Virtual Clusters Over Multiple Institutions

Adrian Ho
About Me

- 3rd year at the University of California San Diego
- Computer Engineering major
- PRIME program
Project Proposal

• Create a Virtual Cluster using resources from multiple institutions
  – Use Rocks Cluster system to deploy virtual machines
  – Create the virtual network using PIAX+OpenVPN

• Test Virtual Cluster using DOCK as a testing application
Background: Cluster Computing

- Cluster - a set of computers referred to as nodes
- Organized as one Head Node with the remaining nodes as Compute Nodes
- Has ability to run applications on multiple nodes at once
Background: Grid Computing

- Collection of the computing resources of many clusters
- Useful for running applications that are computationally heavy
- Heterogeneous in nature
  - Every cluster is not required to have the same set of software installed
Background: DOCK

- Receptor ligand virtual screening simulator
- Tests how well millions of ligands and one receptor fit together
- Assigns a score/rating based on fit
Motivation for making Virtual Clusters

• The heterogeneity of a grid computing environment can cause problems when running certain applications

• Virtual Clusters remove heterogeneity of a GRID computing environment

• Test Application: DOCK (dock.compbio.ucsf.edu)
Physical Cluster

- Physical computer nodes
- Connected with wired network
- Generally, nodes are close to each other
Difference between a Physical Cluster and a Virtual Cluster

Physical Cluster
- Nodes are physical machines
- Networked together using a physical Ethernet switch

Virtual Cluster
- Nodes are virtual machines
- Networked together using virtual network technology
Virtual Cluster built over physical clusters at Osaka University and UCSD

• Used Osaka University's Network Solution

• Virtual machines deployed using Rocks Clusters (www.rocksclusters.org) system already installed on both clusters

• Virtual network created using:
  – PIAX (www.piax.org)
  – TCP Tunnel Agent written by Kusumoto Yasuyuki
  – OpenVPN (www.openvpn.net)
Rocks Cluster System

• Cluster management system
• Reason we used Rocks:
  – Easily deploy virtual machines
  – No need to prepare virtual machine hard disk files or configuration files
PIAX

- P2P overlay network
- Reason we used PIAX:
  - Open source
  - Potential for scalability
  - Fault-tolerant
- Agent Platform
  - More easily deploy TCP tunnel
OpenVPN

• Virtual Private Network technology
• Reason we used OpenVPN:
  – Foundation for structured connections between virtual nodes
  – Free
  – Scalability
  – Secure
<table>
<thead>
<tr>
<th>Clusters used at Osaka University and UCSD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Qoo</strong></td>
</tr>
<tr>
<td>• Osaka cluster</td>
</tr>
<tr>
<td>• 4 virtual nodes</td>
</tr>
<tr>
<td>– 1 head node</td>
</tr>
<tr>
<td>– 3 compute node</td>
</tr>
<tr>
<td><strong>Cylab</strong></td>
</tr>
<tr>
<td>• UCSD cluster</td>
</tr>
<tr>
<td>• 3 virtual nodes</td>
</tr>
<tr>
<td>– 3 compute nodes</td>
</tr>
</tbody>
</table>
Results

- Virtual network was slow
- Initial tests using ping showed:
  - High latency
  - 15% average packet loss
Demo
Results continued

- High latency will multiply the time needed to run DOCK
- Dropped packets risks the loss of data and potential results for DOCK
- Conclusion: PIAX cannot be used as the virtual network of a Virtual Cluster over multiple institutions
Reasons for PIAX failure

- Not all nodes in a PIAX network know of every single node
- In that case, nodes must connect through at least one other node
- Example: compute-0-1-0 in UCSD connects to compute-0-0-0 in Osaka to connect to compute-0-5-0 in UCSD
Future Goals

• Look into alternative P2P overlay networks to use as the virtual network for a Virtual Cluster over multiple institutions
• Create a Virtual Cluster over multiple institutions that matches the performance of a physical cluster
Acknowledgments

• UCSD
  – Dr. Gabriele Wienhausen
  – Dr. Peter Arzberger
  – Teri Simas
  – Dr. Jason Haga
  – Wen-wai Yim

• Osaka University
  – Dr. Susumu Date
  – Kei Kokubo

• National Science Foundation, IOSE-0710726
• Calit2
Questions?