RFID Wake-up in Event Driven Sensor Networks

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Wireless sensor networks (WSN) are most often envisioned with a large number of nodes and their typical range of communication is on the order of tens of meters. By definition, WSNs consist of nodes monitoring their environment and taking action when some event is detected. The action could range from reporting this change to some central or mobile node, to implementing a local control loop through local actuators, either at the nodes themselves or at other local nodes. How the data is aggregated and what is done with it are both problems that are application specific. The common factor in these problems is that they are event driven. It is changes in the environment that cause the nodes to change from local monitoring points to a network of information.

Nodes are generally small and cheap with extremely limited energy reserves. All the energy for sensing, processing, and communication must come from either small batteries or energy scavenging. The energy capacity of batteries is increasing slowly and in most cases, energy scavenging techniques do not supply a steady power source. A major source of power consumption in nodes is communication. It has been found that over short distances, a radio listening to the channel consumes power on the same order of magnitude as the actual receiving or transmitting. The result is that idle listening becomes the dominant power consumer in the system.

Thus, when no changes are detected and there is nothing to tranmsit, it makes sense to turn off the node radios. However, this creates problems with communication. Often it is necessary for nodes that are not directly involved with sensing an event to be involved in communication, such as when acting as a multihop relay node, or to do some local computation or data aggregation. Thus the network must be able to enable communication with nodes that have not sensed any events.

It would be ideal if it were possible to send a message to a node without the penalty of having to listen to the channel. Radio frequency identification tags (RFID) can provide this functionality, but require higher transmit powers. RFIDs are also becoming increasingly common in commercial inventory management systems and are proving both robust and effective. In the context of this paper, they are used as the basis of an energy efficient out-of-band wake up mechanism. A distinction of the proposed RFID scheme is the lack of a high-power reader system, since our scheme is based on an ad-hoc scheme of employing RFID devices, which does not rely on hearing back from the called tags and hence the initial call transmit power is much lower than in regular RFID calls.

In this work, we present an analytical model for both the RFID wake-up scheme and sleep schedules/random scheduling. Using a novel event-driven traffic model, the RFID scheme is compared to both random unsynchronized scheduling and synchronized sleep scheduling. The average power consumption and the delay of establishing either a point-to-point or multicast communication link is found in terms of the event rate and scope.

It was found that for low event rates, even under very low duty cycles, for sleep schedules/random scheduling, the idle listening power dominates the communication power consumption. An optimization is then performed, over the active duty cycle length and total duty cycle length, to find the operating curve of random scheduling in terms of power and delay.

The analysis for the RFID wake-up scheme illustrates the behaviour of RFID wake-up in terms of power and delay with different system and network parameters. In particular, two versions of RFID are examined. The first is a simple RFID, which only gives the capability to broadcast a wake-up signal to all of a node's neighbors. The second is a more advanced wake-up mechanism, where specific subset of nodes can be woken. Performance for all variants is found for different levels of robustness in the RFID system and the network density.

The poster, this abstract, and a list of references can be found at the following url:

http://www.stanford.edu/∼primoz/sigcomm04/