WiseFly Routing—Reliability and Self-organization for Wireless Sensor Networks

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Worldwide experiments using wireless sensor networks have shown that these networks exhibit high end-to-end losses. Inadequate routing protocols are the main cause of this unreliability. WiseFly is a proactive routing protocol based on the ideas of CTP and takes full advantage of the low power operation of WiseMAC as the MAC layer. It corrects the deficiencies of classical WSN routing protocols.

WiseFly routing is CSEM's answer to the industry's need for Wireless Sensor Networks with a higher autonomy, flexibility and reliability. It provides an improvement to the current communication protocol stack (WiseNET [1]) for networks that deliver critical information and therefore require a high service reliability. The protocol adds flexibility to the deployment and maintenance of the network by proactively and automatically handling locally changes such as broken links, adding or removing nodes and optimizing the current routes. Furthermore, local optimization of the topology enhances the scalability of the network.

Protocol Features

The protocol is inspired by the Collection Tree Protocol (CTP); a routing protocol that is considered as the state of the art in the area of self-organized routing for WSN. CTP has been shown to be very effective in providing a high reliability service while coping with the disturbances that a WSN may encounter in field deployments, providing Delivery Rates of 90-99.9% in 13 deployments [2]. CTP combines adaptive beaconing and an efficient link quality estimator. However, CTP heavily relies on broadcast information which is very costly in terms of energy.

WiseFly removes this limitation, adapts beaconing and improves the link estimation efficiency. High reliability is enabled by the accurate identification of high quality routes thanks to a novel metric and the reactivity provided by the beaconing mechanism. As in CTP, the metric takes into account the packet success rate. WiseFly improves further by including statistical information about the received signal strength.

The protocol achieves efficient energy consumption by adapting the period of neighborhood explorations to the connectivity conditions. Furthermore, the protocol takes full advantage of the low power operation of WiseMAC.

Operating Principle

The nodes perform an exploration to gather information about their neighborhood as follows (Figure 1):

1. A node transmits a predefined number of beacons
2. The neighbors with a route to the sink will answer with a route proposal and a cost metric value, calculated from the beacons received
3. The node will choose the best route based on the cost

Every node, except the sink, will repeat periodically the "Neighborhood Exploration" process to find and optimize the routes. The period is increased progressively to reduce the energy consumption and protect isolated nodes from depleting their battery.

The exploration is the only opportunity for a node to change the next hop. This ensures that the decision of changing the current route is well founded on recent and statistical information.

WiseFly does not rely on the data traffic for updating the topology, since it could be scarce in some applications. It also does not require snooping packets or reporting the route changes, which results in simpler mechanisms than CTP.

Experimental Performance

The protocol was tested with the WiseNET stack in OMNeT++ simulations of the embedded code. It provided a Packet Delivery Ratio of 99% in networks of up to 100 nodes.

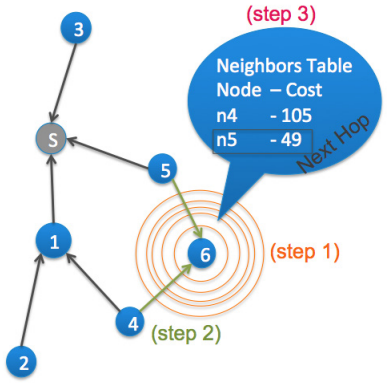

Figure 1: Operation diagram of WiseFly.

The same code was tested in a real deployment that consisted of 11 nodes at CSEM in Neuchâtel and lasted 5 days. Every node produced an application packet every 150s. All the nodes demonstrated a Packet Delivery Ratio of over 99%.

Application Domain

WiseFly is a promising solution for WSNs that convey sensitive information with reliability constraints in environments that are subject to change. Due to its self-organization capabilities and power efficiency, it is especially convenient for large scale deployments composed of hundreds of nodes that are difficult or expensive to access. This includes environmental, industrial and infrastructure monitoring. It also finds applications for IoT projects, such as home automation and body area networks.

[1] C. C. Enz, A. El-Hoiydi, J.-D. Decotignie, V. Peiris, "WiseNET: an ultralow-power wireless sensor network solution," Computer, 37 no. 8 (2004) 62

[2] O. Gnawali, R. Fonseca, K. Jamieson, M. Kazandjieva, D. Moss, P. Levis, "CTP: An efficient, robust, and reliable collection tree protocol for wireless sensor networks," ACM Transactions on Senor Networks (TOSN), 10 no. 1 (2013) 1