A tree-based energy-efficient collision-free MAC in Wireless sensor networks

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Abstract

This paper presents a tree-based energy efficient and collision free MAC in Wireless sensor networks (WSNs). Exploiting the routing tree formed in many-to-one based data dissemination of WSNs, a TDMA scheduling is proposed for nodes wake-up and reception. The scheme is simulated using ns-2 which shows its effectiveness.

Ⅰ. Introduction

The rapid proliferation of miniature wireless networking technologies [1] drives to devise different sensor network applications with diverse QoS requirements. Achieving higher reliability is one of the major requirements for different loss-intolerant applications such as industrial process control, battle-field surveillance etc. On the other hand, providing higher energy efficiency also carries paramount importance in the context of resource constrained WSNs.

Being motivated on these, in this paper, we propose an energy efficient and collision free MAC for WSNs which exploits the routing tree which is formed in many-to-one based data dissemination scheme in WSNs. We propose an efficient and lightweight TDMA-based wake-up scheduling approach which provides an interference free data reception of the nodes. Simulation results show the effectiveness of the proposed scheme.

Ⅱ. Proposed Scheme

In the proposed scheme, we assume a sensor network forming data gathering tree where nodes are arranged in different depth of the tree from the sink and each node knows their corresponding level in the tree. We further assume nodes are aware of their parent and corresponding child in the routing tree. We define the nodes which are in the communication range of a node but neither its parent nor child as sibling node.

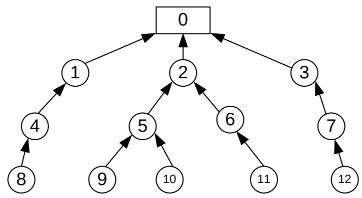


Figure 1: Routing tree.

To provide an energy efficient and collision free transmission, we propose a TDMA-based wakeup scheduling scheme. We assume time is divided into reception slots, *rs*. In each reception slot, a node wakes up to receive multiple data packets from its corresponding child nodes. The size of the reception slot denoted determines the maximum number of packets a node can receive from its children. A number of reception slots constitute a TDMA frame. The TDMA frame size denotes the wakeup cycle of a node. Our proposed wakeup scheduling consists of two phases as described follows.

A. Interfering receiver identification: We define two nodes of the same level are interfering-receiver to each other, if the simultaneous transmission of any of their child interferes their reception or if the child of one node is the sibling of another. To identify the interfering receivers, every node broadcasts the following information. I) Source address, ii) ID of those neighbors which are in the same or upper level of a node and iii) ID of the sibling's parent. In each of the cases, a node also includes the corresponding level value with each ID. A node builds a temporary table upon receiving the information from their neighbors. Every node identifies their corresponding interfering receivers through deducting all the nodes which are not in the same level as those nodes from the temporary table.

Also, the siblings of the neighbor nodes which are in the same level of a node are also deducted from the table which finally identifies the interfering receivers.

B. Slot assignment*:* In this phase, nodes assign reception slots in a top-down approach. Three types of packets are used; *Request* packet for requesting a slot, *Confirm* packet for confirmation of the assigned slot and *Cancel* packet for requesting the cancellation of a slot . A node broadcasts all of its packets to its neighbors. Besides, it broadcasts the corresponding packets of those one hop neighbors which are in the same level or upper level, also the packets of its sibling's parent. The assignment procedure is as follows:

i) Initially, sink sets its reception slot as the last slot and broadcasts it to all of its neighbors.

ii) A node having no slot-assigned so far temporarily sets its reception slot, $rs = rs_{\max}^{ul} - 1$. Before setting this, a node waits for t_w period to receive confirmed slot information of upper level nodes.

iii) If a node receives confirm packet from any of its interfering receiver node, it decreases the slot number by one, otherwise, it embeds the currently chosen slot number in the *Request* packet and waits for t_w period.

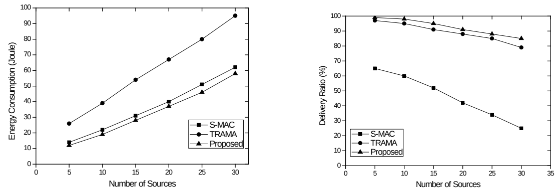
iv) During t_w, if a node receives a *Cancel* packet, it decrements the slot by 1. If no *Cancel* packet is received after t_w expires, a node broadcasts a *Confirm* packet.

v) If a node receives a *Request* packet during t_w, it broadcasts a *Cancel* packet to that node, if the Confirm packet is already broadcasted by the former node, or the ID of the former node is greater than the latter.

After slot-assignment is performed, a node wakes up in its reception slot and transmits beacons. Child nodes follow usual CSMA like approach to transmit their data.

III. Simulation

We perform simulation using ns-2 to evaluate the proposed MAC scheme. In the simulation, 50 nodes are randomly deployed in 100x100 m^2 sensor field. The transmission range is set as 30 m. The length of TDMA frame is set to 2 seconds. The simulation is performed for 100 seconds and the average over 30 runs are taken. We S-MAC [3] and TRAMA [2] with the proposed scheme.



(a) (b)

Figure 1: (a) Energy Efficiency for different no of sources. (b) Delivery ratio varying no. of sources.

Figure 1(a) shows the impact of number of sources on energy efficiency for all the protocols. Due to huge control packet overhead and schedule election at each interval the energy conservation is much higher in TRAMA than S-MAC and the proposed one. However, our proposed protocol achieves significant energy conservation than the other two after schedule has been selected. Figure 1(b) depicts the delivery ratio varying number of sources. As the figure shows, due to collision avoidance scheme, both the proposed one and TRAMA achieves higher delivery ratio than S-MAC.

IV. Conclusion

We present a tree-based energy efficient and collision free medium access control protocol for WSNs. The simulation results illustrate that our proposed scheme achieves higher delivery ratio along with attain high energy efficiency than both TRAMA and S-MAC.

ACKNOWLEDGMENT

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