Wireless Communication and Networked Embedded Systems

Home Assignment - Energy

Problem 1: Data Rate and Energy Efficiency

Device A and device B are 20m apart. Their radios have two modes:

mode 1) transmits at 250 kbps and consumes 10mA
mode 2) transmits at 500 kbps and consumes 10mA

a) Assuming there are no errors, is it more energy efficient for A to send a 125-byte frame (including all headers) using mode 1 or mode 2?

Assume that A sends to B using 250 kbps data rate, B always receives the frame correctly. But when A sends using at 500 kbps, device B has only a 50% chance of successfully receiving the frame. If B receives the frame, it sends an ACK to A. Assume that the ACK is always received correctly and costs nothing. If A does not receive an ACK, it re-transmits the frame.

b) Calculate the expected number of transmissions (ETX) for the given scenario:

ETX = E[transmissions] = $1 + (1 - p) \sum_{k=0}^{\infty} k p^k$

where *k* is the number of transmissions (k-1 corrupted, 1 successful), and *p* the packet error probability.

c) Should A use mode 1 or mode 2 for the transmission and/or re-transmission? Assume that losses are independent - i.e. that the probability of successfully receiving the frame depends only on the data rate.

d) Suppose A can use error coding that allows B to decode data reliably. The code adds redundancy by doing linear combinations over the frame, which adds 50% to the frame size. What is more efficient, to use error coding or doing retransmissions?

Problem 2: Low-Power Listening

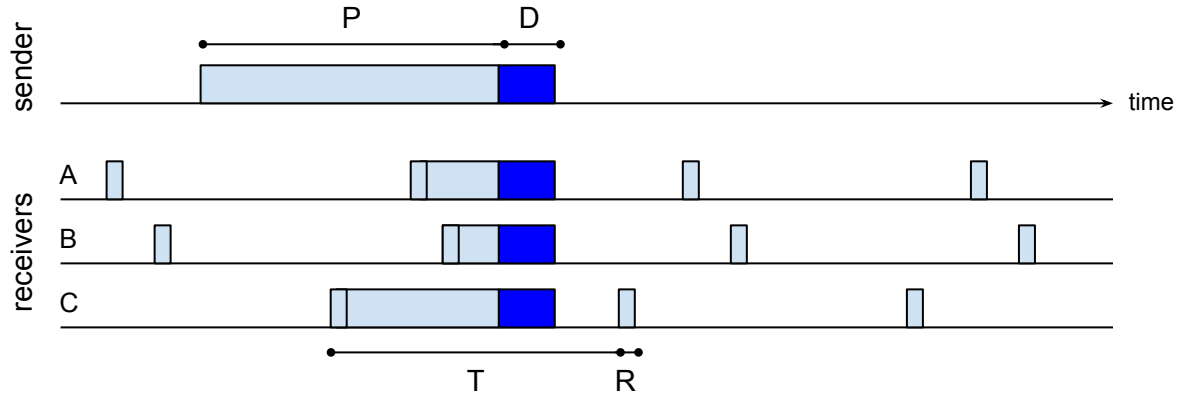

Figure 1: Low-Power listening protocol with long preamble.

Consider the asynchronous low-power wake-up protocol for broadcast with a long preamble of duration P (tone, no data) as illustrated in Figure 1: The receivers listen every T seconds for a preamble. They listen for R seconds and go to sleep again if they do not detect the preamble, else they continue listening until data is transmitted, receive the data packet (duration D) and go to sleep thereafter. Assume for simplicity that the power for listening, sending and receiving is the same.

a) How long does the duration P of the preamble have to be to guarantee reliable operation?

Consider a time interval of N*T, during which the sender transmits M data packets. We assume M<<N such that data is transmitted relatively seldom and with an interval of at least 2*T in between data packets.

b) Compute the expected (average) active time for a receiver when a preamble is detected and data transmitted.

c) Compute the expected active time of a receiver and sender during a time interval of N*T.

d) What are the (dis)advantages of this protocol for the sender/receiver if T is large? Give at least one advantage and disadvantage each.

e) For one of the disadvantages listed in (d), discuss if and how changing the number of data packets M would improve that particular aspect.

f) What is the disadvantage if this protocol is used for unicast?