# 3170103240-张佳瑶-作业三

# 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.

(a)

0000101 01000111 11100011 11100000 01111110

(b)

FLAG A B ESC ESC ESC FLAG FLAG

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).

r位校验位的Hamming code，可以检测1+2+4+...+$2^{r-1}$ = $2^r$-1位上的单个错误。

公式3-1为(m+r+1)<=$2^r$

需要校验的信息位数为m = $2^r$-1。

Hamming code的信息位数加上校验位数为$2^r$-1 +r +1 = $2^r$。

因此图3-6的Hamming code达到了公式3-1的下界。

# 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.

(a)

根据第二题，r位校验码可以校验$2^r$位上的单个错误。因此需要检测12位信息上的单位错误，且$2^5$=16，需要插入5位校验码。

粗体为校验码。

| bit | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| value | 0 | **0** | 1 | 0 | 1 | 0 | 0 | 1 | 1 | **0** | 1 | 1 | 1 | **1** | 1 | **1** | **0** |

bit 15: 01111

Bit 13: 01101

bit 10: 01010

Bit 9: 01001

bit 7: 00111

bit 6: 00110

Bit 5: 00101

Bit 3: 00011

check bit: 00110

(b)

由于海明距离为3，当发生3个1位错误的时候，错误的位置可能会刚好将一个有效码字改为另一个有效码字，所以不能用来检测3个1位错误。例如，当反转3，5，6位时，在校验码异或本身后都体现为0，无法被检测出来。

# 4

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

G(x) = 10011

M(x) = 1101110110110000

计算M(x)对G(x)的模2除法，得到余数为0101。

M(x) / G(x) = 110010000011...0101

CRC: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.

$T_{prop}$=6 * 3000 = 18000 usec = 18 msec

$T_{frame}$=64*8/1.536 = 0.3 msec

$T_{total}$=0.3+18+18 = 36.3msec

36.3/0.3 = 121 frames

2^7 = 128>121

(2^8+1)/2 = 257/2 >121

For protocal 5, 7-bit sequence number are needed.

For protocol 6, 8-bit sequence number are needed.

# 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?

Data rate = 1Mbps

$T_{prop}$ = 270msec

$T_{frame}$=1000/1 = 1msec

$T_{total}$ = 270*2+1 +1= 542msec

(a) utilization = 1/542 = 0.18%

(b)

使用三位序列号，一次可以传输$2^3$-1=7个帧

utilization = 7/542 = 1.29%

(c)

使用三位序列号，一次可以传输(7+1)/2=4个帧

utilization = 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.

Because the sequence numbers are 3 bit, so the window size is 4。

data rate = 50kbps

$T_{prop}$ = 270msec

$T_{frame}$=（3960+40）/ 50 = 80msec

$T_{NAK}$ = 40/50 = 0.8msec

the untilization is 4 * 80/(270 * 2+80+0.8) = 51.5%.

because the error rate for data frames is 1%, a 40bit NAK per 100 frames are needed. When error occurs, 40 header bits waste. 1% * 4000 = 40bits needed. The total is 40+40+0.4 = 80.4bits.

80.4/(3690+80.4) = 1.99%

so the fraction of the useful data bandwidth is 51.5% * (1-1.99%) = 50.5%.