Competition: Using Enhanced OF∂COIN to Monitor Multiple Concurrent Events under Adverse Conditions

Xiaoyuan Ma[1,3], Peilin Zhang[4], Weisheng Tang[1,3], Xin Li[1,2], Wangji He[1,2,3], Fuping Zhang[1], Jianming Wei[1], Oliver Theel[4]

1. Shanghai Advanced Research Institute, Chinese Academy of Sciences, China
2. ShanghaiTech University, School of Information Science & Technology, China
3. University of Chinese Academy of Sciences, China
4. Carl von Ossietzky University of Oldenburg, Germany

{maxy, tangws, lixin01, hewj, zhangfp, wjm}@sari.ac.cn

{peilin.zhang, theel}@informatik.uni-oldenburg.de

Abstract

Monitoring various states of multiple nodes reliably and timely in narrow-band and power-constrained wireless sensor network is extremely challenging, not to mention in existence of interference. An enhanced Oriented Flooding protocol with Partial COnstructive INterference (eOF∂COIN) is proposed to collect the states of sources via many-to-many communication. Basically, eOF∂COIN is based on two phenomena, i.e., constructive interference and the capture effect. To boost the dependability against interference, eOF∂COIN further exploits a channel-hopping scheme. Furthermore, eOF∂COIN maintains a light-weight topology model to achieve oriented many-to-many communication.

1 Introduction

Data packets can be received correctly by a commercial IEEE 802.15.4 device, if the wireless signal 1) is stronger than noise, or 2) is diverse from noise in the domain of time or frequency. In terms of the time domain, transmitting messages when the channel becomes clear is intuitive. It is easy to be implemented via low-power medium access control (MAC) mechanisms with clear channel assessment (CCA) such as ContikiMAC [1]. However, it might not be the best choice since distinguishing a wireless signal from noise is quite challenging for CCA. Moreover, differentiating a signal from noise in the time domain, e.g, wait-and-transmit, introduces latency as most of unknown interference is stochastic. Therefore, our enhanced Oriented Flooding protocol with Partial COnstructive INterference (eOF∂COIN) wakes up all devices globally without CCA and makes the signal as strong as possible (using constructive interference) in different channels (using a frequency hopping mechanism) to avoid the noise. In the given scenario, which is more complicated than the scenario in EWSN Competition 2017, multiple sources need to be monitored and the data should be reported to several destinations in real-time. The observed 8th pin of each source is required to be *OR*ed together in every destination, i.e. many-to-many communication. The states of other pins are sent to the designated destination hop-by-hop, i.e. in one-to-one communication. However, it is necessary that the one-to-one message is replicated on other routes in the network to achieve reliability in spite of consuming more energy such as opportunistic routing [4], MOR [8] and Glossy [2]. Therefore, eOF∂COIN, a many-to-many scheme, is applicable in this scenario to achieve high reliability and low latency.

2 Enhanced OF∂COIN

2.1 Oriented Flooding

An off-the-shelf IEEE 802.15.4 transceiver can be triggered to start recording the wireless signal when the preamble is strong enough and the rate of successful reception can be increased [2, 3]. OF∂COIN [5] is an approach which affords feedback. That is, different information which is located at the end of the packet can be transmitted via the capture effect after the constructively interfered identical information. The feedback including the rank of the receiver, which represents how far it is from the given node, allows the flooding to be oriented. If the given node is the destination node, then it can make messages propagate in the right direction as shown in Figure 1. Nodes decide whether it is in the yellow area in Figure 1 by calculating the ranks to the source and the destination. Gray nodes outside the yellow area will not participate in the communication and sleep. Green nodes on the routes, i.e., inside the yellow area, turn off the radio immediately to save energy once having successfully forwarded the received messages. In this scenario, nodes in colorful blocks relay messages and others sleep as shown in Figure 2. eOF∂COIN reserves the oriented flooding from the original protocol. Besides, it is improved with respect to many-to-many mechanism, message synchronization, frequency hopping and network scalability.

International Conference on Embedded Wireless Systems and Networks (EWSN) 2018
14–16 February, Madrid, Spain

ISBN: 978-0-9949886-2-1

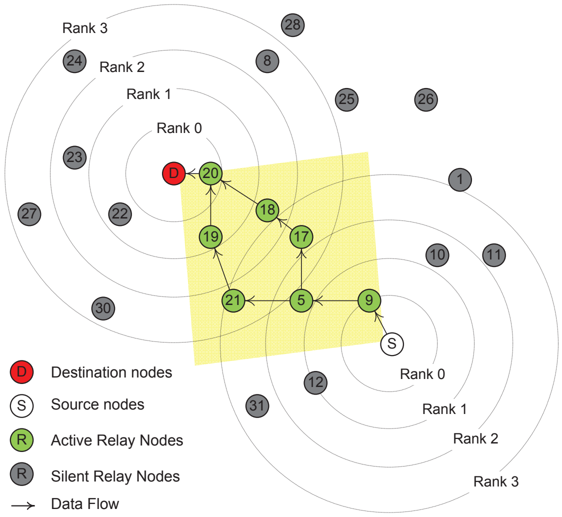

Figure 1. Oriented flooding.

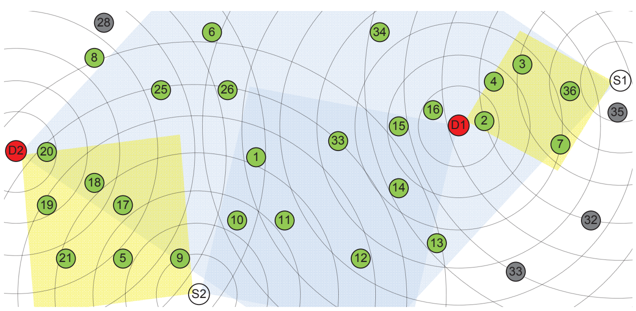

Figure 2. Oriented flooding with multiple sources and destinations.

2.2 Many-to-Many Mechanism

As mentioned above, we need to add the many-to-many characteristic to the original OF∂COIN protocol. Each source fills its states of pins in the private information field (shown in Figure 3) to inject its own information to the network. The lengths of the public information and private information are to be determined by the overall number of sources. Relay nodes mix their private information field to the common information field. All nodes, i.e., sources, relays, and destinations, fill their own rank in the topology information field that are calculated during the set-up phase. The identical part and the different part of one packet could be checked separately.

Octets:								
4	1	1	TBD	1	TBD	1	1	2
Preamble Sequence	Start of Frame Delimiter	Frame Length	Public Information	Identical Part Checksum	Private Information	Topology Information	Different Part Checksum	Footer/ CRC
Identical Part					Different Part			

Figure 3. Frame structure of eOF∂COIN.

2.3 Message Synchronization

Since the states of 8th pin on the sources are required to be *OR*ed in all destinations, all the messages in the network should be highly synchronized, as depicted in Figure 4. Packet loss, delay, or jitter in the network could lead to asynchronous messages, which can induce errors. Every sample of sources is marked and related with each other. The *OR* operation is not executed if the 8th pins of other sources are out of date.

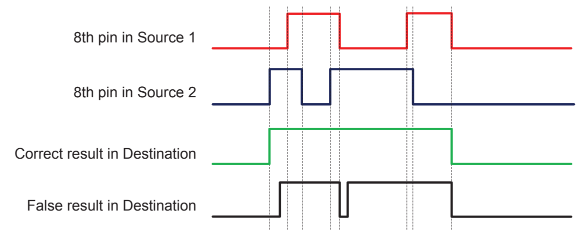

Figure 4. ORed messages are required to be synchronized in the network.

2.4 Hopping More in Frequency

The hopping frequency sequence in the original OF∂COIN protocol is only of length three. Although three channels are well selected so that they can hardly be interfered at the same time, the performance is still affected when the noise reaches the strongest level, according to our experience from the previous EWSN competition. We intend to extend the sequence appropriately to ensure the reliability during strong interference. The timing is similar to the one used in the original protocol [5].

2.5 Scalability

As mentioned in [6] and [7], concurrent transmissions in large-scale and dense networks induces failed reception. In order to avoid false-positive cases as they have occurred last year, we adopt additional methods, such as transmitting power control to limit the density of concurrent transmissions in the network.

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