I. Media Contention & MAC Rules

Week 5

Collisions in Ethernet (specifically 10Mbps – half duplex):

- are not errors
- do not corrupt data
- are the basis for multiple node access on a single half duplex line

10baseT manages collisions using something called **CSMA/CD** (Carrier Sense Multiple Access/Collision Detect).

CSMA/CD (see Ch 2 & Ch 3, pg. 48+)

1. node wishing to transmit listens to media for presence of a carrier signal (i.e. a signal on the wire)
   - if a carrier is present, node must wait
   - if no carrier for IFG time period, transmit

2. if a collision is detected, a (32 bit) **jam signal** is transmitted

3. after sending a jam, all nodes will wait a random amount of time before trying to send again (backoff)

4. goto step 1

Timing Issues:

- **network diameter** – distance between two (most distant) end nodes

- **network segment**

  1) in general, network section that is bounded by bridges, routers, or switches (i.e. a collision domain) per Cisco definition
  2) physical wire connection w.r.t. 5-4-3 rule, not a collision domain

- while signals on the line are very fast (almost 3 x 10^8 m/sec), they still take measurable time. Time is measured in **bit time**, for 10 Mbps:

  10 Mbps = 10 million bits/sec or 10 bits/µsecond, so 1 bit 1/10 millionth of a second or 1 bit transmitted in .1 µsecond

- **interframe gap** (IFG) – time for brief recovery after receiving (tail end of) frame

  - 96 bit times
  - 9.6 µseconds (microseconds) for 10 Mbps

- **slot time** – maximum time required to detect a collision
  - smallest Ethernet frame? 64 octets, or 512 bits, thus 51.2 µseconds
  - approximately twice the signal propagation time between the two end nodes (most distant) on the network
  - why twice? the time it takes a signal to travel from one end two the other end, and back → **physical layer round trip propagation time**
  - slot time is the maximum time required for collision enforcement

- **wire speed & data delivery** (see Gallo, pg 334)
  - smallest Ethernet frame (worst case scenario) transmitted in 51.2 µsec + preamble 6.4 µsec +IFG 9.6 µsec totals **67.2 µsec per frame**
  - thus 1 frame is transmitted in 1/67.2 µsec = 0.0148809 µsec
  - since 1 second is 10^6 µsec, 0.0148809 µsec * 10^6 = 14880 (min size) frames are transmitted in 1 second → this is referred to as **wire speed**
  - **data (payload) delivery**: at 14880 frames per second, 46 data octets (min) per frame, 8 bits/octet, we get 14880 frames/sec * 46 octets/frame * 8 bits/octet = 5.476 (approx) Mbps data
  - largest Ethernet frame: 1518 octets * 8 = 12144 bits transmitted in 1214.4 µsec per frame, + 6.4 + 9.6 = 1230.4 µsec
  - 1 frame in 1/1230.4 µsec = 0.0008127 µsec (approx)
  - .0008127 * 10^6 = 812.74 frames per second
  - 1500 data octets (max) per frame, 8 bits/octet → 812.74 * 1500 * 8 = 9.773 Mbps data

II. CSMA/CD & Backoff Algorithm

- goal: once a collision occurs, goal is to minimize chances of another
- backoff algorithm provides a mechanism for adjusting timing of retransmissions
- based upon slot time multiple with random integers in a given range
- integer (i) chosen such that $0 <= i <= 2^n - 1$ where n is collision attempt and n<=10

collision #	range	wait time
0	-	-
1	0-1	0 * 51.2 μs, 1 * 51.2 μs
2	0-3	0 * 51.2 μs, 1 * 51.2 μs, 2 * 51.2 μs, 3 * 51.2 μs
10	0-1023	
11-15	same as above	
16	discard frame	

III. Ethernet Restrictions

10 Mbps Ethernet:

	Type	Max Seg Len	Max Nodes Seg	Max Diameter	Spacing
Thick coax	10base5	500 m	100	2500 m	2.5 m
Thin coax	10base2	185 m	30	925 m	.5 m
TP	10baseT	100 m	2	500 m	-
fiber	10baseF	2000 m	2	2500 m	-

- see hub handouts and network diameters

IV. 5-4-3 Rule

- rule is applied to Ethernet networks where greater distances are achieved using (repeating) hubs
- used to insure that any data sent will arrive at its destination within a given time, thus reducing collisions
- only applied to hub based Ethernets, does not apply to switched Ethernets
- rule states:
  - given two types of segments, user (populated) segments and link segments
  - for any two end nodes on the LAN, there can be a maximum of **5 segments** between them
  - connected via a maximum of **4 (repeating) hubs**
  - where a maximum of 3 **of the segments are user populated** (i.e. have user nodes connected to them)
  - sometimes called 5-4-3-2-1, where 2 is the number of segments that are not user populated and 1 is the number of collision domains
- workarounds to 5-4-3, stackable hubs, but these are also limited based upon manufacturer
- see handout