Competition: Alternating Multicast with Aggregated Data Collection in Wireless Sensor Networks

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Abstract

We present a reliable and energy-efficient data collection (R2EDC) protocol for condition monitoring in wireless sensor networks. The R2EDC protocol applies data aggregation on the collected data and transmits the aggregated data using an alternating multicast data transmission approach. In this way, the R2EDC protocol aims to: (1) reduce the length and the number of messages carrying the collected data, (2) provide reliable data delivery, even when one or more forwarding nodes fail, and (3) give similar energy costs as unicast data transmissions.

1 Introduction

Wireless sensor networks (WSNs) have been widely researched over the past few decades. This has led to the development of several interesting WSNs applications in a range of domains. WSNs are often used in such applications when wired alternatives are either too expensive or difficult to implement, e.g. in regions where access is not easy (e.g. underground mining, battlefield etc.). The prime concerns in developing such applications are reliable data delivery to the base station (BS) and low energy costs on the sensor nodes. We propose the R2EDC protocol for reliable and energy-efficient data collection in category 1 of this competition. The protocol is designed by using data aggregation, along with alternating multicast. The following sections briefly describe the approach taken in the design of the R2EDC protocol.

2 Data Aggregation

In [4], we proposed an Aggregation based Topology Learning (ATL) protocol that learns the routing topology of a WSN, as an integral part of the data collection and aggregation process in the network. Here, a topology coding method is used to collect and aggregate the routing topology data in such a way that it can be carried in length-constrained messages.

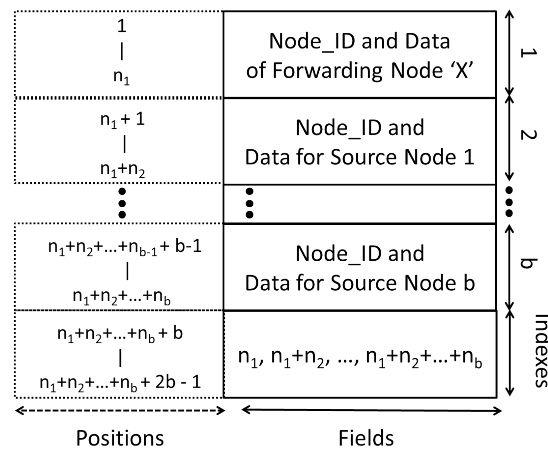

Figure 1. Data Structure used in the R2EDC Protocol.

In the R2EDC protocol, we use the same approach to collect and aggregate sensor node readings. More specifically, the R2EDC protocol performs data aggregation, on the collected data, in three cases: (1) a forwarding node receives readings from multiple source nodes, (2) a forwarding node receives multiple readings from a single source node, and (3) a forwarding node is a source node itself. The data structure for the R2EDC protocol is shown in Figure 1, where a forwarding node 'X' collects data from 'b' source nodes, including itself. The 'b' rows specify the node id and data contained in each 'Branch'. There is no fixed length for a branch, as sensor node readings are of different lengths. To separate these branches from each other at the destination node, the last row carries the index for the last position in each branch.

With this approach, we aim to reduce the length and the number of messages, carrying the collected data, in R2EDC protocol.

3 Alternating Multicast

In [3], we proposed the idea of an alternating multicast approach for data transmission in WSNs, as an optimal tradeoff between the reliability and efficiency properties of the unicast and broadcast data transmission approaches. The ap-

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proach is called alternating multicast, as a node sends its data to two or more forwarding nodes in an alternating fashion.

Figure 2 shows the working of the R2EDC protocol, where each node switches between two forwarding nodes. When there are no failed nodes in the network, the alternating multicast approach gives similar energy costs as that for unicast data transmissions. On the other hand, when a forwarding node fails, the source nodes use the other forwarding node to transmit their data. This provides reliable data delivery even with failed nodes in the network.

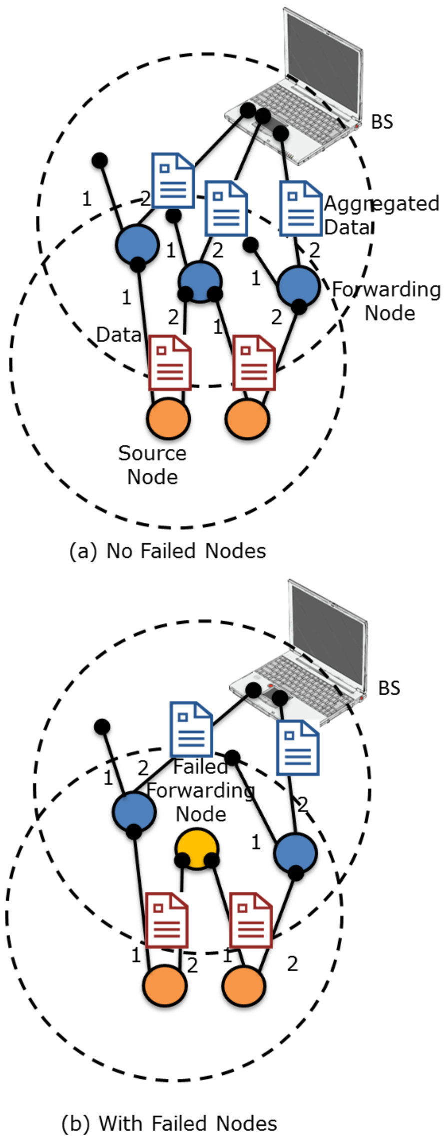

Figure 2. Working of R2EDC Protocol.

4 Experimentation Platform

We have used a nesC implementation of the Collection Tree Protocol (CTP) [1], present in the standard TinyOS installation, as a foundation for our implementations. For the evaluation of the implementations, we have used the Cooja simulator [5], as well as the FlockLab testbed [2]. These evaluations have been carried out under different network topologies and different network conditions. With these evaluations, we have determined the energy costs, data delivery ratios, data collection time and message lengths for the implementations.

5 References

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