Daabaj, K., Dixon, M.W. and Koziniec, T. (2009) *Multihop routing reliability in wireless sensor networks.* In: The Tenth Postgraduate Electrical Engineering & Computing Symposium, 1 October, Perth, Western Australia.

Multihop Routing Reliability for Indoor Wireless Sensor Networks

Khaled Daabaj*, Mike Dixon, Terry Koziniec

School of Information Technology, Murdoch University
South street, Perth, WA 6150, Australia
*k.daabaj@murdoch.edu.au

***Summary*— Recent studies on a reliable energy efficient routing in multihop wireless sensor networks have shown a great reliance on radio channel quality in route selection decisions. If sensor nodes along the routing path and closer to the base station present a high quality link to forwarding upstream packets, these sensor nodes will experience a faster depletion rate in their residual energy levels. This results in a topological bottleneck or network partitioning. In this extended abstract, we present an empirical study on how to improve energy efficiency for reliable multihop communications by integrating additional useful information from different layers: e.g., residual energy level, link quality, and hop count. The proposed approach aims to balance the workload among relay nodes to achieve a balanced energy usage, thereby maximizing the operational network lifetime. The obtained results are presented from prototype real-network experiments based on the Mica2 (MPR400) wireless sensor platform developed by Crossbow Technologies Inc.** [1]**.**

I. Motivations

Wireless Sensor Networks (WSNs) can be invaluable in civil, environmental, industrial, and military applications for collecting, processing, and disseminating wide ranges of complex data. They have therefore, attracted considerable research attention in the last few years. For example, the SmartDust project [2] aims to integrate sensing, computation, and wireless communication capabilities into a small form factor to enable low-cost production of these tiny sensor nodes in large numbers. Sensor nodes are battery-driven, and hence operate on an extremely frugal energy budget and are highly energy constrained. Further, they must have a lifetime on the order of months to years, since battery replacement is not an option for networks with thousands of physically embedded sensor nodes. Energy optimization, in the case of sensor networks, is much more complex, since it involves not only reducing the energy consumption of a single sensor node, but also maximizing the lifetime of an entire network. The network lifetime can be maximized only by incorporating energy-awareness into every stage of wireless sensor network design and operation, thus empowering the system with the ability to make tradeoffs between energy consumption, system performance, and operational fidelity.

The low power design of individual sensor nodes devices is one of the most crucial aspects to reduce energy dissipation in wireless sensor network (WSN). Energy dissipation in a typical sensor node is compound of sensing, communication, and computation energies. However, it is important for the communication between sensor nodes to be conducted in an energy efficient manner as well. Since the wireless communication of data accounts for a major portion of the total energy consumption, energy management schemes that take into account the effect of inter-node communication yield significantly higher energy conservation.

Although the majority of WSN-related research activities have used computer simulations to demonstrate the benefits of employing various WSN routing protocols, simulations have limitations in emulating real low power WSN characteristics. Therefore the work done in this paper has been conducted on a real-world WSN by taking in account the irregular behaviour of wireless signal propagation, and how the real sensor device's behaviour affects a routing protocol's performance or even a device's rate of energy consumption. In low power WSNs, the unreliability of the links and the limitations of all resources bring considerable complications to routing. Even in the presence of static nodes, wireless channel conditions vary due to multipath fading effects [3]. Furthermore, tiny wireless sensor nodes are typically battery-powered, and ongoing maintenance may not be feasible. The progressive reduction of the available residual power needs to be considered as a crucial factor in the route selection process to control nodes' energy drain for the extension of the lifetime of the individual nodes and for the achievement of energy balancing in the entire network [4]. The testbed network was organised using nine identical tiny Mica2 sensor nodes in a grid of three by three with a single perimeter stationary base station.

II. Results and Conclusion

A series of lab experiments were carried indoor with different node spacing. Observations and results obtained from the experimental testing were presented and analysed using Matlab® scripts. Due to space limitations, a set of results is represented here. Although the indoor experiment was performed with stationary sensor nodes, the RSSI (Received Signal Strength Indicator) values have a tendency to fluctuate as shown in fig. 1, where the measurements presented here are average values from the packets that were received and do not imply a steady link with various packet sizes. Data transfer rate changes through multihop communications as demonstrated in fig. 2. As the number of hops increases the transfer rate or reception rate decreases linearly-like for constant transmission rate of 7Kbps as shown table I. Since the radio communication cost is a function of the distance transmitted squared [5], it can be observed from fig. 3 that the average power dissipated by the sensor nodes during their operation increases as the inter-nodes spacing increases.

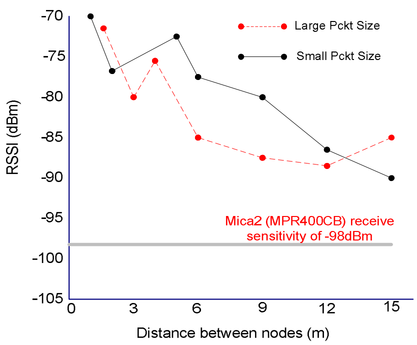

Fig. 1. RSSI readings vs. inter-node spacing

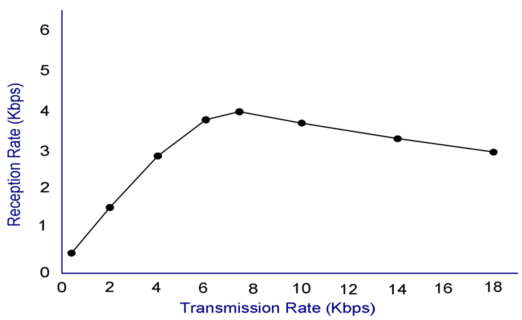

Fig. 2. Data transfer rate over multihop communications

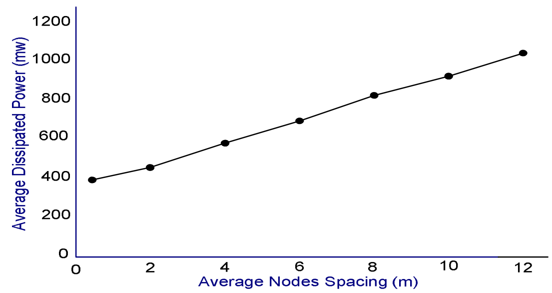

Fig. 3. Average dissipated power vs. nodes spacing

TABLE I
PACKET RECEPTION RATE VS. HOP COUNT

Number of Hops	Reception Rate (Kbps)
1 (Direct transmission)	6.34
2 (One relay node)	5.87
3 (Two relay nodes)	3.98

REFERENCES

[1] Crossbow Technology, Inc., http://www.xbow.com

[2] J. M. Kahn, R. H. Katz, and K. S. J. Pister, “Next century challenges: mobile networking for smart dust”, in Proc. Mobicom, pp. 483-492, 1999.

[3] L. Zhou; S. Zhou; Y. Yao, “Multipath Rayleigh Fading Channels in the Low SNR Regime”, ICC’06 IEEE International Conference, Volume 3, p.p. 1404 – 1409, June 2006.

[4] K Daabaj, M Dixon, T. Koziniec, “Experimental Study of Load Balancing Routing for Improving Lifetime in Sensor Networks”, in Proc. WiCOM’09, Beijing, China, Sept. 2009.

[5] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, “Energy efficient communication protocol for wireless micro-sensor networks”, in Proc. HICSS’00, Maui, Hawaii, pp. 3005 – 3014, Jan. 2000.