Networking and the Internet

Amrita University.

Networking and the Internet

- Network Fundamentals
- The Internet
- The World Wide Web

What is Networks?

- Need to share information and resources among different computers.
- linked computer systems – Networks.
- Computers are connected, so that data can be transferred from machine to machine.
- Computer users can exchange messages and share resources – Printing, Data Storages…

Network Classifications

- Scope
  - Personal area network (PAN)
    - Short range communications
    - Typically less than a few meters
    - such as between a wireless headset and a smartphone or
    - between a wireless mouse and its PC
  - Local area network (LAN)
    - Collection of computers in a single building or building complex
    - For example, the computers on a university campus or
    - Those in a manufacturing plant might be connected by a LAN.
  - Metropolitan area (MAN)
    - Network of intermediate size, such as one spanning a local community
  - Wide area network (WAN)
    - Links machines over a greater distance—perhaps in neighbouring cities or on opposite sides of the world.

Network Classifications

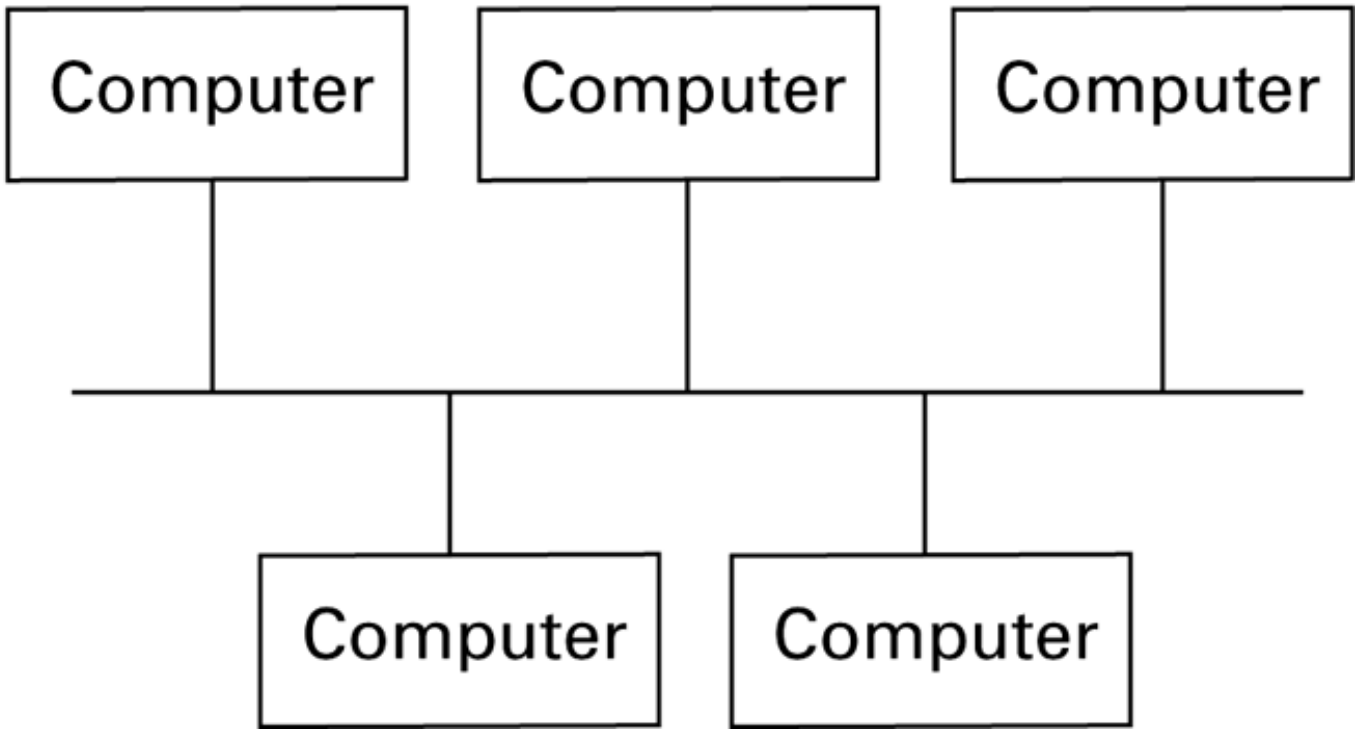
- Ownership based classification
  - Open vs Closed
    - whether the network's internal operation is based on designs that are in the public domain- **Internet**
      - freely circulated and often grow in popularity
    - controlled by a particular entity such as an individual or a corporation- **proprietary.**
      - Innovations owned and controlled by a particular entity such as an individual or a corporation
      - applications are restricted by license fees and contract conditions E.g., Novell Inc

Network Classifications

- Topology
  - pattern in which the machines are connected
  - Bus (Ethernet)
    - machines are all connected to a common communication line
    - popularized in the 1990s when
    - implemented under a set of standards known as Ethernet, and
    - Ethernet networks remain one of the most popular networking systems in use today
  - Star (Wireless networks with central *Access Point*)
    - one machine serves as a central focal point to which all the others are connected

Network topologies

a. Bus

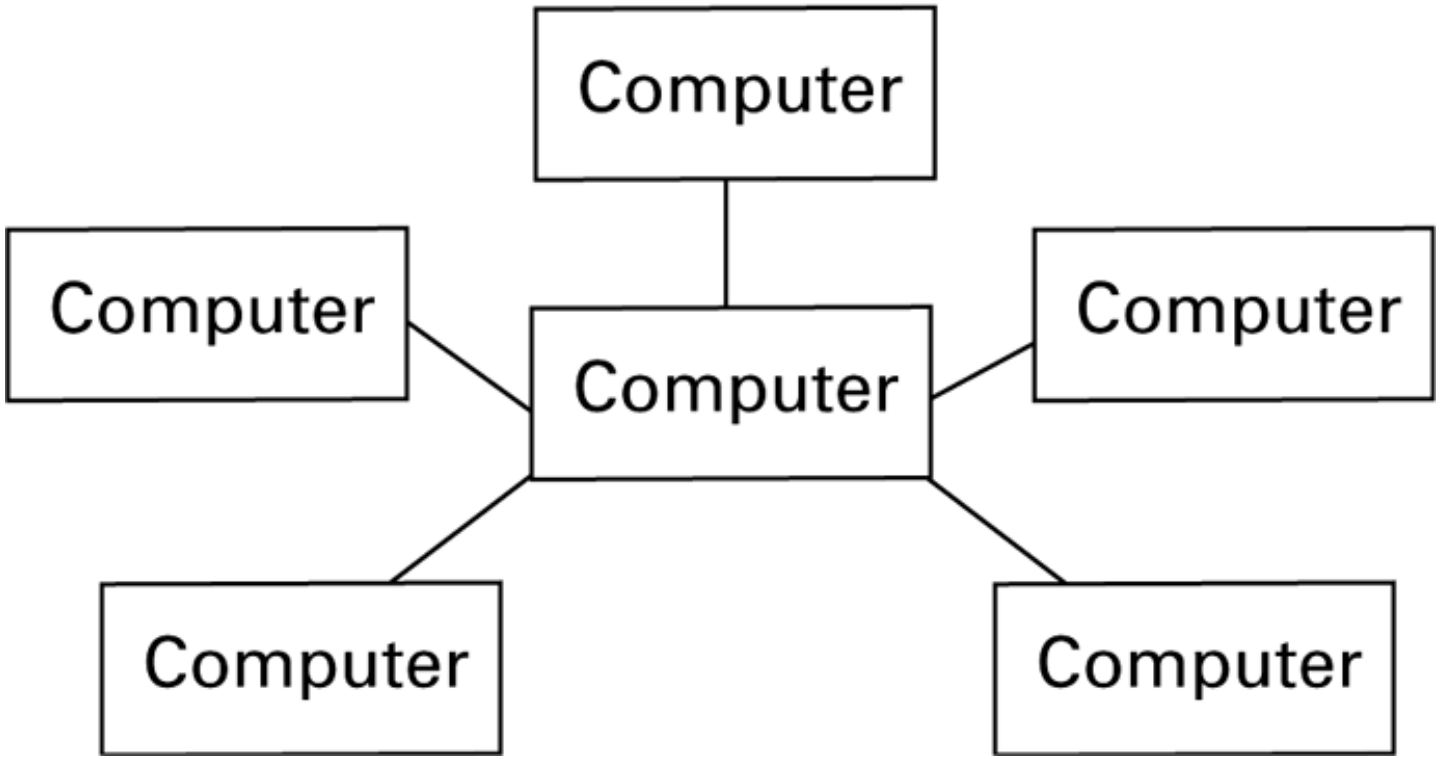


Network Classifications

- Star (Wireless networks with central *Access Point*)
  - one machine serves as a central focal point to which all the others are connected
  - has roots as far back as the 1970s
  - evolved from the paradigm of a large central computer serving many users
  - As the simple terminals employed by these users grew into small computers themselves, a star network emerged.
  - popular today in wireless networks
    - communication is conducted by means of radio broadcast and
    - the central machine, called the **access point (AP),** serves as a focal point around which all communication is coordinated.

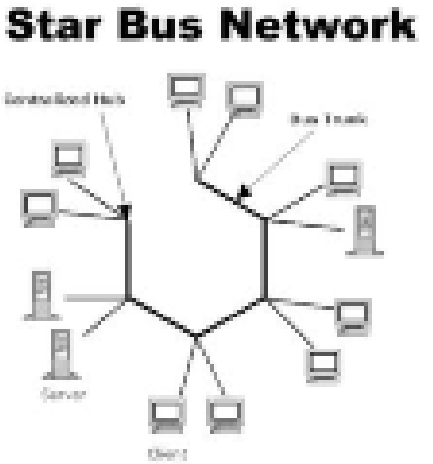
Network topologies (continued)

b. Star



BUS Vs STAR

- Not always with the physical arrangement of equipment.
- Communicating directly with each other over a common bus or indirectly through an intermediary central machine.
- Network that looks like a star network although it operates like a bus network. How?
  - Machines are connected with short bus with long link.
  - A bus network is created by running links f computer to a central location where they to a device called a **hub.**



Hub

- is little more than a very short bus
- relay any signal it receives to all the machines connected to it
- with perhaps some amplification
- The result is a network that looks like a star network although it operates like a bus network

Protocols

- Rules by which activities are conducted by the network
- Allows the network to function reliably
  - Need of Protocols : Vendors are able to build products for network applications that are compatible with products from other vendors.
- Example :
  - Problem of coordinating the transmission of messages among computers in a network.

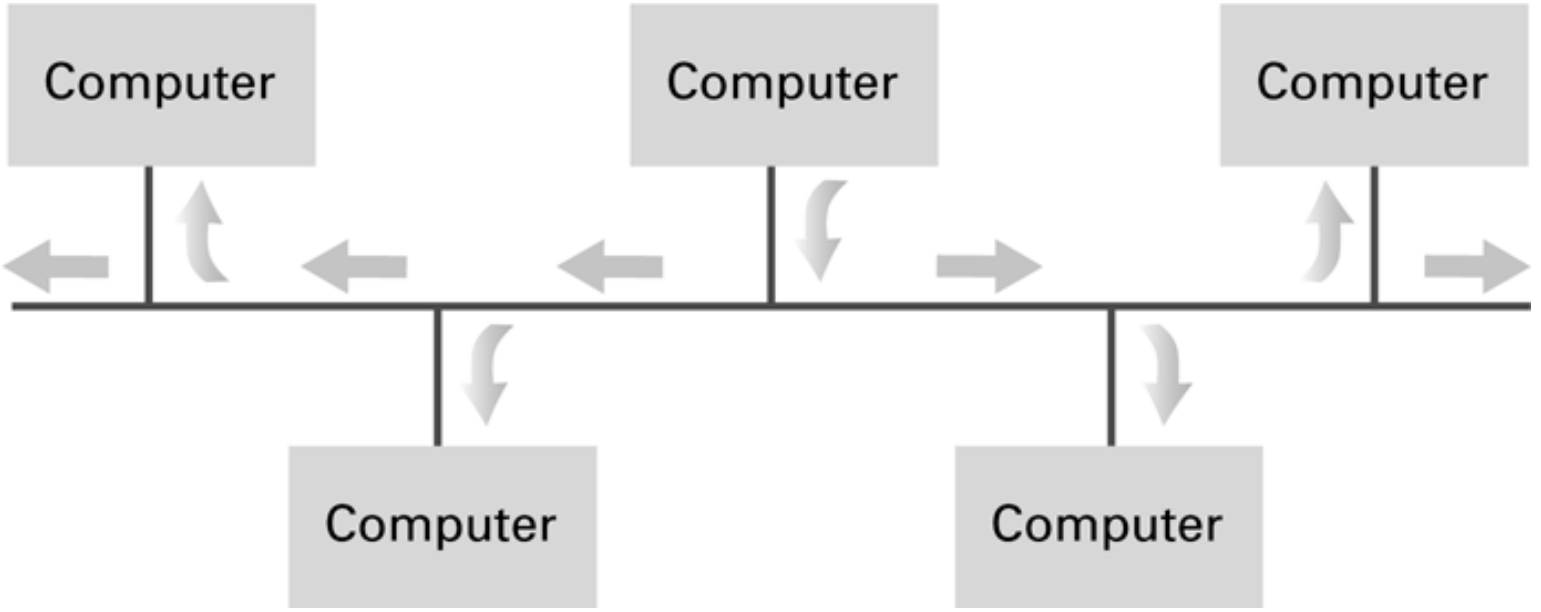
Protocol Standards

- development of protocol standards
  - an indispensable process in the development of networking technologies
- Consider the problem of coordinating the transmission of messages among computers in a network
  - Without rules governing this communication,
    - all the computers might insist on transmitting messages at the same time or
    - fail to assist other machines when that assistance is required.

Protocols

- CSMA/CD (**Carrier Sense, Multiple Access with Collision Detection) ***
  - Used in Ethernet
  - dictates that each message be broadcast to all the machines on the bus
  - Each machine monitors all the messages but keeps only those addressed to itself
  - Silent bus provides right to introduce new message

Communication over a bus network (CSMA/CD)



CSMA-CD Message Transmission

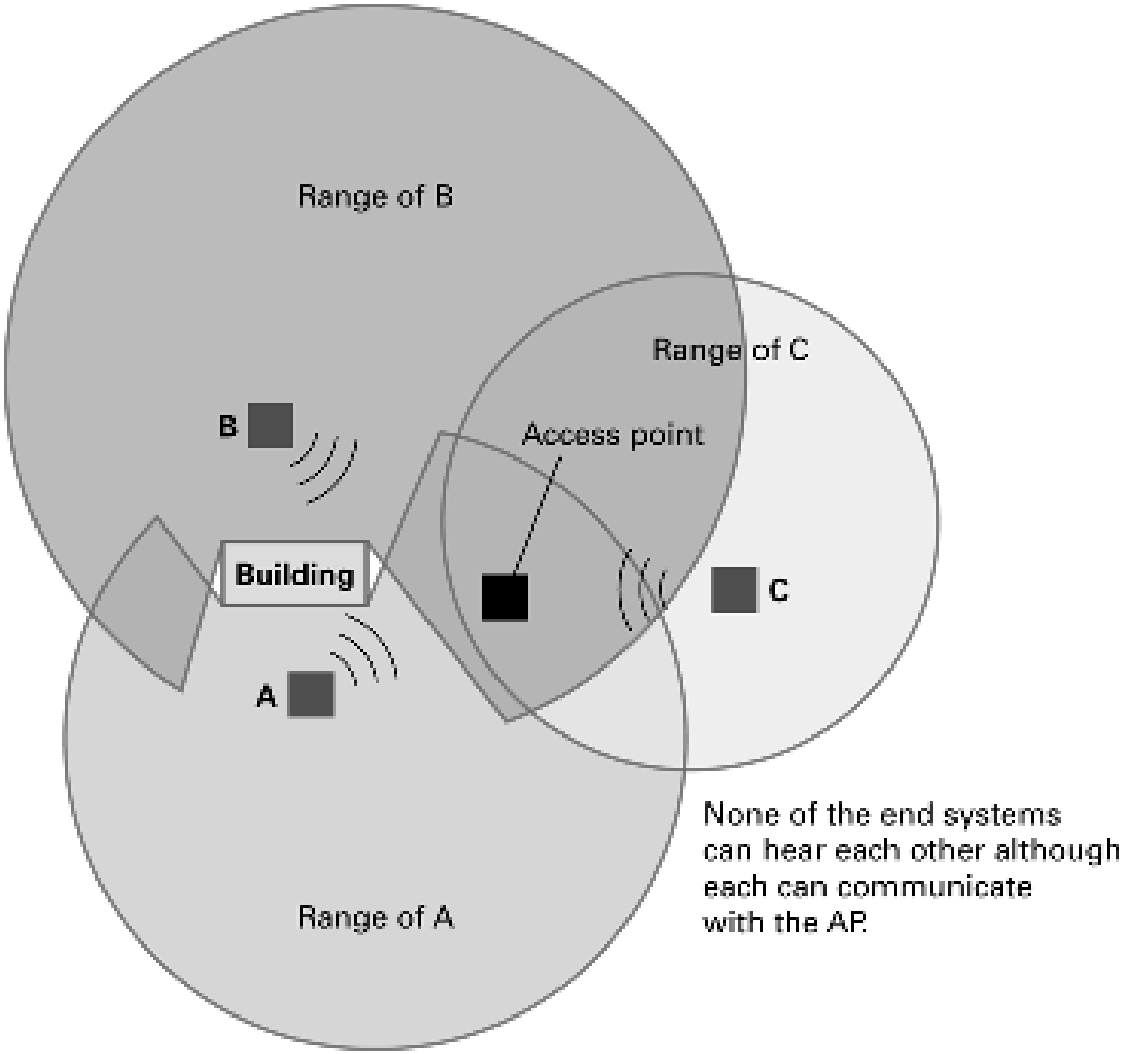
- A machine waits until the bus is silent, and at this time it begins transmitting while continuing to monitor the bus.

- If another machine also begins transmitting, both machines detect the clash and pause for a brief, independently random period of time before trying to transmit again.

CSMA-CD Drawbacks

- not compatible with wireless star networks
- all machines communicate through a central AP
- a machine may be unable to detect that its transmissions are colliding with those of another
  - machine may not hear the other because its own signal drowns out that of the other machine
  - the signals from the different machines are blocked from each other by objects or

The hidden terminal problem- CSMA-CA *



CSMA/CA (**Carrier Sense, Multiple Access with Collision Avoidance) ***

- Wireless networks adopt the policy of trying to avoid collisions rather than trying to detect them.
- Policies are classified as **CSMA/CA**
  - many of which are standardized by IEEE within the protocols defined in IEEE 802.11 and
  - commonly referred to as **WiFi.**

Collision avoidance protocols

- Designed to avoid collisions
- may not eliminate collisions completely.
- When collisions do occur, messages must be retransmitted.
- Collision avoidance approach
  - based on giving advantage to machines that have already been waiting for an opportunity to transmit
  - protocol used is similar to Ethernet's CSMA/CD

CSMA-CD Vs CSMA-CA

- The basic difference is
  - when a machine first needs to transmit a message and finds the communication channel silent,
    - it does not start transmitting immediately.
    - Instead, waits for a short period of time
    - starts transmitting only if the channel has remained silent throughout that period.
    - If a busy channel is experienced during this process, the machine waits for a randomly determined period before trying again
    - Once this period is exhausted, the machine is allowed to claim a silent channel without hesitation

Collision avoidance

- Collisions between “newcomers” and those that have already been waiting are avoided because
  - a “newcomer” is not allowed to claim a silent channel until any machine that has been waiting is given the opportunity to start.

Solving the hidden terminal problem

- Not solved by CSMA-CA
  - each individual station be able to hear all the others to distinguish silent/busy channels
- some WiFi networks require that
  - each machine send a short “request” message to the AP wait until the AP acknowledges that request before transmitting an entire message
  - If the AP is busy because it is dealing with a “hidden terminal,” it will ignore the request,
  - the requesting machine waits.
  - Otherwise, the AP will acknowledge the request, and the machine transmits.

Wi-Fi networks

- all the machines in the network will hear all acknowledgments sent from the AP
- Machines have a good idea of whether the AP is busy at any given time
- machines may not be able to hear the transmissions taking place.

Connecting Networks

- Connect existing networks to form an extended communication system
- can be done by connecting the networks to form a larger version of the same “type” of network
- **Example**
  - connect the buses to form a single long bus in ethernet networks
  - achieved by means of different devices known as
  - **Repeater:** Extends a network
  - **Bridge:** Connects two compatible networks
  - **Switch:** Connects several compatible networks
  - **Router:** Connects two incompatible networks
    - resulting in a network of networks called an **internet ***

Repeater

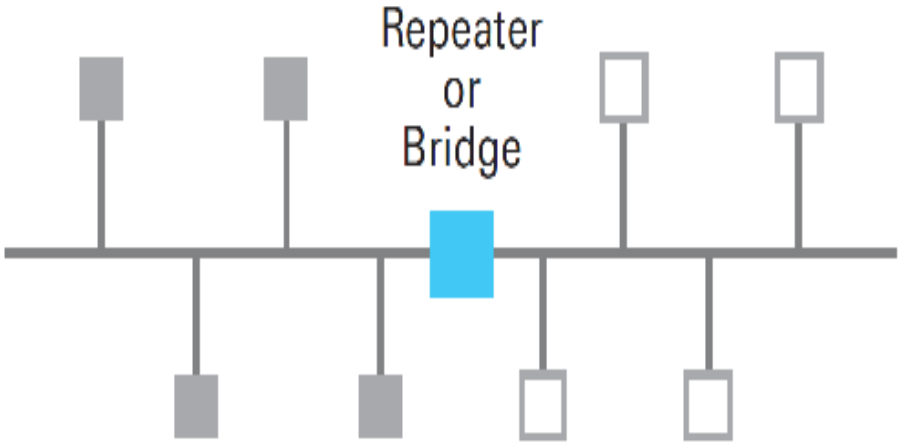
- Little more than a device
- Passes signals back and forth between the two original buses
- usually performs some form of amplification
- Doesn’t consider the meaning of the signals

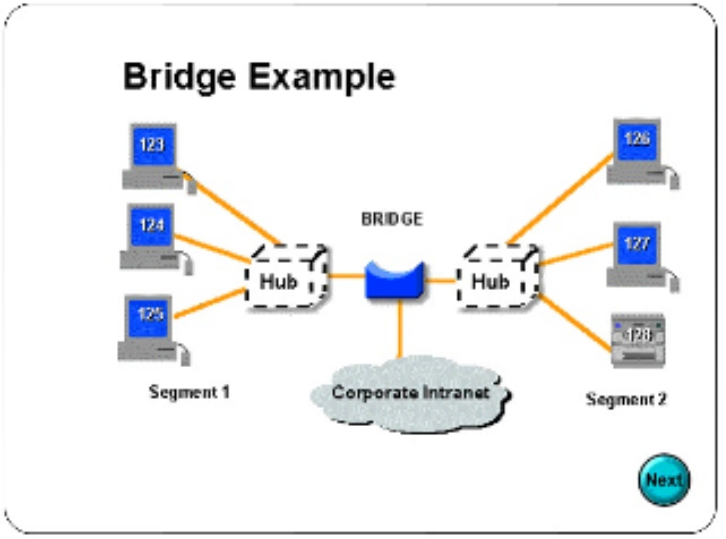
Bridge

- A is similar to, but more complex than, a repeater.
- Connects two buses (like a repeater)
- Does not necessarily pass all messages across the connection.
- Looks at the destination address accompanying each message and forwards the message to the destined computer on the other side of the connection.

Bridge

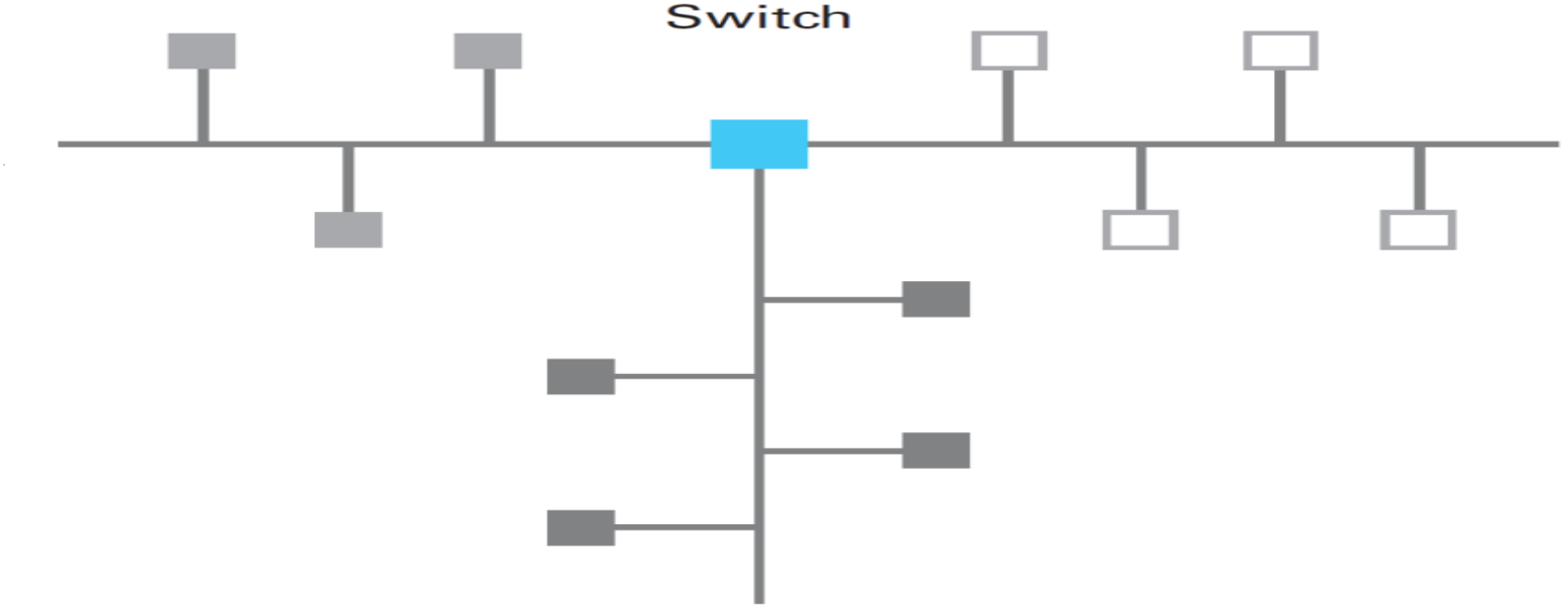
- Two machines residing on the same side of a bridge can exchange messages without interfering with communication taking place on the other side.
- A bridge produces a more efficient system than that produced by a repeater.





Switch

- Essentially a bridge with multiple connections
- Connects several buses rather than just two
- Produces a network consisting of several



Switch

- Considers the destination addresses of all messages
- Forwards only those messages destined for other spokes (similar to bridge)
- Each message that is forwarded is relayed only into the appropriate spoke hence
- Minimizes the traffic in each spoke.

Large Networks

- Result of connecting networks via repeaters,

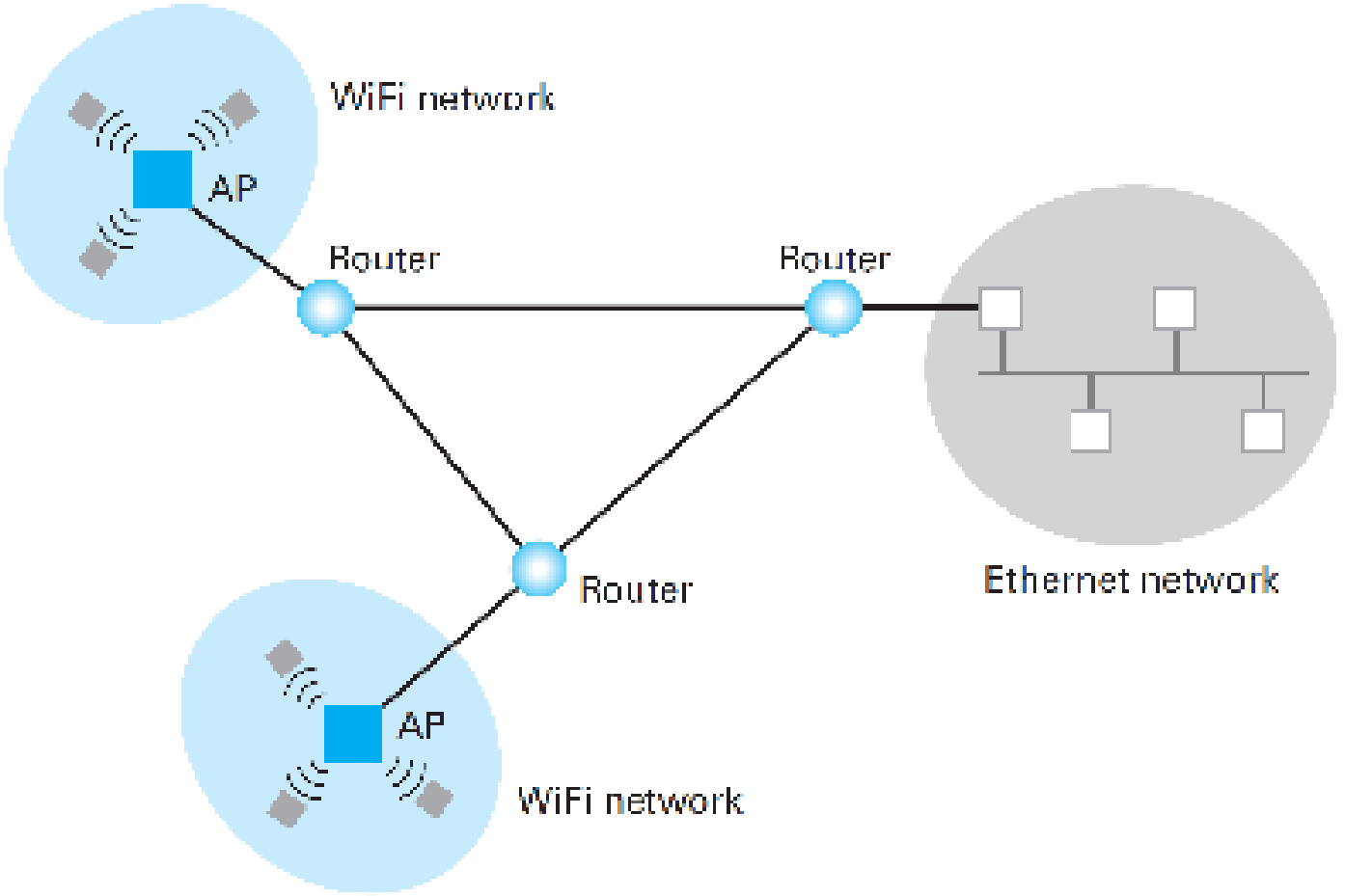
  bridges, and switches
- The entire system operates in the same manner (using the same protocols) as each of the original smaller networks.

Network Incompatibilites

- Sometimes networks to be connected have incompatible characteristics
- Example
  - the characteristics of a Wi-Fi network are not readily compatible with an Ethernet network
    - Solution: Network of networks (a.k.a internet)
- The original networks maintain their individuality and continue to function as autonomous networks

Routers

- Devices to handle connections between networks to form an internet
- Actually special purpose computers used for forwarding messages
- Task of a router is different from that of repeaters, bridges, and switches
- Routers provide links between networks while allowing each network to maintain its unique internal characteristics



Two WiFi star networks and an Ethernet bus network connected by routers

Working of the (previous) Network

- When a machine in one of the Wi-Fi networks wants to send a message to a machine in the Ethernet network,
  - it first sends the message to the AP in its network.
  - From there, the AP sends the message to its associated router
  - this router forwards the message to the router at the Ethernet.
    - The ethernet router forwards the message to a machine on the bus
    - that machine then forwards the message to its final destination in the Ethernet.

Forwarding process of the router using Addressing Mechanism

- Based on an internet-wide addressing system.
- All the devices in an internet (including the machines in the original networks and the routers) are assigned unique addresses.
- Each machine in one of the original networks has two addresses:
  - its original “local” address within its own network and
  - its internet address.

How does Addressing work?

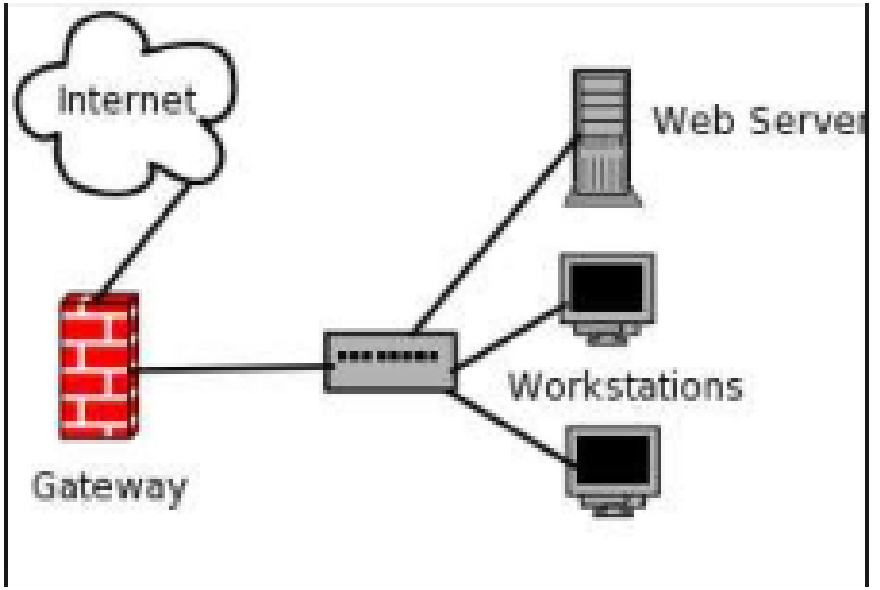
- A machine wanting to send a message to a machine in a distant network attaches the internet address of the destination to the message and directs the message to its local router
- From the local router it is forwarded in the proper direction using “forwarding table”.

Forwarding Table

- Maintained by each router.
- Contains the router's knowledge about
  - the direction in which messages should be sent depending on their destination addresses.

Gateway

- The “point” at which one network is linked to an internet
- it serves as a passageway between the network and the outside world
- Can be found in a variety of forms

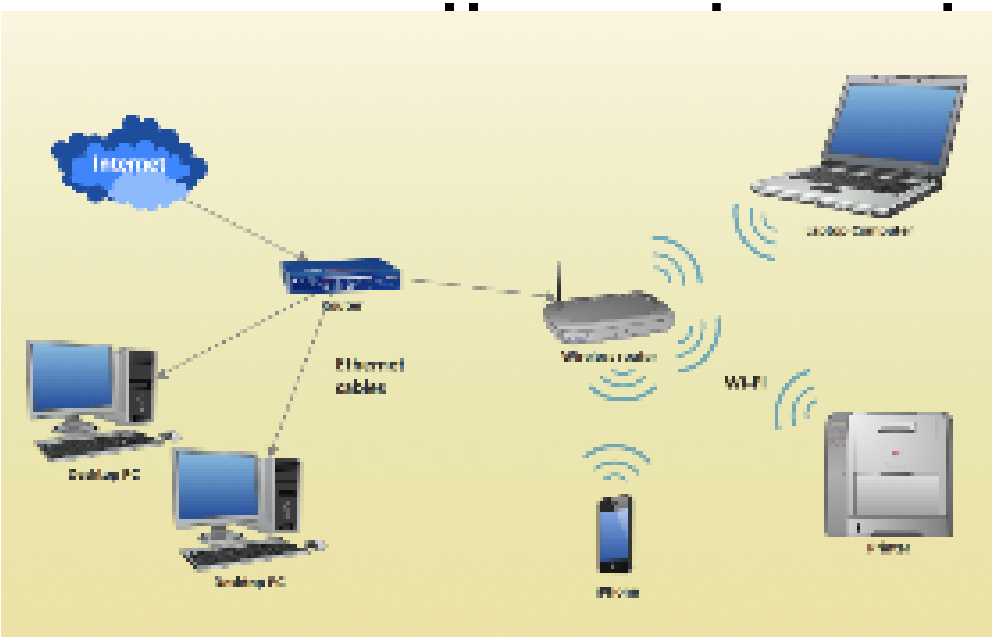


Gateway

- In many cases a network's gateway is merely the router
  - throughwhich it communicates with the rest of the internet.
- In other cases the term *gateway* may be used to refer to more than just a router.
- The term Gateway is hence used loosely

Gateway - Example

- In most residential WiFi networks connected to the Internet, the term *gateway* refers collectively to both the network's AP and the router connected to the AP because
- these two devices in a single unit.



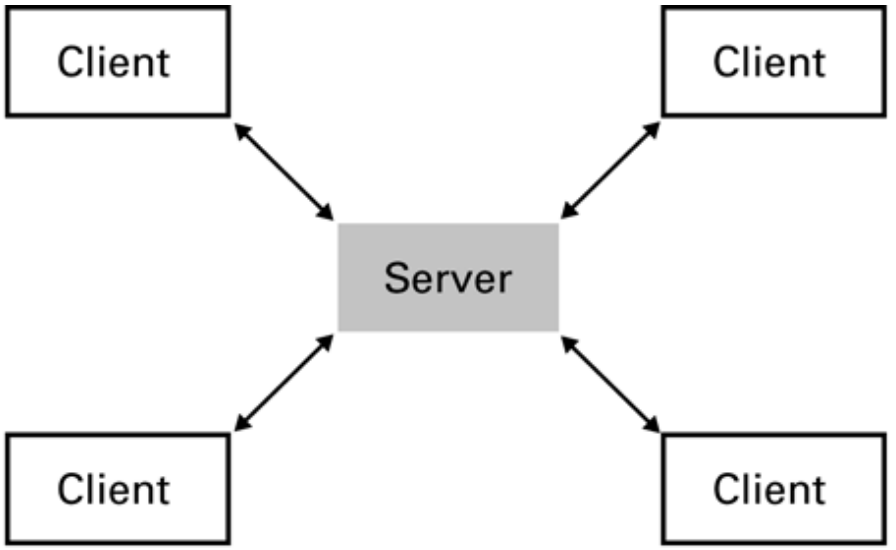
Inter-process Communication

- Different activities (or processes) executing on the different computers within a network - communicate with each other to coordinate their actions – perform their designated tasks – IPC
  - Client-server
  - Peer-to-peer (P2P)

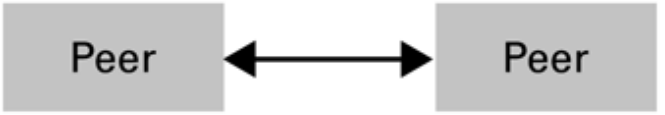
Inter-process Communication

- Client-server (Client – request; Server – response)
  - One server, many clients
  - Server must execute continuously
  - Client initiates communication
  - networks connecting all the computers in a cluster of offices - **print server**
  - reduce the cost of magnetic disk storage - **file server**
- Peer-to-peer (P2P) (service to and from each other)
  - Two processes communicating as equals
  - Peer processes can be short-lived/temporary
  - Examples – instant messaging, interactive games etc.
  - **Swarm** : One peer may receive a file from another and then provide that file to other peers - collection of peers participating in such a distribution Example: Distributing audio video files on internet.

The client/server model compared to the peer-to-peer model



a. Server must be prepared to serve multiple clients at any time.



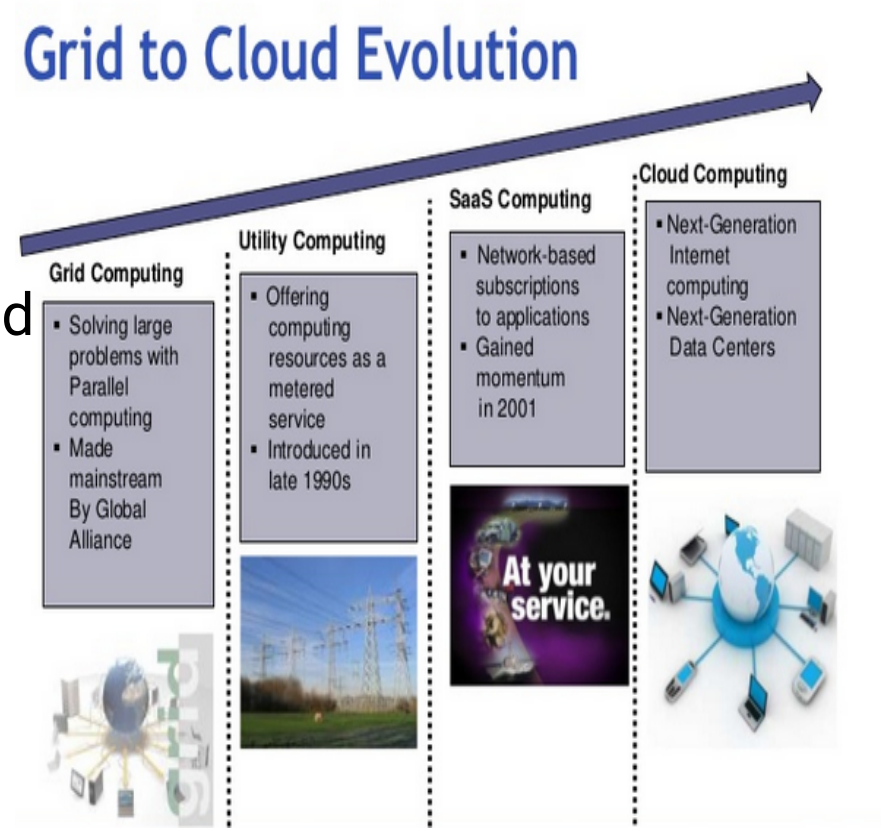
b. Peers communicate as equals on a one-to-one basis.

Why P2P Model replace Client Server model for file sharing?

- It distributes the service task over many peers rather than concentrating it at one server –
- This lack of a centralized base of operation leads to a more efficient system.
- Questionable legality, the lack of a central server makes legal efforts to enforce copyright laws more difficult.

Distributed Systems

- Software units that execute as processes on different computers
- **High-availability && Load-balancing**
  - Cluster computing
  - Grid computing
  - Cloud computing
    - Amazon's Elastic Compute Cloud
    - Google Drive



Grid Computing

- More loosely coupled than clusters
- still work together to accomplish large tasks
- can involve specialized software to make it easier to distribute data and algorithms to the machines participating in a grid
- Examples:
  - University of Wisconsin's Condor system, or
  - Berkeley's Open Infrastructure for Network Computing (BOINC).

Grid Computing

- Both Condor and BOINC are often installed on computers that are used for other purposes, such as PCs at work or at home,
- They then volunteer computing power to the grid when the machine is not otherwise being used.
- This type of voluntary, distributed grid computing has enabled millions of home PCs to work on enormously complex mathematical and scientific problems through internet.

Cloud Computing

- Huge pools of shared computers on the network can be allocated for use by clients as needed
- Similar to electrical grids, cloud refers to the enormous computing resources already available on the network
- Provide reasonable guarantees of reliability and scalability,
- But also raise concerns about privacy and security in a world (we may no longer know who owns and operates the computers that we use.)

Examples of Clou

- Amazon's Elastic Compute Clou
  - allow clients to rent virtual computers by the hour
  - no concern for where the computer hardware is actually located.
- Google Drive and Google Apps
  - allow users to collaborate on information or build
  - Web services
  - No need to know how many computers are working on the problem or

The Internet

- The Internet: An internet that spans the world
  - Original goal was to develop a means of connecting networks that would not be disrupted by local disasters
    - Defense Advanced Research Projects Agency (DARPA)
  - Today a commercial undertaking that links a worldwide combination of PANs, LANs, MANs, and WANs involving millions of computers

Internet Architecture

- Internet Service Provider (ISP)
  - Organizations in which helps to construct and maintain the networks.
  - Tier-1
    - High-speed, high-capacity, international WANs
    - Backbone of the internet
    - typically operated by large companies that are in the communications business
  - Tier-2
    - More regional in scope and less potent in their capabilities
- Tier-1 and tier-2 ISPs are essentially networks of routers that collectively provide the Internet's communication infrastructure (core of internet)

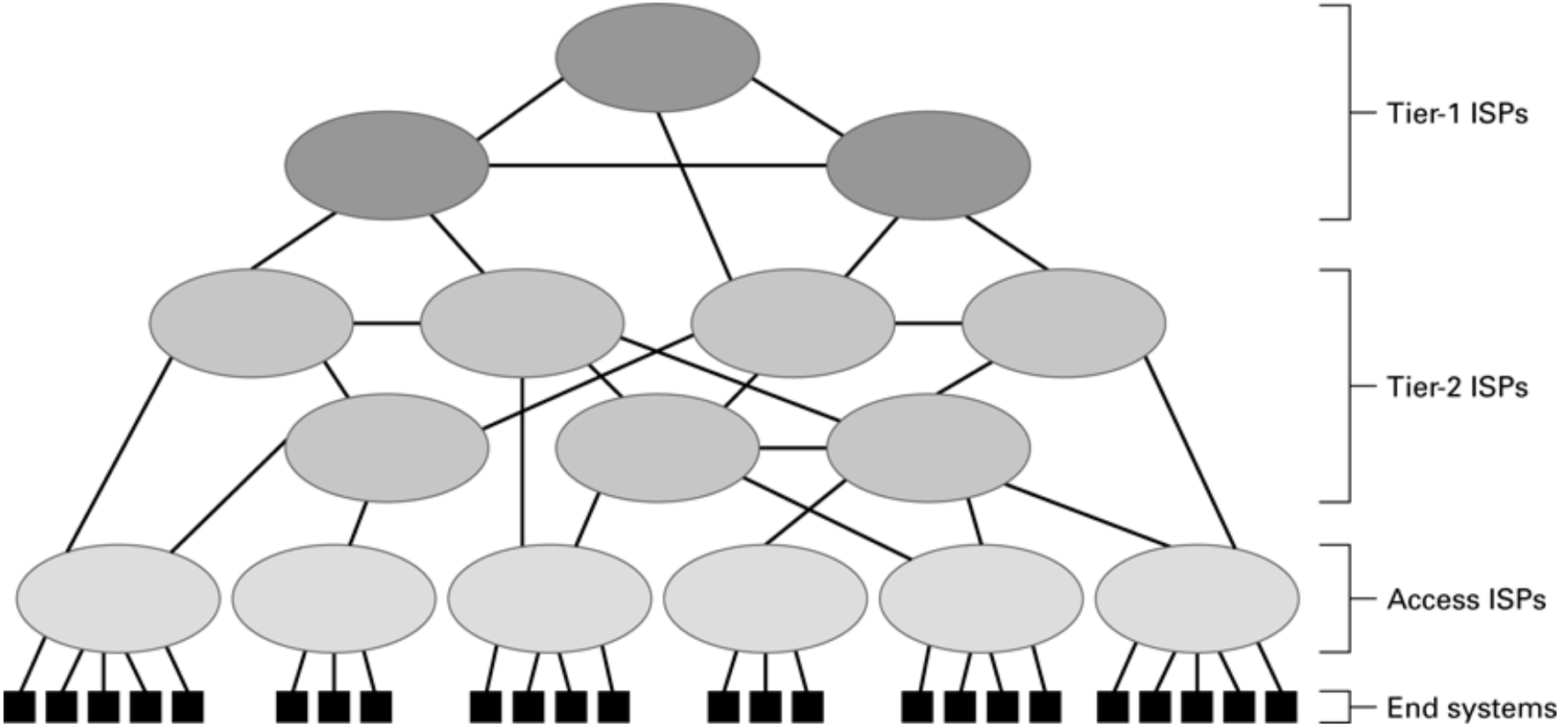
Internet Architecture

- Access or tier-3 ISP: Provides connectivity to the Internet (core)
- Could be an independent internet (or intranet)
- Operated by a single authority that is in the business of supplying Internet access to individual homes and businesses.
- Examples:
  - Cable and telephone companies that charge for their service
  - organizations such as universities or corporations that take it upon themselves to provide Internet access to individuals within their organizations.

End Systems or hosts

- The devices that individual users connect to the access ISPs
- End Systems /Hosts – may be laptops or PCs, telephones, video cameras, automobiles, and home appliances
- Hot spot (wireless)
  - The area within the AP or group of APs' range
- Telephone lines
  - **Dial-up**
  - DSL (digital subscriber line)
  - Modems
- provide direct connection to an end system or to a customer's router to which multiple end systems are connected
- Telephone, cable television, and satellite wide area networks
- Issues arising from these legacy analog linkages are often referred to collectively as the last mile problem.
- fiber optics - high-speed digital technology

Internet Composition



Internet Addressing

- IP address: pattern of 32 or 128 bits often represented in dotted decimal notation.

- Blocks of consecutively numbered IP addresses are awarded to ISPs by the **Internet Corporation for Assigned Names and Numbers (ICANN) , which is a nonprofit corporation established to** coordinate the Internet's operation.

- Allocate the addresses within their awarded blocks to machines within their region of authority.

- **Dotted decimal notation – Example:** 192.207.177.133 (32 – bit pattern)

- Alternative addressing system in which machines are identified by mnemonic names – **domain – Registrars – ICANN- domain name-** unique among all the domain names throughout the Internet. E.g. amrita.edu

Internet Addressing

- **Top-level domains (TLDs)**
- domain name of the Addison-Wesley publishing company is aw*com* – ***commercial*** .
- gov , edu, net, info, org, net, museum and so on ..,
- **Country-code TLDs ,** au for Australia and ca for Canada, in for India.
- **Subdomains,** *ssenterprise.* aw.com, r2d2.compsc. nowhereu.edu
- Domain Name Servers (DNS), Internet's equivalent of a phone book. They maintain a directory of domain names and translate them to Internet Protocol (IP) addresses.
- Process of using the DNS to perform a translation is called a **DNS lookup**

Sub Domains

- means of organizing the names within a domain
- often represent different networks within the domain's jurisdiction

Example: overthruster.propulsion.yoyodyne.com

- the computer overthruster is in the subdomain propulsion within the domain yoyodyne within the TLD com.

Internet Applications

- **Before HTTP – NNTP, FTP, Telnnet, SSH**
- **Electronic Mail**
- **Mail server -** Microsoft's Outlook, Apple's Mail, or Mozilla's Thunderbird
- to read and compose their email
  - **SMTP** (Simple Mail Transfer Protocol), send a new message from its author's local machine to the author's mail server.
  - **MIME** (Multipurpose Internet Mail Extensions), non-ASCII data to SMTP
  - **POP3** (Post Office Protocol version 3) and **IMAP** (Internet Mail Access Protocol), accessing email that has arrived and accumulated at a user's mail server

Internet Applications

- **The File Transfer Protocol,** which is a client/ server protocol for transferring files across the Internet.
- Example
- FTP sites are also used to provide unrestricted access to files.
- *Anonymous as a universal login name,* **anonymous FTP.**

Internet Applications

- **Telnet:**
  - Computer users to access computers from great distances.
  - Contact the telnet server at a distant computer.
  - Distant user has the same access to the applications and utilities on the computer that a local user.
  - No Encryption
- **Secure Shell (SSH),**
  - Encryption of data being transferred as well as authentication.

Internet Applications

- **VoIP (Voice over Internet Protocol):** Internet infrastructure is used to provide voice communication similar to that of traditional telephone systems.
  - **Soft phones,**
    - P2P software that allows two or more PCs to share a call with no more special hardware than a speaker and a microphone.
    - Skype , example for Soft Phones.
  - **Analog telephone adapters,**
    - ATA, is a device used to connect one or more standard analog telephones to a digital telephone system (such as voice over IP) or a non-standard telephone system (modem).
  - **Embedded VoIP** phones,
    - Handset Connected directly to a TCP/IP network (VOIP over ethernet – used by companies for cost cutting
  - **smart phones** are slated to use VoIP technology (4G).

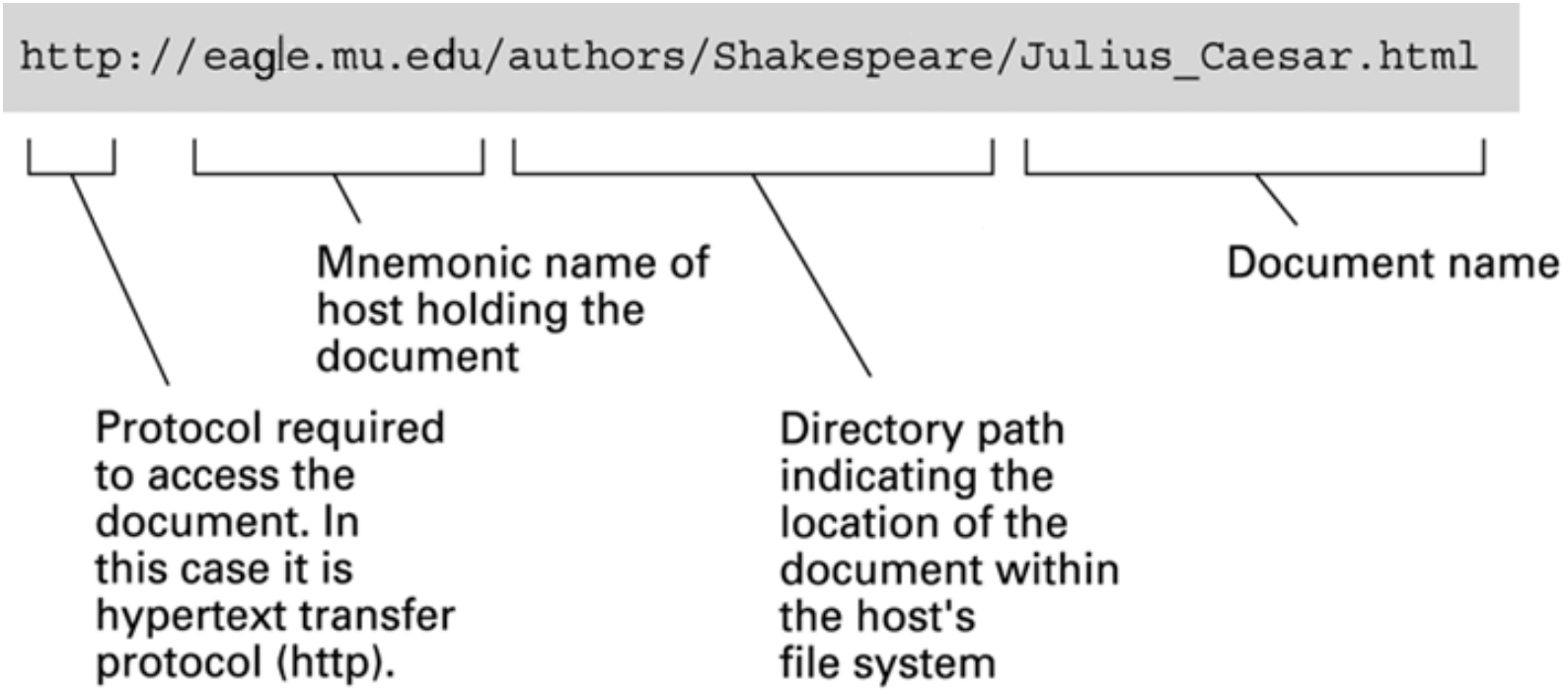
More Recent Applications

- *Webcasting Vs. Broadcasting*
- *Internet Radio*
  - Internet Multimedia Streaming
    - Netflix, Youtube etc.
    - N-unicast - single sender involved with multiple unicasts
    - substantial burden on the station's server as well as on the server's immediate Internet neighbors
    - Multicast burden distributed to routers (expanding the capability of routers
  - On-demand streaming through **content delivery networks (CDNs),**

World Wide Web

- **Hypertext** combines internet technology with concept of linked-documents
  - Embeds **hyperlinks** to other documents
  - **Hyper media**
- **Browsers** present materials to the user
- **World Wide Web**
  - Web page and Web site
- Webservers provide access to documents
- Documents are identified by URLs and transferred using HTTP

A typical URL

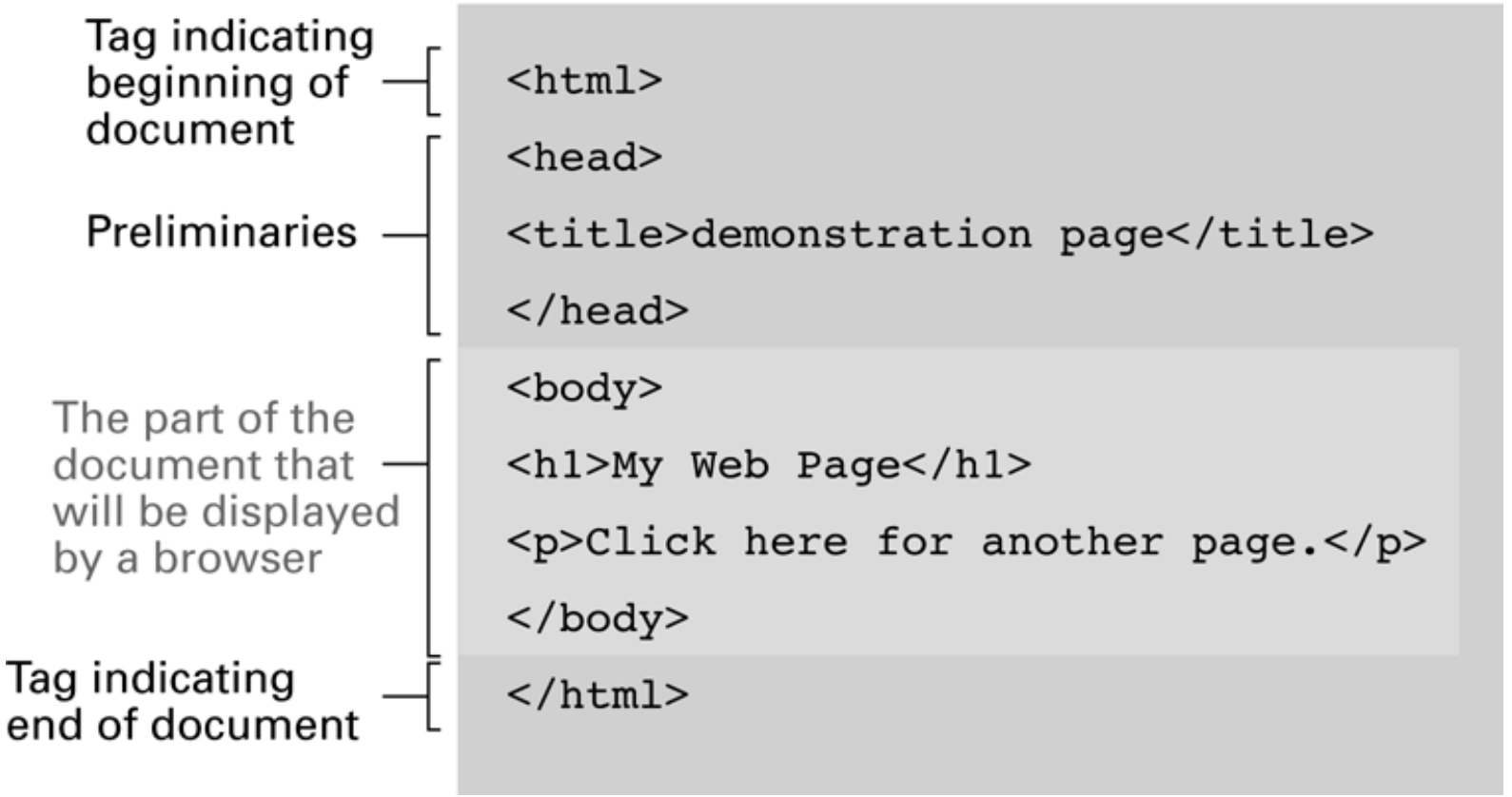


Hypertext Markup Language (HTML)

- Encoded character by character as text file
- Contains tags to communicate with browser
  - Appearance
    - <h1> to start a level one heading
    - <p> to start a new paragraph
  - Links to other documents and content
    - <a href = . . . >
  - Insert images
    - <img src = . . . >

A simple webpage

a. The page encoded using HTML.



A simple webpage (continued)

b. The page as it would appear on a computer screen.

An enhanced simple webpage

a. The page encoded using HTML.

```
<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

Closing anchor tag

An enhanced simple Web page (continued)

b. The page as it would appear on a computer screen.

- <html>
- <body>
- <img src="E:\\IMG_20180117_212033.jpg" alt="Mountain View" width="500" height="377">
- </body>
- </html>

Extensible Markup Language (XML)

- XML: A language for constructing markup languages similar to HTML
  - A descendant of SGML (Standard Generalized Markup Language)
  - Opens door to a World Wide *Semantic* Web

Using XML

<staff clef = “treble”> <key>C minor</key>

<time> 2/4 </time>

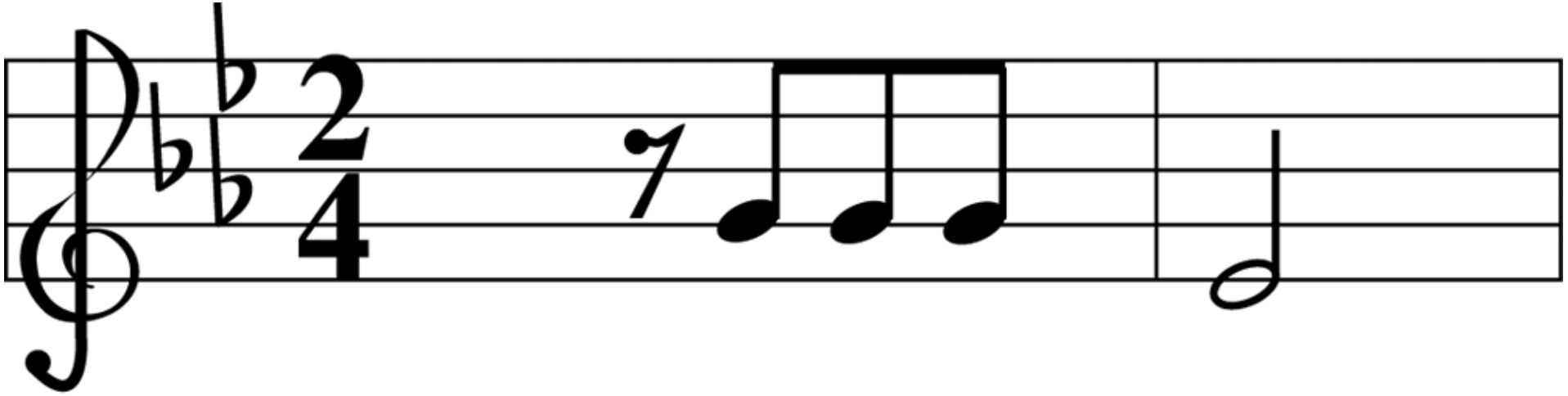
<measure> < rest> egth </rest> <notes> egth G,
egth G, egth G, egth G </notes></measure>

<measure> <notes> hlf E </notes></measure>

</staff>

```
<note>
   <to>Tove</to>
   <from>Jani</from>
   <heading>Reminder</heading>
   <body>Don't forget me this weekend!</body>
</note>
```

The first two bars of Beethoven's Fifth Symphony



Client Side Versus Server Side

- Client-side activities
  - Javascript
  - Macromedia Flash
- Server-side activities
  - Common Gateway Interface (CGI)
  - Servlets
  - JavaServer Pages (JSP) / Active Server Pages (ASP)
  - PHP