Electrical Engineering, IIT Delhi
Computer communications networks (ELL785)
Midterm Examination I

Duration: 1 hour

August 30, 2016
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Name [redacted] Entry number [redacted]

- This examination consists of **four(4)** problems. Please check that you have a complete copy of **four(4)** pages.
- Maximum attainable mark is 80.
- Justify your answers clearly.

1	2	3	4	sum
4	19	15	3	41

1. [11] A receiver receives the following sequence of bits:

0 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 1 0 1 1 0 0 1 1 0 0 1 1 1 1 1 0 1 0 1 1 1 1 1 1 0

It turns out that the transmitter uses a bit stuffing, '0 1 1 1 1 1 1 0' and encodes a message with a linear block code with the following generator matrix $G = [1\,1\,1\,1\,1\,1]$.

(a) [4] What is the transmitted message?

(b) [4] If the transmitter always transmits a 5-bit message, where 0 and 1 appear equally, how many bits ('0') are inserted on average?

(c) [3] Show whether or not this linear block code is a perfect code.

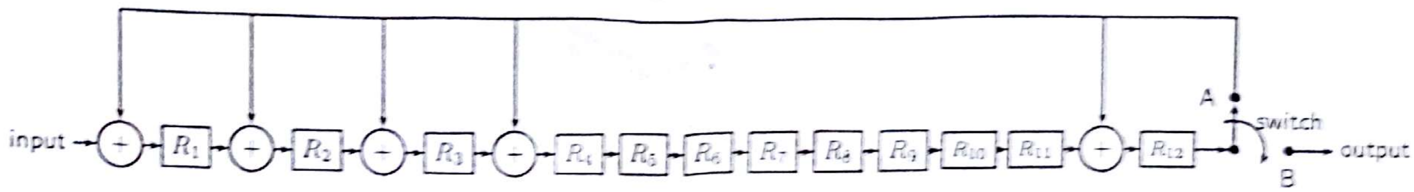
(a) Dimension of Generator matrix = 1×6 Hence code is of form

Encoded message = 11111 1, 1111 1, 110011 00 1111 11

11 11 11 11 11 11 00 11 00 11 11 11

transmitted msg = 1 1 0 1

2. [24] Consider the shift register circuit for CRC generation shown below.



(a) [4] What is the generator polynomial?

(b) [5] Will this CRC guarantee to detect the error represented by polynomial $x^{36} + x^5 + 1$? Justify your answer.

(c) [5] Will it detect the error represented by polynomial $x^{17} + x^5$? Justify your answer.

(d) [5] Will this CRC guarantee to detect the burst error of the following pattern.

. . . 0 0 1 x x x x x x x x x x x 1 0 0 . . .

Here 'x' is either '0' or '1'. Justify your answer.

(e) [5] A burst error of length k occurs with probability $p^k(1-p)$ for $k = 0, 1, \cdots$. What is the detecting probability of this code for such a burst error on average (only in terms of p)?

(a) $g_0 = 1$, $g_1 = 1$, $g_2 = 1$, $g_3 = 1$, $g_{11} = 1$, $g_{12} = 1$

$$g(x) = x^{12} + x^{11} + x^3 + x^2 + x + 1$$

(b) $E(x) = x^{36} + x^5 + 1$

$G(x) = x^{12} + x^{11} + x^3 + x^2 + x + 1 = x^{11}(x+1) + x^2(x+1) + (x+1)$
$= (x^{11} + x^2 + 1)(x+1)$

$x^{24} + x^{23}$

$G(x) \,)\, x^{36} + x^5 + 1$

$x^{36} + x^{35} + x^{27} + x^{26} + x^{25} + x^{24}$

$x^{35} + x^{27} + x^{26} + x^{25} + x^{24} + x^5 + 1$

x^{35}

We know odd bit errors are detected if $G(x)$ has a factor $(1+x)$. $E(x)$ has 3 bit errors, and $G(x)$ has $(x+1)$ as factor. Hence, it can be detected.

(c) $E(x) = x^{17} + x^5$

Double bit error.

$E(x) = x^{19} + x^5 = x^5(1 + x^{12}) = x^5 E_{12}(x)$ $E_{12}(x) = 1 + x^{12}$

clearly $G(x)$ does not divide x^5

also $G(x)$ does not divide $(1+x^{12})$ because $G(x) = (1+x^{12}) + (x^{11} + x^3 + x^2 + x)$

Hence can be detected.

(d) $E(x) = x^i(x^{12} + e_{11}x^{11} + \cdots + e_1 x + 1) = x^i B_e(x)$

Clearly $G(x) \nmid x^i$

length of burst error = 13

degree of $G(x) = 12$

degree of $B_e(x) = 12$

$G(x)$ might divide or might not divide.

Hence, it is not guaranteed to be detected

(e) Pr of burst error of length $k = p^k(1-p)$

~~Pr detecting prob of~~

$$\Pr[\text{not detecting}] = \sum_{r=12}^{\infty} 2^{-(r+1)} \cdot p^{(r+1)}(1-p)$$

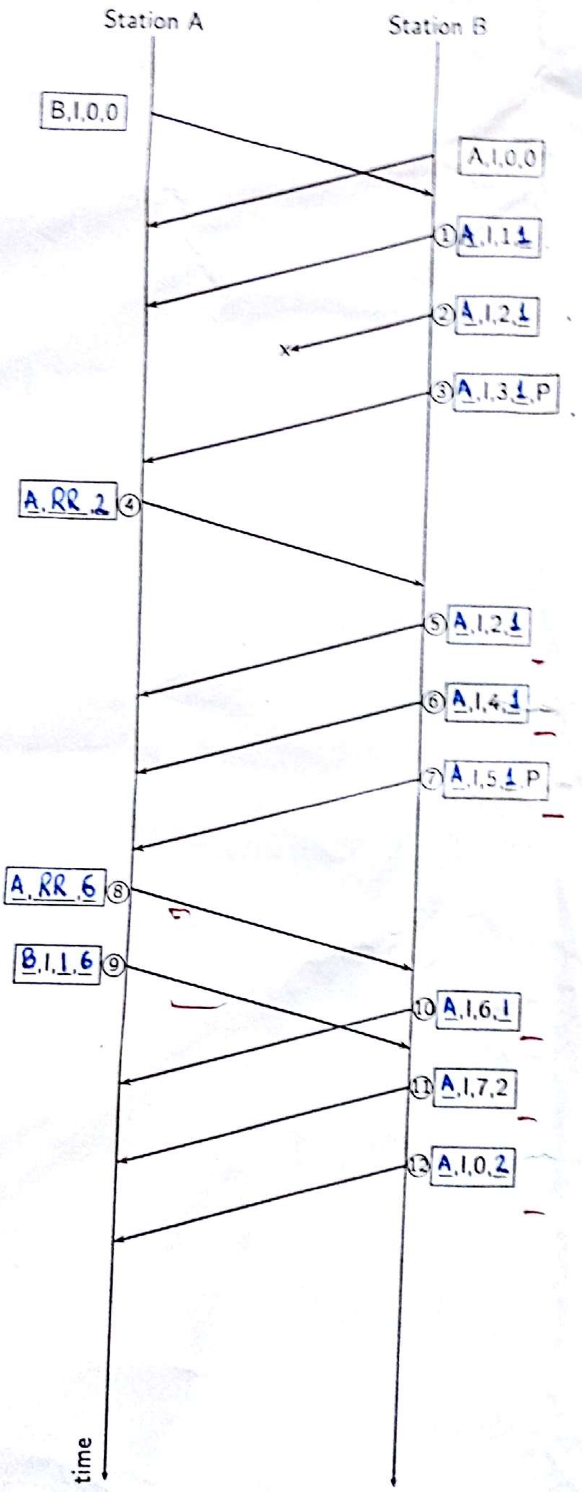
$$= \sum_{r=12}^{\infty} \left(\frac{p}{2}\right)^{r+1}(1-p)$$

$$= \frac{(1-p)\cdot(p/2)^{13}}{1-\frac{p}{2}}$$

$$= \frac{2(1-p)}{(2-p)}\cdot(p/2)^{13}$$

$$\Pr[\text{detecting}] = 1 - \frac{2(1-p)}{(2-p)}(p/2)^{13}$$

3. [20] The diagram below shows a part of frame exchange between two stations A and B using the HDLC protocol. The diagram uses convention introduced in the lecture: $\boxed{a, \text{I}, m, n}$ or $\boxed{a, \text{C}, n}$ where a is the address, C is one of the commands in {RR,RNR,REJ,SREJ}, I indicates an information frame, m is send sequence number and n is receive sequence number. If P appears at the end of the frame, the P/F bit is set. Frame loss is indicated by an 'x'. All the other frames are delivered with no error.



(a) [2] What is the send window size?

(b) [2] What is the receive window size?

(c) [2] What is the type of ARQ scheme used?

(d) [2] Are the stations using NRM (normal response mode) or ABM (asynchronous balanced mode)?

(e) [12] Complete the diagram by providing a, m, n and C in ① through ⑫.

(a) send window size = 1+7 = 8

(b) receive window size = 8

(c) SR-ARQ

(d) ABM

(e) ① A, I, 1, 1
② A, I, 2, 1
③ A, I, 3, 1, P
④ A, RR, 2
⑤ A, I, 2, 1
⑥ A, I, 4, 1
⑦ A, I, 5, 1, P
⑧ A, RR, 6
⑨ B, I, 1, 6
⑩ A, I, 6, 1
⑪ A, I, 7, 2
⑫ A, I, 0, 2

4. [25] Data frames of fixed length are sent using ARQ scheme. It is found that the link is very noisy and modification is made as follows: • Sender sends two copies of a frame, • Receiver, upon receiving both copies of a frame, sends a NAK when both copies are in error. Otherwise, it sends an ACK.
Assume the followings:

(i) Frame transmission time is normalized to one.

(ii) Frame error probability is P.

(iii) Processing time at the sender and the receiver and ACK/NAK transmission time are negligible.

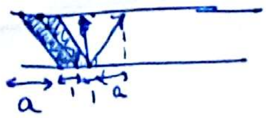
(iv) Propagation delay between the sender and receiver is a (sec), which is an integer.

(v) A frame is a total of n_f bits, whereas n_o bits are overhead bits.

Determine the transmission efficiency for each of the following protocols.
(a) [5] Stop-and-Wait (b) [5] Go-Back-N (c) [5] Selective Repeat

(d) [5] Under what condition for P is the scheme in (a) better than the original Stop-and-Wait ARQ, if $a = 3$?
(e) [5] As in (d), show whether or not the scheme in (c) is better than the original Selective Repeat ARQ.

(a)



$$t_{sw} = 2a+2$$

In case of errors.

Probability of not acknowledging the frame $= P^2$ $= P_f$

$$t^e_{sw} = (1-P_f)\sum_{k=1}^{\infty}\left(t_{sw}+(k-1)t_{out}\right)P_f^{k-1}$$

$t_{out} = t_{sw}$

$$t^e_{sw} = \frac{t_{sw}}{1-P_f}$$

where $\eta = \frac{2n_f-2n_o}{t_{sw}}\cdot\frac{1}{R}$

2

$$U^e_{sw} = \frac{t_f}{t^e_{sw}} = (1-P_f)\,U$$

$$\eta^e_{sw} = (1-P_f)\,\eta = (1-P^2)\cdot\frac{\cancel{2}(n_f-n_o)}{\cancel{2}(a+1)}\cdot\frac{1}{R}$$

$$\eta^e_{sw} = \frac{(1-P^2)\cdot(n_f-n_o)}{R(a+1)}$$

(b) Assuming $W_s \geq 2a$

$$t_{gbn} = (1-P_f)\sum_{i=0}^{\infty}P_f^i\left(2+2i\cdot W_s\right)$$

$P_f = P^2$

$$= 2\left(1+\frac{P_f W_s}{1-P_f}\right)$$

$$U_{gbn} = \frac{1-P_f}{1+(W_s-1)P_f} = \frac{1-P^2}{1+(W_s-1)P^2}$$

$W_s \approx 1+\frac{2aR}{n_f}$

$$\eta_{gbn} = \frac{n_f-n_o}{n_f}\,U_{gbn}$$

(c) for SR-ARQ $\qquad P_f = p^2$

$$U_{sr} = \frac{t_f}{t_{sr}} = 1 - P_f$$

$$= 1 - p^2$$

$$\eta_{SR} = \left(\frac{n_f - n_0}{n_f}\right) \cdot (1 - p^2)$$

1

It is better than the ~~f...~~ original bcoz..

$$1 - p^2 > 1 - p$$

$$(\eta_{SR})_{new} > (\eta_{SR})_{original}$$

(d) for original SW

$$\eta = (1-P) \frac{n_f - n_0}{t_{sw}} \cdot \frac{1}{R}$$

$$= (1-P) \frac{n_f - n_0}{1 + 2a} \cdot \frac{1}{R}$$

$$\frac{(1-p^2)\,\cancel{(n_f - n_0)}}{\cancel{R}(a+1)} \geq \frac{(1-P)\,\cancel{(n_f - n_0)}}{(1+2a)\cancel{R}}$$

$$\Rightarrow 1 + P \geq \frac{a+1}{2a+1} \Rightarrow \text{always better.}$$