Squid Web Proxy
Shared Storage
OSG_DATA
OSG_APP
HOME
GRAM : 2119
GRAM-WS : 9443
GridFTP : 2118
OSG Worker Node
Worker Node Client
Batch System client
Shared Storage
OSG_DATA
OSG_APP
HOME
Local Storage
OSG_WN_TMP
OSG_GRID

An OSG site (CE, GUMS, dCache)



A more compact OSG site



And for testing

- Full cluster on VMs (GUMS, CE, SE, …)
- Deploy different configurations

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Useful links

- Release documentation
  - https://twiki.grid.iu.edu/bin/view/SiteCoordination/SiteAdminsWorkshopAug2010
- Tier 3 documents
  - https://twiki.grid.iu.edu/bin/view/ReleaseDocumentation/HandsOn
- OSG Site planning guide
  - http://indico.fnal.gov/conferenceDisplay.py?confId=3429
  - http://indico.fnal.gov/conferenceTimeTable.py?confId=3429
- Workshop public TWiki:
  - https://twiki.grid.iu.edu/bin/view/ReleaseDocumentation/SiteAdminsWorkshopTutorialsAug10

Credits

- Thank you to Doug and Rik from the ATLAS Tier 3 coordination
- Thank you to Rob Snihur from the CMS Tier 3 coordination
- Thank you to people writing OSG documentation, specially Site planning Guide