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Modeling Network Lifetime in a WSN using Visual Sense

Kepler

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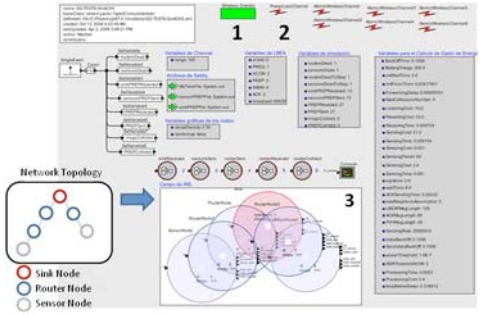
There are many QoS metrics that could be used to measure the performance of a network, but in a wireless sensor network -due to its battery power resource limitations-, its lifetime has become one of the most relevant metrics. Network Lifetime is used as an optimization parameter, where a larger lifetime will be better, but in some applications could be more interesting to consider it as a constrain, in order to warrant a minimum operation lifetime that enables the network to reach its goals [Min04], [Ami07]. The recent technology advances have enabled some devices to operate with common batteries in large periods of time from moths to years. Developing real experiments to evaluate the impact of implemented strategies on this time scale can be impractical. Due to this fact a better strategy would be to develop analytical or simulation model to determine if a Wireless Sensor Network would perform a reliable operation through the whole period of time that it will be needed.



The Whole Network Model

Identifying the Network Lifetime

The network lifetime could be defined as the amount of time that the network could remain fully active to develop its work. But, how can we determine the moment in time when a network starts to lose its fully operative state?. This happened when a sensor node spend its battery power, so it could not be able to sense more environmental data or to route any information that could come from other node.

This could mean that the network would lose a series of measured values, losing also, in that way, some operative grade. Because of this fact, the network lifetime could be defined as the smallest time that it takes for at least one node in the network to drain its energy beyond the point where it can function normally [Lal03].

In a real environment, the identification of the end of the network lifetime should wait until the notification of the death of a sensor is propagated from the dying node to the Sink, because of the distributed nature of a Wireless Sensor Network. However, in VisualSense [Bal04] simulator, we can use an extra Wireless Channel to receive the death notification. This new Wireless Channel should be defined without any range limitation, and should be used only to gather information about depletion of some node batteries in the whole network. This mechanism does not really model any physical functionality of the 802.15.4 network, but could be used to identify, in a simple way, the moment at which some node runs its battery out.

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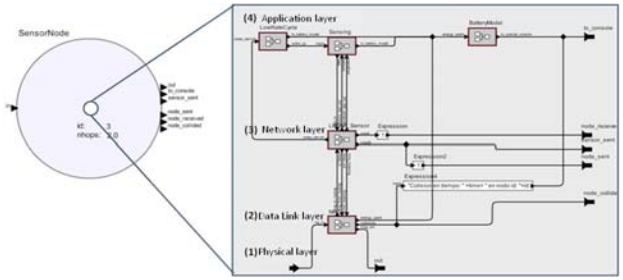
Modeling how a sensor node spends its battery

To estimate how much battery power is being spent during a node duty cycle, we follow a similar formulation to that used by Polastre et al [Pol04], but considering two different types of nodes: Sensor Nodes and Routing Nodes. A sensor node's duty cycle includes sensing a variable, building and sending information package, and finally, entering in a sleep mode, in order to save battery power until the next sense period start. A routing node's duty cycle includes the listening of the wireless medium, and for each effective data reception of a message, a forward should be made, to let the message continue its travel towards the Sink node. This model is also based on Stated -Based Dissipation Model (SEDM) [Min04].



A Wireless Sensor Node Model

Experimental Results and Conclusions

We conduct a series of experiment executing TinyOS 2.1 code to determine the node power operation cost. We measured how much battery power could be drained within sensing, listening, receiving and sleeping mode on a node, and made some estimation of long the execution of each operation will takes. To develop this experiment, we use some of the strategies described by Shnayder et al [Shn04] and by Landsiedel et al [Lan05].

Measuring some program battery spend to parameterize models

We have developed some simulation experiments that use an analytical model to define a sensing rate that enables a certain network topology to reach at least a pre-specified network lifetime. The simulation of this network under normal working situation confirms us that the selected strategies allow the network to reach at least the specified lifetime.

References

[Ami07] Amirijoo, M., Son, S. H., Hansson, J.: QoD Adaptation for Achieving Lifetime Predictability of WSN Nodes Communicating over Satellite Links. Fourth International Conference on Networked Sensing Systems INSS´2007. 6-8 June 2007. pp 19-26.

[Bal04] P. Baldwin, S. Kohli, E. A. Lee, X. Liu, and Y. Zhao, "VisualSense: Visual Modeling for Wireless and Sensor Network Systems," Technical Memorandum UCB/ERL M04/08, University of California, Berkeley, CA 94720, USA, April 23, 2004.

[Lal03] D. Lal, A. Manjeshwar, F. Herrmann, E. Uysal-Biyikoglu, A. Keshavarzian. "Measurement and Characterization of Link Quality Metrics in Energy Constrained Wireless Sensor Networks". Globecom 2003.

[Lan05] O. Landsiedel , K. Wehrle , S. Gotz, Accurate prediction of power consumption in sensor networks, Proceedings of the 2nd IEEE workshop on Embedded Networked Sensors, p.37-44, April 30-May 01, 2005

[Min04] R. Mini. "Prediction-based Energy Map for Wireless Sensor Networks" Doctorate Thesis on Computer Science on UFMG Brasil. 2004.

[Pol04] J. Polastre, J. Hill, and D. Culler, "Versatile low power media access for wireless sensor networks", Proc. ACM International Conference on Embedded Networked Sensor Systems, pp. 95–107, 2004.

[Shn04] V. Shnayder, M. Hempstead, B. Chen, and M. Welsh "Simulating the power consumption of large-scale sensor network applications", Proc. ACM International Conference on Embedded Networked Sensor Systems, pp. 188-200, 2004.