

# **Netexplo Research Group Emulation Cluster Guide**

Department of Computer Science  
The University of Hong Kong

Yu Wu, Linqun Zhang, Zhizhong Zhang

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# Chapter 1

## Overview

### 1.1 Architecture

The architecture of the emulation cluster is given in Fig. 1.1.

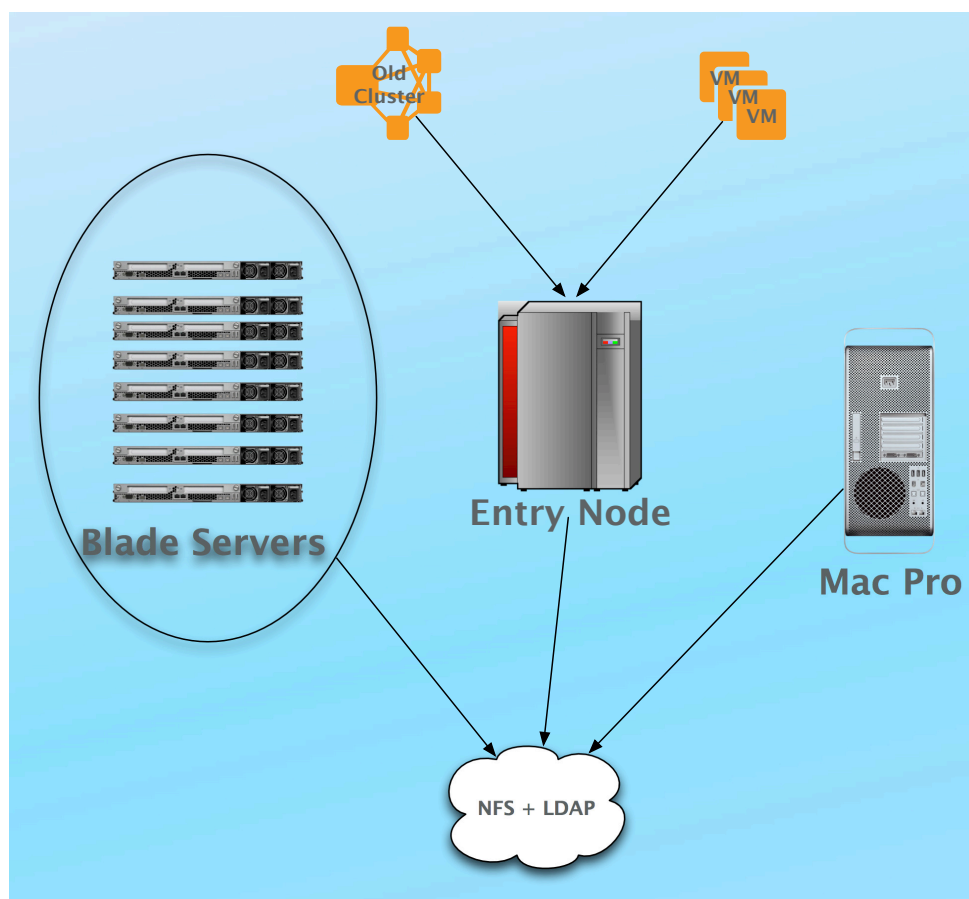


Figure 1.1: Architecture of the emulation cluster.

- **NFS + LDAP**: Dell PowerEdge T410 server at 192.168.1.253 (external IP: 202.45.128.132),

where all users' data are stored. When a user logs in to the cluster via LDAP, NFS directories belonging to the specific authenticated user will be mounted to the machines allocated to the user automatically (a process transparent to the users). The NFS server is configured with RAID-5 for performance optimization and failure tolerance.

- **Entry node:** the gateway to the cluster, which contains two NICs — eth0 and eth1. eth1 is configured with a public IP address (**202.45.128.129**, **ywu-gw.cs.hku.hk**), which is the only entry point to the old cluster and VMs. eth0 is connected to the switch with a private IP address (192.168.1.1). For the same reason, the entry node should only handle necessary external requests and access control functionalities, *e.g.*, firewall. A firewall with default rules has been set up on the entry node, which will be further customized when need arises. **Note: NEVER run any of your simulation/emulation programs on the entry node.**
- **Old Cluster:** all configured with private IP addresses (ranging from 192.168.1.3 to 192.168.1.252). Previously, we hold a bunch of commodity servers as working nodes. Now their functionalities are replaced by the blade servers. There are only 9 nodes left in the old cluster for real-world network experiments.
- **VMs:** Xen virtual machines with IP addresses ranging from 192.168.2.100 to 192.168.2.254. Currently, all virtual machines are hosted in the entry node.
- **Blade Servers:** Eight powerful blade servers for CPU intensive computations and experiments.

Refer to Chapter 4 for hardware details.

## 1.2 Key Services Installed

The important services installed in the emulation cluster include:

1. **FTP** is used to copy disk image for each working node in cases of failure recovery and fast deployment. There are two images: one is for cluster-reserved nodes and the other is for cloud-reserved ones. Compared with other disk ghost method, *e.g.*, “dd”, we think this is the most efficient way after our careful assessment. Using FTP, finer-grained backup can also be achieved for individual working node, and this can be implemented in future if needed.
2. **DHCP** is used to manage and assign IP addresses to machines when they boot up. We set up the simple static mac-IP mapping policy to ease the management and monitoring tasks in a centralized fashion. An alternative policy is to set up an IP pool and dynamically assign each newly-booted machine with an IP within the pre-set range.
3. **LDAP** is in charge of user account management and user authentication. When a user logs in to the gateway (entry node), he will automatically log in to all the machines allocated to him, *e.g.*, he can “ssh” to any allocated machine freely.

4. **Samba** is used for group file sharing across various operating systems. Due to the heterogeneity of operating systems (e.g. Windows, Mac OS X, Linux) that our group members use, samba is the optimal choice to share files within our group.
5. **Mac OS X Remote Desktop** is provided for group members to use the Mac OS X operating system.
6. **OpenMPI** is deployed among the blade servers for high performance computing.

# Chapter 2

## Technical Details of the Emulation Cloud

### 2.1 Gentoo Linux

Gentoo Linux is deployed on all the machines within our cluster, including the entry node, all the commodity servers, all the blade servers, all the VMs. Gentoo is the ultimate Linux distribution designed for extreme performance and customization. Gentoo is also the best way to learn Linux. Group members who are unfamiliar with Linux are strongly recommended to install a Gentoo OS from scratch, following the handbook (<http://www.gentoo.org/doc/en/handbook/>)

### 2.2 Xen-based Virtualization

We include important Xen virtual machine installation techniques in this section.

#### 2.2.1 Hardware Compatibility Test

To support virtualization, the CPU in a machine must, at a minimum, supports Physical Address Extension (PAE). To verify if a CPU supports PAE, run

```
grep pae /proc/cpuinfo
```

To implement full virtualization, the CPU must include intel-VT (vmx) or AMD-V (svm) support, to be verified as follow

```
grep vmx /proc/cpuinfo
```

```
grep svm /proc/cpuinfo
```

Since our machines do not meet this requirement, we implement para-virtualization.

## 2.2.2 OS Modification

Among the free operating systems, Fedora and CentOS both support Xen well (but not for higher versions of Xen). However, Xen can not be launched directly on a standard kernel, since it does not support well enough various hardware configurations, especially new hardwares. We have created a modified kernel based on Fedora 8. As stated earlier, the kernel image for cloud-reversed nodes is stored on the FYP server, and bit-by-bit copied to install on the cloud-reserved working nodes. One thing to note is that, after kernel installation via the network, the IP address and host name should be modified from the default ones in the image, to avoid naming conflict.

We use CentOS with a modified kernel as the guest OS running on top of Xen.

## 2.2.3 Xen Bridging

It will be helpful to gain a deeper understanding on Xen's underlying mechanism of virtualization.

### Xen virtualization mechanism

When xend starts up, it runs the network-bridge script, which:

1. Creates a new bridge named xenbr0
2. "Real" ethernet interface eth0 is brought down
3. The IP and MAC addresses of eth0 are copied to virtual network interface veth0
4. Real interface eth0 is renamed to peth0
5. Virtual interface veth0 is renamed eth0
6. peth0 and vif0.0 are attached to bridge xenbr0.
7. The bridge, peth0, eth0 and vif0.0 are brought up.

When a domU starts up, xend (running in dom0) runs the vif-bridge script, which:

1. Attaches vif<id#>.0 to xenbr0
2. vif<id#>.0 is brought up.

### Xen-bridging configuration

Xen sets default bridge as "eth0", which we should change to bridge to other devices when needed in future by modifying the file `/etc/xen/xend-config.sxp`: uncomment "**network script 'network-bridge netdev=eth1'**" and restart xend. After that, verification can be done by "ifconfig peth1"

## VM's configuration

In our case, we only deal with the “pygrub.cfg” file, which includes

```
vif = ['bridge=eth1, mac = xx:xx:xx:xx:xx:xx']
```

```
disk = ['file /root/centos...]
```

Besides, before launching VMs, make sure SELinux is disabled. To temporarily disable SELinux, run

```
setenforce 0
```

## 2.2.4 Some Tips

### How to install Xen on Gentoo

<http://www.gentoo.org/doc/en/xen-guide.xml>

### How to install paravirtualized DomU via text mode

1. `mount -t iso 9660 fedora-XXX.iso /var/www/html/fedora -o loop, ro`
2. Disable SELinux temporarily by **setenforce 0**
3. Start up Apache by **service httpd start**
4. Disable firewall by **service iptables stop**
5. Check the IP address of virbr0, which by default is 192.168.122.1
6. Install the paravirtualized domU by **virt-install -n fedora -w network:default -p -f /var/lib/xen/images/fedora.img --nographics -r 512 -s 16 -l http://192.168.122.1/fedora/**
7. Enable SELinux by **setenforce 1**
8. Enable firewall by **service iptables start**
9. Disable Apache by **service httpd stop**

For GUI installation, run: **virt-manager**.

## How to start the Xserver after installing Xen

A problem was resolved with “xorg.conf”. The original file of “xorg.conf” is:

```
Section ''Device''
    Identifier  ''Videocard0''
    Driver      ''Intel''
EndSection
Section ''Screen''
    Identifier  ''Screen0''
    Device      ''Videocard0''
    DefaultDepth 24
    subsection ''Display''
        Viewport 0 0
        Depth 24
    EndSection
EndSection
```

which should be modified to

```
Section ''Device''
    Identifier  ''Generic Video Card''
    Driver      ''vesa''
EndSection
Section ''Screen''
    Identifier  ''Screen0''
    Device      ''Generic Video Card''
    DefaultDepth 24
    subsection ''Display''
        Viewport 0 0
        Depth 24
    EndSection
EndSection
```

## How to access the Internet from a VM

1. Set up the IP address and the netmask by running:  
**ifconfig eth0 147.8.177.\* netmask 255.255.252.0**
2. Set up the DNS server by running:  
**echo nameserver 147.8.176.15 > /etc/resolv.conf**
3. Set up the proxy by running:  
**export http\_proxy=http://proxy.cs.hku.hk:8282**



## After cloning the image

After copying the OS image from the FTP server, the cloned machine will show 2 NICs. What we need to do first is to remove the old one which contains the NIC info of the source machine from which the image is made (If needed, remove all the registered NICs). The file is located at `/etc/udev/rules.d/70-net_persistent`.

## 2.3 NFS Service

NFS server is deployed on the Dell file server (192.168.1.253) with OpenSUSE 11. Data files of all users are stored on it and can only be modified by their owners. For users' convenience and security, NFS directories belonging to a specific user will be mounted automatically to every single working node allocated to the user. Although cache is enabled on the local machines, any updates to the data files will be written back to the NFS server. Users' authentication configuration files are also stored on NFS server, which is used for authentication together with the LDAP server.

To enable the NFS server:

1. Edit `/etc/exports`, adding `/export/home (rw)`
2. `chkconfig --level 35 rpcbind on; chkconfig --level 35 nfslock on; chkconfig --level 35 nfs on`

To enable a NFS client:

1. Create the directory `/export/home` (`mkdir -p /export/home`)
2. Add NFS server (Edit file `/etc/fstab`, add one line: `192.168.1.253:/home /export/home nfs defaults 1 1`)
3. Disable selinux by modifying `/etc/selinux`
4. Configure the startup service (`chkconfig --level 35 nsd on; chkconfig --level 35 rpcbind; chkconfig --level 35 netfs on`)

## 2.4 User management based on LDAP

We manage user accounts and implement authentication with *openLDAP*.

### 2.4.1 Configuring LDAP Server

To enable the LDAP server on OpenSUSE 11:

1. disable TLS.
2. Base DN is set as "dc=intgroup, dc=net".

3. Administrator DN is set as “cn=admin”.
4. Database Directory is by default “/var/lib/ldap”, whose type is “hdb”.

When adding or deleting a user:

1. Create the home directory for the user, “mkdir -p /export/home/xxx”
2. Enter the user account panel, filter “LDAP user”
3. Home directory is set to the newly created “/export/home/xxx” with permission “755”

### 2.4.2 Configuring a LDAP Client

1. Configure LDAP client via authorize-gtk, or authorize-cui
2. Choose the option “Use LDAP”
3. Specify the LDAP server, “192.168.1.253”
4. Fill in the LDAP base DN “dc=intgroup,dc=net”
5. Disable TLS/SSL

## 2.5 Installing OS via PXE

Since not all the machines support booting from USB devices, booting via the network is necessary for OS installation from time to time, for which PXE (Preboot eXecution Environment) service is a nice choice. In fact, this is how we set up the old cluster.

### 2.5.1 Configuring PXE Server

To enable PXE server, There are four steps.

1. modify dhcpd.conf, add the following lines:  

```
subnet 192.168.1.0 netmask 255.255.255.0 {  
  range 192.168.1.55 192.168.1.199;  
  option subnet-mask 255.255.255.0;  
  option domain-name “intgroup.net”;  
  next-server 192.168.1.2;  
  filename “/pxelinux.0”;  
}
```

2. configure TFTP server, edit `/etc/xinetd.d/tftp` as follows:

```
service tftp{
  socket_type = dgram
  protocol = udp
  wait = yes
  user = root
  server = /usr/sbin/in.tftpd
  server_args = -s /tftpboot
  disable = no
  per_source = 11
  cps = 1002
  flags = IPv4
}
```

3. Extract the PXE Boot loader archive to folder `/tftpboot`
4. Setup vsFTP server, put `Fedora8.iso` to `/var/ftp/pub/`, so that other machines can access the install files via ftp

## 2.5.2 Configuring a PXE Client

1. Restart the PC;
2. When the Dell's logo shows up, press F12;
3. Choose booting up via NIC;
4. Then the installer will setup Fedora 8 OS automatically.

# Chapter 3

## User Guide

This chapter presents the guidance to use the cluster-reserved nodes for regular simulation/emulation purposes.

### 3.1 How to Access

#### 3.1.1 Within CS Network

To access the Entry Node:

```
ssh username@ywu-gw.cs.hku.hk
```

To access the Blade servers:

```
ssh username@net-bX.cs.hku.hk
```

where **X** could be {1,2,3,4,5,6,7,8}.

Your username is the same as your CS account username, and the default password is "username"+1234. For example, Jian Zhao's username is *jzhao* and the initial password is *jzhao1234*. Note that the ldap password is synced with the samba password, you are not advised to change your password using **passwd**. Instead, you should contact the system administrator (a.k.a. Zhizhong Zhang) to change your password within the ldap server.

#### 3.1.2 Outside CS Network

Group members can access our emulation cloud via CS VPN or SSH port forwarding.

##### CS VPN

See <https://intranet.cs.hku.hk/csintranet/contents/technical/howto/csvpn/win7/install.jsp>

## Netexplo Research Group Emulation Cluster Booking System

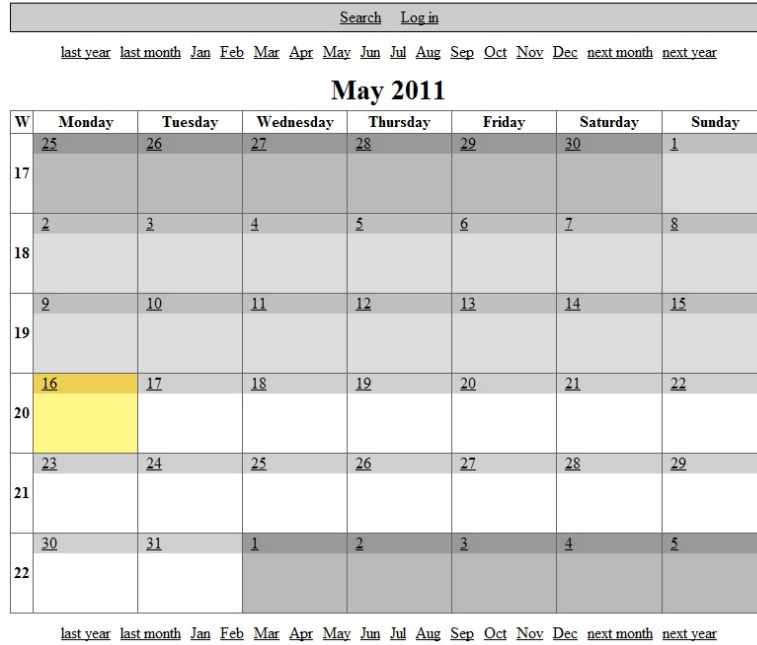


Figure 3.1: Cluster reservation system.

### SSH port forwarding

1. `ssh -L 10022:ywu-gw.cs.hku.hk:22 username@gatekeeper.cs.hku.hk`
2. `ssh -p 10022 username@localhost`

## 3.2 Reservation System

**Update: Anyone within our group is free to use the cluster without reservation, except for the NFS server.**

Before using the cluster, a user is required to book the nodes needed and periods for dedicated usage of those nodes, via the reservation system at <http://202.45.128.129/calendar>. A snapshot of the reservation system is shown in Fig. 3.1.

Steps for making a reservation:

- Log in the reservation system. The user name and password are the same as your account in the cluster, which will be introduced in Sec. 3.1.
- Add a reservation entry by clicking the top right corner ( $\pm$ ) of the time slot(s), in which you wish to use the cluster (Fig. 3.2 ). **You are strongly recommended to check whether your reservation conflicts with those of others.**
- You may edit your reservation entry following what is shown in Fig. 3.3.

## Netexplo Research Group Emulation Cluster Booking System

<a href="#">Add Event</a> <a href="#">Search</a> <a href="#">Log out</a> <a href="#">Calendar Admin</a>							
<a href="#">last year</a> <a href="#">last month</a> Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec <a href="#">next month</a> <a href="#">next year</a>							
May 2011							
W	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
17	25 ±	26 ±	27 ±	28 ±	29 ±	30 ±	1 ±
18	2 ±	3 ±	4 ±	5 ±	6 ±	7 ±	8 ±
19	9 ±	10 ±	11 ±	12 ±	13 ±	14 ±	15 ±
20	16 ±	17 ±	18 ±	19 ±	20 ±	21 ±	22 ±
21	23 ±	24 ±	25 ±	26 ±	27 ±	28 ±	29 ±
22	30 ±	31 ±	1 ±	2 ±	3 ±	4 ±	5 ±

[last year](#)   [last month](#)   Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec   [next month](#)   [next year](#)

Figure 3.2: Cluster reservation system: making a reservation.

## Netexplo Research Group Emulation Cluster Booking System

<a href="#">Add Event</a> <a href="#">Search</a> <a href="#">View Month</a> <a href="#">View date</a> <a href="#">Log out</a> <a href="#">Calendar Admin</a>		
<b>Subject</b>	<input type="text" value="Emulator"/>	
<b>Description</b>	<input type="text" value="Occupy from n200 to n210"/>	
<b>When</b>	<b>From</b>	Date <input type="text" value="2011"/> <input type="text" value="May"/> <input type="text" value="16"/> Time <input type="text" value="8"/> <input type="text" value="0"/>
	<b>To</b>	Date <input type="text" value="2011"/> <input type="text" value="May"/> <input type="text" value="16"/> Time <input type="text" value="15"/> <input type="text" value="0"/>
	<b>Time Type</b>	<input type="text" value="Normal"/>
	<b>Repeats</b>	<input type="text" value="Never"/>
<b>Read-only</b>	<input checked="" type="checkbox"/>	
<input type="button" value="Submit Event"/>		

Figure 3.3: Cluster reservation system: editing a reservation.

There are two ways to access the reservation system from off-campus networks:

1. Start a remote desktop connection to your desktop in the office, then you may use the reservation system via remote desktop.
2. Build a ssh tunnel as follows:
  - a) Open Terminal
  - b) `ssh -L 10002:ywu-gw:80 xxx@gatekeeper.cs.hku.hk` (replace xxx with your CS user name)
  - c) Open browser
  - d) In the address bar, type: `http://localhost:10002/calendar/`  
(you can change 10002 in b) and d) to other available port number on your computer)

### 3.3 How to Deploy your Program in the Cluster

There are currently 9 commodity machines available in the cluster-reserved node group. Their hostnames are *n129*, *n135*, ... *n143*, respectively. If you wish to use node *n136*, you should first log in to the entry node via SSH, then type “ssh n136”, and then you are logged in to node *n136*.

However, the commodity machines are almost obsoleted. Group members are recommended to use the blade servers instead (**net-b1**, **net-b2**, **net-b3**, **net-b4**, **net-b5**, **net-b6**, **net-b7**, **net-b8**).

**Please note: NEVER run any of your simulation/emulation programs on the entry node, which is only meant as an entrance for everyone to access the cluster and is installed with important services to be used by everyone. Running any program on the entry node will lead to significant performance downgrade of the cluster. Log in your reserved working nodes and run your program there instead.**

If you wish to use multiple machines to run the same program, you can do it in the following fashion:

```
[jzhao@net-b5]# for((i=200;i<=223;i=i+1)) do ssh n$i program; done
```

### 3.4 How to Setup a SVN Server

If you wish to set up a SVN server on a machine allocated for your usage (*e.g.*, to maintain the simulation/emulation code you are developing), follow these steps:

1. Suppose that Jian wishes to create a repository for files in the `/src` directory on the machine. First create the directory “`~/src`” by:

```
[jzhao@n0]# mkdir ~/src
```

2. Use the svnadmin command to create the SVN repository within this directory:

```
[jzhao@n0]# svnadmin create /src
```

3. Edit the file svnserve.conf in ~/src/conf to:

```
anon-access = none
auth-access = write
password-db = passwd
```

4. Add user & password into the file passwd in ~/src/conf:

```
[users]
jzhao = password
```

5. Start SVN server by:

```
[jzhao@n0]# svnserver -d
```

## 3.5 SAMBA

Samba service is provided for group members to access our group shared files (such as conference proceedings, paper source TeX files, etc.). You can also use the same username and password to log into the samba file system. Inside the samba file system, you can see your own private directory and a special directory called "share", which is used to share among group members.

For Mac users:

- Go to Finder, click on Go → Connect to Server. (or press **Command + K**)
- Connect to our server by typing "smb://ywu-gw/" (without quotes).
- Log in and choose which directory to mount.

For Windows users:

- Open Windows Explorer
- Type \\ywu-gw, and press enter.
- Log in and choose which directory to mount.

For Linux users:

- Google would be your best teacher.

Note that the "share" directory has sticky bit enabled, which means that a file can only be modified or deleted by its owner(uploader).



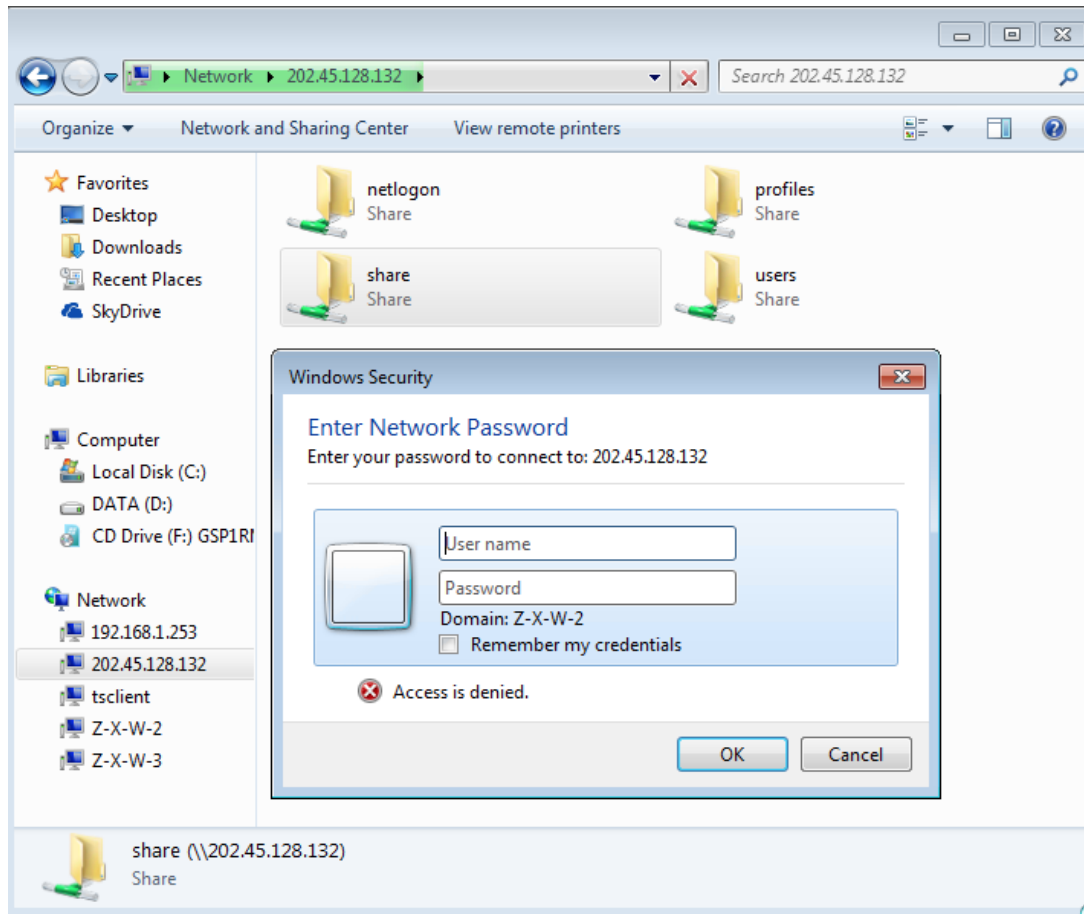


Figure 3.4: Connect to Samba on Windows

## 3.6 Matlab

All Matlab experiments should be performed on **net-b4**.  
To use matlab in console mode:

1. `ssh username@net-b4`
2. `matlab`

To use matlab in X mode:

1. `ssh -X username@net-b4`
2. `matlab-with-x`

## 3.7 Mac Pro Remote Desktop

Group members can make use of the Mac Pro Server ([ywu-mac.cs.hku.hk](http://ywu-mac.cs.hku.hk)) to do all kinds of Mac and iOS developments.

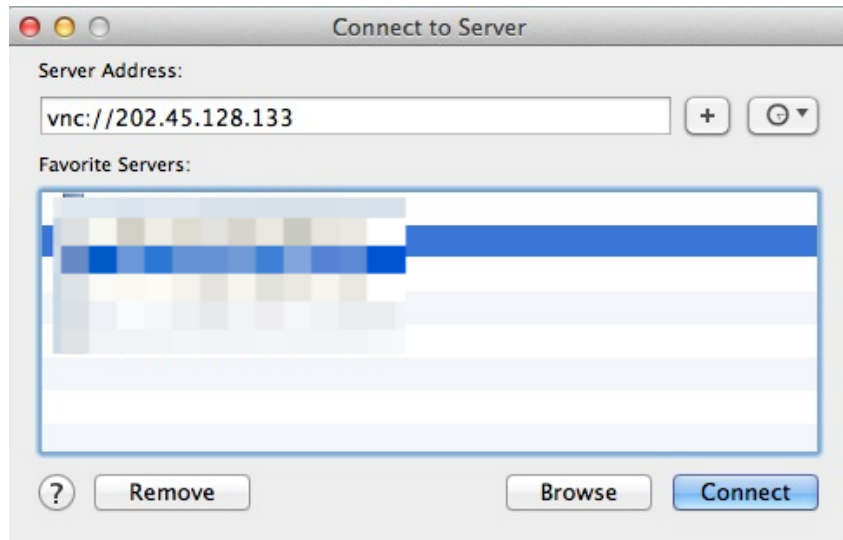


Figure 3.5: Connect to Mac Pro Server

## 3.8 Recommended Websites on Linux

1. Linux kernel newbies: <http://kernelnewbies.org/>
2. Basic knowledge of Linux: <http://linux.vbird.org>
3. Basic knowledge of Vim: <http://vimdoc.sourceforge.net/>
4. Advanced Shell Programming: <http://www.gnu.org/software/bash/manual/bashref.html>

# Chapter 4

## Hardware Details

### 4.1 Switch

Currently the cluster employs three switches to interconnect the machines:

- one Dell PowerConnect 5548 Switch, with 48 wire-speed Gigabit Ethernet ports available for campus switching.
- **(Deprecated)** one IBM Fast Ethernet Desktop Switch 8275 Model 324 (as shown in Fig. 4.1), which offers 24 ports helping drive 10/100 switching. Port trunking capabilities provide aggregate bandwidth (up to 800Mbps) between the switches.
- **(Deprecated)** one Intel Express 510T switch, with 24 Ethernet 10Base-T/100Base-TX ports, supporting 8K MAC addresses, and 100Mbps data transfer rate.
- **(Deprecated)** one linksys SRW2024 switch, with 24 Ethernet 10Base-T/100Base-TX/1000Base-T ports, supporting 10/100/1000Mbps data transfer rate and 48Gbps backplane bandwidth.



Figure 4.1: IBM Fast Ethernet Desktop Switch.

## 4.2 Cluster-Reserved Nodes

Hostname	Processor	RAM	Hard Drive
core (NFS server)	Intel(R) Quad Core E5506 Xeon(R) (4M Cache, 2.13 GHz, 4.80 GT/s Intel(R) QPI)	8GB	4 TB
n0 (Entry Node)	Intel(R) Xeon(R) E5620 (2.40 GHz, 1066 MHz FSB)	32 GB	1 TB
n129	Intel(R) Pentium(R) D Processor 930 (4M Cache, 3.00 GHz, 800 MHz FSB)	1GB	160GB
n135	Intel(R) Pentium(R) 4 Processor 641 (2M Cache, 3.20 GHz, 800 MHz FSB)	1GB	160GB
n136	Intel(R) Pentium(R) D Processor 930 (4M Cache, 3.00 GHz, 800 MHz FSB)	1GB	160GB
n137	Intel(R) Pentium(R) D Processor 930 (4M Cache, 3.00 GHz, 800 MHz FSB)	1GB	160GB
n138	Intel(R) Pentium(R) D Processor 930 (4M Cache, 3.00 GHz, 800 MHz FSB)	1GB	160GB
n139	Intel(R) Pentium(R) D Processor 930 (4M Cache, 3.00 GHz, 800 MHz FSB)	1GB	160GB
n140	Intel(R) Pentium(R) D Processor 930 (4M Cache, 3.00 GHz, 800 MHz FSB)	1GB	160GB
n141	Intel(R) Pentium(R) D Processor 930 (4M Cache, 3.00 GHz, 800 MHz FSB)	1GB	160GB
n142	Intel(R) Pentium(R) D Processor 930 (4M Cache, 3.00 GHz, 800 MHz FSB)	1GB	160GB
n143	Intel(R) Pentium(R) D Processor 930 (4M Cache, 3.00 GHz, 800 MHz FSB)	1GB	160GB

## 4.3 Blade Servers

IBM BladeCenter HS23, with 8 blade servers installed. Uniform configuration for each blade:

CPU	Memory	Storage
Intel(R) Xeon(R) CPU E5-2650 0 @ 2.00GHz	64 GB	2 x 300 GB

## 4.4 Mac Pro Server

CPU	One 3.2GHz Quad-Core Intel Xeon processor
Memory	8GB (four 2GB)
Disk	Two 1 TB hard drives
OS	OS X Server Mountain Lion
Video Card	ATI Radeon HD 5770 with 1GB GDDR5



Figure 4.2: IBM BladeCenter HS23



Figure 4.3: Mac Pro Server with 8GB of memory