Competition: Smart Flooding with Multichannel for Industrial Wireless Sensor Networks

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Abstract

We present a robust and reliable protocol to disseminate events to specific destinations. We proposed a smart flooding method with multiple ranks mechanism and packet id checking to reduce retransmissions and routing loops. We also use multiple channels in order to be resilient to interference. Our routing mechanism is based on a loop avoidance method that disseminates packets in a manner that guarantees load balancing and low latency.

1 Introduction

Wireless sensor networks (WSNs) technology is attracting more attention with the emergence of the Internet of Things (IoT). With recent advances in wireless communications, it is necessary to realize the importance of low-power WSNs. However, low-power WSNs operating in unlicensed spectrum bands may suffer from unavoidable co-channel interference generated by other radio systems [1]. Some industrial control applications have motivation of adoption of low cost wireless systems in order to avoid using complex wired infrastructures. However, the unreliable nature of wireless communications in the unlicensed bands prevents selecting WSNs in industry. In this competition, we propose a communication protocol based on a flooding method. Our proposal supports ad hoc routing where any node can send data to any other node in the network. The routing protocol based on flooding will ensure data delivery to the final destination. Our protocol uses multiple ranks and multiple channels in order to reduce loops and resist against interference. In addition, it supports energy saving operation modes. In what follows, we will briefly describe the main characteristics of our protocol.

2 Multiple ranks mechanism

In [2], T. Winter proposed a rank mechanism for RPL (Routing Protocol for Low-Power and Lossy Networks) to avoid loops. However, this rank mechanism only supports convergecast scenarios with only one sink node. Therefore, we propose a multiple ranks mechanism to support scenarios with multiple sink nodes. In our protocol, each sink node (destination node) has a zero rank value, which represents the lowest rank value in the topology. Other nodes in the network will keep a rank list according to different sink nodes as shown in figure 1.

	Sink_1	Sink_2	...	Sink_n
Rank list	Rank_1	Rank_2	...	Rank_n

Figure 1. Rank list.

Sink / Neighbor	Sink_1	Sink_2	...	Sink_n
Neighbor_1	Rank_11	Rank_12	...	Rank_1n
Neighbor_2	Rank_21	Rank_22	...	Rank_2n
…	...	...	...	...
Neighbor_n	Rank_n1	Rank_n2	...	Rank_nn

Figure 2. Neighbor rank table.

This list will be broadcast to neighbor nodes as numeric metrics. When a node receives rank list information from its neighbors, it will construct a neighbor rank table, which is shown in figure 2.

Once a node receives a packet from a neighbor, it will do a query in its neighbor rank table to check the rank value Rank_ab (where a stands for neighbor id in the table and b stands for the sink id in the table) and do another query in its rank list in order to find its own rank value Rank_b (where b stands for the sink id in the table) according to a specific sink node. If Rank_ab is bigger than Rank_b, it means this packet is from a neighbor node with a higher rank and the node has to forward this packet. If Rank_ab is smaller than Rank_b, it means this packet is from a neighbor node with a lower rank and we need to drop this packet in order to avoid retransmissions and loops.

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3 Smart flooding with multiple ranks mechanism and packet id checking

Traditional flooding method suffers from high traffic congestion, retransmissions and routing loops. We implemented multiple rank mechanism in flooding to reduce loops. In addition, we introduced packet id checking in order to make further efforts on reducing multiple transmissions of the same packets. When a node forwards a packet for the first time, it will keep the packet id for this packet. If the node receives a packet that it has already sent according to packet id, it will drop this packet. Each node can store ten packet ids at the same time. When a node receives a new packet, it will replace oldest packet id with this newest packet id.

4 Resilience to Interference

External interference in the same frequency band leads to inter-network collisions that may cause packet loss and enlarge the delay of sending a packet. Using multiple channels helps to avoid external interferences, and thus decreases the probability of collisions. The use of multichannel protocols can improve the throughput and enhances the overall network performance. When multiple channels are used in the same network for communication, each node has to know the channel that its neighbor has chosen. This requires sharing information on channel allocation among neighboring nodes. We integrate multichannel with smart flooding in order to avoid congestion and packet loss. Its main contribution is improving the network throughput by flooding packets to sink nodes and meanwhile reducing multiple transmissions and routing loops.

5 Time Synchronization

Our protocol uses a relative synchronization mechanism that allows nodes to have a common reference time. This reference time is given by the root node and propagated to all the other nodes of the network. Special control frames will be sent periodically by the root node. The channel on which these messages are sent changes every time in order to avoid interference. The channel switching sequence is known to all nodes.

6 Experimentation platform

Many network simulators exist such as NS2, NS3, OMNeT++, Cooja, TOSSIM, etc. We chose to use Cooja simulator for protocol verification before testing our contribution on the competition platform. It is an emulator for Contiki system. It is compatible with real hardware and the simulation code can be used on real sensor nodes hardware. We made some modifications on the default parameters of Cooja in order to make it more realistic, especially when it comes to emulating signal propagation. There are four propagation models in Cooja. One of them is Multi-path Ray-tracer Medium (MRM) which takes reflections and refractions into account to simulate real environment. In order to make it more suitable for urban and unstable environments, we included a random behavior to its path loss calculation.

7 References

[1] Han, J. S., & Lee, Y. H. (2016). Interference-Robust Transmission in Wireless Sensor Networks. Sensors, 16(11), 1910.

[2] Winter, T. (2012). RPL: IPv6 routing protocol for low-power and lossy networks.