HS 2009 Prof. Dr. Roger Wattenhofer, Philipp Sommer, Johannes Schneider

Ad Hoc And Sensor Networks Sample Solution to Exercise 6

Assigned: October 26, 2009
Due: November 2, 2009

1 MAC Layer

Storms with lightning flashes are rather seldom phenomena. Statistics from the canton of Zurich show that flash lightnings occur on average 1.5 times per year and square kilometer. Although a light sensor can possibly detect flashes a few kilometers away, we can assume that our system will probably not detect anything for days or even weeks until we have a burst of events during a short period of time.

a) If all nodes were equipped with a light sensor and a microphone, there would be a simple solution to the problem. Normally, all nodes have their radios switched off to save energy. A light flash can act as an external global event to switch on all radios and microphones. Then, nodes start to forward the sensor readings towards the base station. When no additional lightning flashes are detected for a specific period (e.g. one minute) nodes go back into energy-safe mode and switch off their radios. However, since in our system some nodes have no light sensor and serve solely as a communication relay, this approach will fail.

   Listening for radio messages is nearly as expensive as the transmission of a message. The radio chip of the TinyNode platform consumes typically 14 mA in receiver mode and 33 mA in transmitter mode. If the chip can be operated in sleep mode, only 0.2 µA are consumed. Therefore, we need to employ a MAC layer which operates the radio chip in sleep mode most of the time. Using *low-power listening (LPL)* each node periodically wakes up and checks the radio channel for activity, see Figure 1. This can be done with little additional power consumed since the radio chip does not need to be put into receive mode. On the other hand, much more energy is required to send a single message and the channel throughput is reduced due to the extended message preamble necessary for LPL.

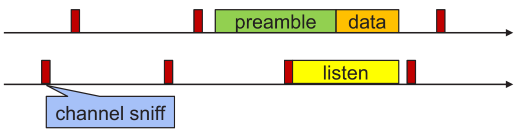

Figure 1: Low-power listening

b) After the system is extended with additional ozone sensors on all nodes, the traffic pattern changes from infrequent bursty traffic to continuous forwarding of gathered sensor data. Transmitting periodic data messages will become very costly if we still stick with LPL due to the extended preamble. In such a scenario a TDMA approach, e.g. the *Dozer* data gathering system, is better suited to prolong the battery lifetime of the sensor nodes. Data is forwarded along a shortest path tree rooted at the base station (sink). Each node in the tree maintains a wake-up schedule with its children in the tree and participates in the schedule of its parent. The increased costs for maintaining a TDMA schedule pays off with a periodic traffic pattern. Nodes have to switch on their radio only during a small time slot reserved for communication, otherwise they can rest in power-safe mode.