Competition: Using OF∂COIN under Interference

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Abstract

Delivering critical information timely and reliably in narrow-band and power-constrained wireless sensor network is challenging, not to mention under interference. We propose Oriented Flooding protocol with Partial COnstructive INterference (OF∂COIN) to propagate the packet in time and dependably. A channel-hopping scheme, constructive interference, capture effect and an easy topology model are all utilized in our protocol to achieve better performance.

1 Introduction

Messages communicated between two off-the-shelf IEEE 802.15.4 devices within the range are able to survive if the received signal is stronger than interference or interference halts. Since the interference is stochastic and unknown, transmitting message until the channel is clean costs time. So we introduce constructive interference into our protocol to strengthen the received signal.

The network with constructive interference is full of identical radio waveforms transmitted from nodes synchronously at one slot, like Glossy[3] and RedFixHop[2]. The same waveforms probably increase the signal strength at the receiver because they are superimposed with each other constructively. Same waveforms mean same packets. The receiver cannot distinguish the proper packet from the others. However, the competition task is a one-to-sink application, the initiator, which generates information, or relays need to know whether the next hop has received the packet successfully to determine the next action (retransmission or sleep to save energy). So we make a partial constructive interference, i.e., the first part of packets are same and the remaining are different. Received signal is superimposed and enhanced due to the same part. Capture effect happens when signal becomes discrepant.

Partial constructive interference capacitates nodes to add various data, i.e. topological information, to the packets. Since the deployment of nodes is unknown, this mechanism can make sure that messages are disseminated toward the sink. The process of broadcast will not be aborted after the message reaches an isolated node far from the sink.

We assume that the noise is distributed uniformly in channels. But practically, we can always find a relatively clean channel at one moment. In an attempt to improve the robustness, a channel hopping scheme exists in the protocol.

From these considerations, we propose Oriented Flooding protocol with Partial COnstructive INterference (OF∂COIN).

2 OF∂COIN

This protocol realizes a partial constructive interference propagation to the sink in multi-bands. The main operating flow is as follows (as illustrated in Figure 2):

As initiator:

1. detects event;
2. waits the timer expired and wakes up;
3. scans the three candidate channels and fixes on the cleanest one;
4. starts to transmit one packet on three channels respectively in a predeterminate order. For instance, assuming locking the channel on the channel 3, the transmitting starts with channel 1, then channel 2, 3 and back to channel 1.
5. returns to the locked channel(for example 3), and starts to listen; turns off the radio if the node has retransmitted once (twice if necessary);
6. turns off the radio if the node received a valid packet; retransmits (go to 4) after receiving an invalid packet; re-scans channels and retransmits (go to 4) if it listened nothing until timeout (4 slots).

Relay's operation is similar to the initiator's. It starts with 2. Another difference is the timeout in 6, which is a random variable at least 4 slots when the node works as a relay. Sink's flow is simpler than the relay's. Sink also begins with 2 and turns off the radio directly in 5. The times of continuous transmissions on channels in 4 depends on the spatial density of nodes. An easy topology model based on slots will be established during the preparation period (first 15 seconds) of the competition through two broadcasts initiated by the sink and the initiator respectively.

We will make further explanations in the following.

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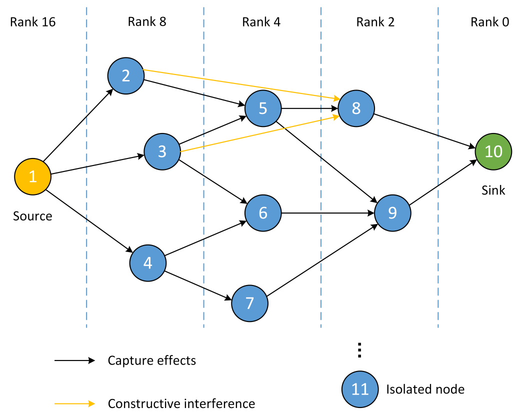

Figure 1. Oriented flooding avoids isolated node problem.

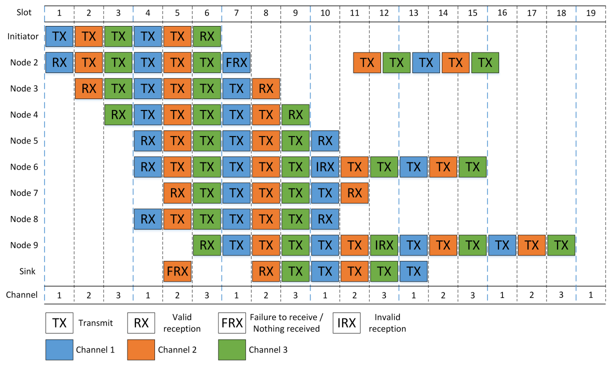

Figure 2. Timing diagram.

2.1 Oriented Flood

For dense and small network, broadcast, which is easy implementation and will not consume much power, is an excellent choice. However, extra power may be expended when the network become sparse. Messages will be delivered to the isolated node which is far from the sink. Other nodes which have transmitted and listened to valid repetitions successfully will turn off their radios to save energy. The isolated node cannot communicate with the sink straightly and all nodes around it have turned off as depicted in Figure 1. The **isolated node** problem will abort the broadcast process unexpectedly.

Therefore we designed an easy method to calculate the rank value which is estimated according to time slots instead of hops. The relay will turn the radio off prudently only if it receives a packet from the node with valid rank.

Another attribute of sparse network is that messages will not benefit from constructive interference so much, which means it is not so easy for nodes to skip intermediates by transmitting identical messages synchronously. But experiences show that when several nodes are deployed sparsely in space, constructive interference still makes link quality steadier. So constructive interference along the main disseminating path is adopted.

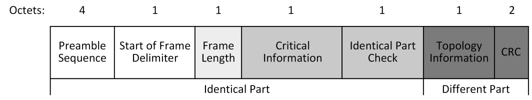

Figure 3. Partial constructive interference frame structure.

2.2 Partial Constructive Interference

We designed a special frame which will be prone to form constructive interference partially as Figure 3. Each packet has the identical part (first part) and the different part (the rest part). Identical part consists of preamble, synchronous word, length, critical info and identical part check. Different part contains the topology info of each nodes and CRC of the whole packet. Identical part of packets will overlay and strengthen the signal at the receiver as long as they are transmitted synchronously. The receiver's RF chip gets synchronized and start to receive during the identical part. Capture effect will work at the moment that discrepancy occurs but the receiver will continue receiving the remaining different part. Sometimes the different part may not receive correctly, particularly when the distances between the receiver and initiator or relays are approximate. But the different part is used to avoid isolated node problem and save energy as mentioned in 2.1 and the most critical information is in the common part which can be received exactly generally.

2.3 Channel Hopping

Three channel candidates which are away from each other are hardly interfered at one moment according to [4]. We also assumed that the noise strength around the environment will not change drastically during a very short period (1-2ms). Thus three channels have been selected in our protocols. Relay nodes will scan the three channels whenever they wake up and lock listening channel on then best one. After forwarding messages, the relay will return to the previous locked channel.

2.4 Duty Cycling

We apply the synchronous radio duty cycling similar to Glossy[3] after a comprehensive trade-off between the synchronous and asynchronous as ContikiMAC[1] in the view of energy efficiency and latency. Constructive interference will perform better when the number of awake nodes is more because it may reduce some hops or make the link steady at least. Nodes will turn off the radio immediately once forwarding messages successfully (transmitted messages and received a valid packet as illustrated in Figure 2).

3 References

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