

# Introduction to LAN

## TDC 363

### Lecture 06

Networking with  
UNIX/Linux Operating Systems  
Book: Chapter 9

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## Course Outline

- History of UNIX™ operating system
- UNIX System Overview
- Basic UNIX commands
- Basic UNIX/Linux System Administration
- NFS, NIF+, OpenLDAP
- X-Windows
- SAMBA

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## Brief History of UNIX

- 1965: Multics
- 1971: 1st version of UNIX on PDP-11
- 1973: UNIX was rewritten in C
  - The 1<sup>st</sup> OS in a high level language and a milestone in CS
- 1977: UNIX ported to Interdata 8/32 (another milestone)
- 1984: 100,000+ system installed

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## History (cont.)

- UNIX System V
  - Released by AT&T in 1983
  - From Research to Commercial Use
- BSD (Berkeley Software Division)
  - Versions of UNIX from researchers at the University of California at Berkeley
  - 1<sup>st</sup> implementation of TCP/IP

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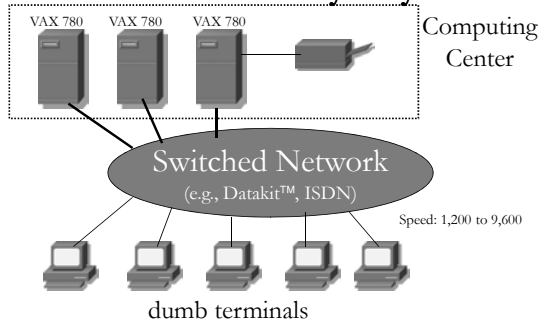
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## UNIX in Early Days



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## Proprietary UNIX

- An implementation of UNIX for which the source code is either unavailable or available only by purchasing a licensed copy from Caldera International and Tarantella (now SCO)
  - Sun's proprietary version of UNIX is called **Solaris**
  - IBM's proprietary version of UNIX is called **AIX**
  - HP's proprietary version of UNIX is called **HP-UX**

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# Open Source UNIX

- Open source software
  - Software made available to anyone without licensing fees
  - Freely distributed software
    - GNU
    - FreeBSD
    - Linux

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# Linux



- Cover Story of Business Week (March 3, 2003)
- Linus Torvalds (now 33) *invented* Linux as a *simplified* version of Unix for the PC in 1991.
- Microsoft: “the No. 1 competitor for this company”
- E\*Trade Group Inc. (ET ) replaced 60 Sparc-based computers (\$250K each) with 80 Intel-based Linux machines costing just \$4,000 a pop.
- Linux Market share (on servers)
  - 0% three years ago
  - 13.7% in 2003 (for the market of \$50.9B), Microsoft: 59.9%
  - 25.2% in 2006 (estimate)

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# Common Linux Features

- Support multiple, simultaneously logged in users
- Hierarchical file systems that incorporate demountable volumes
- Consistent interfaces for input and output of data to and from hardware devices, files, and running programs
- The ability to start processes in the background

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## Common Linux Features (cont.)

- Hundreds of FREE software modules
- Multiple programming languages support
- Source code portability
- X-Windows interfaces
- Security Features
  - Orange Book (Proprietary UNIX)

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## Linux Operating System

- Time-sharing
  - Multiple users login and share the CPU resource *simultaneously*
- Real-time
  - *Immediate* response to user requests
- Supports symmetric multiprocessing (SMP)
- Support the use of both physical and virtual memory efficiently

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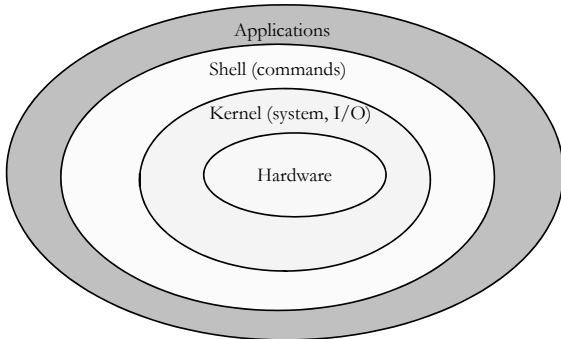
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## UNIX/Linux Architecture



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## Linux Kernel

- Kernel
  - Core of the operating system
    - The term is to distinguish itself from user programs.
  - Interfacing with the hardware via drivers
  - Flexibility in adding or removing functionality by loading and unloading Linux **kernel modules**
    - Analogous to NetWare NLMs

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## Linux Shell

- The outer layer of kernel
- The command environment.
  - An environment that accepts and runs your input commands
- Get inputs from users and invoke system calls to the kernel
- Shell programming
  - A major advantage over Windows

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## Linux Shell (cont.)

- Examples of shells
  - **shell**
  - **cshell (BSD) => tcshell**
    - **.cshrc** (c.f. config.sys and autoexec.bat in DOS)
  - **k(orn)shell (UNIX System V)**
  - **bash (Linux)**
- Keeps track of the command history:
  - [linuxSrv] history
  - [LinuxSrv] which <command>

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## File System

- Linux includes support for multiple types of file systems, including:
  - Local file systems
    - Its native file system is called **ext2**.
  - Remote file systems
  - Sun Microsystem's Network File System (NFS)
  - Physical files: /dev/had[x] [x] ::= a number
  - Logical files: /usr, /home,

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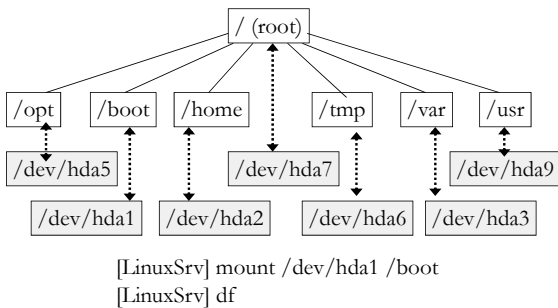
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## File System (LinuxSrv)



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## File and Directory Structure

- Hierarchical file system
  - Organization of files and directories on a disk partition in which directories may contain files and directories

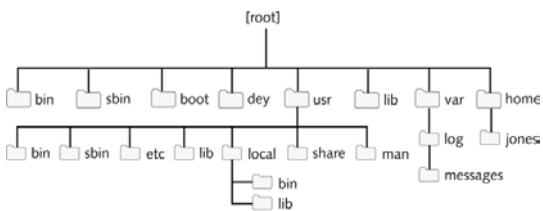


Figure 9-1 UNIX file system hierarchy

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## File System Access Control

- Three levels of access control
  - User (u) – the owner
  - Group (g)
  - Others (o) – the World
- Access rights are specified for the owner, the group, and all others

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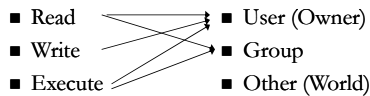
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## File System Access Control

- File Access Permissions (assigned individually to each level):



User: r/w/x Group: r/x Other: none

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## File Systems Info

- Linux systems keep quite a bit of information about each file, including:
  - Filename
  - File size (in bytes)
  - Date and time a file's **i-node** (file information node) was created
    - I-node is the place to store file information.
  - Date and time that the file was last accessed
  - Date and time that the file contents were last modified

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## File Systems Info (cont.)

- Information Linux system keeps about each file
  - Number of “aliases” or links to the file
  - User ID
  - Group ID
  - Access rights for the owner, the group and others

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## The ls command

```

[tyj@linux05] ls -l
total 60
drwxr-xr-x  2 tyj  tyj   4096 May  9 11:32 bin
drwxr-xr-x  2 tyj  tyj   4096 May 16 16:43 courseProgram
drwxr-xr-x  3 tyj  tyj   4096 Feb 13 2003 FTP
drwxr-xr-x  3 tyj  tyj   4096 Apr 28 00:28 perl
drwxr-xr-x  2 tyj  tyj   4096 Mar  7 10:01 personal
drwxr-xr-x  3 tyj  tyj   4096 Mar  3 2005 plug
drwxr-xr-x  8 tyj  tyj   4096 May  4 00:26 program
drwxr-xr-x 15 tyj  tyj   4096 May  9 20:08 public.html
drwxr-xr-x  2 tyj  tyj   4096 Apr 19 22:05 rje
drwxr-xr-x  2 tyj  tyj   4096 Jan 21 2004 rasp
drwxr-xr-x  4 tyj  tyj   4096 May 15 14:42 samp
drwxr-xr-x  2 tyj  tyj   4096 May 16 16:43 tcpdump
drwxr-xr-x  2 tyj  tyj   4096 Aug 11 2005 tdc365
drwxr-xr-x  4 tyj  tyj   4096 May 11 16:57 tdc511
drwxr-xr-x  2 tyj  tyj   4096 May  4 02:03 tdc564
drwxr-xr-x  2 tyj  tyj   4096 Mar 26 00:24 tdc566
drwxr-xr-x  2 tyj  tyj   4096 Dec 19 2004 W.M.H
[tyj@linux05]
[tyj@linux05]
[tyj@linux05]
[tyj@linux05]
    
```

c.f. Fig. 9-2

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## the ls command (cont.)

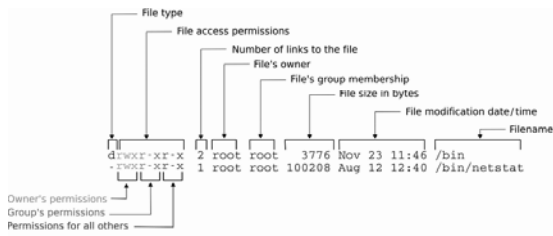


Figure 9-3 Anatomy of ls -l output

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## Setting the File Access Mode

- `umask`
- `umask 022`

000(u)	010(g)	010(o)
111	101	101
rwx	r-X	r-X

- `umask 027`

000(u)	010(g)	111(o)
111	101	000
rwx	r-X	---

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## Changing File Access Permissions

- `chmod u+rwx <file>` to grant read, write, and execute permission to the user
- `chmod g+w <file>` to add write access for the group
- `chmod o-rw <file>` to remove read and write access by others

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## Linux Command Interface

- Unlike Microsoft Windows, user interface is via commands.
  - Users need to learn many commands to become effective and productive on Linux.
  - Even in the X-windows environment (a GUI environment), users still need to be familiar with commands.
- To accomplish a task, users need to execute a command or a series of commands.

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## Sample Commands

- `cd <directory>` # change directory
- `mkdir <directory>` # create a new directory
- `rm <filename>` # remove a file
- `rm -r <directory>` # remove the directory and its content
- `cat <filename>` # show the content of the file
- `cp <file1> <file2>` # copy file1 to file2
- `sort <file>` # sort the file
- `grep <pattern> <file>` # find the pattern in a file
- `find . -name "*c" -print`  
# find all C programs in the current directory and subdirectories

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## PATH Variable

- Commands are provided on Linux server(s).
- Users set their PATH variable to access those commands.
  - Check the PATH variable setting in `.cshrc`
  - `echo $PATH`
- Examples of command directory:
  - `/bin`
  - `/usr/bin`
  - `/usr/sbin`
  - `/usr/local/bin`
- Where is a command: `which <command>`
- Similar to the DOS environment

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## Exercise

- After you create your Linux account, try **ifconfig**. It is likely to fail, why?
- Do the following:

```
cd # go to the home directory
cp /home/tdc363/sample.bashrc .bashrc
.bashrc
```

- Try **ifconfig** again. It should work now. Why?
- Hint: (1) `echo $PATH` (2) `which ifconfig`

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## MAN Page

- Manual Page
  - Format and display the on-line manual pages
- Syntax: `man <command>`
- Output:
  - Name: brief description of the command
  - Synopsis: syntax and usage of the commands
  - Description
  - Environment
  - Examples
  - See Also – related commands

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## Linux Wildcards

- \* - match any character sequence
- ? - match any single character
- [ ] – match any of the characters

Examples:

```
linux> rm tmp.*
```

```
linux> rm tmp.??
```

```
linux> rm tmp.[1234]
```

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## Linux Pipe and Pipeline

- Pipe
  - Serves as the connection between two commands where the output of the 1<sup>st</sup> command becomes the input of the 2<sup>nd</sup> command
  - `ls -l | more`
- Pipeline
  - Two or more commands separated by a pipe
  - `yycat passwd | cut -d":" -f7 | sort | uniq -c`

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## Shell Script (Shell Programming)

### Sequence

```
echo "How are you"  
echo "I am fine. Thank you"
```

### Control

```
INPUT_FILE=$1  
if test "$INPUT_FILE" = ""  
then  
    echo "syntax: command <filename>"  
else  
    ls -l $INPUT_FILE  
fi
```

### Loop

```
IP_LIST="192.168.1.1 192.168.1.2 192.168.1.3"  
for ip in $IP_LIST  
do  
    ping $ip  
done
```

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## super user

- root
  - login as root
  - administrator
- su
  - switch to be a root
  - In a production environment, it is advised to login as a regular user. If there is a need to perform system admin function, use **su** to switch to **root**. Why?
- sudo
  - Grant the root privilege to some users/groups to run certain commands on certain files
  - /etc/sudoers
  - This could be a security hole. Check it regularly.
- user vs. effective user
  - Grant run time permission to users who run an application.
  - Discussion: do you see an issue with **chown**?

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## Linux System Administration

### ■ Adding groups and users

#### ■ groupadd

- add a new group

#### ■ useradd

- add a new user account

#### ■ usermod

- modify user information

#### ■ userdel

- delete a user account
- => know how to undo it before you do it.

```
useradd mary  
groupadd tdc363  
useradd -g tdc363 james  
useradd -g tdc363 john  
usermod -g tdc363 mary
```

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## **/etc/passwd file**

- Each user account is represented by one line in file /etc/passwd
- Each line (user) has seven fields separated by six colons (:)
  - User Name
  - Password (encrypted - set to '\*' or blank for no login / no password)
  - User ID (UID) (must be unique)
  - Group ID
  - Comment
  - Home Directory
  - Login Shell

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## **Shadow password file**

- It was discovered that, even though passwords are encrypted in /etc/passwd, that a determined hacker could use these to break passwords
- So, many Linux systems employ shadow password files, which
  - Substitute "x" for password in the /etc/passwd file
  - Put real encrypted passwords into a separate hidden file (shadow password file)

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## **/etc/group file**

- Each defined user group is represented by one line in file /etc/group
- Each line (group) has four fields separated by three colons (:)
  - Group Name
  - Group Password (can be used to restrict adding oneself to group)
  - Group ID (GID) (must be unique)
  - Users - list of user accounts that are members of this group.

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## Unix Daemons

- **Daemons** are background system processes on a Unix server that provide user or network services.
- Daemon process names typically end in letter “d” – for example, the HTTP (web service) daemon is called “httpd”.
- To start a daemon:
  - <daemon name> &
- To stop a daemon:
  - kill -9 <process num>

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## IP Address Configuration

See the current current setting: `ifconfig -a`  
`netstat -i`

Set an IP address

```
ifconfig eth0 192.168.1.10 \  
netmask 255.255.255.0 up
```

Create a logical interface

```
ifconfig eth0:1 192.168.10.10 \  
netmask 255.255.255.0 up
```

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## Default Gateway

```
Route or netstat -rn
```

```
route add default gw 140.192.40.1
```

/etc/sysconfig/network

```
NETWORKING=yes  
HOSTNAME=linux05.wireless.cti.depaul.edu  
DOMAINNAME=wireless.cti.depaul.edu  
GATEWAY=140.192.40.1
```

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## Linux Network Command

- ifconfig (not ipconfig)
- netstat
- arp
- ping
- traceroute
- nslookup
- dig
- route

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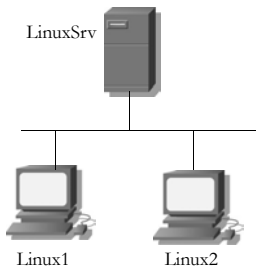
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## CTI Linux Network Environment



Requirements:  
when a user logs in to any machine, he/she shall use the same login name and password and see the same home directory.

Solutions:  
•NFS  
•NIS

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## /etc/hosts files

```
127.0.0.1 localhost.localdomain localhost
140.192.40.5 linux05 linux05.research.cti.depaul.edu
140.192.40.6 linux06 linux06.research.cti.depaul.edu
192.168.1.1 switch01
192.168.1.2 switch02
140.192.40.1 labRouter
```

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# Network File Systems (NFS)

- Common system used to provide shared directories on Linux servers
  - Developed by Sun Microsystems to provide file sharing among heterogeneous systems.
  - Transparently extends local file system.
  - Remote file systems can be mounted as sub-trees of local file system
  - User simply sees new directories

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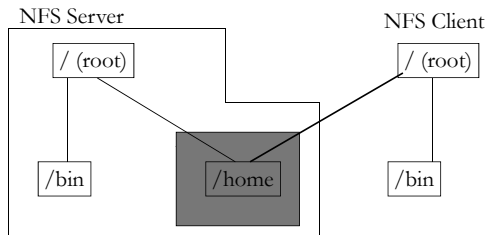
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## NFS



/home is physically on the server but logically available to both the server and the client.

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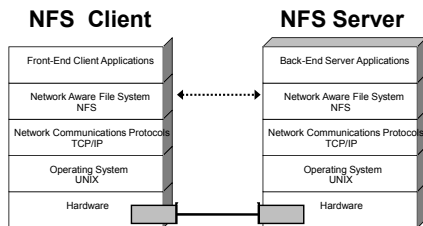
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## NFS Protocols



Reference: GOLDMAN: LAN, Fig 13-01

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## The /etc/exports file

- Controls shared directories on server:
  - Each line specifies
    - an exported directory
    - names of the host machines that can access this directory
    - access rights and options for each host
      - rw: read/write (default) ro: read only
  - Example:  
/home 140.192.40.101(rw) 140.192.40.102(rw)

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## NFS (Server)

- NFS server:
  - Run NFS daemons (system process):
    - **rpc.mountd** - handles requests to mount and unmount NFS shared directories
    - **rpc.nfsd** – handles requests to access shared NFS files
  - Shareable directories and access rights defined in file /etc/exports.
    - To create a new shared directory on server: Edit /etc/exports and then restart **nfs** daemon.

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## NFS (Clients)

- Client executes “**showmount**” command to show what shared directories are available on servers
- Client execute “**mount**” command to set up a link in client’s file directory tree to server shared directory
- Once link is set up, the server directory appears to be another directory on client disk.

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## NFS (Clients)

- `showmount -a <server>`
- Set up access to NFS shared directories using the `mount` command:  
`mount -t nfs <server>:<remote dir>  
<local dir> <options>`
- Shared directories are disconnected using the `umount` command.

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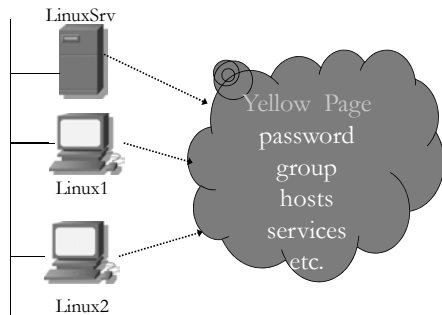
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## Network Information Service (NIS)



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## Network Information Service

- To simplify network administration by providing *centralized* control over a variety of network information.
- Store information about workstation names, addresses, users, the network, and network services.
- **NIS namespace:** the collection of network information.
- **NIS domain:** a collection of systems that are logically grouped together. A group of hosts that share the same set of NIS maps belong to the same domain.

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## Network Information System

- NIS service provides a single database of user information that is shared among multiple workstations and servers.
  - Single login account definition now allows user to log onto any host machine in an extended workgroup.
  - Servers can authenticate users before providing service.

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## Network Information System

- NIS server runs *ybserv* daemon.
- NIS server keeps central copy (called *map*) of
  - /etc/passwd
  - /etc/group
  - /etc/hosts (DNS local resolution)
  - /etc/services

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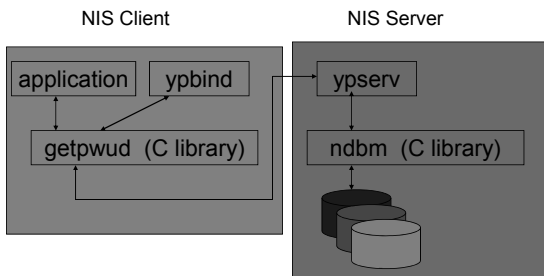
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## How does NIS work?



NISDOMAIN: /etc/sysconfig/network

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# Applications

Requirements: users can use the same login to any workstation, and they shall see the same \$HOME directory.



### Solutions:

**NIS:** Users use the same login to any Linux workstation.

**NFS:** Users see the same \$HOME directory, regardless of which workstation they use.

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# NIS+

- NIS+ is designed to **replace** NIS, not enhance it.
- NIS is for small and medium-sized client-server computing networks, no more than a few hundred clients, a few multipurpose servers, a few remote sites, and trusted users
- NIS+ is scalable for large environment, up 10,000 multivendor clients, 100 specialized servers, and many sites throughout the world.
- NIS+ domain is hierarchical while NIS domain is flat.
- NIS+ is more secure.

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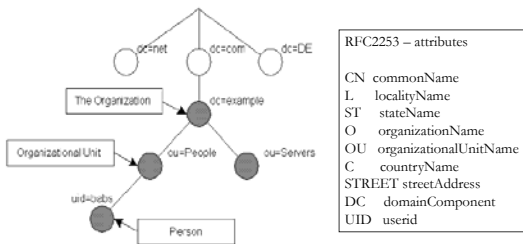
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# Linux OpenLDAP (to replace NIS)



RFC2253 – attributes	
CN	commonName
L	localityName
ST	stateName
O	organizationName
OU	organizationalUnitName
C	countryName
STREET	streetAddress
DC	domainComponent
UID	userid

Reference: <http://www.openldap.org/doc/admin21/>

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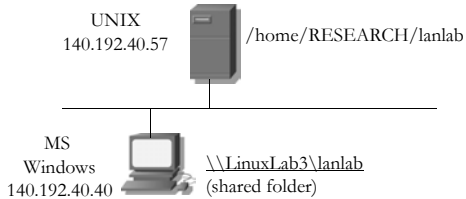
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## Sharing Files between UNIX and Windows

### SAMBA

Open source software package for file and printer sharing



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## X-Windows

- X Window System – Trademark of X Consortium, Inc.
- A network transparent window system
- Graphical User Interface (GUI)
- UNIX/Linux applications that show “graphs” are running on X-Windows.
  - Internet browser
  - PDF reader
  - Many more

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## Running X-Windows on MS Windows

- X-Windows is a GUI environment and there are many GUI applications on Linux.
- You can run X-windows applications from a MS Windows client.
- Virtual Network Computing (VNC) is a popular tool (running X-windows applications on Linux from Windows) and there are many similar tools.



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## Install New Software on Linux

- When you download software, the software is most likely have suffix: \*.rpm (RedHat package Manager) or \*.tar.gz (tape archive and gnu zip)
- If the software package is example.rpm
  - rpm -i example.rpm
- If the software package is example.tar.gz
  - gunzip example.tar.gz
  - tar -xf example.tar
- The above commands work in many cases but not 100%.
- For more information:
  - man rpm
  - man gunzip
  - man tar

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## Questions

- If you are supporting MS Windows users who need to access files on a UNIX server, what is your solution?
- What is the difference between UNIX kernel and shell in the system architecture?
- How do you find your IP address and MAC address on a Linux machine?
- How do you find the default router and DNS of your Linux machine?
  - User approach
  - System administrator approach
- What is the shadow password file and why do we need it?

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## Questions (cont.)

- If you create a file at your home directory on linux1, will you see the same file (at the same location) when you login to linux2? What is the technology that makes it work?
- What is the Linux command you use to change your password? If you change the password on **Linux1**, can you use the new password to logon **Linux2**? Why? What is the technology behind the scene?
- What is a UNIX daemon? How do you show all the daemons that are currently running?

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## Questions (cont.)

- Describe one advantage of Windows over UNIX in setting file access permission.
- What is the difference between pipe and pipeline? Can you give an example for each one? Does Windows support them? Does UNIX support them?
- What is man page?
- Comparison of NIS, NIS+, and OpenLDAP
- Comparison of domain structures and namespaces in Active Directory, Novell Directory Service, and NIS+.

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## Questions (cont.)

- The CTI Linux system is using NIS. I check the `/etc/passwd` file on the server and do not see an account `tjy`. So I run `useradd` command to add a new account `tjy`, but it fails. Can you provide a reason why it fails?
- What is X-Windows? Can you run X-Windows applications from a MS Windows client? How?

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