Computer Networks

Tutorial 3:

Frame Synchronisation, Error Rate, CRC

Scope of This Tutorial

- Frame synchronisation – byte and bit injection mechanisms
- Error rate estimation examples
- CRC calculations

Frame synchronisation

Byte injection mechanisms

We define two special values

- SOH – start of header
- ESC – escape me & transform the next character

Bit injection mechanism

- On the transmitter side

  After each 5 consecutive ‘1’ insert ‘0’

- On the receiver side

  Remove each zero after each 5 consecutive ‘1’

Thus the data bit stream do not contain more than 5 consecutive ‘1’

- Bit patterns:
  - 01111110
  - 01111111
  - 11111110
  - 11111111

    can be used for communication management

Exercise 1

A.

Assume:

- SOH = 01_H, ESC = $1B_H$,
- transformation after ESC is to inverse the most significant bit of the next byte

The data stream is: 55, 00, 01, AA, FF, 1B, CC

What is the transmitted byte stream?

Solution:

B.

Assume:

- SOH = $F5_H$, ESC = $F3_H$,
- transformation after ESC is to inverse all bits of the next byte

The data stream is: 55, 00, F5, F3, FF, 1B, F3, 00

What is the transmitted byte stream?

Solution:

Exercise 2

A bit stream is transmitted using bit injection mechanism

A. Transform the following data bit stream to the transmitted one
   01011110011111001111100

B. Transform the following received bit stream to the original data bit stream.
   01111011111001111101000111110

Error Rate

When an error does occur then the entire packet containing it is lost
For relatively high error rates
is better to send smaller packets

Assume that 1 bit in 10,000 is corrupted

⇒ probability that a single bit is transmitted correctly is 0.9999

⇒ probability that every bit in a 1000-bit packet is transmitted correctly is $(0.9999)^{1000} \simeq 90.5\%$

10,000-bit	$(0.9999)^{10,000} \simeq 37\%$
20,000-bit	below 14%

Assume there is 1,000,000 bits to send

a. 1,000 of 1,000-bit packets
   Success rate is 90% ⇒ 10% packets should be retransmitted, i.e. 100 packets
   Retransmissions can also be lost ⇒ to be sent:
   - 1,000/90% ≃ 1,111 packets
   - 1,111,000 bits

b. 50 of 20,000-bit packets
   Success rate is very poor; each packet needs to be sent on average seven times
   - 7×50 = 350 packets
   - 7,000,000 bits

CRC Calculations

See: http://www.ee.unb.ca/cgi-bin/tervo/calc.pl

frame s(x) = w(x).FCS – *Frame Check Sequence*

FCS = reminder of polynomials division $2^G * w(x) : g(X)$

s(x) = $2^G * w(x) : g(X) + r(x)$

CRC code

e.g.. G=3 w(x)= 0111

$2^3 * w(x)$ $g(X)$

0111000 : 1011 = 0110 ← '0' if shift, '1' if subtraction modulo-2

1011

1010 ← exor

1011

0010 ← exor

010 = **r(x)** => **s(x)** = 0111 010

CRC

Exercise 3

Suppose a message is 110010101. Calculate the CRC-3 checksum using the polynomial $x^3 + 1$, that is, find the 3-bit remainder using divisor 1001.

Exercise 4

Suppose a message is 1001 1011 1100. Calculate the CRC-3 checksum using the polynomial $x^3 + x + 1$, that is, find the 3-bit remainder using divisor 1011.