SOLUTIONS

EEE6432 Wireless Packet Data Networks and Protocols

1. **a.** i)

Three general properties define a circuit switched paradigm are: [3 Marks]

- Point-to-point communication
- Separate steps for circuit creation, use, and termination
- Performance equivalent to an isolated physical path

ii)

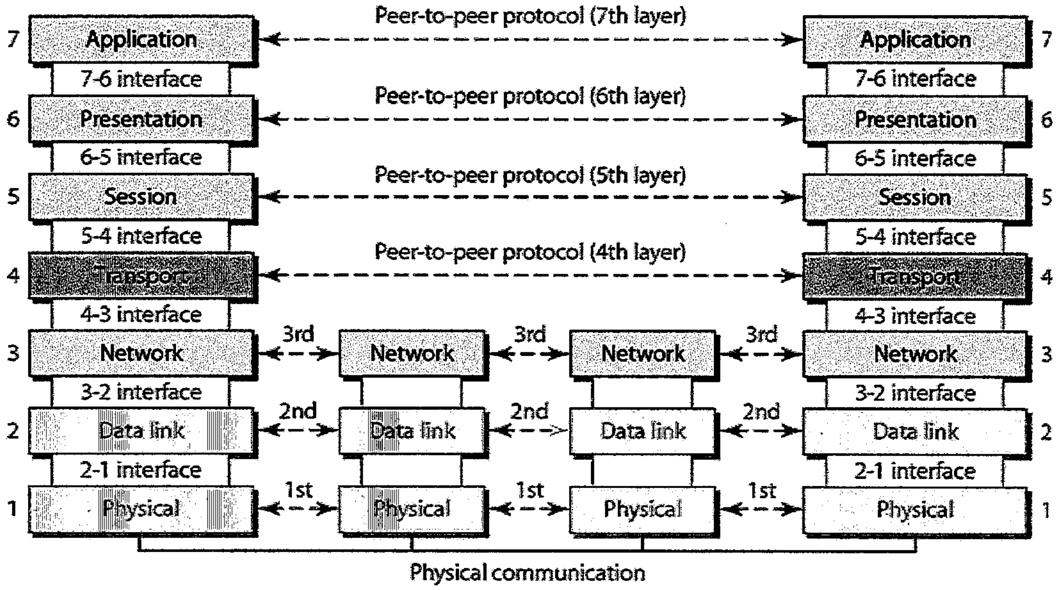
Three general properties define a packet switched paradigm are: [3 Marks]

- Arbitrary, asynchronous communication
- No set-up required before communication begins
- Performance varies due to statistical multiplexing among packets **(6)**

b. Statistical multiplexing is a type of communication link sharing. In statistical multiplexing, a communication channel is divided into an arbitrary number of variable bit-rate digital channels or data streams. The link sharing is adapted to the instantaneous traffic demands of the data streams that are transferred over each channel. [3 Marks]

When performed correctly, statistical multiplexing can provide a link utilization improvement, called the statistical multiplexing gain (SMG). SMG is an important performance metric that quantifies the multiplexing efficiency. The SMG may be calculated as the ratio of the number of VBR (Variable Bit Rate) sources that can be multiplexed on a fixed capacity link under a specified delay or loss constraint and the number of sources that can be supported on the basis of peak rate allocation. To determine and maximize the SMG, admission control rules are formulated that can relate traffic characteristics to performance constraints and system parameters. [3 Marks] **(6)**

c. **(8)**



1 mark to peer to peer protocol, 2 marks to the correct demonstration of the two intermediate nodes, 1 mark to the physical link, 2 marks to the correct layering of protocol stack, 2 marks to the correct names of protocol stacks (at least 4 are correct).

2. **a.** i)

For most applications, a system must guarantee that the data received are identical to the data transmitted or have tolerable errors. Any time data are transmitted from one node to the next, they can become corrupted in passage. Coding is a forward error detection/correction method that can be used to detect/correct errors and guarantee the reliability of data transmission. [2 Marks]

ii)

Any two points below worth 4 marks:

Convolution codes differ from block codes in that the encoder contains memory. For convolution codes, the encoder outputs at any given time unit depend not only on the inputs at that time unit but also on some number of previous inputs.

In block codes, the information bits are followed by the parity bits. In convolution codes the information bits are spread along the sequence. That means that the convolution codes map information to code bits not block wise, but sequentially convolve the sequence of information bits according to some rule.

Block codes have fixed length, convolution codes do not. **(6)**

b. The central concept in detecting or correcting errors is redundancy. To be able to detect or correct errors, we need to send some extra bits with our data. These redundant bits are added by the sender and removed by the receiver. Their presence allows the receiver to detect or correct corrupted bits. [3 Marks]

Redundancy is achieved through various coding schemes. The sender adds redundant bits through a process that creates a relationship between the redundant bits and the actual data bits. The receiver checks the relationships between the two sets of bits to detect or correct the errors. [3 Marks]

(6)

c. i)

Calculating the parity bits at the transmitter: [3 Marks] **(8)**

Modulo 2 arithmetic applied to r0, r1 and r2:

r0 = a2 + a1 + a0 (Modulo 2)

r1 = a3 + a2 + a1 (Modulo 2)

r2 = a1 + a0 + a3 (Modulo 2)

In other words, each of the parity-check bits handles 3 out of the 4 bits of the dataword.

The total number of 1s in each 4-bit combination (3 dataword bits and 1 parity bit) must be even.

Any three equations that involve 3 of the 4 bits in the dataword and create independent equations (a combination of two cannot create the third) are valid.

Calculating the parity bits at the receiver: [3 Marks]

The checker in the decoder creates a 3-bit syndrome (s2s1s0) in which each bit is the parity check for 4 out of the 7 bits in the received codeword:

s0 = b2 + b1 + b0 + q0 (Modulo 2)

s1 = b3 + b2 + b1 + q1 (Modulo 2)

s2 = b1 + b0 + b3 + q2 (Modulo 2)

The equations used by the checker are the same as those used by the generator with the parity-check bits added to the right-hand side of the equation. The 3-bit syndrome creates eight different bit patterns (000 to 111) that can represent eight different conditions. These conditions define a lack of error or an error in 1 of the 7 bits of the received codeword, as shown in the following table.

Syndrome	000	001	010	011	100	101	110	111
Error	None	q_0	q_1	b_2	q_2	b_0	b_3	b_1

ii)

The syndrome is 011. [1 Mark]

There is one bit error. After flipping b_2 (changing the 1 to 0), the final dataword is 0111. [1 Mark]

3. a. **Solution**

The bandwidth-delay product is

$1* (10^3)* 20*(10^{-3}) = 200{,}000$ bits [3 Marks]

The system can send 200,000 bits during the time it takes for the data to go from the sender to the receiver and then back again. However, the system sends only 1000 bits. We can say that the link utilization is only 1000/200,000, or 0.5 percent. For this reason, for a link with a high bandwidth or long delay, the use of Stop-and-Wait ARQ wastes the capacity of the link. [3 Marks]

(6)

b. **Solution:** [6 Marks]

We need to send 1000 frames (1,000,000/1000). We ignore the overhead due to the header and trailer.

(6)

Data frame Transmission time = 1000 bits / 1,000,000 bits = 1 ms

Data frame trip time = 5000 km / 200,000 km/s = 25 ms

ACK transmission time = 0 (It is usually negligible)

ACK trip time = 5000 km / 200,000 km/s = 25 ms

Delay for 1 frame = 1 + 25 + 25 = 51 ms.

Total delay = 1000 ×51 = 51 s

c. **Solution:** [8 Marks]

In the worst case, we send a full window of size 7 and then wait for the acknowledgment of the whole window. We need to send 1000/7 ≈143 windows. We ignore the overhead due to the header and trailer.

Transmission time for one window = 7000 bits / 1,000,000 bits = 7 ms

Data frame trip time = 5000 km / 200,000 km/s = 25 ms

ACK transmission time = 0 (It is usually negligible)

ACK trip time = 5000 km / 200,000 km/s = 25 ms

Delay for 1 window = 7 + 25 + 25 = 57 ms.

Total delay = 143 ×57 ms = 8.151 s

(8)

4. a. (6)

In random-access no station is superior to another station and none is assigned control over another. At each instance, a station that has data to send uses a procedure defined by the protocol to make a decision on whether or not to send. This decision depends on the state of the medium (idle or busy). [2 Marks]

In controlled access, the stations consult one another to find which station has the right to send. A station cannot send unless it has been authorized by other stations. [2 Marks]

Channelization is a multiple-access method in which the available bandwidth of a link is shared in time, frequency, or through code, among different stations. [2 Marks]

b.

1. It uses the combination of RTS and CTS frames to warn other stations that a new station will be using the channel. [2 Marks]
2. It uses NAV to prevent other stations to transmit. [2 Marks]
3. It uses acknowledgments to be sure the data has arrived and there is no need for resending the data. [2 Marks] (6)

c. (8)

Solution:

G is the average number of frames generated by the system during one frame transmission time.

i. For a pure Aloha network, the vulnerable time is ($2 \times T_{fr}$), which means that $\lambda = 2G$. $p[x] = (e^{-\lambda} * \lambda^{x})/(x!) = (e^{-2G} * (2G)^{x})/(x!)$ [4 Marks]

ii. For a slotted Aloha network, the vulnerable time is T_{fr}, which means that $\lambda = G$. $p[x] = (e^{-\lambda} * \lambda^{x})/(x!) = (e^{-G} * G^{x})/(x!)$ [4 Marks]