

NPACI Rocks: Tools and Techniques for Easily Deploying Manageable Linux Clusters

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NPACI Rocks Is Made Possible By ...

- UC Berkeley

- David Culler

- * Co-Principal Investigator for the *Network of Workstations* and *Millennium* projects

- And his talented staff:

- * Eric Frazer
 - * Matt Massie
 - * Albert Goto



- Compaq Computer Corporation

- Especially our account representative Sally Patchen
 - Early access to Itanium and blade servers
 - IA-32 equipment donations
 - Testing of Rocks in corporate environment

- IBM

- Equipment donations through Shared University Research (SUR) program



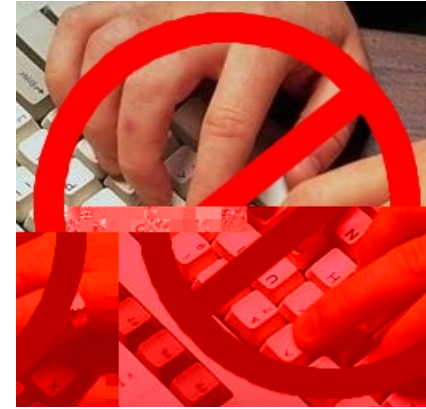
Motivation and Goals

- We Hate System Administration
- Enable Non-Cluster Experts to Run Clusters
 - Should be easy to deploy, expand/contract and manage
- Essential to Track Software Updates
 - Open source moves fast!
 - * Red Hat 6.2: 191 updates
 - * Red Hat 7.0: 176 updates
 - * Red Hat 7.1: 91 updates
 - In 177 days, that's 3.5 updates a week!
- Essential to Track Red Hat Releases
 - NPACI Rocks built on top of a full Red Hat release
- Run on Heterogeneous, Standard High-Volume Components



Philosophy

- All nodes are 100% automatically installed
 - Zero hand configuration
 - * All node-local configuration is automatically generated
- NPACI Rocks is an Entire Cluster-Aware Distribution
 - Included packages:
 - * Full Red Hat release
 - * De-facto standard cluster packages (e.g., MPI, PBS, Maui)
 - * NPACI Rocks packages
 - Focus on ease of use for cluster lifecycle
 - * Deployment, management, application development and execution
 - * All services required to install compute nodes, develop and run parallel jobs are bundled in
 - * Initial configuration via simple web page
 - * One CD installs all servers and nodes in a cluster



More Philosophy - Common-Mode Mechanism: Install

- Software Install is the Common Action Performed When:

- First bringing up a cluster

```
# insert-ethers
```

- Replacing a dead server

```
# insert-ethers --replace=<dead-node>
```

- Adding a new server to the cluster

```
# insert-ethers --cabinet=1
```



- We Use the "Install" Mechanism For One More Function: Software Consistency

- Question: "Is server X's software up-to-date?"
- Question: "Is server X's configuration up-to-date?"
- Question: "How do restore server X to the last known-good state?"
- Answers: Reinstall. Wait 10 minutes. "Yes."

Installation Performance

Nodes	Total Reinstall Time (minutes)
1	10.3
2	9.8
4	10.1
8	10.4
16	11.1
32	13.7

- Setup:
 - HTTP server: dual 733 MHz PIII, 100 Mbit Ethernet
 - Compute nodes: 733 MHz - 1 GHz with Myrinet
 - Each node transfers approximately 150 MB of Red Hat packages

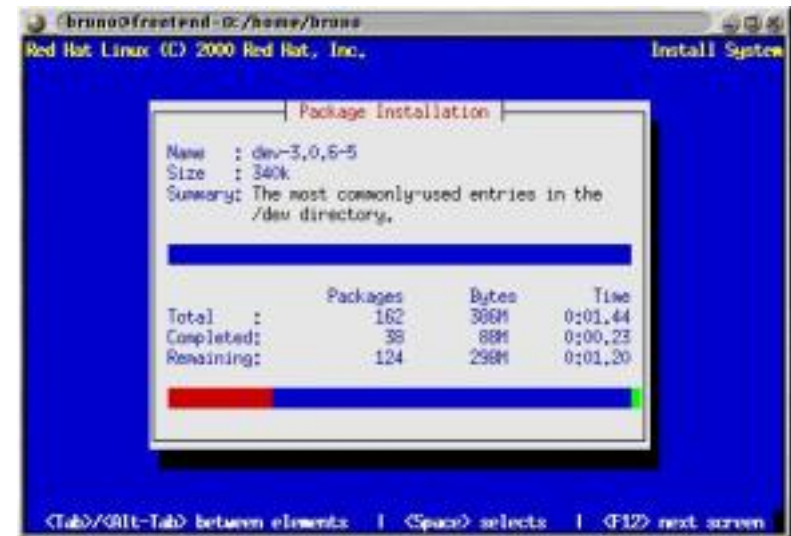


Hardware Configuration

- Minimum Components
 - Server (x86 or IA-64) with a local hard disk
 - Ethernet
 - Power
- Optional
 - High-Performance Network (e.g., Myrinet)
 - Network-Addressable Power Distribution Unit
- Evil Keyboard/Video/Mouse Network Not Required
 - Pros:
 - * Works on all standard high-volume hardware
 - * Don't have to manage yet another (low volume and/or proprietary!) network
 - Cons:
 - * Can't interact with BIOS remotely
 - * Blind until kernel brings up network
 - * Can't interact with installations remotely. Or, can you ...

eKV – Ethernet Keyboard and Video

- Developed eKV to monitor and interact with installations
- After Red Hat's Kickstart brings up the network, one can interact with the installation via telnet
 - Telnet server disabled on normal operation



```
$ telnet compute-1-2 8000
```


Managing Your Software With `rocks-dist`

- Tool to Manage and Customize Your Rocks Distribution
 - Used to keep your distribution up-to-date
 - Used to collect all packages (Red Hat + NPACI Rocks + your own) into a Red Hat++ distribution
 - All the software components that *could be* installed
- Step 1: Mirror

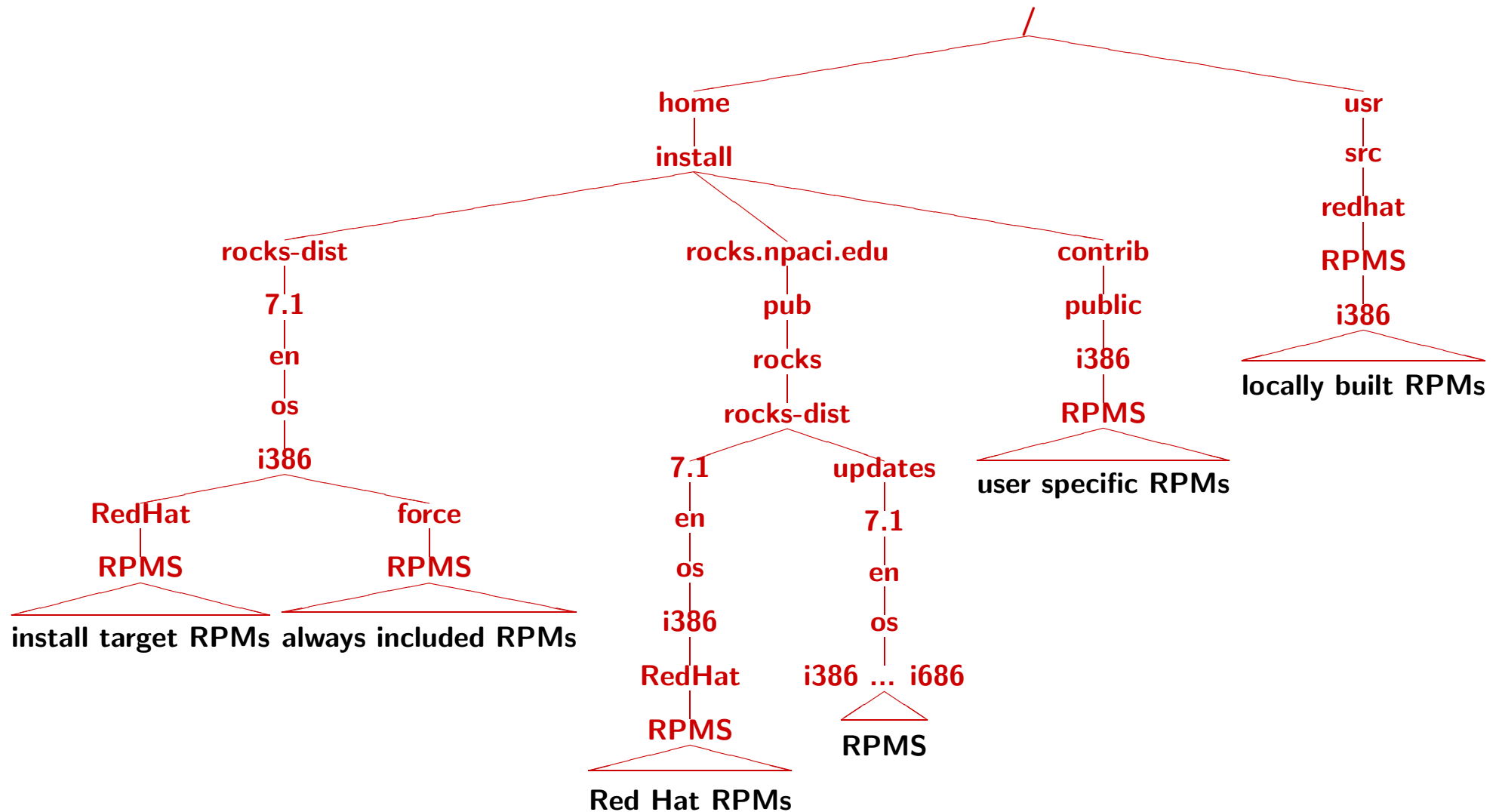
```
$ rocks-dist mirror
```

 - This mirrors the entire Rocks distribution from SDSC
- Step 2: Customize Packages
 - Put in the packages you want
- Step 3: Rebuild Distribution

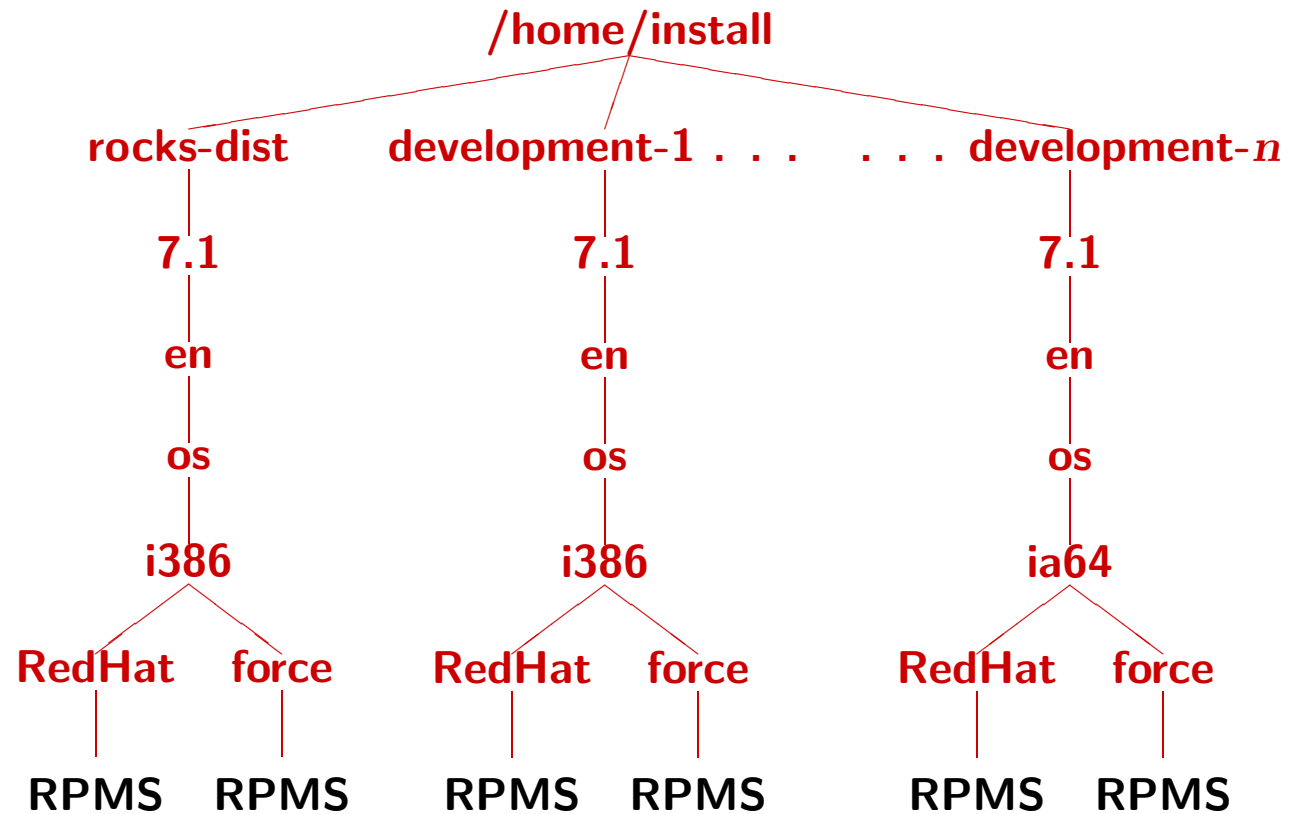
```
$ rocks-dist dist
```

```
$ rocks-dist --dist=development dist
```

rocks-dist – RPM Locations

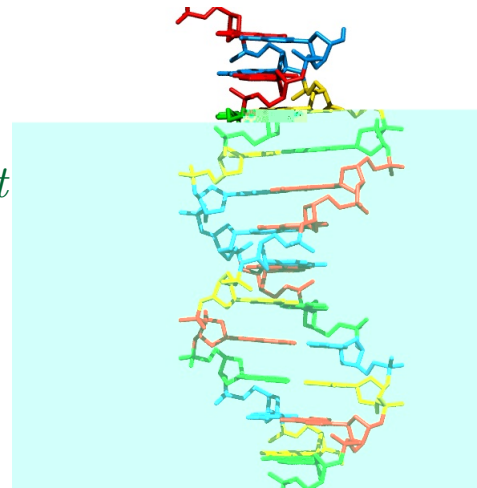


rocks-dist – Default and Development Trees

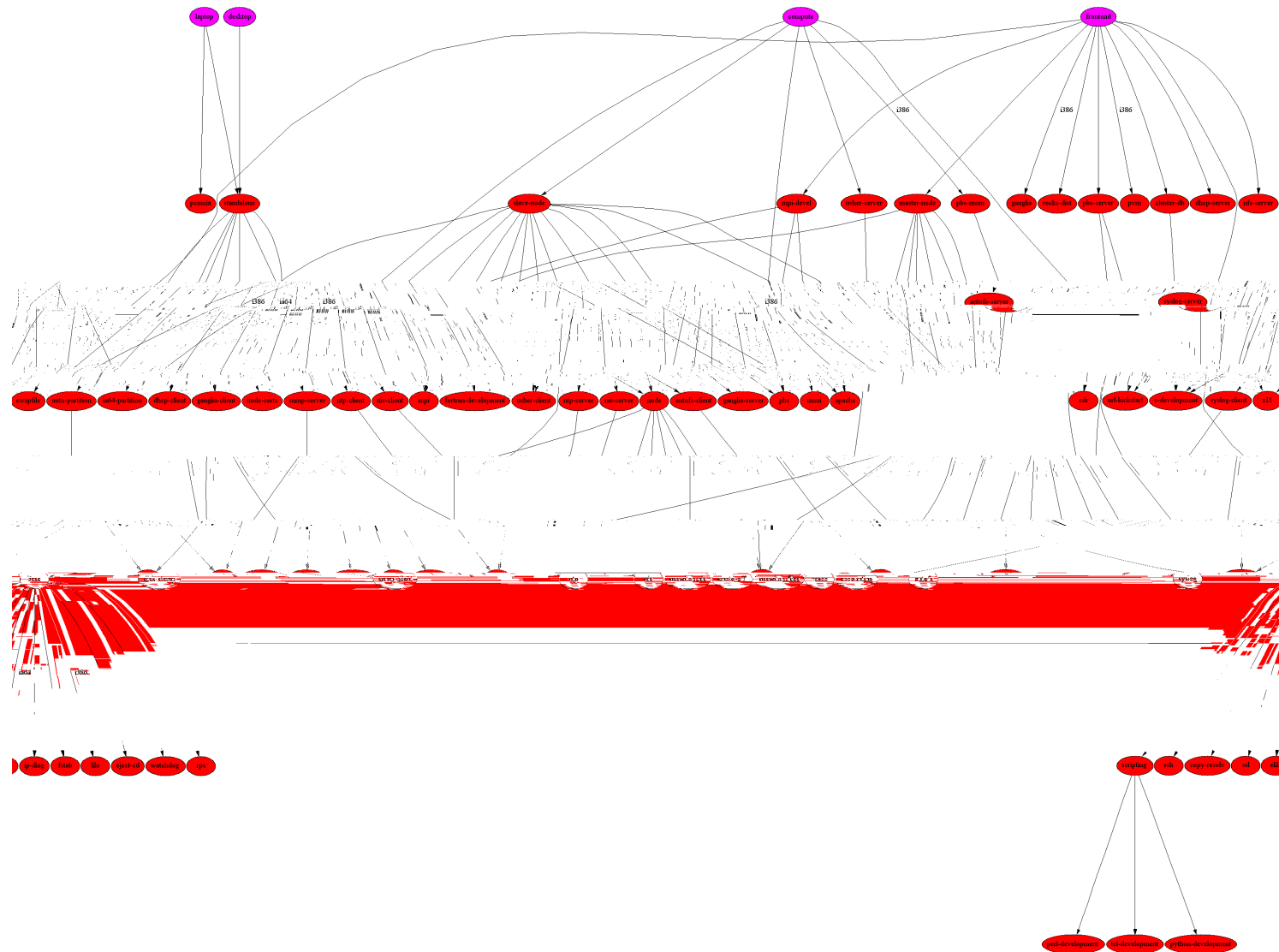


Description-Based Software Configuration

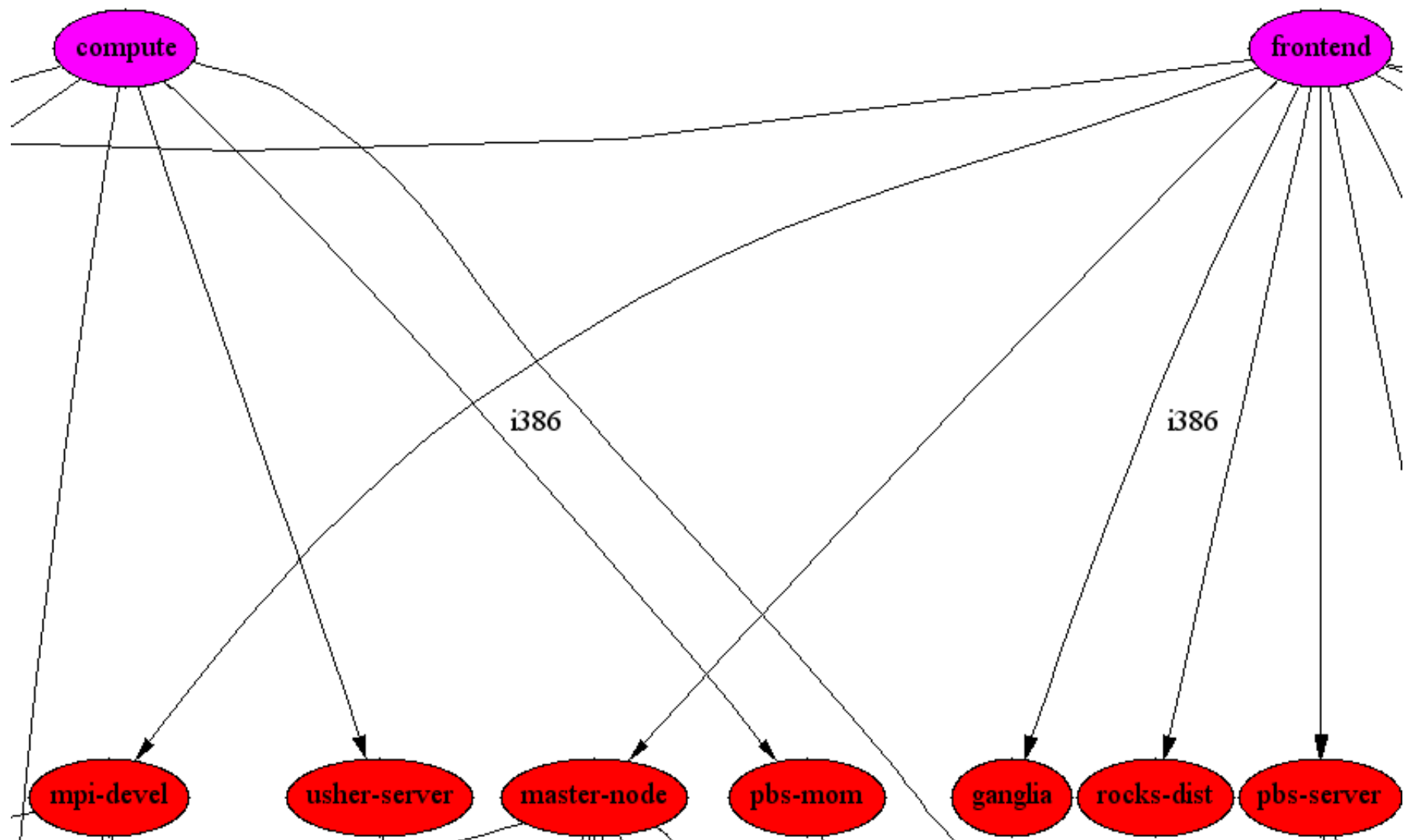
- Built an infrastructure that "describes" the roles of cluster nodes
 - Nodes are installed using Red Hat's *kickstart*
 - Kickstart file: ASCII file with names of packages to install and "post processing" commands
 - NPACI Rocks builds kickstart files on-the-fly tailored for each node
- NPACI Rocks kickstart file is general configuration + local node configuration
 - General configuration is described by modules linked in a configuration graph
 - Local node configuration (applied during post processing) is stored in a MySQL database
- This strategy is extremely flexible
 - Heterogeneous hardware is no harder than homogeneous
 - Straight-forward to customize



General Description Serves Every Cluster Component



Cluster Description – "Appliances"



Cluster Description – Architecture Switches

The Payoff – Integrating Never Before Seen Hardware

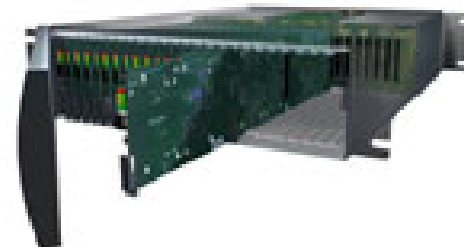
- Dual-Athlon White Box, 20 GB IDE, 3Com Ethernet
 - 3:00 PM: In cardboard box
 - Shook out the loose screws
 - Dropped in a Myrinet card
 - Inserted it into cabinet 0
 - Cabled it up
 - 3:25 PM: Inserted the NPACI Rocks CD
 - Ran `insert-ethers` (assigned node name `compute-0-24`)
 - 3:40 PM: Ran Linpack
- Two IBM Dual-Itanium (IA-64), 18 GB SCSI, Intel Ethernet
 - 2:00 PM: In box
 - 3:40 PM: Debugged problem with nodes and 2.4.6 kernel
 - Downloaded 2.4.9 kernel RPMs from Red Hat's *rawhide* release
 - Rebuilt distribution with `rocks-dist`
 - 4:30 PM: Both integrated into cluster



Both machine types were installed from the same general description

Futures

- IA-64
 - Full IA-64 cluster support (frontend and compute nodes) to be released Nov '01
- Pre-Execution Environment (PXE) Boot
 - Nice for newer rack-mounted servers, but essential for blade servers
 - * Blade servers: CPU + Disk + Ethernet + Proprietary Mgmt Network
 - Will look like any Rocks cluster, as all our tools run over Ethernet
 - Release: Nov '01
- Infiniband Interconnect
- Grid Tools (Development and Testing) -
Rocks is one of many good targets for grid software
 - Globus
 - Grid research tools (APST)
 - Gridport toolkit



Status

- Growing User Base: academic, government and industrial sites around the world
 - We've installed 6 clusters at UCSD
 - * Our cluster, "Meteor", is a 100-node cluster
 - * Currently building out two 128-node clusters for the Scripps Institute of Oceanography
 - Pentium, Athlon, IDE, SCSI, Integrated RAID, Lots of Ethernet chips, Myrinet
- Freely Downloadable ISO Image
- All NPACI Rocks developed code is released in binary and source Red Hat packages

<http://rocks.npaci.edu>

