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Exercises of lecture

Wireless Sensor Networks

Winter 2006/2007

Sheet 3

SECTION 1:
From waves to bits, channel model, CDMA, DSSS

1. Briefly explain techniques used to share the medium.
   (a) Space-Multiplexing
      i. Spatial distance
      ii. Directed antennae
   (b) Frequency-Multiplexing
      i. Assign different frequencies to the senders
   (c) Time-Multiplexing
      i. Use time slots for each sender
   (d) Spread-spectrum communication
      i. Direct Sequence Spread Spectrum (DSSS)
      ii. Frequency Hopping Spread Spectrum (FHSS)

2. Consider a wireless network in which DSSS is used in implementing multiple-access. The spread factor used is k = 8. The code sequence (i.e., chip sequence) assigned to a particular channel (namely Channel A) is

   C = +1+1-1+1+1-1+1+1 (i.e. 11011011)

   Suppose a logical bit 0 (-1) is sent using on this channel,
      i. How does Channel A sender spread this bit to the chip sequence? $-1 \cdot (+1 + 1 - 1 + 1 + 1 - 1 + 1 + 1) = (-1 - 1 + 1 - 1 - 1 + 1 - 1 - 1)$
      ii. Denote the above transmitted chip sequence signals as $S_i (i = 1, 2, , 8)$. What is the code chip sequence used by Channel A receiver to de-spread the received signals? The code chip sequence is +1+1-1+1+1-1+1+1.
      iii. What is the rule applied by the receiver while decoding the received signals? And based on this rule, what is the decoded bit? Rules: if sum $\geqslant 4$ then 1 else if sum $\leqslant -4$ then -1 else nothing. $\sum_i (S_i C_i)$ = (-1)+(-1)+(-1)+(-1)+(-1)+(-1)+(-1)+(-1) = -8. A logical bit 0 is received.

iv. Suppose the transmitted chip sequence -1-1+1-1-1+1-1-1 was hit by interference and one chip was affected to become -1-1+1-1-1+1-1**+1** that was received. How does Channel A receiver de-spread and decode then? And what do you think about the tolerance level of DSSS to bit error? $\sum_i(S_iC_i)$= (-1)+(-1)+(-1)+(-1)+(-1)+(-1)+(-1)+(+1) = -6 = sum. Channel A receiver determines that a logical bit 0 is received, showing that the transmission using DSSS was tolerant to the **bit** error.

v. Suppose a different channel, namely Channel B, uses a code chip sequence of $C' = +1+1+1-1+1+1+1-1$ (i.e., 11101110). As channel A and B use the same frequency band, how does a receiver of channel B de-spread S_i and what is the decoded bit? $\sum_i(S_iC'_i)$ = (-1)+(-1)+(+1)+(+1)+(-1)+(+1)+(-1)+(+1) = 0. The receiver cannot decode correctly the data bit sent on channel A. It gets little signal from the sequence S_i as if it does not hear anything.

3. We are using CDMA and has received (-1, 1, 1, 3) from nodes A, B and C. The code for A was equal to (1, 1, 1, 1), B was equal to (1, 1, -1, -1) and C was equal to (1, -1, 1, -1). What actually was send by A, B and C?

   A = 1/4(-1, 1, 1, 3).(1, 1, 1, 1) = 4/4 = 1 (0 bit from A)

   B =1/4(1, 1, -1, -1).(1, 1, 1, 1) = -4/4 = -1 (1 bit from B)

   C = 1/4(1, -1, 1, -1).(1, 1, 1, 1) = 4/4 = -1 (1 bit from C)

SECTION 2:
Transceiver Design, Networking Basics Revisit

1. What are the considerations to be taken into while designing the transceiver for wireless sensor network?

   (a) Good power efficiency at low transmission power

   (b) Startup energy/time penalty

   (c) Tradeoffs between communication and processing/computation

   (d) Choice of modulation

Choose between true and false for the following questions.

1. In packet switching, packets from a source can be received in out-of-order at a destination. (True)

2. In packet switching, individual packets from a source can travel to a destination using different paths (True)

3. Frame synchronization tells when a packet (data in frame) starts and ends? (True)

4. To correctly receive a message, the signal-to-noise-and-interference ratio (SINR) should be very small? (False)

5. Addition of white noise results in variations of signal to noise ratio (SNR)? (False)

6. Using frequency-hopping-spread-spectrum a missile can be controlled by the destination country to divert back? (False)