KTH Technology and Health

Written exam

December 11th 2012

Wireless networks

(EP2950, HI2001)

Help material: pocket calculator and four handwritten A4 pages.
Maximum points: 50p. The preliminary limit for passing the course is 24p.

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1. An application intends to send a sequence of bits numbered from 1 to $m \times n$. The wireless transmission system uses an interleaving structure with m=4 rows and n=6 columns. A dip in the signal strength causes a loss burst with $2 \times m$ consecutive bits that starts directly from the first transmitted bit on the wireless channel. (4p)
   a) Show the sequence of transmitted and received bit numbers.
   b) What is the length of the loss burst and distance between lost bits seen by the application?

   Ans: a) Transmitted bits: 1, 7, 13, 19, 2, 8, 14, 20, 3, 9, ... , 6, 12, 18 and 24. The first 8 bits in that sequence are lost and not received. b) The length of the loss burst seen by the application is two bits, and the loss gap is 4 bits (-, -, 3, 4, 5, 6, -, -, 9, 10, 11, 12, etc.).

2. Assume that a block of 8 bits arrives to a mobile phone. (6p)
   a) Will the generator polynomial P(x) = x+1 detect two bit errors? Motivate your answer.
   b) Evaluate the ability of the polynomial $P(x)=x^3$ to detect single bit errors.
   c) The bit sequence D=11011100 is transmitted and a parity bit is added. The receiver gets D=10011100 and a parity bit showing that data is correct. What is your interpretation?

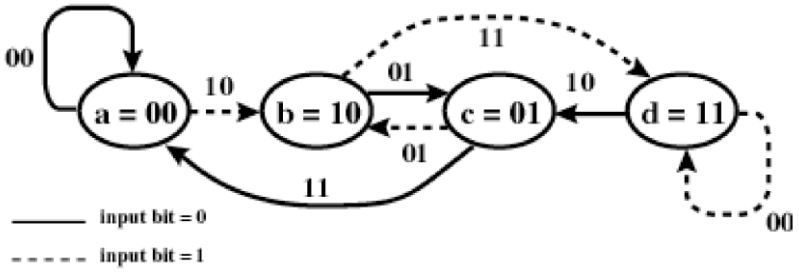
   Ans: a) P(x)=x+1 means a parity bit, which cannot detect an even number of bit errors. b) x^3 detects errors in bit positions 3, 4 etc, but not in bit positions 1 and 2. c) Bit the position 7 and the parity bit are both errored during the transmission.

3. A convolutional encoder (2,1,3) is defined by the following logic: $\upsilon_{n1} = u_n + u_{n-2}$ and $\upsilon_{n2} = u_{n-1} + u_{n-2}$, where the operator + means XOR. (6p)
   a) Draw the state diagram for the encoder.
   b) Draw the Trellis diagram for the encoder.

Ans:

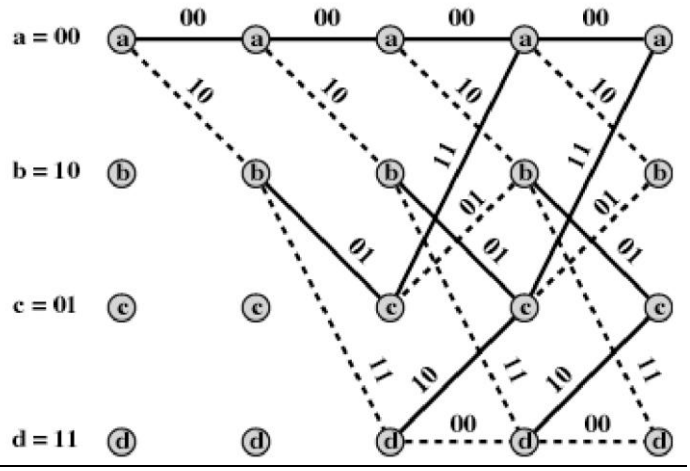
a)

2.



b)

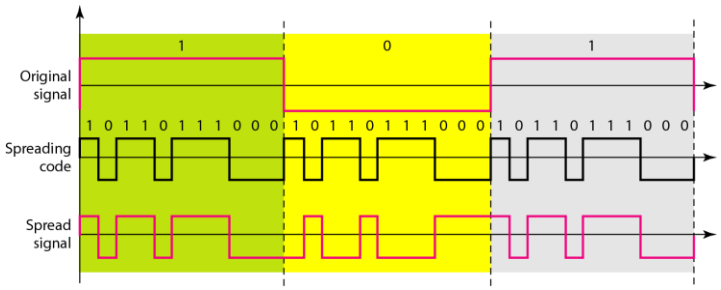
3.



4. A Bluetooth device transmitting power is 4dBm indoors. The fading margin is 15dB and the antenna gain is 1dB for the transmitter and also for the receiver. Determine the maximum distance (line of sight) between the transmitter and the receiver, if the receiver sensitivity is -80dBm? (4p)
   Ans: The link budget: $L_s[dB]=4-(-80)-15+1+1=71dB$.
   Free space loss, $L_s[dB]=-32.4-20\times lgd_{km}-20\times lgf_{MHz}$, used frequency in BT is 2.4GHz=2400MHz.
   $32.44+20\times lgd_{km}+67.6=71$; $20\times lgd_{km}=-29$
   d=0.0355km≈35.5m. The largest distance is approximately 35m.

5. A computer receives a data block, 10 1010 1001 0010, that is coded in Hamming (14,10). Determine if the data block is correctly received. (2p)
   Ans: Bit error in position 7.
6. Assume a frequency division multiplexing system (OFDM) with eight separate sub-carriers. The modulation scheme is 16-QAM, the symbol rate is 250ksymbols/s and the coding rate is 1/2. What will be the data rate for the system? (4p)
   Ans: Data rate=8×4×½×250 kbps= 4 Mbps

7. The figure below shows how a Barker sequence is used as spreading code. (8p)
   a) What kind of spread spectrum technique is used?
   b) Determine the chip rate if the bit rate is B b/s.
   c) What channel encoding is used? Motivate your answer.
   d) Show in a detailed figure how the spread signal is de-spreaded (decoded).
   e) Should Barker sequences have low or high cross-correlation properties?
   f) What property should the auto-correlation of a spreading code have?



Ans: a) Direct sequence spread spectrum b) 11B chip/s c) Non-return to zero (NRZ) d) XOR between the received "spread signal" and the spreading code gives the received bits e) Low cross correlation to avoid confusion with other spreading codes f) The autocorrelation should be high for zero and multiples of 11 shifts and low for other shifts.

8. A wireless system uses orthogonal variable spreading codes. The data rate is 0.48Mbps for the spreading factor 4. What is the data rate for the codes with a spreading factor of 256? (4p)
   Ans: The chip rate is 480k×4=1.92Mchip/s. The data rate for spreading factor 256 is 1.92M/256=7.5kbps.

9. Some wireless systems apply time division duplex whereas others use frequency division duplex. Classify GSM and Bluetooth in those terms and motivate your answer. (2p)
   Ans: GSM applies FDD (different frequencies uplink and downlink). Bluetooth has not reserved specific frequencies for uplink and downlink communication, but uses an odd timeslot from master to slave and an even timeslot from slave to master.

10. Determine the values of the flags ToDS and FromDS, and the MAC addresses for the source address (SA), destination address (DA), receiver address (RA) and transmitter address (TA) for wireless LAN use cases below. Station STA1 has MAC address STA1, station STA2 has MAC address STA2, access point AP1 has MAC address AP1 and access point AP2 has MAC address AP2. STA1 is connected to AP1 and STA2 is connected to AP2. AP1 and AP2 belong to the same extended service set. (6p)
    a) STA1 sends a frame to STA2. Determine ToDS, FromDS, SA, DA, RA and TA for that frame.
    b) STA2 receives the frame sent from STA1 in case a) above. Determine ToDS, FromDS, SA, DA, RA and TA for that frame.

    Ans: a) ToDS=1 and FromDS=0. SA=STA1, RA=AP1, TA= - and DA=STA2. b) ToDS=0 and FromDS=1. SA=STA1, RA= -, TA=AP2 and DA=STA2.

11. Consider a Bluetooth node with a voice connection that needs guaranteed data rate. What kind of physical link is used for this connection? What kind of error correction method is used? (4p)
    Ans: Synchronous connection oriented (SCO) link is used in this case. It means that the connection has reserved timeslots at regular time intervals. Forward error correction is used, since retransmission is not possible due to the strict delay limits.