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

<table>
<thead>
<tr>
<th>Nodes</th>
<th>Total Reinstall Time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.3</td>
</tr>
<tr>
<td>2</td>
<td>9.8</td>
</tr>
<tr>
<td>4</td>
<td>10.1</td>
</tr>
<tr>
<td>8</td>
<td>10.4</td>
</tr>
<tr>
<td>16</td>
<td>11.1</td>
</tr>
<tr>
<td>32</td>
<td>13.7</td>
</tr>
</tbody>
</table>

- **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
  - 7.1
    - en
      - os
        - i386
          - RedHat
            - RPMS
              - install target RPMs
              - always included RPMs
          - force
            - RPMS
    - i386
      - RedHat
        - RPMS
      - contrib
        - public
          - i386
            - RPMS
              - locally built RPMs
        - i386
          - RPMS
            - user specific RPMs
      - rocks
        - rocks-dist
          - 7.1
            - en
              - os
                - i386
                  - RedHat
                    - RPMS
                  - force
                    - RPMS
          - updates
            - 7.1
              - en
                - os
                  - i386
                    - i686
                      - RPMS
                        - Red Hat RPMs
rocks-dist – Default and Development Trees

/home/install

rocks-dist

development-1

development-n

7.1

en

os

i386

RedHat

force

RPMS

RPMS

7.1

en

os

i386

RedHat

force

RPMS

RPMS

7.1

en

os

ia64

RedHat

force

RPMS

RPMS
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

slave-node

i386
ia64
i386

ia64-partition
dhcp-client
ganglia-client
node-certs
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