Homework

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1.

   a) **Transport Layer.**The transport layer provides process-to-process reliable and transparent data transmission services for the Session Layer and Network Layer.

   b) **Data Link Layer.**It provides media access and link management and is responsible for establishing and managing links between nodes.MAC specifically controls access to shared channels.

   c) **Data Link Layer.** On the basis of providing bit stream services at the physical layer, the bit information is encapsulated into a data frame to perform functions such as establishing, canceling, identifying logical links, link multiplexing, and error checking on the physical layer.

   d) **Network Layer.** The Network Layer uses routing algorithms to select the most appropriate path for messages or communication subnets.

2.

   a) ASK(Amplitude Shifted Keying)

   PSK(Phase Shifted Keying) {BPSK,QPSK,8PSK...}

   FSK(Frequency Shifted Keying)

   QAM(Quadratic Amplitude Modulation)

   b) Geostationary (GEO)

   Medium-Earth Orbit (MEO) [e.g.GPS]

   Low-Earth Orbit(LEO) [e.g. starlink]

   c) copper

   fiber optic cable {Multi-mode，Single-mode}

   twisted pair {Cat-3，Cat-5，Cat-5e，Cat-6，Cat-8}

   coaxial cable

   d) Space Division Multiplexing SDM

   Frequency Division Multiplexing FDMA

   Wavelength Division Multiplexing

   Time Division Multiplexing TDM,TDMA

   TIme and Frequency Division Multiplexing

   Code Division Multiplexing CDM,CDMA

3. The end-to-end delay in a packet switching system is not always smaller than in a circuit switching system. Here come the reasons.

   In a **circuit-switched network**, a dedicated communication path is established before the data transmission begins, and this path remains dedicated for the duration of the communication session. This results in reduced delay and latency, because the data packets arrive in the proper order with minimum packet loss. The communication is done with a steady bandwidth and consistent data rate. In a **packet-switched network**, there is no requirement to establish a dedicated channel. The data is broken down into smaller units called packets and transmitted over the network. These packets may take different paths to reach their destination, and they may be transmitted out of order. If there are many users using it at a certain time, congestion will increase its delay. This can result in higher latency than circuit switching because packets must be routed through multiple nodes, which can cause delay.

So, while packet switching can be more efficient in terms of bandwidth usage, it does not necessarily guarantee smaller end-to-end delay compared to circuit switching. The actual delay would depend on factors like network congestion, the number of nodes the packets have to pass through, and the specific protocols used for packet transmission and error correction.

4. a) users $= \dfrac{6\text{ Mbps}}{500\text{ kps}} = 12$

b) If there are total N persons, and M are active

$p(M=k) = C_N^k (0.3)^k (0.7)^{N-k}$

the probability that the link is overloaded is $p(M > 1)$

$p(M > 12) = 1 - p(M \le 12) = 1 - \underbrace{\sum_{k=0}^{12} C_{30}^k (0.3)^k (0.7)^{30-k}}$ calculated by coding is 0.9155

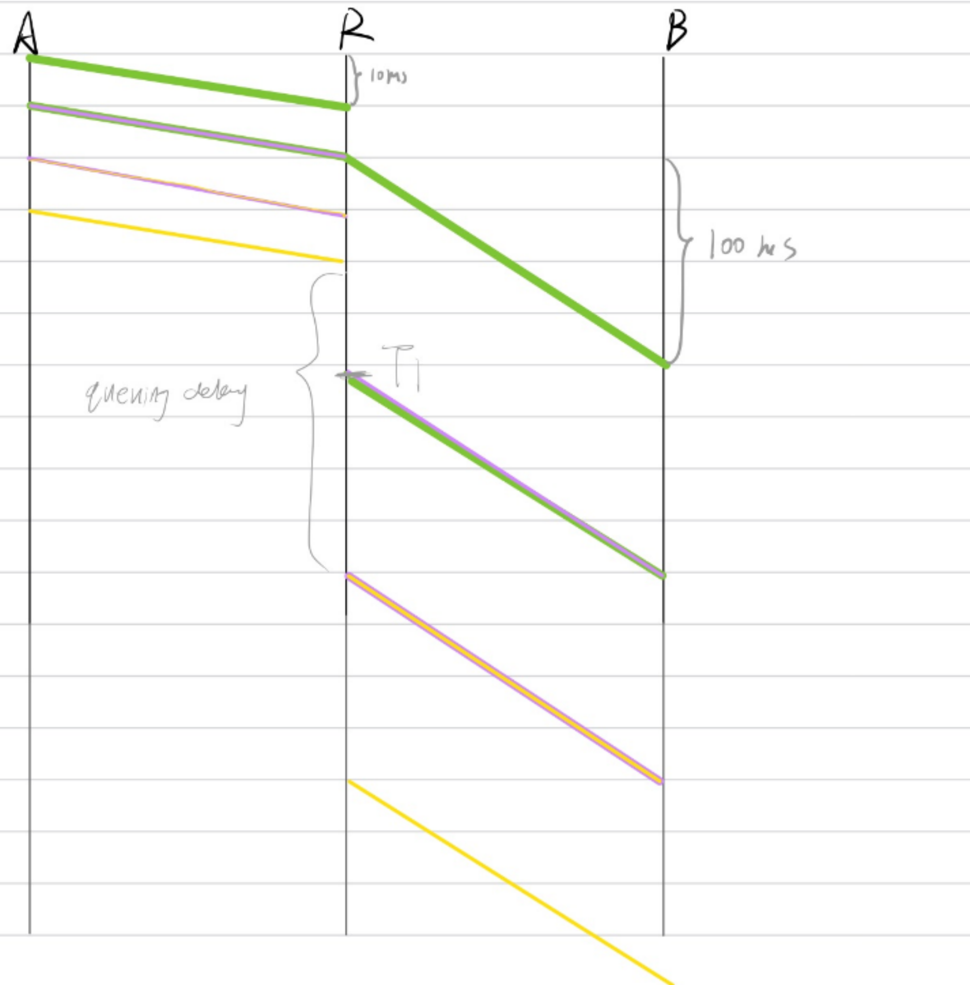
$= 0.0845$

c) $6 = 30 \log_2(1 + \frac{S}{N})$

$2^{0.2} = 1 + \frac{S}{N}$

$\frac{S}{N} = 0.15$

5.



Time when all the third packets arrive at R

$$\frac{50\,kb \times 3}{10\,Mbps} + 10 = 25\,ms$$

$$T_1 = \frac{50kb}{10Mbps} + 10 + \frac{50kb}{1Mbps} = 65\,ms$$

$$\therefore \text{queuing delay} = 65 - 25 + \frac{50kb}{1Mbps} = 90\,ms.$$

6. $m = 8$

$R_A = \langle S \cdot A \rangle = (1-1+3+1-1+3+1+1)/8 = 1$

$\Rightarrow$ A transmitted 1

$R_B = \langle S \cdot B \rangle = (1-1-3-1-3+1-1)/8 = -1$

$\Rightarrow$ B transmitted 0

$R_C = \langle S \cdot C \rangle = (1+1+3+1-1-3-1-1)/8 = 0$

$\Rightarrow$ C did not transmit

$R_D = \langle S \cdot D \rangle (1+1+3-1+1+3+1-1)/8 = 1$

$\Rightarrow$ D transmitted 1

7. Hamming distance : 4

detection capability = 3

correction capability = 1

1	0	0	1	1	1	1		
0	1	0	1	0	1	1		
1	0	0	0	0	0	0		
0	1	0	0	1	0	0		
1	0	0	1	1	0	1		
0	0	0	0	1	1	1		
1	1	1	1	1	0	0	X	
						X		

对于任意3个位置上的错误都可以检查出来

$\therefore$ Hamming distance $\geq 3+1=4$

但此情况无法纠错.

但对于这种情况的4个位置出错，并不能检查出来

1	0	0	1	1	1	1		
0	1	0	1	0	1	1	X	
1	0	0	0	0	0	0		
0	1	0	0	1	0	0		
1	0	0	1	1	0	1		
0	0	0	0	1	1	1		
1	1	1	1	1	0	0	X	

$\therefore$ Hamming distance $< 4+1=5$

$\therefore$ 其检错能力为3

$$
\begin{array}{cccccc|c}
1 & 0 & 0 & 1 & 1 & 1 & 1 \\
0 & 1 & 0 & 1 & 0 & 1 & 1 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 1 & 0 & 0 \\
1 & 0 & 0 & 1 & 1 & 0 & 1 \\
0 & 0 & 0 & 0 & 1 & 1 & 1 \\
\hline
1 & 1 & 1 & 1 & 1 & 0 & 0
\end{array}
$$

此情况证明了并不是任意2位错误都可以纠正

∴纠错能力<2

$$
\begin{array}{cccccc|c}
1 & 0 & 0 & 1 & 1 & 1 & 1 \\
0 & 1 & 0 & 1 & 0 & 1 & 1 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 1 & 0 & 0 \\
1 & 0 & 0 & 1 & 1 & 0 & 1 \\
0 & 0 & 0 & 0 & 1 & 1 & 1 \\
\hline
1 & 1 & 1 & 1 & 1 & 0 & 0
\end{array}
$$

对于任意一位错误，都会引发两个校验位（一个行一个列）的检错，∴一定会定位到具体出错位置

∴纠错能力为1

8. a) $r = \lceil \log_2 9 \rceil = 4$

4 check bits are needed

b) $2^0 = 1$ $2^1 = 2$ $2^2 = 4$ $2^3 = 8$

$\therefore$ check bits is on 1, 2, 4, 8

$3 = 2^0 + 2^1$ $5 = 2^2 + 2^0$ $6 = 2^2 + 2^1$ $7 = 2^2 + 2^1 + 2^0$

$9 = 2^3 + 2^0$ $10 = 2^3 + 2^1$ $11 = 2^3 + 2^1 + 2^0$ $12 = 2^3 + 2^2$

$13 = 2^3 + 2^2 + 2^0$

		1		0	0	1		0	1	0	1	1
1	2	3	4	5	6	7	8	9	10	11	12	13
X	X	D	X	D	D	D	X	D	D	D	D	D
X	-	D	-	D	-	D	-	D	-	D	-	D
-	X	D	-	-	D	D	-	-	D	D	-	-
-	-	-	X	D	D	D	-	-	-	-	D	D
-	-	-	-	-	-	-	X	D	D	D	D	D

$X_1 = D_3 \oplus D_5 \oplus D_7 \oplus D_9 \oplus D_{11} \oplus D_{13}$

$= 1 \oplus 0 \oplus 1 \oplus 0 \oplus 0 \oplus 1 = 1$

$X_2 = D_3 \oplus D_6 \oplus D_7 \oplus D_{10} \oplus D_{11}$

$= 1 \oplus 0 \oplus 1 \oplus 1 \oplus 0 = 1$

$X_4 = D_5 \oplus D_6 \oplus D_7 \oplus D_{12} \oplus D_{13}$

$= 0 \oplus 0 \oplus 1 \oplus 1 \oplus 1 = 1$

$X_8 = D_9 \oplus D_{10} \oplus D_{11} \oplus D_{12} \oplus D_{13}$

$= 0 \oplus 1 \oplus 0 \oplus 1 \oplus 1 = 1$

$\therefore$ Hamming codeword = 1111001101011

9.a) $r=3 \quad K=11$

$$M(X) = X^{10} + X^{7} + X^{6} + X^{3} + X^{2} + 1$$

$$r(X) = \text{Remainder}\left[\frac{M(X)\cdot X^{r}}{G(X)}\right]$$

$$
\begin{array}{r|l}
 & x^{10} + x^{4} + x^{3} + x^{2} + x \\
\hline
x^{3}+1 & x^{13} + x^{10} + x^{7} + x^{6} + x^{5} + x^{3} \\
 & x^{13} + x^{10} \\
\cline{2-2}
 & x^{7} + x^{6} + x^{5} + x^{3} \\
 & x^{7} + x^{4} \\
\cline{2-2}
 & x^{6} + x^{5} + x^{4} + x^{3} \\
 & x^{6} + x^{3} \\
\cline{2-2}
 & x^{5} + x^{4} \\
 & x^{5} + x^{2} \\
\cline{2-2}
 & x^{4} + x^{2} \\
 & x^{4} + x \\
\cline{2-2}
 & x^{2} + x
\end{array}
$$

$$r(x) = x^{2} + x$$

$$\therefore T(X) = x^{13} + x^{10} + x^{7} + x^{6} + x^{5} + x^{3} + x^{2} + x$$

b) ∵ the received $r(x) = x^{12}+x^{11}+x^{10}+x^{7}+x^{6}+x^{5}+x^{3}+x^{2}+x$

$$
\begin{array}{r}
x^{9}+x^{8}+x^{7}+x^{6}+x^{5}+1 \\
x^{3}+1 \enclose{longdiv}{x^{12}+x^{11}+x^{10}+x^{7}+x^{6}+x^{5}+x^{3}+x^{2}+x} \\
\underline{x^{12}+x^{9}} \\
x^{11}+x^{10}+x^{9}+x^{7}+x^{6}+x^{5}+x^{3}+x^{2}+x \\
\underline{x^{11}+x^{8}} \\
x^{10}+x^{9}+x^{8}+x^{7}+x^{6}+x^{5}+x^{3}+x^{2}+x \\
\underline{x^{10}+x^{7}} \\
x^{9}+x^{8}+x^{6}+x^{5}+x^{3}+x^{2}+x \\
\underline{x^{9}+x^{6}} \\
x^{8}+x^{5}+x^{3}+x^{2}+x \\
\underline{x^{8}+x^{5}} \\
x^{3}+x^{2}+x \\
\underline{x^{3}+1} \\
x^{2}+x+1
\end{array}
$$

the remainder $\neq 0$

∴ the errors can be detected.