Computer Networks and Internets with Internet Applications, 4e

By Douglas E. Comer

Lecture PowerPoints

By Lami Kaya, LKaya@ieee.org

Chapter 2

Motivation and Tools

Topics Covered

- 2.1 Introduction
- 2.2 Resource Sharing
- 2.3 Growth Of The Internet
- 2.4 Probing The Internet
- 2.5 Interpreting A Ping Response
- 2.6 Tracing A Route
- 2.7 Summary

2.1 Introduction

This chapter

- discusses the size and rapid growth of the Internet, and
- introduces a few basic tools that can be used to explore NW

2.2 Resource Sharing (1)

- Some of the earliest computer NW were built to extend existing computing facilities.
  - NW were devised that allowed multiple computers to access a shared peripheral device such as a printer or a disk
- Main motivation for the first NW were share large-scale computational power
- The U.S. Department of Defense (DoD)
  - Advanced Research Projects Agency (ARPA) was concerned about the lack of high-powered computers

2.2 Resource Sharing (2)

- Many of the ARPA research projects needed access to the latest equipment
  - Each research group wanted one of each new computer type
- By the latter 1960s, it became obvious that the ARPA budget could not keep up with demand
  - As an alternative, ARPA started investigating data NW
  - The agency decided to give each group one computer
  - Interconnect the computer with a data NW
- The ARPA NW research turned out to be revolutionary

2.3 Growth Of The Internet

- The Internet has grown from the early research prototype
  - to a global communication system that reaches all countries
- Figure 2.1 illustrates how the Internet has grown
  - The figure contains a graph of the number of computers attached to the Internet as a function of the years from 1981-2003
- When plotted on log-scale as in Figure 2.2
  - the growth appears approximately linear
    - meaning that the Internet has experienced exponential growth over two decades
  - The Internet has been doubling in size every 9-12 months

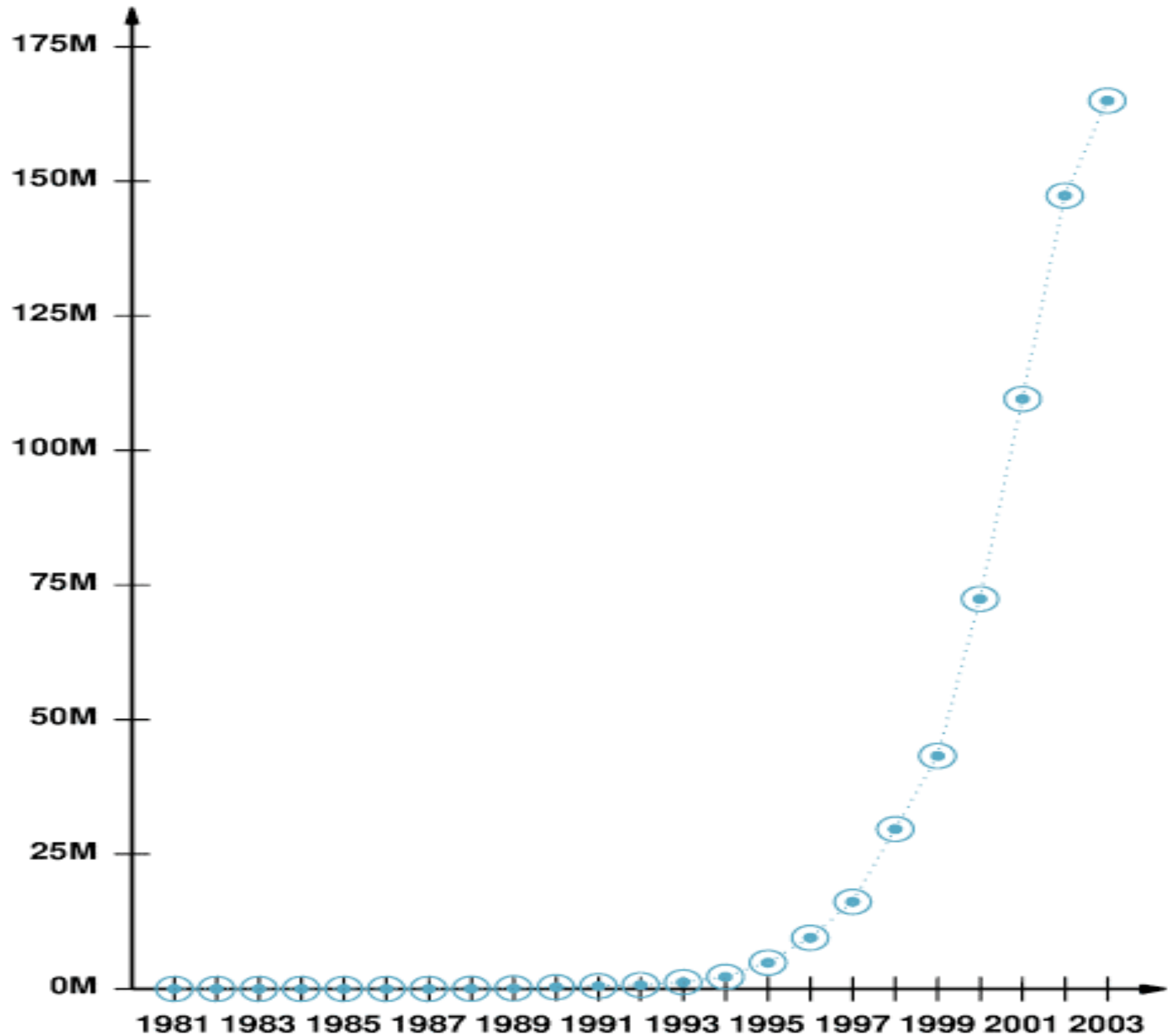

Figure 2.1 Internet growth measured by the number of computers attached to the Internet in each year from 1981 though 2003. The y-axis is labeled in millions of computers.

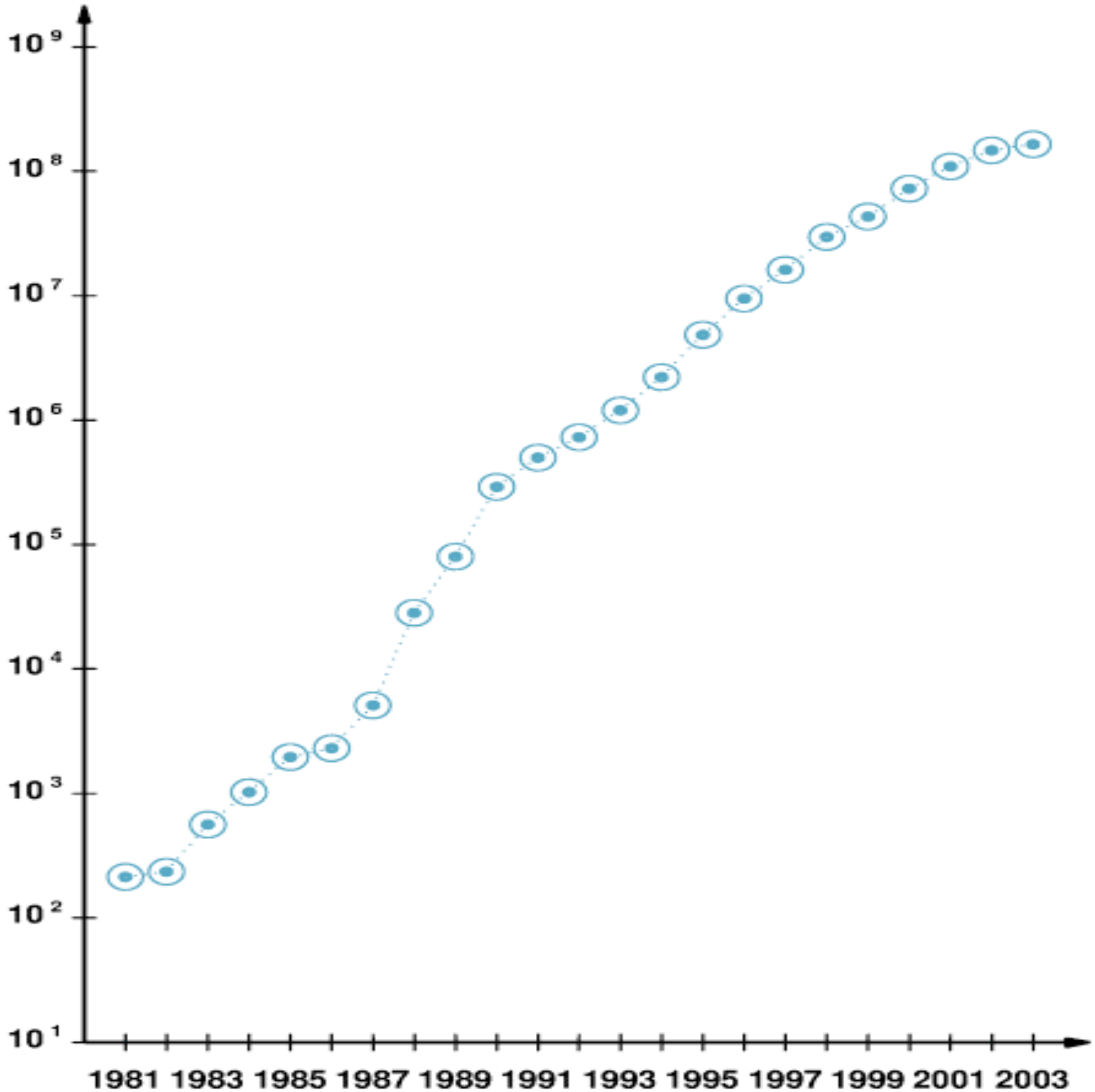

Figure 2.2 Internet growth from 1981 through 2003 plotted on a log scale illustrates the exponential growth.

2.4 Probing The Internet (1)

- The program begins by walking through the Domain Name System (DNS),
  - system that stores names for computers and then uses a program that tests to see whether the computer is currently online
- Tools used to probe the Internet are also available to users
- One of the simplest probing tools is a program known as ping:
  - Ex: ping www.netbook.cs.purdue.edu
- The ping program sends a message to the specified computer and then waits a short time for a response.
  - If a response arrives, ping reports to the user that the computer is alive
  - otherwise, ping reports that the computer is not responding
  - Ex: www.netbook.cs.purdue.edu is alive
- Figure 2.3 shows an example of ping output with the timing and repetition options turned on


```
PING www.sears.com: 56 data bytes
64 bytes from 129.33.131.220: icmp_seq=0. time=10. ms
64 bytes from 129.33.131.220: icmp_seq=1. time=11. ms
64 bytes from 129.33.131.220: icmp_seq=2. time=11. ms
64 bytes from 129.33.131.220: icmp_seq=3. time=10. ms
64 bytes from 129.33.131.220: icmp_seq=4. time=10. ms
----www.sears.com PING Statistics----
5 packets transmitted, 5 packets received, 0% packet loss
round-trip (ms)  min/avg/max = 10/10/11
```

Figure 2.3 Example output from the ping program run on the author's workstation. The destination was www.sears.com, and the program was manually interrupted after five responses were received.

2.4 Probing The Internet (2)

- In Figure 2.3, ping sends one request each second
  - and produces one line of output for each response received
- The output tells the size of the packet received
  - the sequence number, and the round-trip time in milliseconds
- When the user interrupts the program,
  - ping produces a summary that specifies the number of packets sent and received
  - packet loss
  - and the minimum
  - mean
  - and maximum round-trip times

```
PING Berkeley.EDU: 56 data bytes
64 bytes from chaparral.Berkeley.EDU (128.32.25.19): icmp_seq=0. time=49. ms
64 bytes from chaparral.Berkeley.EDU (128.32.25.19): icmp_seq=1. time=48. ms
64 bytes from chaparral.Berkeley.EDU (128.32.25.19): icmp_seq=2. time=48. ms
64 bytes from chaparral.Berkeley.EDU (128.32.25.19): icmp_seq=3. time=48. ms
64 bytes from chaparral.Berkeley.EDU (128.32.25.19): icmp_seq=4. time=48. ms
----Berkeley.EDU PING Statistics----
5 packets transmitted, 5 packets received, 0% packet loss
round-trip (ms)  min/avg/max = 48/48/49
```

Figure 2.4 Example output from the ping program for destination berkeley.edu, which is located on the west coast. Round-trip times are higher than than those reported in Figure 2.3.

```
PING MIT.EDU: 56 data bytes
64 bytes from SICARIUS-SPATULATUS.MIT.EDU (18.7.21.77): icmp_seq=0. time=32. ms
64 bytes from SICARIUS-SPATULATUS.MIT.EDU (18.7.21.77): icmp_seq=1. time=31. ms
64 bytes from SICARIUS-SPATULATUS.MIT.EDU (18.7.21.77): icmp_seq=2. time=31. ms
64 bytes from SICARIUS-SPATULATUS.MIT.EDU (18.7.21.77): icmp_seq=3. time=31. ms
64 bytes from SICARIUS-SPATULATUS.MIT.EDU (18.7.21.77): icmp_seq=4. time=31. ms
----MIT.EDU PING Statistics----
5 packets transmitted, 5 packets received, 0% packet loss
round-trip (ms)  min/avg/max = 31/31/32
```

Figure 2.5 Example output from the ping program for destination mit.edu, a location on the east coast. Round-trip times are significantly higher than in previous examples.

2.5 Interpreting A Ping Response (1)

- When no response is received, ping cannot help determine the reason:
  - The remote computer could be turned off
  - disconnected from the NW
  - its NW interface could have failed
  - SW running may not respond to ping
  - the local computer could be disconnected from the NW
  - the NW to which the remote computer attaches could have failed
  - failure of an intermediate computer or NW
  - Finally, ping sometimes fails because the NW has become so congested with traffic that delays are unreasonably long
- Ping has no way to determine the cause of the problem

2.5 Interpreting A Ping Response (2)

- Another reason why ping may fail to generate a response is less subtle:
  - some companies configure their site to reject ping packets
- The motivation for disabling ping is security:
  - if a corporation allows ping traffic to enter its site
    - the site becomes susceptible to a denial-of-service or flooding attack
  - so many ping packets arrive that the company's NW and computers cannot respond to legitimate requests
  - To avoid such attacks,
    - the company merely rejects ping packets before they enter

2.6 Tracing A Route (1)

- traceroute used to determine the intermediate computers along the path to a remote destination
  - Ex: traceroute www.netbook.cs.purdue.edu
- Figure 2.6 shows the output from traceroute with the destination berkeley.edu
- traceroute provides more information than ping
  - Each line corresponds to each of intermediate computers
  - and one corresponds to the final destination itself
- traceroute cannot be used for all destinations
  - NW administrators may choose to disable it
    - to prevent outsiders from obtaining detailed information about their architecture

```
traceroute to berkeley.edu (128.32.25.19), 30 hops max, 40 byte packets
 1  cisco5 (128.10.2.250)  0.958 ms 0.746 ms 0.705 ms
 2  cisco-tel3-242.tcom.purdue.edu (128.210.242.24) 552.223 ms 443.787 ms 1.206 ms
 3  tel-210-m10-01-242.tcom.purdue.edu (128.210.242.251) 0.736 ms 1.123 ms 0.924 ms
 4  gigapop.tcom.purdue.edu (192.5.40.14) 16.793 ms 2.789 ms 2.614 ms
 5  abilene-ul.indiana.gigapop.net (192.12.206.249) 2.702 ms 11.644 ms 2.521 ms
 6  kscyng-iplsng.abilene.ucaid.edu (198.32.8.81) 12.938 ms 12.088 ms 21.926 ms
 7  snvang-kscyng.abilene.ucaid.edu (198.32.8.102) 47.417 ms 47.088 ms 47.137 ms
 8  198.32.249.161 (198.32.249.161) 47.435 ms 47.191 ms 47.093 ms
 9  BERK--SUNV.POS.calren2.net (198.32.249.13) 48.464 ms 48.265 ms 48.445 ms
10  pos1-0.inr-000-eva.Berkeley.EDU (128.32.0.89) 48.223 ms 48.434 ms 48.664 ms
11  vlan199.inr-202-doecev.Berkeley.EDU (128.32.0.203) 49.085 ms 49.358 ms 48.877 ms
12  vlan210.inr-203-eva.Berkeley.EDU (128.32.255.10) 48.660 ms 48.933 ms 48.848 ms
13  * * chaparral.Berkeley.EDU (128.32.25.19) 48.794 ms
```

Figure 2.6 Example output from traceroute run on the author's workstation to destination berkeley.edu, which is an alias for computer chaparral.Berkeley.edu.

2.6 Tracing A Route (2)

- Figure 2.6 illustrates another features of traceroute:
  - a report of packet loss
- Traceroute sends three probes for each intermediate computer
- When the three responses arrive,
  - traceroute prints the name of the intermediate computer, and gives the minimum, average, and maximum round-trip times.
- The line with asterisks indicates two of three probes received no response (i.e., packets were lost)
- In a later test, all probes were received successfully
- We can conclude that the loss was a temporary condition
  - probably caused by congestion on one of the paths between the source and destination

