Exercise Sensor Networks - (till may 23, 2005)

Lecture 4: MAC and energy efficiency

Exercise 4.1: Genie Aided Aloha

Genie-aided Aloha was an estimate for the energy efficiency of the Aloha protocol. Is GAA better than pure Aloha in every case and if not when and why?

Exercise 4.2: Slotted Aloha

In what way does Slotted Aloha differ from pure Aloha with regard to the channel access? Try to quantify how the two approaches differ (in this context the packet delivery rate is not important).

Exercise 4.3: Comparison of medium access approaches

Why is the delivery rate of 1- persistent CSMA better than the one of slotted Aloha and why do both of them converge against the same delivery rate in very busy channels?

Exercise 4.4: p-persistent CSMA

1-persistent CSMA means to send instantly at the beginning of a frame time while non-persistent CSMA means that a random time has to pass before sending in case of an occupied channel. In between those extremes a probability p can be chosen which is the likeliness for sending at the beginning of the next frame time.

For what reason may probabilities in between 0 and 1 be more optimal than than 0 or 1?

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Exercise 4.5: Aloha with preamble sampling

Basic consumption	: 8 mA
Energy f. sending	: 12 mA
Energy f. receiving	: 6 mA
Sleep mode	: ~0mA

$b^{PAS} = 1 - e^{-gN(T_P+T_M+T_R+T_A)}$	P' for incoming message
$b_1^{PAS} = 1 - e^{-g(T_P+T_M+T_R+T_A)}$	P' for sending a message
$Pow^{PAS} = b_1^{PAS} P_{TX} + (b^{PAS} - b_1^{PAS}) P_{RX}$	Mean consumption f. send. and recv.

Let the length of a packet T_M be 0,8 times the frame time, and let the time T_R for switching the transceiver between sending and receiving and the time T_A for an acknowledgment be 0.1 times the frame time, so that a full transmission attempt occupies exactly one frame time (0.8+0.1+0.1). The preamble T_P for waking up the neighbors should take another full frame time which means that a sensor node has to wake up once per frame time. The sending rate g should be 0.01 (attempts to send per frame time) and the total number of nodes should be 10.

a) How high is the mean energy consumption in this scenario?

b) How high is the energy consumption if waking up and listening to the channel consumes T_W=14,0mA of energy. In order to check, whether the channel is free or occupied a node has to stay awake and keep listening for at least 1% of the frame time.

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Exercise 4.6: Optimizing the preamble

In the following scenario there are 100 nodes. Each of them produces and arrival rate of 0.00005 packets per frame (so communication is somewhat rare). A packet occupies a full frame length. Acknowledgments are not implemented, at least not on the mac layer. Nodes that encounter an active channel stay awake until the channel is clear again. Transmitting a packet is as expensive as receiving one.

a) Imagine to be a node. How many percent of our lifetime do we spend to send a packet, do we spend to hear a packet and do we sleep?

b) A node wakes up during a transmission. How many percent of the preamble and the actual packet does the node hear on average?

c) Aloha with preamble sampling requires to wake up once within the time of a full preamble. We assume that waking up, listening into the channel and going pack to sleep in case of silence is expensive and costs 10% of the energy require to transmit a packet. What is the optimal length for the preamble (measured in frame times) in this situation?

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Exercise 4.7: Simulation of the Aloha approach

The program for simulating the packet delivery rate at different arrival rates (used in the lecture) can be downloaded from the homepage.

a) Compile the program on our computer. You may want to port it to Java (only marginal changes are necessary).

b) Change the program in order to simulate slotted Aloha. This can be accomplished by swapping few lines of code and adjusting the arrival rate.

c) Now extent the class 'Station' in order to simulate p-persistent Aloha. It should be possible to vary p between 0 (for non-persistent aloha) and 1 (for 1-persistent Aloha). Which instance of p is optimal for 100 stations?

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