Chapter 93
Energy Efficient Data Transmission Mechanism in Wireless Sensor Networks

Seong Cheol Kim, Jun Heon Jeon and Hyun Joo Park

Abstract In dense deployments of sensor nodes in a Wireless Sensor Networks (WSNs), sensors are spatially correlated and they may sense same information and send the same information to its sink node. So each sensor node wastes energy in transmitting redundant data. Furthermore, sensor nodes near sink node may treat more data and use more energy than other node. In this paper we propose a energy efficient data transmission mechanism which reduces redundant data transmission and saves node energy. Using modified RTS control frame of IEEE 802.11 MAC and direction information of received data packet, each sensor node may drop its measured redundant data. Results have shown that our data transmission mechanism outperforms other mechanisms in terms of energy saving and amount of data traffics.

Keywords MAC · Protocol · Wireless sensor networks · Data gathering · Clustering · Energy efficient

93.1 Introduction

Wireless sensor networks (WSNs) consist of lots of small sensor nodes with a limited processing power, storage and energy capacity. Each sensor node is usually battery powered and it is not easy to replace the battery. So it is necessary to use

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sensor energy efficiently to extent the network life time. Many research works have been done on saving sensor node energy [1–8]. One of effective ways to reduce energy consumption is to implement low power technique at Medium Access Control (MAC). Current MAC design for wireless sensor networks can be classified into two categories: contention-based protocols and TDMA protocol. The advantages of contention-based protocols are the low implementation complexity, the ad hoc nature, and the flexibility to accommodate mobile nodes and traffic fluctuations. But the major advantage of frame-based TDMA protocols is the inherent energy-efficiency due to the lack of collisions, overhearing, and idle-listening overheads.

WSNs have a wide range of potential applications including habitat and environment monitoring, military, health-care industry, and transportation. Each sensor node detects, measures, and senses, then send data to sink node or base station. So sensor nodes near sink node take part in the operation, because many data from around networks converge to the sink node. So load balancing data transmission mechanism is required. In this paper we proposed a energy efficient data transmission mechanism. The basic idea of this mechanism is to reduce duplicated data transmission. In WSNs many sensor nodes may collect same data when a event occurs and try to send the collected data to its sink node. In the proposed data transmission mechanism, only one node send data to sink node and other nodes give ups to send data. Overhearing information from neighbor node and direction information of received packets are used for this purpose.

The rest of this paper is organized as follows. In Sect. 93.2, we discuss related works and Sect. 93.3 presents the details design of the proposed data transmission mechanism. Section 93.4 presents a performance evaluation of the data transmission mechanism. Finally, in Sect. 93.5, we present our conclusion.

93.2 Related Works

Some data collection mechanisms are based on spatial and temporal correlation in sensor networks, others use energy efficient clustering, and routing based on correlation in sensor data. There also some data collection mechanisms which are based on tree structure for collecting data. But almost of data collecting mechanisms focus on network lifetime and energy saving. The Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol [9] is one of most famous mechanisms so far. The LEACH uses a random approach for selecting cluster head and distributing energy consumption among sensor nodes in the cluster. Cluster head collects data from all nodes in the same cluster and send the collected data to other cluster head. So cluster head spends lots of energy compared to other member nodes. Cluster head will be changed to other node to extend network life time. A dynamic and distributed cluster head selection algorithm based on two level clustering schemes was proposed in ETEP [10]. Cluster heads at each level are selected on the basis of probability function considering the residual energy and distance factor was presented in An Energy Efficient Multi Level Clustering (EEMC) [11]. Hierarchical routing like LEACH is an efficient method for reducing energy consumption within a cluster, and by performing data aggregation, it decreases the number of transmitted data packets to the base station. In OBMAC [12], it is assumed that sensors are spatially correlated and they may sense and send the same information to the sink. So using overhearing mode, many sensor nodes stop to send redundant data. But in OBMAC each node do not consider relayed data from its neighbor node. So a relayed data may be dropped in OBMAC mechanism.

93.3 Energy Efficient Data Collection MAC Protocol Design

In the Energy Efficient Data Collection method, only one of the duplicated measured data by some sensor nodes is transmitted to sink node. All other nodes except a selected node give ups to send their data packet so unnecessary data transmission can be avoided. The data collection process is shown in the Fig. 93.1. The Fig. 93.1 shows a wild-animal habitat monitoring application. The sensor nodes detect wild-animal appearance and report to base station. In Fig. 93.1, the node A and B measured data of event 1 (wild-animal show up) to send and try to send the measured data to relay node. We assumed here that node A and B are in the same transmission area. So the measured data are the same. If node A gets permission to send its data packet, node A sends measured data to node E. Then node B also knows the transmission by overhearing. So node B will gives up to send its data packet, because the node considers the node A's data packet as the same data.

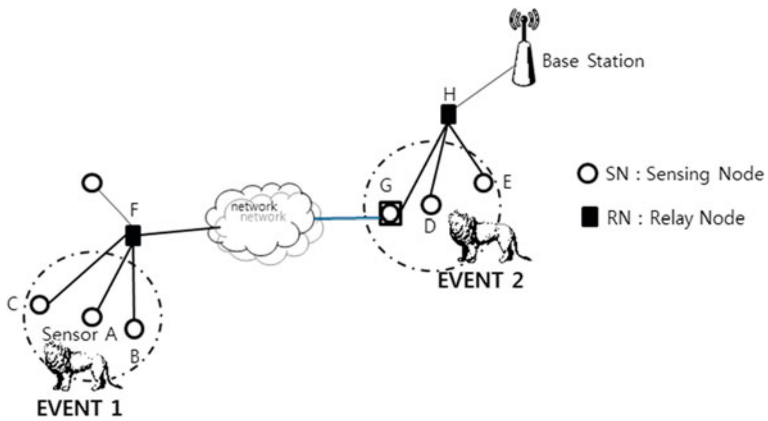

Fig. 93.1 A wild-animal habitat monitoring application

When event 2 occurs, node F and C will detect the event. In this case node F may have two types of data packets. One is a relayed data packet from the network 1 and the other one is measured packet by itself. If node C transmit its data packet to node G, then the node F will know that through overhearing, drop its measured data packet, and try to send the relayed packet soon. Since only one sensor node sends data packet to the sink node, the amount of data traffic will be decreased compared to the legacy data transmission mechanism. If there are many nodes in the same transmission range of the occurred event, the proposed data transmission mechanism overwhelms other mechanisms.

Two types of data packets are used in the mechanism. This One is measured data packet and the other is relayed data packet. Using modified RTS and CRS control packets, two types of data packets are differentiated. The frame formats are described in the next subsection. All sensor nodes may play as a sensing node or relay node. If a sensor node receives any relayed data packet from its neighbor node, the sensor node try to send the received packet. But if s sensor node receives measured data packet from its neighbor node, then the sensor node gives up to send the measured data packet. Receiving a measured data packet means that its neighbor node already have sent the same packet to its sink node. In other words, after receiving a measured data packet from its neighbor node, a sensor node deletes its data packet from the buffer.

93.3.1 Frame Format

Control frame formats of the proposed data transmission mechanism are shown in the Fig. 93.2. Two types RTS control frames are used. One is for measured or sensed data and the other is for relayed data. The reserved subtype field of the IEEE 802.11 frame control frame is used for this purpose. With 1000 (8) subtype field presents measured or sensed data packet and control frame with 1001(9) means a relayed data.

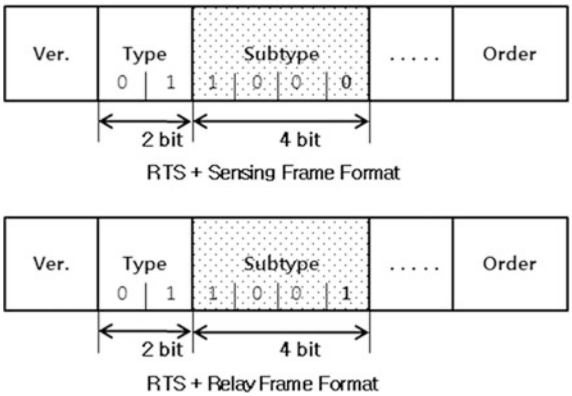

Fig. 93.2 Control frame formats

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1: Sensor : Data Generation
2: Sensor : Sense Carrier
3: Sensor : if Data_Pkt == Sensing
{ send RTS_Sensing }
4: Sensor : else if Data_Pkt == Relay
   { send RTS_Relay }
5: Other Sensors : received RTS
6: Other Sensors : if RTS == RTS_Sensing
7: Other Sensors : if RTS_Direction <= Dirction_Range
   { My_Buffer = NULL }
8: Other Sensors : else
   { Data_Pkt transmission }
9: Other Sensors : else if RTS == RTS_Relay
   { Data_Pkt transmission }
10: end
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Fig. 93.3 Algorithm of the proposed data transmission mechanism

93.3.2 Algorithm

Figure 93.3 shows the algorithm of the proposed data transmission mechanism.

93.3.3 Direction Range

If an event occurs, all sensors in the same cluster sense the event and try to send the data. In this case, only one sensor node can send data with RTS-sensing signal and all the other sensors drop their data using overhearing. But Fig. 93.4 shows other data sending case. In this scenario, sensor node B senses another event 2, and has two different data packets to send. When node B overhears RTS_sensing control signal from sensor node A, it drop first data packet but not second one. For this, we use information about direction of input data. Since event 1 and 2 occurred in different direction at sensor node B, the node considers them different information.

93.4 Performance Evaluation

In this section, the proposed data transfer approach is simulated and evaluated. Many simulation parameters were used as in [12]. Table 93.1 shows the used simulation parameters. We assumed that random numbers of nodes from 1 to 8 are located in a same cluster and maximum two events can be occurred

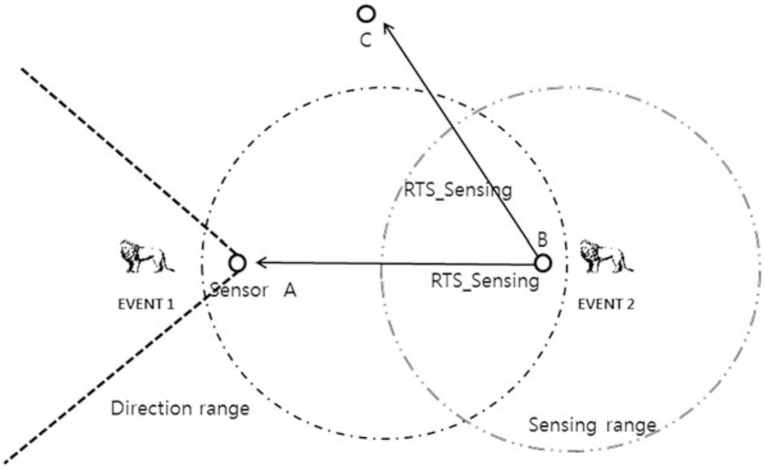

Fig. 93.4 Data transmission procedure with dual events

Table 93.1 Simulation parameters

Number of nodes	1–8
Battery energizer lithium AA	2900 mAh
Processor(active/sleep)	8 mA/15 μA
RF transceiver (TX/RX/Sleep)	27 mA/10 mA/1 μA
RF power	3 mW
Receive Sensitivity	−98 dBm
Active/Sleep period	0.1/9.9 s
Data transfer frequency	1 pkt/10 s

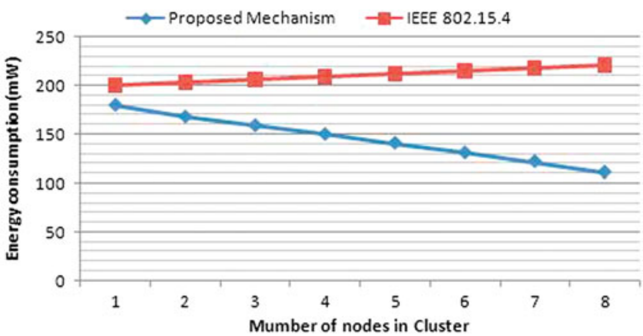

Fig. 93.5 Comparison of the average energy consumption

simultaneously. Comparison of the average energy consumption of each sensor node is shown in the Fig. 93.5. As shown in the figure we find that our data transmission mechanism shows better energy saving than other mechanisms.

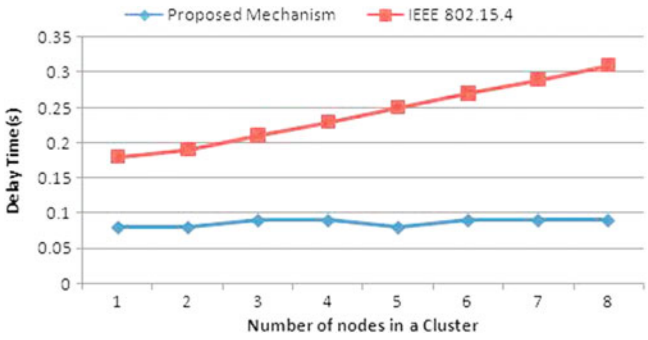

Fig. 93.6 Comparison of the average delay time of packet delivery

Figure 93.6 shows the packet delay comparison as number of nodes in a cluster increase. We can find that the proposed data transmission mechanism deliver data packet faster than IEEE 802.15.4 mechanism.

93.5 Conclusion

In WSNs, sensor nodes are generally deployed randomly over application area and sense occurred events redundantly. When an event occurs, many sensor nodes collect the same information and try to send it to its sink node. Since unnecessary data are transmitted at the same time, the network congestion increases and sensor nodes spend energy. In this paper, in order to increase the sensor networks life-time, we proposed an energy efficient data transmission mechanism in wireless sensor networks which use an efficient strategy to forward data packet toward sink node. In our mechanism, there are three.

With the suggested mechanism, the consuming energy of the nodes will be decreased especially in dense deployments of sensor networks and the life time of whole network will be increased.

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