527 — Computer Networks and Distributed Systems — Data Link Layer

Note that the solution notes below only briefly list (some of) the key points that should be included in an answer. They are by no means complete. In an exam, you are expected to spell out the solution more fully and include a detailed explanation of your reasoning.

Framing

The following character encoding is used in a data link protocol:
A: 01000111; B: 11100011; FLAG: 01111110; ESC: 11100000

Show the bit sequence transmitted (in binary) for the four-character frame:
A B ESC FLAG
for the following two framing methods:

1. Character count
2. Flag bytes with byte stuffing.

1. Character count:
$\underbrace{00000100}_{\text{Count: 4}}\underbrace{01000111}_{\text{A}}\underbrace{11100011}_{\text{B}}\underbrace{11100000}_{\text{ESC}}\underbrace{01111110}_{\text{FLAG}}$
2. Flag bytes:
$\underbrace{01111110}_{\text{FLAG (start)}}\ \underbrace{01000111}_{\text{A}}\underbrace{11100011}_{\text{B}}\ \underbrace{11100000}_{\text{ESC (stuffing)}}\ \underbrace{11100000}_{\text{ESC}}\ \underbrace{11100000}_{\text{ESC (stuffing)}}\ \underbrace{01111110}_{\text{FLAG}}\ \underbrace{01111110}_{\text{FLAG (end)}}$

Minimum Frame Size

1. Why has Ethernet got a minimum frame size?
2. What is the trade-off when choosing the minimum frame size?

1. Ensure that transmission is still in progress when collision is detected at maximum segment length
2. (a) *Small* minimum frame size: more header overhead to send data; lower access delay; shorter segment length
   (b) *Large* minimum frame size: padding for small data; larger access delay; longer segment length

Calculating the Minimum Frame Size

1. Nodes on a shared CSMA/CD network communicate at 10Mb/s. If their minimum frame size is 64bytes and the signal propagation speed in the wire is $2 * 10^8\,\mathrm{m/s}$, determine the theoretical maximum length of the cable.
2. Compare your answer with the IEEE recommended maximum length for Ethernet (which is 2,500m). Explain the apparent disparity.
3. If the transmission speed stays the same, what effect would reducing the maximum wire length to 1km have on minimum frame size? Would this be worthwhile? (Assume IEEE 802.3 framing).

1.

$$\begin{aligned}\text{End-to-end propagation time} &= \text{length} \;/\; \text{transmission speed}\\ \text{Time to transmit frame} &= \text{frame size} \;/\; \text{link data rate}\end{aligned}$$

Collision detection requires that time to transmit be at least *twice* end-to-end propagation time, so

$$\begin{aligned}2 * \text{length} \;/\; \text{transmission speed} &\leq \text{frame size} \;/\; \text{link data rate}\\ 2 * \text{length} \;/\; 200,000,000\,\mathrm{m/s} &\leq 64 * 8\,\mathrm{bit} \;/\; 10,000,000\,\mathrm{bit/s}\end{aligned}$$

$$\begin{aligned} \text{length} &\leq 64 * 8\,\mathrm{bit} * 200,000,000\,\mathrm{m/s} \;/\; (10,000,000\,\mathrm{bit/s} * 2) \\ \text{length} &\leq 5120\,\mathrm{m} \end{aligned}$$

2. Standard states 2500m with 4 repeaters: The difference in length is due to (a) delay caused by repeaters, (b) shorter length to ensure collision detection is not marginal (safety margin).
3.

$$\begin{aligned} & \text{Minimum frame size} \\ = \; & 2 * \text{length} * \text{link data rate} \;/\; \text{transmission speed} \\ = \; & 2 * 1000\,\mathrm{m} * 10,000,000\,\mathrm{bit/s}/200,000,000\,\mathrm{m/s} \\ = \; & 100\,\mathrm{bits} \end{aligned}$$

However, frame overhead is: $(7 + 1 + 2 + 2 + 2 + 4) * 8 = 128\,\mathrm{bits}$
Reducing the length to 1km would eliminate the need for padding but it is not ideal.

Token vs. CSMA/CD

1. Why does token-passing make more efficient use of available bandwidth at high loads than CSMA/CD?
2. Why might CSMA/CD be preferable to token-passing on a network with low load?

1. With CSMA/CD, as the number of transmitting stations increases, collisions increase correspondingly, resulting in more retransmissions and relatively lower throughput. This does not happen with token passing, as the medium is only accessed at any moment by the current token holder. The medium is used up to near its maximum capacity.
2. With CSMA/CD there is minimum delay — if the medium is free, a station can transmit. With token-passing, a station must wait for the token to arrive, giving it permission to transmit for its allotted time.

Collisions: Detect or Avoid?

1. What is the difference between collision detection and avoidance?
2. What benefits does each offer?

1. Both back off but CD backs off after a collision and CA backs off before transmitting to minimise chance of collision.
2. Depends on the situation:
   - CD has less delay to send
   - CA more practical for wireless where collisions not detected
   - CA with tokens gives bounded access time to network
   - CD gives higher peak rate than tokens for bursty traffic