EFFICIENT MAC FOR LEACH PROTOCOL IN WIRELESS SENSOR NETWORK

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ABSTRACT

The goal of the wireless sensor network is to deliver the desired QoS while supporting the long life the network. LEACH is one of the important and most discussed protocols in this area. The LEACH protocol works in phases wherein the set-up phase, the cluster head and the associated member nodes are finalized. Then a TDMA schedule is prepared for data transfer.

In this paper, we have proposed two approaches to adjust the TDMA schedule depending upon the current situation thereby enhancing the quality of the WSN. The results are supported through simulation in Matlab.

Keywords: ***Wireless Sensor Network/s, LEACH, MAC, TDMA, QoS***

I. INTRODUCTION

A WSN consists of many autonomous units called sensor nodes that work in distributed fashion in an unattended, highly resource constraint, and possibly hostile environment. Conveying the sensed information to the base station is considered to be the most energy draining operation of the sensor node [1]. This paper suggests the improvement of QoS issues of MAC layer in the case of LEACH protocol.

LEACH [2] is one of the important and most discussed hierarchical routing protocols in WSN. It works in rounds. Each round consists of two phases, namely the setup phase and the steady-state phase. The functioning of this protocol can be shown by the following Figure (1).

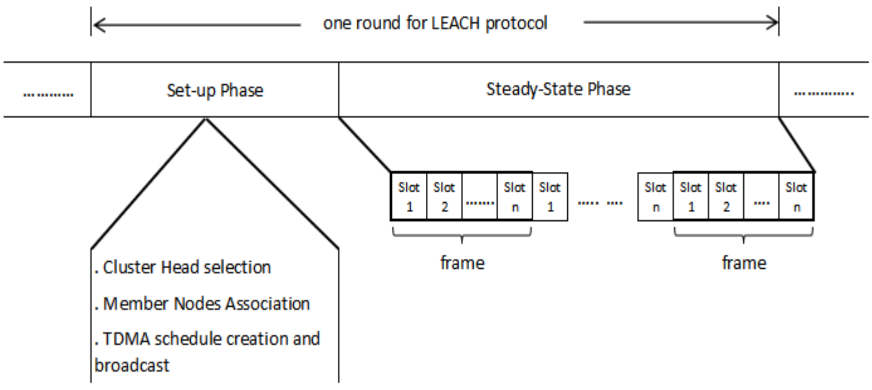

Figure (1): LEACH Protocol

In the setup phase, the different clusters along with the TDMA schedules for data transfer are setup. This phase is followed by steady-state phase in which the member nodes convey the sensed information to the cluster head following the received TDMA schedule by the concerned CH.

The paper has been organized as follows: section 1 provides an introduction of the WSN and the LEACH protocol. Section 2 explains the issues associated with MAC protocol in WSN. Section 3 presents a brief overview of some of the MAC protocol in WSNs. Section 4 presents the proposed approaches with the simulation results. The paper is concluded in section 5 followed by references.

II. BASIC ISSUES IN MAC PROTOCOL IN WSNS

MAC protocols affect the efficiency of the network in a great way. The waste of energy/issues in MAC protocol can be summarized as follow: [3] [4]

- **Packet collision:** Owing to the wireless media that is a shared channel by nature. The collided packets require retransmission resulting in the wastage of energy.
- **Control/Protocol overhead:** Most of the MAC protocols in WSN require control messages for data transmission (e.g., request-to-send/clear-to-send messages), which consume precious & limited energy.
- **Overhearing and idle listening:** Overhearing means that a node receives packets destined for other nodes. Idle listening refers to keep open the radio even at idle time. This is a situation where nodes need to listen on the channel to get its status.

III. OVERVIEW OF MAC PROTOCOLS

This section gives a brief overview of some of the MAC protocols defined for WSNs.

Self-organizing MAC for sensor networks (SMACS) [5] is one of the earliest attempts to develop MAC for network startup and link layer organization in a static WSN networks. Sensor-MAC (S-MAC) [6] presents an algorithm based on synchronization to let sensor nodes sleep at a certain time. TRAMA [7] is an adaptive protocol that uses traffic-based information to decide on schedules for individual nodes. The average queuing delay for TRAMA is relatively large due to overhead involved in scheduling.

Power-Efficient and Delay-Aware Medium Access Protocol for sensor networks (PEDAMACS) [8] combines the characteristics of cellular network with the WSN. It is associated with a large overhead. T-MAC (Timeout-MAC) [9] uses time-out windows to adjust the length of active states to remove the drawback of S-MAC protocol.

D-MAC [10] is based on data gathering trees which achieves low latency but without compromising energy. Wise-MAC [11] is an asynchronous protocol which uses the preamble sampling technology and it is based on non-persistent CSMA protocol. This protocol selects few nodes that function as access points (APs) to collect the node schedule.

Op-LEACH [12] presents a modification to MAC protocol of LEACH by using the free slots in the schedule by the cooperation of the member nodes.

Along with the optimization of the issues at MAC level, a number of other approaches have also been proposed for enhancing the LEACH protocol in [13] [14] [15] [16] [17] to name the few.

IV. PROPOSED PROTOCOL

The normal steady state TDMA schedule for LEACH protocol can be shown by Figure (2). But suppose if all the member nodes are not willing to send data as they don't have any meaningful data to communicate to cluster-head node. This will result into loss of throughput as well as wastage of resources (very precious in the case of WSN).

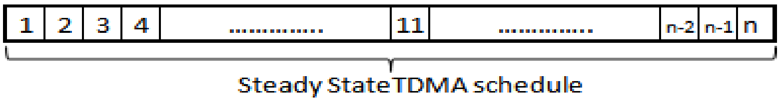

Figure (2): Steady State TDMA Schedule for LEACH Protocol

Also, the unwilling member nodes will loose their radio power as they have to be in ON state during their slot time, irrespective of whether they have data to send or not.

To remedy this problem, some form of adaptation is required. For this, we propose an additional step in the set-up phase. In this step, along with the other required information, the member nodes also mark their willingness for data transfer for the given round under consideration, so that the CH makes the TDMA schedule only for the interested nodes. We have suggested two different approaches for the same.

If we take that it requires 1-bit to mark this willingness, then with this minimal increased overhead of n-bits (where, n is the number of member nodes in the cluster), the latency of the network can be highly reduced, as supported by the simulation results (Figure (5)).

Once, the CH has this information with it, it can use any one of the following two approaches to maximize the data transfer:

1. Either increase the time for the time-slot keeping the total schedule time equal as before. This way, the nodes with data can transmit for longer period of time
2. Or, we can increase the number of TDMA schedules within the original schedule time to serve our purpose.

The respective approaches can be shown in Figure (3) and Figure (4). To explain the methodology, we have assumed the number of member nodes to be 20, and p is the %age of nodes that have data to send.

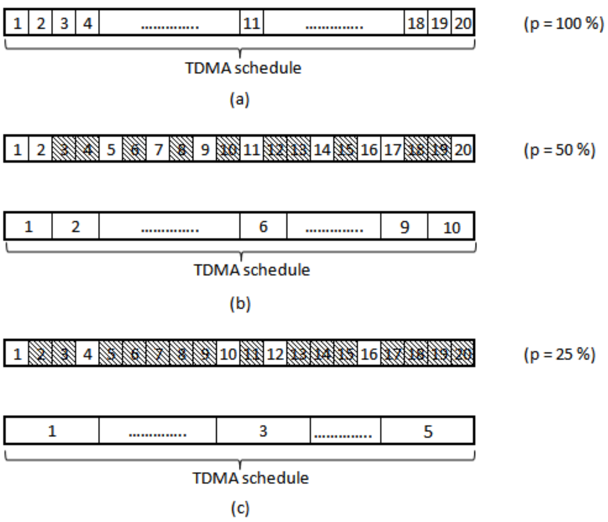

Figure (3): Approach 1. Extending the time for the time-slots

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Figure 3(a), 3(b) and 3(c) represent the scenario when the % age nodes willing to send data are 100%, 50% and 25% respectively for approach 1.

Similarly, figure 4(a), 4(b) and 4(c) represent the scenario when the %age nodes willing to send data are 100%, 50% and 25% respectively for approach 2.

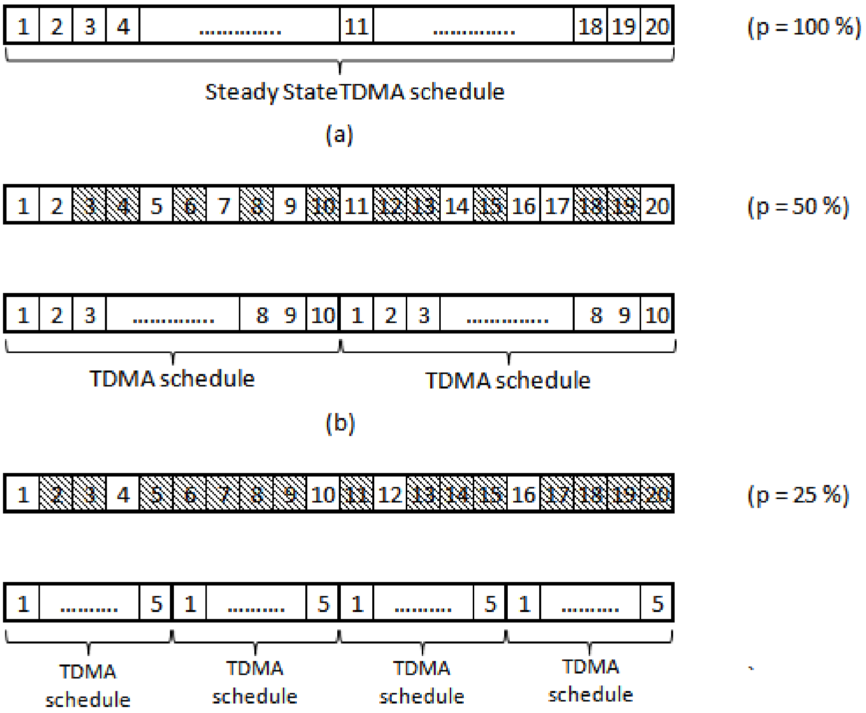

Figure (4): Approach 2. Increasing the TDMA schedules

To support the claim, we have drawn a graph as shown in Figure (5) between the time taken to transmit some fixed amount of data by the LEACH protocol and the proposed modification.

(We have assumed the case that there are 20 member nodes in the cluster. The total amount of data to be transferred is 2000K. The per slot data transfer is 50K and the data to be transferred is equally contributed by the different member nodes. Also we have ignored the impact of extra control information overhead as it is very negligible.)

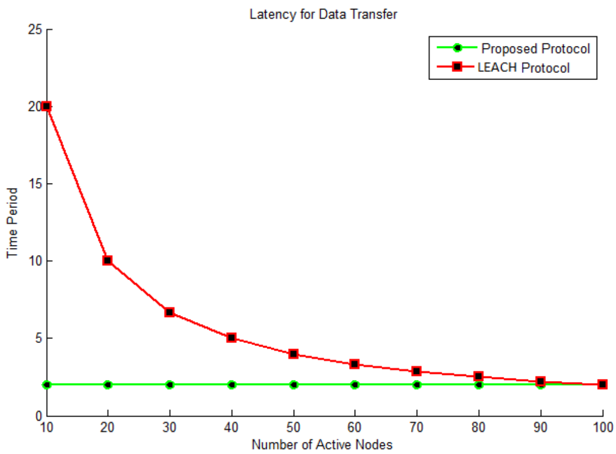

Figure (5): Latency Comparison

The above graph supports our claim. This approach is very useful when the data is of bursty nature. As the number of active nodes increases, the proposed protocol approaches to the behavior of normal LEACH protocol.

V. CONCLUSION

MAC protocols play a very important role for the lifetime, throughput and the latency of the network. By this work, we conclude that if the proposed enhancement to the existing LEACH protocol are incorporated, then the throughput of the network can be greatly increased and the latency can be highly reduce especially in the case of bursty nature of traffic.

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