Exercise Sensor Networks

Lecture 6: MAC in radio networks

Exercise 6.1: Aloha with preamble sampling

A sender wants to transmit a packet to exactly one receiver via unicast (in contrast to broadcast). On the MAC layer, Aloha with Preamble Sampling is implemented.

a) Why is transmitting a packet in this situation (unnecessarily) energy consuming both for the sender and the receiver?

Solution:

The longer the preamble the less idle listening is needed. But from the viewpoint of the sender, a long preamble has to be sent prior to transmitting data. From the viewpoint of the receiver, most nodes are woken up even though they are not addressed. Again, long preambles consume energy, this time for the listeners as they have to overhear half of the preamble on average.

Exercise Sensor Networks

Lecture 6: MAC in radio networks

Exercise 6.1: Aloha with preamble sampling

A sender wants to transmit a packet to exactly one receiver via unicast (in contrast to broadcast). On the MAC layer, Aloha with preamble sampling is implemented.

b) How could the protocol be improved with regard to the problems identified in a) without having to synchronize the nodes? In other words: The solution should be able to work without a synchronized clock.

Solution:

The solution would be to used the preamble time for a more sensible purpose rather than only for occupying the channel as suggested by El-Hoiydi in the original work.

First suggestion:

E.g., the data packet could be sent (repeatedly) instead of the preamble. Nodes not being involved into the communication could go to sleep after having read the header of each data chunk which includes the ID of the receiver. Even the intended receiver should go to sleep after having heard the data at least once. The sender would however have to transmit the data even after the “data-preamble” since it can not know when the intended receiver woke up.

Second suggestion:

Another solution would be to fill the preamble only with the ID of the receiver. Everyone not involved could go to sleep again shortly after having woken up. If the length of the rest of the preamble was added after the ID even the intended receiver could go to sleep until the start of the data chunk.

Exercise Sensor Networks

Lecture 6: MAC in radio networks

Exercise 6.2: S-MAC

Ye, Heidemann and Estrin describe in their paper „An Energy-Efficient MAC-Protocol for Wireless Sensor Networks“ their S-MAC approach. Therefor, nodes have to synchronize themselves from time to time. Otherwise their sleep- and listen periods would diverge too much.

Some nodes may adopt more than one schedule, the one of their own cluster and one or more of neighboring clusters. The authors only describe how the schedule is synchronized within one's own cluster.

a) What is special about nodes that store more than one schedule and which know about the existence of more than one cluster, especially with regard to the synchronization?

Solution:

A node will only follow its initial schedule. The node also knowns about a neighboring cluster, however, the cluster might be active while the considered node sleeps. In the meantime, neighboring nodes synchronize themselves at the beginning of the listening phase. But the considered nodes can not take part in this synchronization.

Exercise Sensor Networks

Lecture 6: MAC in radio networks

Exercise 6.2: SMAC

b) The authors do not address the problem from a). How could it be solved?

Solution:

First suggestion

Nodes wake up at all known schedules and synchronize like they would with their initial home cluster.

+ Synchronization is not a problem
- The most important border nodes will run out of energy first because they have to be running at two active listening periods. If border-nodes fade first the sensor network gets partitioned after about 50% of its lifetime. Partitioning means that most parts of the network are lost.

Second solution

Neighboring nodes add sync information (their time to sleep) to their data packets. A receiver can sync. the schedule accordingly. This is often called piggy-backing in literature.

+ Hardly any additional overhead
- Nodes that do not often/never get packets are not synchronized. This is in particular true for sensor networks and one-way communication. Maybe in this case adding the information to the ACKs or CTS messages would mitigate the problem.

Possible solution for sparse communication: A node which has not synchronized with another cluster for a longer time could wait for a full listen- and sleep period to catch a sync packet.

Exercise Sensor Networks

Lecture 6: MAC in radio networks

Exercise 6.3: Hidden- and exposed station problem

Six stations are grouped around a mountain in a chain topology. Each station is able to hear the next and the previous neighbor in the chain. Station 6 and station 1 can also hear one another. Stations optimize their behavior in order to avoid collisions if possible. We consider only single packets which means that no RTS/CTS is used.

a) Station 2 is sending to station 1 already. Station 3 wants to address station 4. Is 3 allowed to send a packet and will it do so? Where does the collision occur?

Solution: 3 may send to 4. There will be a collision at station 2 and station 3. But these station do not listen but only send. The receiver 4 does however not hear 2 anymore and 1 hears 2 but not 3 anymore. In general collisions at sending stations are no problem.

b) Station 3 sends to station 2 and 5 would like to send a packet to station 4. Will station 5 start sending and should it?

Solution: Station 5 does not hear 3 and will send. At station 4 packets arrive both from 5 and 3 so that they collide. This means that station 5 should not send but can not tell.

c) Station 1 and 2 are sending. Which stations belief that they can send and which ones are actually allowed to do so?

Solution: Stations 3 and 6 know that they would possibly cause collisions somewhere and will not send. Stations 4 and 5 do not hear anything and would send, however they would also cause collisions at station 3 and 6.

Exercise Sensor Networks

Lecture 6: MAC in radio networks

Exercise 6.3: Hidden- and exposed station problem

Six stations are grouped around a mountain in a chain topology. Each station is able to hear the next and the previous neighbor in the chain. Station 6 and station 1 can also hear one another. Stations optimize their behavior in order to avoid collisions if possible. We consider only single packets which means that no RTS/CTS is used.

d) Station 1 and 4 send. Which stations belief that they can send and which ones are actually allowed to do so?

Solution: In this case every station has a sender in the direct neighborhood. So stations 2, 3, 5 and 6 believe that they must not send and they are right.