

CENG 362 Computer Networks Laboratory

Introduction to the Lab, Networking Tools and Linux

Computing Engineering Department
Fatih University



Wednesday, February 20, 2008

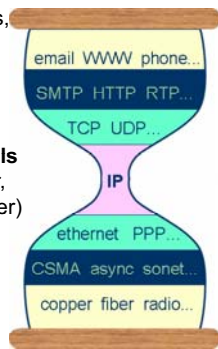
Outline

1. Objectives of the Lab Experiments
2. Experiments
3. Lab Activities, Procedures and Grading
4. Lab Hardware
5. Networking Tools
6. Linux

2

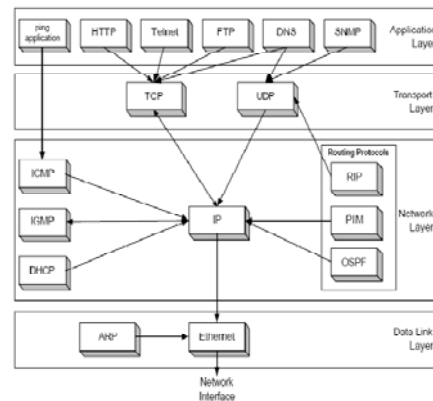
Objectives of the Lab Experiments

- ◆ **Hand-on experience on networking**
(using routers, host computers, switches, cables, network monitoring and management tools, ...)
- ◆ Teaching the **fundamentals of data communication**:
 - Mainly **TCP/IP layers and protocols** (Application Layer, Transport Layer, Network Layer, and Data Link Layer)
- ◆ Opening the **hood of the Internet** and learning how Internet works...



The Internet Protocol Hourglass (Deering)

Lab Objectives: TCP/IP Layers and Protocols



4

1. Objectives of the Lab Experiments
- 2. Experiments**
3. Lab Activities, Procedures and Grading
4. Lab Hardware
5. Networking Tools
6. Linux

5

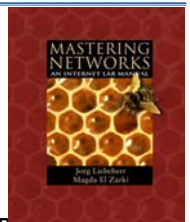
Lab Main Text Book

Lab Manual:

- **Mastering Networks: An Internet Lab Manual**, J. Liebeherr, M. E. Zarki, Addison-Wesley, 2004.

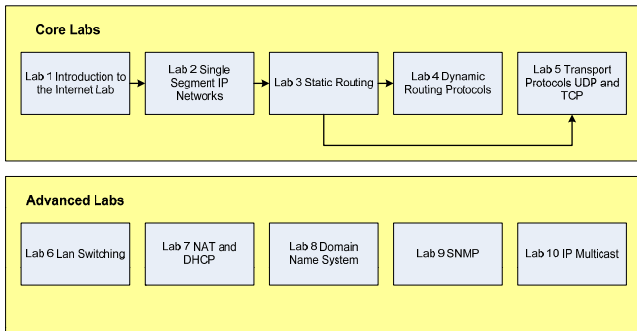
Chapters

1. Introduction to the Internet Lab
2. Single Segment IP Networks
3. Static Routing
4. Dynamic Routing Protocols (RIP, OSPF, BGP)
5. LAN Switching
6. Transport Protocols (UDP and TCP)
7. NAT and DHCP
8. The Domain Name System
9. SNMP
10. IP Multicast



6

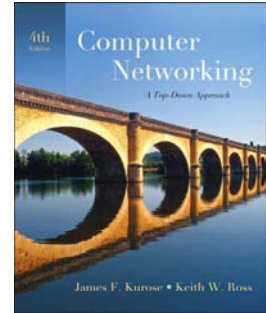
Labs of the Internet Lab Manual



7

Labs (from the text book) done in the last year

1. **Getting started**
2. **HTTP**
3. **DNS**
4. **TCP**
5. **IP**
6. **ICMP**
7. **Ethernet and ARP**
8. **DHCP**



Computer Networking: A Top-Down Approach Featuring the Internet, 4th Edition, J. F. Kurose, K. W. Ross, Addison Wesley, 2007.

8

Lab Outline

(Tentative, look at the course web site for changes)

1	Lab 0: Introduction I: Overview, procedures used in all labs, lab equipment and software, network protocol analyzers (tcpdump, ethereal), Cisco Internet Operating System (IOS) TCP/IP Tutorial 1/3: TCP/IP networking principles that form the basis of discussion for many of the laboratories that are covered in this text (You can also use this e-book to learn the basics of TCP/IP)
2	Lab 1: Introduction to the Internet Lab: Becoming familiar with the lab equipment, introduction to ethereal and tcpdump, basic Linux commands, Ethereal Lab, Getting Started TCP/IP Tutorial 2/3
3	Lab 2: Single Segment IP Networks: Configuring a network interface for IP networking; address resolution with ARP; security problems of common Internet applications.
4	HTTP and DNS ethereal Labs from the main text book TCP/IP Tutorial 3/3
5	TCP from the main textbook
	Midterm
6	Lab 3: Static Routing: IP forwarding and routing between IP networks; setup a Linux PC and a Cisco router as an IP router; manual configuration of routing tables.
7	Lab 5: Transport Protocols (UDP and TCP): Data transmissions with TCP and UDP; TCP connection management; TCP flow control; retransmissions in TCP; TCP congestion control
8	Lab 4: Dynamic Routing Protocols (RIP, OSPF, BGP): Routing protocols RIP, OSPF and BGP; count-to-infinity problem in RIP; hierarchical routing in OSPF; setup of autonomous systems in BGP
9	Lab 6: LAN Switching: LAN switching in Ethernet networks; forwarding of Ethernet frames between LAN switches/bridges; spanning tree protocol for loop free routing between interconnected LANs
10	Lab 7: NAT and DHCP: Setup of a private network; dynamic assignment of IP addresses with DHCP

9

1. **Objectives of the Lab Experiments**
2. **Experiments**
3. **Lab Activities and Grading**
4. **Lab Hardware**
5. **Networking Tools**
6. **Linux**

10

Lab Activities

- **Lab Experiments:** Practical foundations and hands-on experience. There will be 10 labs.
- **Each lab has three phases: Prelab, Lab Session, and Lab Report**
- **Short Lab Tutorials:** Theoretical foundations and background as needed before some lab experiments will be given by your TA.
- **Lab Exam:** There will be 1 lab exam.
- **Attendance:** % 80. That is if you miss 3 lab sessions you will fail the lab.

11

Pre-laboratory Assignment (Prelab)

- ◆ **Before you come to the Lab**
 - Exercises to be completed in advance of the associated lab session
 - The prelabs ask you to acquire background knowledge that is needed during the lab exercises.
 - Each prelab has a question sheet that must be completed before the corresponding lab session.
 - Read lab manual and do related reading (a few hours).
 - Complete prelab (<1 hour, if you have done the reading).

12

Lab Session

◆ In the lab

- Show up for your time slot only, you can not use other time slots
- Bring your **lab manual, a memory stick**
- You will take a quiz on prelab.
- Complete exercises (2 hour to several hours)
- Take measurements
- Save data to your memory stick
- All lab exercises can be completed without supervision.
- The time to complete a lab session should be 2 hours on the average, but may vary. Complete the laboratory activities to the extent that you can.
- The activities during the lab session are not graded, however, data collected during the lab session are needed to complete a lab report.
- Floppy disk symbol in the lab manual indicates when you have to collect data.



13

Lab Session (cont.)

- ◆ Each lab has an **anonymous feedback sheet**. The feedback is used to improve the setup and organization of the labs.
- ◆ Since you have administrative (root) privileges on the Lab equipment, exercise caution when modifying the configuration of the Lab equipment.

14

Lab Reports

◆ After the lab: Lab Reports

- Use data saved on memory stick
- Write lab report
- Submit lab report by due date (include lab feedback pages from book. Book pages are perforated).
- After each lab session, you prepare a lab report that summarizes and analyzes the findings from the lab session.
- A **notepad symbol** indicates an assignment for the lab report.
- The lab reports should be submitted as a **typewritten document**.
- The lab report is generally due 1 week after the lab session.
- The lab report is graded.
- Note: Saved data should be included in the report only if it is requested in the lab report, and if it is used to answer a question.
- Filtering the relevant measurements for the answers of the lab report is part of the analysis.



15

General Requirements for the Lab Reports

- ◆ You need to prepare a **cover sheet**, indicating the lab name and the team members' names.
- ◆ Please staple your prelab with your lab report, under the cover sheet.
- ◆ Truncate long output file, insert relevant supporting output into the place where you answer the lab questions. The data you used must be supporting your answers. The grader of lab reports are advised to deduct points (significantly) if collected data is included that is not needed to support the answer.
- ◆ Please organize your lab report according to the lab exercise part number. Avoid using your own numbering system. Type each of the lab questions briefly, so that the grader knows which question you are answering.
- ◆ Separate your **feedback sheet** from your lab report. You **must** include one feedback sheet per lab report.



16

Rules for Using the Lab

- ◆ Your lab time slot is allocated for the entire semester.
- ◆ You are guaranteed access to the lab during your time slot.
- ◆ If you want to switch lab sections after the sign-up, you need to find a partner to swap with.
- ◆ Outside your assigned lab section, you may use the lab if the lab assistant is available in the lab.
- ◆ The lab report is due 1 week after your assigned lab slot.
- ◆ Submit lab report in class.
- ◆ Late policies for pre-labs and lab reports:
 - 20% of total grade per day
 - Nothing accepted that is more late than 2 days

17

Grading

Course Grading (tentative)

- 25 % : Lab Experiments and Lab Exam
- 15 % : Homework Assignments
- 20 % : Midterm
- 25 % : Final Exam

Lab Grading (tentative)

- Each Lab Grade =**
- 20 % Quiz (must be prepared individually) +
- 80 % Lab Report (team report)

Final Lab Grade = 65 % Lab Grades Average + 35 % Lab Exam

18

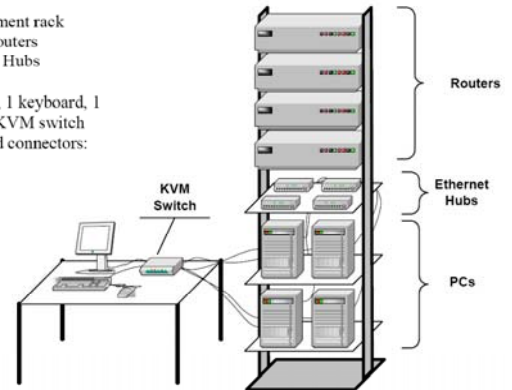
Outline

1. Objectives of the Lab Experiments
2. Experiments
3. Lab Activities, Procedures and Grading
- 4. Lab Hardware**
5. Networking Tools
6. Linux

19

Basic Computer Networks Lab Equipment

1. 19" equipment rack
2. 4 Cisco Routers
3. 4 Ethernet Hubs
4. 4 hosts
5. 1 Monitor, 1 keyboard, 1 mouse, 1 KVM switch
6. Cables and connectors:



20

General Features of the Computer Networks Lab

1. The **Computer Networks Lab** is a **miniature version of the Internet**.
 - Instead of millions of hosts and routers, the lab has only **4 routers**, **4 personal computers (PCs)** (as Hosts), and 4 Ethernet switches.
 - Still, the available **equipment is sufficient to emulate many traffic scenarios found on the real Internet**.
2. The lab is mainly isolated from the Internet.
 - Therefore, students will perform tasks that would cause significant disruptions in an operational network (such as unplugging network cables) or would raise security concerns (such as capturing and studying network traffic).
3. If needed the lab will have a secure public internet connection.
4. All PCs in the Lab have the **Linux** and **Windows** (only student computers) operating system installed.
5. One set of rack equipment for 4 students.

21

PCs and Routers

PCs

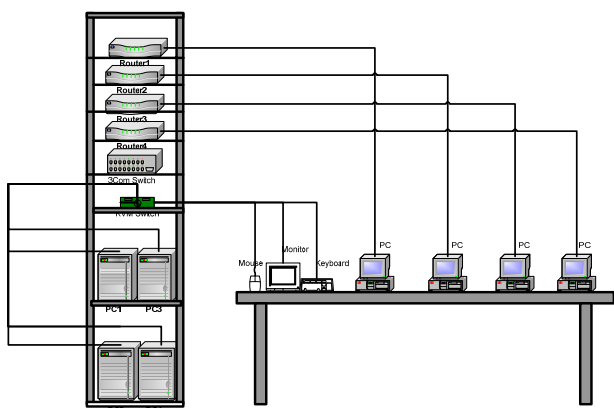
- ◆ 4 PCs, which are labeled as PC1, PC2, PC3, and PC4.
- ◆ Each PC has 2 **10/100 Mbps Ethernet interface** cards.
- ◆ All PCs are controlled from a single **KVM (Keyboard-Video-Mouse)** switch, which connects a keyboard, monitor, and mouse to the PCs. You can access only one PC at a time.
- ◆ 4 Ethernet Switches.

Routers

- ◆ The Internet lab requires **4 routers (Cisco 2811)**, labeled as Router1, Router2, Router3, and Router4.
- ◆ Each router has **2 Ethernet interfaces** and **one serial port**. The Ethernet interfaces operate at 10 or 100 Mbps and the serial interfaces have a rate of up to 2 Mbps.

22

Routers, PCs, and Connections



23

Network Interface Card (NIC)

- ◆ **At source:**
 - Lives at the Data Link and Physical Layers
 - Provides the physical connection to the media
 - Receives the data packet from the Network Layer (IP)
 - Attaches its MAC address to the data packet
 - Attaches the MAC address of the destination device to the data packet
 - Converts data in to packets suitable for the particular network (Ethernet, Token Ring, FDDI)
 - Converts packets in to electrical, light or radio signals
- ◆ **As a destination device**
 - Provides the physical connection to the media
 - Translates the signal in to data
 - Reads the MAC address to see if it matches its own address
 - If it does match, passes the data to the Network Layer



24

Switch

◆ Link layer device

- Stores and forwards Ethernet frames
- Examines frame header and selectively forwards frame based on MAC destination address
- When frame is to be forwarded on segment, uses **CSMA/CD** to access segment

◆ Transparent

- hosts are unaware of presence of switches

◆ Plug-and-play, self-learning

- Switches do not need to be configured

25

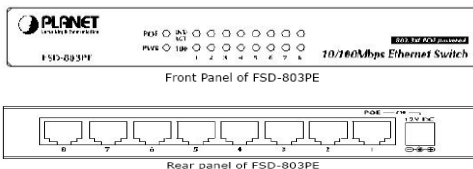
3Com Switch

- ◆ Functioning at the Data Link and Physical Layers
- ◆ Each port of the switch decides whether to forward data packets to the attached network
- ◆ Keeps track of the Mac addresses of all attached devices

26

Ethernet Switch (Planet)

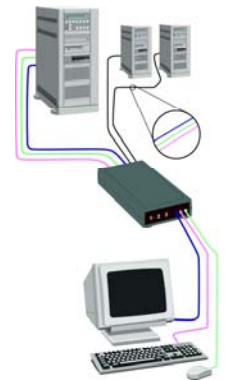
- ◆ Small switches in the lab cabinets, act like a **Hub** (physical layer device functioning as a repeater) in our lab experiments, but may filter data packets also.
- ◆ Each switches has 8 RJ-45 ports
- ◆ Ports operate at 10 Mbps, 100 Mbps or both



27

KVM (Keyboard, Video, Mouse) Switch

- ◆ KVM Switch is used to reduce cable clutter.
- ◆ Using a single keyboard, monitor, and mouse, switch between your attached computers and perform multiple tasks with the simple push of a button.



28

Router

- ◆ Works at **Network Layer** in an intelligent manner.
- ◆ Can connect different network segments, if they are in the same building or even on the opposite side of the globe
- ◆ Work in LAN, WAN environments.
- ◆ Allows access to resources by selecting the **best path**
- ◆ Can interconnect different networks.
- ◆ Changes packet size and format to match the requirements of the destination network

29

Router (cont.)

- ◆ Two primary functions – to determine the 'best path' and to share details of routes with other routers.
- ◆ **Routing Table** – a database which keeps track of the routes to networks and the associated costs.
- ◆ **Static Routing** – routes are manually configured by a network administrator
- ◆ **Dynamic Routing** – adjust automatically to changes in network topology, and information it receives from other routers
- ◆ **Routing Protocol** – uses a special algorithm to route data across a network eg. RIP

30

2811 Cisco Routers in the Lab

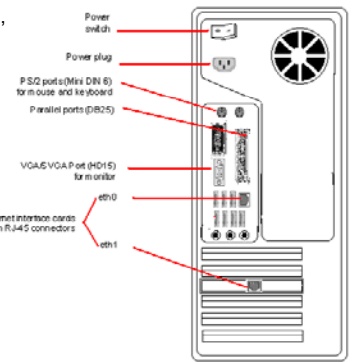
- ◆ Routers are labeled: Router1, Router2, Router3, Router4
- ◆ Routers run Cisco IOS Release 12.3 or a later version
- ◆ Each router has:
 - a console port
 - Two 10/100 Mbps Ethernet interfaces
 - two WAN serial interfaces



31

Linux PC

- ◆ PCs are labeled as: PC1, PC2, PC3, PC4.
- ◆ Linux Ubuntu installed
- ◆ Each PC has:
 - a floppy drive,
 - a serial port,
 - 2 10/100 Mbps Ethernet network interface card (NICs).



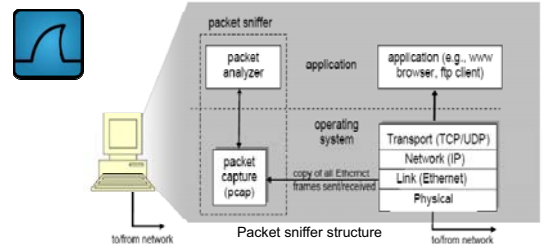
32

1. Objectives of the Lab Experiments
2. Experiments
3. Lab Activities, Procedures and Grading
4. Lab Hardware
5. Networking Tools
6. Linux

33

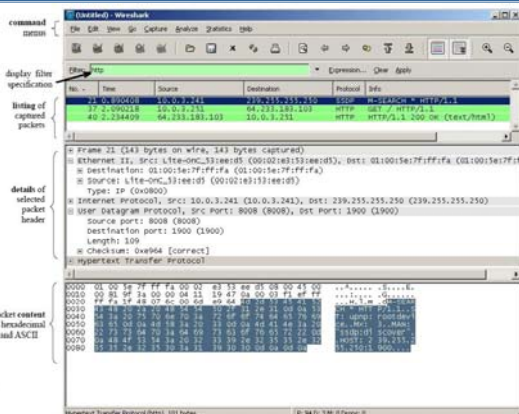
Software Tools

- ◆ **Network Protocol Analyzers (Packet Sniffers):** Basic tools to monitor, display, and analyze network traffic.
 - **Tcpdump:** System network utility.
 - **Wireshark:** The most popular **free** network protocol analyzer having support for hundreds of network protocols. Used by **network professionals** around the world for **troubleshooting, analysis, software and protocol development, and education.**



34

Analysing the Captured Packets



35

Linux tcpdump Command

- **Tcpdump** is started by running the command: **%tcpdump**
- **tcpdump -i interface**
 - Specifies that tcpdump is started on the given interface. (i.e. eth0.)
- **tcpdump -n**
 - With the **-n** option, tcpdump does not print host names, but prints the IP addresses in the packet.
- **tcpdump -x**
 - With this option, the first 68 bytes of the captured packet are displayed in hexadecimal form.
- **tcpdump -t**
 - This option suppresses the display of a timestamp at the beginning of each line.

36

Linux tcpdump Command

- **tcpdump -vv**
 - Prints additional information on each packet.
- **tcpdump -l**
 - Buffers the output to the terminal window and enables to save output to a file.
 - When saving the output of tcpdump to file frame use the command `tcpdump -l | tee frame or tcpdump -l > fname & tail -f fname`

Note: As always, multiple options can be used in the same command line. For example, the command `tcpdump -i eth0 -n -x -t -vv` enables all of the above options.

37

Output of tcpdump

```

#tcpdump
1. 16:54:51.340712 128.143.137.144.1555 > 128.143.137.11.53: 1+ A? neon.cs. (25)
2. 16:54:51.341749 128.143.137.11.53 > 128.143.137.144.1555: 1 NXDomain* 0/1/0 (98) (DF)
3. 16:54:51.342039 128.143.137.144.1556 > 128.143.137.11.53: 2+ (41)
4. 16:54:51.342036 128.143.137.11.53 > 128.143.137.144.1556: 2 NXDomain* 0/1/0 (109) (DF)
5. 16:54:51.344147 128.143.137.144.1557 > 128.143.137.11.53: 3+ (38)
6. 16:54:51.345220 128.143.137.11.53 > 128.143.137.144.1557: 3* 1/1/2 (122) (DF)
7. 16:54:51.350996 arp who-has 128.143.71.21 tell 128.143.137.144
8. 16:54:51.351614 arp reply 128.143.71.21 is-at e9:23:a9:20
9. 16:54:51.351712 128.143.137.144.1558 > 128.143.71.21.21: S 607569:607569(0)
    win 8192 <max 1460> (DF)
10. 16:54:51.352895 128.143.71.21.21 > 128.143.137.144.1558: S 3964010655:3964010655(0)
    auk 607569 win 17520 <max 1460> (DF)
11. 16:54:51.353007 128.143.137.144.1558 > 128.143.71.21.21: . ack 1 win 8760 (DF)
12. 16:54:51.365603 128.143.71.21.21 > 128.143.137.144.1558: P 1:6(159)
    ack 1 win 37520 (DF) [tos 0x10]
13. 16:54:51.507399 128.143.137.144.1558 > 128.143.71.21.21: . ack 60 win 8701 (DF)
  
```

Timestamp Source IP address and destination IP address Packet headers from other protocols

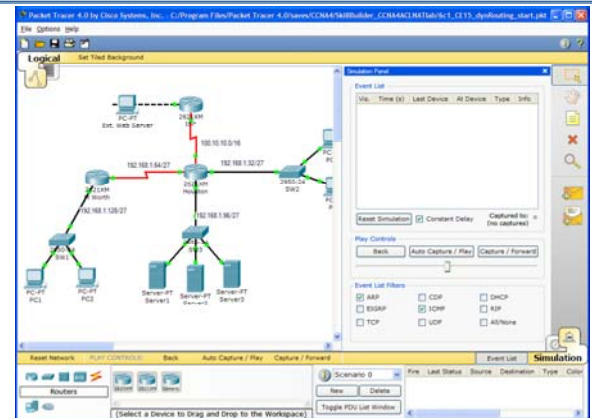
38

CISCO Packet Tracer v4.1

- ◆ Stand-alone, medium-fidelity simulation and visualization environment **designed for networking novices**
- ◆ Design, configure, and troubleshoot CCNA-level networks
- ◆ Show the fundamental concepts of data propagation and filtering through network devices.
- ◆ **Enhances classroom presentations** by providing a **real-time visualization** of data transmission over network devices.

39

CISCO Packet Tracer v4.1



1. Objectives of the Lab Experiments
2. Experiments
3. Lab Activities, Procedures and Grading
4. Lab Hardware
5. Networking Tools
6. **Linux**

41

Linux Overview

- ◆ Since the PCs run the Linux operating system, you need to become familiar with the Linux operating system.
- ◆ Linux is a clone of the Unix operating system.
- ◆ Unix was developed in the late 1960s at Bell Laboratories.
- ◆ Linux is a new branch of Unix, whose development was initiated by the Finnish computer science student Linus Torvalds.



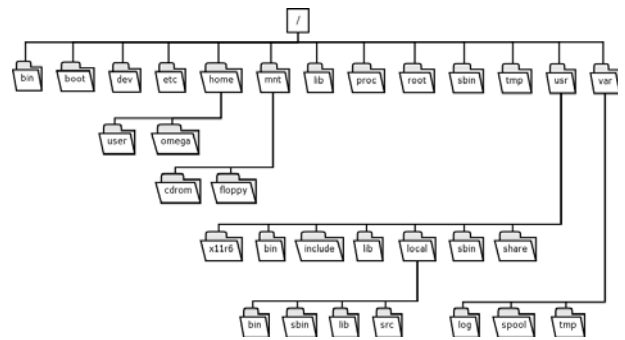
42

Linux Kernel and Shell

- A Unix operating system consists of a **kernel** and a set of **common utility programs**.
- The **kernel** is the core of the operating system, which manages the computer hardware, provides essential facilities, such as the control of program executions, memory management, a file systems, and mechanisms for exchanging data with attached devices, other programs, or a network.
- The utility programs include a **shell**, a command line interface for Unix systems, and numerous commands, compilers, and other programs.

43

Linux Directory Structure



44

Linux Directory Structure (2)

root	The home directory for the root user
home	Contains the user's home directories
bin	Commands needed during bootup that might be needed by normal users
proc	This directory holds information about kernel parameters and system configuration
usr	Contains all commands, libraries, man pages, games and static files for normal operation
lib	Shared libraries needed by the programs on the root filesystem
dev	Device files for devices such as disk drives, serial ports, etc.
etc	Configuration files specific to the machine.
var	Contains files that change for mail, news, printers log files, man pages, temp files
mnt	Mount points for temporary mounts by the system administrator.

45

Getting Help and Starting Linux

•Getting Help

•man *cmd*

- Displays the on-line manual pages. For example, the command **man ls** displays the manual pages of the command **ls**.

•Rebooting Linux

•reboot

- Stops and restarts the Linux operating system.

•halt

- Stops Linux without restarting.

46

Directory Commands: pwd, cd, mkdir, rmdir

•pwd

- Prints the absolute path of the current directory.

•cd *dirpath* / *cd..*

- Changes the current directory to the relative or absolute pathname of the directory *dirpath*. If no directory is given, the command changes the current directory to the home directory.

•mkdir *dirname*

- Creates a new directory with name *dirname* in the current directory.

•rmdir *dirname*

- Deletes the directory *dirname* from the current directory. A directory cannot be deleted when it still contains files or subdirectories.

47

File Commands: ls and mv

•ls *dirname*

- Lists information about files and directories in the current directory. **ls -l** includes extensive information on each file, including, the access permissions, owner, file size, and the time when the file was last modified.

•mv *fname newfile* and **mv *fname dirname***

- Renames a file or directory with name *fname* as *newfile*, or moves a file or directory to the directory *dirname*. If the destination file (*newfile*) exists, then the content of the file is overwritten, and the old content of *newfile* is lost.

48

File Commands: cp, rm

•cp *fname newfile* / cp *fname dirname*

•Copies the content of file *fname* to *newfile*. If a file with name *newfile* exists, the content of that file is overwritten. If the second argument is a directory, then a copy of *fname* is created in directory *dirname*.

•rm *fname*

•Removes a file. Once removed, the file cannot be recovered. For example, **rm *** removes all files in the current directory.

Note: Linux may not issue a warning when a file is overwritten or when a file is removed. When you use the option *-i*, Linux asks for confirmation before overwriting or deleting files. Ex: **cp -i, rm -i, mv -i**

•Linux does not have an **undo!**

49

View and Modify Text Files

•more *fname*

•Displays the contents of file *fname*, one page at a time.

•cat *fname*

•This is similar to the more command, but the file is displayed without stopping at the end of each page.

•gedit *fname* / gedit

•This command opens the file *fname* in the text editor *gedit*. A new *textfile* can be written by running *gedit* without an argument.

50

Redirecting the Output of Programs

•cmd > *fname*

•The output of *cmd* is written to file *fname*. The file is created if it doesn't already exist, and its contents is overwritten if the file exists. Ex: **ls > mlist.txt**

•cmd >> *fname*

•The >> operator *appends* the output of command *cmd* to the end of file *fname*.

•cmd | tee *fname*

•Both commands have the effect that the output of command *cmd* is displayed in the terminal window, and also written to file *fname*. The file is created if it does not exist, or the content is overwritten if the file exists.

•Both **cmd > fname** and **tail -f fname** can be used for the same purpose

51

Control of Commands

•Ctrl-c

•Terminates the command running in the foreground.

•Ctrl-z

•Stops the command running in the foreground.

•cmd &

•Executes the command *cmd* in the background.

•Jobs

•Lists all background and stopped commands of the current user, and assigns a number to each command.

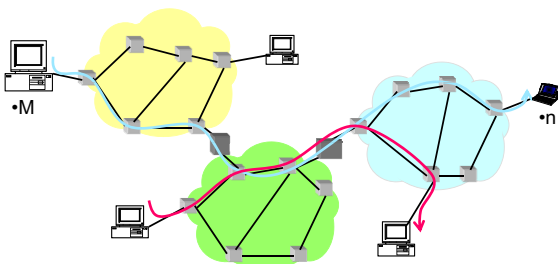
•kill %n

•Terminates the *n*-th command of the user.

52

Basic Networking Commands

- ◆ How to detect if another machine is alive, the path to it, and resolve its DNS name to ip address, etc. ...?



53

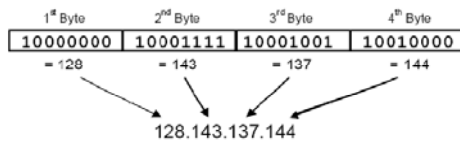
Basic Networking Commands

- ◆ ping – check if machine is alive
- ◆ ifconfig – interface (ip addr / mask) configuration
- ◆ arp – link / network layer address mapping
- ◆ netstat – status info of network configuration
- ◆ telnet – remote terminal
- ◆ ftp – file transfer tool
- ◆ route – set static route of a machine
- ◆ traceroute – gather route information
- ◆ tcpdump – dump packet header
- ◆ nslookup – resolve DNS name of target hostname

Key : What can you *infer* about the network or end-to-end properties with these commands?

54

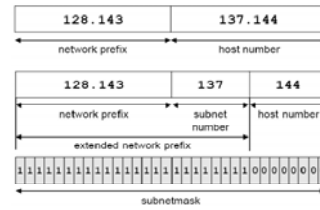
IP Addressing



- An IP address is an identifier for a network interface at the network layer.
- When the network interface is connected to the Internet, the IP address must be globally unique within the address space of the Internet.
- Each IP address consists of a network number which is followed by a host number

55

Subnet Masks



- 128.143.137.144/24 : IP address of the host
- 128.143.0.0/16 : IP address of the network
- 255.255.255.0 : Subnetmask of the host

56

ifconfig

- ifconfig**
 - Displays the configuration parameters of all active interfaces
- ifconfig -a**
 - Displays the configuration parameters of all network interfaces, including the inactive interfaces
- ifconfig interface**
 - Displays the configuration parameters of a single interface. For example, **ifconfig eth0** displays information on interface eth0.
- ifconfig eth0 down**
 - Disables the eth0 interface. No traffic is sent or received on a disabled interface.
- ifconfig eth0 up**
 - Enables the eth0 interface.
- ifconfig eth0 10.0.1.8 netmask 255.255.255.0**
 - Assign interface eth0 the IP address 10.0.1.8/24.

57

Telnet (TELEtype NETWORK))

- TELNET** is a network protocol used on the Internet or LAN connections. It is a remote login network protocol for executing commands on a remote host.
- SSH** is a protocol which has the same purpose with TELNET, becomes more dominant and popular.

```

Issue Telnet command on PC1 — PC1# telnet 10.0.1.12
                               Trying 10.0.1.12...
                               Connected to 10.0.1.12 (10.0.1.12).
                               Escape character is '^]'.
                               Red Hat Linux release 7.1 (SeaWolf)
                               Kernel 2.6.2 on an i686
                               login: root
                               Password:
                               Last login: Fri Mar 9 21:18:32 from 10.0.1.11
                               PC2#
                               PC1# exit
                               Connection closed by foreign host.
                               PC1#
Shell prompt at PC1 —
    
```

58

FTP (File Transfer Protocol)

- FTP** is used to connect two computers over the Internet so that the user of one computer can transfer files and perform file commands on the other computer.

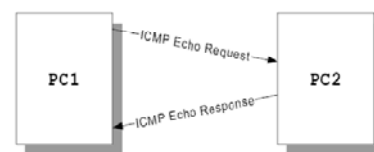
```

Issue FTP command on PC1 — PC1# ftp 10.0.1.12
                               Connected to 10.0.1.12.
                               220 FTD FTP server (Version wu-2.6.1-16) ready.
                               Name (10.0.1.12:root): root
                               Password:
                               Remote system type is UNIX.
                               Using binary mode to transfer files.
                               ftp> get x.txt
                               local: x.txt remote: x.txt
                               226 Transfer complete.
                               61 bytes received in 0.00062 seconds (96 Kbytes/s)
                               End FTP session — ftp> quit
                               Shell prompt at PC1 — PC1#
    
```

59

Ping

- Ping** tests whether a given IP address is reachable.
- The **ping** command sends an **ICMP Echo Request** message to an interface with the specified IP address, and expects an **ICMP Echo Response** message in return.



60

Ping

- **ping *IPaddress***

- Issues a *ping* command for the host with the given IP address. The system will issue one *ICMP Echo Request* packet with a size of 56 bytes every second.

- The command is stopped by typing **Ctrl-c**.

- **ping -c *num* *IPaddress***

- The command stops after sending *num*, where *num* is a number.

- **ping -f *IPaddress***

- The sender transmits *ICMP Echo Response* messages as quickly as possible.