Linux in Engineering Education

Dr. Alexei Kotelnikov
Professor Doyle Knight
School of Engineering, Rutgers Univ.

Presented at RITE conference 05/13/2004
Overview

- Linux in Engineering Computing
- Linux in Undergraduate Education
- Linux in Graduate Education and Research
- Prospective for Future Development
- Discussion
What is the role of Linux in Engineering Computing?

- Engineering analysis and design
- Smaller companies: ELS, OTEC …
- Research

Brands: Boeing, Hess, Chrysler, Los Alamos, Sandia, NASA
Examples of software used by engineers for analysis and design:

- ProEngineer
- Fluent
- Matlab

Point: Commercial engineering design codes run under Linux ...
Research

- Need for High Performance Computational resources

Great Performance

- high maintenance cost

Good performance

- low maintenance cost
Engineer in Computational or IT field needs to know

At a minimum:
Graduate engineers need to know how to effectively use Linux system

But more importantly:
Graduate engineers need to know how to configure and administer Linux desktops, servers, and high performance computational clusters

Why? ~40% of new jobs are in small companies (< 50 employees)
Researcher in Engineering needs to know

- Your work will be done on a cluster
- You may have to assemble your own cluster
Undergraduate Education

- Unisys Scholars Program
- Linux course, Linux for Engineering and IT applications, http://linuxcourse.rutgers.edu
- Summer Governor School
Unisys Program of Excellence

- **Year 2001:** Prof. D. Knight submitted proposal to Unisys Corporation.
- **Objective:** Select talented MAE and ECE students to learn IT over the junior or senior year; financial support from Unisys Corporation. In 2003, we had 27 applications for 4 positions.
- **AY 01/02:** the first Unisys Scholar, J B Kim
- **AY 02/03:** two Unisys Scholars, Christopher Lilgeberg and Mike Miller
- **AY 03/04:** four Unisys Scholars, Malik Khan, Paul Arias, Lucas Machado, Diane Palla
Unisys Program

- **Fall semester:**
  - Learn advanced Linux Administration

- **Spring semester:**
  - Final Project
  - TA for the Linux course

- Seniors are qualified for J.J. Slade scholars nomination
Built in January 2002
- 16 desktops
- 16 cluster nodes
- Private network
- Servers
- DHCP, NFS, Apache
Unisys Projects

- **2002:**

- **2003:**
  - **Windows/Linux Unified Authentication** by Mike Miller;
  - **Parallel Computing with Matlab** by Chris Lilgeberg

- **2004:**
  - **Centralized Departmental Printing** by Malik Khan;
  - **Web Interface of Linux Print Server** by Diane Palla;
  - **Parallel Numerical Simulations with MPI and SGE** by Paul Arias;
  - **Centralized Linux Security Server** by Lucas Machado
J B Kim: VPN implementation in cluster computing

- FreeS/WAN
- Private subnets
- SGE cluster
Mike Miller: Windows/Linux unified authentication

<table>
<thead>
<tr>
<th>Software</th>
<th>User Information</th>
<th>Login (Auth)</th>
<th>File Sharing</th>
<th>Print Sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Win</td>
<td>Linux</td>
<td>Win</td>
</tr>
<tr>
<td>Samba</td>
<td></td>
<td>P</td>
<td>P</td>
<td>1/2</td>
</tr>
<tr>
<td>NFS</td>
<td></td>
<td></td>
<td>1/2</td>
<td>P</td>
</tr>
<tr>
<td>Kerberos</td>
<td></td>
<td>P</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>YP/NIS(+)</td>
<td></td>
<td>P</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>LDAP</td>
<td></td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
</tbody>
</table>

\[ P = \text{Secure} \quad \text{\textcolor{red}{P}} = \text{Insecure} \]
Malik Khan: Centralized Departmental Printing

- TCP/IP
- LPRNG
- BOOTP
- TFTP (ACL)
- Printbill
Lucas Machado: Centralized Linux Security Server

- Linux and Windows system logging; send logs to the server
- Log analysis with logwatch
- Linux IDS with LANTrip
- System status monitoring with Nagios
Linux Course

- Linux for Engineering and IT applications, [http://linuxcourse.rutgers.edu](http://linuxcourse.rutgers.edu), taught in Spring Semester 02, 03 and 04
- 16 students in the class
- Special topics in Mechanical and Computer Engineering curriculum
- Attracted ECE and MAE students with interest in server administration and High Performance Computing
Course topics

- **Week 1**: Basic concepts of the operating system
- **Week 2**: System installation configuration and upgrade
- **Week 3**: Linux Networking
- **Week 4**: Network File System (NFS)
- **Week 5**: Network Information Service (NIS)
- **Week 6**: Integrating Linux and Windows (Dual boot, Samba)
- **Week 7**: Shell scripting, startup/shutdown, run levels, scheduled jobs, logging
- **Week 8**: LDAP
- **Week 9**: Security
- **Week 10**: Midterm exam
- **Week 11**: Linux clusters
- **Weeks 12, 13**: Final Projects (LVS and HPC)
Course Final Projects

- **Computational Cluster**
  - NIS, NFS, MPI,
  - Sun Grid Engine (SGE)

- **Linux Virtual Server**
  - Apache, ipvsadm,
  - monitoring tools
Rutgers Governor School of Technology

- Summer 2002 and 2003
- Linux Web Applications by J B Kim, Amit Freeman, and Hun Yi
  [http://remnant.rutgers.edu/gs](http://remnant.rutgers.edu/gs)
  - Linux basic commands
  - HTML
  - PHP
  - MySQL
Future Plans in Undergraduate Programs

- Extend the Unisys Program to a larger number of students; Involve more juniors.

- Modify the Linux course material to include the Linux Professional Institute (LPI) certification program.

- Switch from Red Hat to Debian
Graduate Education and Research

High Performance Computing on a Linux cluster

MPI, OpenMP
MATLAB
GASP
FLUENT
AMBER
NAMD
Cluster parameters

Deployed 2002

44 dual AMD MP 1.6 GHz
8 AMD Athlon 1.2 GHz
8 dual P-III 866 MHz
100 MBit private network
Red Hat 7.3
Sun Grid Engine queue system
MPI, OpenMP, commercial and open source software

http://linuxcluster.rutgers.edu
Future Development in Graduate Research

- High Performance Computing Project (HPCP) courses and workshops for students and faculty: MPI, Globus Toolkit, proposals for NSF PACI.
- Cluster upgrades – AMD Opteron nodes
- New clusters for research labs
Plans for Linux in continuous education courses

- LPI level I (exams 101 and 102); includes 14 topics:
  - Unix commands
  - Devices, File systems
  - Bootup, shutdown, run levels
  - Documentation
  - Administrative tasks
  - Hardware and Architecture
  - Installation, pkg management
  - Kernel
  - Text editing, processing, printing
  - Shell scripting
  - X11
  - Networking fundamentals
  - Network services
  - Security
Concluding remarks and Discussion

- The engineering graduates find the Linux education at SOE very helpful;
  - J B Kim became a Unix engineer at Deutsche bank
- Graduate students take advantage of the Linux computational cluster
- In the future, we plan to offer LPI certification program to undergrads and within Rutgers continuous education
Acknowledgements

- Dr. David Gardner (Unisys Corporation)
- J B Kim (Deutsche bank)
- Amit Freeman (ECE senior)
- Unisys Scholars:
  - Mike Miller
  - Chris Lilgeberg
  - Malik Khan
  - Lucas Machado
  - Paul Arias
  - Diane Palla
- Linux class graduates 02, 03, and 04
- MAE department