

Networks

CSC 790

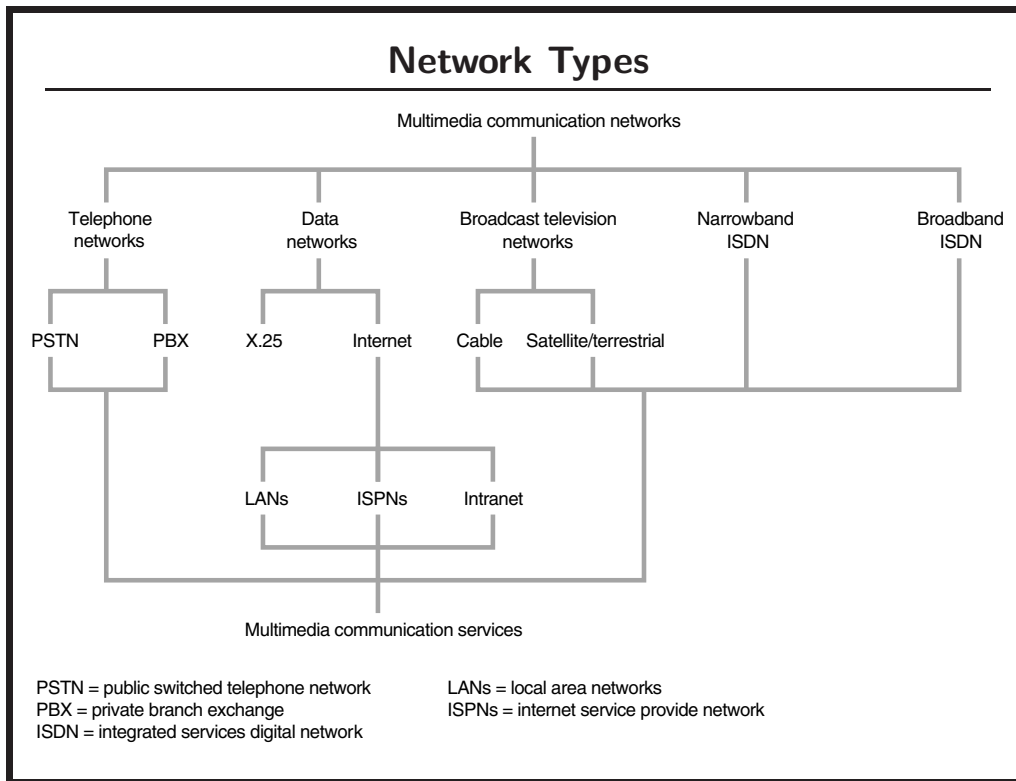
WAKE FOREST
UNIVERSITY

Department of Computer Science

Fall 2009

Networks

- A network is an interconnected set of autonomous computers
 - Transfers information between entities at different locations
What type of information?
- Historically there have been 5 network categories
 - Telephone network
 - Broadcast television network
 - Data networks
 - Integrated services digital networks
 - Broadband multiservice networks
- As the names imply, first three were designed to carry a single type of **service**, while last two provide multiple **services**



E. W. Fulp

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Telephone Network

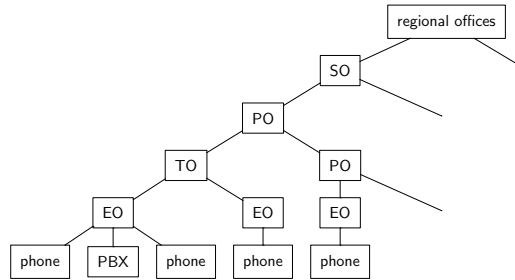
- Public Switched Telephone Network (PSTN)
 - Designed to provide *switched* telephone service
- Speech is an analog signal that varies continuously
 - Let's assume the network will carry the analog signal
 - Connect two analog telephones requires a dedicated circuit
 - Called **circuit mode** or a **circuit switched**
 - *Of course a significant part of the infrastructure is digital, but the principles remain the same*

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Telephone Network Design

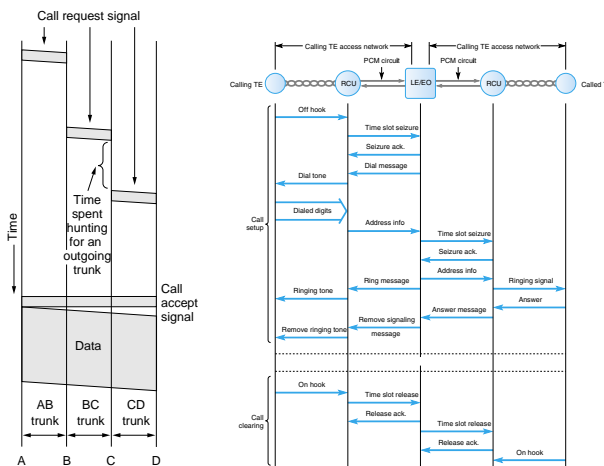
- Historically the telephone network has a hierarchical design
 - Which is (was) reflected in telephone numbers
- A phone call is made through the following process
 - For home or small office, phone connects to **end office**, larger offices use a **private branch exchange (PBX)**



- End office, toll office, primary office, sectional office, regional office

Circuit Switch Connection

- Circuit switch does require establishment overhead



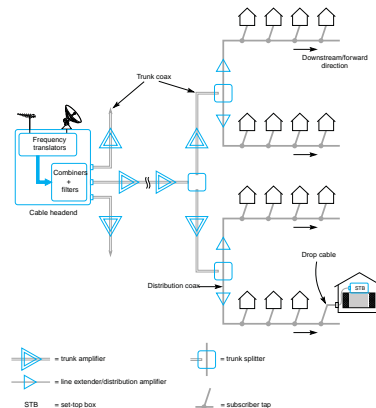
Advantages and disadvantages of circuit switched?

Integrated Services Digital Networks

- Designed to provide PSTN with additional services
 - Requires access circuits (telephone) to all digital form
 - Provides two channels, telephone and data
 - Access circuit is known as a **Digital Subscriber Line (DSL)**
- Speech uses a constant bit rate connection
 - 8000 samples/second with 8 bits/sample, or 64 Kbps
 - Originally channels 64 Kbps each, used separate or together
 - Now a $p \times 64$ Kbps channel is available
- Broadband-ISDN was introduced to provide higher rates
 - Asynchronous Transfer Mode (ATM) technology

Television Networks

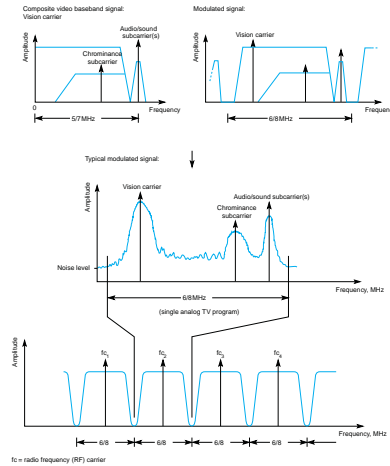
- Network designed to carry television programs
 - Consists of cable, satellite, and terrestrial broadcast
- Cable network consists of *shared medium* tree-branch network



- Media sent concurrently using **frequency division multiplexing**

Analog TV

- For North America each analog channel has 6 Mhz of bandwidth



- Signal consists of luminance and two chrominance
- Digital is now available, but the network is still *broadcast oriented*

Data Networks

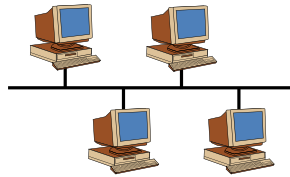
- Packet networks were designed for basic data communications
 - For example file transfers between computers
 - However the types of data has increased to include data, telephony, and video (*the triple play*)
- The original information divided into packets for transmission
 - Packets move from the source to the destination
 - Original data is reassembled from the packets at the receiver

How are packets routed?

Designed for data, what are the issues for multimedia?

Computer Networks

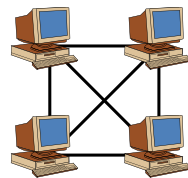
- A Network is an interconnected set of autonomous computers
 - Interconnected - can exchange information
 - Autonomous - separate independent computers
- *How are computers connected?* (network topology)
 1. **Broadcast**
 - Single channel (medium of communication) shared by all



Examples? Advantages and disadvantages?

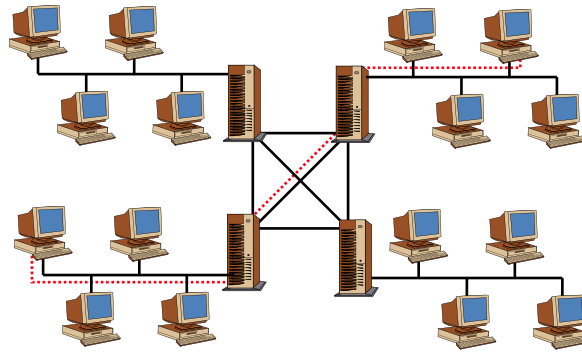
2. Point-to-point

- All machines are directly connected



Examples? Advantages and disadvantages?

- The previous two types of networks do not scale
 - Consider a large number of computers (the Internet)
 - As an alternative, connect a subset of computers and allow machines to *forward* messages



Implications for multimedia?

- This is how most networks operate, **message passing**
 - An inter-connection of *smaller* Local Area Networks (LAN)
 - Communication is more complicated
- Need **protocols** for sending and receiving

Protocols

- Set of rules governing the exchange of data between two entities

Why are protocols needed in a broadcast network?

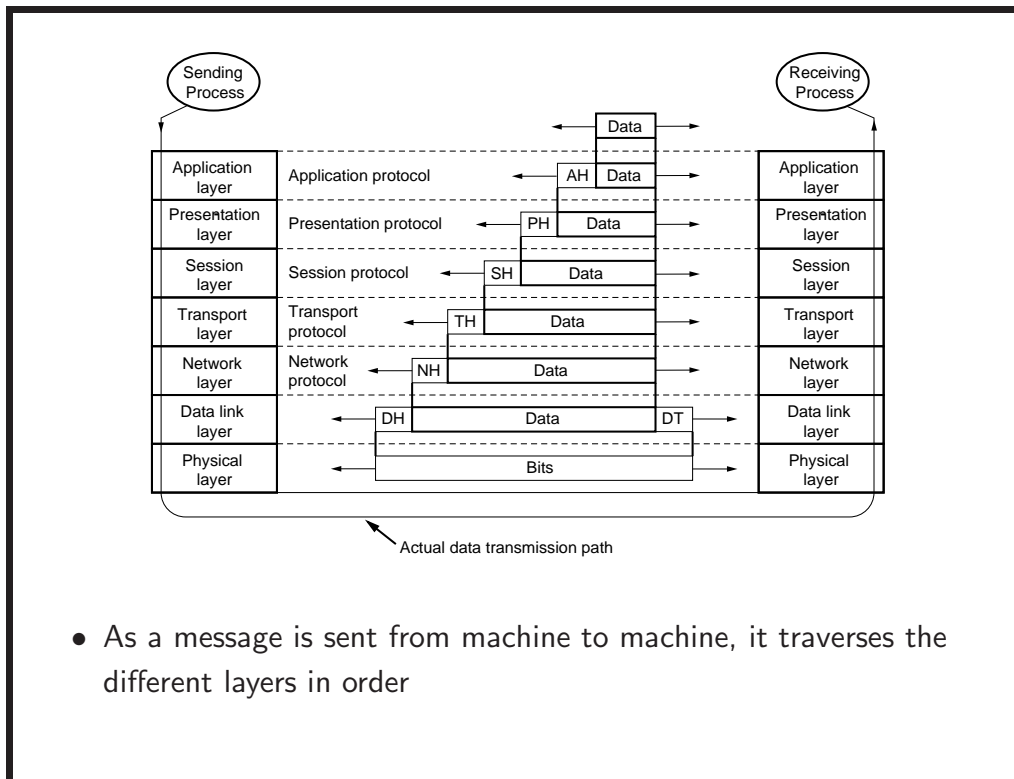
Why are protocols needed in a message passing network?

- Many different protocols are needed to address different questions
 - *How do you represent a bit?*
 - *When can you access a channel?*
 - *How should bits be grouped together to form a message, packet, or frame?*
 - *How are computers identified?*

OSI

- Open System Interconnection (OSI) model provides organization to the different protocols
 - Model consists of 7 layers
 - Each layer defines a protocol and performs certain tasks
- OSI 7 layers
 1. **Physical** - bit transmission
 - Addresses: *How do you send/represent a bit?*
 2. **Data link** - frame transmission
 - Groups bits into frames (more efficient)
 - Addresses: *What is the frame structure? How do you access the channel?*

3. **Network** - routing messages (**packet**)
 - Addresses: *How do you forward a packet?*
Is this layer required for a broadcast network?
4. **Transport** - end-to-end transmission
 - Addresses: *How do you inform the sender to speed-up, slow down, or repeat a data segment?*
5. **Session** - ?
6. **Presentation** - data representation
7. **Application** - provides network service to users



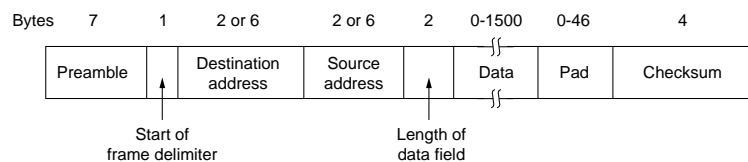
Physical Layer

- Concerned with sending information in the form of electromagnetic signals across a transmission medium
 - Transmission medium includes, copper, fiber, and wireless
- Specifies items such as
 - *How do you represent a bit?*
Can you give an example?
 - Encoding/decoding techniques
- Not many (if any) security issues at this layer
 - If you want to learn more, take CSC 330 in the Fall

Data Link

- Provide reliable and efficient communication between two machines physically connected via a channel
- Data link layer specifies
 - How bits are grouped together into **frames**
 - Line discipline, when can you access (MAC)
 - Error detection (possibly correction)
 - Flow control between two adjacent machines
- Frames typically consist of
 - Start and stop characters indicates beginning and end of frame
 - **Data**
 - Error correction/detection (parity bit)

- Sequence number
- **Address** (MAC address) uniquely identifies a machine



- Addresses
 - Every machine should have a unique data link address
 - Also called MAC or hardware address
 - Different from IP address (which is one layer above)
- We have described the format of a frame
 - Need a protocol indicating how/when to transmit frames
 - **Medium Access Control** (MAC)

Medium Access Control

- Medium Access Control (MAC)
 - Method for controlling access (**transmission rules**)
 - Answers the question: *Who sends next?*
What is the protocol to ask a question in a classroom?

- MAC categories
 - Contention - no permission to send required
Can you give an example?

 - Round-robin - send when you have permission
Can you give an example?

 - Reservation - request before sending

CSMA/CD

- Carrier Sense Multiple Access Collision Detection (CSMA/CD)
 - Contention based MAC
 - Used in **Ethernet** Local Area Networks (LAN)
What type of network topology is required?

- Transmission rules
 1. Medium idle transmit
 2. Medium busy, listen until idle then transmit
 3. If collision, transmit jamming signal
 4. After jamming, wait random amount of time then go to step 1*Is this how you interact in a classroom? What is its performance?*

Token Passing

- Round-robin based MAC
 - Small frame called a *token* is passed from station to station when idle (specific order)
 - Used in Token Ring and FDDI networks

What type of network topology is required?

- Transmission rules
 1. Station waits for token
 2. Station takes token and sends frame
 3. Frame circulated around ring
 4. Station releases token

IEEE 802 Standards

- IEEE has produced several LAN standards called the 802 series

Why are standards needed?
- 802.*x* standards defines
 - Physical layer and data link layer
 - Examples include 802.3 (Ethernet) and 802.5 (Token Ring)
- 802.3 Ethernet, defines the following
 - Cabling type - category 5
 - Signal encoding - differential manchester
 - Frame structure - what the bits represent
 - Line discipline - CSMA/CD

- CSMA/CD performance decreases as the number of computers connected to the medium increases
 - Switched 802.3 was introduced to reduce collisions
 - Switched 802.3 (Switched Ethernet)
 - Each computer connects directly to a *switch*
 - Switch reads frames and forwards to destination computer **only**
- Can collisions still occur?*

How does this impact security?

Network Devices

Classify the devices based on the OSI *layers* they implement

- Hub
 - Connects several Ethernet-enabled computers together
 - Each computer connects directly to the hub
 - Hub **repeats** what is sent on one wire to all other wires

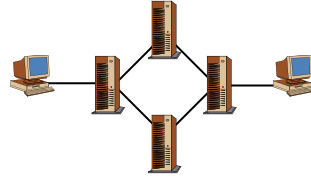
What layer(s) is/are implemented by a hub? What is the difference between a hub and a switch?
- Network Interface Card (NIC)
 - Ethernet card is an example
 - Connects a computer to a LAN
 - Sends bits over wire and follows medium protocol

What layer(s) is/are implemented by a NIC?

Network Layer

- Concerned with delivering packets from source to destination

Isn't this the same as the data link layer?



- Messages are forwarded from machine to machine until destination
 - Messages (**packets** or **datagrams**) are **routed**
 - Network layer describes how packets are routed
 - Network layer also provides congestion control
- Transport protocols also have addresses

- **Routers** implement layers 1, 2, and 3
 - Receive packets and forward to *next* machine
 - Identifying the *next* is important
 - Routing decisions could be based on metrics, tables, or flooding
- Internet Protocol (IP) is the most prevalent network protocol

Transport Layer

- Provides reliable transmission of data across the network
 - Concerned with end-to-end transmission of data
 - Items include loss and Quality of Service (QoS)
Is QoS not a concern for the other network layers?
- Example transport layer protocols
 - User Datagram Protocol (UDP)
 - Transmission Control Protocol (TCP)
- Transport protocols also have addresses

Application Layer

- Applications built to use the network
- Examples include
 - http
 - FTP
 - telnet