Factoring the Network into the Grid

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Collaboration

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Agenda

- What is Grid?
- Potential Grid Applications
- On-Demand Grid Network System (OGNS)
  - What is it?
  - Concepts
  - Use Cases
  - Phase 1 and beyond
- Multi-Provider/AS Issues and Standards

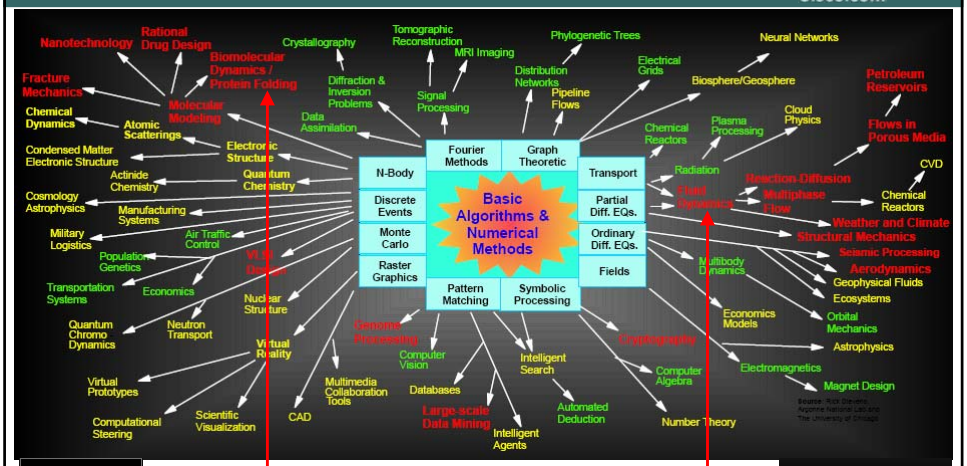
What is Grid?

"A grid is a hardware and software infrastructure that provides ubiquitous, on-demand, and cost-effective access to and sharing of resources distributed across LAN, MAN and WAN."

The term Grid Computing originated in the early 1990s as a metaphor for making computer power as easy to access as an electric power Grid

Potential Applications on Grid

High Performance Computing Applications



Typical Commercial/Enterprise Applications

- **Applications need not be inherently distributed or parallel like HPC applications**
  - **CRM (Customer Relationship Management) applications**
  - **ERP (Enterprise Resource Planning) applications**
  - **Media Applications (i.e. Movie studio production)**
  - **Various Web Services applications**
  - **Database applications on huge datasets**
- **Increasing demands/loads on these applications can be daunting to an enterprise**
  - **Demands in terms of data, execution, and time**
    - **More clients/customers requiring access to applications**
    - **Return execution results with increasing loads within reasonable time-frame**
    - **Achieve result in a cost-effective manner**
- **Run more instances of applications on available resources**

Grid is …

- **Resource Sharing**
  - Ubiquitous sharing of resources distributed globally across LAN, MAN, and WAN
- **Resource Virtualization**
  - Resources virtualized to isolate users, applications or clients from exact nature and source of resources
  - Utility like (a la electrical power grid) consumption of resources
- **Dynamic Resource Access**
  - On-demand and as-needed consumption and sharing of resources
  - On-demand configuration & provisioning of resources
- **Resource and Application Optimization**
  - Achieve better performance and price ratio
- **(IOS/OSI) Layer 7 (L7) Infrastructure systems**
  - Supercomputers + Clusters + Low-end PCs, servers, workstations + Storage
- **AND Network (Layers 1, 2, 3, 4: L1/2/3/4) factored in**

What is OGNS?

What is OGNS?
Major Concepts behind OGNS

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- OGNS = On-Demand Grid Network System
- Facilitate effective deployment of Grid in existing, production and heterogeneous networks operated or owned by service providers (SP) or Enterprise IT (EIT), not just in green-field or future-oriented purely research networks
- Keep the existing domain and layer separations intact while providing some level of "control" to Grid or other (layer 7: L7) clients → provide abstracted and virtualized resources and services to Grid clients
- Provide on-demand network services for provisioning, monitoring and scheduling of network resources or services
- Facilitate resource sharing across wider network domain (not just LAN, but also Enterprise campus network, multi-site Data Center, MAN and WAN)
- Facilitate cost-effective (Grid) resource sharing and deployment
- Facilitate execution of High-Performance Computing (HPC) application across wider network domain with latency far exceeding fast interconnects used in (single-rack/room) dedicated clusters
- Facilitate co-management of (L7) Grid AND Network resources and services (the latter exposed as abstract and virtualized resources and services to Grid clients)
- Support above by interfacing existing Cisco NMS's with Grid middleware (Globus GT4, for example) or other L7 resource provisioning systems

What is OGNS?

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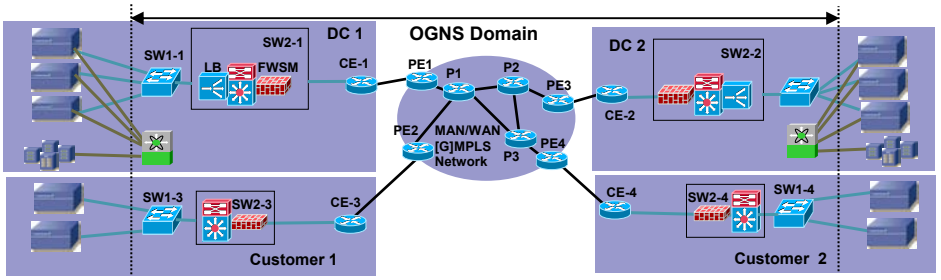
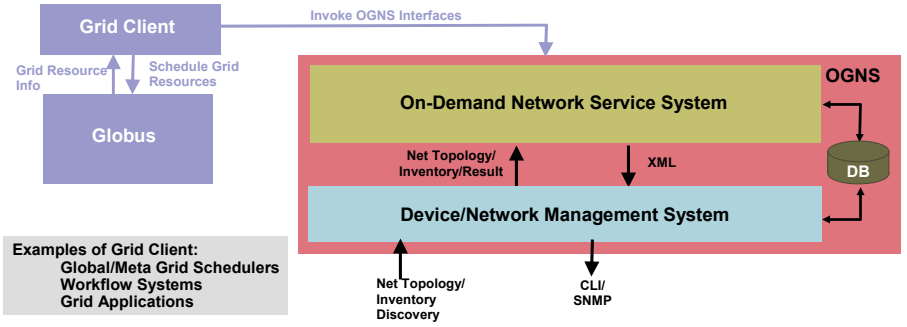
- OGNS is an on-demand network management solution with application to Grid or other on-demand environments
- Resources considered in OGNS are all the *network-based* resources (L1/2/3/4) existing between Grid/L7 resources (applications, Computers, storage)
  - Physical resources: Routers, switches
  - Logical resources: Bandwidth, QoS, VPN, etc.



What is OGNS?

- Built on top of NMS → Provides an on-demand layer on NMS
- Provides *network abstraction and virtualization* to Grid or other clients
  - Exposes abstract and virtualized network resources and services
- Major On-demand OGNS functions: Provisioning, Monitoring, Scheduling (PMS)
- Interfaced with Globus GT4 facilitating end-to-end co-PMS of Grid & Net resources



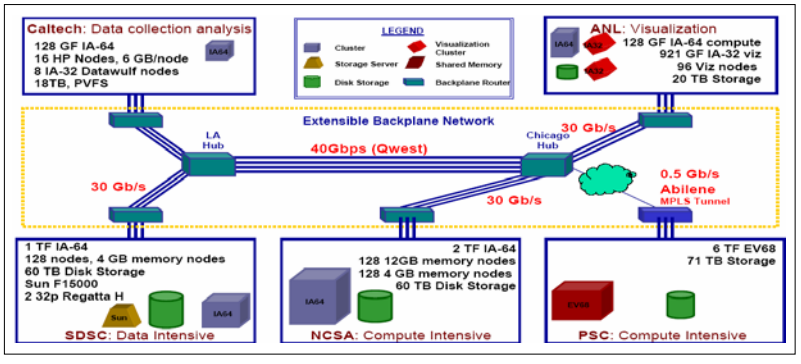
Concepts behind OGNS

High-End/Cutting-edge vs. Existing Network Infrastructure

- Can build a high-end grid with new network infra, technologies, and models (admin domain, topology) by throwing in
  - High-bandwidth pipes
    - Lightpath over dark-fiber (LoDF) between clusters
      - Research networks, NRN (National Research Network)
      - $O(N^2)$ LoDF
    - High-end clusters and supercomputers
- Service providers (SP) or Enterprise IT (EIT) have to provide grid services over existing networks with existing infra, technologies, and architecture
- OGNS considers both

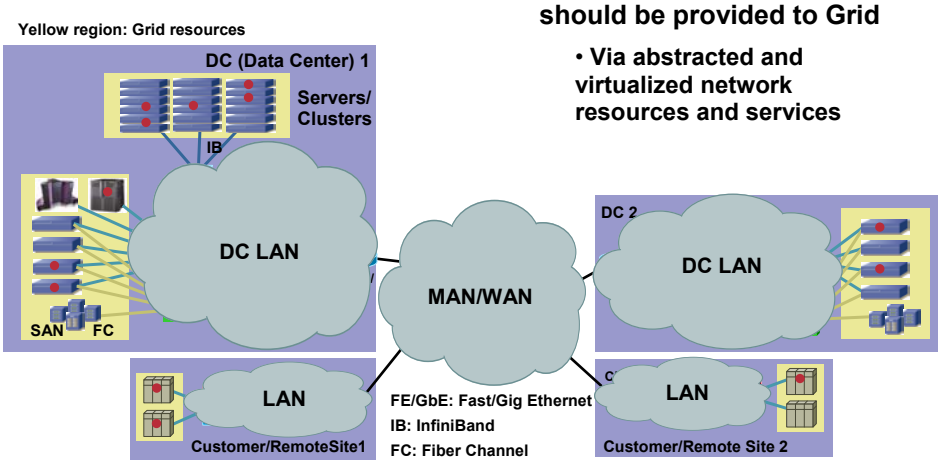
Grid with High-End Special-Purpose Systems and Network—TeraGrid

- High-end clusters, supercomputers
- High-end network devices and connectivity
- Potential future Grid network



Network Abstraction, Virtualization for Grid Network is Cloud to Grid

- Network is Cloud to Grid
- Some level of "control" should be provided to Grid
  - Via abstracted and virtualized network resources and services



Network Abstraction, Virtualization for Grid Domain and Layer Separation

- Domain and layer separation is predominant in network world
  - ISO/OSI or protocol layer separation
  - UNI (User to network interface) between network domains
    - Between client and server networks
    - Between a customer and a Service Provider (SP)
    - Between an IP data and a Sonet/SDH/optical transport network
  - Separation of management and control between data and transport networks in NSP Environment
- If Enterprise IT (EIT) or SP has to offer grid services on existing infrastructure, similar domain and layer separation is needed in grid environment

Network Abstraction, Virtualization for Grid Network Resources, Services

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- Grid clients should/need not have access to full network topology of EIT or SP
- Grid clients should/need not be able to configure routers, switches directly
- Grid clients should/need not be exposed to underlying network details
  - For example, grid clients will be isolated from
    - Exact nature of underlying QoS mechanism
      - DiffServ, IntServ, 802.1p, or MPLS
      - OGNS abstracts/virtualizes this as *priority*
    - Exact nature of bandwidth "tunnel"
      - [G]MPLS TE LSP or Sonet/SDH circuit or DWDM LightPath
      - OGNS abstracts/virtualizes this as plain *bandwidth*
    - Exact nature of VPN
      - L3 (IPSEC, GRE, MPLS) or L2 VPN (VPLS, PVC, L2TP)
      - OGNS abstracts/virtualizes this as VVPN

On-Demand Network Services for Grid

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- Provide on-demand network services for provisioning, monitoring and scheduling of network resources or services
  - Network resources and services: (abstracted and virtualized) bandwidth, QoS, VPN, security, etc.
  - Monitoring: Network-based monitoring (contrast with host-based monitoring)
  - Scheduling: Network resource or service scheduling

On-Demand Network Services for Grid
contd..

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- Resource scheduling can be:
  - Immediate
  - Future (batch)
- Service domain is end-to-end (E2E) between L7 grid resources
- E2E provisioning may involve combination of multiple methods
  - Classical RSVP, RSVP aggregation, RSVP-TE, SIP, CLI, XML, and other interfaces
- These services can be utilized in other application domains
  - VoIP, IMS, VoD, IPTV

Network-Based Performance/QoS Monitoring

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- In network-based monitoring, operations initiated from within
  - Routers/switches
  - Enterprise IT (EIT) or Network Service Provider (NSP)
- Contrast network based monitoring with host or end-system based (generally TCP) monitoring typical in grid domain
- An EIT or SP can provide network-based monitoring as a service to grid
  - A Grid client (such as a global scheduler) can make use of this service to perform network aware grid functions

Network-Based Performance/QoS Monitoring vs. Host/End System-Based Monitoring

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- Host/End system-based monitoring (typical in Grid environment) may not be accurate in the absence of access to network-based monitoring features
- SP may not allow measurement (ICMP/UDP) packets originating from outside
- In MPLS networks ICMP ping will not be enough
  - ICMP (if allowed) will pass through IP control plane only
  - Need MPLS data plane monitoring with MPLS OAM
  - MPLS OAM supports ECMP (Equal Cost Multi-Path: multiple IGP [OSPF/IS-IS] routing paths for load balancing) tree trace for accuracy
- Host-based monitoring will not be able to perform network QoS or VPN-based (such as MPLS, VPN, VRF, or MPLS EXP-based) monitoring

Amdahl's Law—Parallel Speedup

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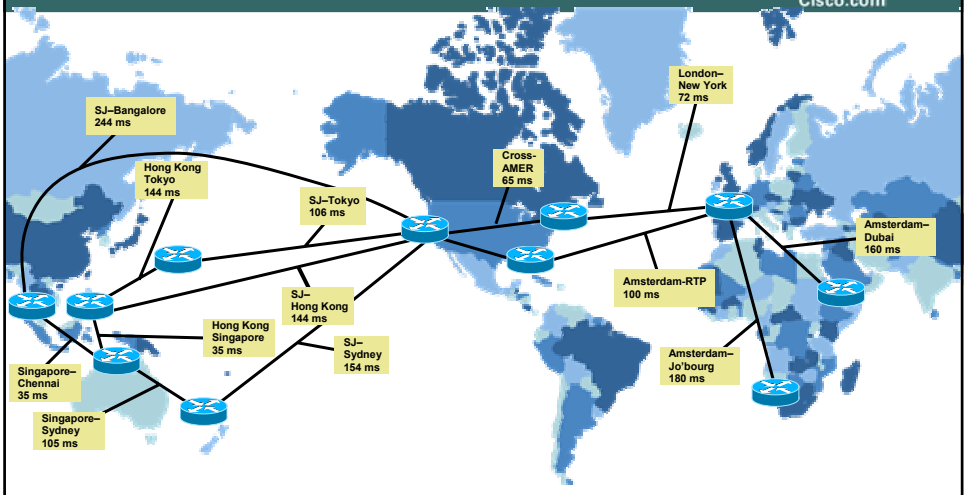
- Amdahl's law dictates faster processors and interconnects for clusters and supercomputers running HPC applications
- Communication (IPC, other network traffic) not considered
  $S_N = (t_s + t_p)/(t_s + t_p/N)$
  S_N : Speed-up ratio on N processors
  t_s : time spent in serial part
  t_p : time spent in parallel parts, if only single processor is used
- Communication Considered
  $S_{cN} = (t_s + t_p)/(t_s + t_p/N + K*t_c)$
  t_c : communication time; K in $K*t_c$ can be $O(N^2)$ (for all-to-all communication)
- Bottom-line, for better speedup/performance, need
  - Faster processors → minimize t_s and t_p
  - Faster interconnects → minimize t_c

Wide-Area Network Latency



Is Wide-Area (Beyond a Single Cluster/Supercomputer to Campus LAN, MAN, WAN) Network Latency Suitable for HPC?

HPC Across Wide-Area Grid possible Use Case

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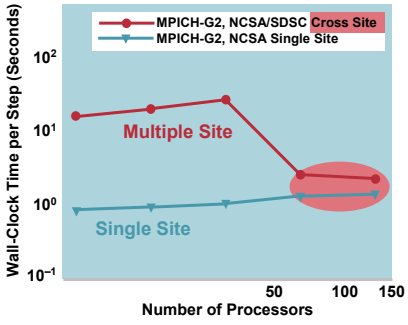
- Application: Human Arterial Tree Simulation (CFD problem)
- Network: TeraGrid
- Grid resources: multiple sites on TeraGrid with 90 millisec latency
- Shows comparable execution time across WAN as the problem size and the number of processors grows
- With proper network "control" HPC across large delay network possible

Source: Computing in Science and Engineering, Special Issue on Grid Computing, September/October 2005



Network Performance of Teragrid

	Intra-Connected Network	Inter-Connected Network
Latency	2E-3–8E-3 ms	3–90 ms
Bandwidth	240–1600 Mbps	4–700 Mbps

On-demand Network Services for Grid Network Management Aspects

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- Factoring network management into grid is key
  - While deploying grid in an existing, operational and heterogeneous network
  - In order to provide network services to grid clients
- Some of the key functions provided by an NMS are very important in providing network services to grid
  - Network device, and topology discovery
  - Access to network inventory
  - Configuration Management (CM)
    - In order to provide on-demand grid services on existing networks existing configuration should remain intact or modified in a graceful manner
      - For example, if a priority Q has been configured, either new on-demand grid traffic will not be allowed into it or the Q size expanded on-demand to accomodate new grid traffic
    - Fault and performance management
- OGNS relies on existing network/device management systems

On-demand NMS

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- NMS based configuration generally static
  - For example, Network administrators or operators generally limit or prioritize resource usage via static configuration
    - Example: classification, policing, queuing, etc.
- Static configuration prevents on-demand or immediate servicing of, for example
  - Increment of Q bandwidth for admitting more traffic in that Q
  - New QoS priority for a new application or traffic
- Scheduling or future resource reservation is not possible in current NMS
- OGNS provides on-demand access to NMS

OGNS Use Cases

Network-Aware/Network-Based Grid Scheduling

L7 resource requirements: #of CPUs: 2
CPU speed: 800 Mhz
Memory: 200MByte each
Local Disk: 1GB each
[Rendering] CPU: 1
CPU speed: 1 Ghz
Memory: 100 GB

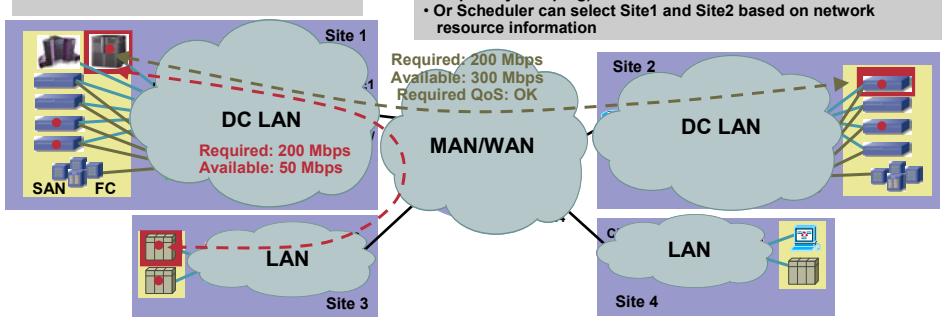
Network Requirements:
Between Processors: 200Mbps
QoS: Transactional priority
Between Renderer & Workstation: 600Mbps
QoS: High for streaming

Typical on-demand Grid resource scheduling:

- Scheduler has no Network information or cannot reserve network resources
- Schedules on resources on Site1 and Site 3 (even though insufficient network BW and QoS available between sites)

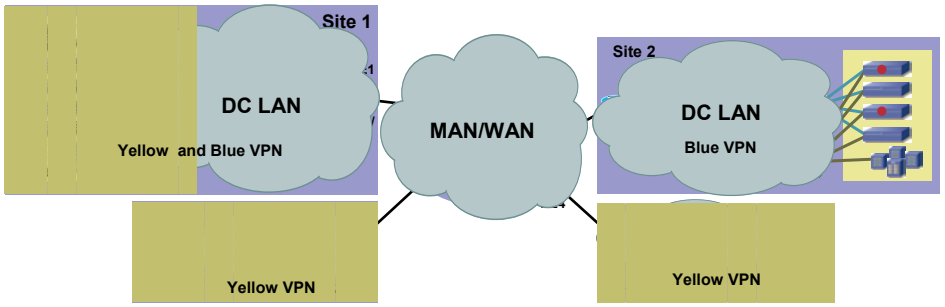
Network-aware/Network-based scheduling:

- Scheduler has access to Network information or can reserve network resources
- If scheduler selects Site1 and Site3 and attempts to reserve resource, it may be granted by the network service (possibly via priority bumping)
- Or Scheduler can select Site1 and Site2 based on network resource information



Grid VVPN Service

- A grid site (Site 3) finds out about VPN capabilities from grid resource (directory) service provided by a grid Service provider (SP or EIT)
- It then requests to join a VPN (yellow VPN) on-demand
- Needed provisioning is performed transparently, if possible (for example, if MPLS VPN VRF limit has not reached, in case VPN is MPLS VPN)
- Site 3 joins yellow VPN
- Information on this new VPN site is added to the resource service
- Any collaborating grid site can join any existing VPN on-demand



OGNS Phase I

OGNS Features - Phase I

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- Phase I OGNS support includes
  - On-demand QoS provisioning in Ethernet, DiffServ and MPLS networks
  - Mapping of QoS at network cross points
    - For example, DiffServ DSCP to MPLS EXP
  - On-demand provisioning of MPLS TE LSP (Traffic Engineering Label Switched Path)
  - Mapping of DiffServ and Ethernet traffic to MPLS TE LSP
  - Phase I NBNSI
    - CosLink (EPR1, EPR2, bandwidth, priority)
      - EPR: End-Point-Reference (EPR's are Grid/L7 nodes)

OGNS Lab

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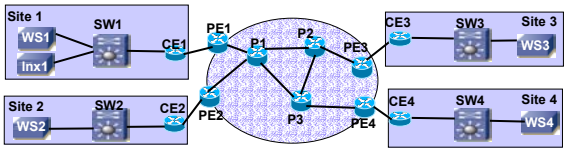


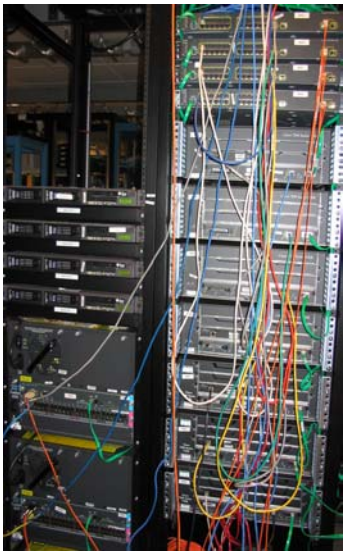
Grid lab emulates four Grid sites connected by a MPLS WAN

SW1/2/3/4: Catalyst 4500 (IOS version 12.2(25)SG)
CE1/2/3/4: Catalyst 3750 Metro Ethernet release (IOS version 12.2(25)EY3)
PE1/2/3/4: 7204 (IOS version 12.0(30)S3)
P1/2/3: 7206 (IOS version 12.0(30)S3)
WS1/2/3/4 and lnx1: Linux Machines (Fedora Core 4)
lnx1 (real machine name sdk-linux1) runs the OGNS server

Links are 100Mbps
There are 1Gbps links, but they fallback to 100Mbps

SW1/2/3/4, CE1/2/3/4 are connected to the Grid Lab gateway (for outside and management access; not shown)

Sheer server (Blitzen) is 1 Hop away from the Grid Lab gateway



OGNS Deployment Diagram

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Globus GT4 Components:

GRAM: Globus Resource Allocation Manager for job scheduling and data staging (transfers)

RFT: Reliable File Transfer - a web-services interface on top of GridFTP; GRAM invokes RFT

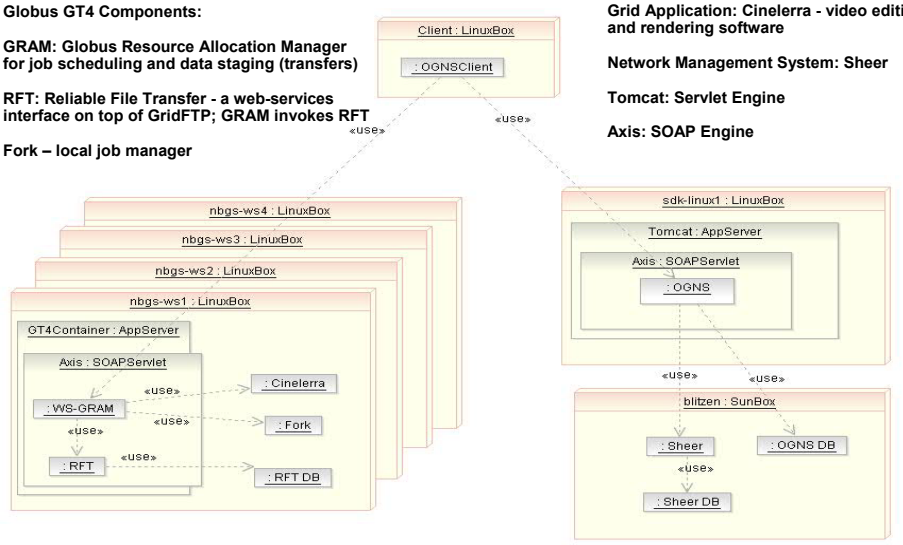
Fork – local job manager

Grid Application: Cinelerra - video editing and rendering software

Network Management System: Sheer

Tomcat: Servlet Engine

Axis: SOAP Engine



OGNS Workflow Topology/Inventory Discovery

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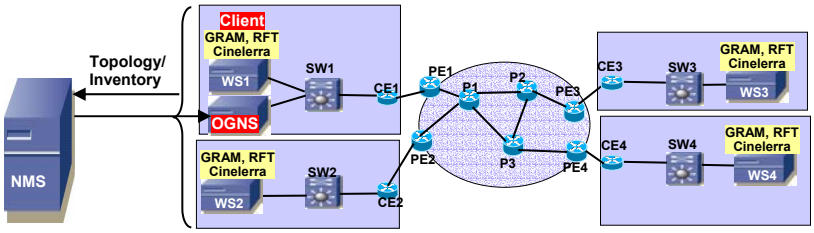
- **Topology/Inventory discovered by NMS and put into DB**
- **OGNS accesses the DB**



OGNS Client Application – Task Definition

```
<job>  <!- All tasks defined in a job are launched in parallel on different hosts -->
  <task>  <!- Subtasks defined within a task are executed sequentially -->
     <logfile>/home/nbgs/nbgs/out/host_1.log</logfile>
     <subtask> <!-- Stage In -->
        <coslink from="nbgs_ws1.cisco.com" to="$TASK_EXECUTE_HOST" bw="100Mbps"></coslink>
        <jobfile>/home/nbgs/nbgs/jobs/stagein_from_nbgsws1_1.xml</jobfile>
     </subtask>
     <subtask>  <!-- Execute -->
        <jobfile>/home/nbgs/nbgs/jobs/renderjob.xml</jobfile>
     </subtask>
     <subtask>  <!-- Stage Out -->
        <coslink from="$TASK_EXECUTE_HOST" to="nbgs_ws1.cisco.com" bw="50Mbps"></coslink>
        <jobfile>/home/nbgs/nbgs/jobs/stageout_to_nbgsws1_1.xml</jobfile>
     </subtask>
  </task>
  <task>
     <logfile>/home/nbgs/nbgs/out/host_2.log</logfile>
     <subtask> <!-- Stage In -->
        <coslink from="nbgs_ws1.cisco.com" to="$TASK_EXECUTE_HOST" bw="100"></coslink><!–bw unit mbps-->
        <jobfile>/home/nbgs/nbgs/jobs/stagein_from_nbgsws1_2.xml</jobfile>
     </subtask>
     <subtask> <!-- Execute -->
        <jobfile>/home/nbgs/nbgs/jobs/renderjob.xml</jobfile>
     </subtask>
     <subtask> <!-- Stage Out -->
        <coslink from="$TASK_EXECUTE_HOST" to="nbgs_ws1.cisco.com" bw="50Mbps"></coslink>
        <jobfile>/home/nbgs/nbgs/jobs/stageout_to_nbgsws1_2.xml</jobfile>
     </subtask>
  </task>
</job>
```

A Subtask may define a associated CosLink which is created before the subtask is launched and deleted after completion of subtask.

WS GRAM Job Definition File.

User doesn't need to specify the actual name of the host where the task will be executed. Only the name of the host where resources are stored is used in file.

OGNS Workflow
CosLink Creation by OGNS and Sheer

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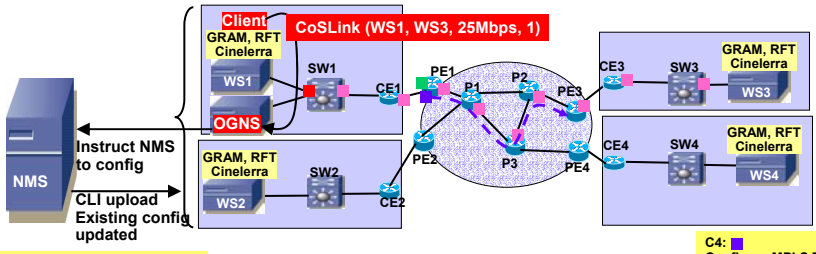
- **Simple (abstract) interface called CoSLink mapped to multiple and complex network configuration steps**

  Router and switch configurations dynamically updated (added, modified or deleted)



C1: Classification based on source & destination IP addresses; Marking (DSCP) based on Priority (if priority=1, DSCP=46 (EF)); Policing on BW (CIR=25)

C2: Queuing based on Priority

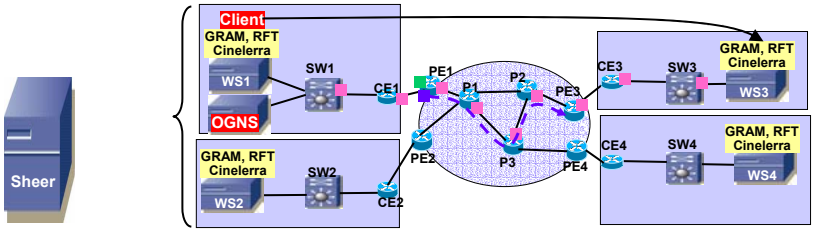
C3: Map DSCP (46) to MPLS EXP (5) for priority Qing in MPLS network

C4: Configure MPLS TE LSP; Designate this TE LSP for priority traffic so that priority traffic goes to the priority TE LSP (IOS CBTS: Class Based Tunnel Selection; packets carrying MPLS EXP=5 forwarded to this TE LSP)

OGNS Workflow
WS-GRAM Job Stage In/Out

Portion of GRAM RSL: Job (describing EDL, Video software invoking script, Video file) submitted to destination host GRAM; RFT/GridFTP transfers files over CosLink

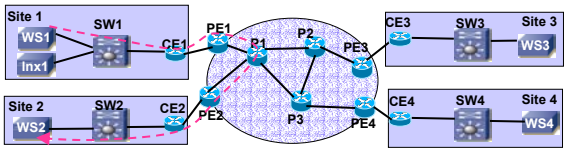
```
<fileStageIn>
        <transfer>
                <sourceUrl>gsiftp://nbgs-ws1.cisco.com:2811/home/nbgs/nbgs/videos/project_1.xml</sourceUrl>
                <destinationUrl>file:///${GLOBUS_USER_HOME}/nbgs/stage/project.xml</destinationUrl>
        </transfer>
        <transfer>
                <sourceUrl>gsiftp://nbgs-ws1.cisco.com:2811/home/nbgs/nbgs/videos/fountain.avi</sourceUrl>
                <destinationUrl>file:///${GLOBUS_USER_HOME}/nbgs/stage/fountain.avi</destinationUrl>
        </transfer>
        <transfer>
                <sourceUrl>gsiftp://nbgs-ws1.cisco.com:2811/home/nbgs/nbgs/scripts/renderAV.sh</sourceUrl>
                <destinationUrl>file:///${GLOBUS_USER_HOME}/nbgs/stage/renderAV.sh</destinationUrl>
        </transfer>
</fileStageIn>
```



On-demand Network Performance Control with OGNS

- **Comparison of GridFTP times without and with CoSLink**

	From Host	To Host
Noise BW Rate: 50 mbps	lnx1	WS2
Coslink BW Rate: 80mbps	WS1	WS2
Grid FTP Data Size (1007 MB)	Transfer Times	
	Without Coslink	With Coslink
	193 seconds (41.7 mbps)	106 seconds (75.9 mbps)



Dynamic CoSLink Creation Trace


```
[root@nbgs-ws1 ~]# traceroute nbgs-ws4
traceroute to nbgs-ws4.cisco.com (10.1.3.2), 30 hops max, 38 byte packets
 1  10.1.5.1 (10.1.5.1)  0.413 ms  0.384 ms  0.363 ms
 2  10.1.1.29 (10.1.1.29)  0.335 ms  0.279 ms  0.282 ms
 3  10.1.1.1 (10.1.1.1)  0.557 ms  0.406 ms  0.402 ms
    MPLS Label=32 CoS=0 TTL=1 S=1                          ← Initial QoS marking of traceroute packets: CoS=0
 4  10.1.1.17 (10.1.1.17)  0.477 ms  0.421 ms  0.401 ms
    MPLS Label=34 CoS=0 TTL=1 S=1
 5  10.1.1.22 (10.1.1.22)  0.498 ms  0.430 ms  0.425 ms
 6  10.1.1.42 (10.1.1.42)  0.597 ms  0.588 ms  0.571 ms
 7  nbgs-ws4 (10.1.3.2)  0.456 ms  0.376 ms  0.381 ms

[root@nbgs-ws1 ~]# traceroute nbgs-ws4                     ← CoSLink has been invoked just before this
traceroute to nbgs-ws4.cisco.com (10.1.3.2), 30 hops max, 38 byte packets
 1  10.1.5.1 (10.1.5.1)  0.402 ms  0.376 ms  0.388 ms
 2  10.1.1.29 (10.1.1.29)  0.308 ms  0.277 ms  0.279 ms
 3  10.1.1.1 (10.1.1.1)  0.567 ms  0.419 ms  0.419 ms
    MPLS Label=32 CoS=5 TTL=1 S=1
 4  10.1.1.17 (10.1.1.17)  0.441 ms  0.416 ms  0.423 ms
    MPLS Label=34 CoS=5 TTL=1 S=1                          ← QoS marking (of traceroute packet) changed to CoS=5 after CoSLink provisioned
 5  10.1.1.22 (10.1.1.22)  0.477 ms  0.455 ms  0.443 ms       dynamically and DSCP=46 mapped to MPLS EXP=5
 6  10.1.1.42 (10.1.1.42)  0.639 ms  0.603 ms  0.589 ms
 7  nbgs-ws4 (10.1.3.2)  0.421 ms * 10.1.1.42 (10.1.1.42)  0.931 ms

[root@nbgs-ws1 ~]# traceroute nbgs-ws4
traceroute to nbgs-ws4.cisco.com (10.1.3.2), 30 hops max, 38 byte packets
 1  10.1.5.1 (10.1.5.1)  0.403 ms  0.376 ms  0.389 ms
 2  10.1.1.29 (10.1.1.29)  0.337 ms  0.284 ms  0.272 ms
 3  10.1.1.1 (10.1.1.1)  0.627 ms  0.498 ms  0.473 ms
    MPLS Label=37 CoS=5 TTL=1 S=1
 4  10.1.1.6 (10.1.1.6)  0.588 ms  0.475 ms  0.461 ms      ← Packet route (path) changed to the dynamically configured MPLS TE SLP
    MPLS Label=36 CoS=5 TTL=1 S=1                            Packets with MPLS EXP=5 (CoS=5) takes this path of MPLS TE LSP
 5  10.1.1.14 (10.1.1.14)  0.530 ms  0.479 ms  0.460 ms
    MPLS Label=36 CoS=5 TTL=1 S=1
 6  10.1.1.22 (10.1.1.22)  0.517 ms  0.492 ms  0.494 ms
 7  10.1.1.42 (10.1.1.42)  0.677 ms  0.652 ms  0.666 ms
 8  nbgs-ws4 (10.1.3.2)  0.468 ms  0.444 ms  0.445 ms
```


OGNS Post Phase I

OGNS Planned Features

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- **Monitoring System (OGNS-MS)**
  - **Network-based monitoring**
  - **Grid and other clients can make use of this service, for example, for making Grid scheduling decisions**
- **Network-aware Scheduling Service (OGNS-NSS)**
  - **Make scheduling decisions based on OGNS-MS data and OGNS-CP (CP: Configuration & Provisioning) information (especially already provisioned CoSlink information) → This is more like "call" (request) admission control, not only for current requests, but for requests with future (batch) reservation**
  - **This is an extension of CoSLink**
  - **A Grid Meta/Global scheduler can make use of this service for making network-aware scheduling decisions**

OGNS Planned Features contd…

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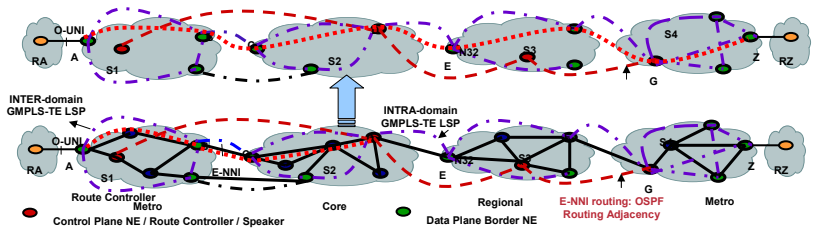
- **Firewall Pinholing (OGNS-FP)**
  - **OGNS-DFP will open and close firewall pinholes dynamically after proper authentication and authorization and do so per application/service and per "customer" basis**
  - **Grid or other clients can use this service for on-demand firewall pinholing**
- **Virtual VPN Service (OGNS-VVPN)**
  - **Abstract or virtual VPN (VVPN) service that may incorporate underneath following services spanning multiple sites**
    - **L3 VPN (MPLS VPN, IPSEC, GRE)**
    - **L2 VPN (Any Transport over MPLS, etc.)**
    - **VLAN**
  - **Grid or other clients can use this service to join a VVPN on-demand**

Multi-Provider/AS Issues and Standards

E2E provisioning and QoS in Multi-Provider Networks

- E2E provisioning and QoS is specifically required in Grid environments as multiple organizations may enter into a Grid for resource sharing
- E2E provisioning
  - [G]MPLS supports inter-domain TE LSP, MPLS VPN
  - More work in progress in standard forums: ITU, IETF, IPSphere
- E2E Multi-provider QoS
  - Standard forums: IPSphere, IETF

Example of E2E Provisioning in Multi-Region/provider, Multi-Technology, Multi-Layer (IP, Transport/Optical) Networks



Standards

Cisco.com

- General Grid related standards
  - Global Grid Forum (GGF) – http://www.ggf.org
- GGF makes use of many web services standards
  - OASIS - http://www.oasis-open.org/
  - W3C - http://www.w3.org/
- Other GGF Liaison or joint standards with
  - IETF – http://www.ietf.org/
  - ITU-T – http://www.itu.int/home/index.html
  - DMTF (Distributed Management Task Force) – http://www.dmtf.org/
  - TMF (TeleManagement Forum) - http://www.tmforum.org/
  - EGA (Enterprise Grid Alliance) - http://www.gridalliance.org/
- Not standard forum, but consortium for major open-source Grid Middleware Globus – http://www.globusconsortium.org/

Summary

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- As Grid applications become more widely deployed, OGNS is key to deploying Grid systems over Service Provider and Enterprise networks
- On-demand Grid Network System (OGNS) provides an abstracted interface into the network layer (i.e. service control layer) for Grid applications
- Cisco working with the various standards bodies to ensure interoperability and inter-provider support

Q and A

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