CSIS 4222

Ch 9: Transmission Modes
Ch 10: Modulation & Modems
Ch 17: LAN Extensions
Ch 18: Intro to WAN Technologies

Internet Protocol Stack

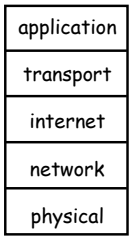
Application: supports network apps
- FTP, SMTP, HTTP

Transport: host-host data transfer
- TCP, UDP

Internet: routing of datagrams from source to destination
- IP, routing protocols

Network interface: data transfer between neighboring network elements
- Ethernet

Physical: bits "on the wire"



Taxonomy of Transmission Modes

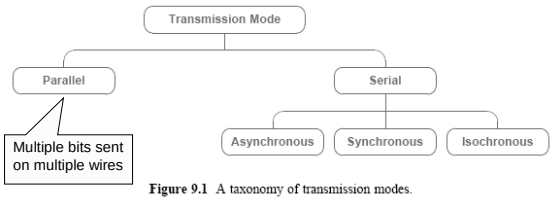


Figure 9.1 A taxonomy of transmission modes.

Serial Transmission

Sends one bit at a time
- Slower than parallel, but
  - Much cheaper over long distances
  - Doesn't have the timing problems inherent with multiple wires
- Sender and receiver need hardware to convert data from the parallel form used in the device to the serial form used on the wire

Ethernet Transmission Order: Bits and Bytes

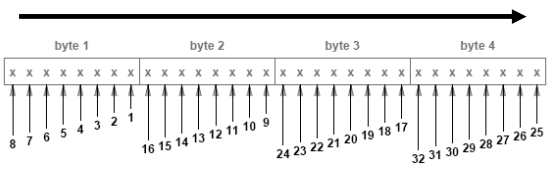


Figure 9.4 Illustration of byte big-endian, bit little-endian order in which the least-significant bit of the most-significant byte is sent first.

Timing of Serial Transmission

Asynchronous: can occur at any time with arbitrary delay between the transmission of two data items

Synchronous: occurs continuously with no gap between the transmission of two data items

Isochronous: occurs at regular intervals with a fixed gap between the transmission of two data items

RS-232 Asynchronous Character Transmission

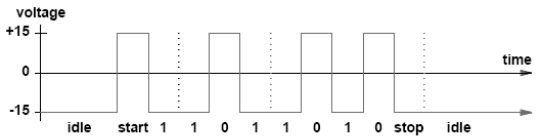


Figure 9.5 Illustration of voltage during transmission of an 8-bit character when using RS-232.

Sender transmits extra bits before each data item to inform the receiver that a data transfer is starting

Synchronous Transmission

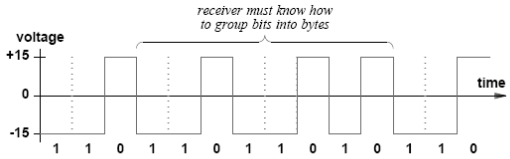


Figure 9.6 Illustration of synchronous transmission where the first bit of a byte immediately follows the last bit of the previous byte.

A block of bytes is grouped into a *frame* that starts with a special sequence of bits for synchronization

Isochronous Transmission

Designed to provide steady bit flow for multimedia applications

– variations in delay known as jitter can disrupt reception (cause pops or clicks in audio/make video freeze for a short time)

– Isochronous network is designed to accept and send data at a fixed rate, *R*

– Network interface passes data to the network for transmission at exactly *R* bits per second

Direction of Transfer

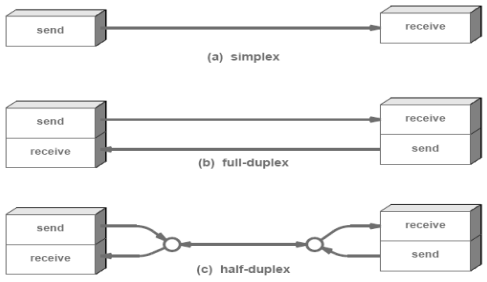


Figure 9.8 Illustration of the three modes of operation.

Analog Modulation

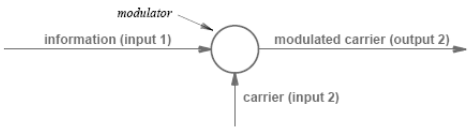


Figure 10.1 The concept of modulation with two inputs.

Long-distance communication systems usually use an oscillating electromagnetic wave called a carrier
The system makes small changes to the carrier (modulations) that represent information being sent

Modems

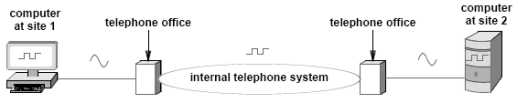


Figure 10.10 Illustration of digital and analog signals (denoted by a square wave and a sine wave) that occur when a dialup modem is used to send data from one computer to another.

Dialup modem uses an audio tone (analog)
The carrier is modulated at the sending end and demodulated at the receiving end

Optical and RF Modems

- Modems are also used with other media
  - Radio Frequency (RF) transmission
  - Optical fibers
- Modems can use entirely different media, but the principle remains the same
  - at the sending end, a modem modulates a carrier
  - at the receiving end, data is extracted from the modulated carrier

Carrier Sense Multiple Access (CSMA)

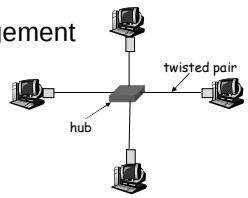
- Ethernet uses cable as a shared medium
  - Nothing controls access to the medium
- CSMA: listen before transmitting
  - If cable sensed idle: transmit a frame
  - If cable sensed busy, wait

Collision Detection CSMA/CD

- A collision can occur if two stations find the cable idle, and both start transmitting
- If adapter detects another transmission while transmitting, it aborts and sends jam signal
- Each adapter waits a random time and retransmits
  - If another collision occurs, they double the maximum time and try again (binary exponential backoff)

Hubs

- Bits coming from one link are repeated on all other links
- No frame buffering
- No collision detection
- Minimal network management functionality



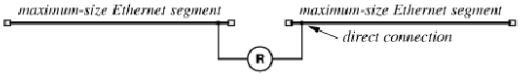
Extending LANs

Recall

- Each LAN technology has distance, speed, and cost limitations
- Typical LAN technology can span, at most, a few hundred meters

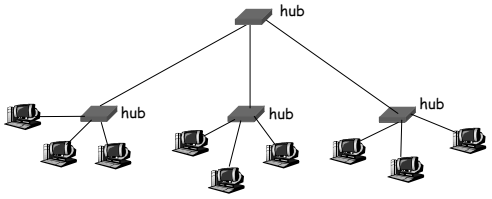
Repeaters copy signals from one segment to the other

- One repeater can effectively double the length of a LAN segment
- But it also propagates noise and collisions



Interconnecting with hubs

- A backbone hub interconnects LAN segments
- Extends max distance between nodes
- But individual segment collision domains become one large collision domain



Bridges

- Also connect LAN segments
- Retransmits frames from one segment to other segment(s)
- Handles *complete frames*
  - Uses a NIC like any other station
  - Performs some processing on frame
- Invisible to other attached computers
- Isolates collisions, noise

Bridges and Bridging

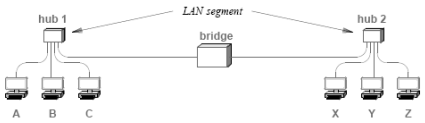


Figure 17.3 Illustration of six computers connected to a pair of bridged LAN segments.

Learning Bridges and Frame Filtering

- A bridge does not forward a frame onto a LAN segment unless necessary
  - Must forward broadcast or multicast frames to all segments
  - Filters frames using destination MAC addresses
- How can a bridge know which computers are attached to which segments?

Learning Bridges and Frame Filtering

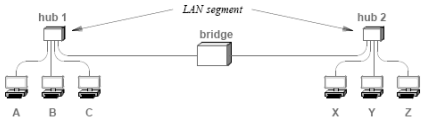
When a frame arrives from a given segment

- extract the source MAC address
- adds the address to a list of computers attached to the segment
- extract the destination MAC address and determine where to forward the frame

- A bridge learns that a computer is present on a segment as soon as the computer transmits a frame

Learning Bridges and Frame Filtering

Fig 17.3



Event	Segment 1	Segment 2	Frame Sent
Bridge boots	–	–	–
A sends to B	A	–	Both Segments
B sends to A	A, B	–	Segment 1 only
X broadcasts	A, B	X	Both Segments
Y sends to A	A, B	X, Y	Both Segments
Y sends to X	A, B	X, Y	Segment 2 only
X sends to Z	A, B	X, Y	Both Segments
Z sends to X	A, B, C	X, Y, Z	Segment 2 only

Fig 17.4

Bridging in Other Devices

- A DSL or cable modem provides a form of bridging:
  - Provides an Ethernet connection at a subscriber's residence
  - Transfers Ethernet packets between the subscriber's location and the provider's network
- Some wireless technologies also use a form of bridging to transfer frames from a mobile device to a provider's network

Switches

- Has multiple ports like a hub
- Logically similar to a bridge
  - Operates on frames
  - Understands MAC addresses
  - Only forwards when necessary
- Permits separate pairs of computers to communicate at the same time

Ethernet (Layer 2) Switch

- Stores and forwards Ethernet frames
  - Examines frame header and selectively forwards frame based on destination MAC address
  - When a frame is to be forwarded on a segment, it does collision detection
- Transparent
  - Hosts are unaware of presence of switches
- Plug-and-play, self-learning
  - Switches do not need to be configured

Layer 2 Switches

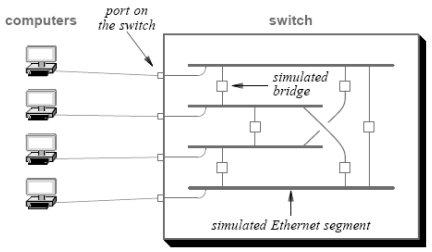


Figure 17.6 Conceptual organization of a switched LAN.

VLAN Switches

Virtual Local Area Network (VLAN) switches

- Allow a manager to configure a single switch to emulate multiple, independent switches
- Specify a set of ports to be on virtual LAN 1, another set of ports to be on virtual LAN 2, and so on
- Once configured, a VLAN switch makes it appear that there are multiple switches

D017 Switch and Routers

Filtering/Forwarding

When a switch receives a frame:

index into switch table using MAC dest address

if entry found for destination

  if dest is on segment from which frame arrived

    drop the frame

  else

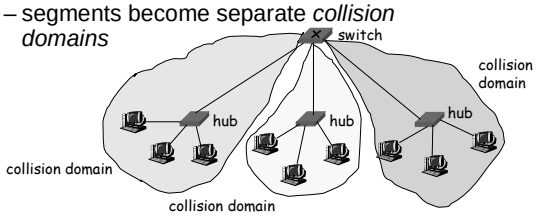
    forward the frame on interface indicated

else flood

forward on all but the interface on which the frame arrived

Switch - traffic isolation

- Switch installation breaks subnet into LAN segments
- Switch *filters* packets:
  - same-LAN-segment frames are not forwarded onto other LAN segments
  - segments become separate *collision domains*



Introduction to WAN Technologies

- LANs can be extended but
  - not arbitrarily far and
  - not to handle arbitrarily many computers
- WAN must be *scalable* to long distances **and** many computers

Packet Switches - the basic building blocks for long distance data connections

To span long distances or many computers, a network must replace *shared medium* with *packet switches*

Packet switch: A small computer with network interfaces, memory and software dedicated to packet switching function

- Each switch moves an *entire packet* from one connection to another

A packet switch provides

- local connections for computers at the site
- connections for data circuits that lead to other sites

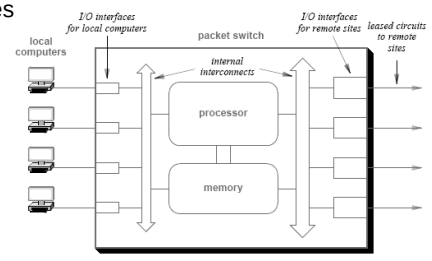


Figure 18.1 Illustration of traditional packet switch architecture.

Most WANs separate a packet switch into two parts:

- a Layer 2 switch that connects local computers
- a router that connects to other sites

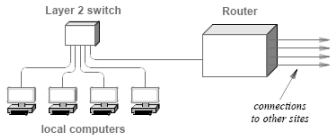


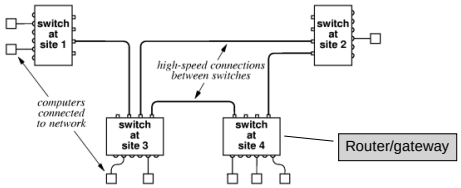
Figure 18.2 Illustration of a modern WAN site with local communication handled by a separate LAN.

Addressing in a WAN

Figure 18.4 Example of an address hierarchy where each address identifies a packet switch and a computer attached to the switch.

These are the network number and host number in IP addressing

WAN Illustration

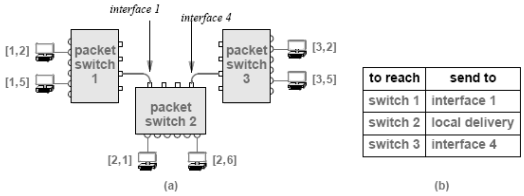


Store and Forward – the basic paradigm used in packet switched networks

Packet
- Sent from source computer
- Travels switch-to-switch
- Delivered to destination

Switch
- ‘‘Stores’’ packet in memory
- Examines packet’s destination address
- ‘‘Forwards’’ packet toward destination

Next-Hop Forwarding



to reach	send to
switch 1	interface 1
switch 2	local delivery
switch 3	interface 4

Figure 18.5 (a) A network of three packet switches, and (b) the next-hop forwarding table for switch 2.

Switches vs. Routers

- Both are store-and-forward devices
  - routers: internet layer devices (examine internet layer headers)
  - switches are network interface layer devices
- Routers maintain routing tables (IP), implement routing algorithms
- Switches maintain switch tables (MAC), implement filtering, learning algorithms