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1. (a) **How computers access the shared channels in CSMA/CD networks?**

- To send data, a station first listens to the channel to see if anyone else is transmitting.
- If so, the station waits until the end of the transmission (1-persistent) or waits a random period of time and repeats the algorithm (non-persistent). Otherwise, it transmits a frame.
- If a collision occurs, the station will detect the collision, abort its transmission, waits a random amount of time, and starts all over again.

Under what conditions a collision may occur?

Whenever more than one station detect an idle channel and their transmission times overlap.

How long it takes for a transmitting computer to be sure it has seized the channel without any collision?

Figure above shows an example of how two computers access the shared channel in CSMA/CD network. Suppose the competing computers A and B want to send frames to each other. At time 0, A finds the channel idle and sends out a frame. Suppose the propagation time from A to B is τ, at time $\tau - \varepsilon$, the frame almost arrives at B. At the same time, B sends out one frame. B detects the collision immediately at time $\tau - \varepsilon$. The frame from B arrives at A and A detects the collision at time 2τ. Therefore it takes 2τ time for a transmitting computer to be sure it has seized the channel without any collision.

(b) **Explain what is flow control and congestion control respectively.**

Flow control is the process of managing the rate of data transmission between two nodes in the network to prevent a fast sender from outrunning a slow receiver. It relates to the point-to-point traffic between a given sender and a given receiver.

Congestion control is concerned with controlling traffic entry into a network, to prevent or handle the congestion situations where too many packets are present in the subnet and performance degrades sharply. It is a global issue.

A situation where flow control is needed but congestion control is not:

A fiber optic network with a capacity of 1000G bps on which a supercomputer was trying to transfer a file to a personal computer at 1G bps.

A situation where congestion control is needed but flow control is not:

A store-and-forward network with 1M bps lines and 1000 larger computers, half of which were trying to transfer files at 100K bps to the other half.

2. (a) ① B delivers frames 0, 1, 2, 3, 4 to network layer.
② B saves frame 6 in the buffer.
③ B positively ackownledges A sequence number 4.
④ Sequence numbers 5, 6, 7, 0 are within the receiving window of B.

(b) **Under what circumstances will machine A receive a negative acknowledgement?**
A receives negative acknowledgements from B under 2 circumstances:
① a frame sent by A is lost and the frame received by B is not what B is expecting for. B will send a negative acknowledgement to A.
② a frame sent by A is damaged and there is checksum error. This event will trigger B to send a negative acknowledgement to A.

Under what conditions will machine A retransmit a frame?
A will retransmit the frame only if the sequence of the frame to be retransmitted is within A's sending window. (i.e. between(ack_expected, (r.ack + 1) % (MAX_SEQ + 1), next_frame_to_send) is true).

Explain why such condition is required using a concrete scenario.
Suppose initially B's receiving window is 0-3. A sends B frames 0-3 and B receives them. B will rotate the receiving window to 4-7 and sends A the acknowledgement (ACK) with sequence number 3. Suppose the ACK is lost and A's retransmission timer times out, A will retransmit frames 0-3. These frames are outside B's receiving window. Therefore B will reject these frames and send A back a negative acknowledgement (NAK) r with r.ack = 3.

Without such condition we mentioned, A will send frame 4 once it receives the NAK (since (r.ack + 1) % (MAX_SEQ + 1) equals to 4). However, A has never sent frame 4 before and A has not even received frame 4 from network layer. Hence, error will happen.
With such condition, A will check and find that frame 4 is not within the sending window and A will not send it.
Therefore, such condition is required.

3. The measured delays from C to B, D and E are 8, 6, and 10, respectively. Therefore,
Going to other routers via B gives the delays: (14, 8, 16, 20, 14, 10);
Going to other routers via D gives the delays: (18, 20, 12, 6, 15, 16);
Going to other routers via E gives the delays: (12, 16, 13, 19, 10, 14);

Compare the delays for each router, we have the new routing table for C:

Destination	Expected Delay	Outgoing Line
A	12	E
B	8	B
C	0	-
D	6	D
E	10	E
F	10	B

4. ① if round-trip time is 200ms, then in 1 second, 5 windows can be sent, which is equivalent to 5 * 65535 bytes/sec. Hence the line efficiency is:

$$\frac{5 * 65535\ bytes/sec}{1\ Gbps} * 100\% = 0.24\ \%$$

② if round-trip time is 500ms, then in 1 second, 2 windows can be sent, which is equivalent to 2 * 65535 bytes/sec. Hence the line efficiency is:

$$\frac{2 * 65535\ bytes/sec}{1\ Gbps} * 100\% = 0.10\ \%$$

5.

A	/^\d\d\d\d\d\d$/ equivalently, /^\d{6}$/, or /^[0-9]{6}$/
B	pos != 0
C	userPIN.focus()
D	checkConfirmPIN()
E	userPIN.value != userConfirmPIN.value
F	userConfirmPIN.focus()
G	document.getElementById("pin")
H	userPIN.value
I	method = "POST"
J	onblur = "checkPIN()"
K	onblur = "checkConfirmPIN()"
L	onclick = "encryptPIN()"

6.

A	"givenName"
B	"familyName"
C	"gender"
D	"pin"
E	$pin / 2
F	$index ++
G	19 - $index
H	$originalPIN = 0
I	19 - $index
J	$exp = $exp * 2
K	$originalPIN
L	"user_information.txt", 'w+'
M	$output

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