Introduction to Clusters and Rocks Overview

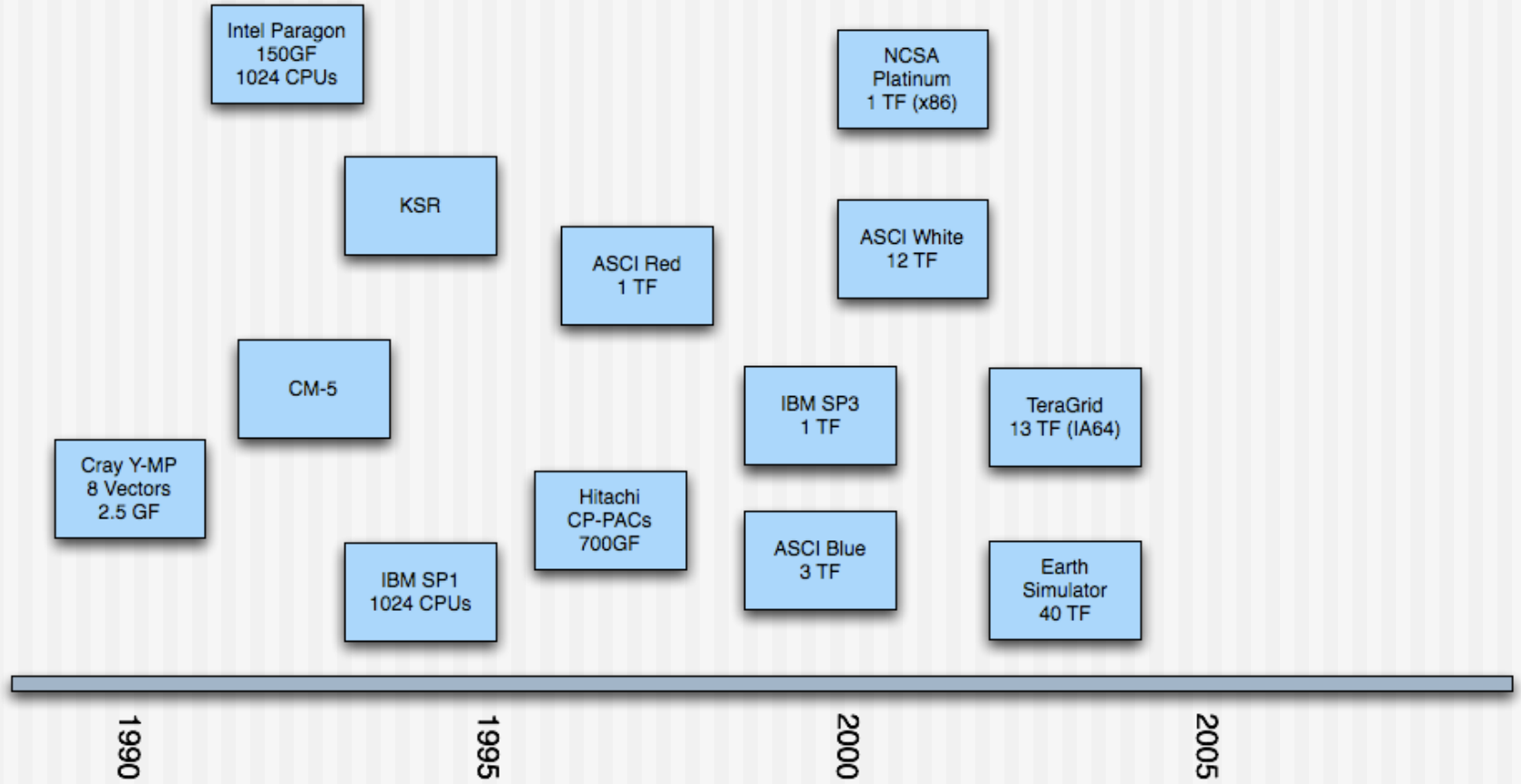
Rocks for Noobs

SDSC

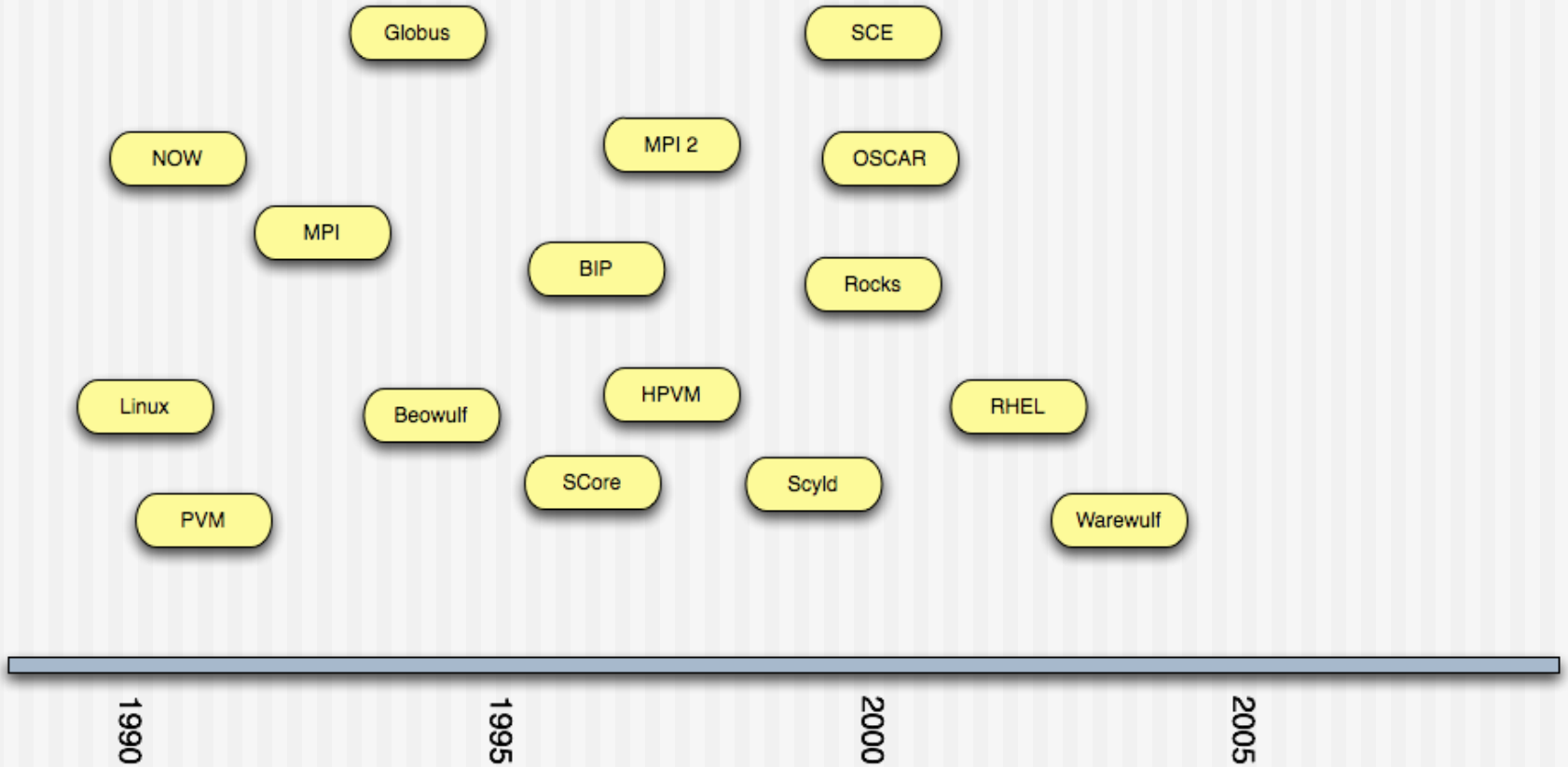
Outline

- History of Clusters
- Lesson on Optimization
- Rocks
  - Philosophies
  - Components
  - Architecture
- Complex Computing Infrastructures
  - Visualization Walls
  - Bio-Informatic Systems

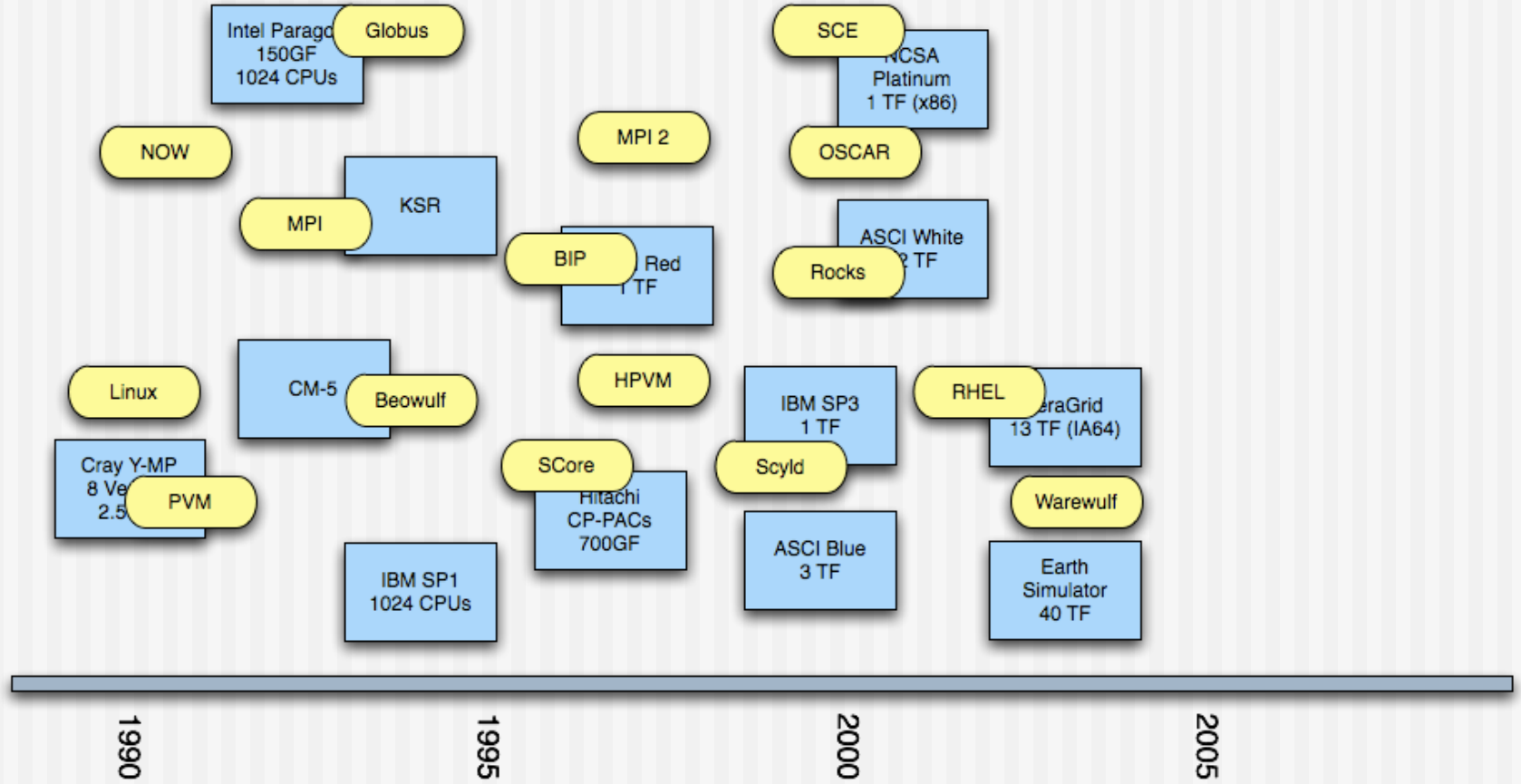
Sampling of High Performance Computing (HPC) Hardware



Some Significant Software



Relationships



NOW

Network of Workstations

- Pioneered the vision for clusters of commodity processors.
  - David Culler (UC Berkeley) started early 90's
  - SunOS on SPARC Microprocessor
  - High Performance, Low Latency Interconnect
    - First generation of Myrinet
    - Active Messages
  - Glunix (Global Unix) execution environment
- Brought key issues to the forefront of commodity-based computing
  - Global OS
  - Parallel file systems
  - Fault tolerance
  - High-performance messaging
  - System Management

Beowulf

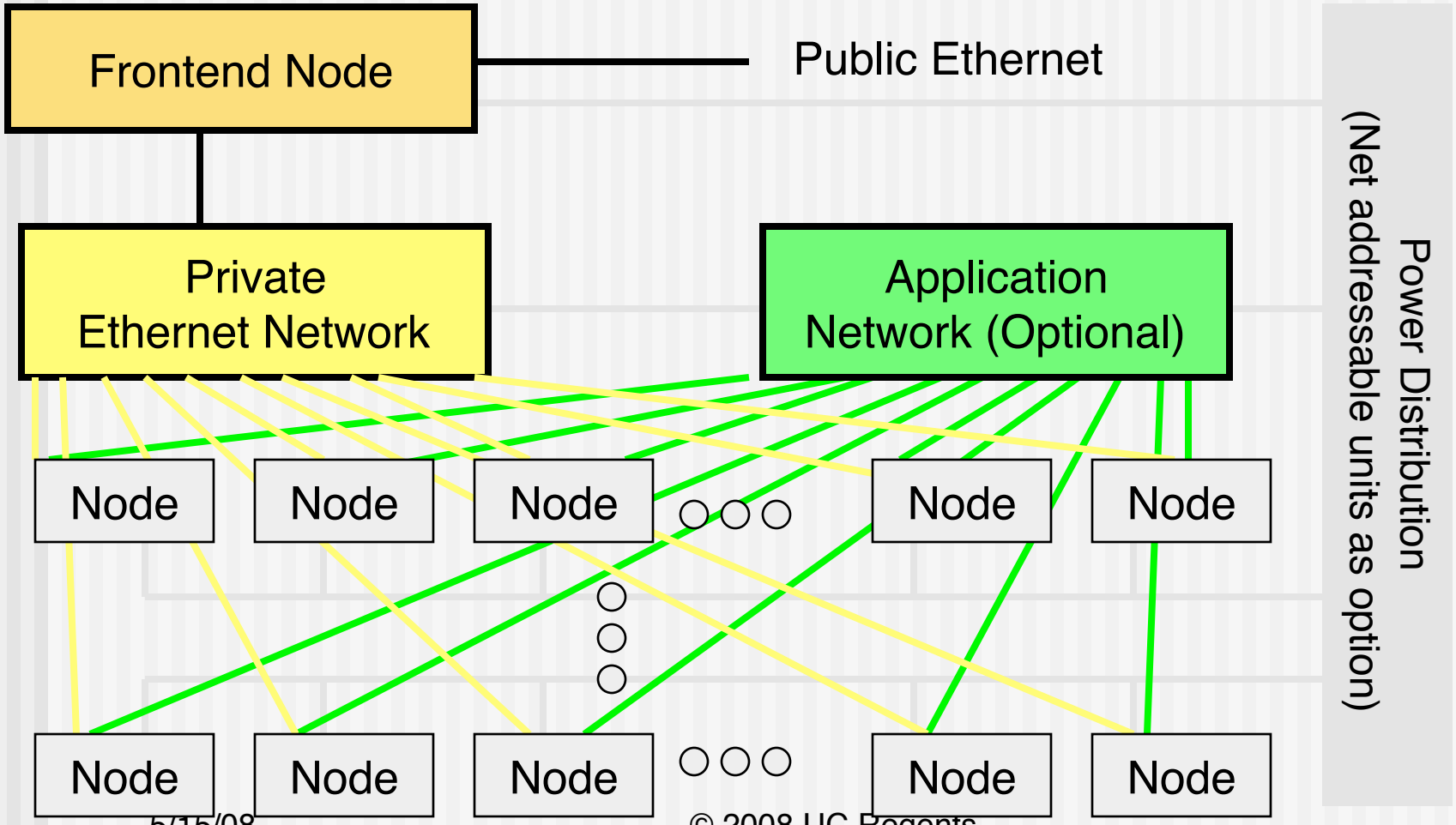
www.beowulf.org

- Definition
  - Collection of commodity computers (PCs)
  - Using a commodity network (Ethernet)
  - Running open-source operating system (Linux)
- Interconnect
  - Gigabit Ethernet (commodity)
    - High Latency
    - Cheap
  - Myrinet, Infiniband, … (non-commodity)
    - Low Latency
    - OS-bypass
    - Expensive
  - Programming model is Message Passing
- NOW pioneered the vision for clusters of commodity processors.
- Beowulf popularized the notion and made it very affordable
- Come to mean any Linux cluster

Outcomes of NOW / Beowulf

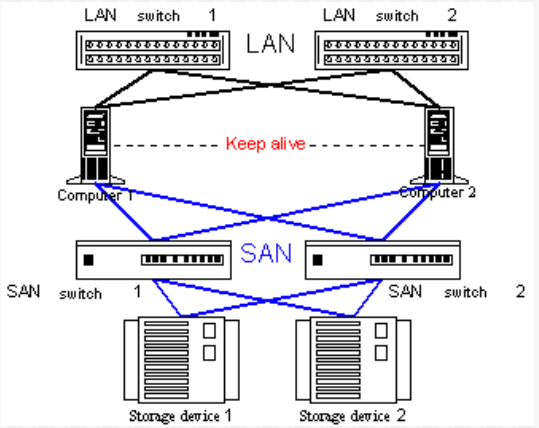
- Clusters of PCs Popularized
- Allowed more people to work on parallel computing
- Almost all software components published as open-source
- Brought key ingredients of MPPs into the commodity space
  - Message passing environments
  - Batch processing systems
- Extremely hard to build and run

High Performance Computing Cluster



Other Clusters

- Highly Available (HA)
  - Generally small, less than 8 nodes
  - Redundant components
  - Multiple communication paths
  - This is not Rocks
- Visualization Clusters
  - Each node drives a display
  - OpenGL machines
  - This is not core Rocks
  - But, there is a Viz Roll



The Dark Side of Clusters

- Clusters are phenomenal price/performance computational engines …
  - Can be hard to manage without experience
  - High-performance I/O is still unsolved
  - Finding out where something has failed increases at least linearly as cluster size increases
- Not cost-effective if every cluster “burns” a person just for care and feeding
- Programming environment could be vastly improved
- Technology is changing very rapidly. Scaling up is becoming commonplace (128-256 nodes)

The Top 2 Most Critical Problems

- The largest problem in clusters is *software skew*
  - When software configuration on some nodes is different than on others
  - Small differences (minor version numbers on libraries) can cripple a parallel program
- The second most important problem is adequate job control of the parallel process
  - Signal propagation
  - Cleanup

Rocks (open source clustering distribution)

www.rocksclusters.org

- Technology transfer of commodity clustering to application scientists (non-technical people)
  - "make clusters easy"
  - Scientists can build their own supercomputers and migrate up to national centers, or international grids, as needed
  - Supports more than just MPI machines
- Rocks is a cluster on set of CDs (or a DVD)
  - Red Enterprise Hat Linux (open source, *de facto* standard, and **free**)
  - Clustering software (PBS, SGE, Ganglia, GT4, …)
  - Highly programmatic software configuration management
- Core software technology for many UCSD projects
  - BIRN, CTBP, EOL, GEON, NBCR, OptIPuter, CAMERA, …
- First Software release Nov, 2000
  - Began as an MPI cluster solution
  - Now builds grid resources
  - Moving towards virtualization (XEN) and other OSes (Solaris)
- Supports x86, Opteron/EM64T, and Itanium

Simple Deployment

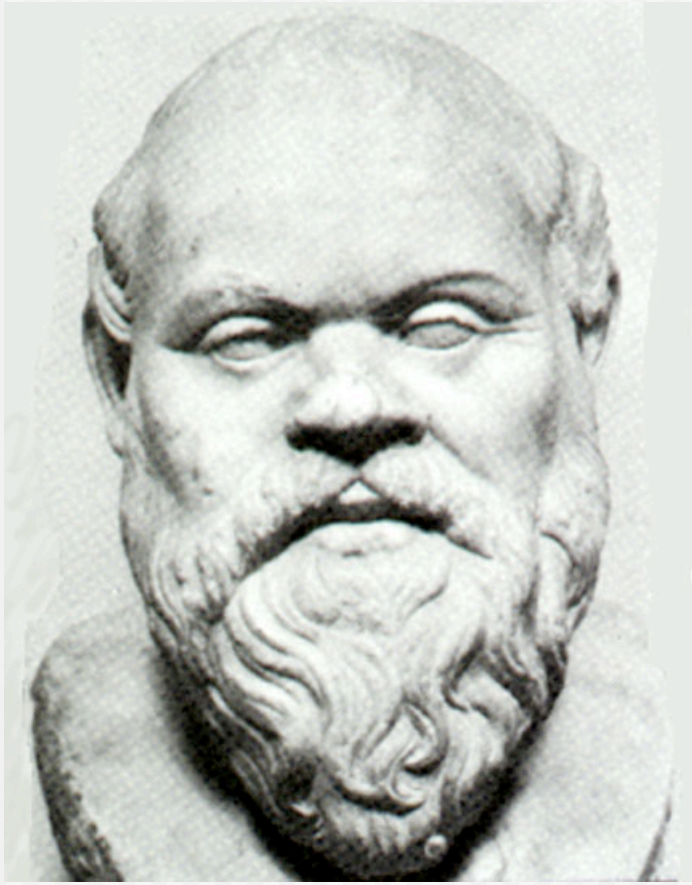
- Install a frontend
  1. Insert Rocks Base CD
  2. Insert Roll CDs (optional components)
  3. Answer 7 screens of configuration data
  4. Drink coffee/tea/beer (takes about 30 minutes to install)
- Install compute nodes:
  1. Login to frontend
  2. Execute insert-ethers
  3. Boot compute node with Rocks Base CD (or PXE)
  4. Insert-ethers discovers nodes
  5. Goto step 3
- Add user accounts
- Start computing

Optional Rolls

- Condor
- Grid (based on NMI R4)
- Intel (compilers)
- Java
- SCE (developed in Thailand)
- Sun Grid Engine
- PBS (developed in Norway)
- Area51 (security monitoring tools)
- Many Others …

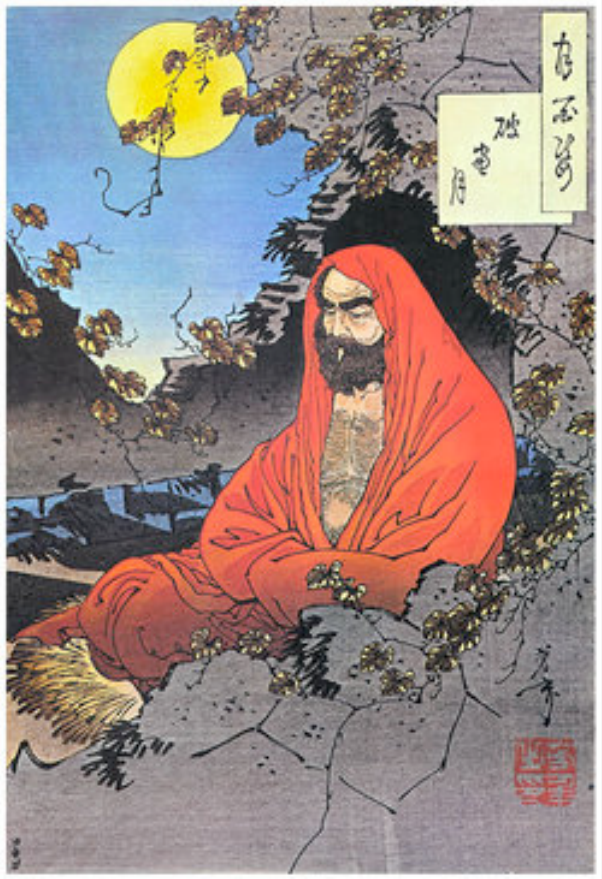
Philosophy

- Caring and feeding for a system is not fun
- System Administrators cost more than clusters
  - 1 TFLOP cluster is less than $100,000 (US)
  - Close to actual cost of a fulltime administrator
- The system administrator is the weakest link in the cluster
  - Bad ones like to tinker (make small changes)
  - Good ones still make mistakes



Philosophy
continued

- All nodes are 100% automatically configured
  - Zero “hand” configuration
  - This includes site-specific configuration
- Run on heterogeneous standard high volume components (PCs)
  - Use components that offer the best price/performance
  - Software installation and configuration must support different hardware
  - Homogeneous clusters do not exist
  - Disk imaging requires homogeneous cluster



Philosophy
continued

- Optimize for installation
  - Get the system up quickly
  - In a consistent state
  - Build supercomputers in hours not months
- Manage through re-installation
  - Can re-install 128 nodes in under 20 minutes
  - No support for on-the-fly system patching
- Do not spend time trying to issue system consistency
  - Just re-install
  - Can be batch driven
- Uptime in HPC is a myth
  - Supercomputing sites have monthly downtime
  - HPC is not HA (High Availability)

Rocks Basic Approach

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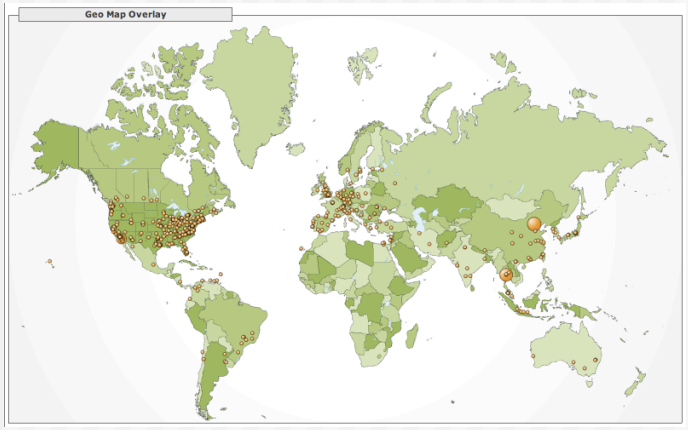
Minimum Requirements

- Frontend
  - 2 Ethernet Ports
  - CDROM
  - 18 GB Disk Drive
  - 512 MB RAM
- Compute Nodes
  - 1 Ethernet Port
  - 18 GB Disk Drive
  - 512 MB RAM
- Complete OS Installation on all Nodes
- No support for Diskless (yet)
- Not a Single System Image
- All Hardware must be supported by RHEL

Rocks Users

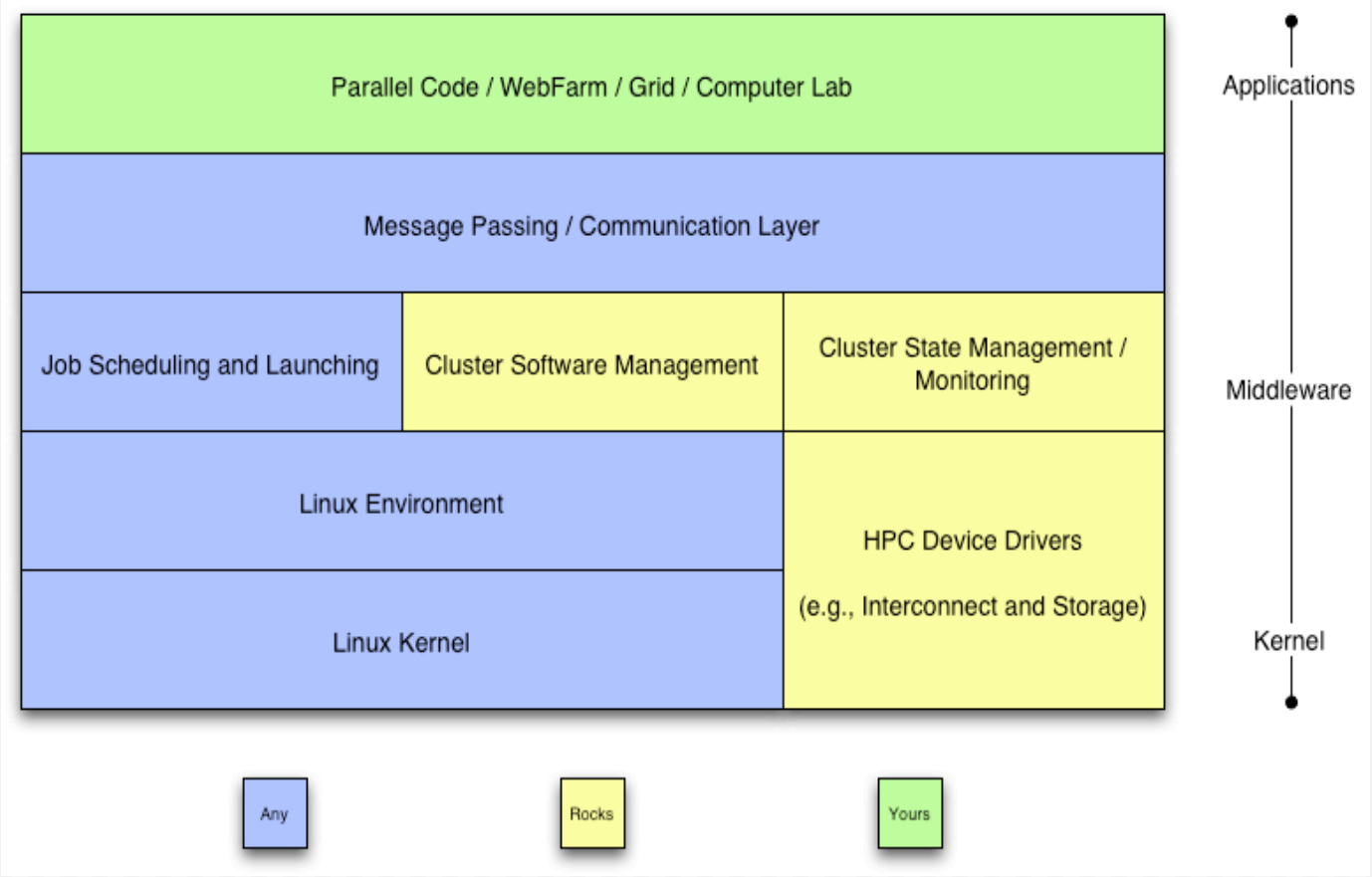
- HPC wire awards
  - 2004, and 2005
  - Competition was commercial
- User base is international
  - Still U.S. heavy
  - Europe and Asia well represented
- High Performance Computing community is eager to adopt open-source clustering solutions



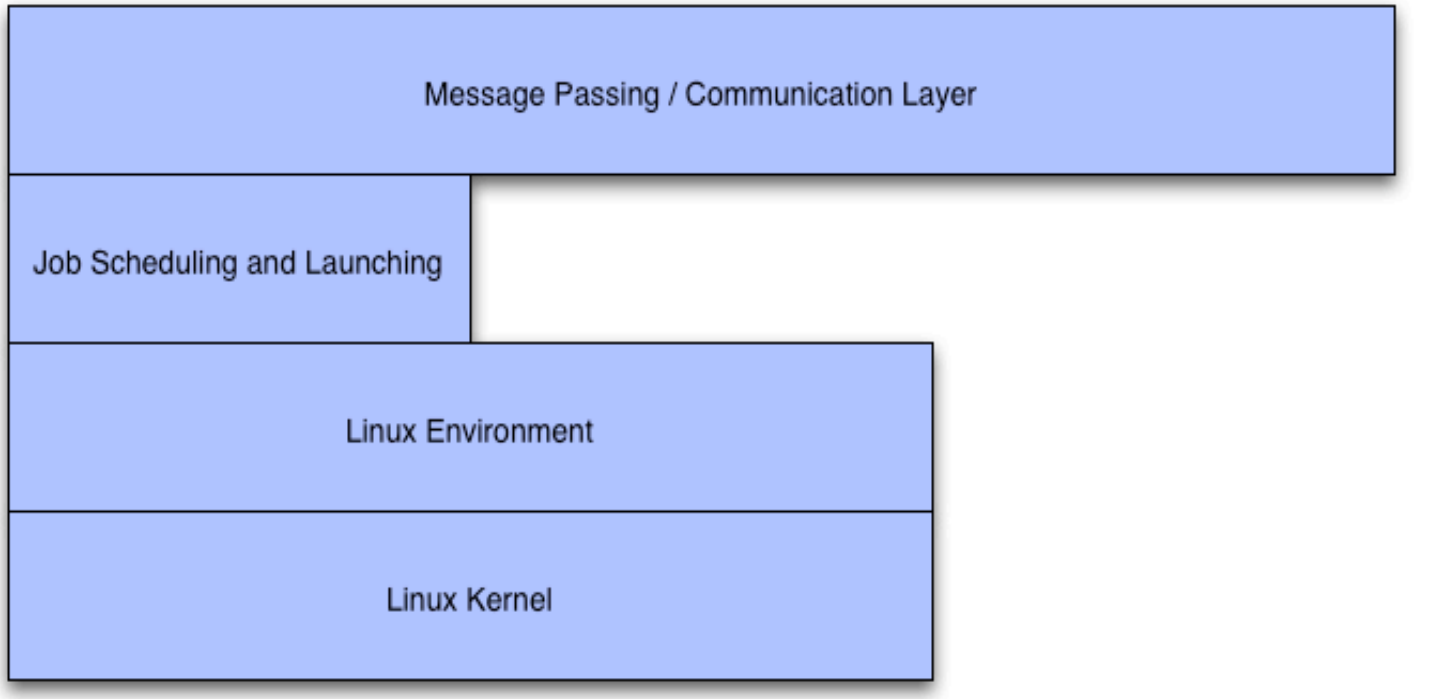
Making Clusters Easy

ROCKS

Cluster Software Stack



Common to Any Cluster



Red Hat

- Enterprise Linux 4.0
  - Recompiled from public SRPMS, including errata updates (source code)
  - No license fee required, redistribution is also fine
  - Recompiled for all CPU types (x86, Opteron, Itanium)
  - *Rocks 5.0 will be based on RHEL 5.0 (Centos, or RHEL)*
- Standard Red Hat Linux kernel
  - No Rocks added kernel patches
- No support for other distributions
  - Red Hat is the market leader for Linux
    - In the US
    - And becoming so in Europe
  - Trivial to support any Anaconda-based system
  - Others would be harder, and require vendor support (SuSe ~ 12 months work)
- Excellent support for automated installation
  - Scriptable installation (Kickstart)
  - Very good hardware detection

Dell Invests in Red Hat

Michael Dell puts $99.5M in Red Hat

Billionaire chairman of No. 1 PC maker places big bet on Microsoft competitor.

May 10, 2005: 1:41 PM EDT

NEW YORK (CNN/Money) - Red Hat is getting a $99.5 million boost from Michael S. Dell, billionaire founder and chairman of Dell Inc., according a regulatory filing.

Through his private investment firm, MSD, Dell bought the largest share of $600 million in debentures offered by the software developer in January 2004, a Securities Exchange Commission filing showed.

Red Hat's main product, the Linux operating system for PCs, is a direct competitor to Microsoft's Windows. The Raleigh, N.C.-based company also provides support services for "open source" technology, which is software developed by communities of programmers for free use.

Dell (Research) is the nation's largest PC maker.

Debentures are similar to bonds in that the issuer promises a fixed return for a stated period of time on the investment.

In the case of a public company, a debenture can also be converted into shares or equity. ■

COURTESY: DELL COMPUTER

Michael Dell, billionaire chairman of Dell Inc., has given Red Hat a $99.5M injection.

Tech

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Batch Systems

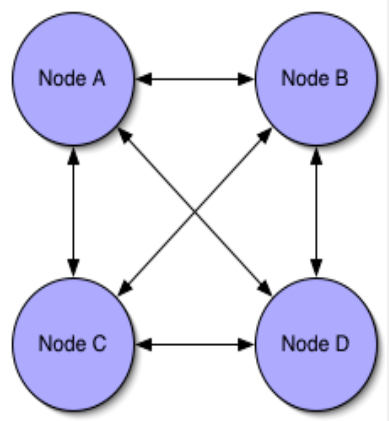
- Portable Batch System and Maui
  - Long time standard for HPC queuing systems
  - Maui provides backfilling for high throughput
  - PBS/Maui system can be fragile and unstable
  - Multiple code bases:
    - PBS
    - OpenPBS
    - PBSPro
    - Scalable PBS
- Sun Grid Engine
  - Rapidly becoming the new standard
  - Integrated into Rocks by Scalable Systems
  - Now the default scheduler for Rocks
  - Robust and dynamic

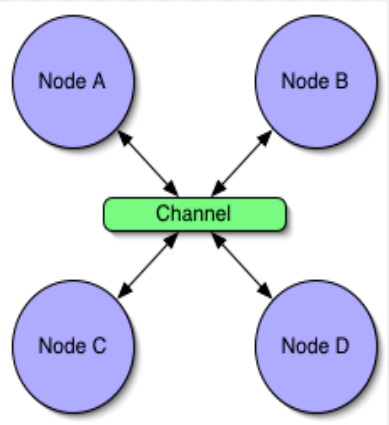
Communication Layer

- None
  - “Embarrassingly Parallel”
- Sockets
  - Client-Server model
  - Point-to-point communication
- MPI - Message Passing Interface
  - Message Passing
  - Static model of participants
- PVM - Parallel Virtual Machines
  - Message Passing
  - For Heterogeneous architectures
  - Resource Control and Fault Tolerance

Sockets are low level

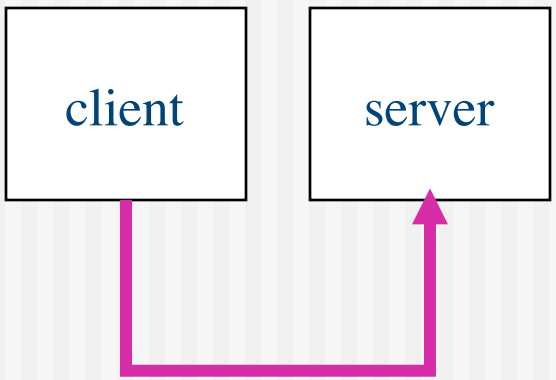
- Sockets
  - Point-to-Point
  - N machines = (n^2 - n)/2 connections
  - 1, 3, 6, 10, 15, …
- MPI/PVM
  - Shared virtual channel
  - Implementation could be sockets
  - Easier to program





Sockets

- Open an endpoint
- Specify IP address and port
- Send / receive messages
  - If TCP, only point-to-point messages
  - If UDP, option of point-to-point or multicast (broadcast)
- Shutdown connection



High-level TCP Example

```
/*
 * SERVER CODE
 */

fd = socket();
.
.
saddr.s_addr    = INADDR_ANY;
saddr.port      = 1234;
bind(fd, &saddr);
listen(fd);
accept(fd);
.
.
read(fd, buffer, size);
.
.
close(fd);
```

```
/*
 * CLIENT CODE
 */

fd = socket();
.
.
saddr.s_addr    = gethostbyname("c0-0");
saddr.port      = 1234;
.
.
write(fd, buffer, size);
.
.
close(fd);
```

Challenges with Sockets

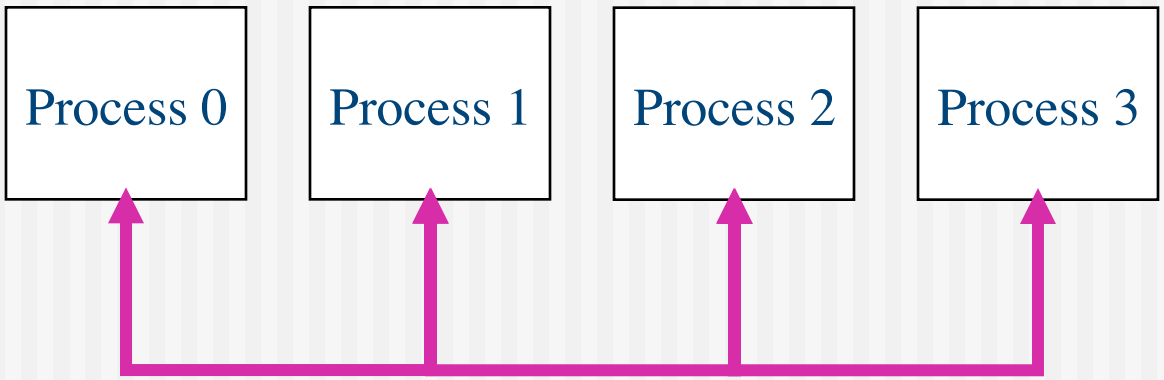
- TCP
  - Reliable, but byte oriented
  - Need to write code to send and receive *packets* (at the application level)
- UDP
  - Unreliable
  - Need to write code to reliably send packets

MPI

- Message Passing Interface
- *De facto* standard for message passing
  - Runs over many CPU architectures and many communication substrates
- There are (and were) lots of good messaging libraries
  - But, MPI is the most pervasive
  - Developed a practical, portable, efficient and flexible standard
  - In development since 1992

MPI

- Explicitly move data like sockets, but virtualizes the endpoints
  - Remote endpoints addressed by integer 0, 1, …, n
- Primitives to support point-to-point and broadcast



High-level MPI Example

```
MPI_Init();
.
.
MPI_Comm_rank(&my_mpi_id);
.
.
Remote_mpi_id = 1
MPI_Send(send_buffer, buf_size, remote_mpi_id)
.
.
MPI_Recv(recv_buffer, buf_size, remote_mpi_id)
.
.
MPI_Finalize()
```

Challenges with MPI

- If a node fails, no easy way to reconfigure and route around the problem
  - Basically, your program stops
- Hard to manage deployment
  - network X compiler = mpi binaries
  - Result is several versions of MPI / cluster

Compile

- MPICH with GNU Compilers and Ethernet

Compiler	Path
C:	/opt/mpich/ethernet/gcc/bin/mpicc
C++:	/opt/mpich/ethernet/gcc/bin/mpiCC
F77:	/opt/mpich/ethernet/gcc/bin/mpif77

- MPICH with GNU Compilers and Myrinet

Compiler	Path
C:	/opt/mpich/myrinet/gcc/bin/mpicc
C++:	/opt/mpich/myrinet/gcc/bin/mpiCC
F77:	/opt/mpich/myrinet/g77/bin/mpif77

Compile

- MPICH with Intel Compilers and Ethernet

Compiler	Path
C:	/opt/mpich/ethernet/ecc/mpicc
C++:	/opt/mpich/ethernet/ecc/mpiCC
F77:	/opt/mpich/ethernet/ecc/mpif77
F90:	/opt/mpich/ethernet/ecc/mpif90

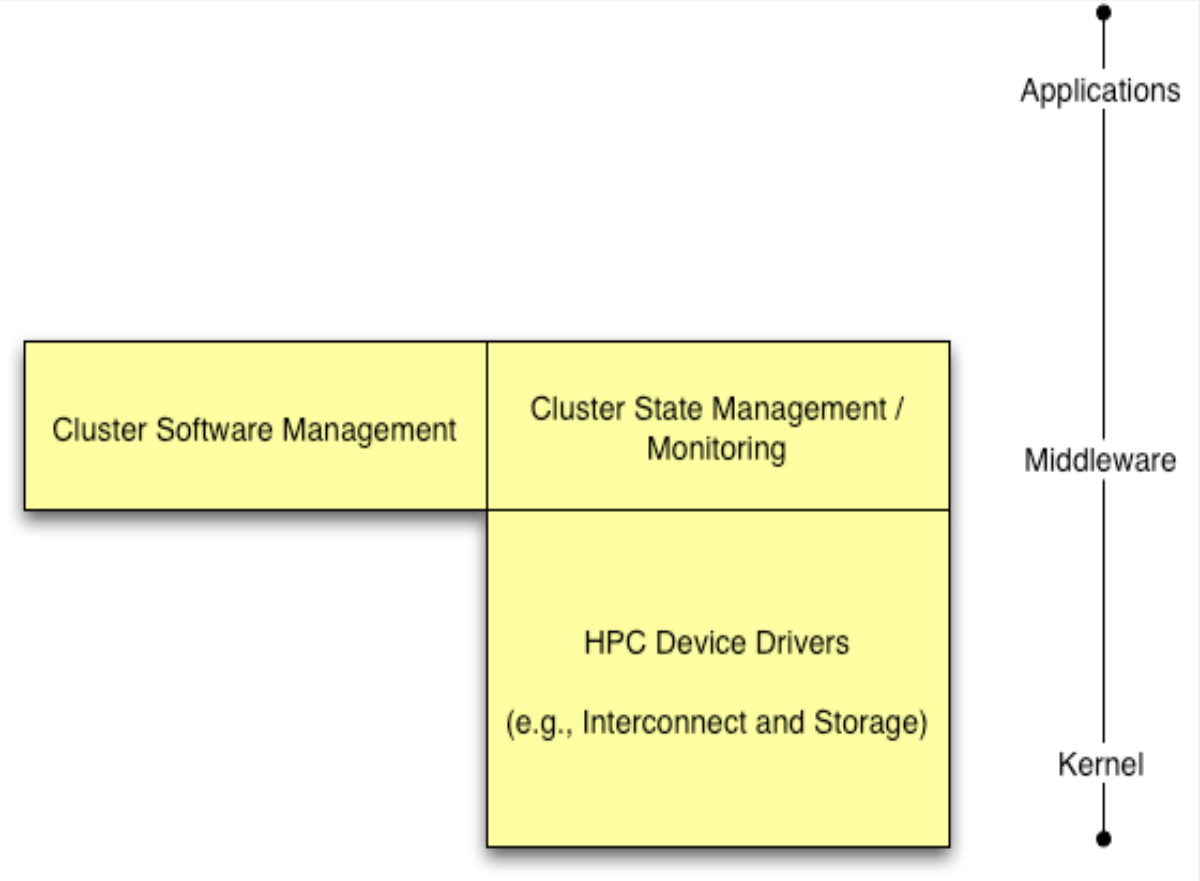
- MPICH with Intel Compilers and Myrinet

Compiler	Path
C:	/opt/mpich/myrinet/ecc/mpicc
C++:	/opt/mpich/myrinet/ecc/mpiCC
F77:	/opt/mpich/myrinet/efc/mpif77
F90:	/opt/mpich/myrinet/efc/mpif90

Network File System

- User account are served over NFS
  - Works for small clusters (<= 128 nodes)
  - Will not work for large clusters (>1024 nodes)
  - Network Attached Storage (NAS) is better than Linux
    - Rocks uses the Frontend machine to server NFS
    - We have deployed NAS on several clusters
- Applications are not served over NFS
  - /usr/local/ does not exist
  - All software is installed locally from RPM

Rocks Cluster Software



Optional Drivers

- PVFS
  - Parallel Virtual File System
  - Kernel module built for all nodes
  - User must decide to enable
- Myrinet
  - High Speed and Low Latency Interconnect
  - GM/MPI for user Applications
  - Kernel module built for all nodes with Myrinet cards
- Video
  - nVidia (from Viz Roll)
- Add your own
  - Cluster Gigabit Ethernet driver
  - Infiniband driver
- Kernel Modules are dynamically built
- No need to manage binary Kernel Modules
- Burn CPU time, not human time

SNMP

- Enabled on all compute nodes
- Great for point-to-point use
  - Good for high detail on a single end-point
  - Does not scale to full cluster wide use
- Supports Linux MIB
  - Uptime, Load, Network statistics
  - Install Software
  - Running Processes

Syslog

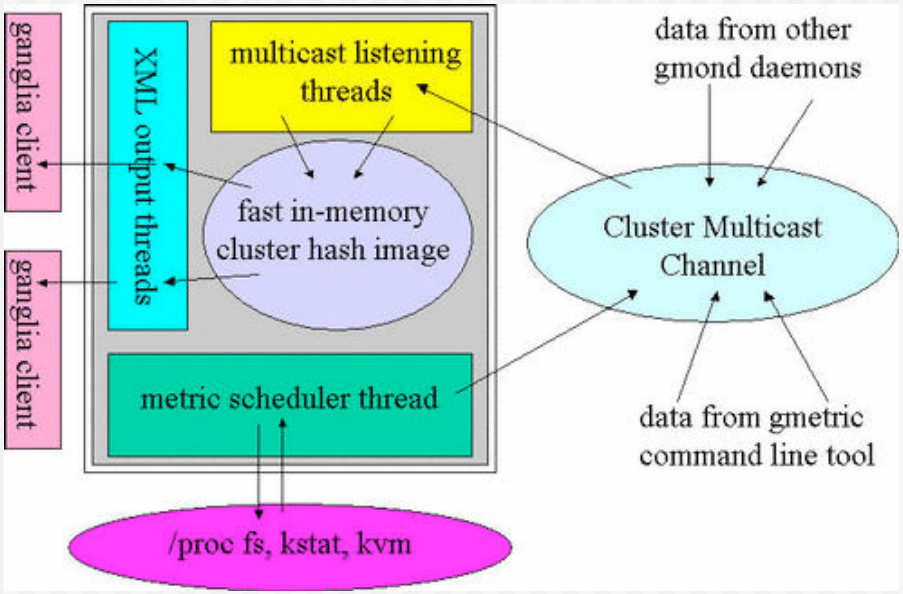
- Native UNIX system event logger
  - Logs events to local dist
    - /var/log/message
    - Rotates logs daily, eventually historic data is lost
  - Forwards all message to the frontend
- Scalable
  - Can add additional loghosts
  - Can throttle verbosity of loggers
- Uses
  - Predicting hardware and software failures
  - Post Mortem on crashed nodes
  - Debugging System startup

eKV

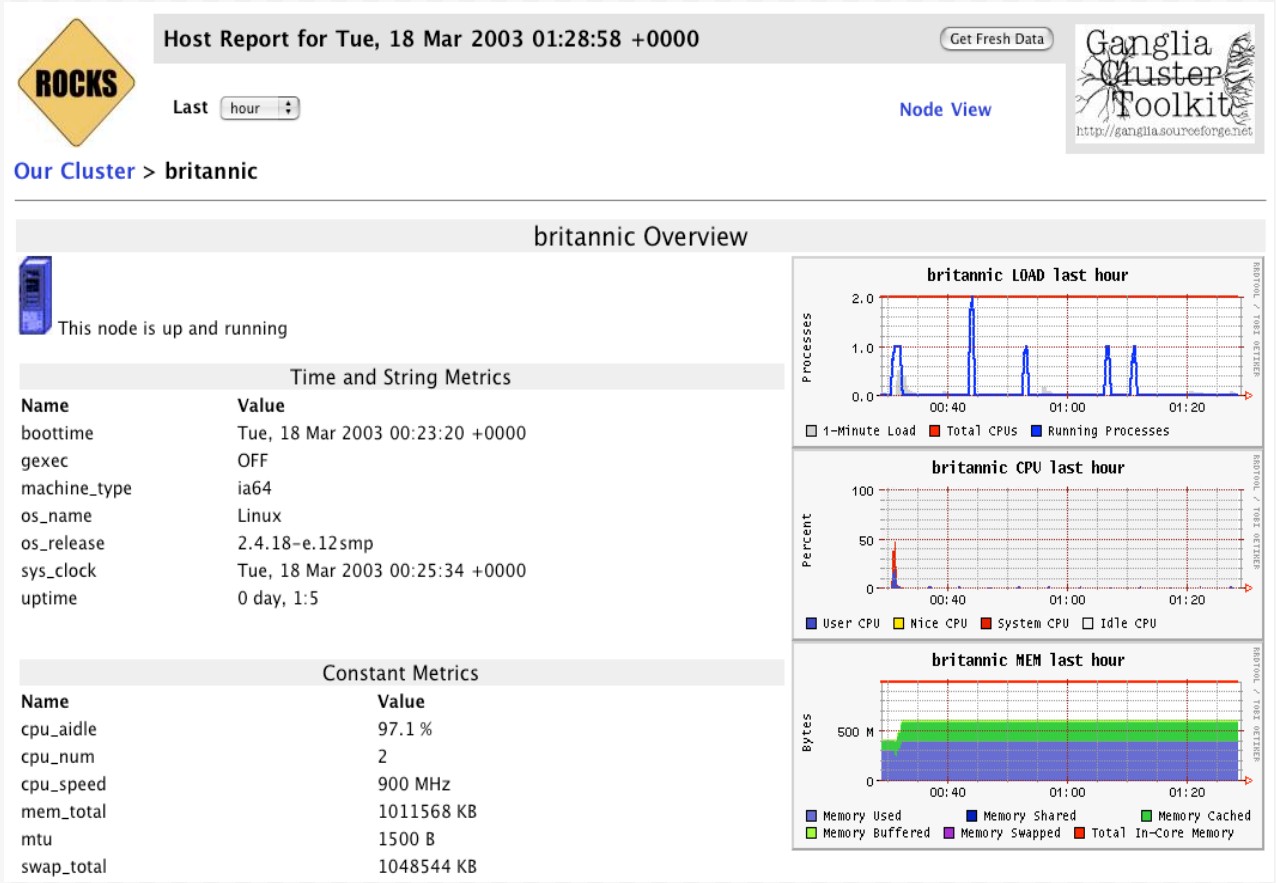
- Remotely Interact with Installation
  - Initial kickstart
  - Re-Installation
- Shoot-node
  - Reinstall OS and brings up eKV
- eKV
  - Ssh to node while it is installing
  - See the console output over Ethernet
- Newer versions of Rocks (4.0+) use VNC
  - Graphical
  - Works on headless machines

Ganglia (or SCMSWeb / SCE Roll)

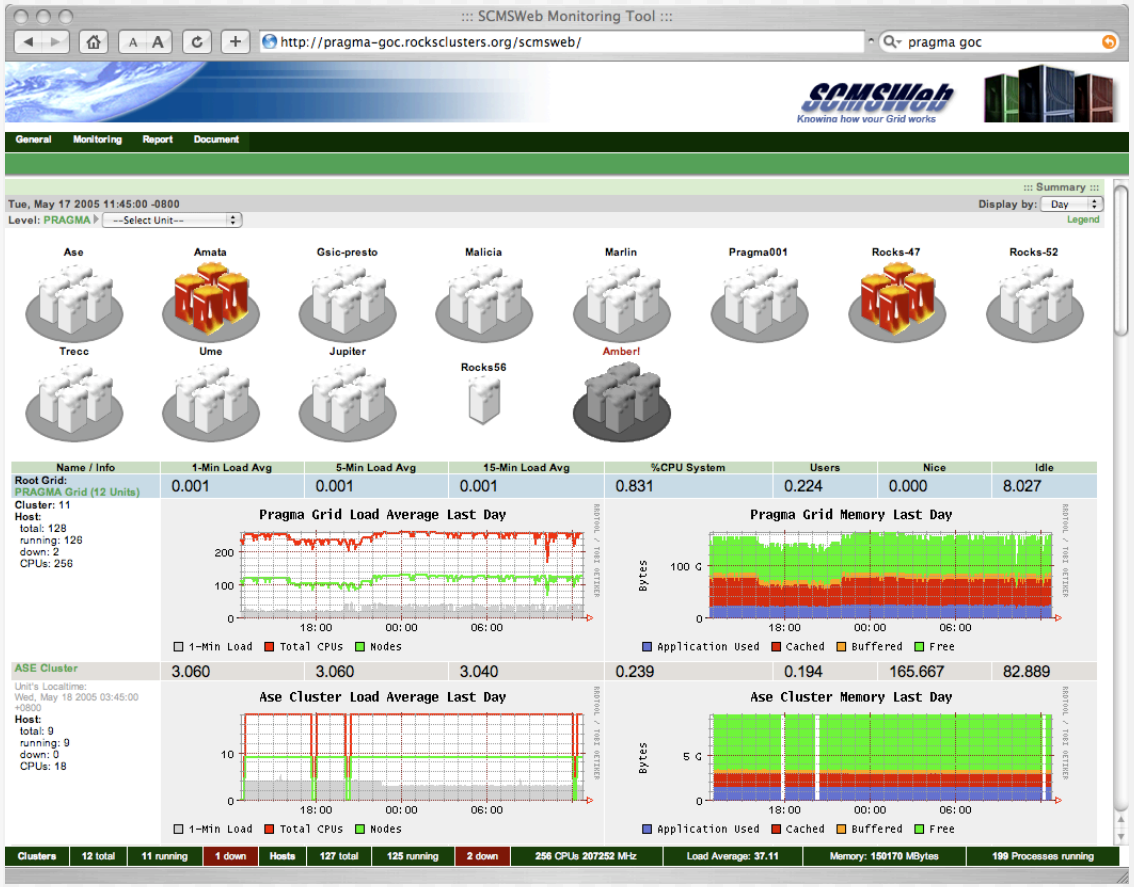
- Scalable cluster monitoring system
  - Based on IP multi-cast
  - Matt Massie, et al from UCB
  - http://ganglia.sourceforge.net
- Gmon daemon on every node
  - Multicasts system state
  - Listens to other daemons
  - All data is represented in XML
- Ganglia command line
  - Python code to parse XML to English
- Gmetric
  - Extends Ganglia
  - Command line to multicast single metrics



Ganglia Screenshot



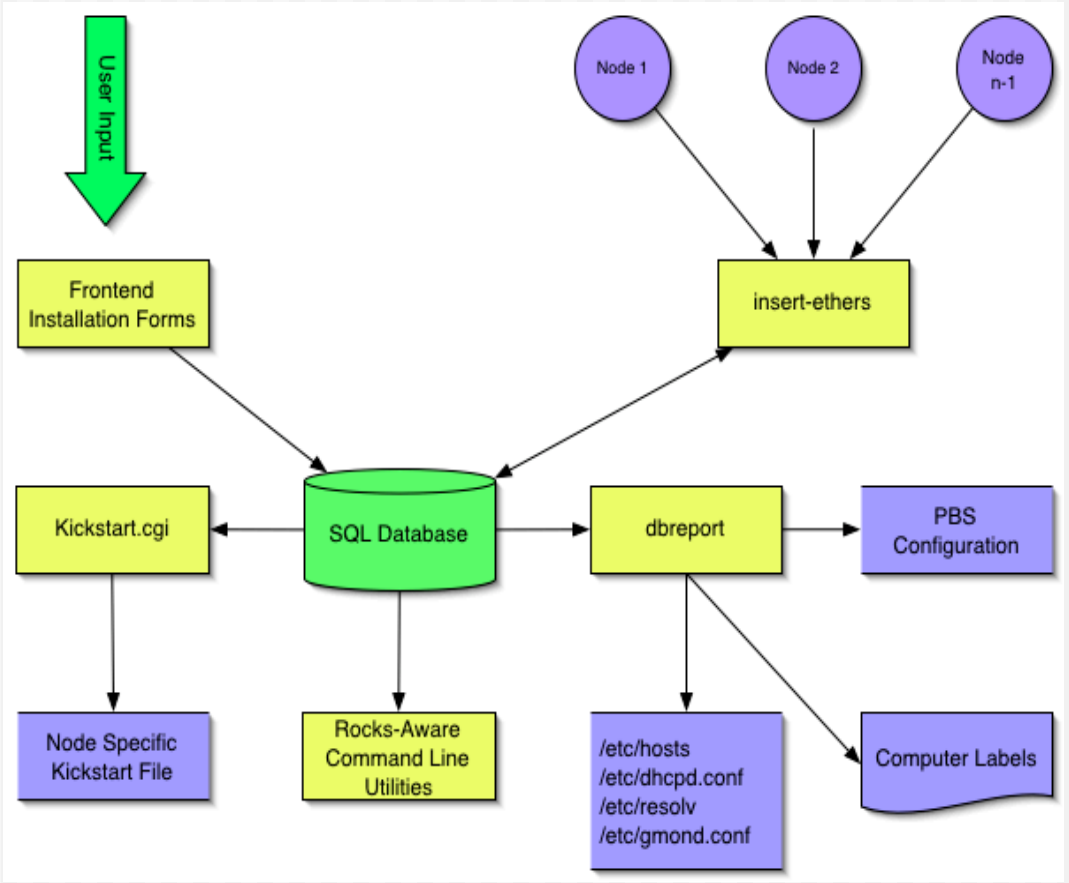
SCMSWeb Screenshot



Cluster State Management

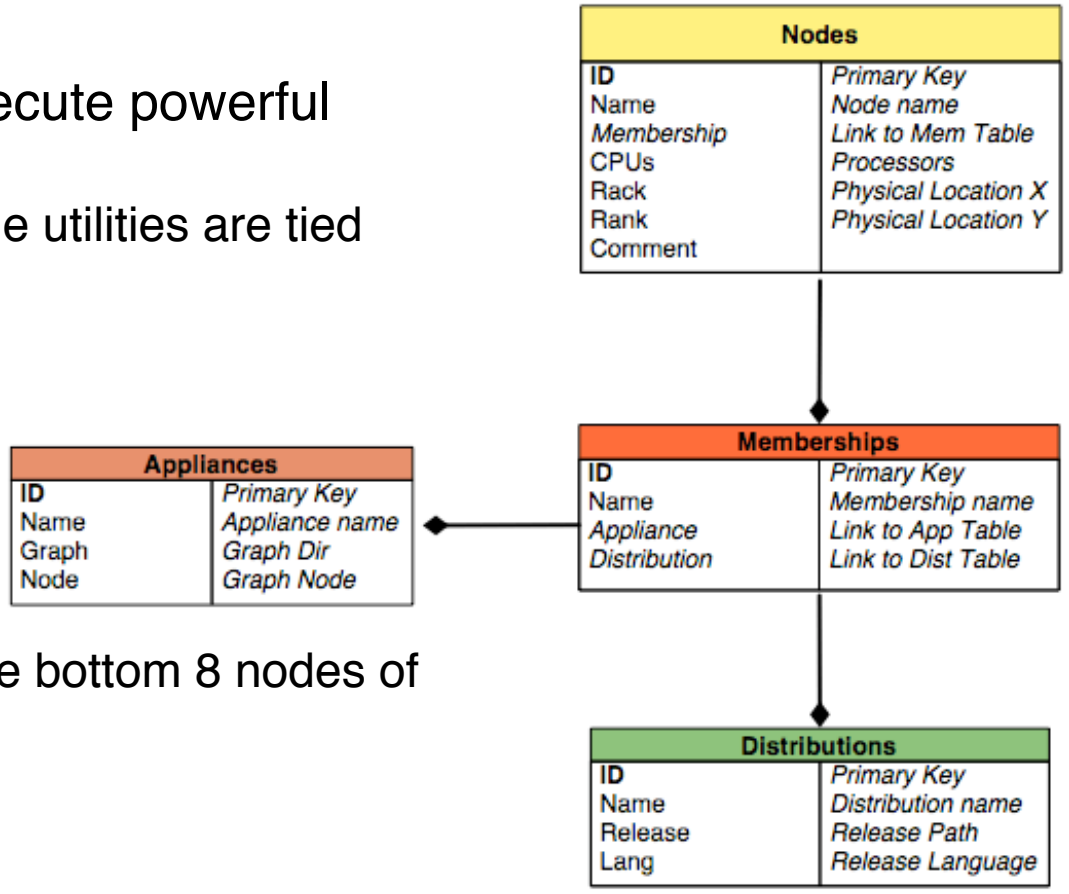
- Static Information
  - Node addresses
  - Node types
  - Site-specific configuration
- Dynamic Information
  - CPU utilization
  - Disk utilization
  - Which nodes are online

Cluster Database



Node Info Stored In A MySQL Database

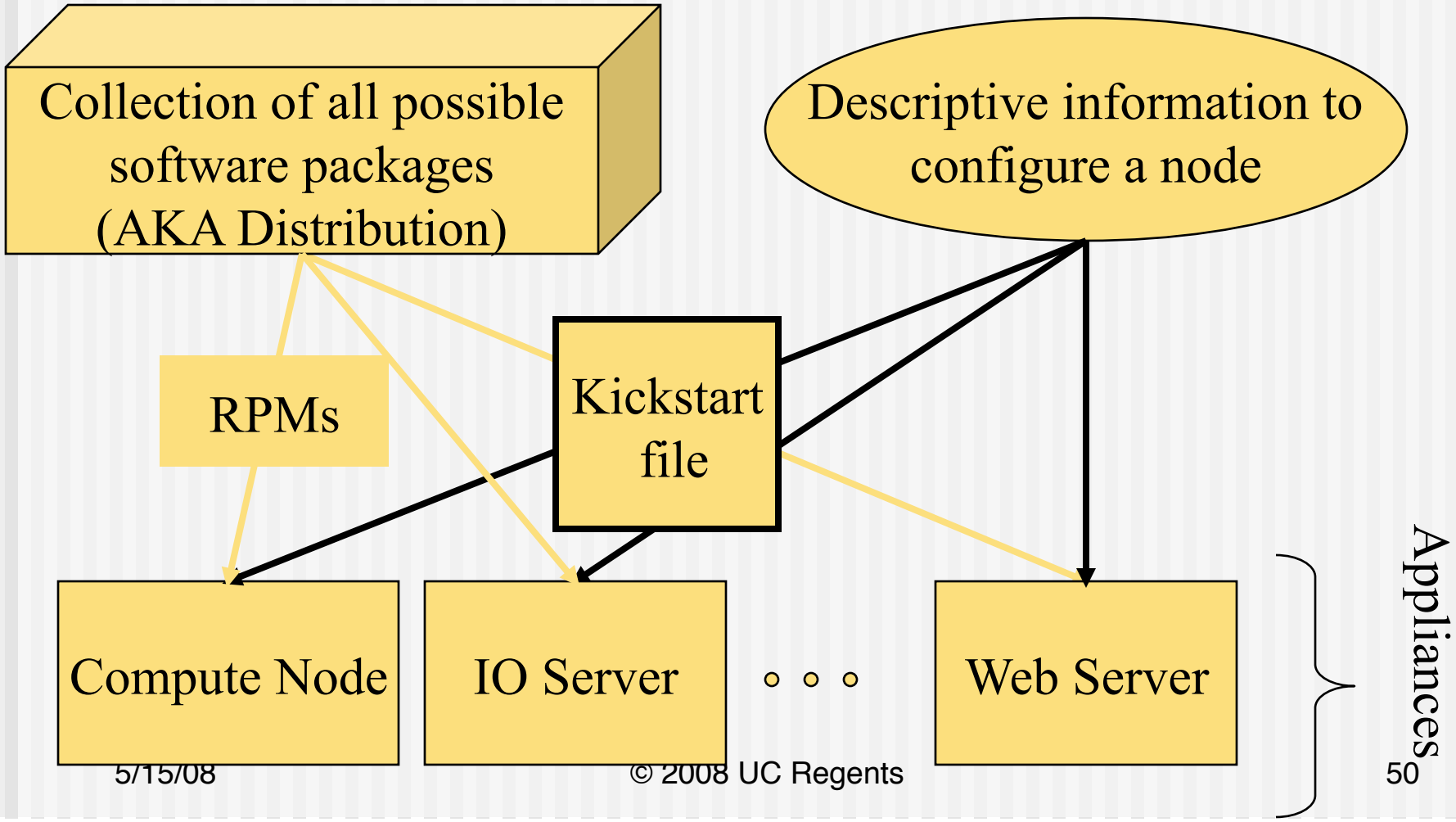
- If you know SQL, you can execute powerful commands
  - Rocks-supplied command line utilities are tied into the database



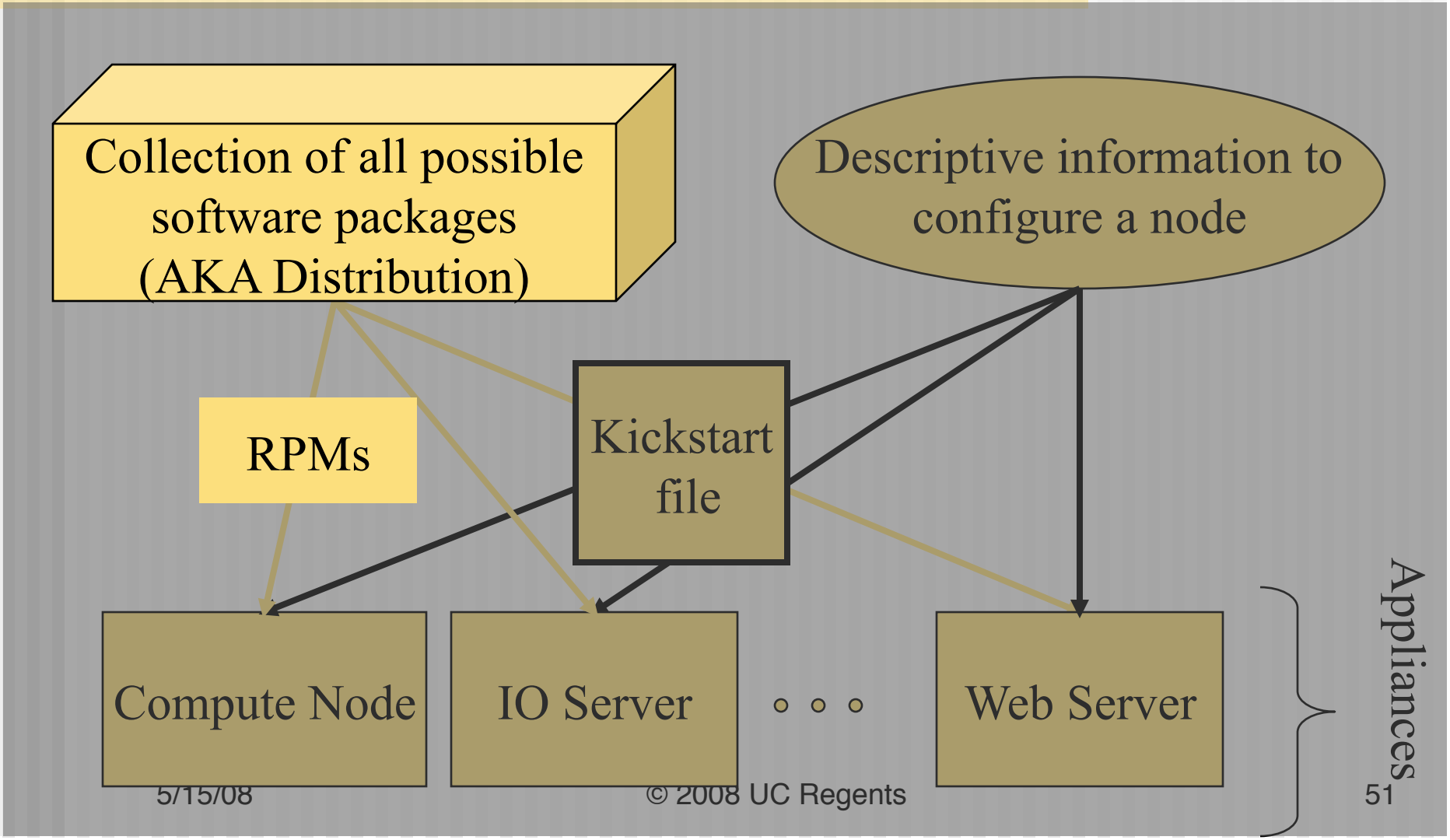
  - E.g., get the hostname for the bottom 8 nodes of each cabinet:

```
# cluster-fork --query="select name from nodes where rank<8" hostname
```

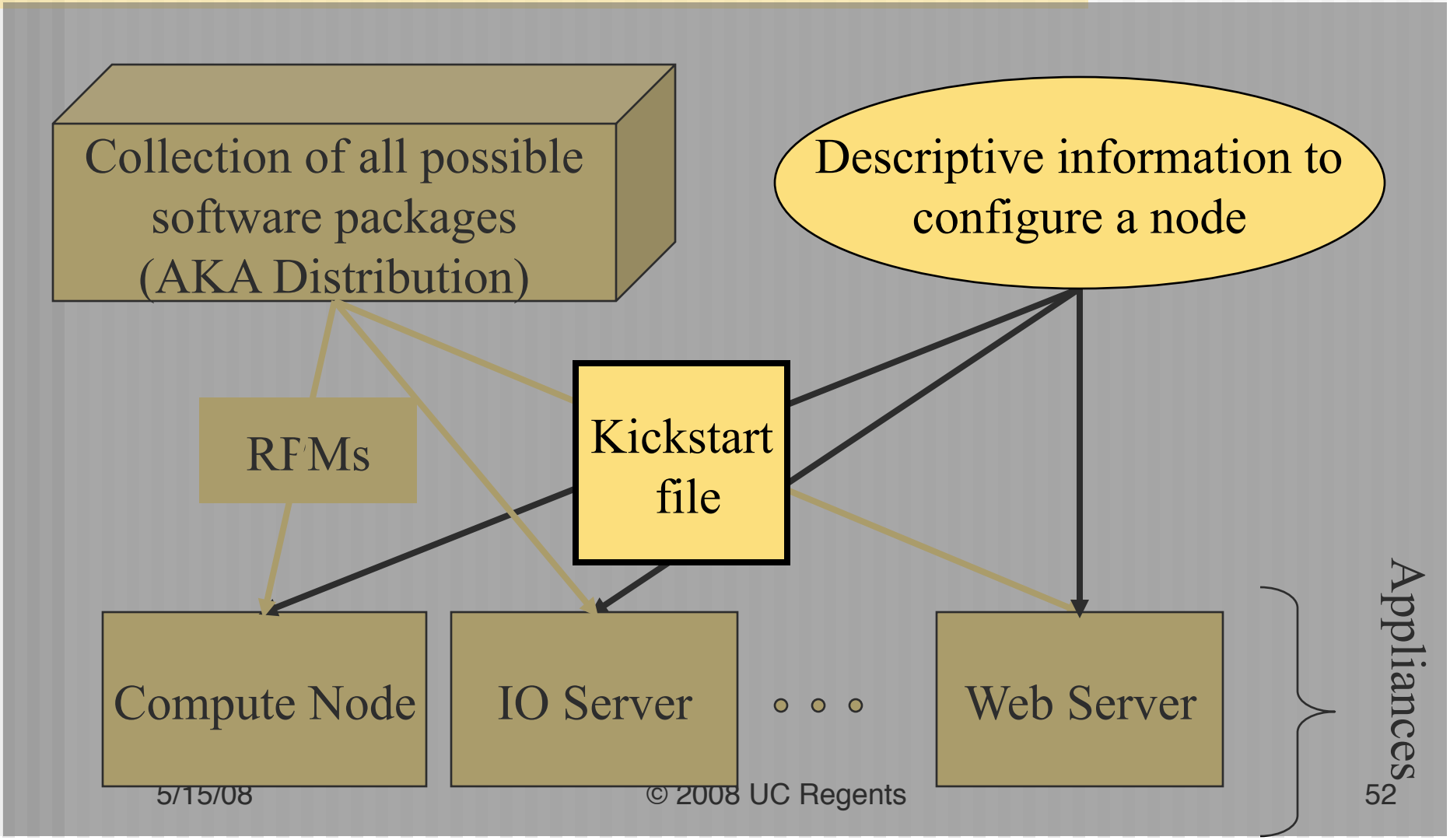
Software Installation



Software Repository



Installation Instructions



Cluster Software Management

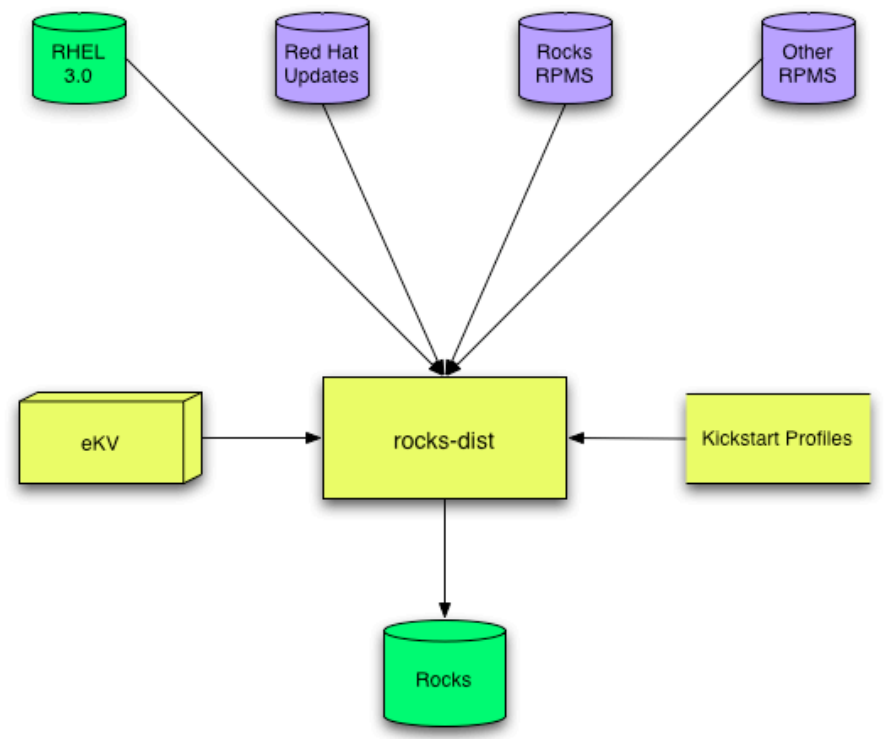
Software Packages

- RPMs
  - Standard Red Hat (desktop) packaged software
  - Or your own addons
- Rocks-dist
  - Manages the RPM repository
  - This is the distribution

Software Configuration

- Tuning RPMs
  - For clusters
  - For your site
  - Other customization
- XML Kickstart
  - Programmatic System Building
  - Scalable

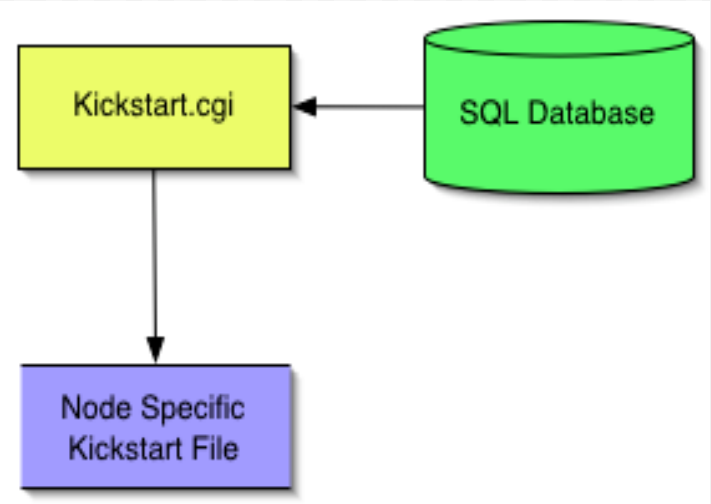
Building a Rocks Distribution



- Start with Red Hat
- Add updates, Rocks (and optional other) software
- Add Kickstart profiles
- Modify Red Hat installation boot image
- Resulting in a Red Hat compatible Rocks distribution

Kickstart

- Red Hat's Kickstart
  - Monolithic flat ASCII file
  - No macro language
  - Requires forking based on site information and node type.
- Rocks XML Kickstart
  - Decompose a kickstart file into nodes and a graph
    - Graph specifies OO framework
    - Each node specifies a service and its configuration
  - Macros and SQL for site configuration
  - Driven from web cgi script



Kickstart File Sections

- Main
  - Disk partitioning
  - Root password
  - RPM repository URL
  - …
- Packages
  - List of RPMs (w/o version numbers)
  - The repository determines the RPM versions
  - The kickstart file determines the set of RPMs
- Pre
  - Shell scripts run before RPMs are installed
  - Rarely used (Rocks uses it to enhance kickstart)
- Post
  - Shell scripts to cleanup RPM installation
  - Fixes bugs in packages
  - Adds local information

What is a Kickstart File?

- Setup & Packages (20%)

```
cdrom
zerombr yes
bootloader --location mbr --useLilo
skipx
auth --useshadow --enablemd5
clearpart --all
part /boot --size 128
part swap --size 128
part / --size 4096
part /export --size 1 --grow
lang en_US
langsupport --default en_US
keyboard us
mouse genericps/2
timezone --utc GMT
rootpw --iscrypted nrDq4Vb42jjQ.
text
install
reboot

%packages
@Base
@Emacs
@GNOME
```

- Post Configuration (80%)

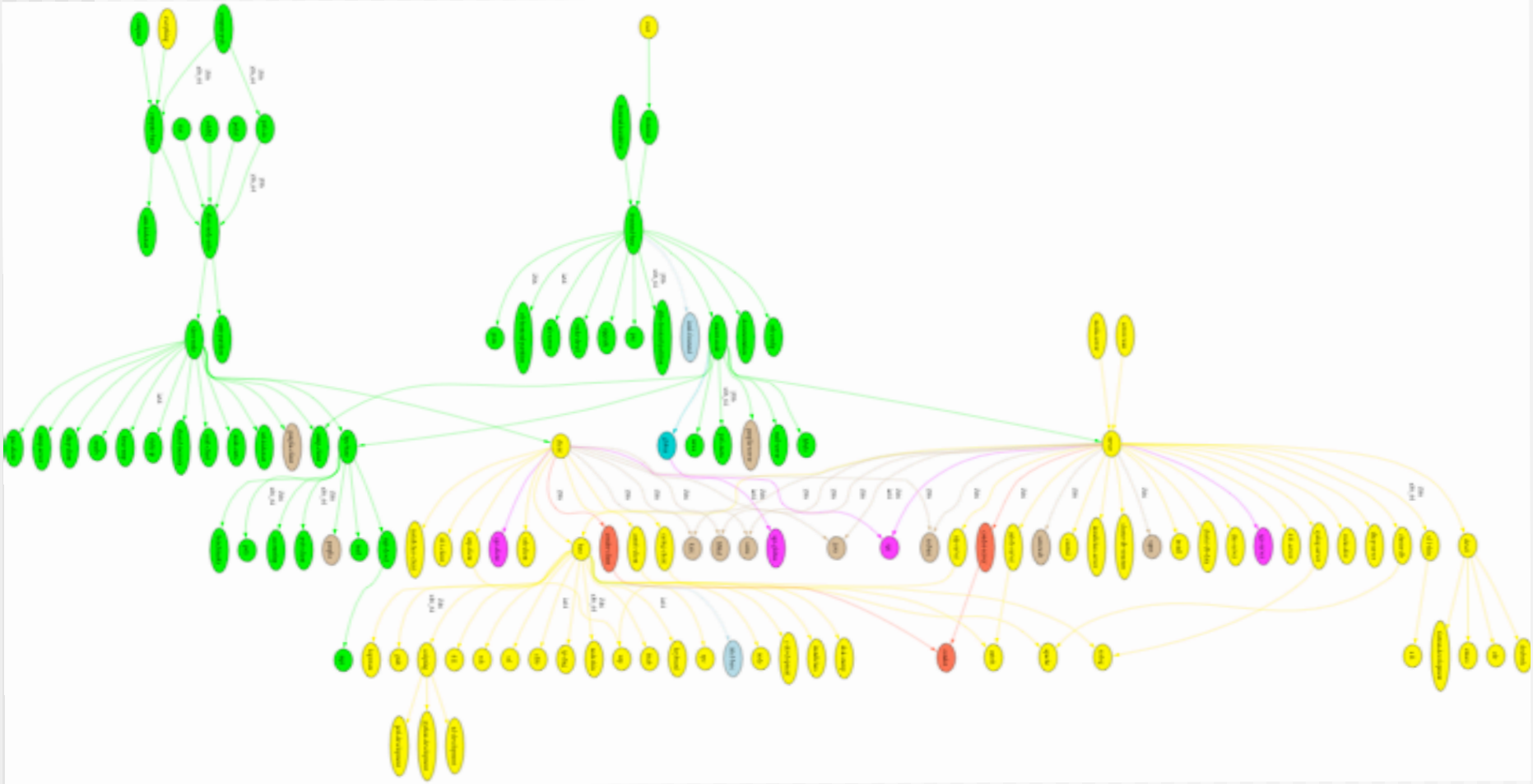
```
%post

cat > /etc/nsswitch.conf << 'EOF'
passwd:     files
shadow:     files
group:      files
hosts:      files dns
bootparams: files
ethers:     files
EOF

cat > /etc/ntp.conf << 'EOF'
server ntp.ucsd.edu
server         127.127.1.1
fudge          127.127.1.1 stratum 10
authenticate no
driftfile /etc/ntp/drift
EOF

/bin/mkdir -p /etc/ntp
cat > /etc/ntp/step-tickers << 'EOF'
ntp.ucsd.edu
EOF

/usr/sbin/ntpdate ntp.ucsd.edu
/sbin/hwclock --systohc
```

Issues

- High level description of software installation
  - List of packages (RPMs)
  - System configuration (network, disk, accounts, …)
  - Post installation scripts
- *De facto* standard for Linux
- Single ASCII file
  - Simple, clean, and portable
  - Installer can handle simple hardware differences
- Monolithic
  - No macro language
  - Differences require forking (and code replication)
  - Cut-and-Paste is not a code re-use model

XML KICKSTART

It looks something like this

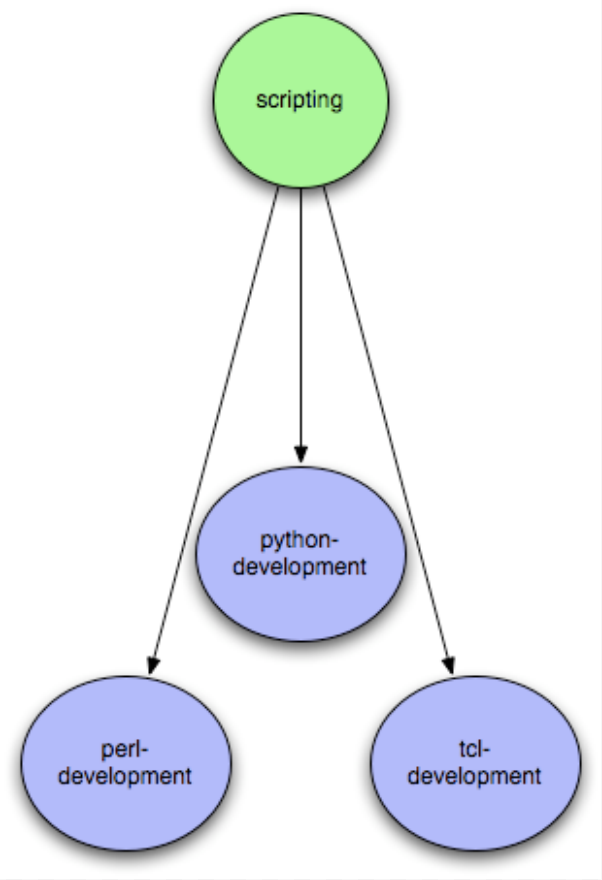


Implementation

- Nodes
  - Single purpose modules
  - Kickstart file snippets (XML tags map to kickstart commands)
  - Approximately 200 node files in Rocks
- Graph
  - Defines interconnections for nodes
  - Think OOP or dependencies (class, #include)
  - A single default graph file in Rocks
- Macros
  - SQL Database holds site and node specific state
  - Node files may contain <var name="state"/> tags

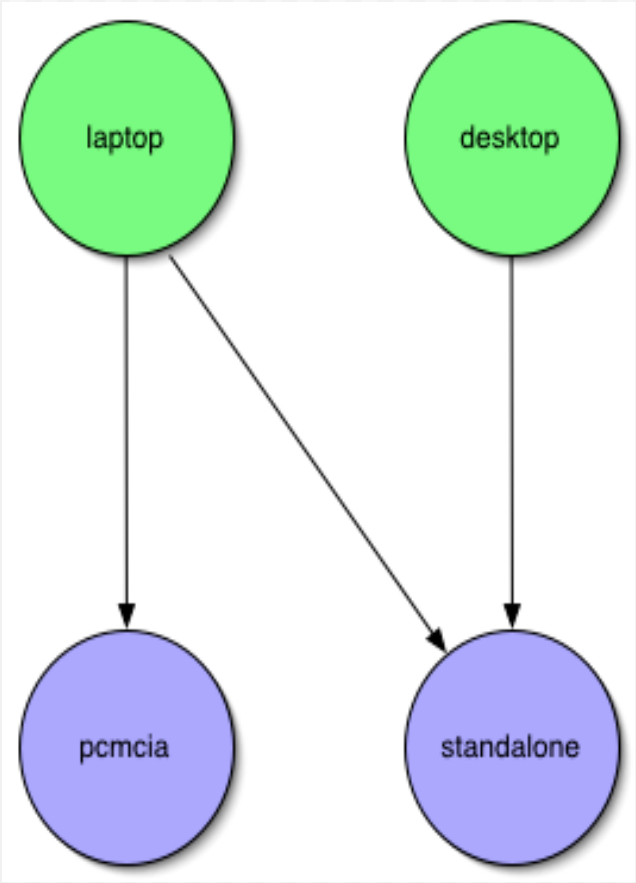
Composition

- Aggregate Functionality
- Scripting
  - IsA perl-development
  - IsA python-development
  - IsA tcl-development



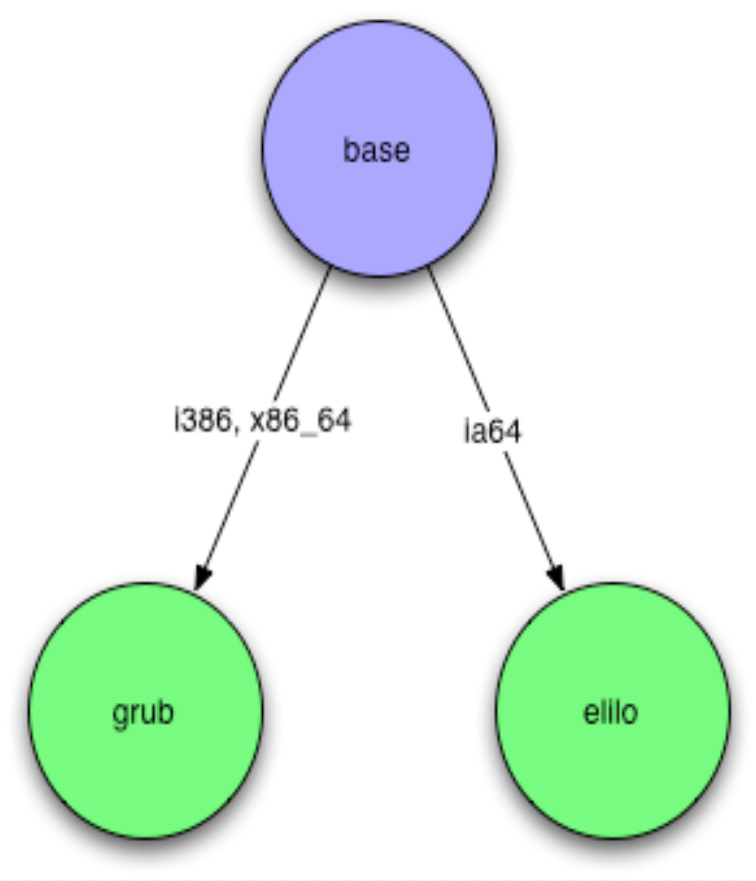
Appliances

- Laptop / Desktop
  - Appliances
  - Final classes
  - Node types
- Desktop IsA
  - standalone
- Laptop IsA
  - standalone
  - Pcmcia
- Specify only the differences

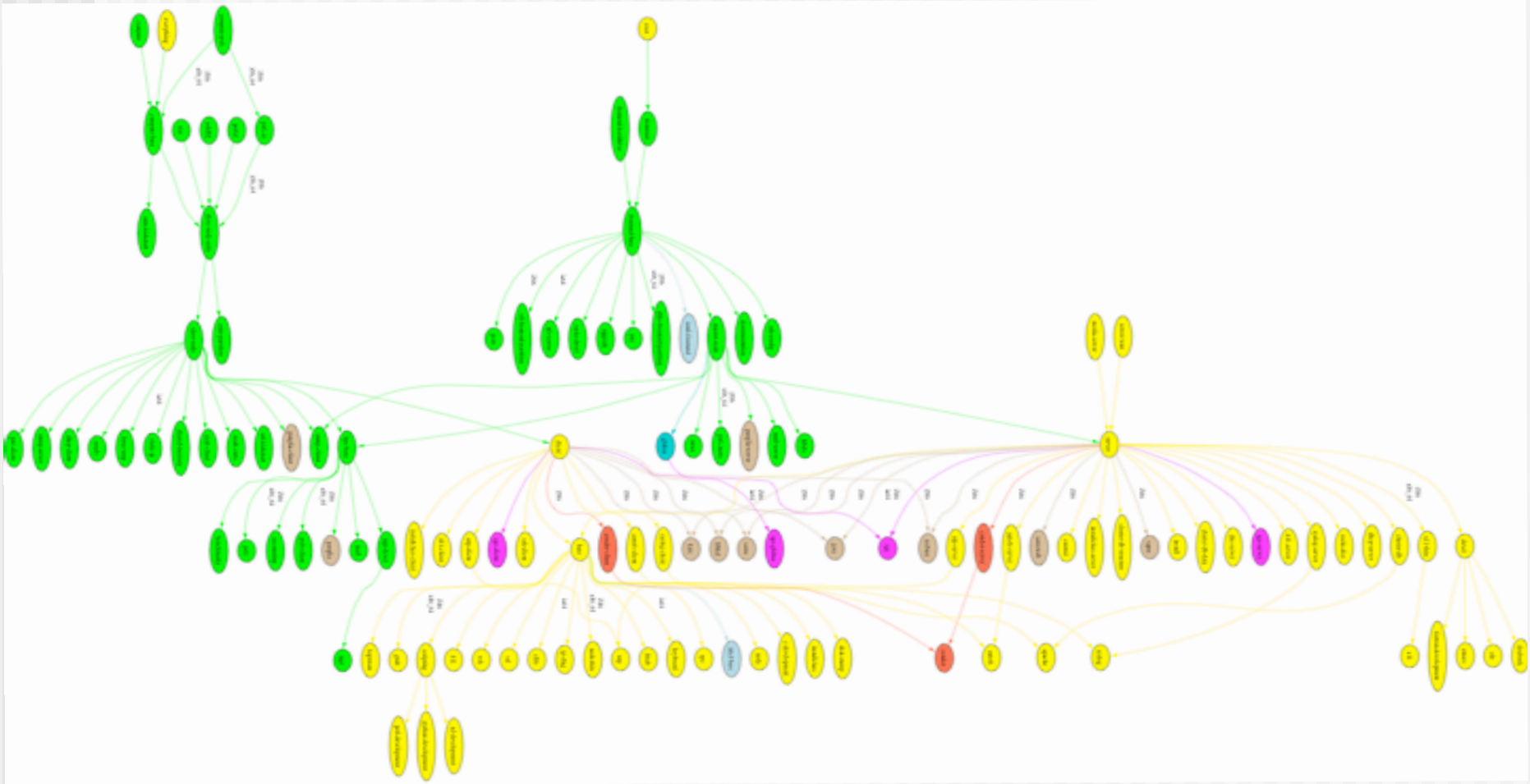


Architecture Differences

- Conditional inheritance
- Annotate edges with target architectures
- if i386
  - Base IsA grub
- if ia64
  - Base IsA elilo
- One Graph, Many CPU Architectures
  - Heterogeneity becomes easy
  - Not true for SSI or Imaging



Putting in all together



Sample Node File

```
<?xml version="1.0" standalone="no"?>
<!DOCTYPE kickstart SYSTEM "@KICKSTART_DTD@" [<!ENTITY ssh "openssh">]>
<kickstart>
            <description>
            Enable SSH
            </description>

            <package>&ssh;</package>
            <package>&ssh;-clients</package>
            <package>&ssh;-server</package>
            <package>&ssh;-askpass</package>
<post>

cat &gt; /etc/ssh/ssh_config &lt;&lt; 'EOF' <!-- default client setup -->
Host *
        ForwardX11 yes
        ForwardAgent yes
EOF

chmod o+rx /root
mkdir /root/.ssh
chmod o+rx /root/.ssh

</post>
</kickstart>>
```

Sample Graph File

```
<?xml version="1.0" standalone="no"?>

<graph>
            <description>
            Default Graph for NPACI Rocks.
            </description>

            <edge from="base" to="scripting"/>
            <edge from="base" to="ssh"/>
            <edge from="base" to="ssl"/>
            <edge from="base" to=”grub"  arch="i386"/>
            <edge from="base" to="elilo" arch="ia64"/>
                        …
            <edge from="node" to="base"/>
            <edge from="node" to="accounting"/>
            <edge from="slave-node" to="node"/>
            <edge from="slave-node" to="nis-client"/>
            <edge from="slave-node" to="autofs-client"/>
            <edge from="slave-node" to="dhcp-client"/>
            <edge from="slave-node" to="snmp-server"/>
            <edge from="slave-node" to="node-certs"/>
            <edge from="compute" to="slave-node"/>
            <edge from="compute" to="usher-server"/>
            <edge from="master-node" to="node"/>
            <edge from="master-node" to="x11"/>
            <edge from="master-node" to="usher-client"/>
</graph>
```

CLUSTER SQL DATABASE

Cluster State Management

- Static Information
  - Node addresses
  - Node types
  - Site-specific configuration
- Dynamic Information
  - CPU utilization
  - Disk utilization
  - Which nodes are online

Nodes and Groups

ID	MAC	Name	Membership	Hardware	Rack	Rank	IP	C
1		frontend-0	1	0	0	0	10.1.1.1	
2	00:30:c1:d8:59:00	network-1-0	6	0	1	0	10.255.255.254	
3	00:01:e7:1a:be:00	network-0-0	6	0	0	0	10.255.255.253	
4	00:30:c1:d8:ac:80	network-3-0	6					
5	00:50:8b:a5:4d:b1	nfs-0-0	12					
6	00:50:8b:c5:c3:72	nfs-0-1	12					
7	00:50:8b:a5:57:ff	nfs-1-0	12					
8	00:50:8b:a5:4c:f4	nfs-1-1	12					
9	00:50:8b:e0:3a:a7	compute-0-0	2					
10	00:50:8b:e0:44:5e	compute-0-1	2					
11	00:50:8b:e0:40:95	compute-0-2	2					
12	00:50:8b:e0:40:93	compute-0-3	2					
13	00:50:8b:e0:42:df	compute-0-4	2					

Nodes Table

ID	Name	Appliance	Distribution	Compute
1	Frontend	1	1	no
2	Compute	2	1	yes
3	PVFS I/O Node	3	1	no
4	Compute with PVFS	4	1	yes
5	Laptop	5	1	no
6	Ethernet Switches	6		no
7	Myrinet Switches	6		no
8	Power Units	7		no
9	Remote Management	8		no
10	DTF Compute	9	1	yes
11	Web Portal	10	1	no
12	NFS Server	11	1	no

Memberships Table

Groups and Appliances

ID	Name	Appliance	Distribution	Compute
1	Frontend	1	1	no
2	Compute	2	1	yes
3	PVFS I/O Node	3		no
4	Compute with PVFS	4		yes
5	Laptop	5		no
6	Ethernet Switches	6		no
7	Myrinet Switches	6		no
8	Power Units	7		no
9	Remote Management	8		no
10	DTF Compute	9		yes
11	Web Portal	10		no
12	NFS Server	11	1	no

Memberships Table

ID	Name	ShortName	Graph	Node
1	frontend	f	default	frontend
2	compute	c	default	compute
3	pvfs	pv	default	pvfs-io
4	comp-pvfs	cp	default	compute-pvfs
5	laptop		default	laptop
6	network	n		
7	power	p		
8	manager			
9	dtf	d	default	dtf-compute
10	portal	pl	default	portal
11	nfs	n	default	nfs

Appliances Table

Simple key - value pairs

ID	Membership	Service	Component	Value
1	0	Kickstart	PublicNTPHost	ntp.ucsd.edu
2	0	Kickstart	ZeroMBR	yes
3	0	Kickstart	PrivateKickstartCGI	kickstart.cgi
4	0	Kickstart	PublicNetmask	255.255.255.0
5	0	Kickstart	PublicNetwork	192.31.21.0
6	0	Kickstart	PrivateNISMaster	frontend-0
7	0	Kickstart	PrivateHostname	frontend-0
8	0	Kickstart	PrivateIPForwarding	yes
9	0	Kickstart	PrivateGateway	10.1.1.1
10	0	Kickstart	PublicKickstartBasedir	install
11	0	Kickstart	Lang	en_US

- Used to configure DHCP and to customize appliance kickstart files

Nodes XML Tools: <var>

- Get Variables from Database
  - `<var name="Kickstart_PrivateGateway"/>`
  - `<var name="Node_Hostname"/>`

```
10.1.1.1
compute-0-0
```

  - Can grab any value from the *app_globals* database table

Nodes XML Tools: <eval>

- Do processing on the frontend:
  - **<eval shell="bash">**
- To insert a fortune in the kickstart file:

```
<eval shell="bash">
/usr/games/fortune
</eval>
```

"Been through Hell? Whaddya bring back for me?"
-- A. Brilliant

Nodes XML Tools <file>

- Create a file on the system:

```
<file name="/etc/hi-mom" mode="append">
    How are you today?
</file>
```

- Used extensively throughout Rocks post sections
  - Keeps track of alterations automatically via RCS.

```
<file name="/etc/hi" perms="444">
How are you today?
I am fine.
</file>
```

```
…RCS checkin commands...
cat > /etc/hi << 'EOF'
How are you today?
I am fine.
EOF
chmod 444 /etc/hi-mom
…RCS cleanup commands…
```

Fancy <file>: nested tags

```
<file name="/etc/hi">

Here is your fortune for today:
<eval>
date +"%d-%b-%Y"
echo ""
/usr/games/fortune
</eval>

</file>
```

…RCS checkin commands...
cat > /etc/hi << 'EOF'

Here is your fortune for today:
13-May-2005

"Been through Hell? Whaddya bring back for me?"
-- A. Brilliant

EOF
…RCS cleanup commands…

Nodes Main

- Used to specify basic configuration:
  - timezone
  - mouse, keyboard types
  - install language
- Used more rarely than other tags
- Rocks main tags are usually a straight translation:

```
<main>

  <timezone>America/Mission_Beach
  </timezone>

</main>
```

```
…
timezone America/Mission_Beach
…
rootpw --iscrypted sndk48shdlwis
mouse genericps/2
url --url http://10.1.1.1/install/rocks-dist/..
```

Nodes Packages

- **`<package>java</package>`**
  - Specifies an RPM package. Version is automatically determined: take the *newest* rpm on the system with the name 'java'.
- **`<package arch="x86_64">java</package>`**
  - Only install this package on x86_64 architectures
- **`<package arch="i386,x86_64">java</package>`**

```
<package>newcastle</package>
<package>stone-pale</package>
<package>guinness</package>
```

```
%packages
newcastle
stone-pale
guinness
```

Nodes Packages

- RPM name is a basename (not fullname of RPM)
  - For example, RPM name of package below is ‘kernel’

```
# rpm -qip /home/install/rocks-dist/lan/i386/RedHat/RPMS/kernel-2.6.9-22.EL.i686.rpm
Name        : kernel                       Relocations: (not relocatable)
Version     : 2.6.9                           Vendor: CentOS
Release     : 22.EL                        Build Date: Sun 09 Oct 2005 03:01:51 AM WET
Install Date: (not installed)              Build Host: louisa.home.local
Group       : System Environment/Kernel    Source RPM: kernel-2.6.9-22.EL.src.rpm
Size        : 25589794                        License: GPLv2
Signature   : DSA/SHA1, Sun 09 Oct 2005 10:44:40 AM WET, Key ID a53d0bab443e1821
Packager    : Johnny Hughes <johnny@centos.org>
Summary     : the linux kernel (the core of the linux operating system)
Description :
The kernel package contains the Linux kernel (vmlinuz), the core of any
Linux operating system
```

Nodes Post

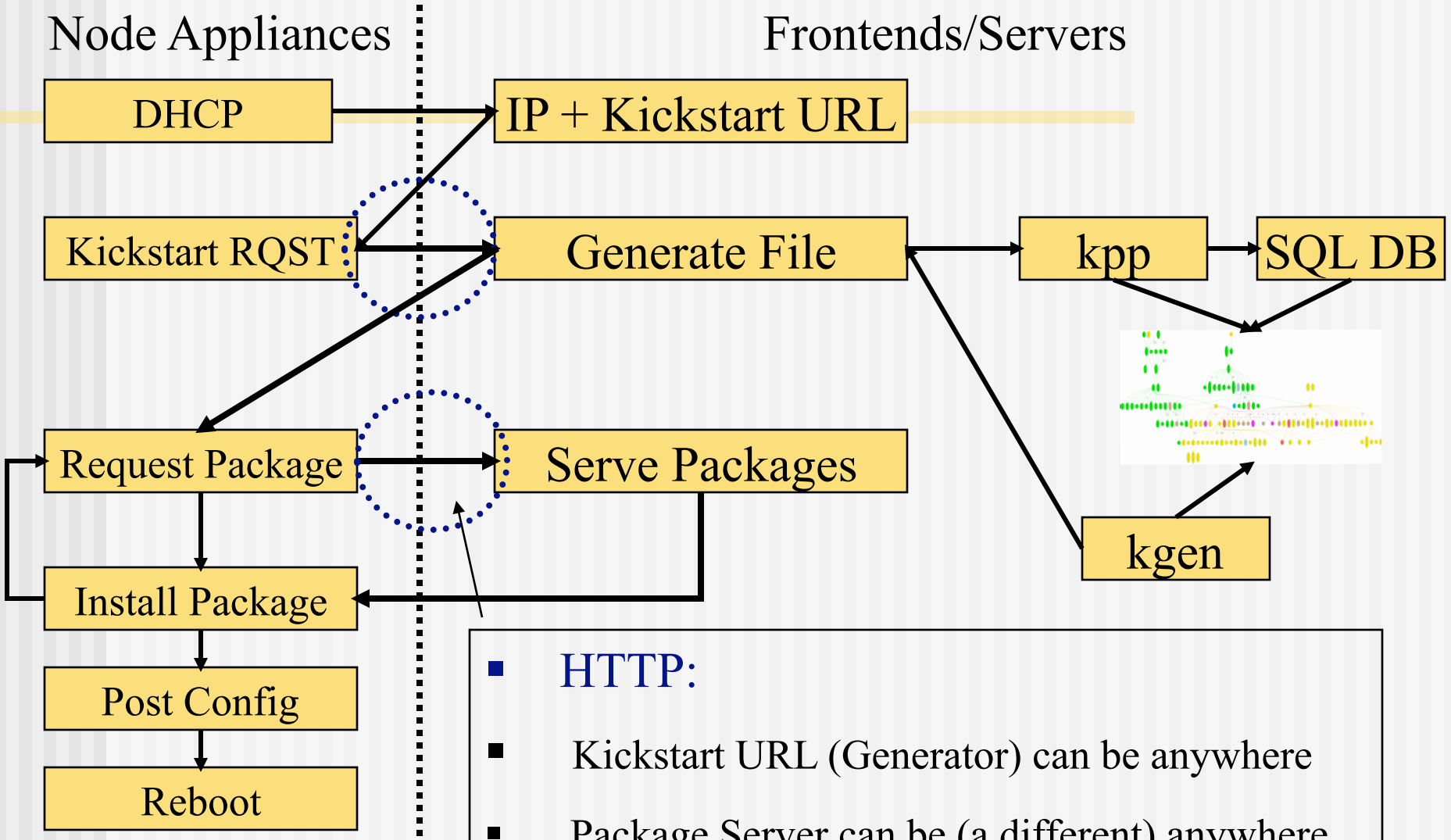
ntp-client.xml

```
<post>

/bin/mkdir -p /etc/ntp
/usr/sbin/ntpdate <var name="Kickstart_PrivateNTPHost"/>
/sbin/hwclock --systohc

</post>
```

```
%post

/bin/mkdir -p /etc/ntp
/usr/sbin/ntpdate 10.1.1.1
/sbin/hwclock --systohc
```

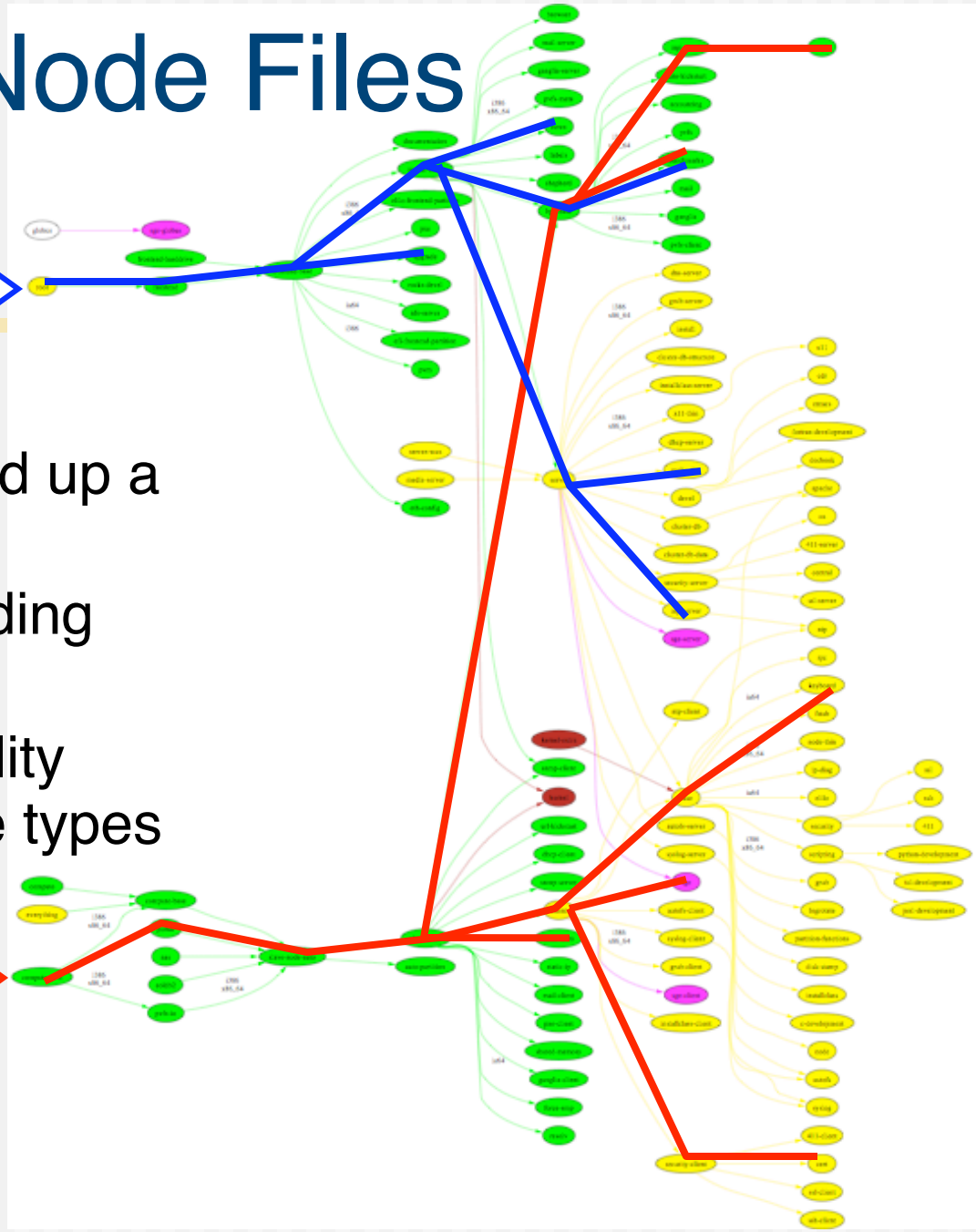
PUTTING IT TOGETHER

Space-Time and HTTP



- HTTP:
- Kickstart URL (Generator) can be anywhere
- Package Server can be (a different) anywhere

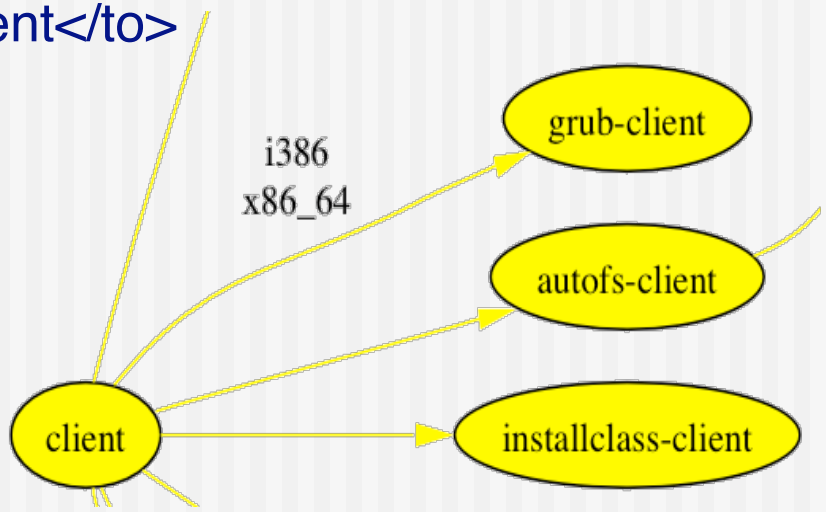
Gathering Node Files



- Traverse a graph to build up a kickstart file
- Makes kickstart file building flexible
- Easy to share functionality between disparate node types

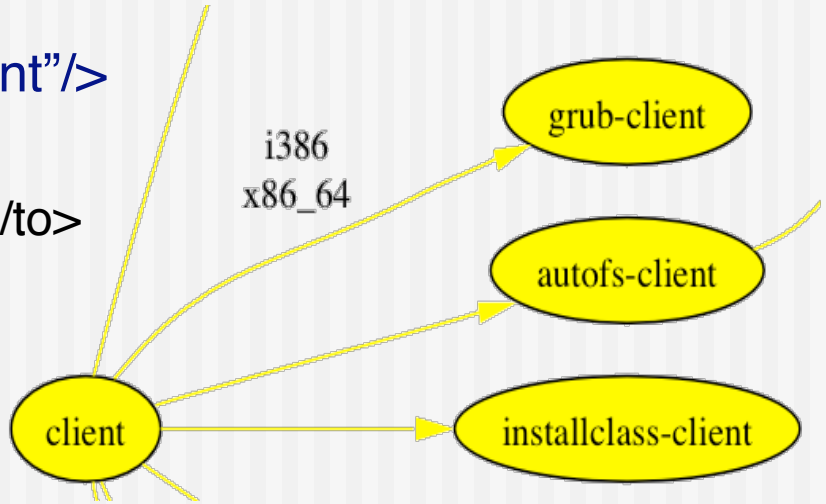
Another Look at XML

```
<graph>

    <edge from="client">
        <to arch="i386,x86_64">grub-client</to>
        <to>autofs-client</to>
        <to>installclass-client</to>
    </edge>

</graph>
```



Partial Ordering

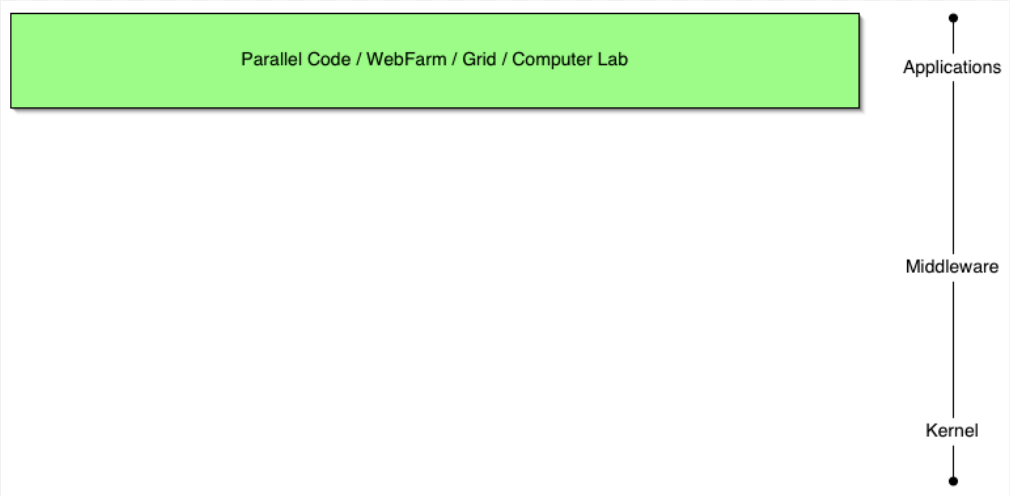
```
<graph>
    <order head="autofs-client" tail="client"/>
    <edge from="client">
        <to arch="i386,x86_64">grub-client</to>
        <to>autofs-client</to>
        <to>installclass-client</to>
    </edge>

</graph>
```



- Forces autofs-client <post> section to run before client's <post> section
- In order graph traversal enforces a partial ordering
- Applying standard graph theory to system installation

Application Layer

- Rocks Rolls
  - Optional component
  - Created by SDSC
  - Created by others
- Example
  - Bio (BLAST)
  - Chem (GAMESS)
  - Visualization Clusters

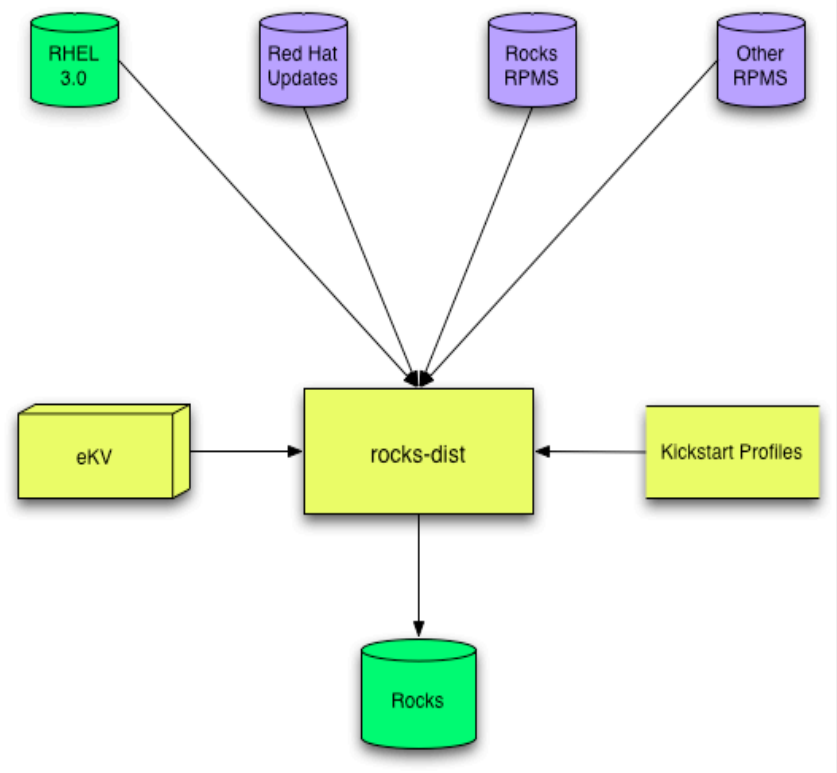


Inheritance and Rolls

BUILDING ON TOP OF ROCKS

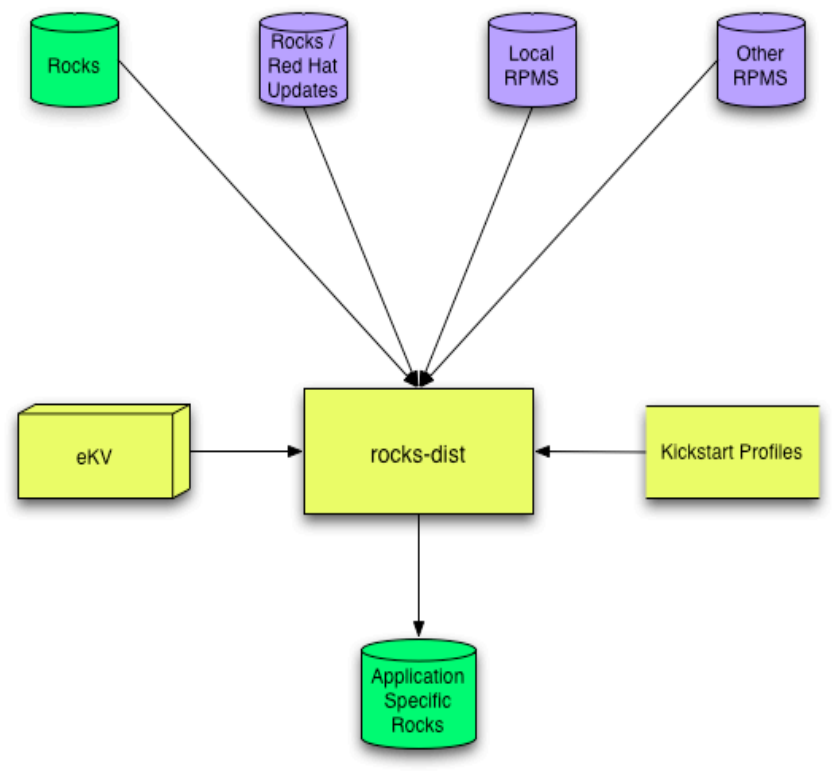
How Rocks is Built

- Rocks-dist
  - Merges all RPMs
    - Red Hat
    - Rocks
  - Resolves versions
  - Creates Rocks
- Rocks distribution
  - Looks just like Red Hat
  - Cluster optimized Red Hat



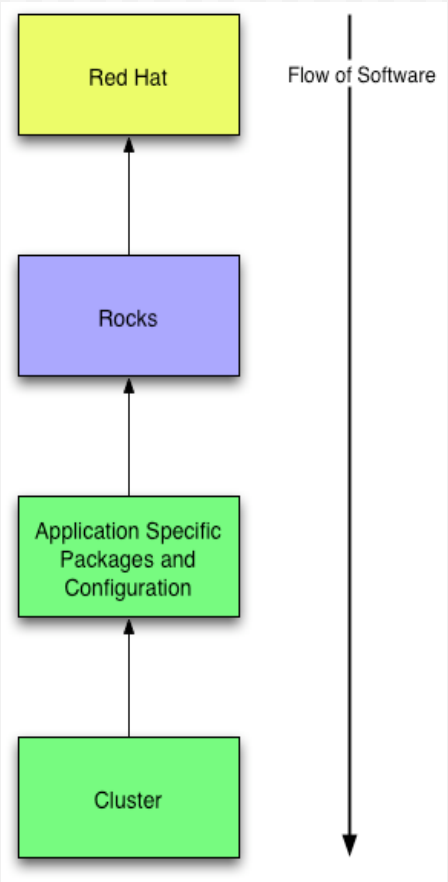
How You Create Your Own Rocks

- Rocks-dist
  - Merges all RPMs
    - Rocks
    - Yours
  - Resolves versions
  - Creates Rocks++
- Your distribution
  - Looks just like Rocks
  - Application optimized Rocks



Extension Through Inheritance

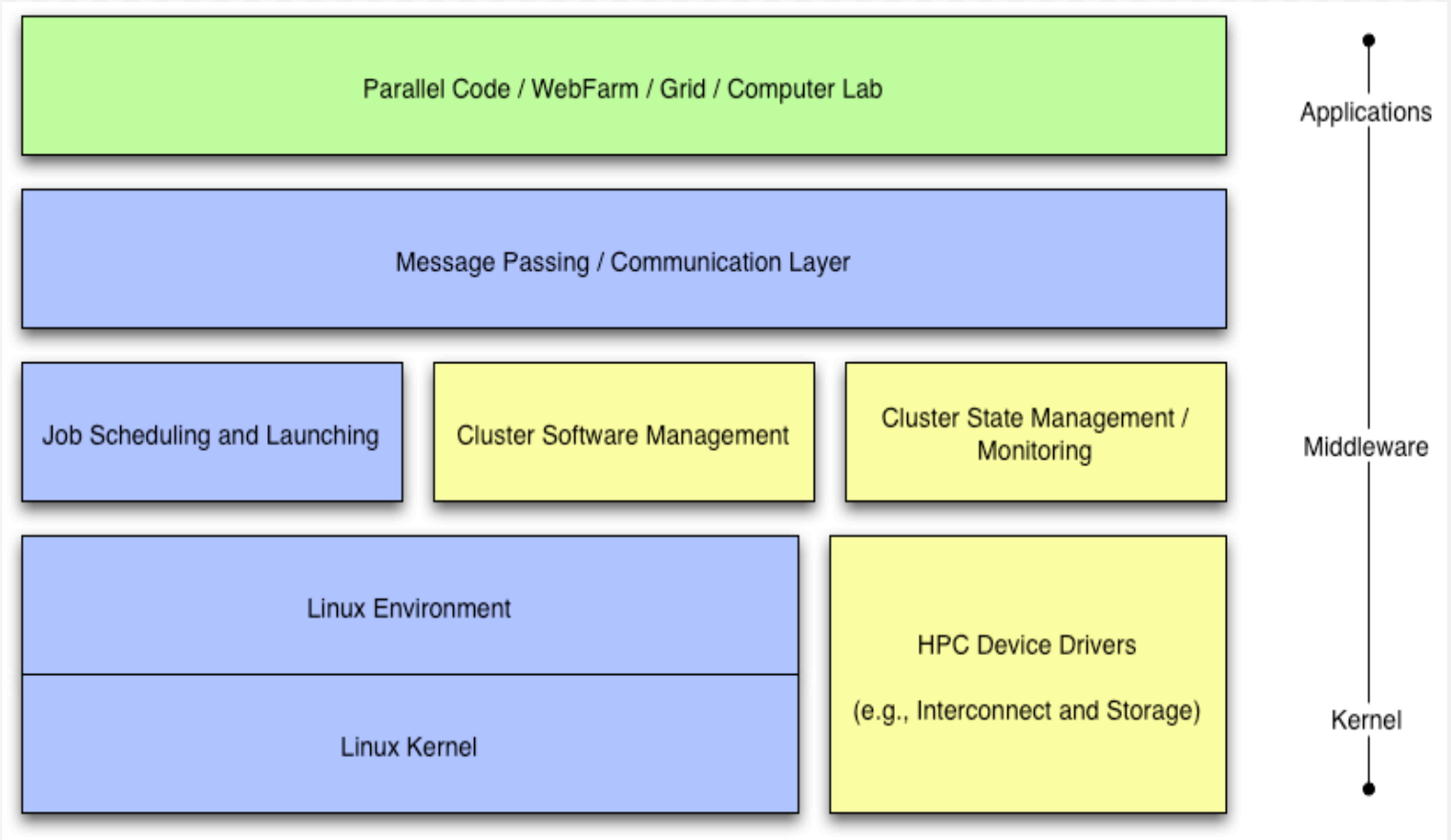
- UCSD/SDSC Rocks
  - BIRN
  - GAMESS Portal
  - GEON
  - GriPhyN
  - Camera
  - Optiputer
- Commercial
  - Scalable Systems
  - Platform Computing
- Can also override existing functionality
  - Rocks without NFS?
  - Rocks for the desktop?



Need Better Flexibility in Stack

- Issues
  - Static Stack
    - Cannot redefine
    - Cannot extend
  - Monolithic Stack
    - Cannot “opt out”
    - All or nothing solution
    - E.g. PBS not SGE
- What we need
  - Dynamic Stack
  - Component Based Stack
  - User / Developer Extensible

Rolls Break Apart Rocks



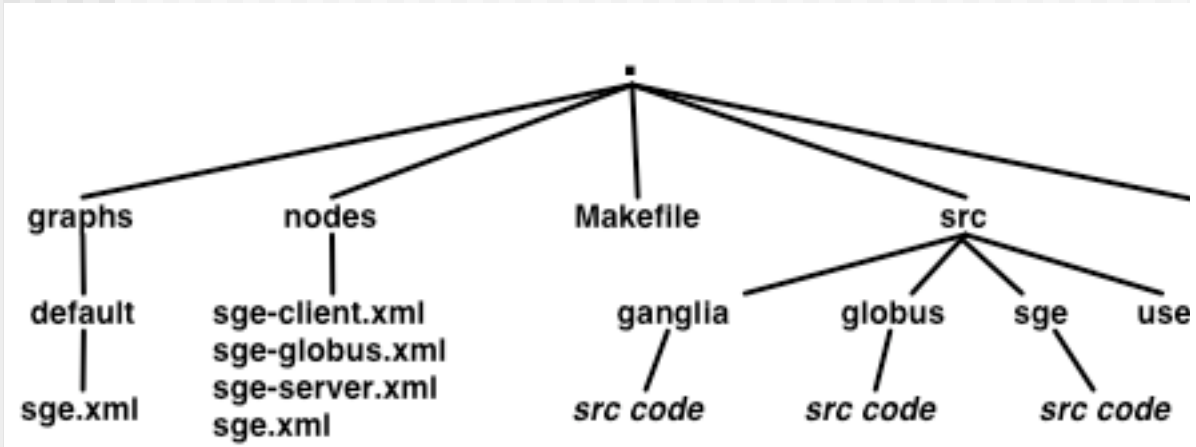
Rolls: Modifying a Standard System Installer to Support User-Customizable Cluster Frontend Appliances. Greg Bruno, Mason J. Katz, Federico D. Sacerdoti, and Phil M. Papadopoulos. *IEEE International Conference on Cluster Computing*, San Diego, California, Sep. 2004.

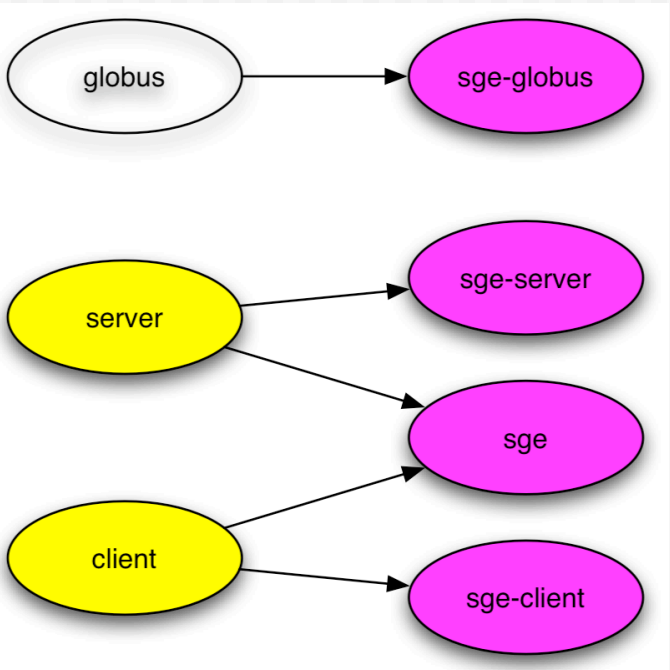
Rocks is What You Make it

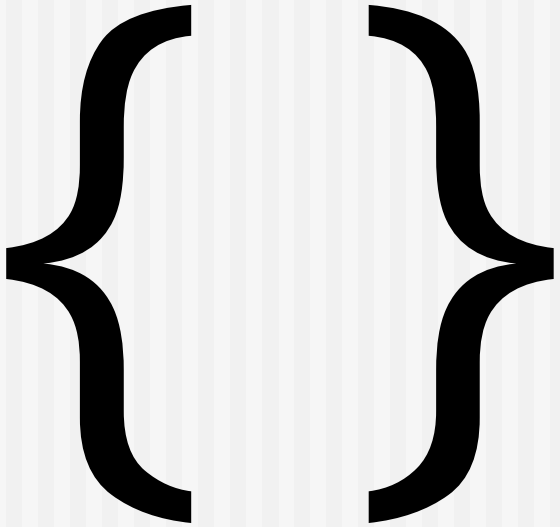
- Motivation
  - "I'm concerned Rocks is becoming everything for everyone" - rocks mailing list
  - "Building a cluster should be like ordering a car. I want the sports package, but not the leather seats, …" - z4 owning rocks developer
  - We need to let go of Rocks but hold onto the core
    - Recruit more external open-source developers
    - Only trust ourselves with fundamental architecture and implementation
  - We wanted to move the SGE but need to still support PBS
- Rolls
  - Optional configuration and software
  - Just another CD for installed (think application pack)
  - SGE and PBS are different Rolls
    - User chooses scheduler
    - PBS Roll supported by Norway
    - SGE Roll supported by Singapore (and us)
  - Rolls give us more flexibility and less work
- Rocks is done
  - The core is basically stable and needs continued support
  - Rolls allow us to develop new ideas
  - Application Domain specific
- IEEE Cluster 2004 - "Rolls: Modifying a Standard System Installer to Support User-Customizable Cluster Frontend Appliances"

Rolls are sub-graphs

- A graph makes it easy to ‘splice’ in new nodes
- Each Roll contains its own nodes and splices them into the system graph file

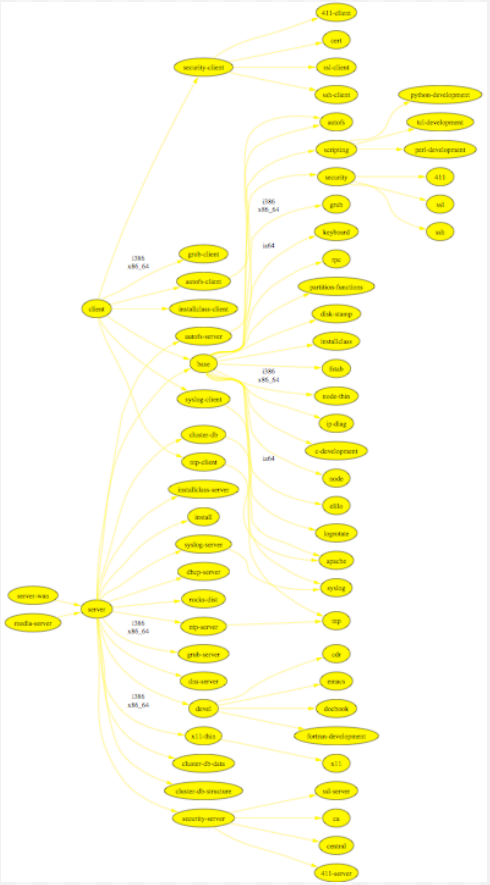




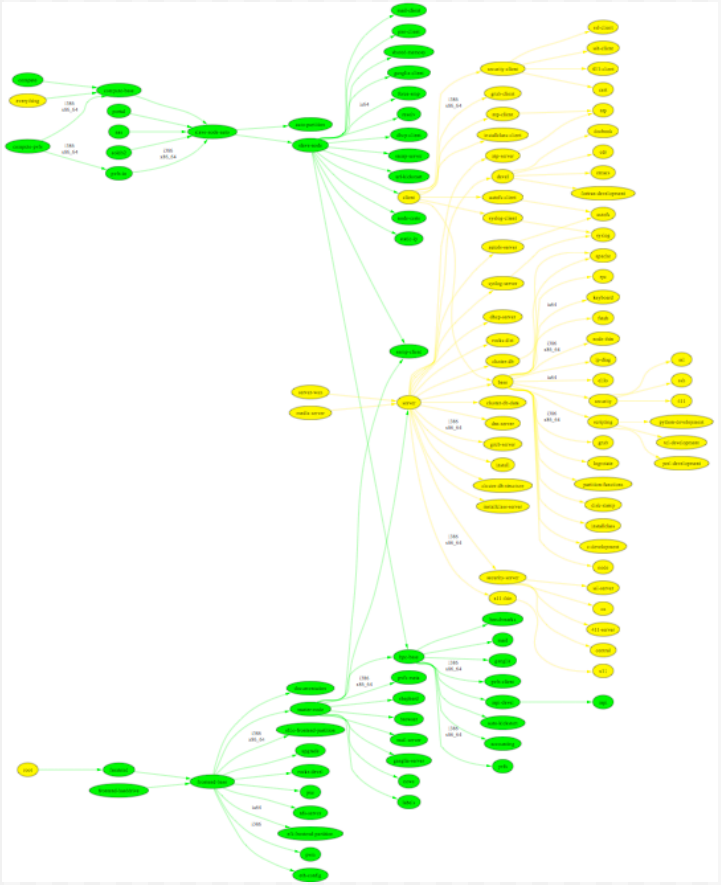


STARTING FROM THE EMPTY SET

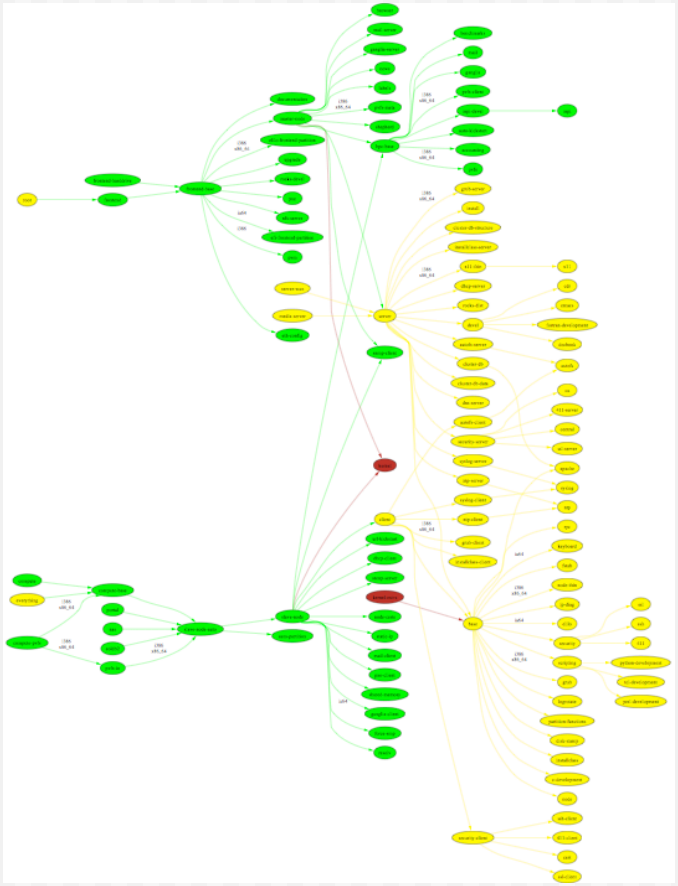
{ base }



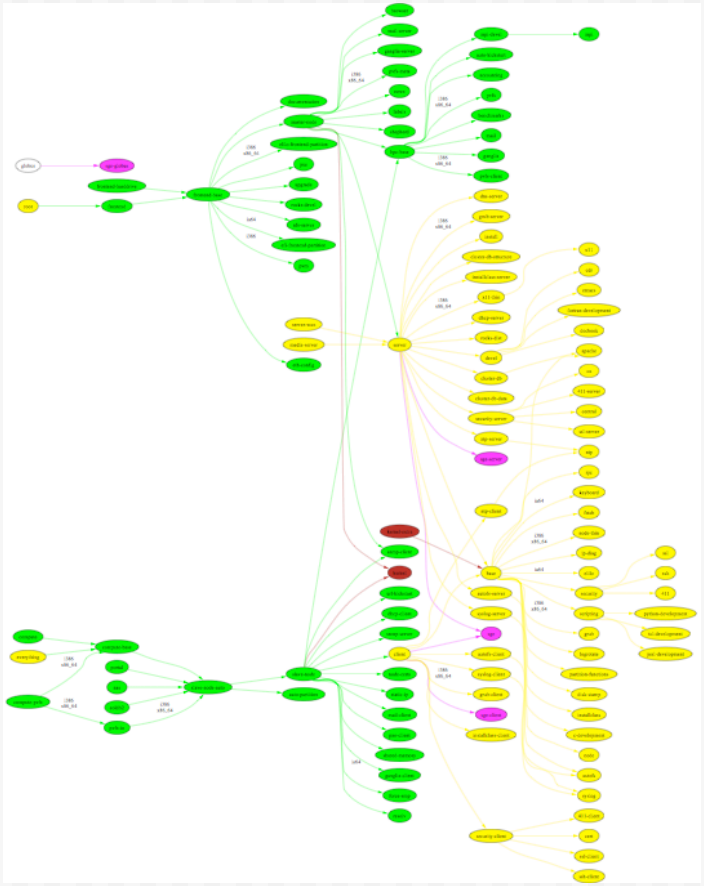
{ base, hpc }



{ base, hpc, kernel }

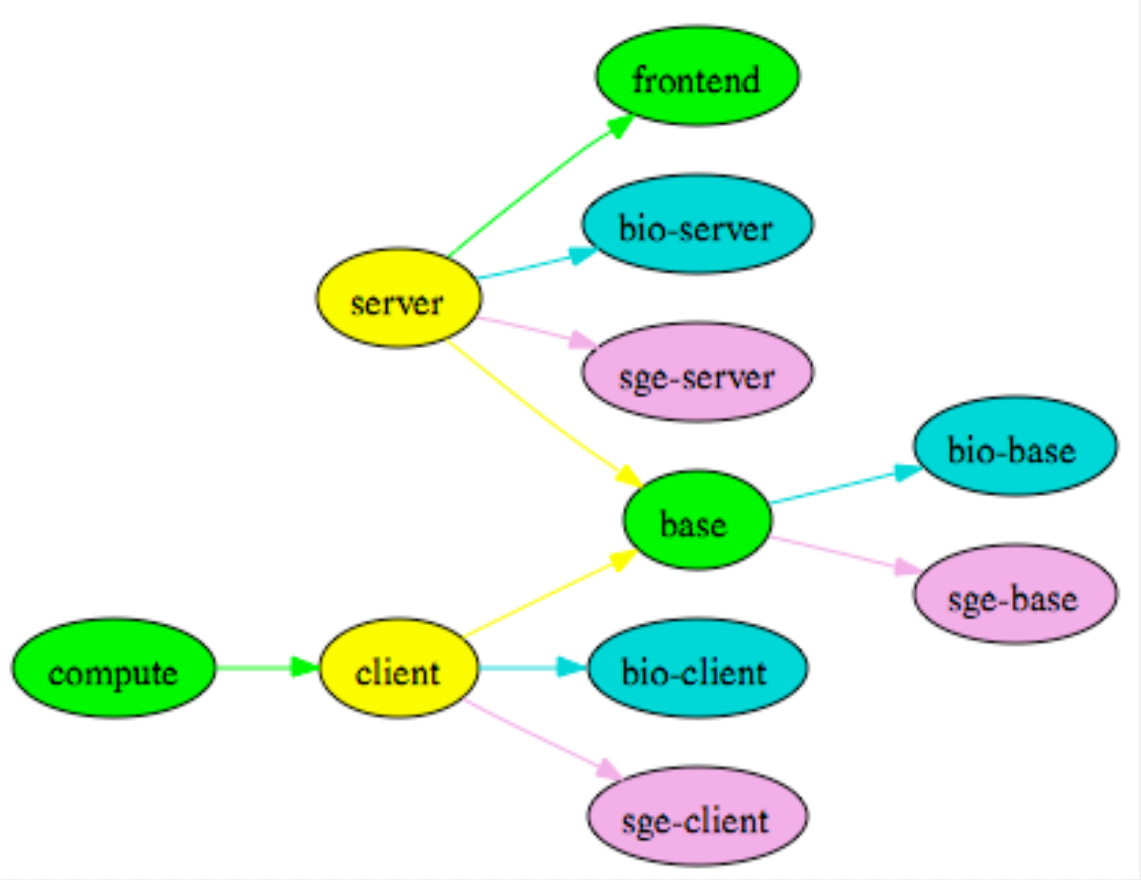


{ base, hpc, kernel, sge }



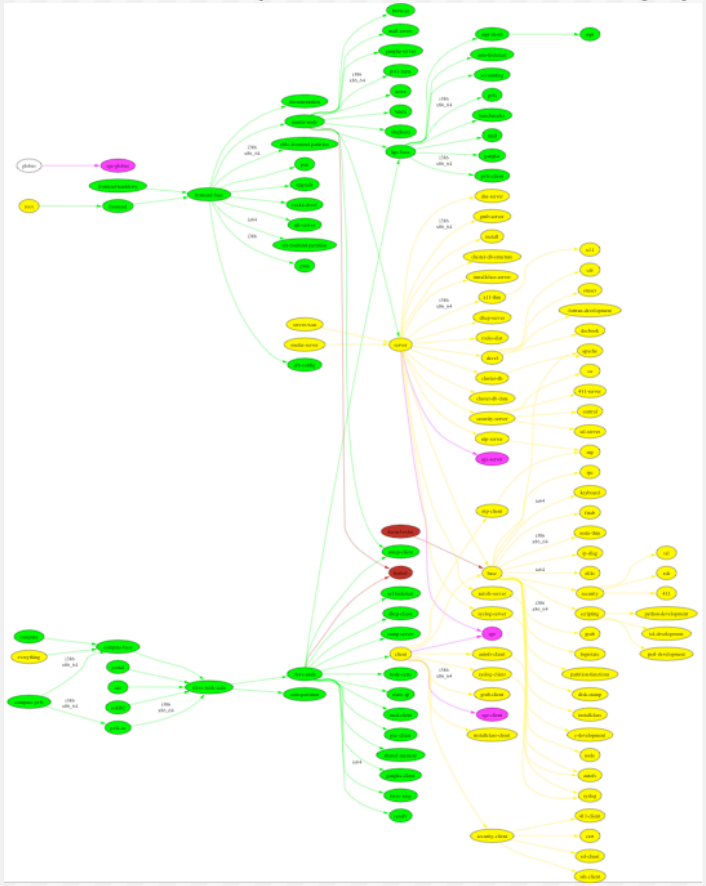
Simplified Example

{base, hpc, sge, bio}

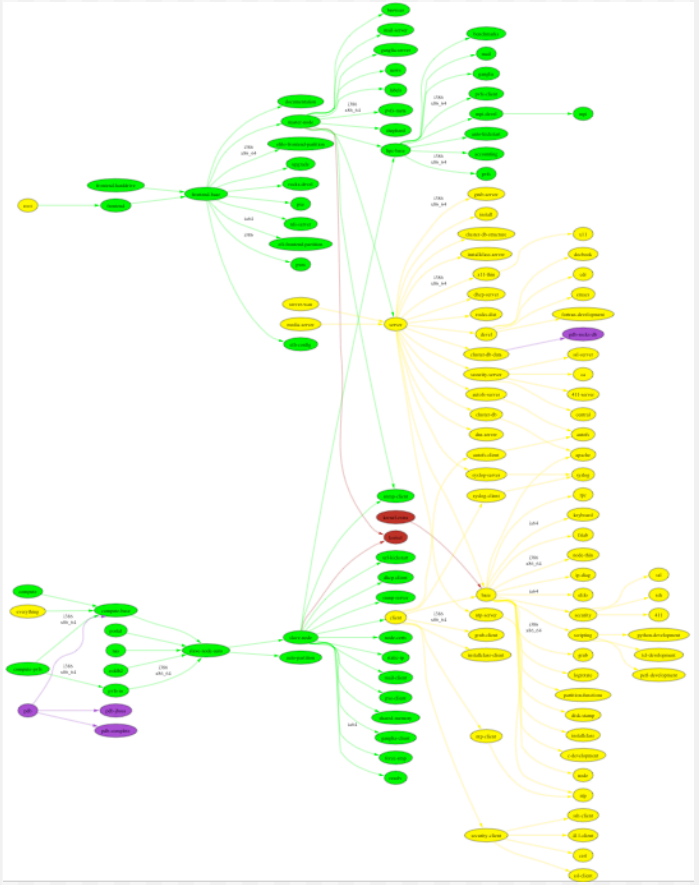


Two different Clusters

MPI Cluster::{base, hpc, kernel, sge}



Protein Databank::{base, hpc, kernel, pdb}



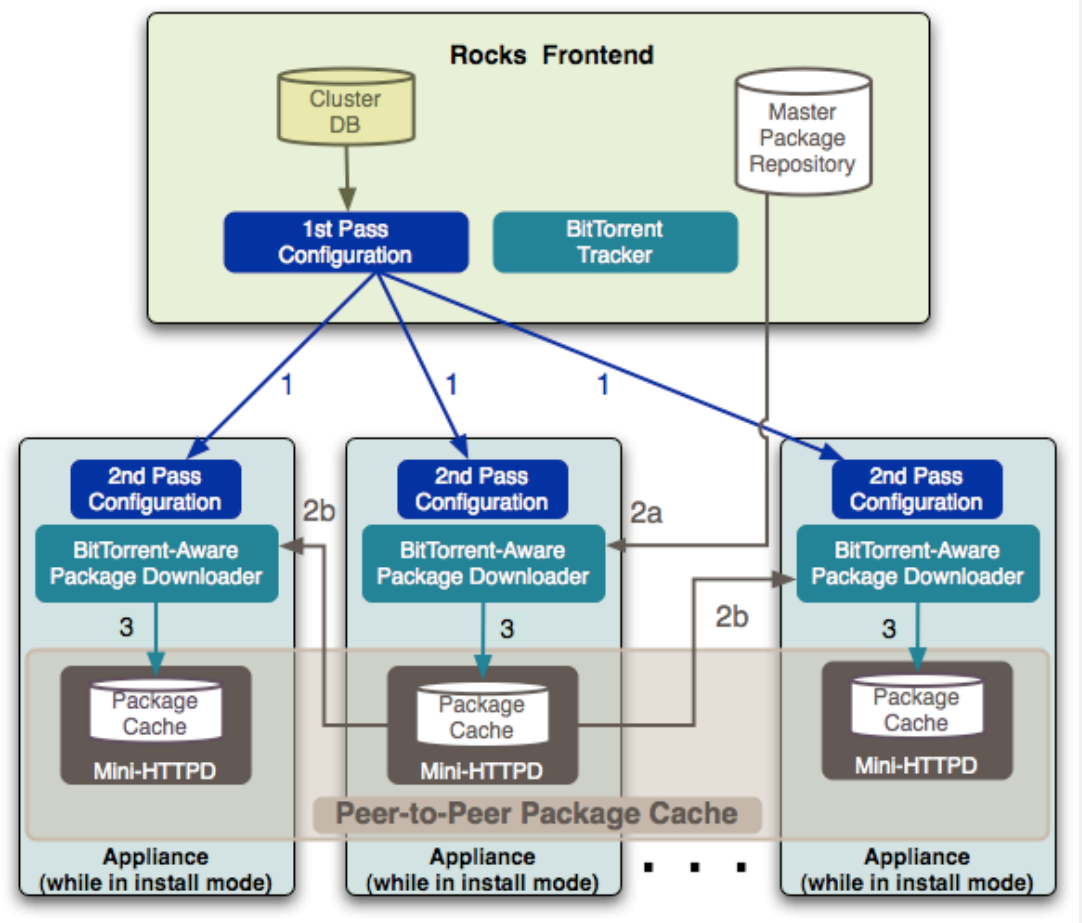
Where are the Scaling Limits?

- Time for Kickstart Generation
  - 3 - 4 s / host
  - *O*(n)
- Time to Download Packages
- Rocks uses HTTP to transport Packages
- Linux easily serves HTTP files at
  - 100MB/sec @ 1Gbit
  - 12 MB/Sec@100Mbit
- Time = <#nodes> * <total MB packages> / HTTP Speed
  - Total Packages ~ 350MB

	128 Nodes	1024 Nodes
100 Mbit	3700s (1hr)	9 hours
1 Gbit	460s (8 min)	1 hour

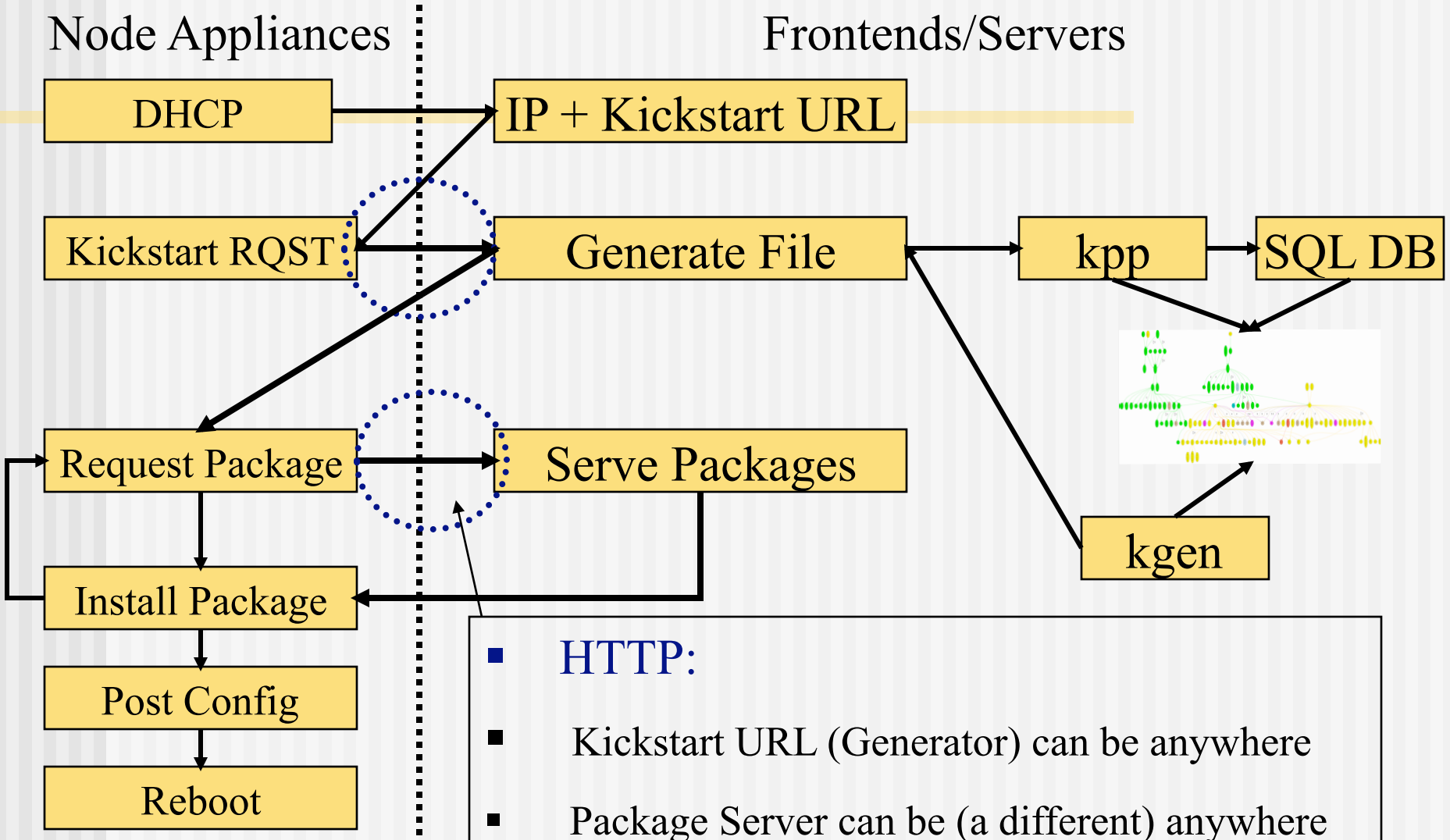
Avalanche Installer

- Install nodes from a peer-to-peer package cache
- Takes advantage of switched networks to unload the frontend
- Kickstart generation is split between frontend and nodes
- Backoff mechanisms keep the frontend load under control
- Zero administration



Pre-Avalanche

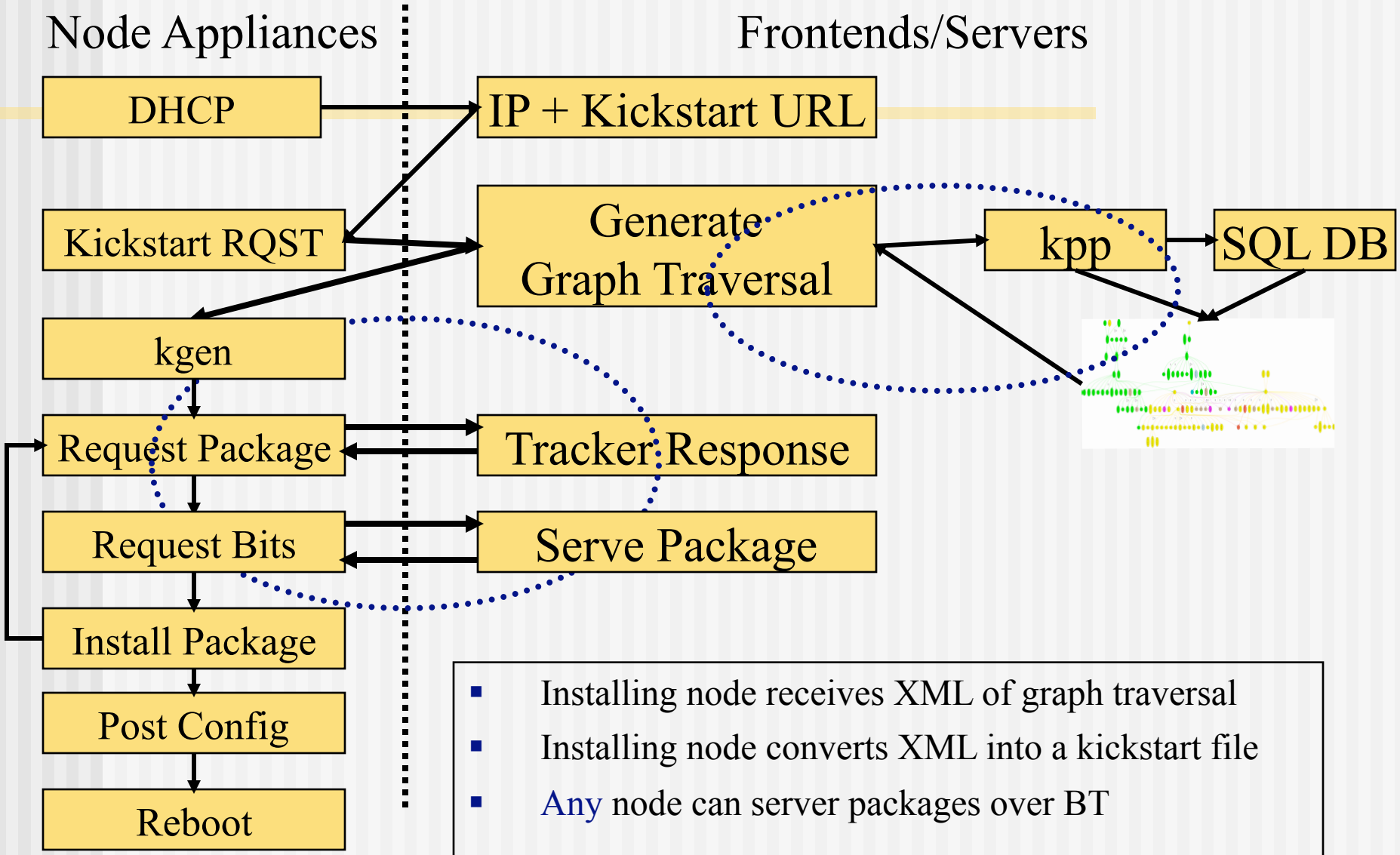
Space-Time and HTTP



- HTTP:
- Kickstart URL (Generator) can be anywhere
- Package Server can be (a different) anywhere

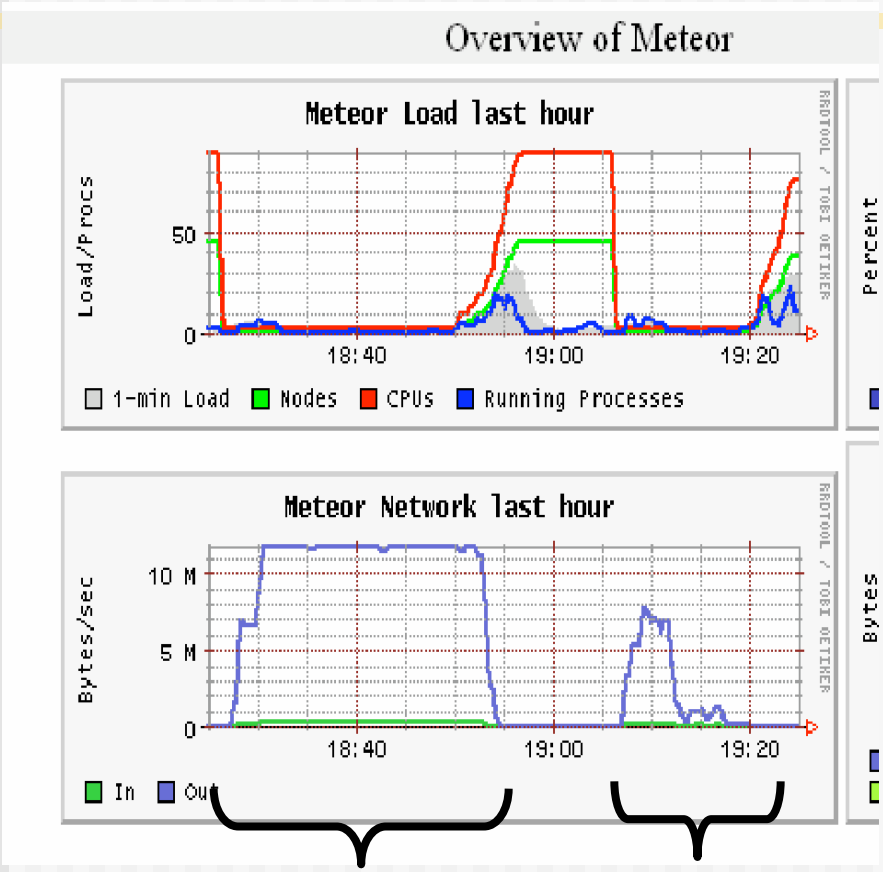
Avalanche

Space-Time and HTTP



- Installing node receives XML of graph traversal
- Installing node converts XML into a kickstart file
- Any node can server packages over BT

A Glimpse at Performance



- 45 Nodes – 100 Mbit
  - Old and Slow!
  - 350MB (Slim Compute Node)
- Pre-avalanche:
  - Estimate: 1600s
  - Actual: 1700s
- Avalanche:
  - Estimate: 900s
  - Actual: 1000s
- Avalanche is significantly quicker – and reduces load on the frontend

OptIPuter

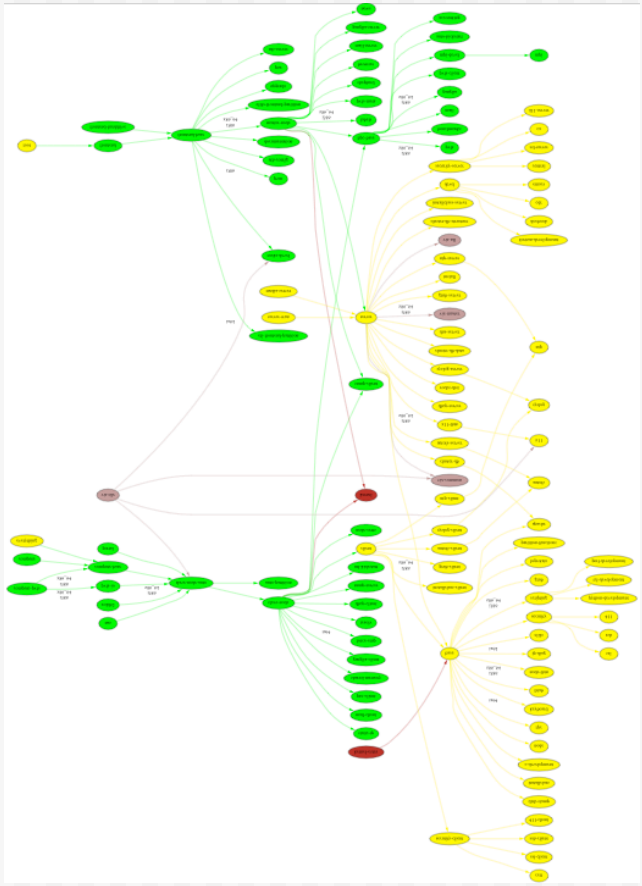
CalIT/2

EVL / UIC

OPTIPORTAL

VIZ ROLL

{ base, hpc, kernel, viz }

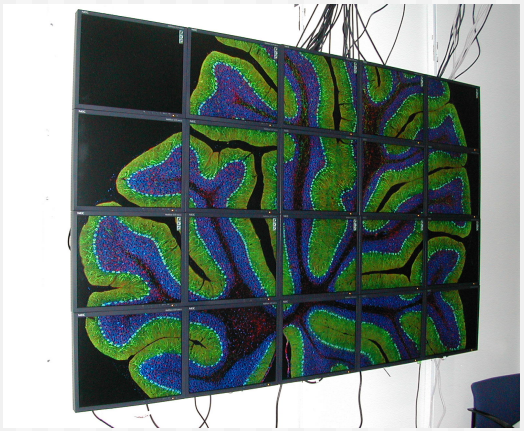


Early Work: NCSA

- LCD Cluster
  - Custom framing
  - One PC / tile
  - Portable (luggable)
  - SC 2001 Demo
- NCSA Software
  - Pixel Blaster
  - Display Wall In-A-Box
    - OSCAR based
    - Never fully released

NCMIR

- Using Rocks
- Hand configured a visualization cluster
- "Administered the machine to the point of instability"
  - David Lee
- Automation is needed



COTS Vis: GeoWall

- LCD Clusters
  - One PC / tile
  - Gigabit Ethernet
  - Optional Stereo Glasses
  - Portable
  - Commercial Frame (Reason)
- Applications
  - Large remote sensing
  - Volume Rendering
  - Seismic Interpretation
  - Brain mapping (NCMIR)
- Electronic Visualization Lab
  - Jason Leigh (UIC)

OptIPortal (SAGE)

One Node per Display

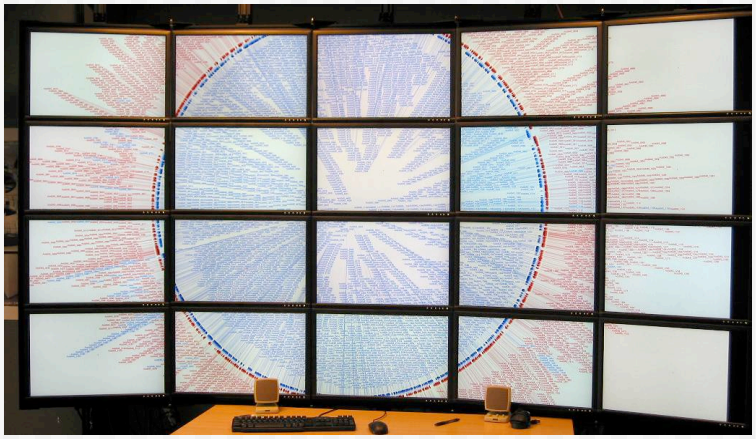
OptIPortal

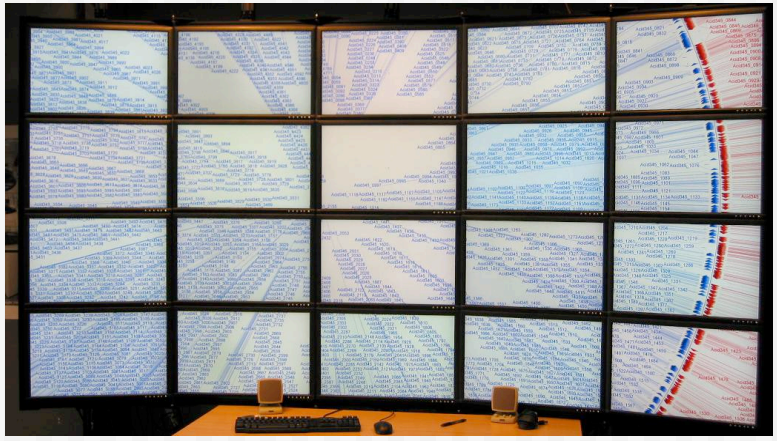
Nodes Behind the Wall

Use of OptIPortal to Interactively View Microbial Genome (CGView)

Acidobacteria Bacterium Ellin345 (NCBI)

Soil Bacterium 5.6 Mb





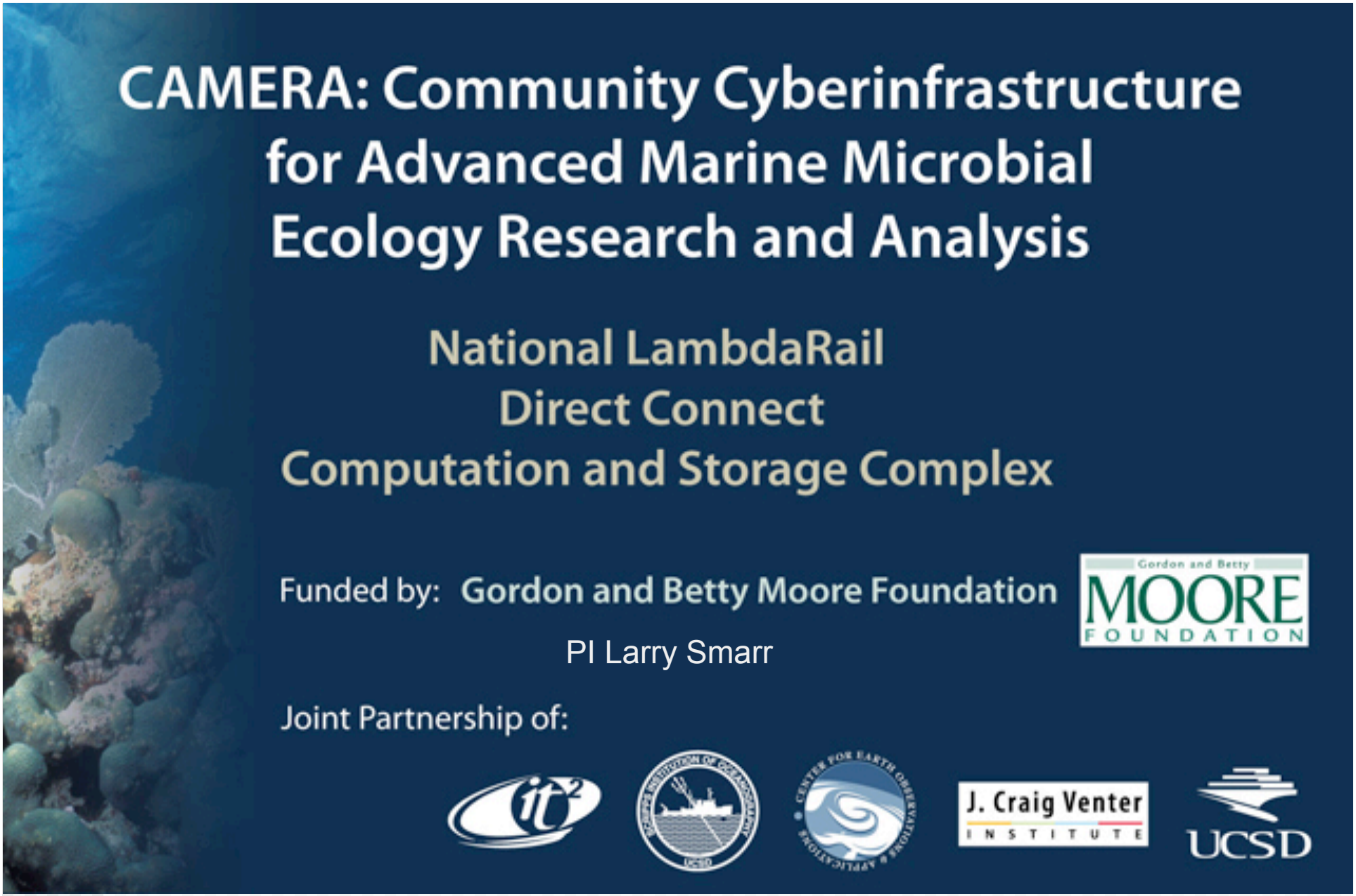
Acidobacteria bacterium Ellin345 (NCBI) Soil Bacterium 5.6 Mb

Source: Raj Singh, UCSD

Genomic Map (cgview)

A Meta-Genomic / Bio-Informatic Compute and Data Infrastructure

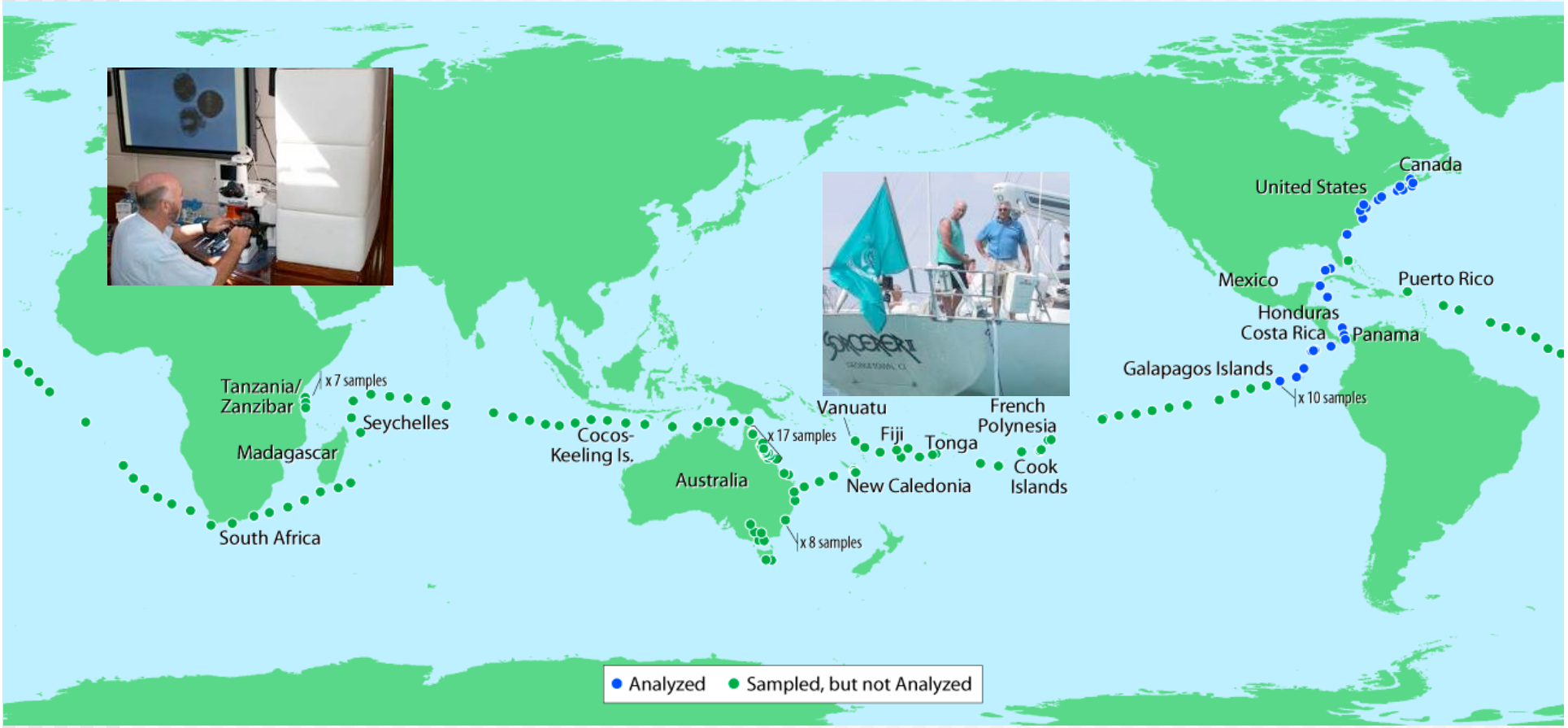
CAMERA



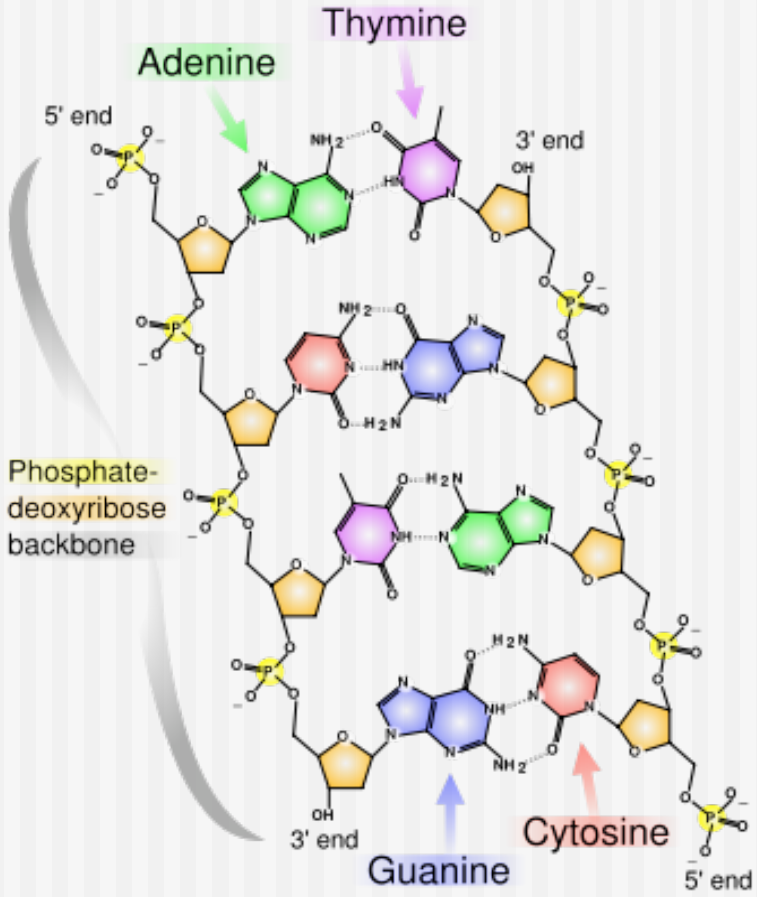
Announced 17 Jan 2006. Public Release 13 March 2007

$24.5M Over Seven Years

Marine Genome Sequencing Project – Measuring the Genetic Diversity of Ocean Microbes

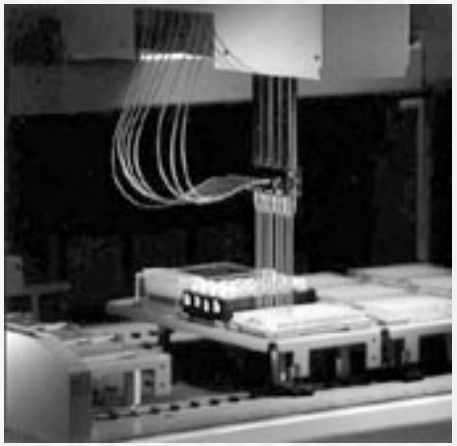


DNA Basics for Non-Biologists

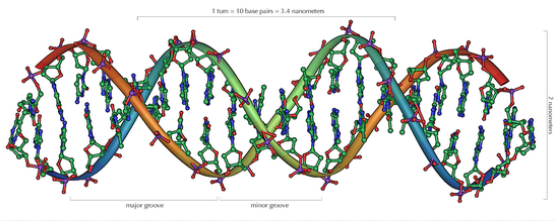


- Nucleotide bases of DNA
  - ACTG (Adenine, Cytosine, Guanine, Thymine)
  - A Sequence of Bases Forms One Side of a DNA Strand
  - Complementary Bases form the other side of DNA
    - A matches T (pair)
    - C matches G (pair)
- During cell replication, DNA is “unzipped” . The complementary side can then be replicated perfectly
- Human DNA is about 3 billion base pairs on 23 Chromosomes

Sequencers Generate FASTA



>JCVI_READ_299 /library_id=JCVI_LIB_GS-00a-01-01-2P5KB-T13532
/template_id=JCVI_TMPL_SHAA001 /sequencing_direction=forward
/sample_id=JCVI_SMPL_1103283000001 /clr_range_begin=85 /clr_range_end=969 /full_length=969
GCGGTTTGGAAGGAACTTCTATTCAGAAAACAAGATAATTTATTTCAATAGGCAAATATATTATCC
AAGAGGTAAAGTCCTTTGTGGCTCTGGCTCAATAAATGCAATGGTCTATGCAAGAGGATTAGAA
ACAGATTATGAGAATTGGGGCACCAATAAGGAATGGAGTTTTGAAAATATAAAAAAAATATACAG
ATCTATGGAGCAACAAATAAATGATGATAAAGAATTTCTTACAAAAGAAAAGATTCCAGTAAATAA
TGTAAGTAAGCATCATCATCCAATTTTAGAATATTTTTTTAATGCTAGTAATGAAATTG ….



Bases → Amino Acids

- Triplets of nucleotide bases are called **codons** and define amino acids.
  - Amino acids are the basic building blocks of proteins
  - There are 20 amino acids, but 4^3 = 64 nucleotide combinations.
  - Many amino acids have multiple codons
  - Special codons (called start and stop codons) assist in DNA translation during cell replication.
- Ambiguity in codon interpretation
  - Depends of where you start
  - For example: GGGAAACC could be:
    - GGG, AAA, CCC (Glycine, Lysine, Proline)
    - CCA, AAC (Glycine, Asparagine)
    - CAA, ACC (Glutamic Acid, Threonine)

Open Reading Frame → Protein

- Open Reading Frame (ORF)
  - portion of an organism's genome which contains a sequence of bases that could potentially encode a protein
    - ATG is a DNA start Codon,
    - An ORF has no stop Codon (TAA, TAG, TGA)
- When processing a raw DNA read from a Gene Sequencer, you do not know which is the correct reading frame.
  - For double-stranded DNA – one of 6 starting positions (3 forward, 3 reverse)

Sequence Analysis and Comparison

- Raw reads are possible fragments of genes
- Determining the proper reading frame is difficult
- Fragment reads are assembled into possible genes (or a complete Genome)
  - Shotgun Sequencing, DNA strand is broken up randomly into numerous small segments
  - Fragments are then recombined (assembled) to build a whole genome

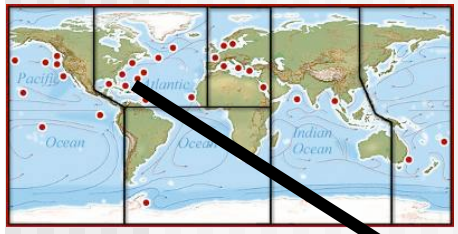
Sequence Search and Alignment

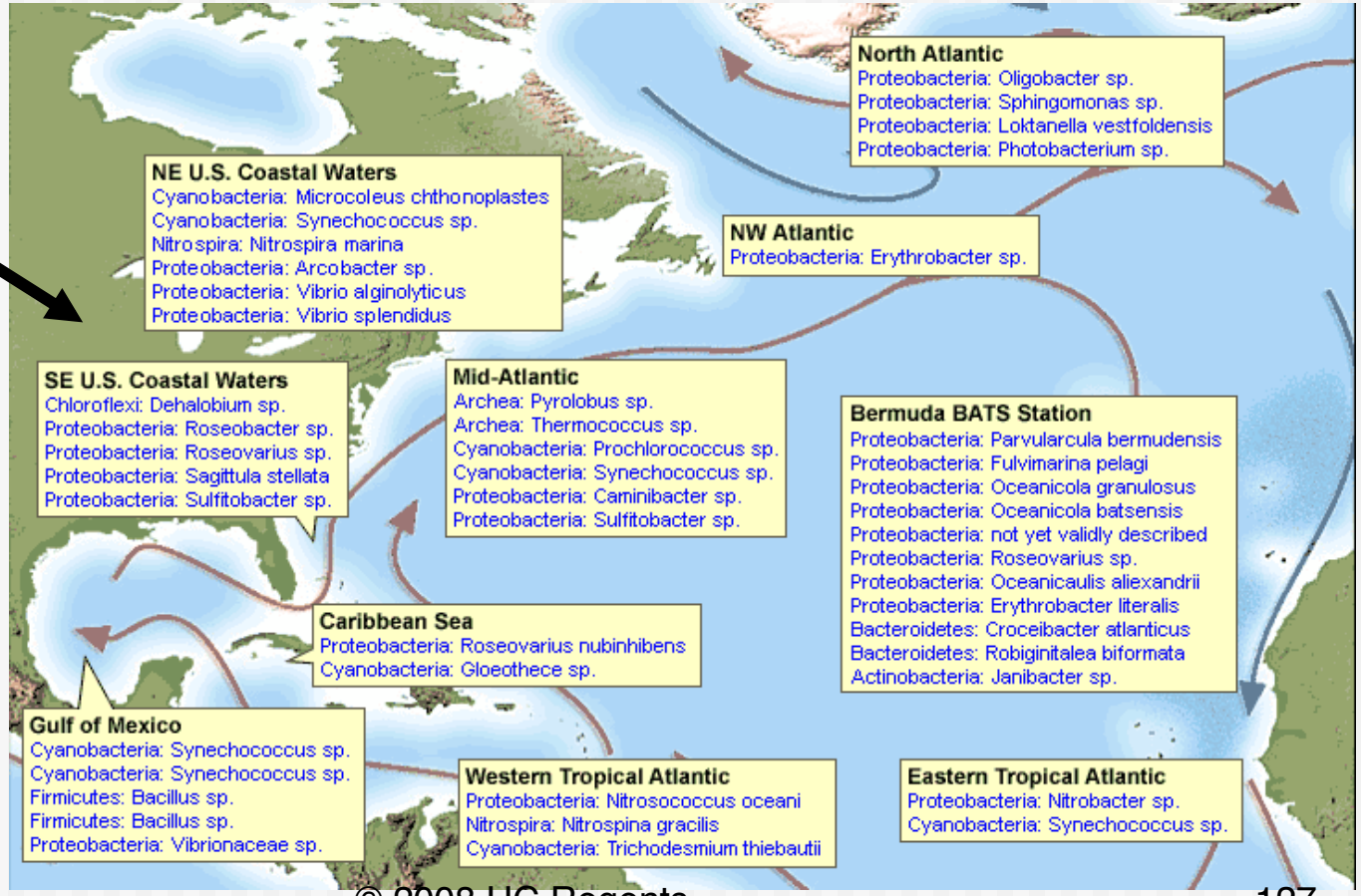
- BLAST (Basic Local Alignment Search Tool)
  - Finds regions of local similarity between sequences.
  - Compares nucleotide or protein sequences to sequence databases and calculates the statistical significance of matches.
  - Can be used to infer functional and evolutionary relationships between sequences
- How well do the following sequences align with each other?

  TTGGAGTATCTAAACATCCAATCATATTCATTAAAGTCGATTTTCCAGAACCAGAG
  GGGCCCATAATGAAATATATTCATTTTGATTTATAGTCAAATCGACTCCATCCAAA
  GCGCGAACT

  TTGGTGTATCAAGACAACCAATCATATTCATTAATGTTGATTTTCCAGAACCGGAA
  GGCCCCATAATAGAAATATATTCATTATGATTAATATTTAAATCAACTCCATCTAAAG
  CCCGAACT
- BLAST statistically matches a query sequence against a database of sequences

Moore Microbial Genome Sequencing Project
Selected Microbes Throughout the World's Oceans





www.moore.org/microgenome/worldmap.asp

New Application of Shotgun Sequencing

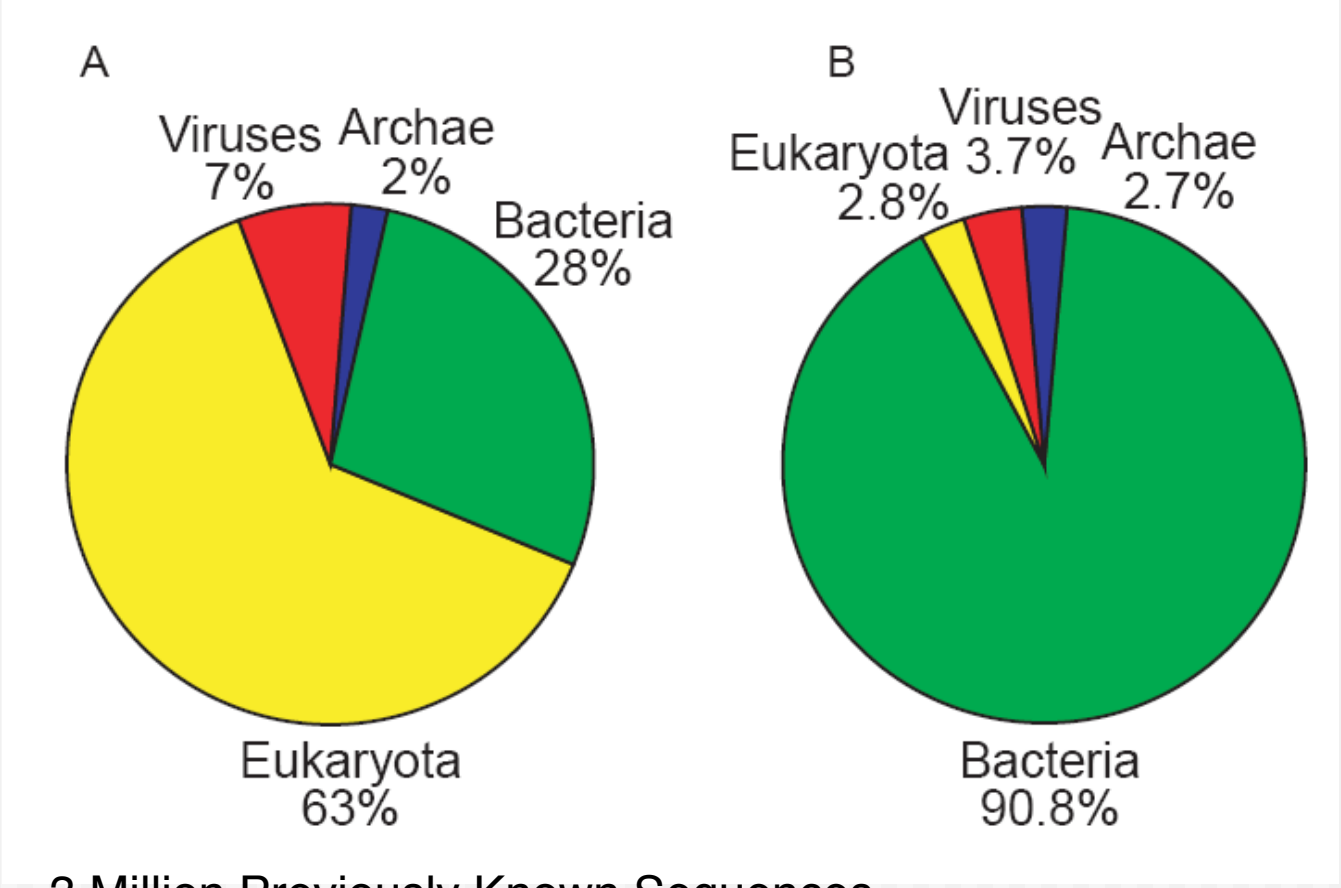
- Shotgun sequencing is typically performed on single, known organism
  - DNA of that organism is cloned for many samples
  - It may be difficult/impossible to isolate the DNA of a single microbe
- Venter Institute applying to whole microbial communities
  - A Filtered water sample contains many microbes.
    - This community of microbes is freeze-dried, and sent to Lab
    - This community is then sequenced
  - Each individual microbe genome O(2M) base pairs
  - A Read is ~1000 base pairs, it is unknown
    - Where in the genome
    - Which microbe is represented
    - Sequencing a Microbial community is believed to be about as complex as building the human Genome
    - It is critical to record the environmental conditions for further comparison

Some CAMERA Goals

- Provide an infrastructure where scientists from around the world can perform analysis on genetic communities
  - Global Ocean Sampling (GOS) is the initial large data set
    - ~ 8.5 Billion base pairs of raw Reads
  - **Metadata** is available for samples
    - Saline, Temperature, Geographic Location, Water Depth, Time of Day …
    - Other metadata will be correlated with samples (e.g. MODIS Satellite)
- Allow others to search and compare input sequences against CAMERA data.
- Overall provide a resource dedicated to metagenomics
  - Support new datasets
  - Support new analysis tools and web service

Global Ocean Survey (GOS) Sequences are Largely Bacterial

~5.6 Million GOS Sequences



~3 Million Previously Known Sequences

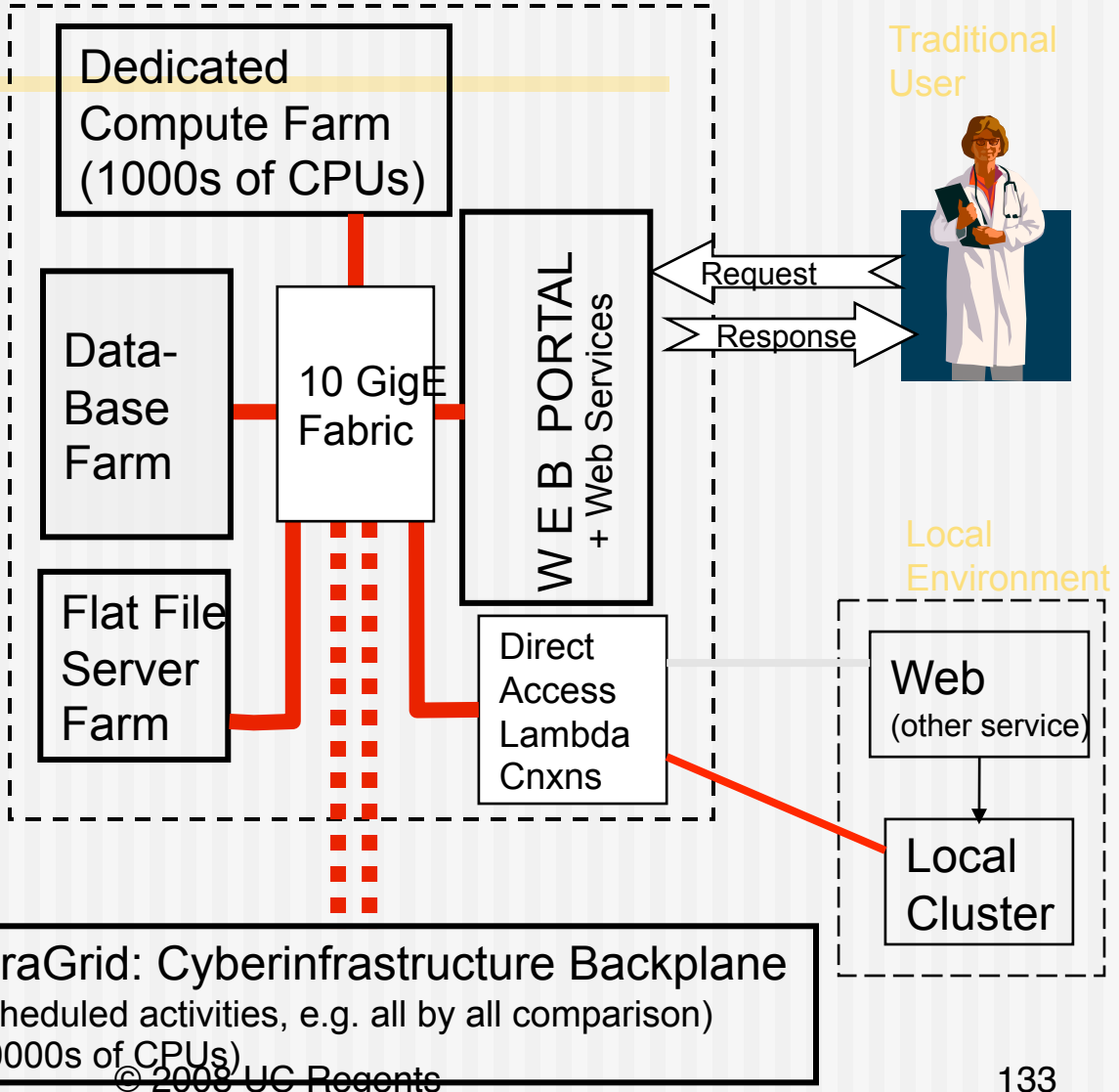
Source: Shibu Yooseph, et al. (PLOS Biology in press 2006)

Meta Data

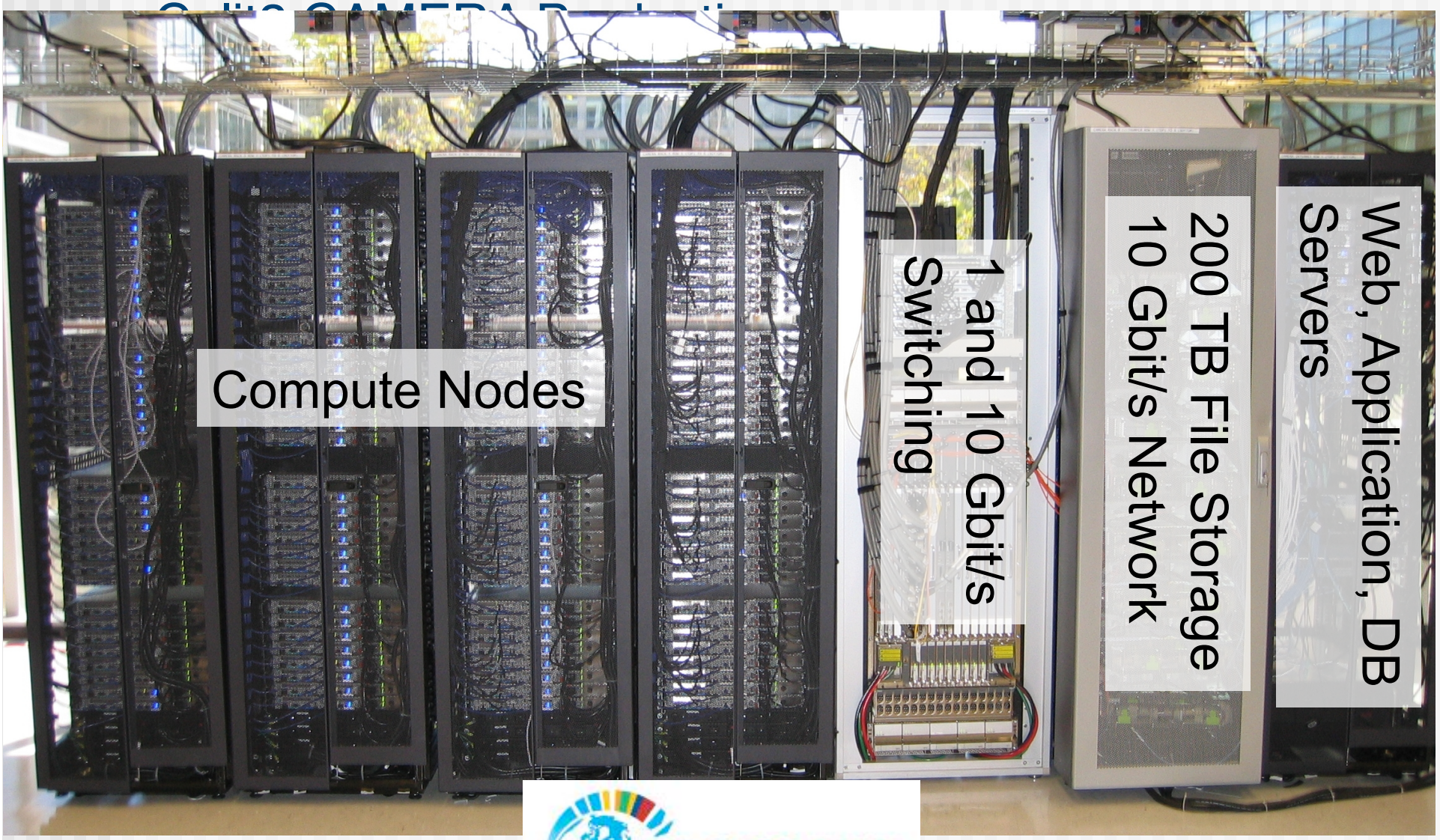
ID	Sample Loca	Country	Date mm/dd	Time	Location	Sample Dept
JCVI_SITE_GS	Sargasso Sea,	Bermuda (UK)	2/26/03	03:00	31°32'06"n; 6	5
JCVI_SITE_GS	Sargasso Sea,	Bermuda (UK)	2/26/03	03:35	31°32'06"n; 6	5
JCVI_SITE_GS	Sargasso Sea,	Bermuda (UK)	2/26/03	10:10	31°10'30"n; 6	5
JCVI_SITE_GS	Sargasso Sea,	Bermuda (UK)	2/26/03	10:43	31°10'30"n; 6	5
JCVI_SITE_GS	Sargasso Sea,	Bermuda (UK)	2/25/03	13:00	32°10'29.4"n;	5
JCVI_SITE_GS	Sargasso Sea,	Bermuda (UK)	2/25/03	17:00	31°32'06"n; 6	5
JCVI_SITE_GS	Sargasso Sea,	Bermuda (UK)	5/15/03	11:40	32°10'00"n; 6	5
JCVI_SITE_GS	Sargasso Sea,	Bermuda (UK)	5/15/03	11:40	32°10'00"n; 6	5
JCVI_SITE_GS	Sargasso Sea,	Bermuda (UK)	5/15/03	11:40	32°10'00"n; 6	5
JCVI_SITE_GS	Gulf of Maine	USA	8/21/03	06:32	42°30'11"n; 6	1
JCVI_SITE_GS	Browns Bank,	Canada	8/21/03	11:50	42°51'10"n;	1
JCVI_SITE_GS	Outside Halifa	Canada	8/22/03	05:25	44°8'14"n; 6	2
JCVI_SITE_GS	Bedford Basin,	Canada	8/22/03	16:21	44°41'25"n; 6	1
JCVI_SITE_GS	Bay of Fundy,	Canada	8/23/03	10:47	45°6'42"n; 6	1
JCVI_SITE_GS	Northern Gulf	Canada	8/25/03	08:25	43°37'56"n;	1
JCVI_SITE_GS	Newport Harb	USA	11/16/03	16:45	41°29'9"n; 7	1
JCVI_SITE_GS	Block Island, N	USA	11/17/03	10:30	41°5'28"n; 7	1
JCVI_SITE_GS	Cape May, NJ	USA	11/18/03	04:30	38°56'24"n;	1
JCVI_SITE_GS	Delaware Bay,	USA	11/18/03	11:30	39°25'4"n; 75	1
JCVI_SITE_GS	Chesapeake B	USA	12/18/03	11:32	38°56'49"n; 7	13.2
JCVI_SITE_GS	Off Nags Head	USA	12/19/03	06:28	36°0'14"n; 75	2.1
JCVI_SITE_GS	South of Charl	USA	12/20/03	17:12	32°30'25"n; 7	1
JCVI_SITE_GS	Off Key West,	USA	1/8/04	06:25	24°29'18"n; 8	1.7

Calit2's Direct Access Core Architecture
CAMERA's Metagenomics Server Complex

- Sargasso Sea Data
- Sorcerer II Expedition (GOS)
- JGI Community Sequencing Project
- Moore Marine Microbial Project
- NASA and NOAA Satellite Data
- Community Microbial Metagenomics Data



Source: Phil Papadopoulos, SDSC, Calit2

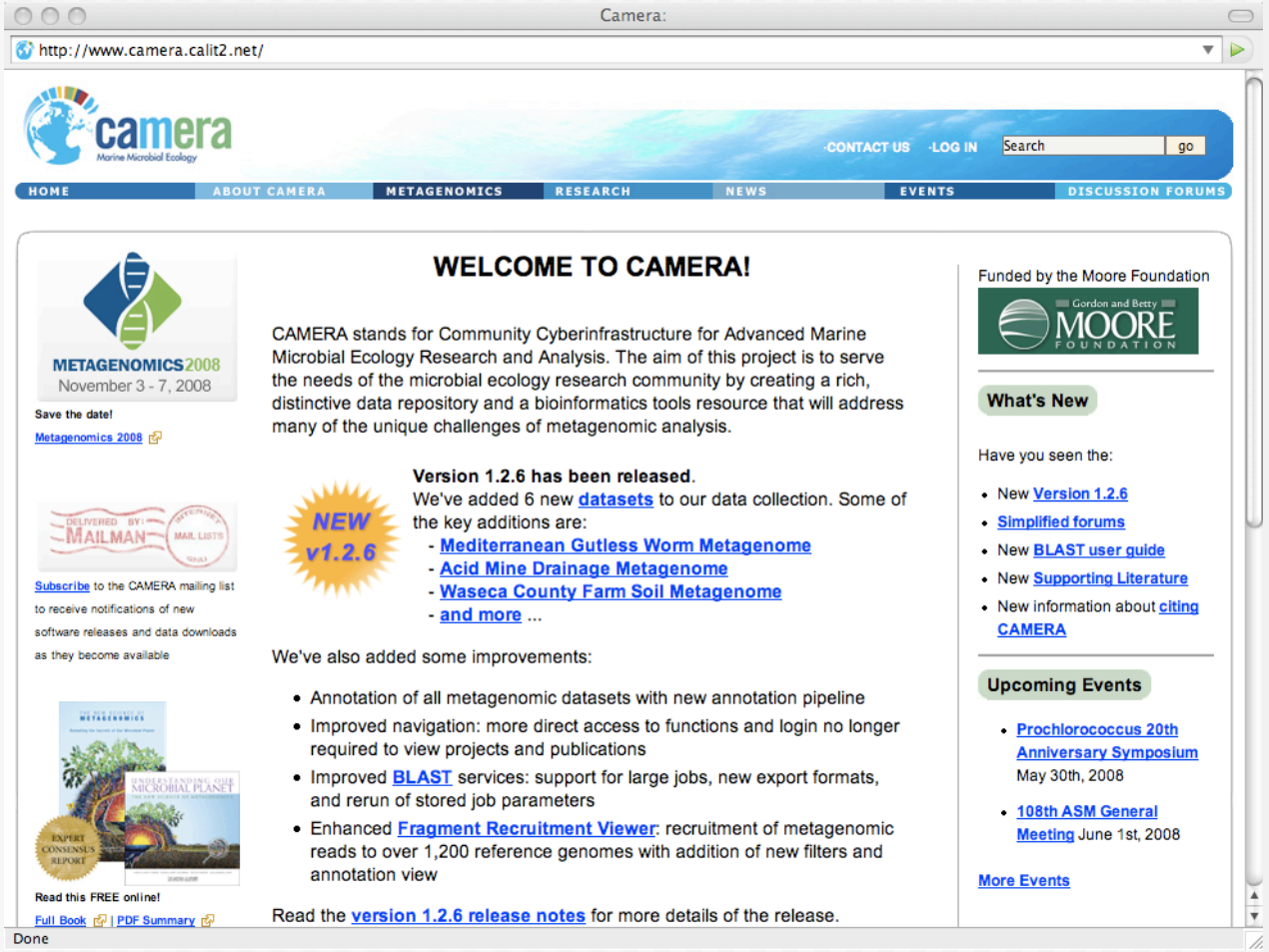


Component Sizing

- ~ 1000 CPU Cores
  - 512 Cores in now, Another 512 – 1024 in about 1 Year
- ~ 225 TB Raw Disk
  - 200TB now, 400TB in about year
- 10 Gigabit Ethernet as large subsystem interconnect
  - GigE for all Nodes
  - IB on ½ of Cluster Nodes
  - Force10 E1200 Switch/Router
- Database servers – as needed

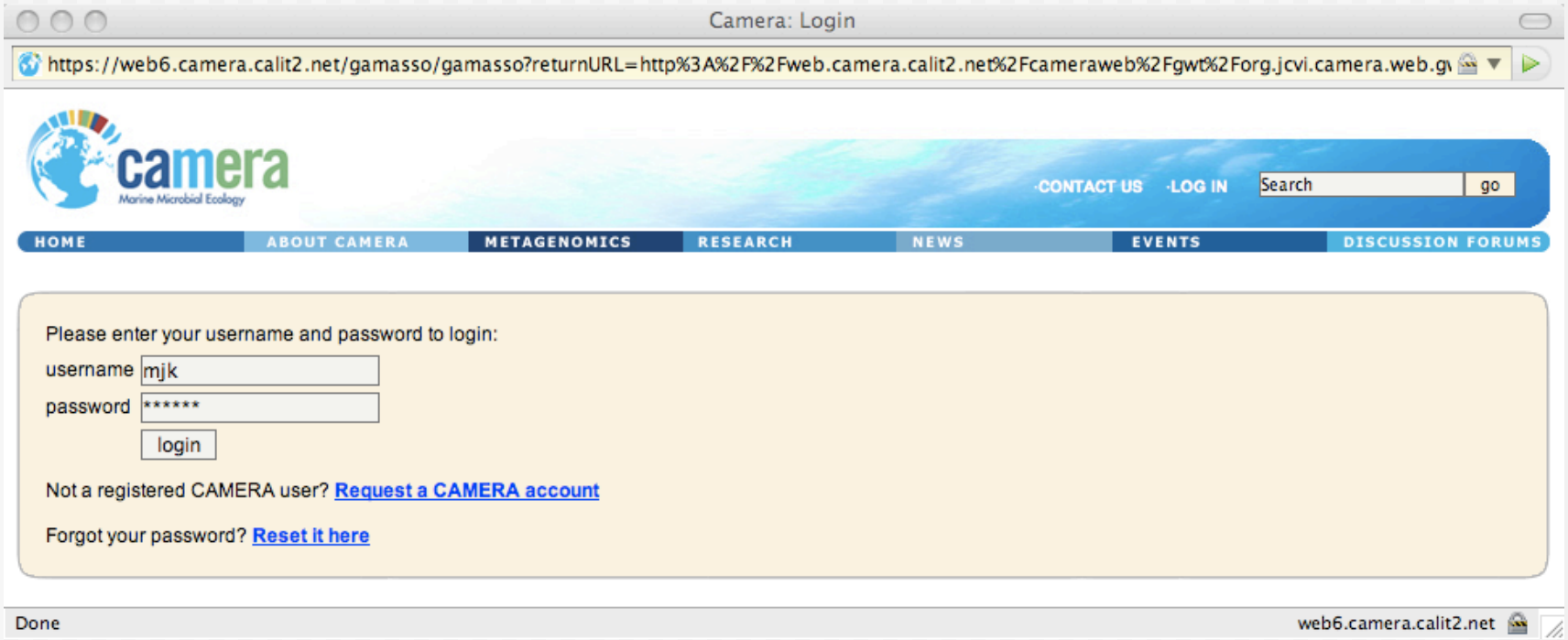
CAMERA Main Page

www.camera.calit2.net



CAMERA Portal Login

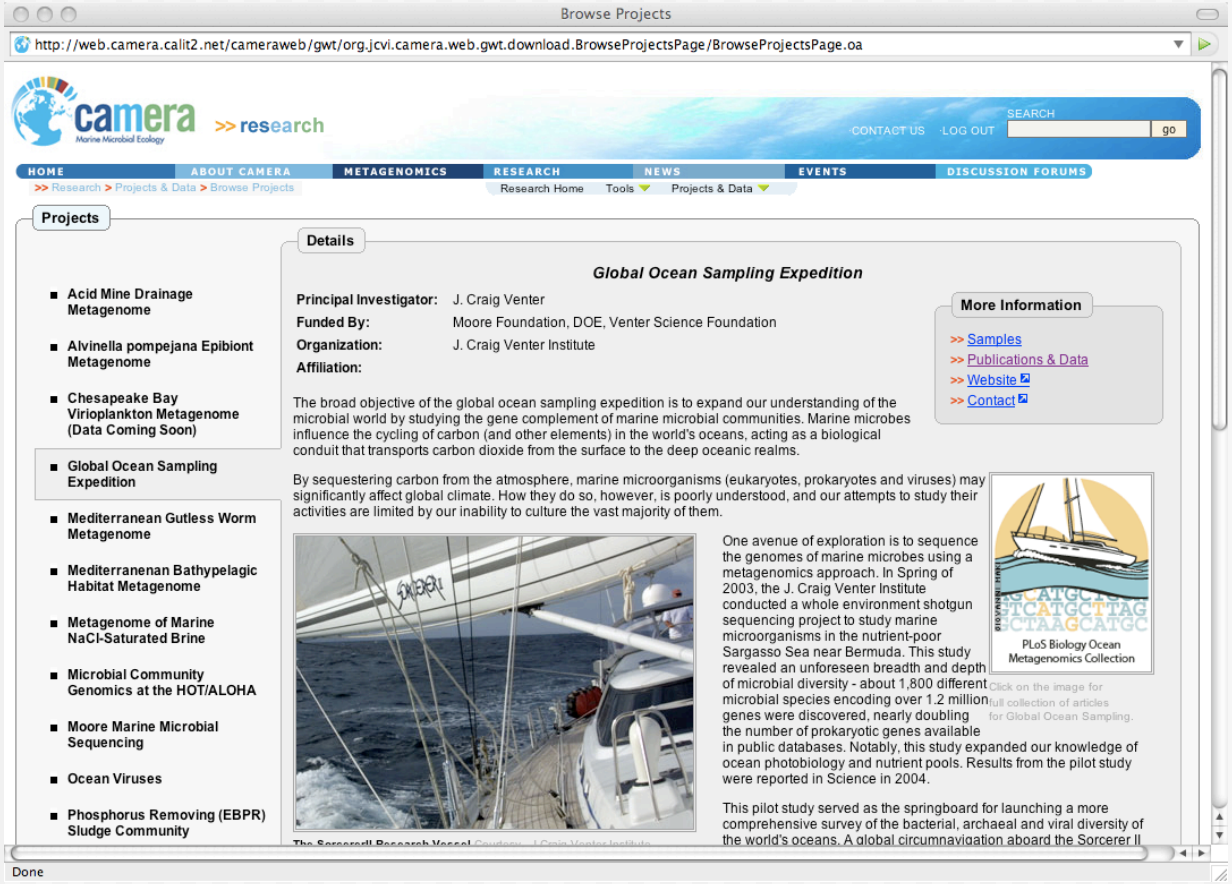
web6.camera.calit2.net



BLAST Portal

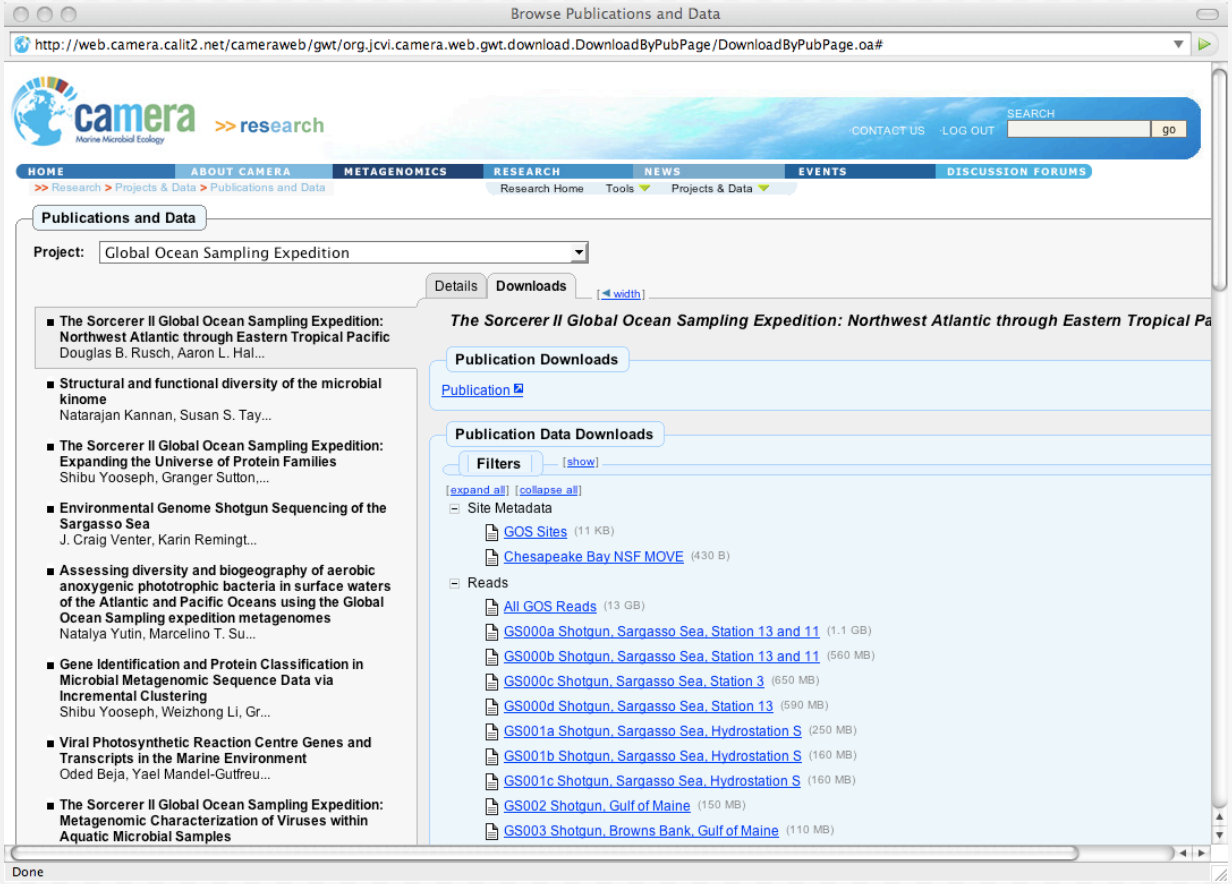
web.camera.calit2.net

Projects Include
(postgres SQL database)



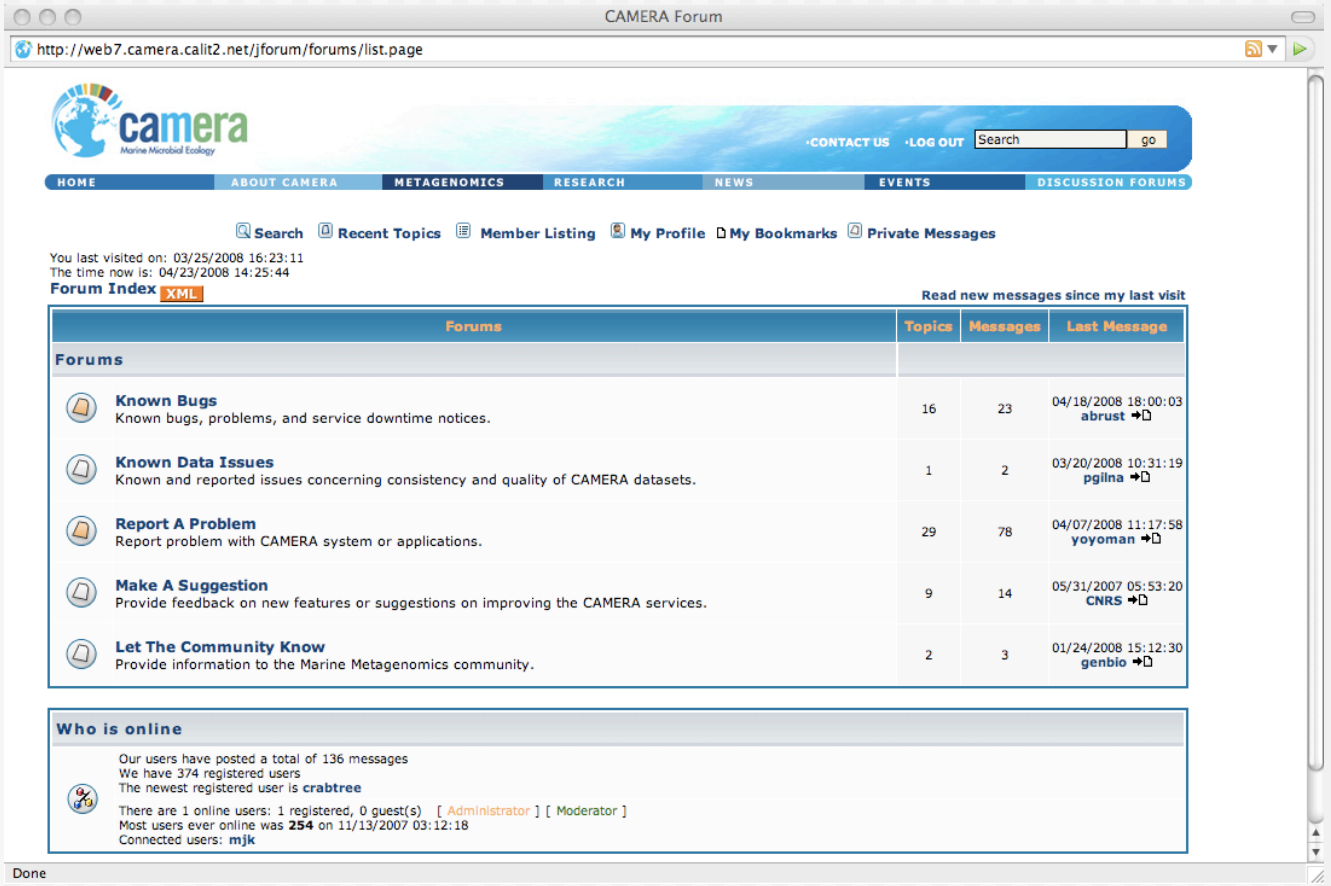
Download Data

ftp.camera.calit2.net



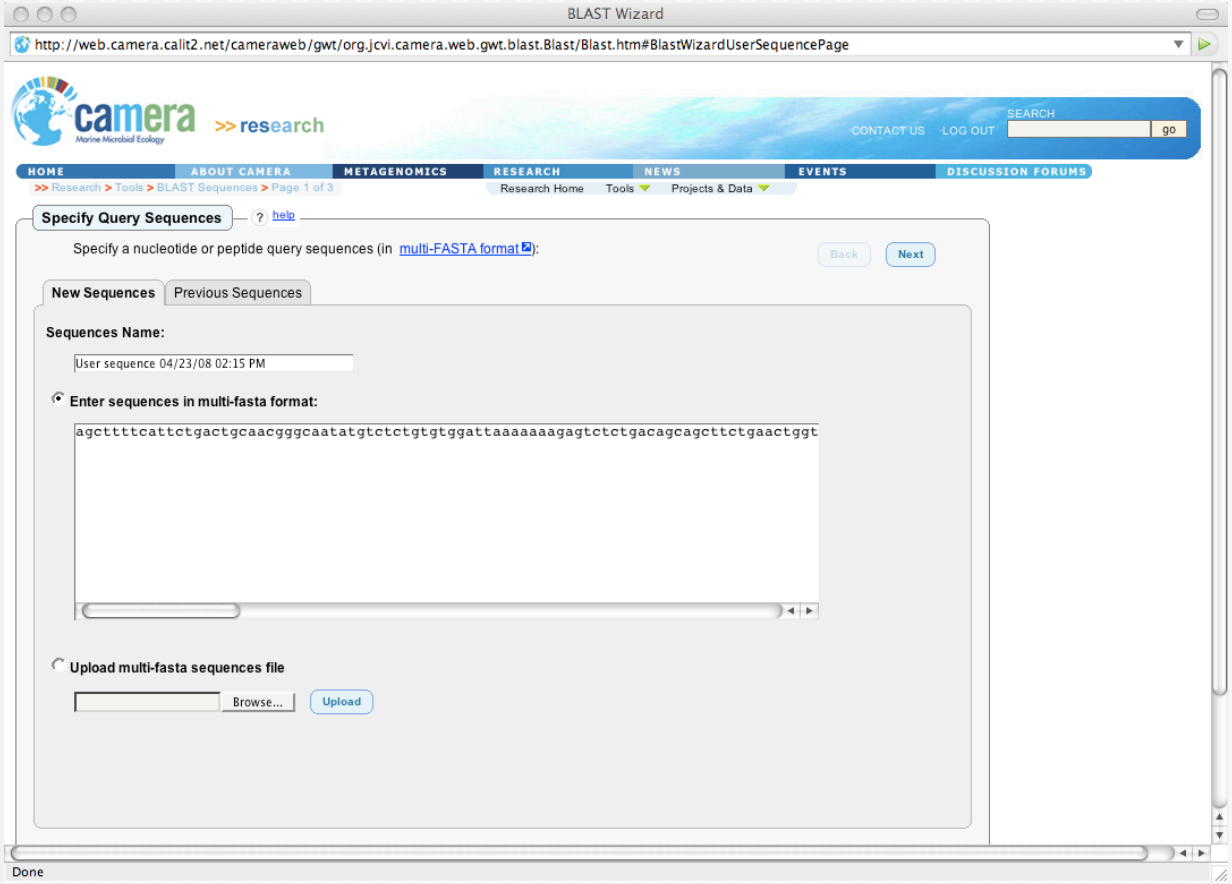
User Forums

web7.camera.calit2.net

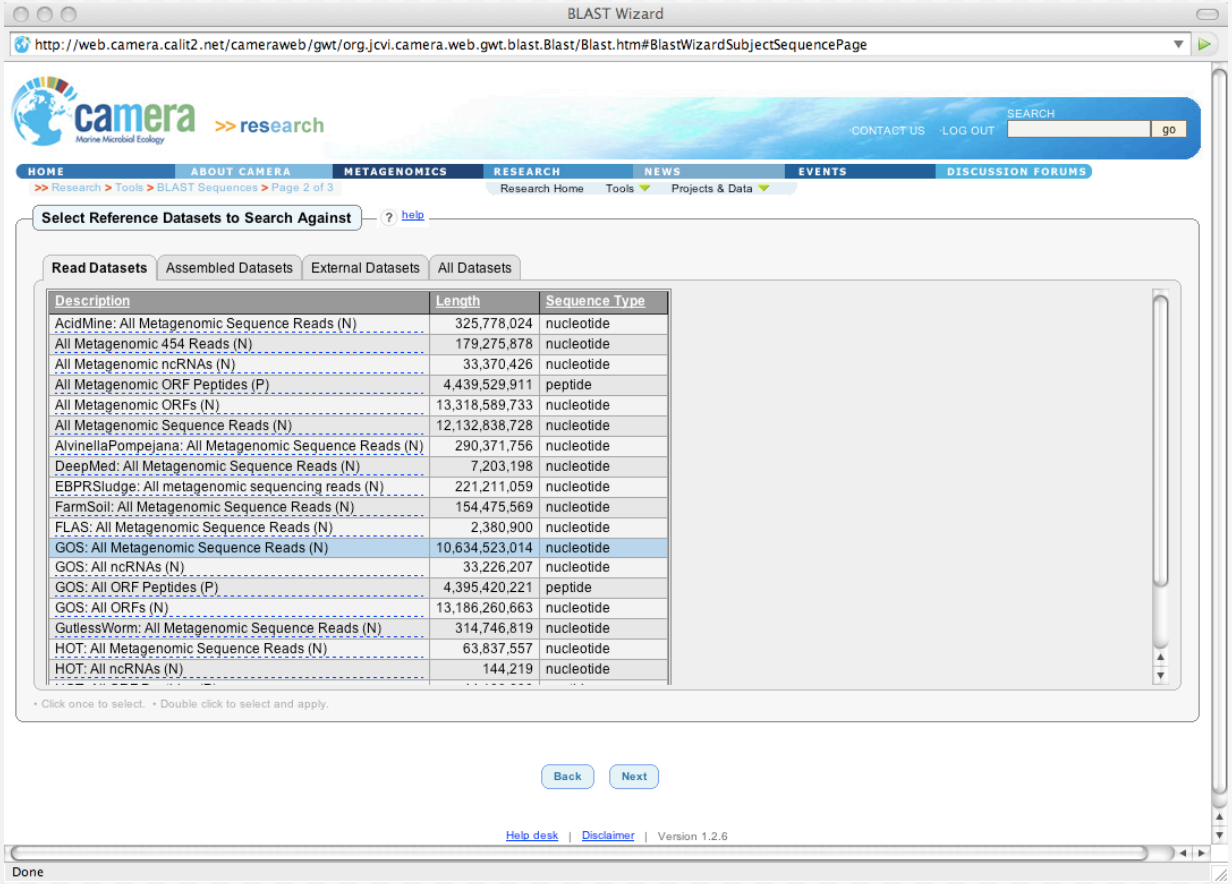


BLAST Query

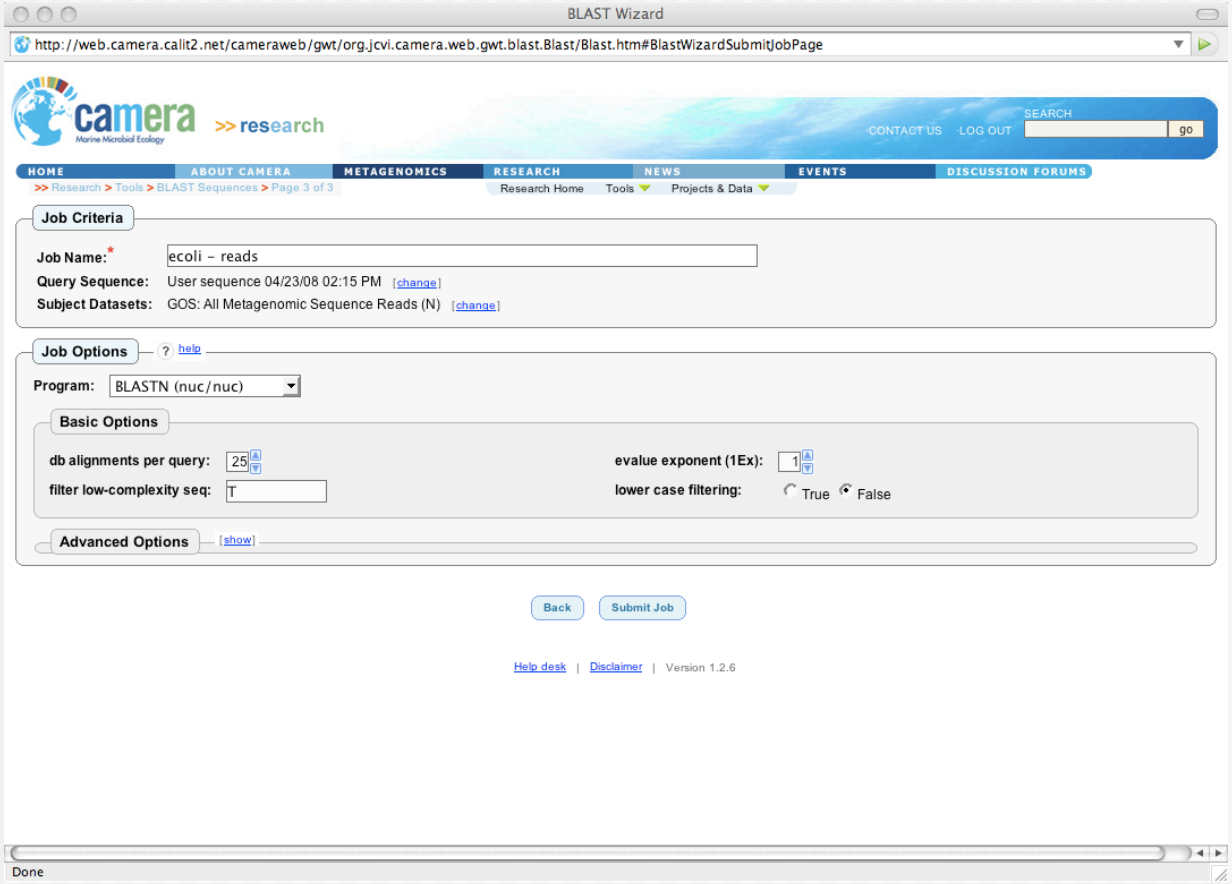
searching for ecoli



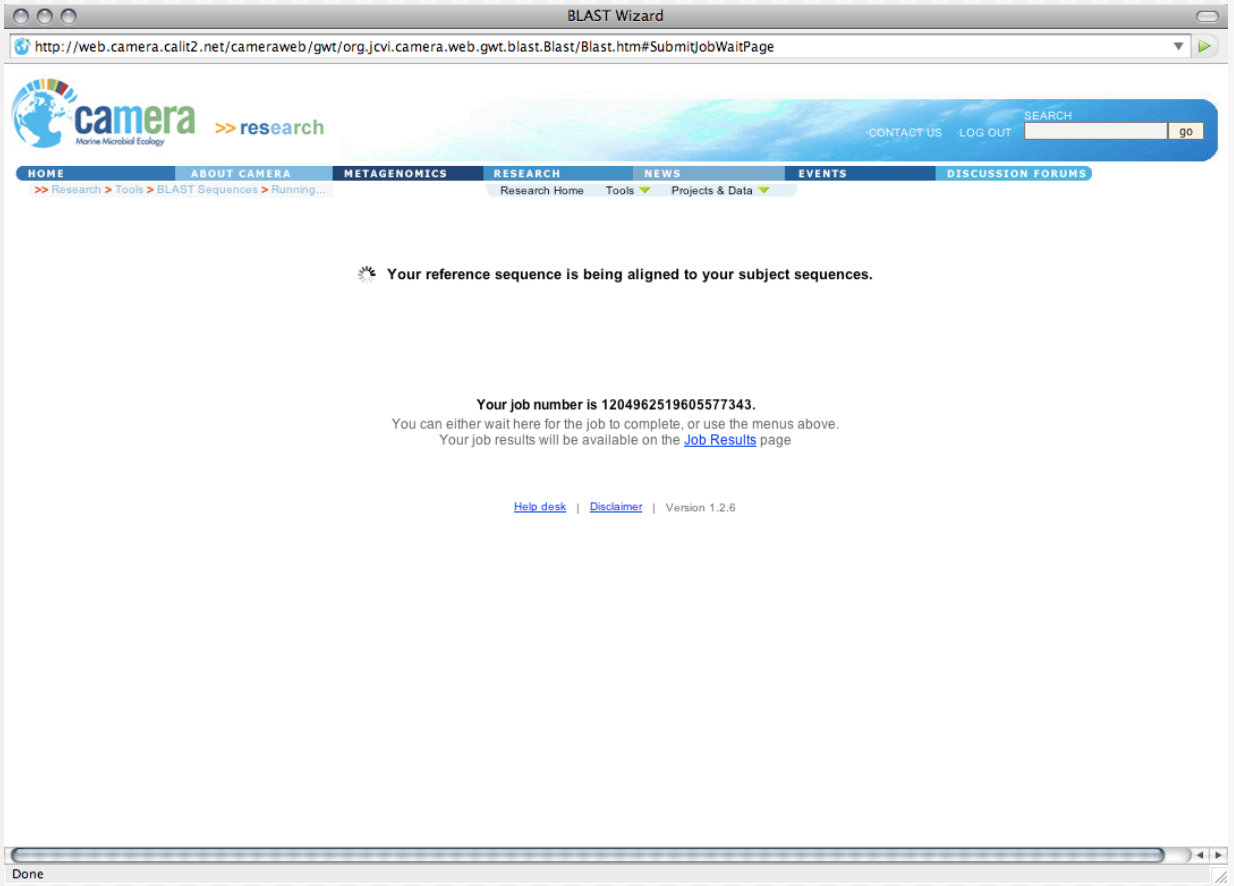
Choose Dataset
(~ .5TB FASTA files & SQL DB)



Name Your Job

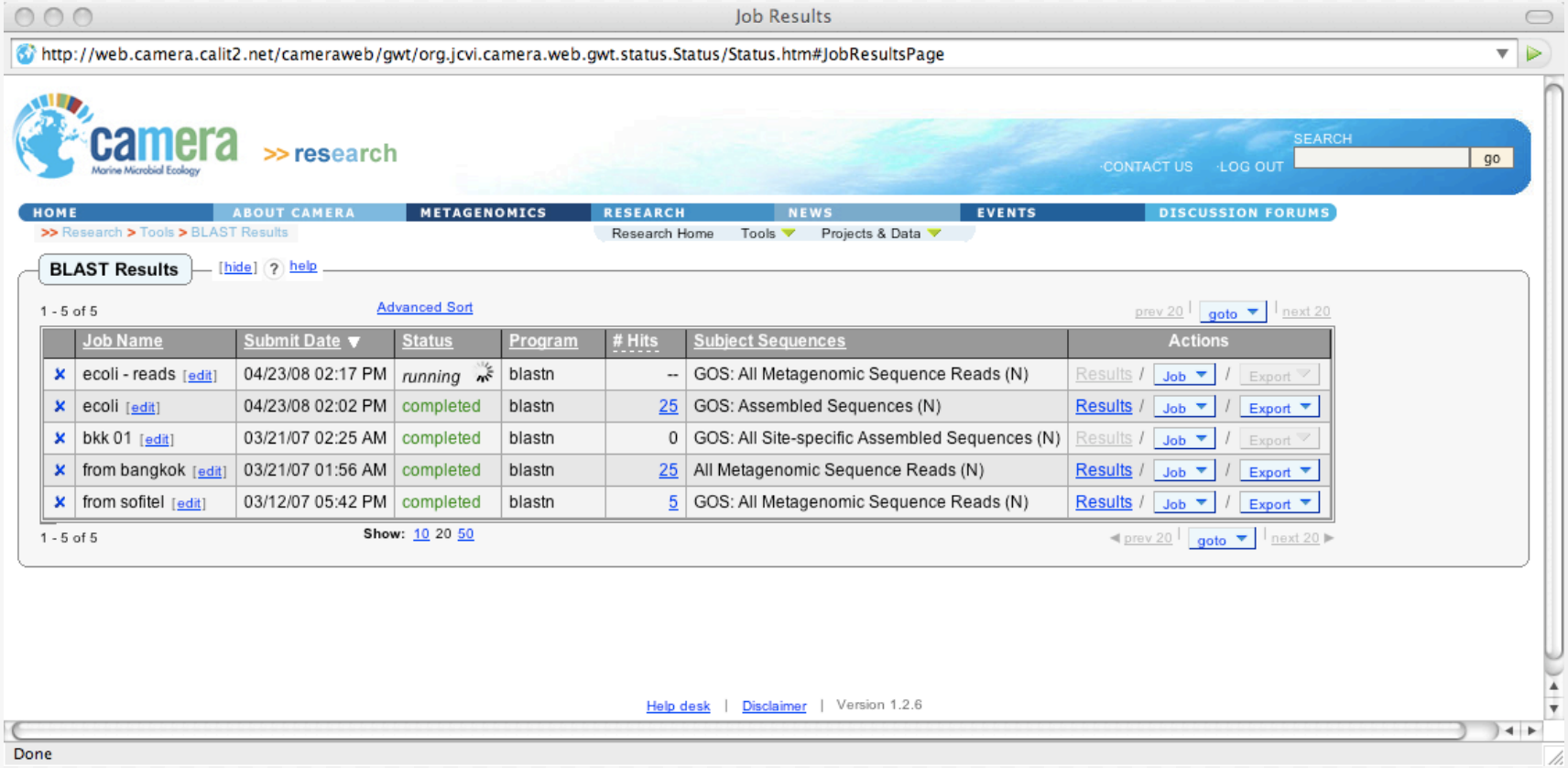


Running
(Sun Grid Engine Job)

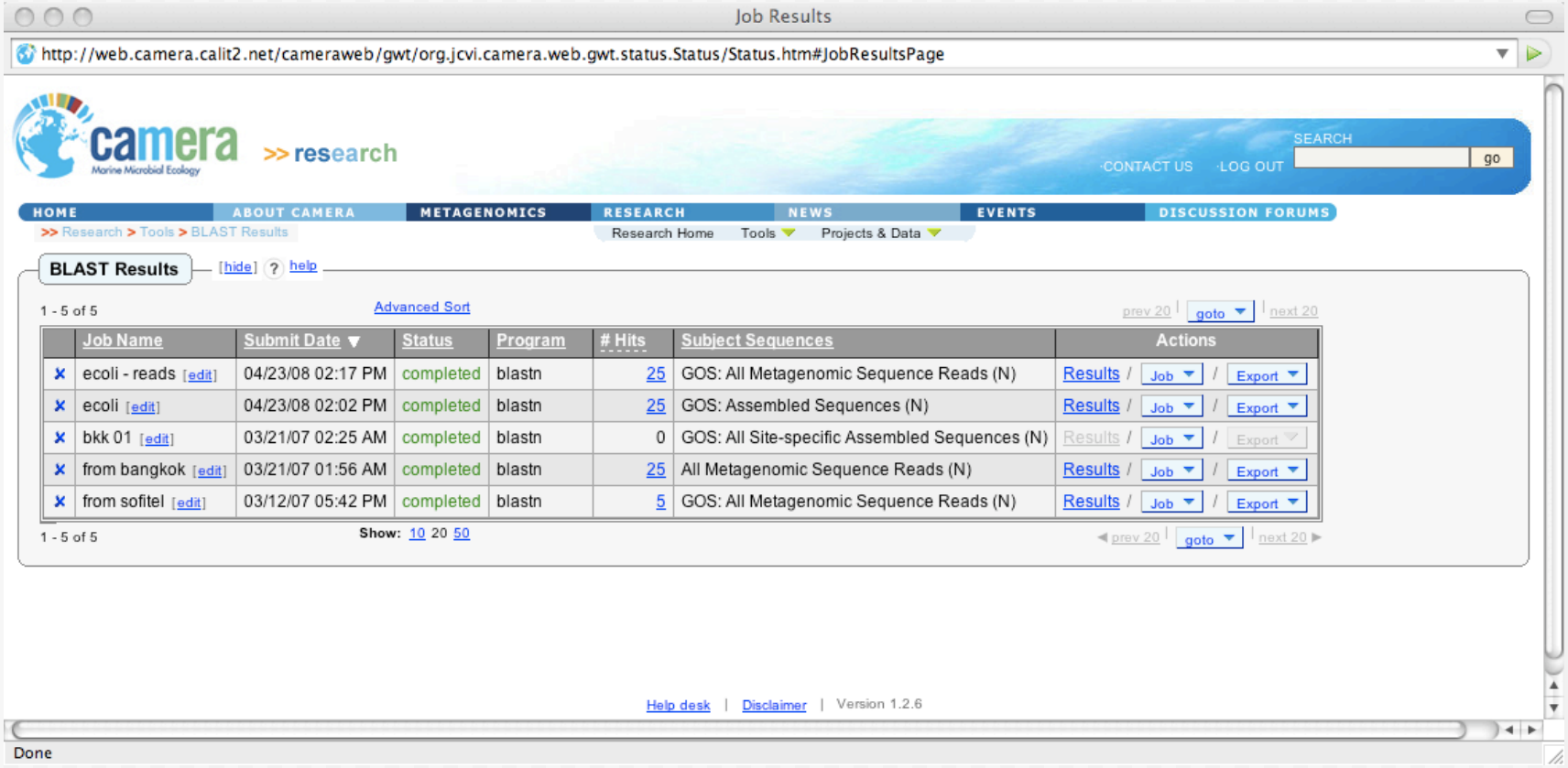


Waiting…

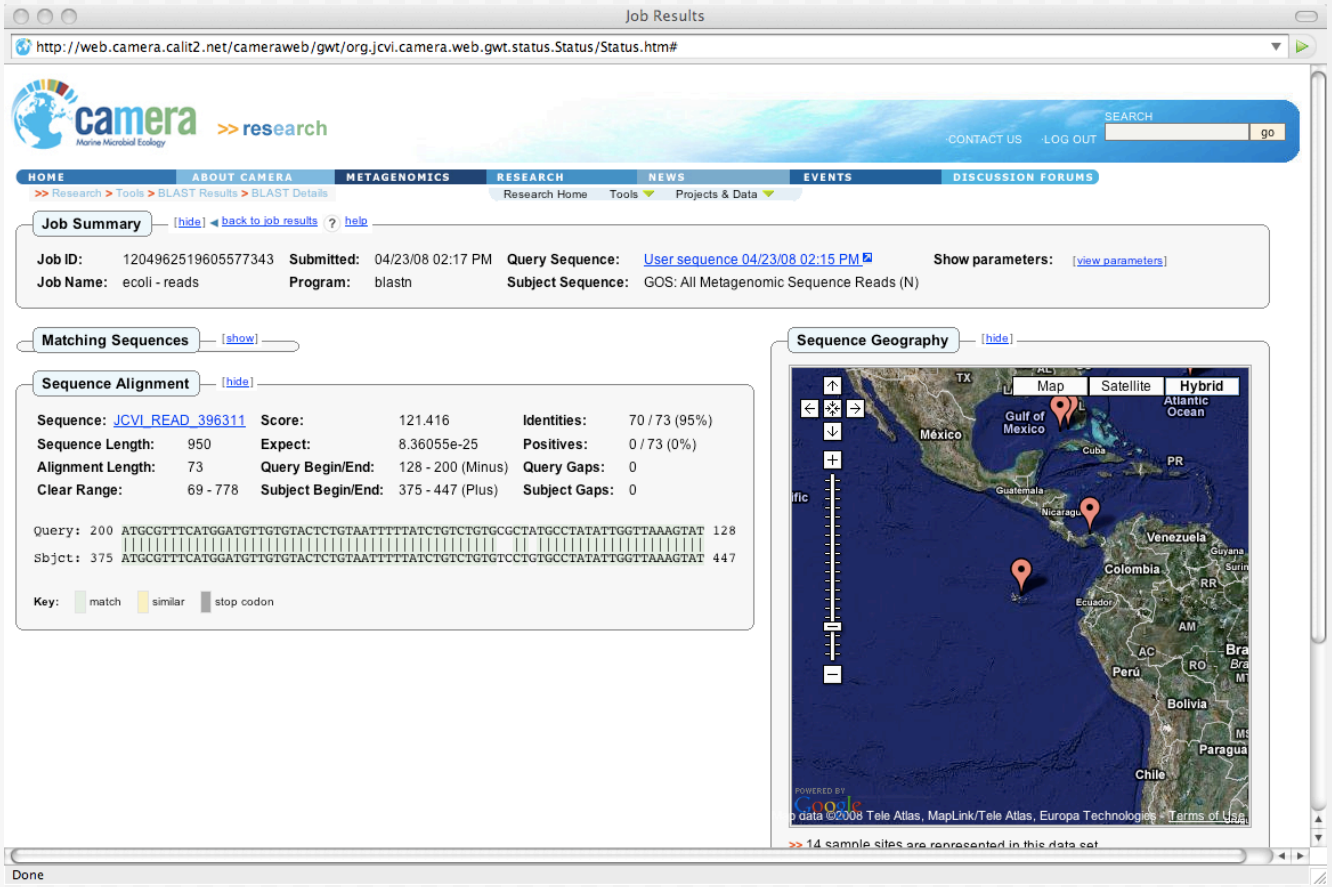
(Job running on cluster)



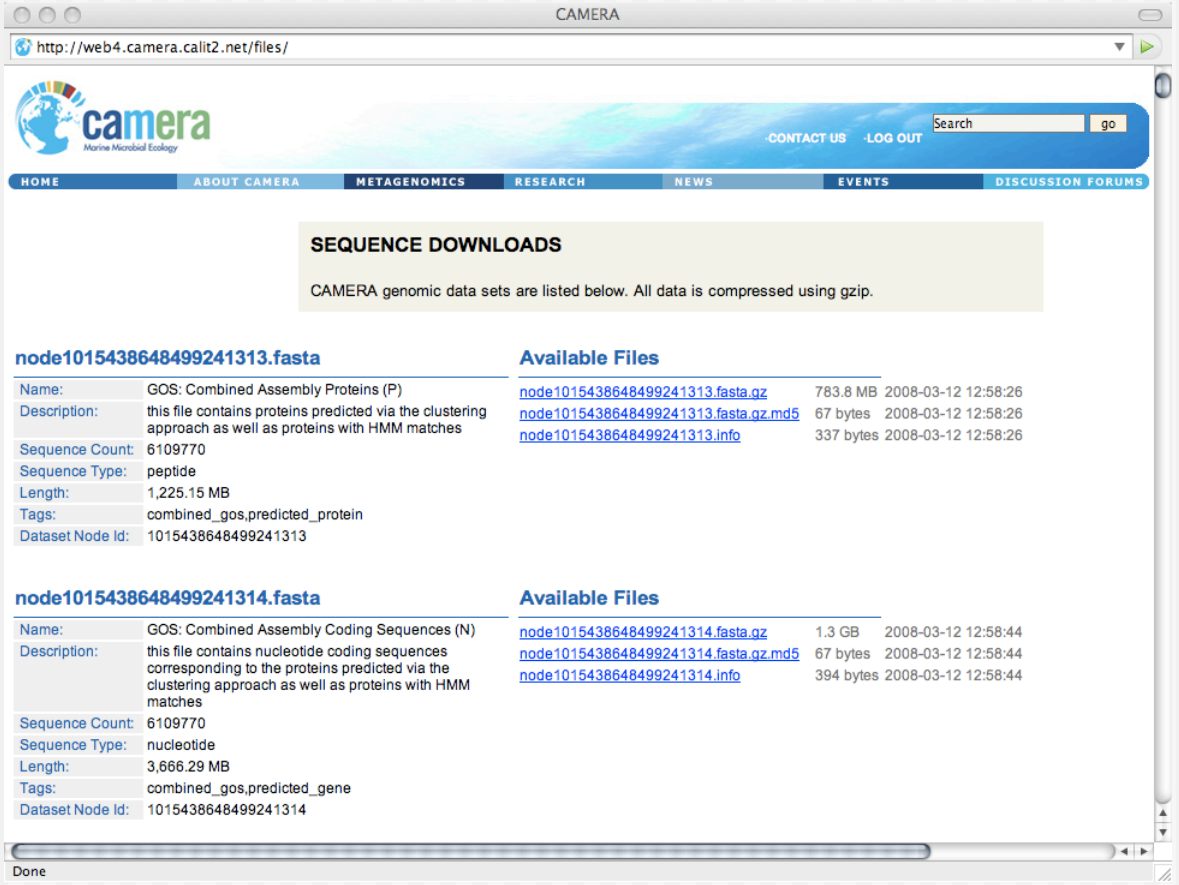
Done



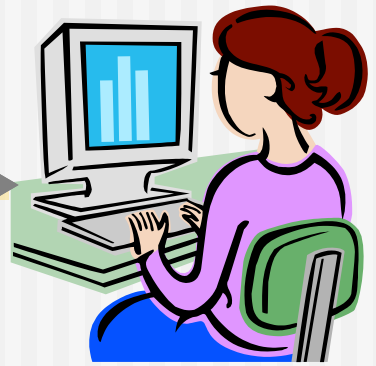
Results



Download Datasets
(simple http server)



Logical Layout of Servers



Single Sign On Layer

Web Server

Portal Server (Tomcat)

Single Sign-on Server

Public Net

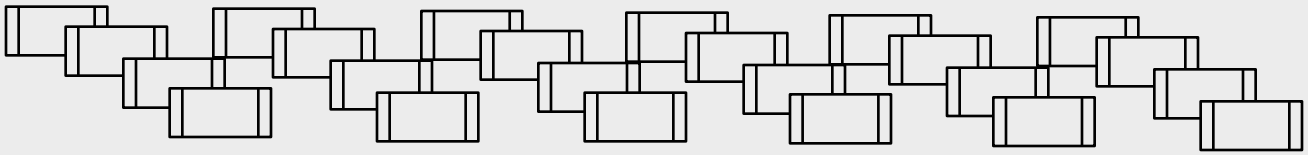
Private Net

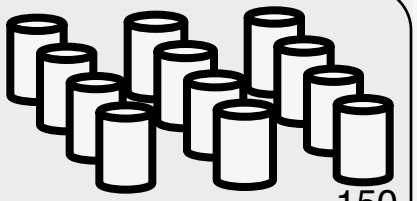
Cluster Frontend

Blast Master (Jboss)

Postgres Database

GAMA Server

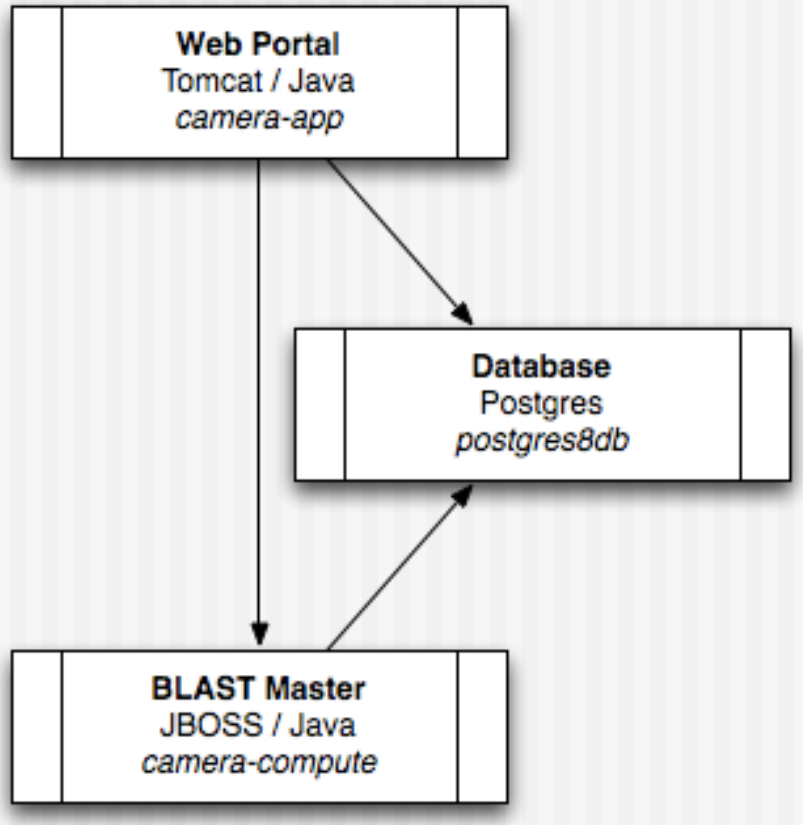




Cluster Nodes and File Servers

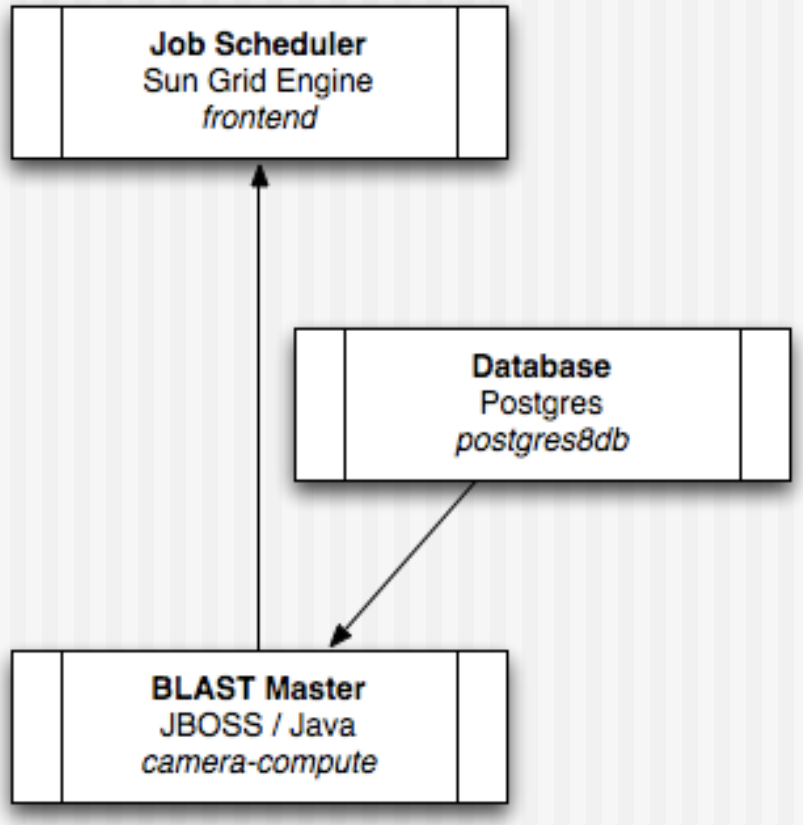
Portal/Database/Blast Server Interactions

- Portal is a Tomcat Java application. (camera-app appliance)
  - All data presented in the portal is kept in a Postgres Database
- When a BLAST job is submitted, control of the job is handed to a JBOSS application (Camera-Compute)
- The Camera-Compute formats a batch job and submits to the cluster frontend via DRMAA interface

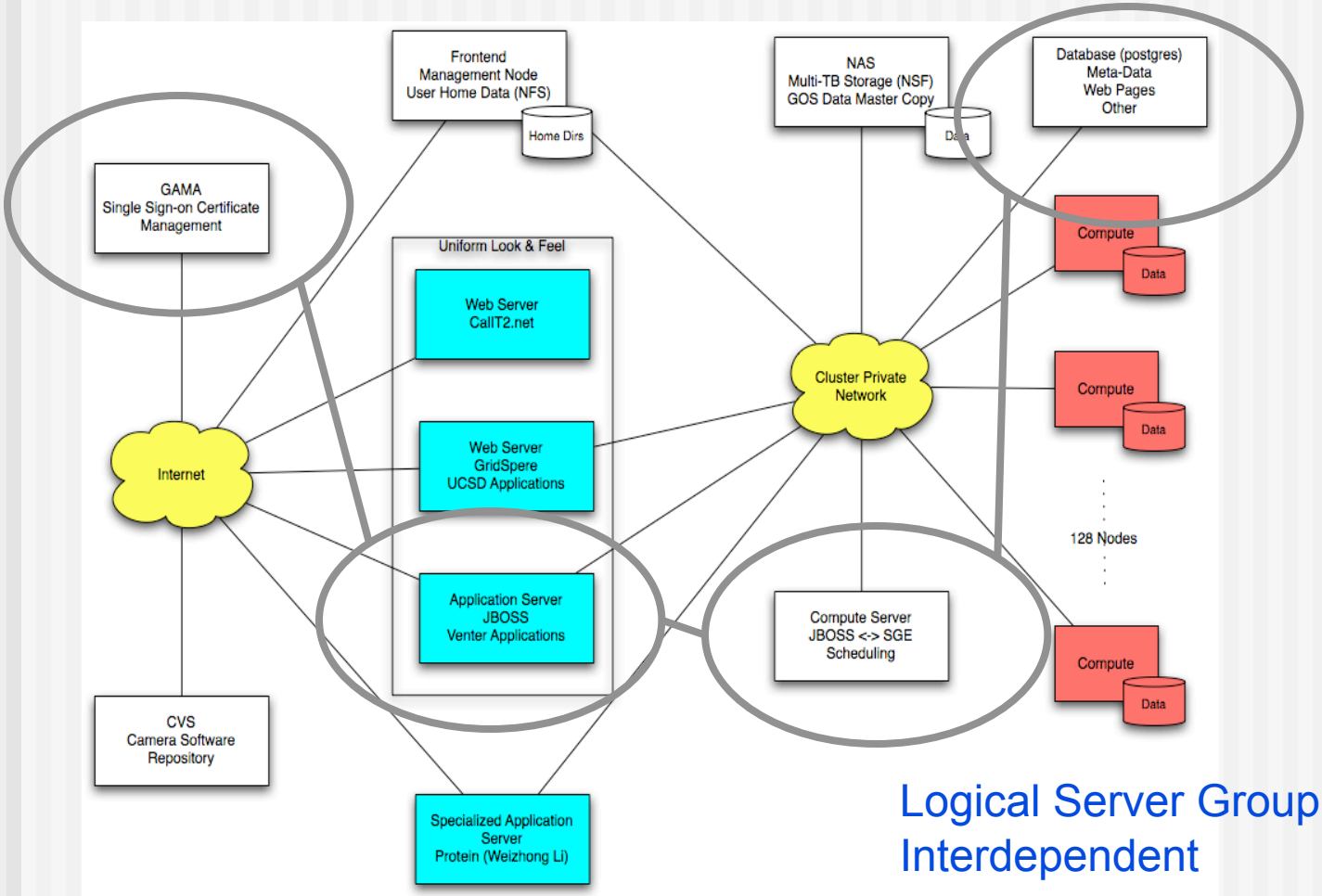


Compute Server Segmenting

- Blast Master receives job request from Portal Server
- Reads from Postres Database how Blastable files have been segmented
  - All ORFs – 134 Segments
  - All Reads – 84 Segments
- An SGE Array Job is send to the queue master for submission to compute cluster
- Raw Results are stored in the file system



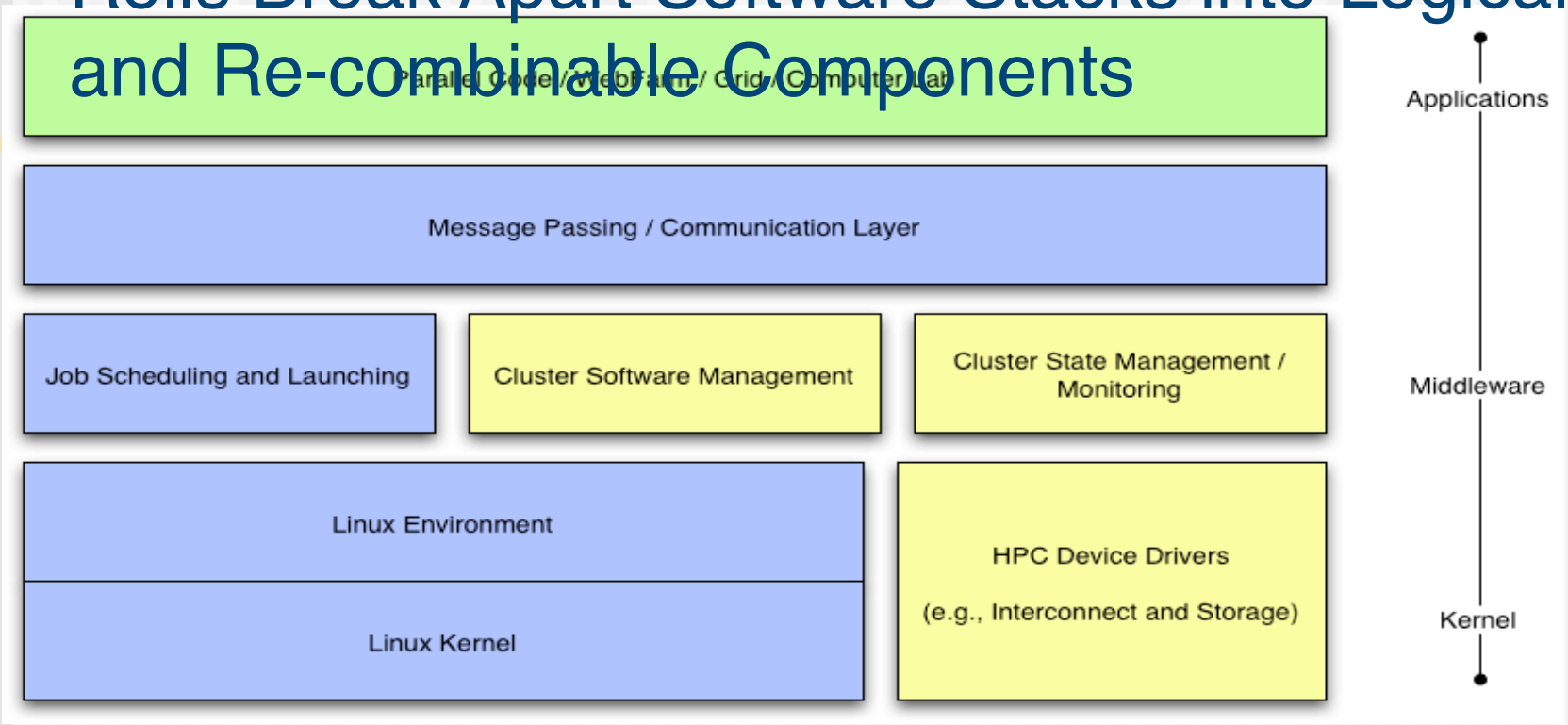
CAMERA System Architecture. A Modestly Complex Grid Endpoint

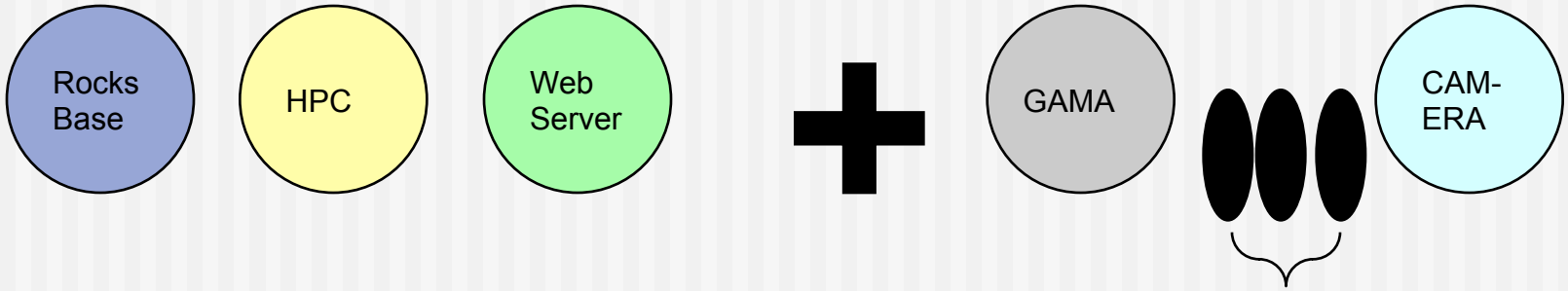


Using Rocks to Manage Complete Deployment

- Production CAMERA is deployable by one system engineer
- We have to support three phases of software development
  - Development
  - Staging (Testing)
  - Production
- Development is a done on a completely separate cluster
  - Development in rockscluster.org domain
  - Production/Staging in camera.calit2.net domain
  - All share the same GAMA (Certificate Authority) server

Rolls Break Apart Software Stacks into Logical and Re-combinable Components

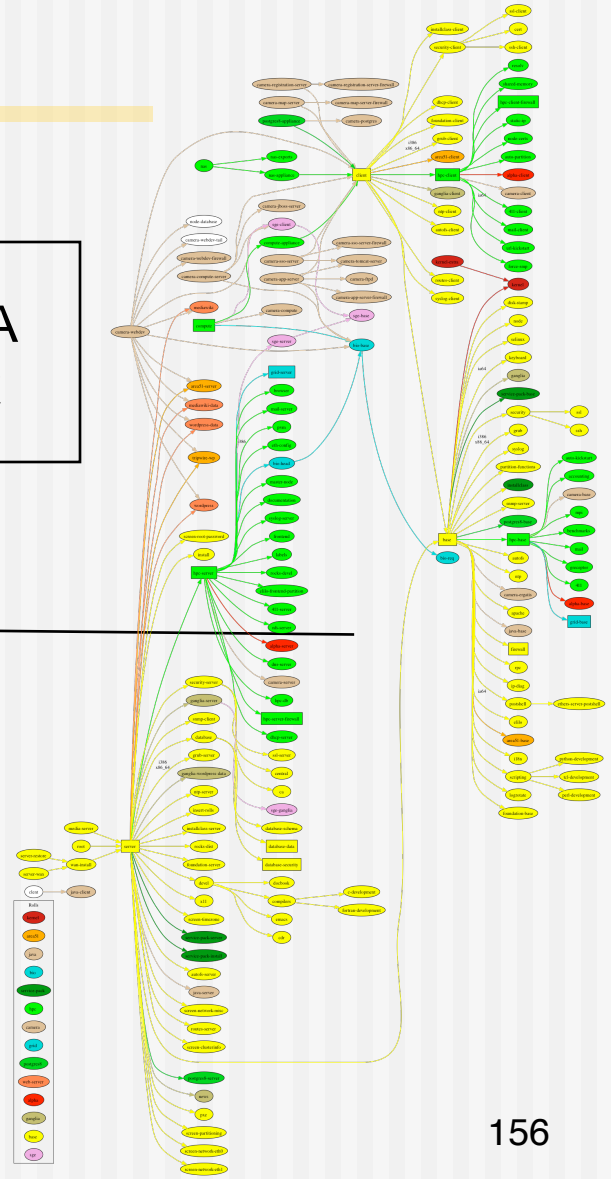




Why CAMERA is not too different

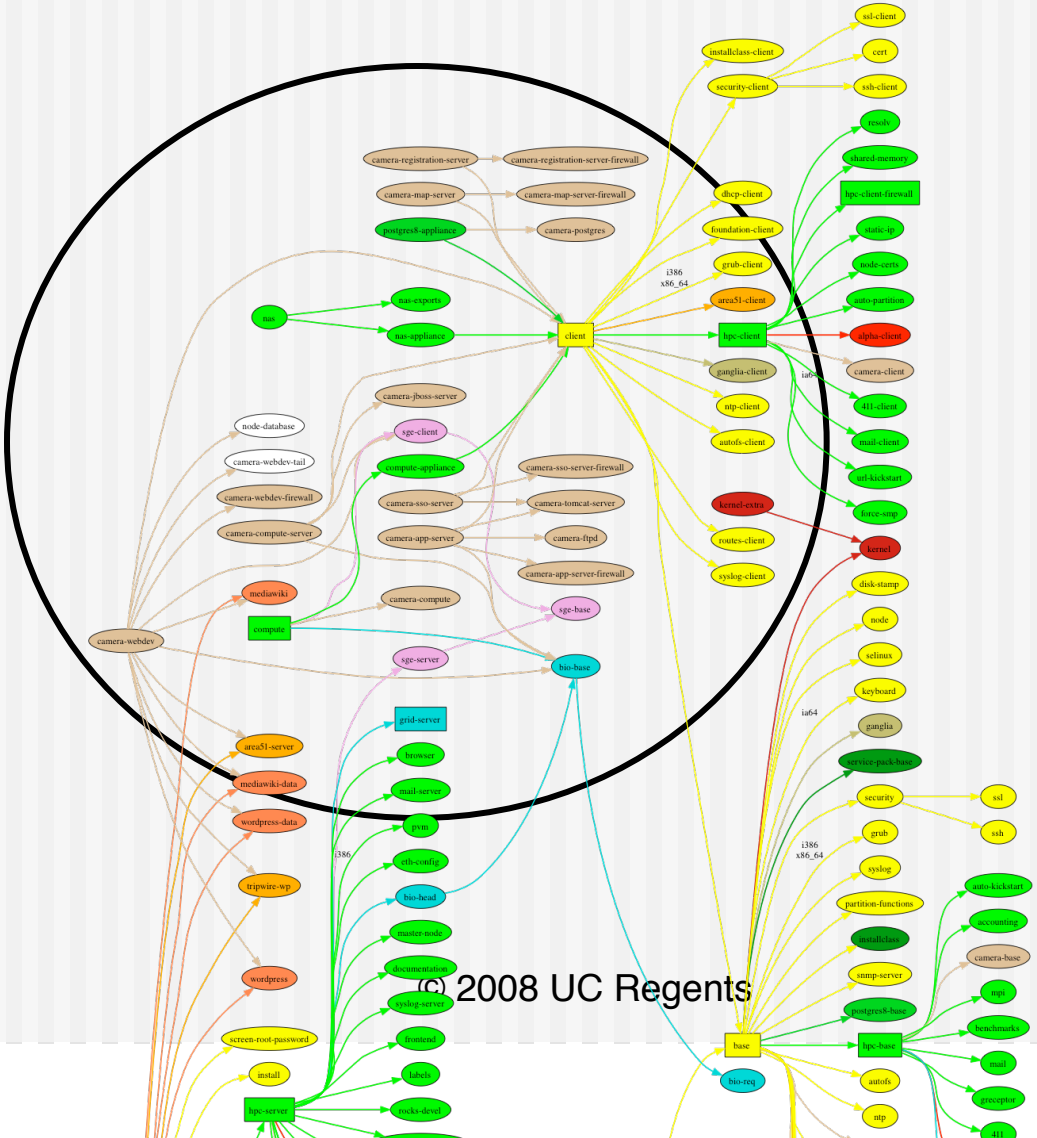
Standard Compute Cluster

CAMERA Complex

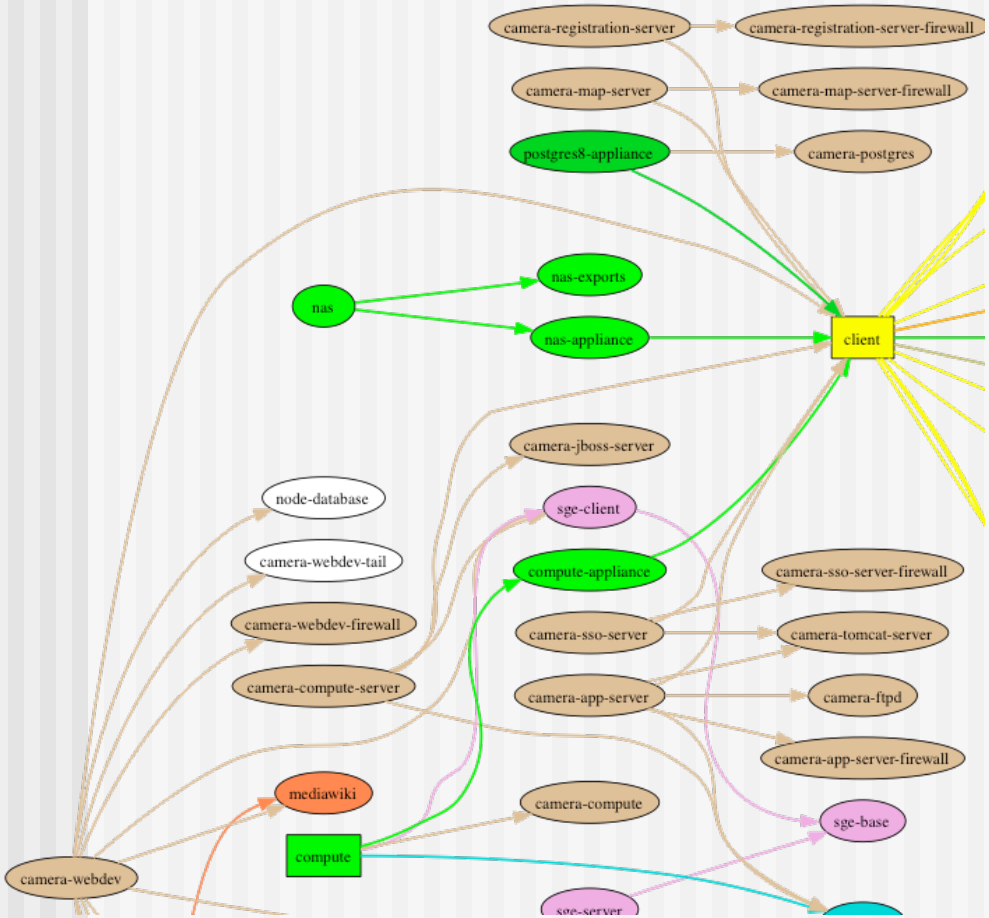


Configuration Graphs Describe how to build a complex of clusters

CAMERA Graph In Detail



How the Different Appliances Are Defined



- Appserver
  - FTP server
  - App server Firewall
  - Tomcat Server
  - Bio Roll Base
  - Client
- Camera Compute Server
  - SGE Client
  - Jboss Server
  - Bio Roll Base
  - Client
- Cluster Compute Node
  - Bio Roll Base
  - Camera Compute addons
  - SGE Client
  - Compute-Appliance → Client

Inside the Camera-app-server - Packages

```
<kickstart>
        <package>cameraweb</package>
        <package>cameraweb-jaas</package>
        <package>gama-sso-client</package>
        <package>postgres8</package>
        <package>libungif</package>
        <package>fonts-xorg-75dpi</package>
        <package>Xaw3d</package>
        <package>emacs-common</package>
        <package>emacs</package>
        <package>emacs-el</package>
        <package>emacs-nox</package>

</kickstart>
```

- 3 Camera Specific
- One generic, but different version
- Remainder are standard RedHat packages

Inside the Camera-app-server - Config

```
<post>
<file name="/etc/fstab" mode="append">
<var name="GAMASSO_filestore-server"/>:/var/tmp/gama   /var/tmp/gama  nfs
   ro,soft,actimeo=3        1 1
</file>
/sbin/chkconfig --add gama-sso-client

<file name="/opt/tomcat/webapps/cameraweb/WEB-INF/classes/camera.properties">
<eval>
file=/opt/tomcat/webapps/cameraweb/WEB-INF/classes/camera.properties
/opt/rocks/bin/rocks list camera javaprops $file
</eval>
</file>
chown 412.412 /opt/tomcat/webapps/cameraweb/WEB-INF/classes/camera.properties
```

- Mount the single-sign-on file system from the SSO server
- Localize the Cameraweb java application

How to Handle Java Application Location

- Many Java applications have properties files that are read to define localization
  - Where to find files
  - Location of support servers
  - Debug level
- The CAMERA Blast Portal has over 50 localized variables
  - Editing manually can lead to higher error rates
- Variables are different for Production, Development, and Staging

Camera.properties File Rewriting

Original file with paths defined in developers environment

```
…
# DRMAA Blast Merge/Sort settings
BlastServer.GridJavaPath=/usr/local/bin/java
BlastServer.GridMergeSortClassPath=/project/camera/runtime-shared/1.0.x/jars/
   camera-blast-grid-merge.jar
BlastServer.GridMergeSortProcessor=org.jcvi.camera.shared.blastxmlparser.Blast
   GridMergeSort
BlastServer.GridMergeSortMinimumMemoryMB=384
…
```

Deployed file with paths defined for production environment

```
…
# DRMAA Blast Merge/Sort settings
BlastServer.GridJavaPath=/usr/java/jdk1.5/bin/java
BlastServer.GridMergeSortClassPath=/opt/camera/camera-blast-grid-merge.jar
BlastServer.GridMergeSortProcessor=org.jcvi.camera.shared.blastxmlparser.Blas
   tGridMergeSort
BlastServer.GridMergeSortMinimumMemoryMB=384
…
```

Generic Properties (Not Just Java)

- The Rocks Database is the Master Record for variables
  - Any variables set in a configuration file are defined here
- Key, Value table (app_globals) has four critical fields
  - Appliance, Service, Key, Value
- For example
  - 0 (0 = valid for any appliance, >0 for a particular appliance only)
  - /opt/tomcat/webapps/cameraweb/WEB-INF/classes/camera.properties
  - BlastServer.GridJavaPath
  - <indirect service="CAMERAETC" component="JavaPath"/>

<indirect> Construction

- In Building CAMERA we found that
  - Many different (non-Rocks) components needed the identical value
  - E.g.
    - Cameraweb application needed name of SSO server
      - /etc/fstab also needed name of SSO server
    - Cameraweb needed name of Database server and connection info
      - So does the Jboss Compute server
      - So does an Administrative (read-only) console
  - Production/Staging environments required small changes
    - Staging Server needed it a Staging (test) database
    - Most other variables were identical with production version
- <indirect>
  - In the “value” part of the database.
  - Acts a data pointer to another [Service, Key, Value] triplet
  - When a non-zero appliance is supplied, can overwrite for the generic version

Using <indirects>

- Rocks de-references all indirects at kickstart generation – application/roll developer need not know about indirects.
- Available `as <var name="Service_Component">`
  - Appliance-specific overrides are handled automatically
- From appserver definition

```
<var name="GAMASSO_filestore-server"/>:/var/tmp/gama   /var/tmp/gama  nfs    ro,soft,actimeo=3
    1 1
</file>

+---------+-----------------+-------------------------------------------------------------------+
| service | Component       | value                                                             |
+---------+-----------------+-------------------------------------------------------------------+
| GAMASSO | filestore-server | <indirect service="GAMASSO" component="PrivateHostname"/>       |
| GAMASSO | Debug           | false                                                             |
| GAMASSO | FileDirectory   | /var/tmp/gama                                                     |
| GAMASSO | CookieName      | gamasso                                                           |
| GAMASSO | PrivateHostname | <indirect service="CAMERAHOSTS" component="SSOServerPrivate"/> |
| GAMASSO | SiteDomainname  | camera.calit2.net                                                 |
+---------+-----------------+-------------------------------------------------------------------+
```

- Filestore_server is double indirect as
  - CAMERAHOSTS, SSOServerPrivate

Production and Staging Hosts

Membership	service	Component	value
0	CAMERAHOSTS	AppServer	web.camera.calit2.net
13	CAMERAHOSTS	AppServer	web3.camera.calit2.net
14	CAMERAHOSTS	AppServer	web3.camera.calit2.net
0	CAMERAHOSTS	ComputeServerPrivate	computeserver-0-0
13	CAMERAHOSTS	ComputeServerPrivate	computeserver-test-0-0
14	CAMERAHOSTS	ComputeServerPrivate	computeserver-test-0-0
0	CAMERAHOSTS	ForumsServer	web7.camera.calit2.net
0	CAMERAHOSTS	GamaServer	gama-camera.rocksclusters.org
0	CAMERAHOSTS	GridSphereServer	web7.camera.calit2.net
0	CAMERAHOSTS	PostgresServerPrivate	postgres8db-0-3
13	CAMERAHOSTS	PostgresServerPrivate	postgres8db-0-0
14	CAMERAHOSTS	PostgresServerPrivate	postgres8db-0-0
0	CAMERAHOSTS	PRWebServer	camera.calit2.net
0	CAMERAHOSTS	SSOServer	web6.camera.calit2.net
0	CAMERAHOSTS	SSOServerPrivate	sso-0-0.local

13 == Appserver Testing Appliance
14 == Computeserver Testing Appliance

Summary of Layout

- Different servers must be applied as a group
  - [application, camera compute, database, SSO]
  - We have production and staging (test) versions
- Configuration variables are held in a database
  - Data “pointers” are supported using <indirect>
  - Rocks Kickstart framework dereferences all <indirect> statements
- Today, there are 142 direct and indirect references in our Configuration Database
  - 72 of these are <indirects>

Viz & CAMERA Taught Us

- Viz and CAMERA helped Rocks
  - Better abstractions in XML
  - Learned new ways to use the existing framework
- We were surprised at
  - How small the differences are between Viz, CAMERA, and HPC Clusters
  - How well our framework supported such functionally different systems