Unit 10

Ethernet, ARQ

Acknowledgments: These slides were originally developed by Prof. Jean Walrand for EE122. The past and current EE122 instructors including Kevin Fall, Abhay Parekh, Shyam Parekh, and Adam Wolisz have contributed to their evolution.

Some Answers and Clarifications…

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Framing Review

- Physical Layer encoding (e.g., NRZ, NRZI, Manchester, 4B/5B)
- Link Layer frames
  - Byte oriented (e.g., BISYNC, DDCMP)
  - Bit oriented (e.g., HDLC)
  - Clock based (e.g., SONET)

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Internet Checksum Update

- See RFC 1624
- Basic idea: Update the checksum using the old checksum and the difference in the updated 16 bit field of interest
- Algorithm:
  - New_Checksum = ~(~Old_Checksum + (m’ – m))
  - ~ denotes one’s complement, m and m’ are the old and new 16 bit fields of interest

Continue Ethernet Discussion…

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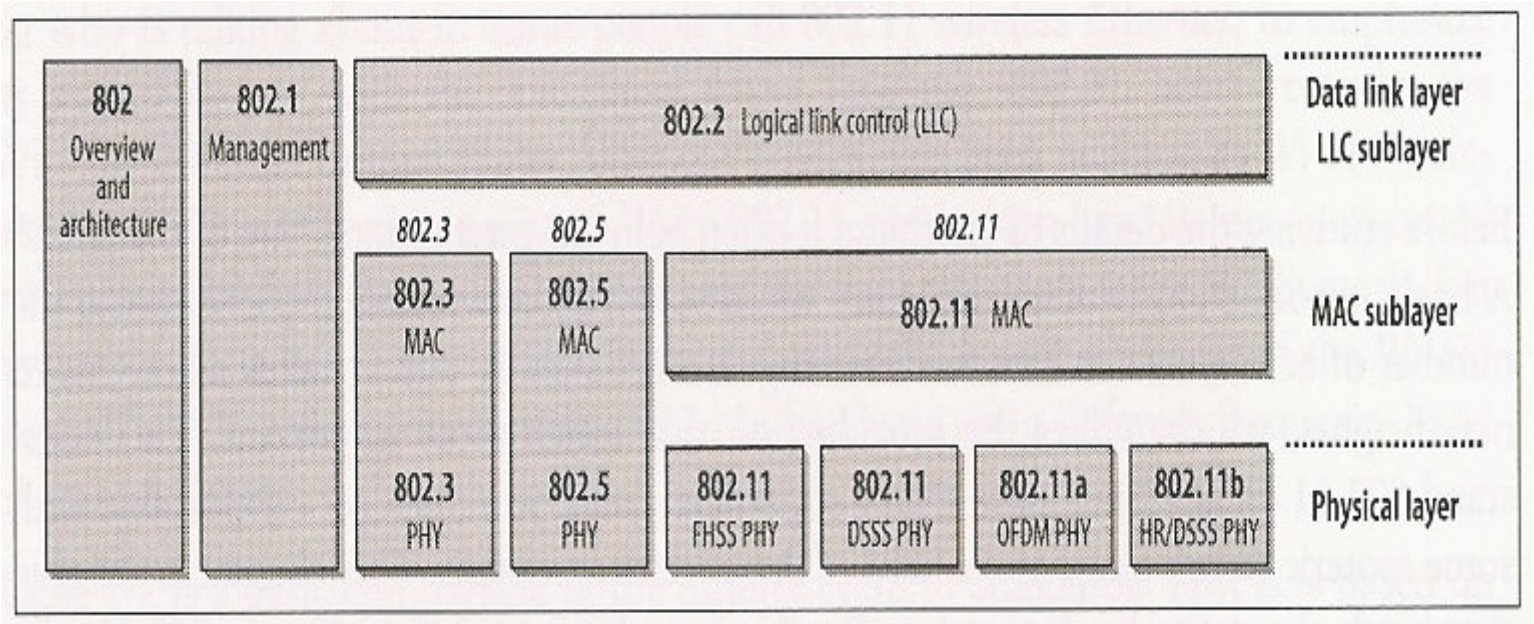
IEEE 802 Standards & OSI Model



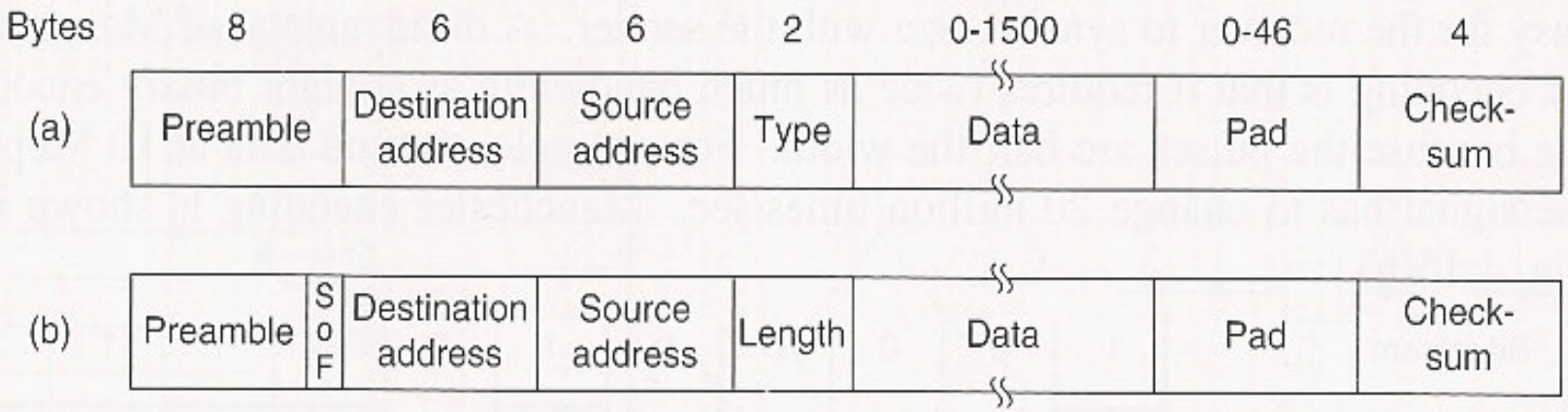
[Gast]

- Observe 802.11 MAC is common to all 802.11 Physical Layer (PHY) standards
- 802.11 PHY is split into Physical Layer Convergence Procedure (PLCP) and Physical Medium Dependent (PMD) sublayers

Names

- Structure: [rate][modulation][media or distance]
  - 10Base5 (10Mbps, baseband, coax, 500m)
  - 10Base-T (10Mbps, baseband, twisted pair)
  - 100Base-TX (100Mbps, baseband, 2 pair)
  - 100Base-FX (100Mbps, baseband, fiber)
  - 1000Base-CX for two pairs balanced copper cabling
  - 1000Base-LX for long wavelength optical transmission
  - 1000Base-SX for short wavelength optical transmission.
- Wireless:
  - Wi-Fi = 802.11
  - Versions: a, b, g, n

Frame



Frame formats. (a) DIX Ethernet. (b) IEEE 802.3.

- 8 byte preamble (DIX Ethernet): alternating 1/0 combination producing 10Mhz square wave [@ 10Mbps] for 6.4 μsec; used for receiver synchronization

Ethernet Addresses

- Ethernet (and other IEEE 802) protocols make use of 48 bit addresses

I/G	U/L	46 BIT ADDRESS

I/G = 0 Individual Address
I/G = 1 Group Address
U/L = 0 Globally Administered Address
U/L = 1 Locally Administered Address

- IEEE allows for per-port and per-host addressing
  - Ports connecting to the same “subnet” need unique addresses
  - Locally Administered Addresses (LALs) can be used for distinguishing such ports
  - LALs are rarely used in Ethernet, but more commonly used in Token Ring

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Ethernet Addresses – More Details

From http://www.mynetwatchman.com/pckidiot/chap04.htm

- Addresses are allocated by IEEE in blocks containing 2^24 (16,777,216) addresses
- The first 3 bytes identify the vendor and are called Organizationally Unique Identifier (OUI) (e.g., 00-00-0C is Cisco)
- Each byte is transmitted with LSB first

Individual

MAC Type	Address range
Globally Unique	*0-**-**-**-**-** *4-**-**-**-**-** *8-**-**-**-**-** *C-**-**-**-**-**
Locally Administered	*2-**-**-**-**-** *6-**-**-**-**-** *A-**-**-**-**-** *E-**-**-**-**-**
Multicast	*1-**-**-**-**-** *3-**-**-**-**-** *5-**-**-**-**-** *7-**-**-**-**-** *9-**-**-**-**-** *B-**-**-**-**-** *D-**-**-**-**-** *F-**-**-**-**-** Note: except broadcast address
Broadcast	FF-FF-FF-FF-FF-FF

Valid Use	MAC Type
Source address	Globally Unique Locally Administered
Destination address	Globally Unique Locally Administered Multicast Broadcast

Individual

Addressing

- 48 bit Ethernet/MAC/Hardware Addresses
- Prefix assigned per-vendor by IEEE
- Unique per-adapter, burned in ID PROM
- Multicast & Broadcast (all 1's) addresses
- Many adapters support *promiscuous* mode

Addressing - Multicast

- Each vendor assignment supports 2^24 individual and group (multicast) addresses
- Each adapter supports multiple group "subscriptions"
  - usually implemented as hash table
  - thus, software may have to filter at higher layer

Fast Ethernet

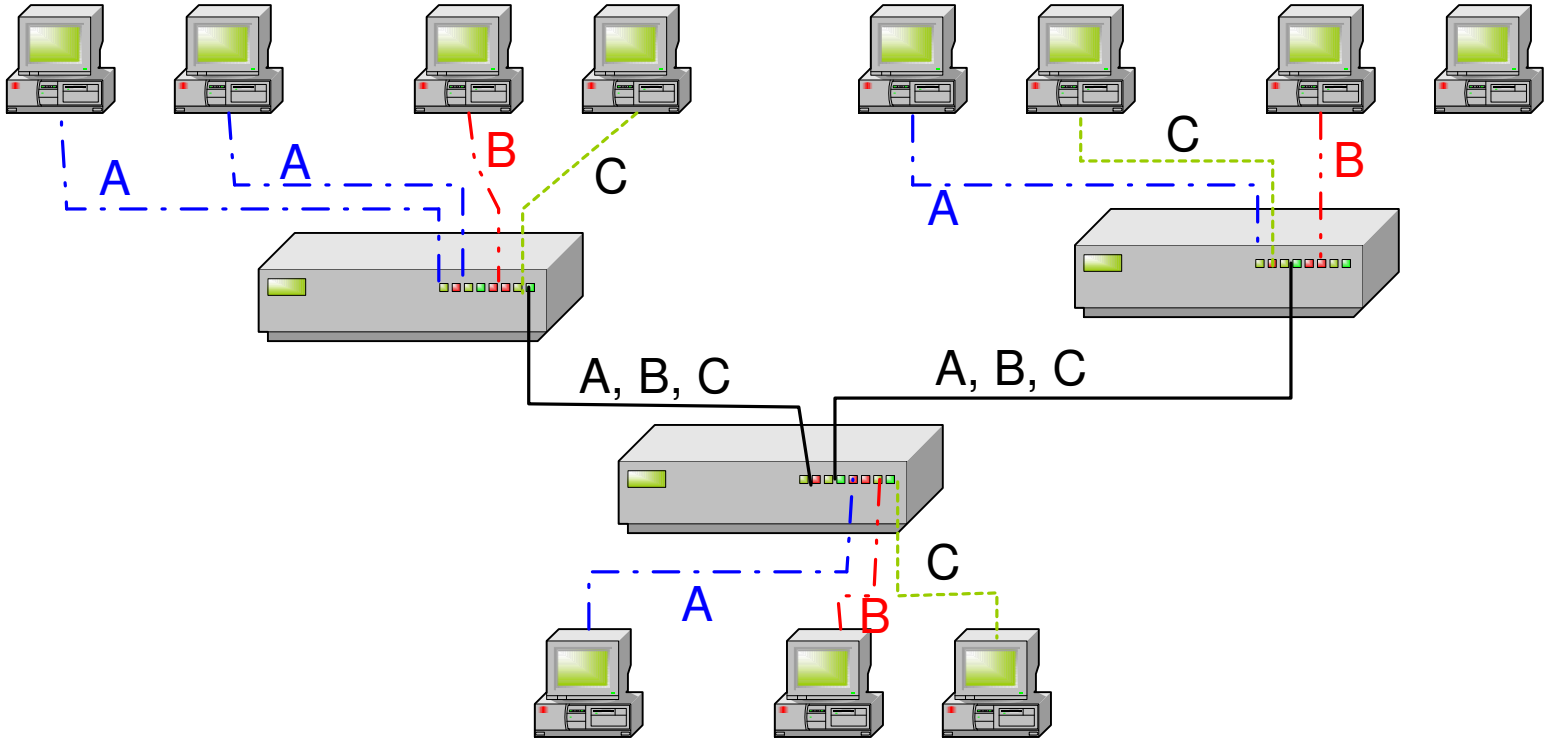
- “Fast Ethernet” (1995) adds:
  - 10x speed increase (100m max cable length retains min 64 byte frames)
  - replace Manchester with 4B/5B (from FDDI)
  - full-duplex operation using switches
  - speed & duplex auto-negotiation

Gigabit Ethernet

IEEE 802.3{z,ab} 1000 Mb/s

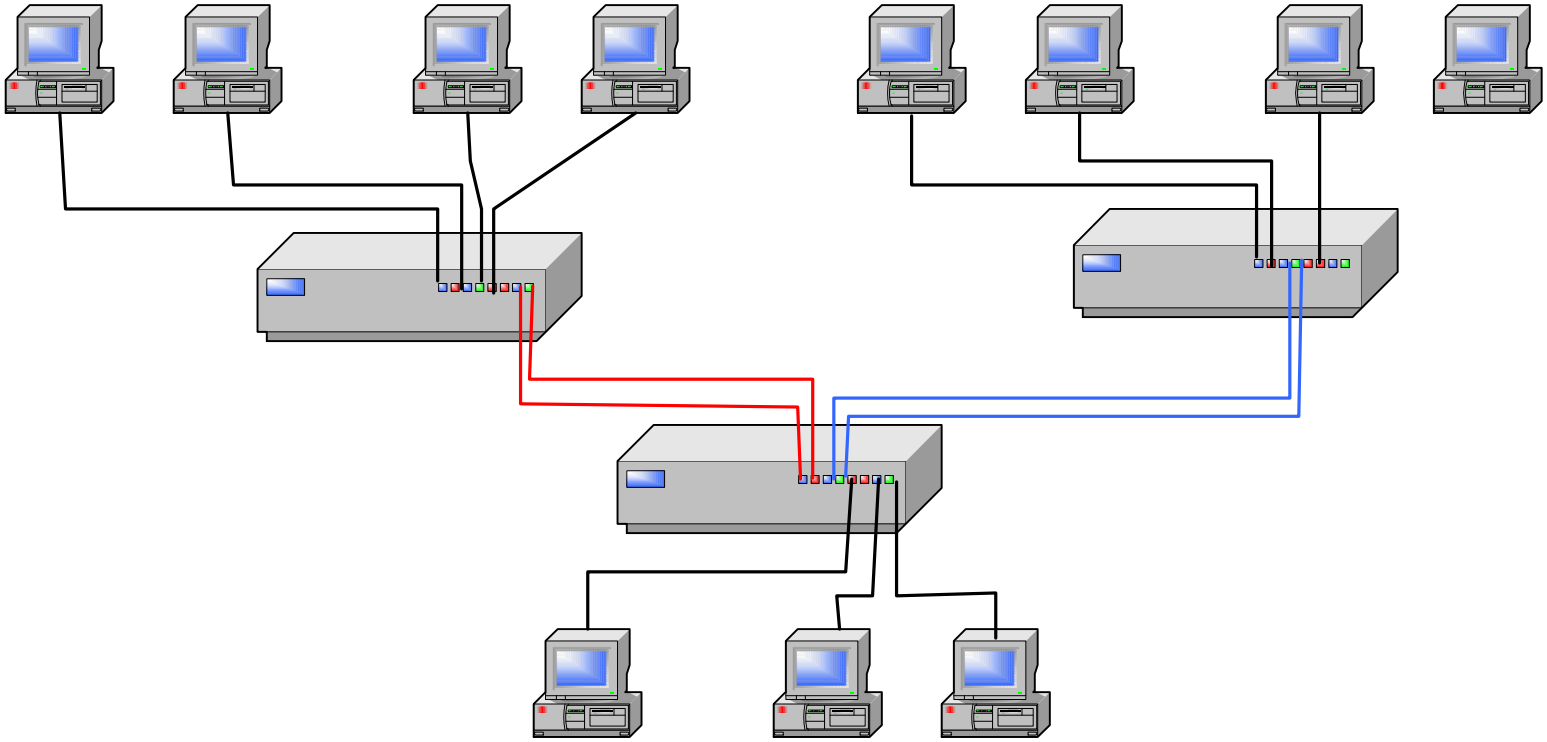
- “Gigabit Ethernet” (1998,9) adds:
  - 100x speed increase
  - carrier extension (invisible padding...)
  - packet bursting

VLAN – Virtual LAN



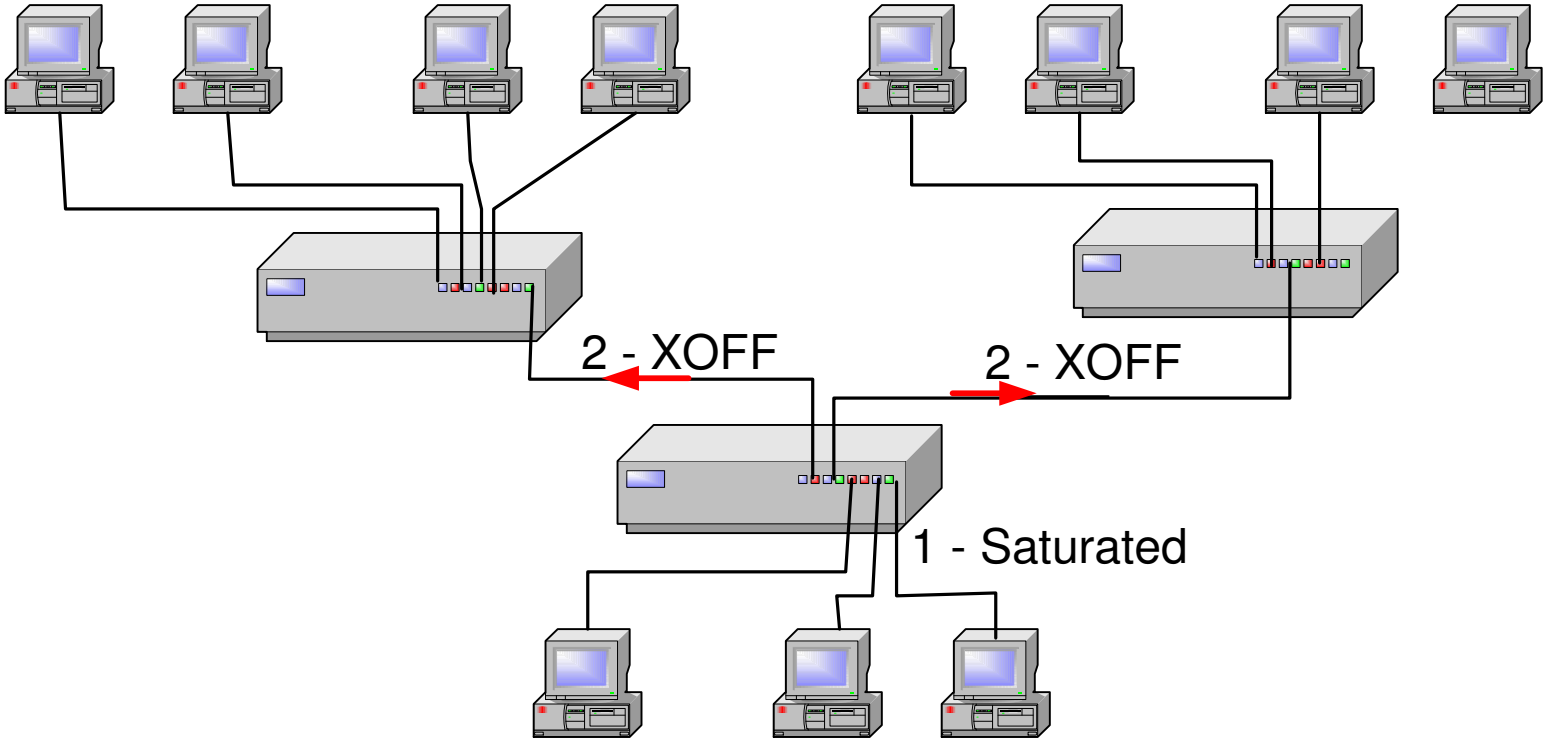
Each port belongs to a set of VLANs and transmits only packets that belong to these VLANs

Link Aggregation



Links are combined. Hello protocol determines which links are working and transmits across working links.

XON/XOFF



XON/XOFF is a backpressure scheme designed to prevent nodes from saturating links. Unfortunately, in its present version, the scheme is not very effective – it stops too many flows.

Automatic Repeat Request (ARQ)

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Reliable Transmission:
Error correction or Retransmission?

- Error Correction requires a lot of redundancy
  - Wasteful if errors are unlikely
- Retransmission strategies are more popular
  - As links get reliable this is just done at the transport layer
- Error correction is useful when retransmission is costly (satellite links, multicast)

Reliable Transmission:
Error correction or Retransmission?

- Model:
  - Assume Packets have P bits
  - D extra bits for error detection → P(error) = e
  - C extra bits for error correction (C > D)
- Question: What is more efficient?
- Answer:
  - Error Correction → P + C bits/packet
  - Error Detection → (P + D)/(1 – e) bits/packet
  - Hence: ED if e < (C – D)/(P + C)

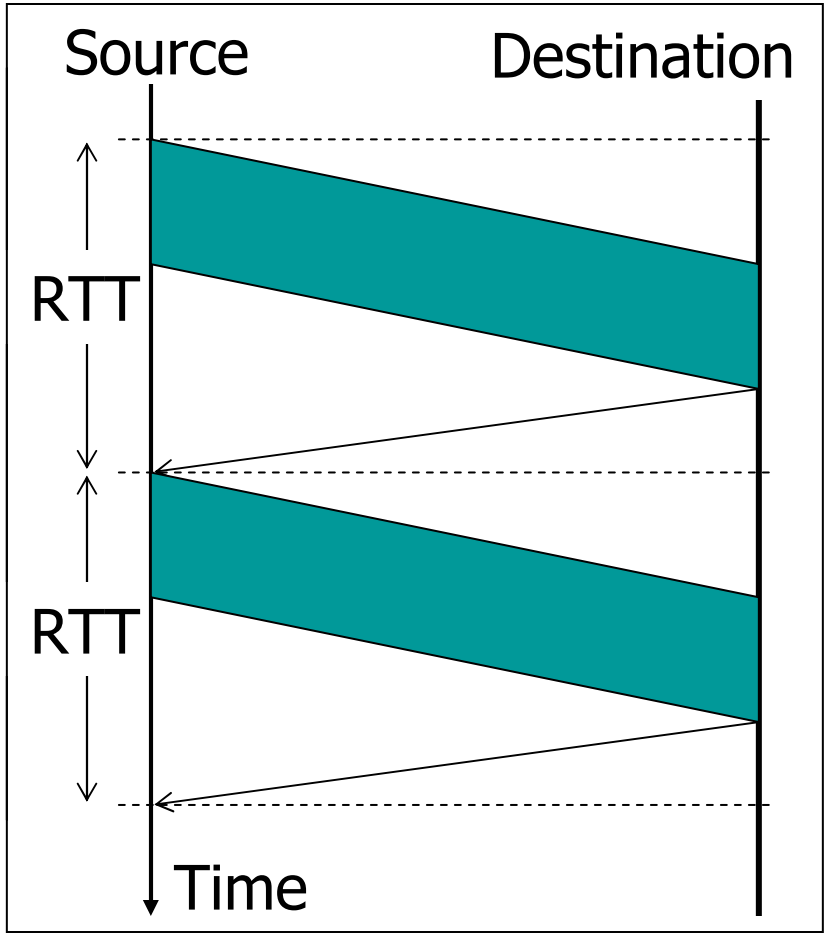
Reliable Transmission:
Link by Link or End-to-End?

- Model:
  - Assume L links with P(error) = e for each (ind.)
- Link by Link:
  - $L/(1 - e)$ transmissions per packet
  - However, there is a processing time T per link
  - Hence $TL + L/(1 - e)$
- E2E:
  - L/s transmissions per packet where $s = (1 - e)^L$
- Hence:
  - E2E if $L/(1 - e)^L < L(T + 1/(1 - e))$, which is the case if $e << T/L$

Connection Throughput

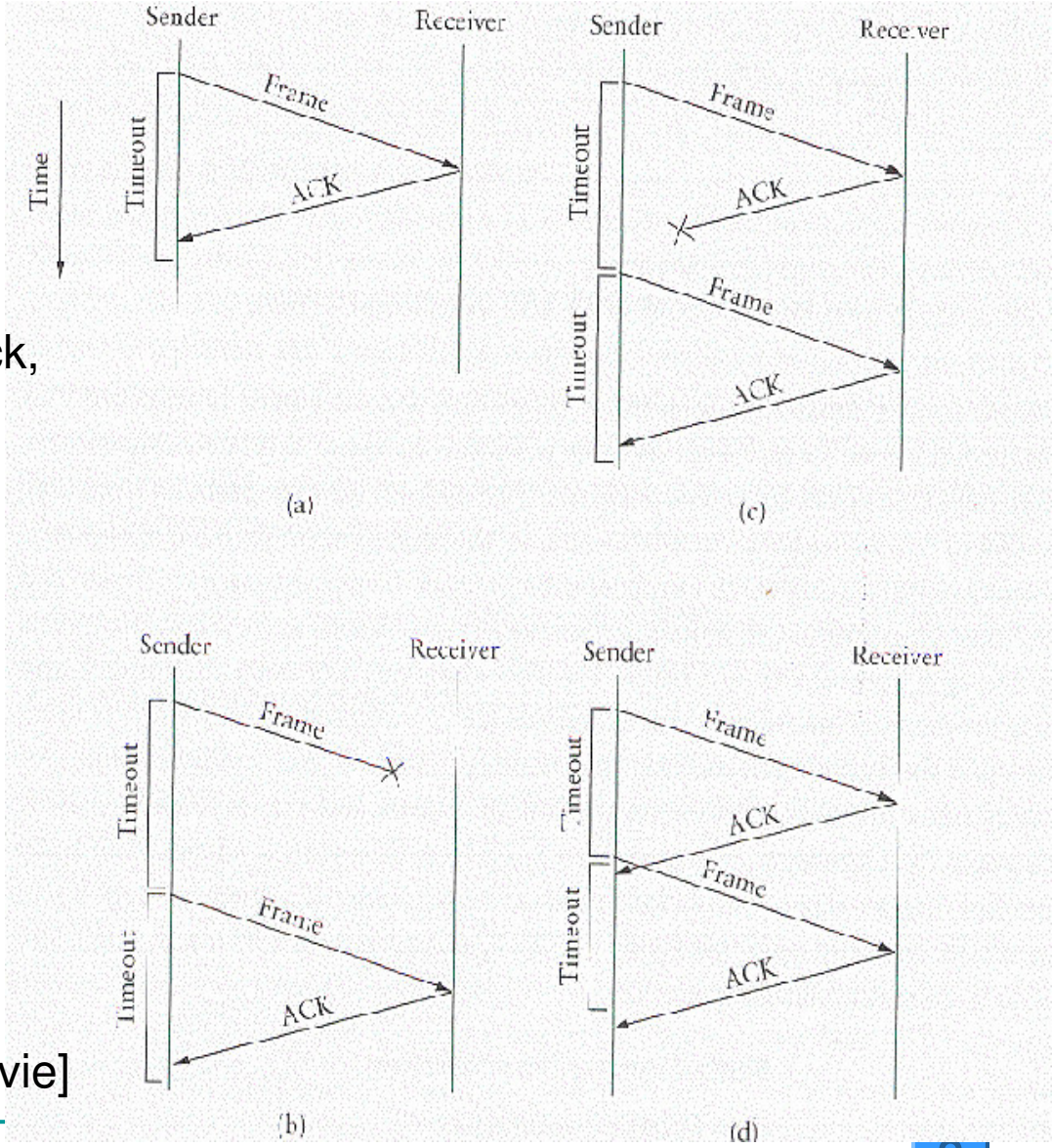
- Connection:
  - Send W bits (window size)
  - Wait for ACKs
  - Repeat
- Assume that the round-trip time is RTT seconds
- Throughput = W/RTT bps

- Numerical Example:
  - W = 64KBytes = 512 kbits
    = 512x1,024 = 524,288 bits
  - RTT = 200ms
  - Throughput = W/T = 2.6Mbps



Stop-and-Wait Scenarios

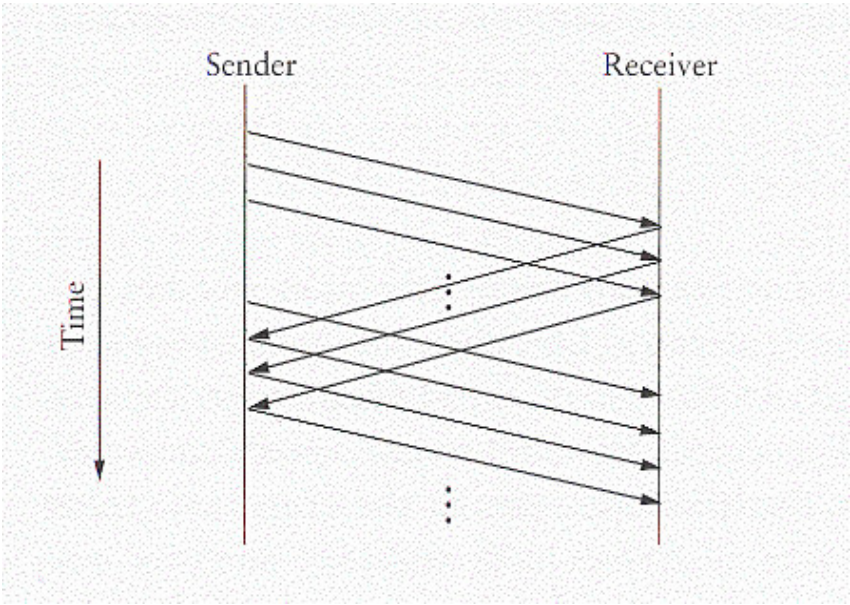
- Transmit one packet, wait for ack, and repeat
- Set timeout for retransmission



[Peterson & Davie]

Sliding Window

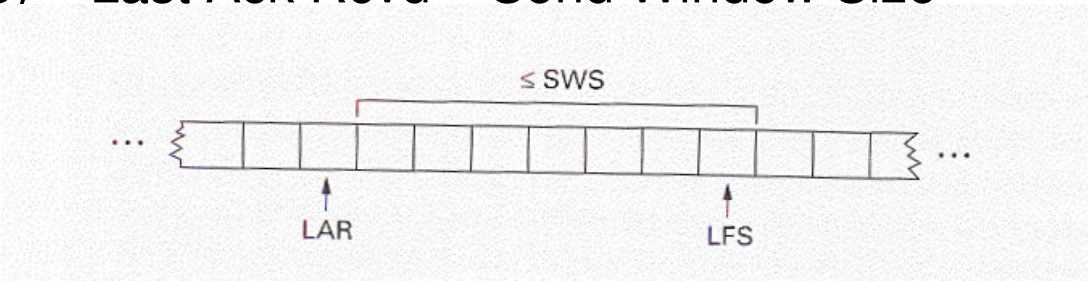
- Start with a window size of W packets
- Decrement available window size for each packet transmitted
- Increment available window size for each ack received



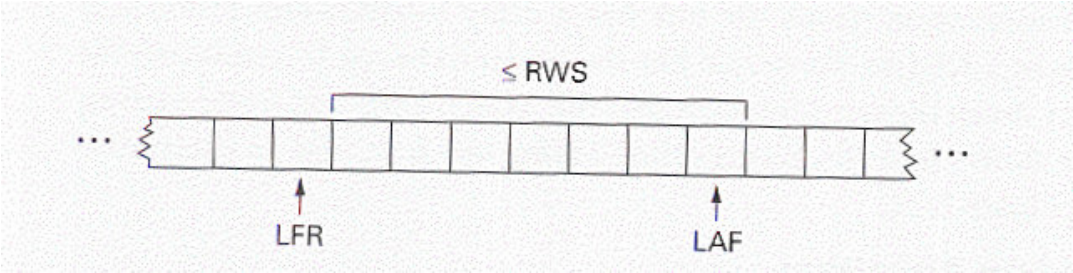
[Peterson & Davie]

Sliding Window Algorithm

- Sending side
  - Last Frame Sent (LFS) – Last Ack Rcvd ≤ Send Window Size (SWS)



- Receiving Side
  - Largest Acceptable Frame (LAF) – Last Frame Rcvd ≤ Receive Window Size (RWS)



- Typically RWS = 1 or RWS = SWS