Ch 3: Making the Connection

- The Basics of Networking
  - Societal changes driven by networked computers
  - Different communications technologies: synchronous vs. asynchronous, broadcast vs. point-to-point
  - Different protocols: Ethernet, TCP/IP, etc.
  - Internet addresses, domain names, DNS servers

Networks...

- Computers are useful alone, but are more useful when connected (networked)
  - Access more information and software than is stored locally
  - Help users to communicate, exchange information … changing ideas about social interaction
  - Perform other services -- printing, Web,...

UC's networks move more than trillion bytes per day

Networked Computers Change Our Lives

- The Information Age has brought profound changes
  - Nowhere is remote
  - People are interconnected
  - Social relationships are changing
  - English is becoming a universal language
  - Freedom of speech and association have expanded

Nowhere Is Remote

- Internet is a complete information resource no matter where you are
  - Some differences remain because older sources are not yet all online
- Homes are not remote from work
  - Information workers can telecommute and live long distances from their offices

Social Interactions Are Changing

- Time spent online displaces other in-person social activities (*displacement effect*)
- The Internet is changing social interactions
- Spending too much time online could be bad
- The effects are being studied, but we don't yet fully understand them

English Is Becoming a Universal Language

- Influence of American pop culture since World War II
- Dominance of science and technology in English-speaking countries
- Much software is available only in English
- Most web pages are in English

Freedom of Speech and of Association Have Expanded

- Internet use is *unmediated*
  - Little editorial oversight or significant restrictions
- Allows for political and artistic expression
- *Blogs* record personal thoughts for public viewing
- Like-minded people can communicate, even on private topics

People Are More Interconnected

- Family and friends stay in closer, more frequent contact via Internet than via telephone or "snail mail"
- WWW lets us meet more people
  - People with similar interests find each other through search engines
  - Associations can form rapidly

Communication Types

- General Communication
  - *Synchronous:* sender and receiver are active at the same time: e.g. telephone call
  - *Asynchronous:* sending and receiving occur at different times: e.g. mail
  - *Broadcast communication* (or multicast): single sender and many receivers
  - *Point-to-point communication:* single sender and single receiver

Which of these does the internet use?

The Internet's Communication Properties

- Internet provides a general communication "fabric" linking all computers connected to it
  - The "fabric" can be used in many ways:
    - Point-to-point asynchronous
      - Email is alternative to standard mail
    - Point-to-point synchronous
      - IM, VoIP are alternatives to standard telephone
    - Multicasting
      - Chat rooms are alternatives to magazines
    - Broadcasting
      - Web pages are alternatives to radio and television

internet "fabric"

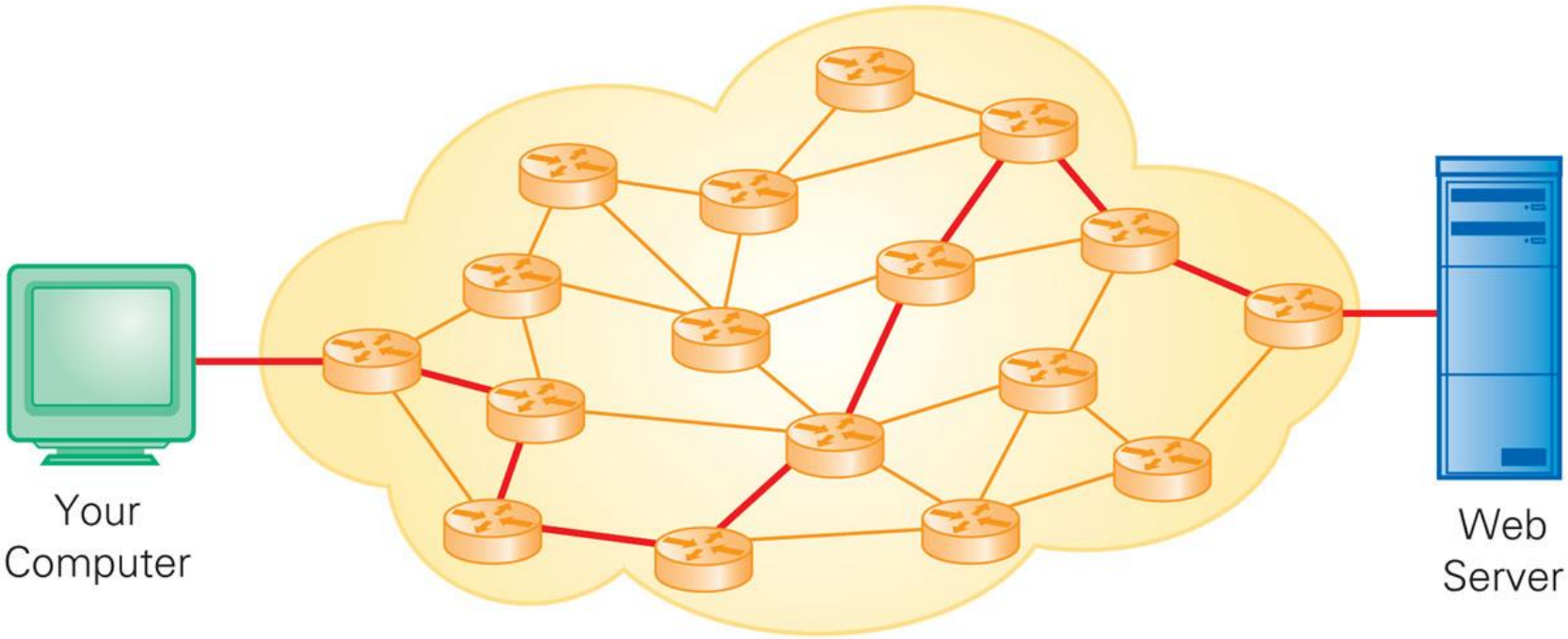


Figure 3.1. *A diagram of the Internet.*

Far and Near: WAN and LAN

- Internet is a collection of *Wide Area Networks (WAN)*, designed to send information between widely separated locations
- A *Local Area Network (LAN)* connects computers close enough to be linked by a single cable or wire pair
- A LAN is connected to the Internet through a *gateway*

Moving Packets: Wires and More

- Information is sent using electrical, electronic, and optical communication technologies
  - Copper telephone lines, dedicated fiber optic lines, microwave links, etc.
- The physical technology used to move the information is independent from the *protocol*
  - transmission of information may use multiple technologies and multiple protocols

Protocol Rules!

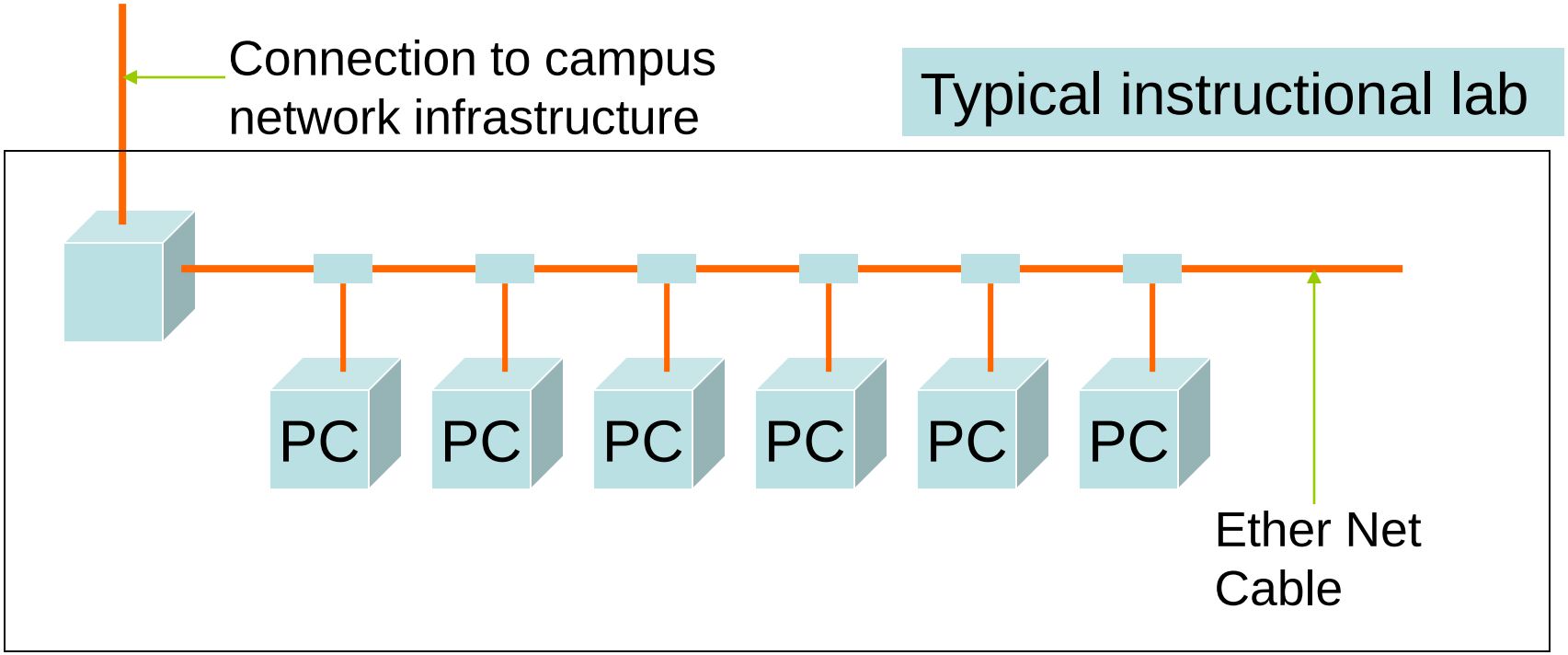
- To communicate, computers need to know:
  - how to format the information to be sent
  - how to interpret the information received
  - how to conduct the communication
- The rules for doing this are a *protocol*

Some protocols

- EtherNet
  - for communication over a LAN
- TCP/IP -- Transmission Control Protocol / Internet Protocol
  - for sending packets on the Internet
- HTTP -- HyperText Transfer Protocol
  - for client/server interactions on the Web
- SMTP – Simple Mail Transfer Protocol
  - for email
- FTP – File Transfer Protocol
  - for files
- SSH – Secure Shell
  - for secure shell connections and transfer of files

LAN in the Lab

- EtherNet is a popular LAN protocol
  - It's a “party line” protocol

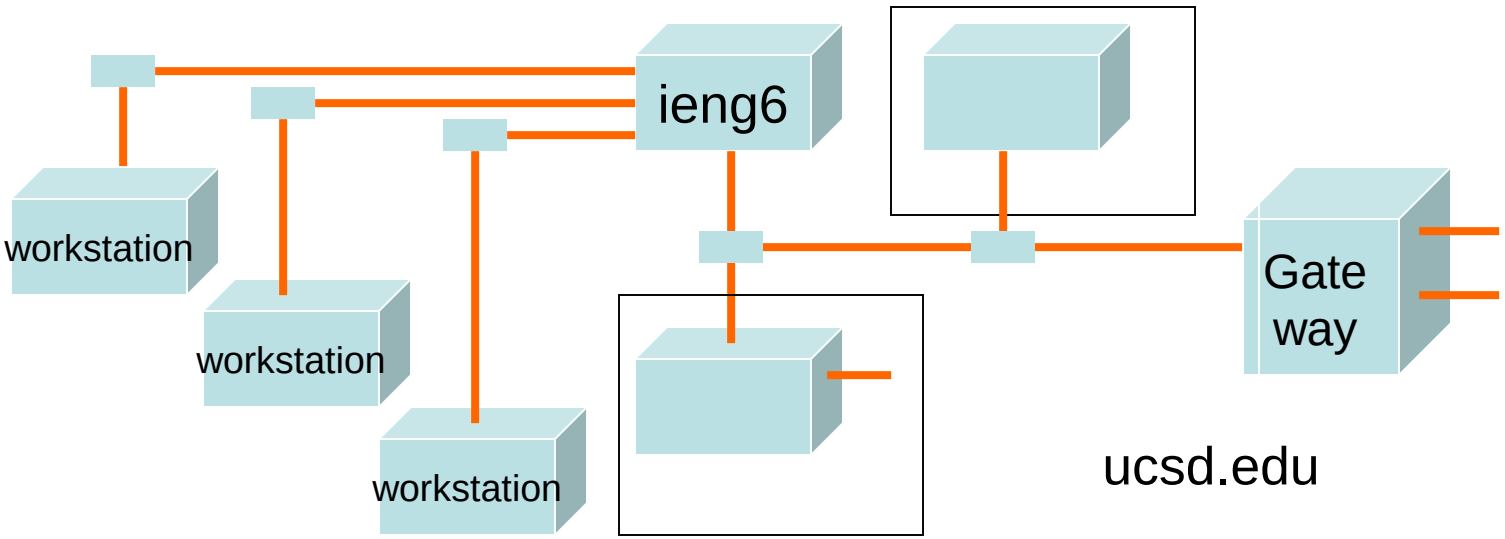


Ethernet protocol

- Channel (wire, wire pair, or optical fiber) that connects a set of computers
- Each computer is connected to the channel, allowing it to send a signal that can be detected by all computers connected to the channel
- Decentralized scheme: Each computer listens to the channel, and if it's quiet, it's free. The computer transmits unless another starts at the same time. In that case, both stop for a random time and then try again.

Campus & The World

- The campus subnetworks connect computers of the ucsd.edu domain, which connects to Internet via a gateway



Communication here is by TCP/IP

Internet protocols

TCP/IP (Transmission Control Protocol/ Internet Protocol)

- Information is broken into a sequence of small fixed-size chunks called *IP packets*
- Each packet has space for the chunk of data, the destination IP address, and a sequence number
- The packets are sent over the Internet one at a time using whatever route is available, passing through different switches, routers, and other computers
- Because each packet can take a different route, congestion and service interruptions do not disrupt transmissions

IP -- Like Using Multiple Postcards

- Using IP is like sending a message on multiple postcards
  - Break message into smaller chunks
  - Construct IP packets: each has destination IP address, sequence number and a message chunk
  - Send packets. Each packet makes its way separately to destination, possibly taking different routes
  - Message is reassembled at destination

Taking separate routes lets packets by-pass congestion and out-of-service switches

Figure 3.7. The TCP/IP postcard analogy.

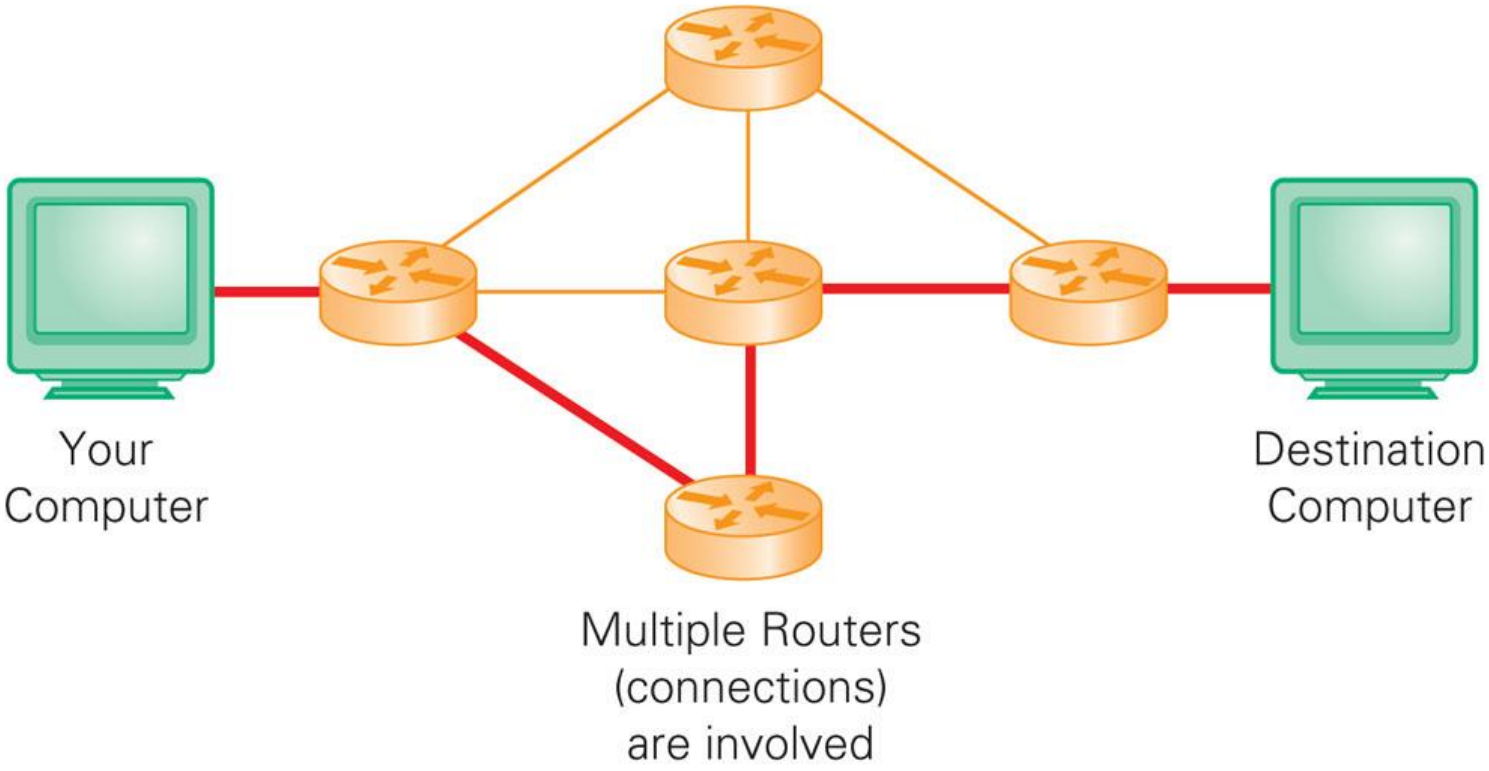
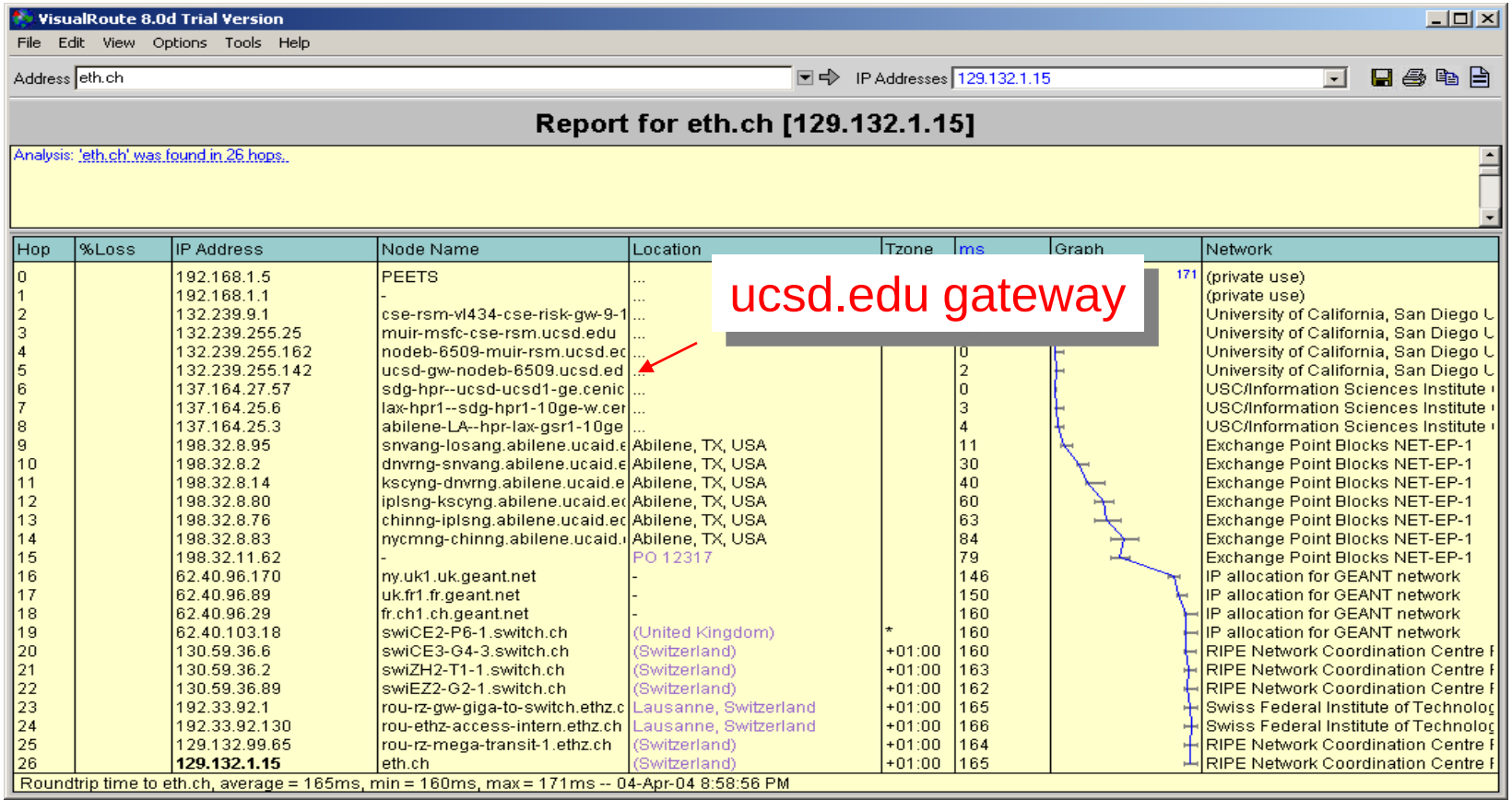


Figure 3.8. *The Internet makes use of whatever routes are available to deliver packets.*

A Trip to Switzerland

- A packet sent from UCSD to ETH (Swiss Fed. Tech. University) routed through 26 'hops'!



Check Internet Hops

- To explore more...
  - Find software called Visual Routes (personal evaluation copies are free)

    at http://www.visualroute.com
  - Download a copy of the software
  - Install software and type in foreign URLs
    - Switzerland eth.ch
    - Australia www.usyd.edu.au
    - Japan kyoto-u.ac.jp
    - South Africa www.uct.ac.za

Naming computers

- Every computer on the internet needs to be identifiable, so packets can be sent to it reliably
- Otherwise the internet wouldn't work!
- There are two ways to do this:
  - numerical IP addresses, used in IP packets
  - textual domain names, used by humans
- The Domain Name System relates the two naming schemes

Naming Computers I

- Computers are named by *domain names* -- a hierarchical scheme that groups related computers
  - `.edu` The .edu domain: All computers at educational institutions
  - `.ucsd.edu` The ucsd.edu domain: All computers at ucsd
  - `ieng6.ucsd.edu` A particular computer at ucsd
- Domains begin with a “dot” and get “larger” going to the right...

Naming Computers II

- Computers are also named by IP address, four numbers in the range 0-255

  ieng6.ucsd.edu: `128.54.70.238`

  - Remembering IP addresses would be brutal for humans, so humans use domain names
  - Computers find the IP address for a domain name from the *Domain Name System* -- an IP address-book computer

How many different IP addresses are there?...
... is that enough?

Top-level Domains

- A *domain* is a related group of networked computers
- *Top-level* domains appear in the last part of domain name, all the way to the right:

.edu	educational institutions
.com	commercial companies
.org	other organizations
.net	networks
.mil	military
.gov	government agencies

Mnemonic two-letter country designators such as .ca (Canada)

Top-level Domains

- .edu .com .mil .gov .org .net domains are “top level domains”, mainly for the US
- Occasionally, new TLD names added
- Each country has a top level domain name: .ca (Canada), .es (Spain), .de (Germany), .au (Australia), .at (Austria), .us (United States)

The FIT book contains the complete list

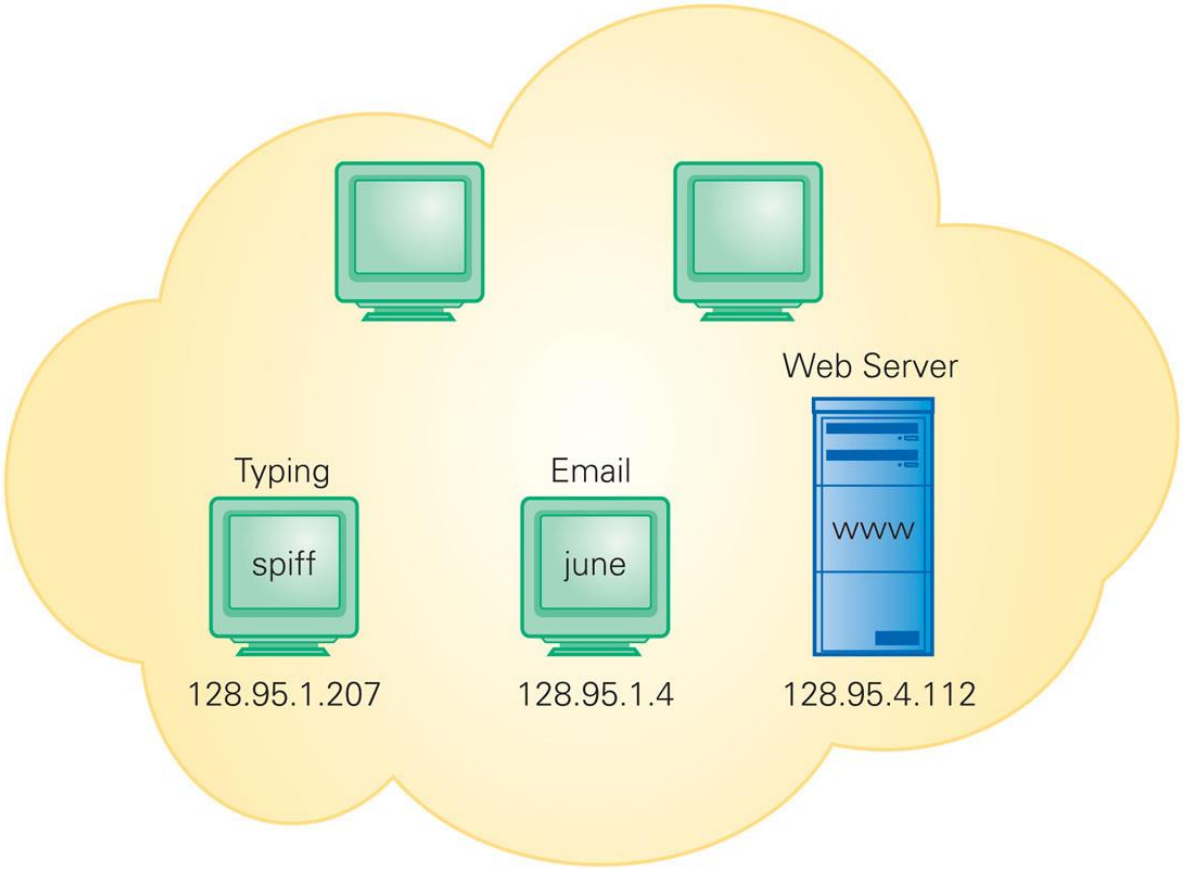


Figure 3.4. *Computers connected to the Internet are given IP addresses.*

The Medium of the Message

- The Name Game of Computer Addresses
  - *IP addresses:* Each computer connected to the Internet is given a unique numerical address
    - Good for fast processing by machine
  - *Domain Names:* Human-readable symbolic names, based on domain hierarchy
    - Easier to read and remember and type

DNS Servers

- The *Domain Name System* translates the human-readable names into IP addresses
- A computer connected to the internet must know the IP address of a nearby DNS server, a computer that keeps a list of domain names and corresponding IP addresses
- When you use a domain name to send information, your computer asks the DNS server to look up the IP address
- If the nearby DNS server doesn't know the IP address, it asks a *Root name server,* which keeps the master list of name-to-address relationships

Logical vs Physical

- There are 2 ways to view the Internet
  - Humans see a hierarchy of domains relating computers -- logical network
  - Computers see groups of four number IP addresses -- physical network
  - Both are ideal for the “users” needs
- The Domain Name System (DNS) relates the logical network to the physical network by translating domains to IP addresses

A computer needs to know IP address of a DNS server!

Summary

- Networking increases the usefulness of computers, but has social implications
- There are local area and wide area networks (LAN's and WAN's)
- The Internet uses different protocols to exchange different kinds of information
- The Domain Name System (DNS) relates the logical network to the physical network by translating domains to IP addresses