Övning 2
EITF25 & EITF45 - 2017
Feldektering, felhantering och flödeskontroll

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Uppgift 1.
Antag att en dataöverföring får en kraftig störning under två millisekunder. Hur många bitar kan ha blivit fel på grund av störningen om bithastigheten är:

1.1 10 kbps?

1.2 100 kbps?

1.3 1 Mbps?

Solution 1.
If a transmission is subject to period of severe interference, the bits during that time might have been corrupted. For example: a 1 Mbps transmission is subject to a period of 1 milliseconds of interference. A 1 Mbps transmission produces bits at a rate of 10^6 bit per second or $\frac{10^6}{10^3}$ bits per millisecond. As such, during a period of 1 milliseconds 1000 bits might have been corrupted.

1.1 Following the reasoning in the example above: $10 \cdot \frac{10^3}{10^3} = 10$ bits per millisecond, during 2 milliseconds $10 \cdot 2 = 20$ bits.

Answer: 20 bits

1.2 Following the reasoning in the example above: $100 \cdot \frac{10^3}{10^3} \cdot 2 = 200$ bits.

Answer: 200 bits

1.3 Following the reasoning in the example above: $\frac{10^6}{10^3} \cdot 2 = 2000$ bits.

Answer: 2000 bits

Uppgift 2.
Antag att jämn paritet används vid dataöverföring på en länk. Vad blir värdet på paritetsbiten i följande fall?

2.1 1001001

2.2 1100111

2.3 1001011

2.4 1110111

Solution 2.
Adding a parity bit to a sequence is the simplest for of error detection. You compute the even parity bit by doing a bit-wise sum of the sequence. Which will give you a one if there is an odd number of ones in a sequence or zero if there is a even number of ones in the sequence.

2.1 Following the reasoning in the explanation above.

Answer: 1

2.2 Following the reasoning in the explanation above.

Answer: 1

2.3 Following the reasoning in the explanation above.

Answer: 0

2.4 Following the reasoning in the explanation above.

Answer: 0

Uppgift 3.
Bestäm CRC för följande meddelanden om generatorpolynomet är $C(x) = x^3 + x^2 + 1$. Kontrollera din lösning också!

3.1 00111010

3.2 1010011110

3.3 111000111

3.4 1100110011

Solution 3.
In this set of problems we are asked to compute the CRC bit sequence $R(x)$ for the specified outbound bit sequences $M(x)$ to produce the $F(x)$ sent sequence, on the sender side. See the equation below.

$$F(x) = \underbrace{M(x) \cdot x^k}_{B(x)} + R(x)$$

Moreover, k is the degree of the CRC generator polynomial. You may have noticed that the bit sequences are represented as a function of x. You can express a bit sequence $M(x)$ as a polynomial by, from right to left, multiplying the n^{th} bit with the n^{th} polynomial term, as exampled below.

$$011001 \rightarrow 0 \cdot x^5 + 1 \cdot x^4 + 1 \cdot x^3 + 0 \cdot x^2 + 0 \cdot x^1 + 1 \cdot x^0 \rightarrow x^4 + x^3 + 1$$

Multiplying the resulting polynomial $M(x)$ with x^k yields the term $B(x)$. This done to shift the sequence enough to give space to the k CRC bits. Dividing the polynomials $\frac{B(x)}{C(x)}$ in modulo-2 yields a reminder that when appended to the target bit sequence polynomial $B(x)$ yields the polynomial $P(x)$ that is evenly divisible with the generator polynomial $C(x)$. The final polynomial $P(x)$ is then expressed as a sequence of bits and transmitted.

3.1 $C(x) = x^3 + x^2 + 1 \rightarrow k = 3$
$M(x) = x^5 + x^4 + x^3 + x$
$B(x) = x^8 + x^7 + x^6 + x^4$
$R(x) = x$

Answer: 010

3.2 $C(x) = x^3 + x^2 + 1 \rightarrow k = 3$
$M(x) = x^9 + x^7 + x^4 + x^3 + x^2 + x$
$B(x) = x^{12} + x^{10} + x^7 + x^6 + x^5 + x^4$
$R(x) = x^2 + 1$

Answer: 101

3.3 $C(x) = x^3 + x^2 + 1 \rightarrow k = 3$
$M(x) = x^8 + x^7 + x^6 + x^2 + x + 1$
$B(x) = x^{11} + x^{10} + x^9 + x^5 + x^4 + x^3$
$R(x) = x^2 + x + 1$

Answer: 111

3.4 $C(x) = x^3 + x^2 + 1 \rightarrow k = 3$
$M(x) = x^9 + x^8 + x^5 + x^4 + x + 1$
$B(x) = x^{12} + x^{11} + x^8 + x^7 + x^4 + x^3$
$R(x) = x^2 + 1$

Answer: 101

Uppgift 4.
Antag att en 4-bitars CRC med generatorpolynom $C(x) = x^4 + x^3 + 1$ har använts. Vilka av följande tre bitströmmar blir godkända av mottagaren?

4.1 11010111

4.2 10101101101

4.3 10001110111

Solution 4.

On the receiver side, if no errors have been injected into the inbound bit sequence $P(x)$, it should be evenly (modulo-2) divisible with the CRC generator polynomial $C(x)$, i.e. no reminder, $E(x) = 0$. If no remainder is produced, removing the appended CRC bit sequence of length k from inbound sequence yields the original sequence.

4.1 $C(x) = x^4 + x^3 + 1 \rightarrow k = 4$
$P(x) = x^7 + x^6 + x^4 + x^2 + x + 1$
$E(x) = x^2 + x$

Answer: NOK

4.2 $C(x) = x^4 + x^3 + 1 \rightarrow k = 4$
$P(x) = x^{10} + x^8 + x^6 + x^5 + x^3 + x^2 + 1$
$E(x) = x^3 + x^2 + 1$

Answer: NOK

4.3 $C(x) = x^4 + x^3 + 1 \rightarrow k = 4$
$P(x) = x^{10} + x^6 + x^5 + x^4 + x^2 + x + 1$
$E(x) = 0$

Answer: OK

Uppgift 5.

Bestäm en 8-bitars kontrollsumma (checksum) för följande bitsekvenser:

5.1 10010011 10010011

5.2 00011001 01010011

5.3 11000111 00001101

Solution 5.

The checksum in produced by performing a bitwise addition of the two halves of the sequence from right to left, and where the remainder is carried to the next digit. The inverse of the resulting bit sequence is then appended to the original sequence and transmitted. In other words, an n-bit checksum is the inverse of the bit-wise sum of size n data bit-sequences.

5.1 Following the reasoning in the explanation above.

Answer: 11011000

5.2 Following the reasoning in the explanation above.

Answer: 10010011

5.3 Following the reasoning in the explanation above.

Answer: 00101011

Uppgift 6.

Antag att en mottagare tar emot följande bitsekvenser och att en 8-bitars kontrollsumma används. Är sekvenserna korrekta? Motivera ditt svar med korrekta beräkningar.

6.1 10010011 10011011 11011001

6.2 00110011 10110111 00010101

6.3 01110000 00111000 01010111

Solution 6.

On the receiver side, the inbound sequence is bit-wise summed as sections of size n. The inverted result is compared to the checksum sequence, if they match the sequence is accepted, if not errors have most likely been introduced during transmission.

6.1 Sum: 1101000Ø

Answer: NOK

6.2 Sum: 00010101

Answer: OK

6.3 Sum: 01010111

Answer: OK

Uppgift 7.

Hur ser följande bitsekvenser ut, tagna slumpmässigt ur en länk på vilken HDLC-protokollet används, efter att eventuella bitstuffade nollor tagits bort?

7.1 0101011111010111011111100 ...

7.2 010101111110101110111110 ...

Solution 7.

The avoid wrongful detection of the HDLC (High-Level Data Link Control) frame delimiter, represented by the bit-sequence: 01111110. Therefore, on the transmitter side, zeros have been added after each consecutive five ones. As such, the bit-stuffed bits carry no information that is relevant to the sender/receiver applications and are thus removed on the receiver end.

$$000111110111110111001011 0 \rightarrow 00011111Ø11111Ø1110010110$$

HDLC deploys NRZ, and uses the frame delimiter to synchronize the signal.

7.1 0101011111Ø10111011111Ø0 ...

When bit stuffed zeros are removed:

Answer: ...0101011111101110111110 ...

7.2 0101<u>01111110</u>10111011111Ø ...

Note that this sequence contains an actual frame delimiter, underlined. When bit stuffed zeros are removed:

Answer: ...0101011111101011101111 1 ...

Uppgift 8.
Bitstuffa följande bitsekvenser (inga flaggor forekommer):

8.1 0001111110111110011111001

8.2 000111111111111111111111111111110011111001

Solution 8.
The frame delimiter in HDLC (High-Level Data Link Control) is 01111110. To avoid any wrongful detection on the receiver side, any occurrence of a sequence of ones of length six or greater is stuffed with a zero after each consecutive five ones. For example, at the transmitter side:
00011111110011111110010110 → 00011111011001111101110010110

As seen in the previous question 7, the bit-stuffed zeros are removed on the receiver side.

8.1 0001111110111110011111001 → 0001111101011111000111110001

Which yields:

Answer: 0001111101011111000111110001

8.2 000111111111111111111111111111110011111001 →
000111110111110111110111110111110111100111110001

Which yields:

Answer: 000111110111110111110111110111110111100111110001

Uppgift 9.
Antag att dator A skickar ramar till dator B och använder sekvensnummer som är kodade med 3 bitar. En go-back-n-ARQ används med ett sändfönster som har storleken 4. Visa hur sändfönstret ser ut i följande fall:

9.1 **Innan** A har skickat några ramar.

9.2 **Efter** det att A sänt ramarna 0,1 och 2; B har skickat ACK på 0 och 1; och dessa ACK har tagits emot av A.

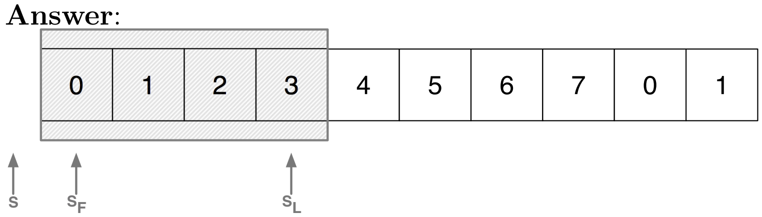
9.3 **Efter** det att A har skickat 3,4,5 och 6; B har skickat ACK på 4; och detta ACK har tagits emot av A.

Solution 9.

Since the sequence number is represented with 3 bits, it can represent 8 frames. The S marker marks the last transmitted frame, S_F, where the window starts i.e. one frame after the last consecutively acknowledge frame. Moreover, thus S_L marks the end of the window.

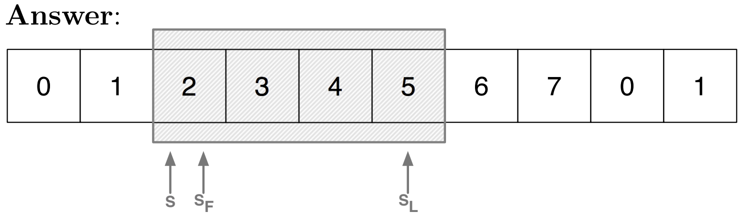
9.1 Before anything has been sent, the windows will envelope the first 4 frames.

Answer:



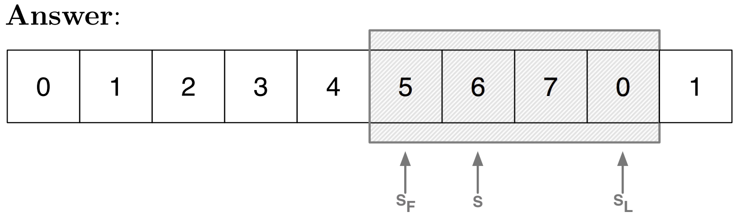
9.2 ACKs have been received for frames 0 and 1, hence the S_F marker will be at frame 2, the earliest unacknowledged frame.

Answer:



9.3 The P marker till point to packet 6, as it is the highest sent frame. Nevertheless, only frame 4 has been acknowledged, as such S_F will not de mark the beginning of the open window at frame 5.

Answer:



Uppgift 10.

Dator A använder stop-and-wait-ARQ för att skicka ramar till dator B. Antag att avståndet mellan A och B är 4 000 km. Svara på följande frågor:

10.1 Hur lång tid tar det innan A kan få ett ACK på ramen? Använd ljushastigheten som utbredningshastighet samt antag att det inte tar någon tid från dess att B får ramen till dess att ett ACK skickas.

10.2 Hur lång tid tar det för A att skicka iväg en ram på 1000 byte om transmissionshastigheten är 100 000 kbps?

10.3 Använd svaren i 10.1 och 10.2 och beräkna hur stor andel av tiden som A är ledig, det vill säga inte gör något.

Solution 10.

10.1 The speed of light in vacuum is $c = 299792458$ m/s. Sending a packet in one direction thus takes $\frac{4000000\text{m}}{c} = 0.01334$ seconds $= 13.34$ milliseconds. Assuming that the process time is 0 seconds, the total time will henceforth be packet round trip of $2 \cdot 13.34 = 26.68$ milliseconds.

Answer: 26.68 milliseconds

10.2 As one byte contains 8 bits, 1000 bytes equates to 8000 bits. Transmission time is thus: $\frac{8 \cdot 10^3 \text{bits}}{100 \cdot 10^6 \text{bps}} = 0.08$ milliseconds $= 80$ microseconds. Note that bytes are mainly used when referring to data storage as one byte is historically the size of an ASCII symbol, and thus the smallest addressable space in a computers memory.

Answer: 0.08 milliseconds

10.3 Out of the total transmission (0.08 ms) and propagation (26.68 ms) time the sender is only occupied while transmitting. Hence, for the event the that sender sends multiple consecutive frames it is vacant $\frac{26.68}{26.68+0.08} = 99,7\%$ of the time.

Answer: 99.7 %