Competition: RedFixHop with Channel Hopping

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Abstract

A constructive interference (CI) based flooding mechanism, using hardware-generated acknowledgments (ACKs), is proposed to achieve highly reliable source-to-sink communication of very short critical packets within a wireless sensor network (WSN) working in harsh environments. CI is achieved only when the senders synchronize their packet transmissions with sub-microsecond precision. In order to achieve the required synchronization accuracy, the packet retransmissions at the relay nodes are triggered by using hardware ACKs. To further increase packet reception probability, channel diversity is exploited using a predefined hopping sequence. The protocol performance is experimentally evaluated by implementing it using IEEE 802.15.4 radio transceivers.

1 Introduction

RedFixHop was created to compete at the Dependability Competition of the International Conference on Embedded Wireless Systems and Networks (EWSN 2016), where it took First Place [1]. It also won Best Demo at the IEEE International Conference on Sensing, Communication and Networking (IEEE SECON 2016) [2].

The protocol exploits constructive interference (CI) and the capture effect [3], like Glossy [4], Splash [5], Sparkle [6] or Disco [7]. The idea was to create an efficient mechanism to disseminate short messages with optimal latency and high reliability in a one-to-all or source-to-sink scenario with multiple hops (Fig. 1).

RedFixHop's main innovation is the usage of hardware acknowledgements (ACKs) to propagate the message within the network. Hardware ACKs are usually implemented in IEEE 802.15.4 radio transceivers [8]. ACKs are controlled autonomously by the radio, without interferences from the firmware running in the microcontroller, that usually has a slower clock. This avoids hard-to-predict firmware delays and jitter that occur in software-initiated transmissions and might destroy the tight synchronization needed to achieve CI [4].

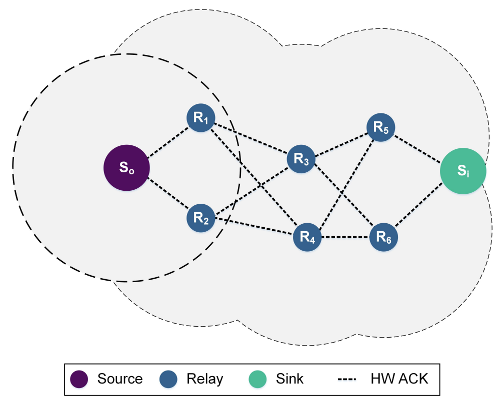

Figure 1. Source-to-sink communication with multiple levels of intermediate relays

This year we present an optimized version of the protocol which, as a major novelty, exploits channel diversity to increase packet reception probability.

2 RedFixHop

The flooding mechanism uses synchronous radio duty-cycling based on periodic active bursts (Fig. 2). Only one source-to-sink message is transmitted in each burst. Between the flooding bursts, the radio of the nodes can be turned off to save power. The time between flooding slots is application-dependent, taking into consideration the existing trade-off between latency and energy consumption [9].

RedFixHop works as follows (Fig. 3):

1. Every node is synchronized to turn its radio on at the beginning of the flooding period.
2. The transmission source sends the packet in the main

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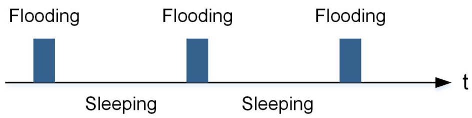

Figure 2. Synchronous radio duty-cycling mechanism

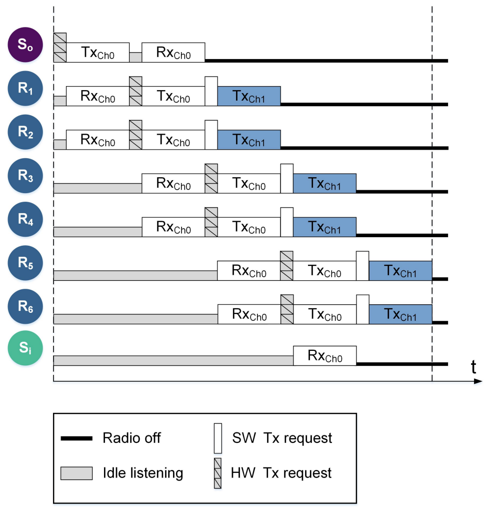

Figure 3. RedFixHop protocol

channel.

3. All the relays receiving the original packet from the source transmit it immediately, using hardware ACKs; potentially interfering constructively or exploiting the capture effect [3]. Immediately after, they also send the packet in an auxiliary channel, to introduce channel diversity.
4. The radios switch off until the beginning of the next flooding cycle.

The source selects as main channel the one in which a reply is received from a relay. Every relay listens cyclically in a predefined channel sequence until it receives a valid packet. Then, this channel is selected as main channel and the radio duty cycling starts.

3 Simulations

In order to optimize the existing trade-off between reliability, latency and power consumption, we plan to build a system model of the competition scenario. Jammer models are obtained from JamLab [10], the source generates a light toggle with a period of no less than 1 seconds and the channel gives the path loss with variance derived from indoor measurements with 802.15.4 transceivers (Fig. 4).

The parameters, which will be adjusted in the simulations, are the number of used channels and of transmissions per channel. For example, we want to analyze if it is better to transmit the signal toggle from the source 3 times on 3 channels or 1 time on 9 channels. This way, we can find the optimum trade-off between energy, latency and reliability for different given scenario (number and placement of nodes and jammers).

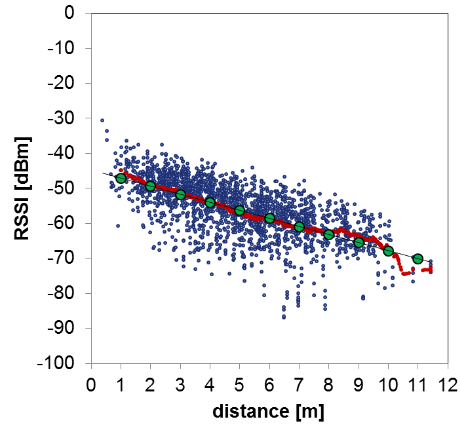

Figure 4. Indoor 802.15.4 channel model

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