KTH Technology and Health

Written exam March 11th 2014

Wireless networks (EP2950, HI2001)

Help material: pocket calculator and four handwritten A4 pages (two sheets).
Maximum points: 50p. The preliminary limit for passing the course is 25p with grade E to A in steps of approximately 5p.

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1. A Bluetooth device is transmitting with 0dBm indoors. Assume a fading margin of 10dB, an antenna gain of 1dB for both transmitter and receiver. What is the maximum distance (with line-of-sight) between transmitter and receiver if the receiver wants – 80dBm? (4p)
   Ans: Ls = 110-30-10+2=72dB. The free space loss is $20\log(d_{km})=L_s - 32.4 - 20\log(f_{MHz})= 72-32.4-67.6 = -28$. $d \approx 40$m.

2. Explain what hidden terminals mean in wireless networks and suggest methods to solve the problems related to hidden terminals. (4p)
   Ans: The signals from two stations reach the access point but not each other. RTS/CTS is a solution.

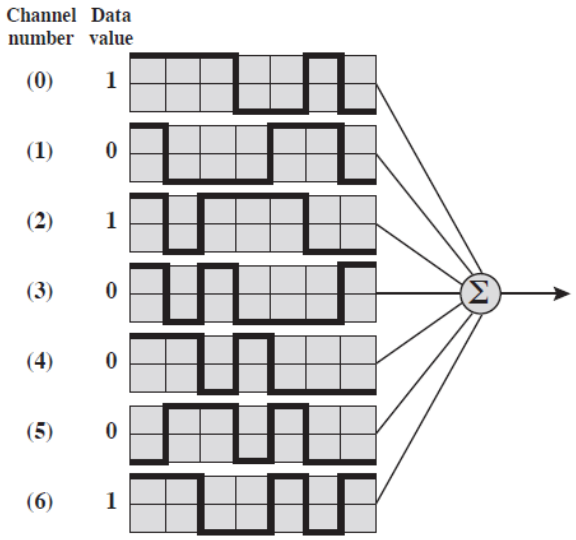
3. What is the thermal noise level of a channel with a bandwidth of 10kHz carrying 1000W at the temperature 50°C? (4p)
   Ans: N = –228.6 dBW + 10 log T + 10 log B. We have T = 273.15 + 50 = 323.15 K, and B = 10,000. N_{dB} = –228.6 dBW + 25.09 +40 = –163.51 dBW. $N_W = 10^{N/10} = 4 \times 10^{-17}$ W.

4. Show that E_b/N_0 = S/(kTR), where E_b is the energy per bit, N_0 is the noise per hertz, S is the signal power, R is the data rate and T is the temperature in Kelvin. (4p)
   Ans: See the textbook.

5. How many check bits are needed if the Hamming error correction code is used to correct single bit errors in a 1024 bit data word? (4p)
   Ans: Need $n - k$ check bits such that $2^{(n-k)} - 1 \geq 1024 + (n - k)$. The minimum value of $n - k$ that satisfies this condition is 11.

6. Explain the difference between sniff mode, hold mode and park mode in Bluetooth. (4p)
   Ans: See the textbook.

7. In a CDMA network, seven channels transmit the following data bits using spreading codes (see the figure below). Show how the bit value from channel five is obtained from the aggregated signal. (6p)



Ans: Channel five's spreading code is {1 -1 -1 1 -1 1 1}. The aggregated signal from all channels is {5 1 1 -3 1 -3 -3}. Multiply the vectors element by element and sum up gives -7 which is interpreted as zero (0).

8. Describe the differences between hard, soft and softer handover procedures. (4p)
Ans: Hard handover. Contact is switched from one base station to another at one moment. The mobile only has contact with one base station at a time. Soft handover: The mobile is in contact with two or more base stations at the same time, giving a 'smooth switch'. Softer handover: The mobile is in contact with one station but in two different sectors of that station.

9. In IEEE 802.11, the stations have two different ways to detect if the medium is busy. Describe these two ways. (4p)
Ans: The physical sensing, which means that the radio listens for the carrier. The virtual sensing means that the station reads the NAV, network allocation vector, which is carried in the duration field. This value is the estimated time that the medium will be busy for the coming transmission. Stations can wait until then before trying to send again (according to the control logic).

10. When a station wants to associate to an access point (AP), the station performs a scanning to discover access points in the proximity. Describe the possible ways for a station to discover the access points. (4p)
Ans: The scanning can be active or passive. In active scanning the stations send a probe request and in passive scanning the station only listens to the beacon frames sent by an AP.

11. What is the reason for having four address fields in the MAC header in wireless Ethernet (IEEE 802.11) instead of two address fields as in wireline Ethernet? (4p)
Ans: See the textbook.

12. A Bluetooth slave receives a POLL packet. Let the previous values be ARQN=1 and SEQN=0. What will be the values of ARQN and SEQN when a NULL packet is transmitted? The answer has to be motivated. (4p)
Ans: ARQN=1 and SEQN=0.