浙江大学《计算机网络》课程课后作业三

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1. 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 when each of the following framing methods is used:
(a) Byte count.
(b) Flag bytes with byte stuffing.
(c) Starting and ending flag bytes with bit stuffing.

Answer:
(a) 00000101 01000111 11100011 11100000 01111110
(b) 01111110 01000111 11100011 11100000 11100000 11100000 01111110 01111110
(c) 01111110 01000111 110100011 111000000 011111010 01111110

2. Hamming code is an effective way for error correcting. Show that the # of check bits(i.e. r) in the Hamming codes described in the textbook(e.g., Fig.3-6) (almost) achieves the low bound of Eq (3-1).

Answer:
等价于证明，对于任意$0 < r < 4$，不等式$(m + r + 1) \leq 2^r$恒不成立，而对于任意$r \geq 4$等式恒成立。由枚举得，当$r = 1, r = 2, r = 3$时，分别有$9 \leq 2, 10 \leq 4, 11 \leq 8$，即三个不等式均不成立，而当$r \geq 4$时，要证明$(8 + r) \leq 2^r$，即证$f(r) = 2^r - r \geq 8$，求导得：

$$df(r)/dr = ln2 * 2^r - 1 \geq 16ln2 - 1 > 0$$

因此$f(r)$在$r \geq 4$时为单调递增函数，故$f(r) \geq 16 - 4 = 12 \geq 8$成立，因此$r = 4$是该不等式的下界，所以最少需要 4 位校验码。

3. Suppose you have the following 12-bit message: 010100111111
(a) Numbering bits from right to left (ie least-significant bit on the right), insert check bits according to to Hamming's 1-bit error correction system. Indicate which bits are check bits and which are message bits.
(b) Hamming's scheme only corrects 1-bit errors. Since it' s a distance 3 code, it could also be used to detect 2-bit errors. Describe a 3-bit error (3 *1-bit errors) in the above codeword affecting only message bits (not check bits) that would be undetected (and of course uncorrected). Be sure to describe how and why the algorithm fails.

Answer:
(a) 由$(m + r + 1) \leq 2^r$得，$r \geq 5$，因此需要 5 位校验码，该编码为(17,5)海明码，初始状态如下图所示：

No.	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
val	0	P5	1	0	1	0	0	1	1	P4	1	1	1	P3	1	P2	P1

现计算各个校验码：
由于 $(P1 + D3 + D5 + D7 + D9 + D11 + D13 + D15 + D17)\ mod\ 2 = 0$ 得 D1 = 0
同理得到以下结果：

位数 D					
3	0	0	0	1	1
5	0	0	1	0	1
6	0	0	1	1	0
7	0	0	1	1	1
9	0	1	0	0	1
10	0	1	0	1	0
13	0	1	1	0	1
15	0	1	1	1	1
异或值	0	0	1	1	0

因此编码结果为：

No.	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
val	0	0	1	0	1	0	0	1	1	0	1	1	1	1	1	1	0

(b) 将 D7，D10， D13 反转，使其均变为 0，因为：(D7 xor D10 xor D13) = 0，所以不影响其结果，因此该错误不会被检测到。

7	0	0	1	1	1
10	0	1	0	1	0
13	0	1	1	0	1

4.Consider an original frame 110111011011. The generator polynomial x^4+x+1, show the converted frame after appending the CRC.

Answer:
1101110110110000 *mod* 10011 = 0101
因此 CRC 的计算结果为 1101110110110000 + 0101 = 1101110110110101

5.A 3000-km-long T1 trunk (with data rate 1.536Mbps) is used to transmit 64-byte frames. How many bits should the sequence numbers be for protocol 5 and protocol 6 respectively? The propagation speed is 6usec/km.

Answer:
线路传输耗时 3000km*(6usec/km)=18000usec=18ms，准备传输或接收 64Byte 的帧需要耗时 64*8/1536=0.33ms，为了使得传输效率最大，窗口的大小应该足够大使得能够接收到第一次返回的帧，从发送第一帧到接收到第一帧的总时间为: 18ms*2+0.33ms=36.33ms，所以缓冲区中应该能够容纳 36.33ms 所发送的帧的数量，即 36.33/0.33=110 帧，即 w=110
(a)对于 Protocol5 而言，因此需要$\lceil \log_2 110 \rceil = 7$bits
(b)对于 Protocol6 而言，(MAXSEQ+1)/2=110，需要$\lceil \log_2 220 \rceil = 8$bits

6.Frames of 1000 bits are sent over a 1-Mbps channel using a geostationary satellite whose propagation time from the earth is 270 msec. Acknowledgements are always piggybacked onto data frames. The headers are very short. Three-bit sequence numbers are used. What is the maximum achievable channel utilization for

(a) Stop-and-wait?

(b) Protocol 5?

(c) Protocol 6?

Answer:

在 t=0 时, 开始发送请求, t=1ms 时, 第一帧被发送, t=271ms 时, 第一帧被接收到, t=272ms 时，确认帧被发出，t=542ms 时，确认帧被收到。因此发送的周期 542ms

(a)stop-and-wait 协议的窗口大小 k=1，因此 e=1/542=0.18%

(b)Protocol5 的协议窗口大小 k=2^3-1=7，因此 e=7/542=1.29%

(c) Protocol6 的协议窗口大小 k=(7+1)/2=4，因此 e=4/542=0.74%

7. Compute the fraction of the useful data bandwidth for protocol 6 on a heavily loaded 50-kbps satellite channel with data frames consisting of 40 header and 3960 data bits. Assume that the signal propagation time from the earth to the satellite is 270 msec. ACK frames never occur. NAK frames are 40 bits. The error rate for data frames is 1%, and the error rate for NAK frames is negligible. The sequence numbers are 3 bits.

Answer:

由 SequenceNumber=3 知，滑动窗口的大小 w=(2^3)/2=4

数据帧的大小为 3960+40=4000bits，需要 4000/50000=80ms

NAK 帧的大小为 40bits，需要 40/50000=0.8ms

故链路的利用率 utilization=(4*80)/(270*2+80+0.8)=51.5%

在每 1 帧中，需要浪费 40bits 的头部，如果出现差错，还需要带上 40bits 的 NAK，即由于差错导致的浪费需要耗费(40+4000)*0.01=40.4bits，因此总的浪费为 80.4bits，故对于每一帧而言的利用率为 1-80.4/(3960+80.4)=98%

总的链路利用率为 51.5%*98%=50.47%