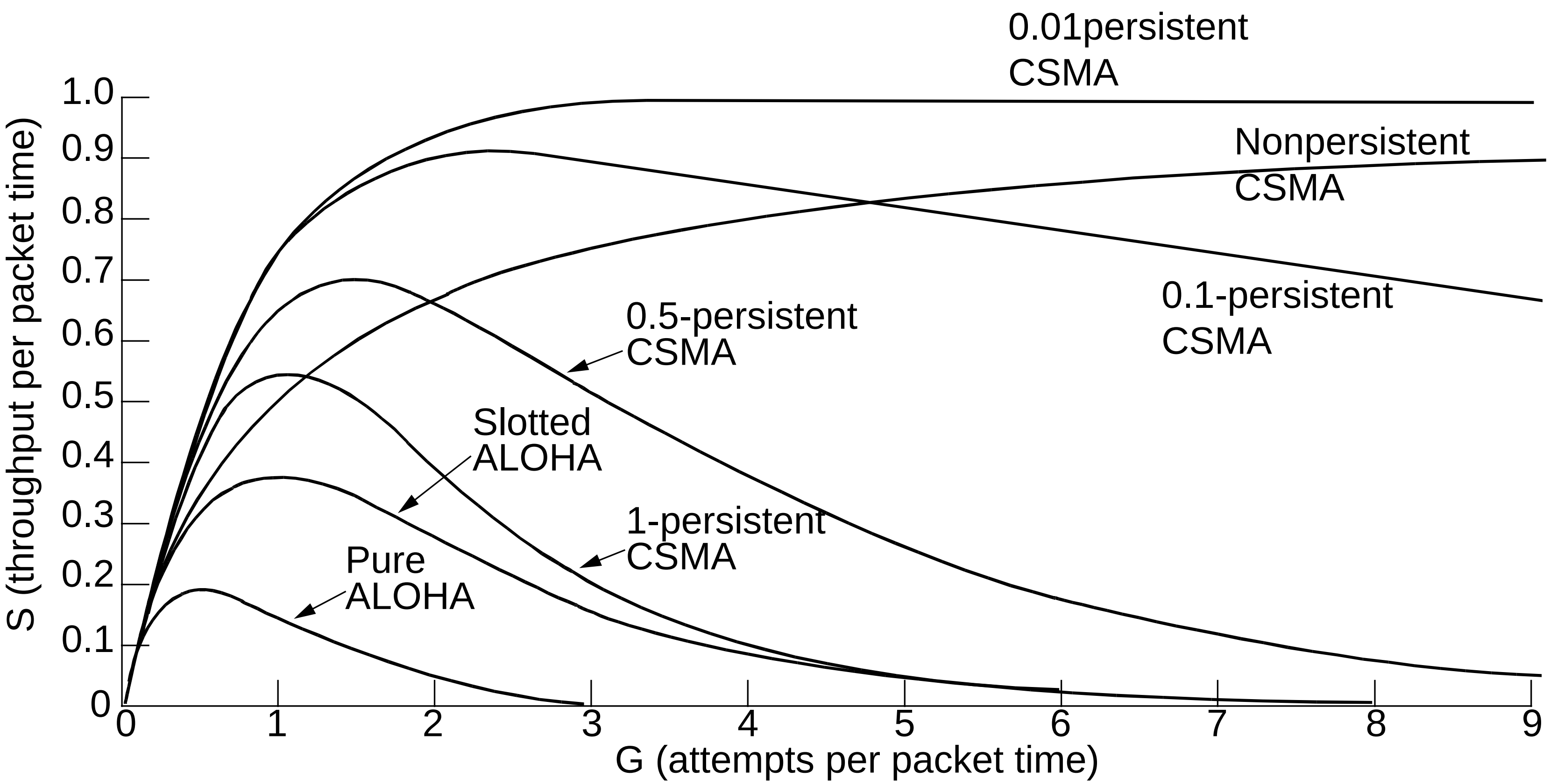
Announcements

- Reading
  - Chapter 4 (4.3.1, 4.4, 4.5)
- Homework #1
  - Due today
- Midterm #2
  - 11/8/01 in class
- No office hours next week

Carrier Sense Multiple Access

- look before you leap!
  - don't send if someone else is sending
- collisions are still possible
  - propagation delay induces uncertainty into sensing
  - possible two hosts both start sending at the same time
- persistence: when to send after detecing channel in use
  - 1-persistent
    - as soon as the channel is free, starting sending
  - nonpersistent CSMA
    - if channel is sensed busy, wait a random time and try again
  - p-persistent CSMA
    - if slot is idle send with probability p, else wait for next idle slot

Impact of Carrier Sense



From: *Computer Networks*, 3rd Ed. by Andrew S. Tanenbaum, (c)1996 Prentice Hall.

Collision Detection

- If a sender senses a collision
  - stop sending at once
  - apply random backoff
- “contention” period
  - after contention period, there will be no collision
  - send for for 2τ (max propagation delay)
    - need 2τ since might be a collision at far end at $\tau-\varepsilon$

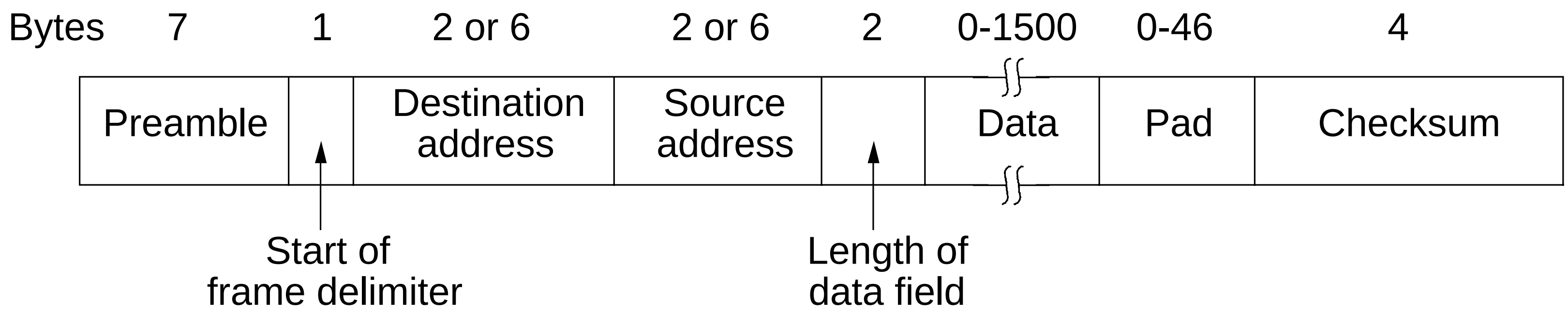
Ethernet Cable Options

- 10base5: Thicknet - first Ethernet
  - Thick cable, doesn’t bend well
  - vampire taps used to “tap” the network
  - max run is 500 meters
- 10Base2: Thin coax (cheaper net),
  - uses “T” connectors
  - max run is 200 meters
- 10baseT: twisted pair
  - uses a central hub
  - easier to find faults and problems
  - max run is 100 meters to hub

Manchester Encoding

- Problem: How to send zero/ones?
  - need to know timing information
  - when does on bit end?
- Answer: Force many transitions
  - every bit is half low and half high
  - 1 is high then low
  - 0 is low then high
  - but this doubles bandwidth
- Differential Manchester Encoding
  - better noise immunity
  - 0 is a transition at the start, 1 none
  - both transition during the middle

Ethernet Frame Format



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- Preamble used to sync clock
- Addresses
  - 48 bits
  - if it starts with a 0 it is globally unique (assigned by IEEE)
  - if it starts with a 1 it is locally unique
- Length
  - 0 to 1500 bytes
  - **min** length is 46 bytes
    - ensures frame reaches end of cable before end of frame is sent
- Checksum
  - 32 bit CRC to detect garbled data at link level

Collision Management

- Binary Exponential Backoff
  - after collision, divide into slot times
  - after first collision, wait either 0 or 1 slot times
  - after second collision, wait either 0, 1, 2, or 3 slot times
  - limited to 1023 slots
  - after 16 collisions, link layer gives up
- Performance
  - each station wants to transmit with probability p, then
    - $A = k\,[p^1(1-p)^{k-1}]$
    - A --> 1/*e* as k --> infinity
  - probability a contention interval has j slots is $A(1-A)^{j-1}$
  - mean number of slots per contention is:

$$\sum_{j=0}^{\infty} jA(1-A)^{j-1} = \frac{1}{A}$$

mean contention interval is then $2\tau/A$

Ethernet Performance (cont.)

- Ethernet Channel efficiency is then:

$$\frac{P}{P + 2\tau / A} = \frac{1}{1 + 2BLe / cF}$$

B = bandwidth

L = cable length

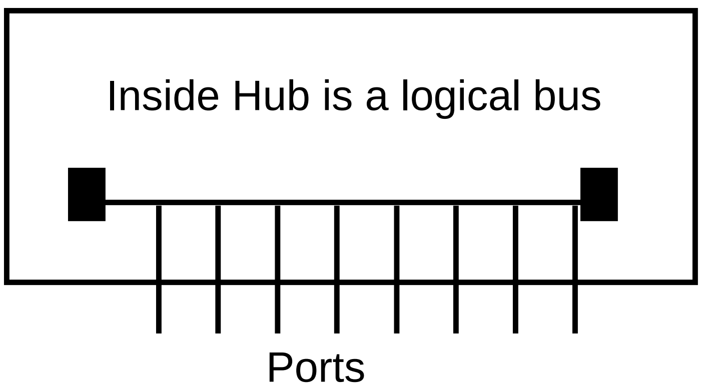
c = speed of light

F = frame length

- Traffic models
  - traditional analysis assume Poisson arrival
  - recent studies have demonstrated self similar properties
    - traffic variance does not decrease with wider samples

Variations on Ethernet

- Traditional Ethernet is a bus
  - limited to one host at a time
  - Requires long wires
- Hub based Ethernet
  - Cables form a star
  - Basic bus is still used (one large collision domain)



Bridges

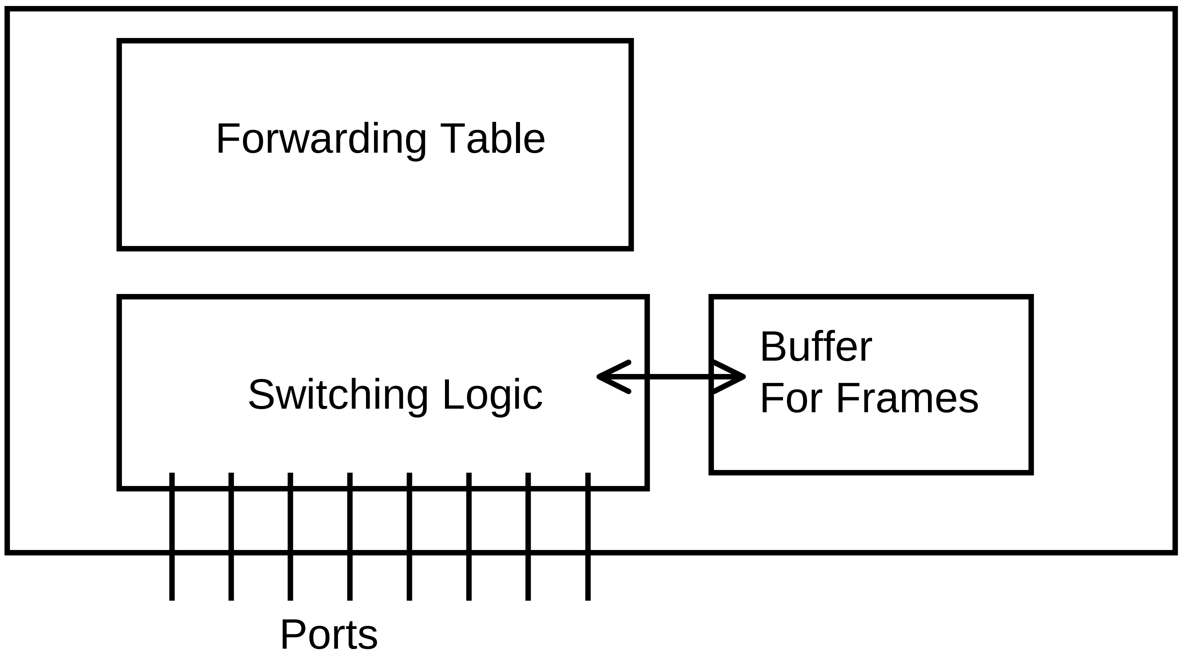
- Split one logical LAN into multiple physical LANs
  - permit mixing types of 802.X networks
    - 100 Megabit Ethernet with 10Mbps
    - token ring with Ethernet
  - extend the physical network
    - limits on cable length
  - improve security
  - reduce traffic
- Forward traffic between the physical layers
  - regenerate the signal
  - convert between 802.X formats
    - this is non-trivial

Learning Bridges

- Transparent to users
  - traffic just gets to the correct location
  - no software configuration required
- Selectively forward traffic among segments
  - used 48bit Ethernet addresses
  - at first, forward all traffic via flooding
  - use **source** address to learn where a host is located
    - do not forward a packet if the destination is known to be on the local network
- need to have a spanning tree to prevent loops
  - use lowest serial number to elect root
  - compute shortest path to root as the spanning tree
  - some bridge may be disabled to ensure a tree

Switched Ethernet

- Make Bridge with multiple ports
  - different ports can each form there own Ethernet segment
    - frames for other segment travel over backplane
  - individual stations retain the same card and cabling



Source Routing Bridge
(skipped Fall 2001)

- Each host knows how to reach other hosts
  – it builds a full path to that host
- Every LAN and bridge has a number
  – a LAN has a 12 bit identifier
  – a bridge a 4 bit id
- To discover a route
  – broadcast a discovery packet
  – destination responds
    • bridges fill in their information in the response
    • results in a full path to the remote destination

Source vs. Transparent Bridges (skipped Fall 2001)

- Source Bridges
  - always use optimal routes
  - could exploit multiple paths between two LANs for load sharing
- Transparent Bridges
  - require no changes to nodes
    - nodes are now more complex
  - no need to configure the bridges
    - source bridges need LAN and Bridge Ids

Faster Ethernet

- Based on hubs
  - advantages of hubs rendered bus cables useless
  - limits cable length to 100 meters for copper
  - can be switched or use a single collision domain
- 100 Mbps
  - 100Base-T4
    - uses 4 pair cat 3 wiring
    - 33Mbps in each direction and two reversible channels
    - 25Mhz with trinary signaling and 4 bits per baud
  - 100Base-TX
    - two pairs of cat 5 wiring
    - 125Mhz with 4bits our of 5 for data
- 1000 Mbps
  - Uses 4 pair of cat 5e wiring (at 250Mhz)
  - Uses fiber