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Increasing QoS Parameters in WSNs through Spiral-Based Clustered Architecture

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Abstract

Wireless sensor networks composed of individual nodes that are able to interact with the environment by monitoring or sensing physical parameters. However, these sensors are deployed randomly and in large scale which creates a huge number of redundant sensed data which saturates network resources and consumes nodes energy. Many applications of WSNs require Quality of service (QoS) in terms of high bandwidth for real time applications including multimedia audio and video without much delay. In this scope, and to reduce the number of transmitted packets to sink node, data aggregation may be effective technique, which is a critical function of WSNs. The main goal of data aggregation algorithms is to gather and aggregate data in an energy efficient manner so that network lifetime is enhanced, and bandwidth reserved for each node maximized. Eliminating collisions and idle listening for low energy consumption in the network is a crucial issue which will be done by the use of deterministic access protocols as TDMA which are more power efficient since nodes in the network can enter inactive states until slot times will be assigned to them. Our contribution focus on maximizing bandwidth reserved for each sensor node. In this paper we present a Spiral-Based Clustered with Data Aggregation (SBCDA) architecture approach combining data aggregation with TDMA protocol in WSNs for improving connectivity and avoiding inter-cluster collisions and to increase bandwidth reserved for each sensor node, by computing the length of the superframe generated by all sensor nodes in the network. We conclude with possible future research directions in affecting each time slot to each sensor node.
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Keywords: Spiral-based architecture; Data aggregation; TDMA; Bandwidth; superframe length; time slot; real time

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1. Introduction

Wireless sensor networks are very attractive because these networks enable promising applications, but there are many system challenges to resolve[1] like the limited communication bandwidth of the sensors, energy, that is an essential problem since sensors are usually battery-powered, and in some emergency applications, a short time of data collection is also required, and to satisfy the above requirements, TDMA is a good choice towards such a data gathering sensor networks. Saving energy is done by eliminating collisions, avoiding idle listening, entering inactive states where another sensors transmit there packets, bounding the delays of packets which is important for the time-driven data aggregation[2] and guaranteeing reliable communication, which is maintained by TDMA protocol, as a collision-free access method.

Clustering in WSN[3] is the process of grouping the sensor nodes in a densely deployed large-scale sensor network. In cluster based environment, data aggregation is the way to combine and compress the data belonging to a single cluster. The process of clustering in a wireless sensor network is constrained by: the number of clusters that should be formed which may optimize some performance parameter, the number of nodes should be taken into a single cluster and the Cluster Head selection procedure in each cluster. Another issue where user can select some more energy-powerful nodes in the network to act as a Cluster-Head and other simple nodes acts as cluster-member only[4].

An essential paradigm for wireless routing in sensor networks which is put forward called “Data aggregation”[5,6]. The idea is to combine the incoming data from different child nodes eliminating redundancy, minimizing the number of transmissions and thus saving energy. This paradigm shifts the focus from finding short routes between pairs of addressable end-nodes (address-centric) to finding routes from multiple sources to a single destination that allows in-network consolidation of redundant data (data-centric)[7].

Our contributions are as follows. First, while generating new clusters in spiral architecture, each cluster had only two nodes, cluster head “CH” and cluster member “CM”. Second, after completing the cluster formation, all CMs of 3-hop away clusters can concurrently transmit data to their respective CHs without inter-cluster collision.

The rest of this paper is organized as follows. In section 2, we present some related works about bandwidth assignment in WSN, real-time data aggregation and communication protocols as TDMA model. System model and problem statement are presented in section 3. Simulations are presented in section 4. Section 5 concludes this paper.

2. Related work

Dawood K. et al[8] address the problem of allocating and reconfiguring the available bandwidth by designing and analyzing wireless sensor networks in a versatile manner. The framework proposed applies probabilistic and component-based design principles for the wsn modelling and consequently analysis; while maintaining flexibility and accuracy.

In our previous work[9], we present a new approach combining data aggregation with TDMA protocol in Tree-Based Clustered Data Aggregation WSNs (TBCDA), by minimizing the huge number of transmitted packets to the sink node. Each cluster head (CH) collects and aggregates, (according to an aggregation function) received packets from its child nodes in its cluster, before transmitting the resulting packet (aggregation result as a single packet) to its parent, until the data reaches the sink node.

Pengye X. et al[10] investigates the issue of how to assign bandwidth to each description in order to maximize overall user satisfaction by formulating it as an optimization problem, with the objective to maximize user bandwidth experience by taking into account the encoding inefficiency due to MDC.

The problem of performing timely detection of events by a WSN is tackled in[11]. Nastasi C. et al. propose a real-time bandwidth allocation mechanism for IEEE 802.15.4 that maximizes event detection efficiency and reduces statistical uncertainty under network overload conditions. On-line strategies complement off-line guarantees to enhance the confidence level of the measurements. A distributed compressive sparse sampling (DCSS)[14] algorithm is proposed for data aggregation to solve the problem of recovering the n-dimensional data values, which is based on sparse binary Compressed Sensing/Compressive Sampling (CS) measurement matrix.

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