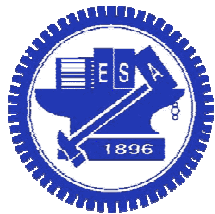# Networking and Internet
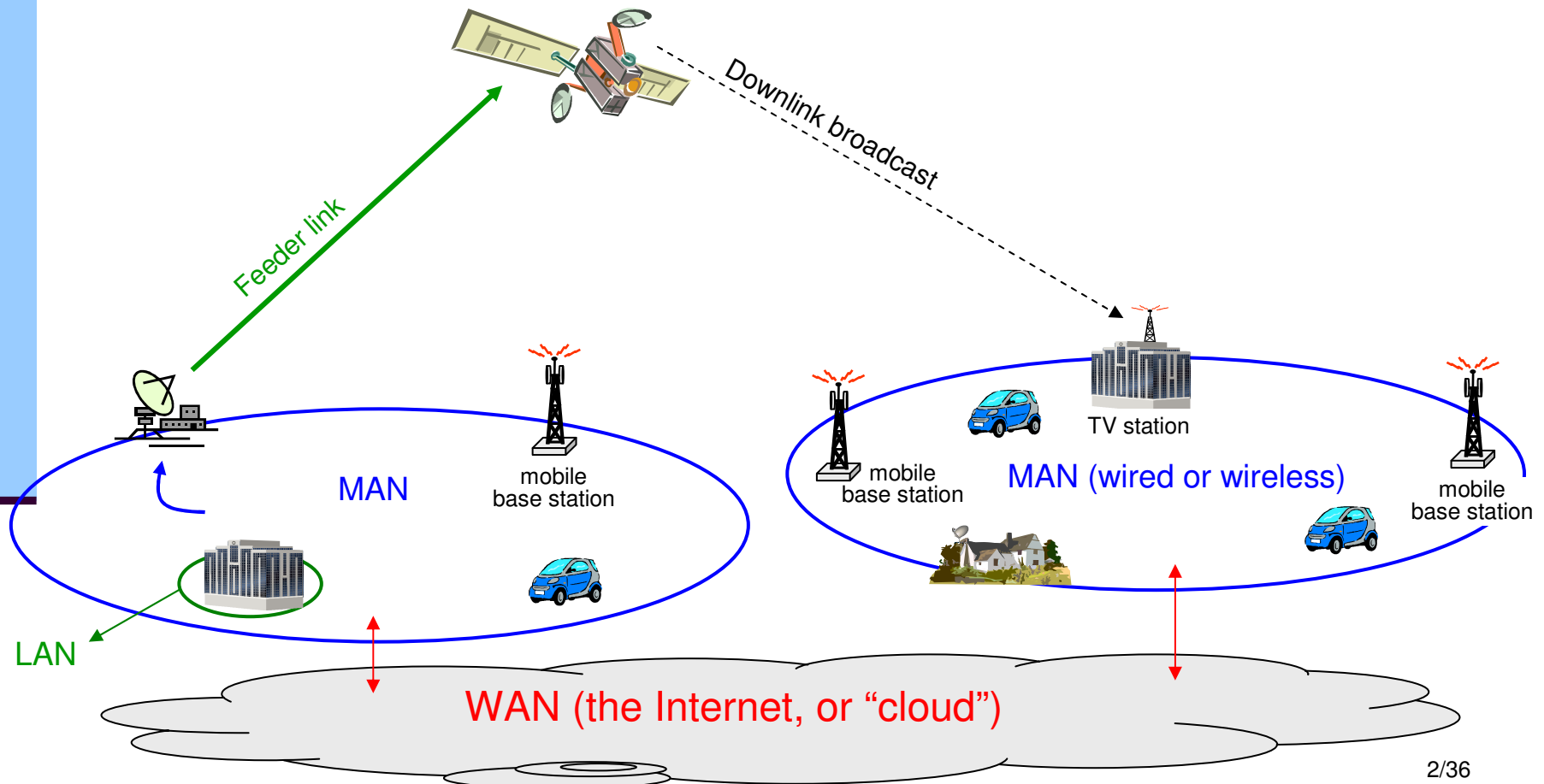
National Chiao Tung University

Chun-Jen Tsai

3/30/2012

A Networked World

❑ The world is connected by heterogeneous networks:

Downlink broadcast

Feeder link

TV station

MAN

mobile
base station

mobile
base station

MAN (wired or wireless)

mobile
base station

LAN

WAN (the Internet, or "cloud")

Service Network Classifications

- ❑ Broadcasting Networks (TV Networks)
  - ◼ Satellite Networks
  - ◼ Terrestrial Networks
  - ◼ Cable Networks
- ❑ Communication Networks
  - ◼ Public Switched Telephone Networks (PSTN)
  - ◼ Mobile Networks (2G, 3G)
- ❑ Computer Networks (using Internet Protocol)
  - ◼ Ethernet
  - ◼ Integrated Service Digital Network (ISDN)
  - ◼ Asymmetric Digital Subscriber Line (ADSL)

Network Geographic Classifications

❑ Local area network (LAN)
  - Small scale, usually within a diameter of a few kilometers (e.g., a company, lab, or school)
  - High speed (> 100 mega bits-per-second)
  - Complete ownership by a single organization

❑ Metropolitan Area Network (MAN)
  - Medium scale, say, within a city
  - "Broadband" speed (around 1~10 mbps)
  - Examples: ADSL or Cable Modem

❑ Wide area network (WAN)
  - Large scale, may cover entire country or across countries
  - Usually low speed (< 1 mbps)
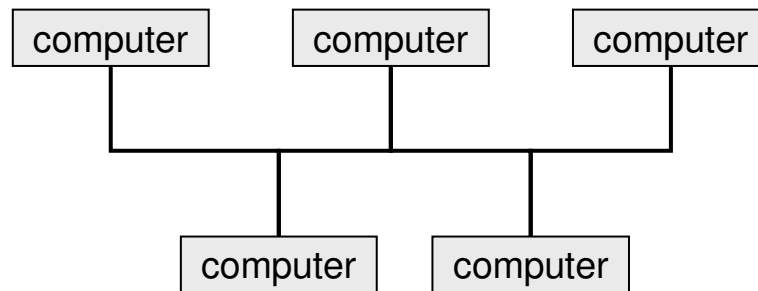
Network Topologies

❑ Ring:
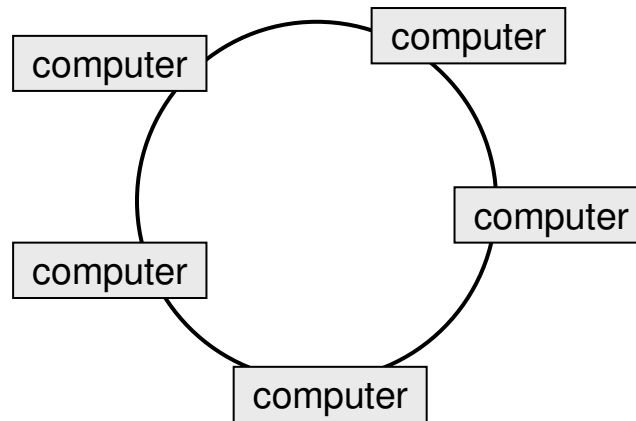
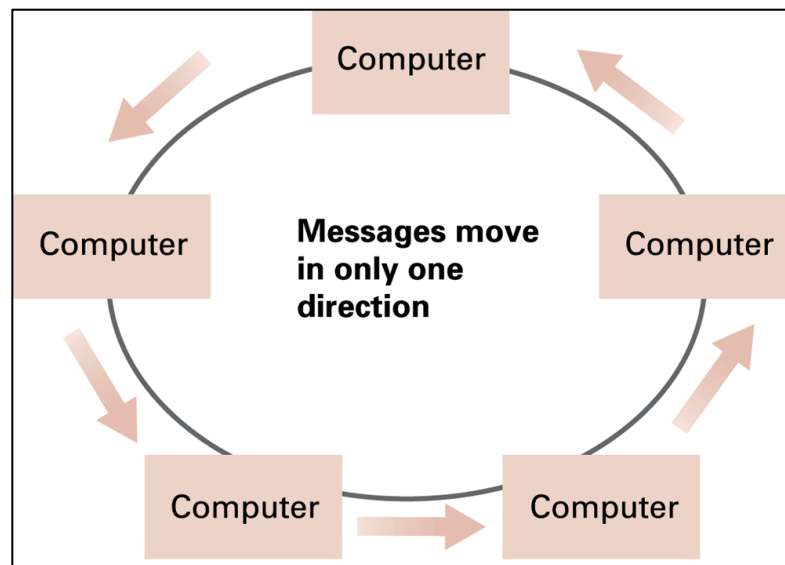❑ Star:
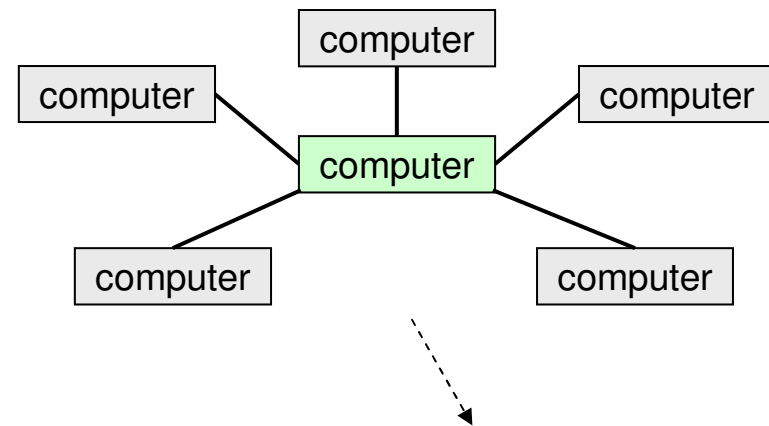
The star configuration is popular today since wireless networks use this configuration; the central computer is called access point (AP) or base station (BS)
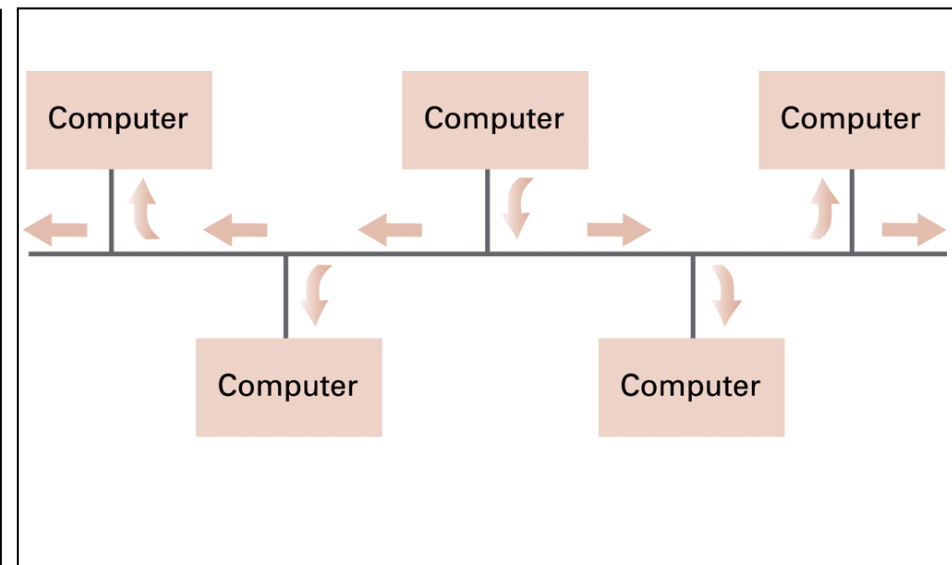
❑ Bus:

Communication over a Network

❑ The topology of a network determines its communication protocols

❑ A network protocol is a set of rules for computers in a network to perform data exchange

Ring Network

Bus Network

Token Ring Protocol†

- ❑ Developed by IBM in 1970
- ❑ The computer that receives the "token" message can become the originating computer of a data message
- ❑ Data messages are transmitted in one direction
  - ■ Each computer on the ring topology forwards the message to the next one
  - ■ Only the destination machine keeps a copy of the data message before it forward the message
  - ■ The originating computer of the message will not forward it again when it received the message

† The textbook removes the discussion of token ring protocol in 10th edition.

Ethernet Protocol for Bus Network

❑ Ethernet protocol uses the rule called "Carrier Sense, Multiple Access with Collision Detection (CSMA/CD)"

- Each computer on the network has an address ID
- Any messages are broadcasted to all computers on the network
- A computer only keeps the message addressed to it
- If more than one computers try to send messages at the same time, they will all detect the "collision" and stop sending messages
  - They will try again later, after a random period of waiting

Wireless Protocol

❑ Wireless network uses Carrier Sense, Multiple Access with Collision Avoidance (CSMA/CA) protocol

- A "newcomer" must wait until it does not "hear" any messages before it can *request* to use the channel
- To avoid the "hidden terminal problem," the newcomer must wait for the AP to grant its request before it sends messages

AP

Invisible to other mobile terminals
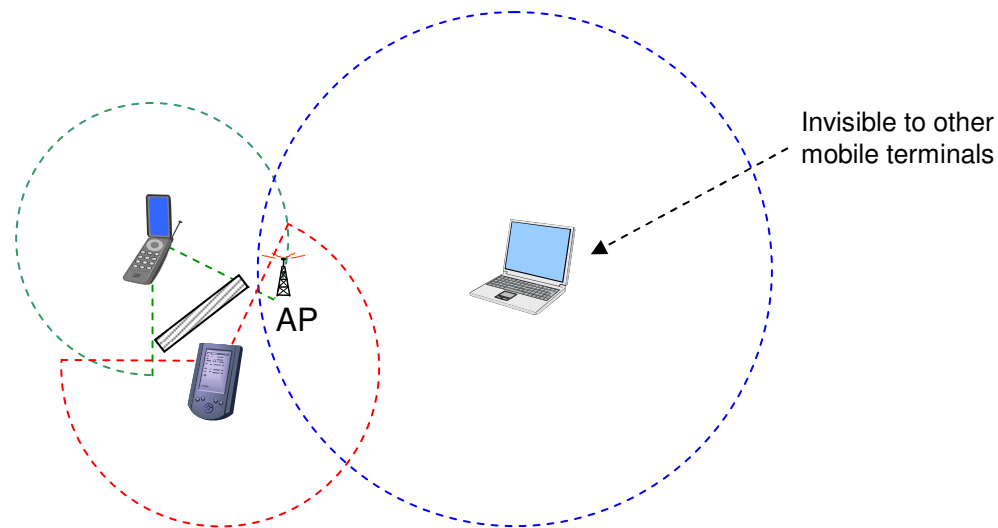
Combining Networks (1/2)

❑ To connect two or more smaller networks to form a big network, we need some special devices

- Repeater – a device that passes signals between two networks back-and-forth

- Bridge – a device similar to a repeater, but it only performs "meaningful" message-forwarding

- Switch – a bridge with multiple connections
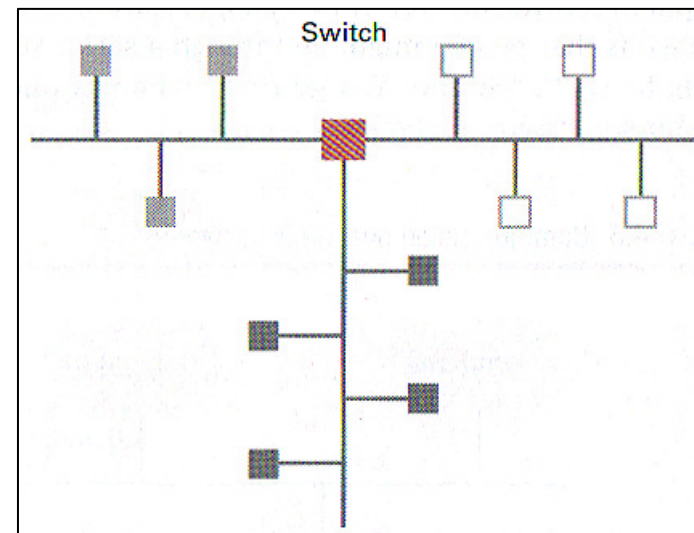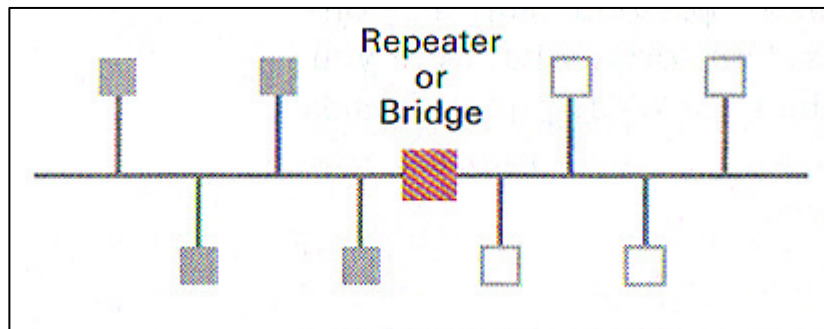
Combining Networks (2/2)

❑ A router is a device (maybe a computer) that connects two (possibly heterogeneous) networks together

  ▪ The two networks may be using different protocols and address IDs

computer	computer	Router	computer

computer   computer   computer   computer

computer   computer
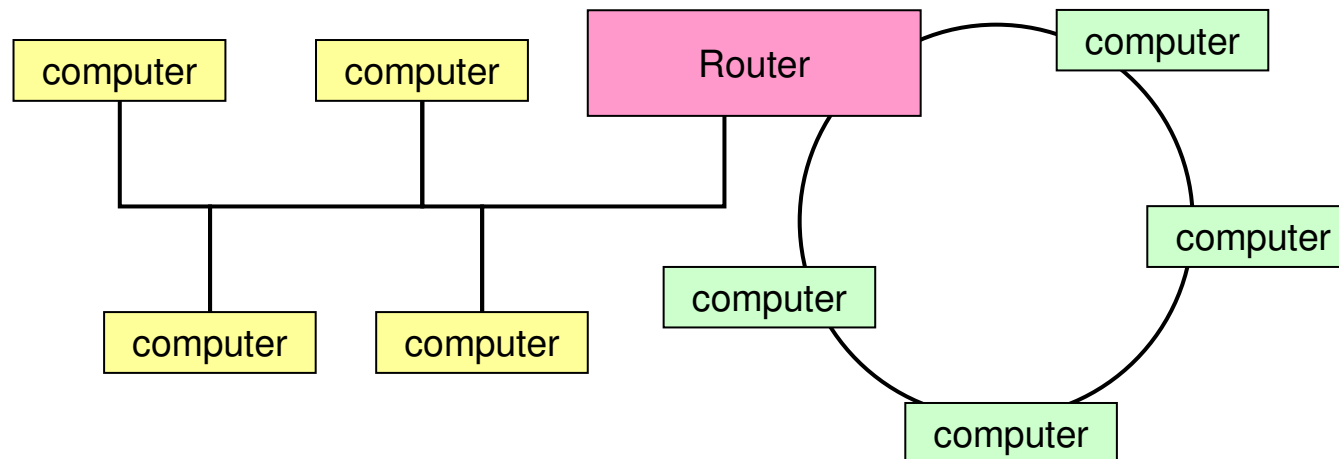
Interprocess Communication Model

❑ Client-server model

- One server, many clients
- Server must execute continuously
- Client initiates communication
- Example: print server, file server

server ← requests ← client

server → services → client
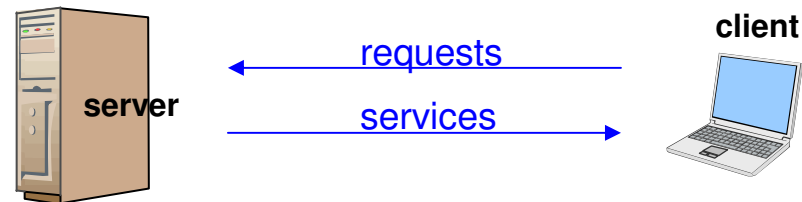
❑ Peer-to-peer model

- Two hosts communicating as equals
- Peer hosts can be short-lived
- Peer-to-peer **network** is a misuse of the terminology

Client/Server Model vs. P2P Model
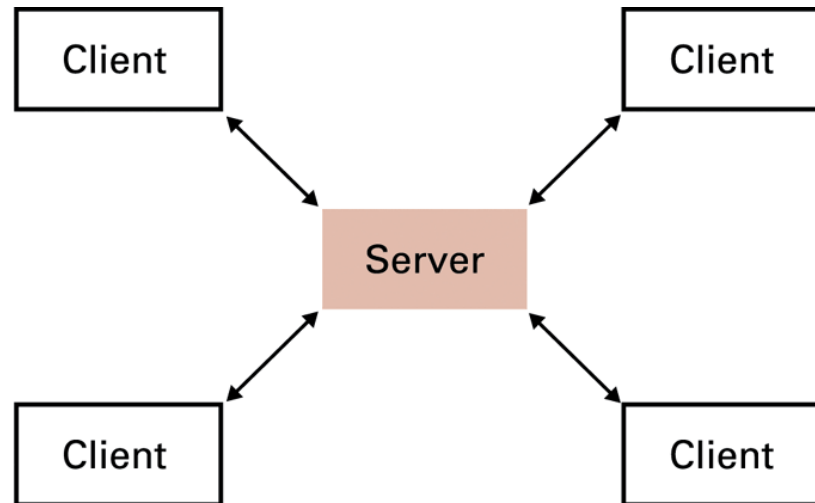
a. Server must be prepared to serve multiple clients at any time.
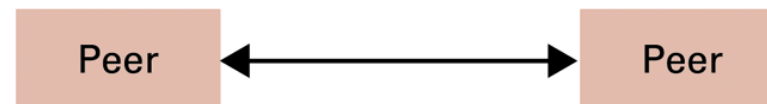
b. Peers communicate as equals on a one-to-one basis.

Distributed Systems

❑ A distributed system is a system with software units that run on different computers across the network

- Each software unit is a process running on a host (i.e. a computer on the network)

- Distributed processes usually have to perform data exchange, remote invocation, synchronization, etc.

- Various distributed computing models

  • Cluster computing – tightly-coupled, supercomputer style

  • Grid computing – loosely-coupled, SETI@HOME style

  • Cloud computing – hyping-based, scammer style

The Internet

❑ The Internet: one internet spanning the world

- Started by DARPA in 1970's
- Today involves millions of machines

❑ The Internet is a packet-switched network. That is, all the data are transmitted on a packet-by-packet basis

- Another type of network is called circuit-switched, which means a virtual connection will be established before the transmission of data

Internet Architecture

❑ The Internet is a collection of domains

- Each domain is a network or a set of inter-connected networks controlled by a single organization
- Domains must be registered through ICANN, Internet Corporation for Assigned Names & Numbers

❑ A gateway is a router connecting a domain to the rest of the Internet (referred to as the *cloud*)

Domain

The Internet cloud

Router

Regional network of gateways

Domain

Domain

Domain
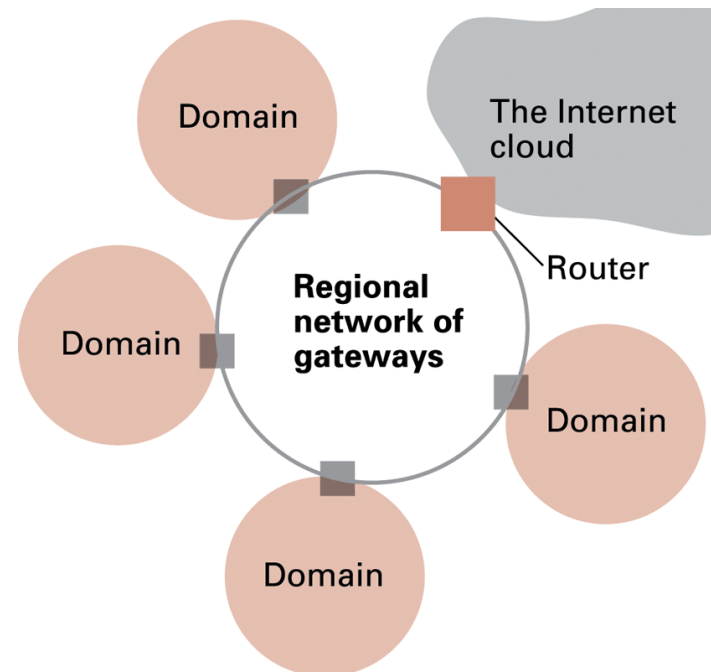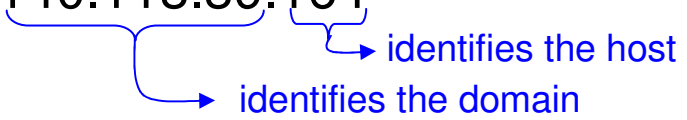
Strategies for Internet Connections

❑ There are several ways to connect your computers to the Internet:

- For a large organization, you can lease direct connections
  - Example: TANet run by Ministry of Education in Taiwan
- For a small organization, you can link your domain to the domain of an Internet Service Provider (ISP)
  - There are three levels: Tier-1 ISPs, Tier-2 ISPs, Access ISPs
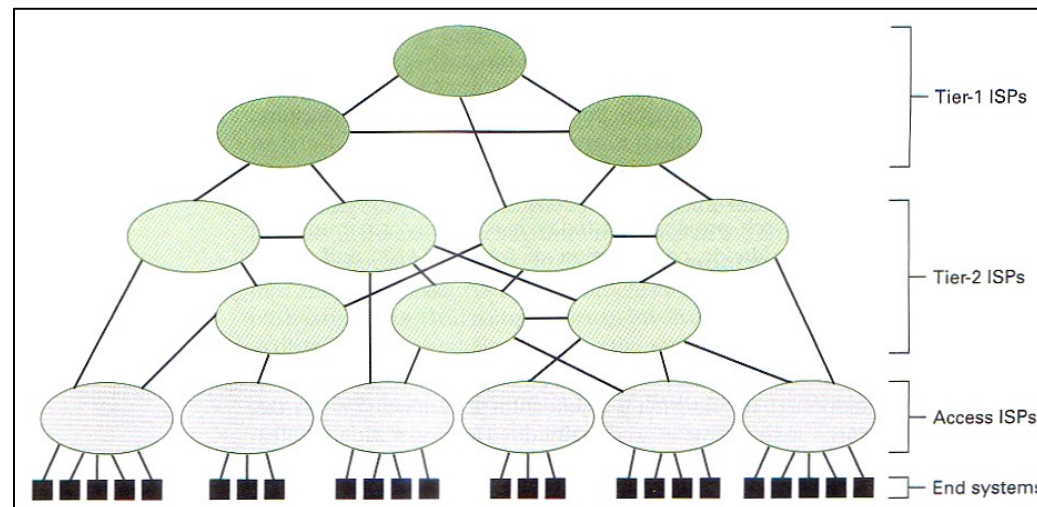
Internet Addressing

❑ Each machine on a network must have a unique address: for the Internet, this is called the Internet Protocol (IP) address

- For IPv4, an IP address is a 32-bit identifier for a machine
- For IPv6, an IP address is 128 bits

❑ IP address is often written in dotted decimal notation

- IPv4 example: 140.113.39.164

  identifies the host

  identifies the domain
- IPv6 example:

fe80::3153:525f:6964:8d84

or

fe80:0000:0000:0000:3153:525f:6964:8d84

Internet Textural Addressing

❑ IP addresses are difficult for human to remember
❑ Each IP may have an equivalent mnemonic address, which is composed of a domain name and a host name (e.g. bsd1.cs.nctu.edu.tw)

- Domain name is the part assigned by a registrar
  - Top level domain (TLD) is the classification of domain owner (for example, .com and .tw)
  - A domain name server (DNS) on the network translates the mnemonic addresses to binary IP addresses
- Host name is assigned by domain administrator
  - Domain owner must run a name server in order for other computers to find your computer

Internet Applications

❑ Electronic mail (e-mail)

❑ File Transfer Protocol (FTP)

❑ Telnet and Secure Shell

❑ Voice-over-IP (VoIP)

❑ World Wide Web

World Wide Web (WWW)

❑ The WWW application model is a model of servers spreading hypertext (or hypermedia) documents over the Internet

❑ A web site is a server hosting all hypertext documents controlled by one organization or individual

❑ HTML is the most popular language of hypertext documents

World Wide Web Implementation

❑ Web server:
- provides access to documents on its machine as requested

❑ Browser:
- allows user to access web pages

❑ Hypertext Transfer Protocol (HTTP):
- communication protocol used by browsers and web servers

❑ Uniform Resource Locator (URL):
- unique address of a document on the web

`http://ssenterprise.aw.com/authors/Shakespear/Julius_Caesar.html`

Server protocol | Server name | Server's directory path | document
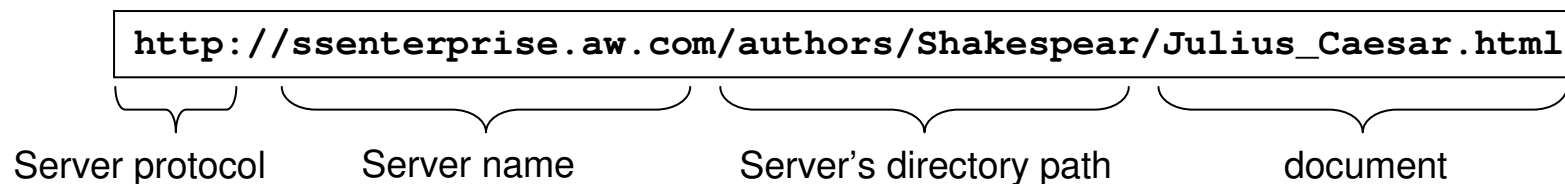
Hypertext Document Format

❑ Entire document is printable characters

❑ Contains tags to control display, links to other documents (or contents), and dynamic functions

Tag indicating beginning of document	`<html>`
Preliminaries	`<head>`
	`<title>demonstration page</title>`
	`</head>`
Part of the page that will be displayed by browser	`<body>`
	`<h1>My Web Page</h1>`
	`<p>Click here for another page.</p>`
	`</body>`
Tag indicating end of document	`</html>`
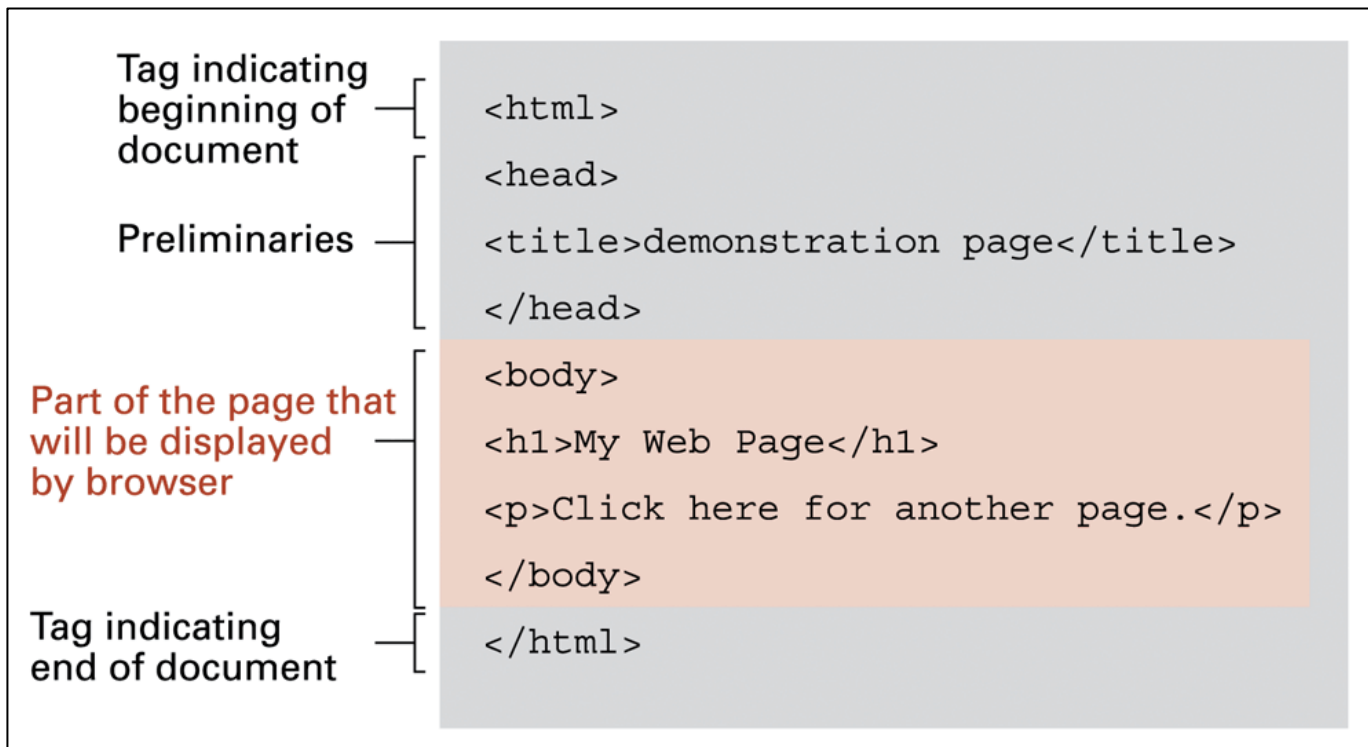
A Hyper-Linked Web Page

```
<html>
<head>
<title>demonstration page</title>
</head>
<body>
<h1>My Web Page</h1>
<p>Click
    <a href="http://crafty.com/demo.html">
    here
    </a>
    for another page.</p>
</body>
</html>
```

Anchor tag containing parameter ─[`<a href="http://crafty.com/demo.html">`

Closing anchor tag ─[`</a>`

Extensible Markup Language (XML)

❑ Due to the success of HTML, some people decided to design a general presentation language similar to HTML, the result is the XML designed by W^{3}C

❑ XML: a language for constructing markup languages similar to HTML

- XML has been extensively used for all kinds of presentation languages on the Internet (e.g. SMIL or SVG)

- XML has been adopted as general configuration languages as well (e.g. for MS Visual Studio or Apple Quicktime server)

- Microsoft uses XML, Open Office XML (OOXML), for all its MS Office file formats since Office 2007

Dynamic Web Pages

❑ To create multimedia-rich interactive web pages, you may require *client-side activities* and *server-side activities*

❑ Client-side activities can be created using Java applets, Javascript, Macromedia Flash, etc.

❑ Server-side activities can be created using:

- Common Gateway Interface (CGI)
- Sun's JavaServer Pages (JSP) or Microsoft's Active Server Pages (ASP)
- PHP Hypertext Processor

ISO Network Models

❑ Most networks are designed using layered approach (ISO 7-layer model[†]):

Host A	Host B
Application	Application
Presentation ←----------------→	Presentation
Session	Session
Transport ←----------------→	Transport
Network ←----------------→	Network
Data link ←----------------→	Data link
Physical ←----------------→	Physical

Host A   Host B

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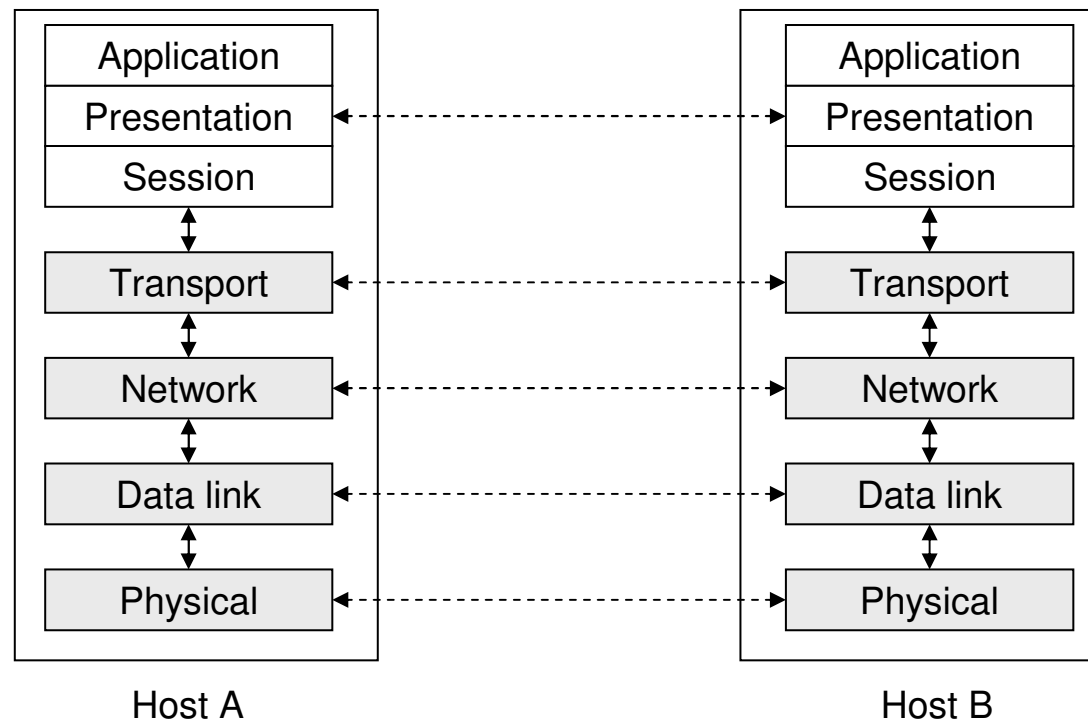
† This model is beyond the scope of the course

Internet Protocols

❑ The Internet, just like the ISO 7-layer model, is also using a layered protocol approach
❑ The Internet only have four layers
- ■ Application layer:
  - ● Example: browser
- ■ Transport layer:
  - ● TCP – reliable transport
  - ● UDP – unreliable transport
- ■ Network layer:
  - ● Internet Protocol (IP)
  - ● Handles routing through the internet
- ■ Link layer: handles actual transmission of packets
  - ● Token ring or Ethernet

Package-Shipping Example

Origin

Pepares package for shipping → You

Places package in container for airline → Shipping company

Places container in airplane → Airline

Intermediate stops

Airline → Airline

Transfers container to another airplane

Final destination

Receives and opens package → Friend

Removes package from container and delivers it to addressee → Shipping company

Sends container to shipping company → Airline

Send a Message through the Internet

At each intermediate stop the network layer assigns a new intermediate address to the packet and returns it to the link layer for transmission across another network.

Origin

Prepares message and attaches destination address — Application

Chops message into packets — Transport

Assigns intermediate address to each packet — Network

Transfers packet to its intermediate address — Link

Intermediate stops

Network — Link

Network — Link

Final destination

Application — Receives message

Transport — Collects packets and reassembles message

Network — Detects that packet has reached its final destination

Link — Receives packet
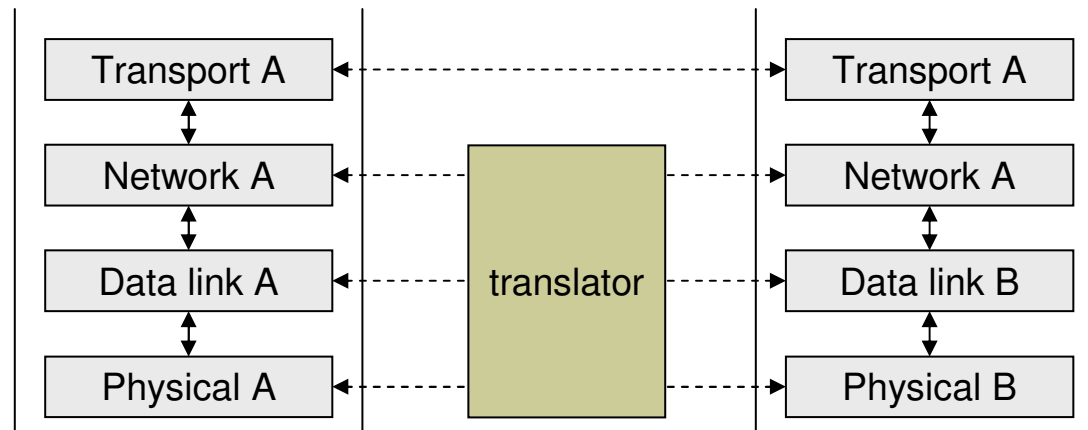
ISO Internetworking

❑ To connect two networks together, one need a host that can handle translation of one protocol to another:

Transport A		Transport A
Network A	translator	Network A
Data link A		Data link B
Physical A		Physical B

❑ The translator can be called bridge, router, or gateway, based on their functions

† This slide is beyond the scope of the course

Port Number

❑ A computer have a unique IP address; all applications running in this computer shares the same IP address

❑ When an Internet packet arrives at an IP addresses, which application on the computer will receive it?

  ■ Answer, port numbers are used to identify a particular application at an IP address

  ■ Each packet will be delivered to a IP:Port address that belongs to an application

Choosing between TCP and UDP

Application layer

TCP is a connection-based protocol: a two-way communication channel between the origin and destination must be established before any messages can be sent

?

UDP is a connectionless protocol: consecutive messages may be send to the destination through different routes

Transport Layer

TCP
More "reliable" but less efficient

UDP
More efficient but less "reliable"

Network Security

❑ Integrity of machine exposed to internet can be attacked by

- Viruses and worms
- Trojan horses
- Spywares (sniffing) and phishing
- Denial of service attacks
- Spamming

❑ Defense techniques

- Firewall
- Virus and spam filters
- Proxy server

Privacy of Communication

❑ In the old days, most data send over the Internet were unprotected

- A network sniffer can be used to collect your private data

❑ Today, encryptions are used to protect your privacy

- Secure versions of network protocols such as FTPS, HTTPS, and SSL are used to transmit data with encryption
- You can also encrypt data by yourself using public key encryption system such as the PGP system

Public Key Encryption Concept

❑ Before you do encryption, you must generate a pair of keys called the public key and the private key†

❑ You broadcast your public key to everyone who wants to send you a message so that your friend can encrypt the message using your public key

  ■ **Certificate authorities** may be needed to ensure the correctness of a public key

❑ The encrypted message can only be decoded using the private key, which is available only to you

---

† The most popular public-key encryption algorithm, RSA, will be discussed in Chapter 12.