Hybridization of TDMA and CSMA/CA for Synchronization in Cluster Based Wireless Sensor Networks

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***Abstract*—The main focus of the recent years in Cluster based Wireless sensor networks was to develop the network with low cost and low power. In a cluster based wireless sensor network, how to save the limited power resources of sensors to increase the network lifetime of the wireless sensor network(WSNs) as long as possible while performing the sensing and sensed data reporting to sink, is the most critical issue in the network formation design. In Cluster based wireless sensor networks, the communication between intra-cluster and inter-cluster are unavoidable. The intermediate hop nodes are continuously working for the data transmission so those nodes will immediately discharge their battery energy and shorten the network lifetime of the cluster based WSN. The proposed work uses hybridization of two medium access control techniques such as TDMA and CSMA/CA based scheduling for the communication synchronization in cluster based WSNs. It can solve communication overhead. When communicating between the clusters if traffic is low, it works as CSMA and if high then TDMA. Finally this approach gives cluster based network as fundamental topology in WSNs.**

Keywords-Wireless sensor network, clustering, communication synchronization, Data gathering.

I. INTRODUCTION

Now these days wireless sensor networks have gained much more attention due to their limitless potential and has great value of applications. Wireless sensor network is having nodes communicating among themselves using radio signals. It provides connection between virtual and real physical worlds. There are many technologies having crucial need of cluster based wireless sensor networks to monitor it completely. The important areas are traffic control application, weather checking, environmental monitoring and regularity checking of the temperature. Cluster based wireless sensor networks contribute to overall system scalability, lifetime, and energy efficiency.

Sensor nodes send collected data to corresponding cluster heads(CHs). CH node aggregate those data and send to sink as shown in fig 1. There are two types of communication needed to transmit data to sink, inter-cluster communication and intra-cluster. The communication is carried out between the source and the destination by multi-hopping process. The relay nodes are continuously working and sends data to sink so these nodes will immediately discharge their battery energy and shorten the network lifetime of the cluster based WSN. To overcome this problem proposed work uses two medium access control (MAC) based scheduling techniques such as TDMA and CSMA/CA. TDMA scheduling is used when traffic is high and CSMA when traffic is low.

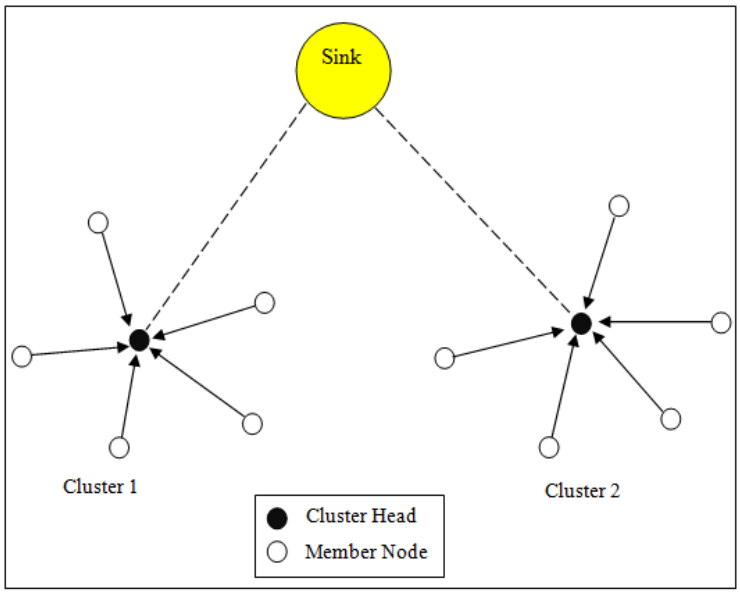

Figure 1. Cluster based wireless sensor network

MAC protocol help nodes to access the communication channel which control when and how node can access the medium to communicate with other nodes. It has main goals like mobility management, power conservation and fault tolerance. Scheduled protocols like TDMA (Time Division Multiple Access), CDMA (Code Division Multiple Access) and FDMA (Frequency Division Multiple Access) are widely used MAC protocols. Interference is avoided by dividing nodes into sub channels.

TDMA is slotted transmission schemes which allow nodes to regularly schedule sleep intervals to minimize energy used [1, 2]. Node can be active only if it is ready and scheduled to send or receive data. Another scheduling technique is CSMA which is contention based. Here nodes listening to the channel before transmission. When channel is busy node can delay access and try later. CSMA/CA can not be used when traffic becomes intense.

II. LITERATURE SURVEY

Clustering is best topology in wireless sensor network which achieve goals like energy efficiency and scalability. Following MAC protocols are utilized in cluster based wireless sensor networks.

A. *Sensor-MAC (S-MAC)*

- The basic idea behind the Sensor-MAC (S-MAC) protocol [3,10] is it locally manage synchronizations and periodic sleep listen schedules which are based on these synchronizations.
- SMAC is widely used for energy conservation purpose in wireless sensor networks.
- Common sleep schedule is set up by neighboring nodes and it form virtual clusters. In the case where two neighboring nodes reside in two different virtual clusters, they failed to wake up at listen period of only one cluster but wake up for both clusters.
- A drawback of S-MAC algorithm is for some schedules, which results in more energy consumption via idle listening and overhearing.
- S-MAC having important feature in message-passing in which long messages are divided into small frame structures and sent in a burst. With this technique, we can achieve minimizing communication overhead at the expense of unfairness in medium access and energy will automatically saved .

B. *Timeout-MAC (T-MAC)*

- In S-MAC static sleep-listen periods result in high latency and lower throughput to overcome this problems Timeout-MAC (T-MAC) [4] is proposed, which enhance the poor results of S-MAC protocol under variable traffic load.
- Sensor networks have variable load in different nodes, since the nodes that are closer to the sink must relay more traffic. T-MAC gives better results under these variable loads.
- Drawback in T-MAC is the synchronization of the listen periods within virtual clusters is broken.

C. *DMAC*

- The important goal of DMAC [5] is to gain very low latency with energy efficient performance.
- DMAC solves interruption problem. It allow continuous packet forwarding by giving the sleep schedule of a node and adjusts duty cycles as per traffic load in network.
- Advantages: DMAC achieves good latency. Enable continuous data forwarding on the multi-hop path and use staggered active/sleep schedule. Generally most of the traffic in WSNs is from sensor nodes to sink this construct data gathering tree.
- DMAC uses this tree to achieve low packet delivery latency and energy efficiency.
- Disadvantages: Many nodes that having the same schedule, it try to send to the same node, collisions will occur this happens because of collision avoidance methods are not utilized.

D. *Convergent MAC (C-MAC)*

- Convergent MAC (CMAC) protocol design is based on low duty cycle [6].
- CMAC supports very low duty cycles at same condition it improves throughput and significantly reduce latency also.
- CMAC improves the latency and energy efficiency by utilizing aggressive RTS and convergent packet forwarding mechanisms.
- When there is no packet to transmit, CMAC uses unsynchronized sleep scheduling. When there are packets to transmit CMAC first uses aggressive RTS and then detects traffic.

In literature various scheduling approaches are proposed. In this paper two types of scheduling considered for wireless clustering structure which is as bellow.

- Synchronous scheduling.
- Asynchronous scheduling.

A. *Synchronous Scheduling*

It uses cycle-based scheduling(CBS) in which TDMA based approach works effectively [9]. CBS having consecutive cycles, each node in cluster is assigned some fixed time interval. Node in this cluster will active only in that assigned time intervals otherwise node must in sleep condition. This achieves the synchronization problem and overhead between transmission pair is minimized. Main aim of this approach is minimize average end-to-end delay. CBS solves these problems by separating inter-cluster and intra-cluster communication. The switching between inter-cluster and intra-cluster is avoided by limiting the all communications for a cycle in consecutive period. This approach assigns different radio channel to two adjacent clusters, which achieve the interference problem in inter-cluster communications. Inter-cluster communication is considered between the CHs and sink. All CHs are arranged into fixed routing tree which is rooted at sink

B. *Asynchronous Scheduling*

Asynchronous scheduling uses unique New Clustering Scheduling (NCS). NCS eliminate the synchronization problem. NCS has new clustering structure which removes the need of algorithm to schedule inter-cluster communication. It has new clustering structure includes new node, which has highest residual energy called as relay node. The new clustering structure contains CHs, member nodes, relay nodes. The relay node is nothing but the node which takes part in inter-cluster communication. Cluster members collect data and send it to cluster head then cluster head instead of sending data to next hop it sends data to relay node of its own cluster. Relay node add its own data and forwards the packets to next hop relay node. This process is repeated until packets reach to sink. This approach uses TDMA protocol for intra-cluster

communication and CSMA protocol for inter-cluster communication. Drawback of this approach is relay node continuously working for the data transmission so those nodes will immediately discharge their battery energy and shorten the network lifetime of the cluster based WSN.

In flat topology of wireless sensor networks Z-MAC [8] achieves high channel utilization and low latency under low contention and like TDMA, it acts as CSMA under light traffic. Z-MAC have important feature that its performance is robust to synchronization errors, slot assignment failures and time varying channel conditions.

III. PROPOSED ARCHITECTURE

The system architecture contains following structure.

A. Member sensor nodes

The basic function of member node is to collect data and send it to cluster head. Sensor nodes are designed to collect the data.

B. Cluster Head

Cluster head collect data from member nodes. Collected data is aggregated at cluster head. One of the most important functionalities that in-network aggregation technique should provide is the ability to combine data coming from different nodes. There are several types of aggregation functions and most of them are closely related to the specific sensor application.

C. Gateway Node

It participates in inter-cluster communication. During data collection process, while cluster members send sensing packet to its own CH, the CH no longer sends the aggregated packet the next-hop CH but sends to the gateway node of its own cluster instead. When packets are reached at the gateway node, it further combines them with its own sensed data and forward these all packets to the next-hop gateway node until the packets reach the sink. This communication pattern greatly simplifies the communication synchronization. CHs can continue intra-cluster data collection immediately after sending out the aggregated packet, reducing the data collection delay. In the meanwhile, inter-cluster communication can be performed without any restrictions, incurring no waiting delays for synchronization. Thus the wireless channel can be better utilized and lower packet delay can be achieved.

D. Hybrid Approach

It has advantage of both TDMA and CSMA/CA such that the hybrid approach acts like CSMA under light traffic and TDMA when traffic becomes heavier. The nature of TDMA: nodes can sleep in any idle slots to preserve energy. On the other hand, approach yields lower end-to-end packet delay. Moreover, the CSMA based protocol makes system more tolerant to interference and collisions.

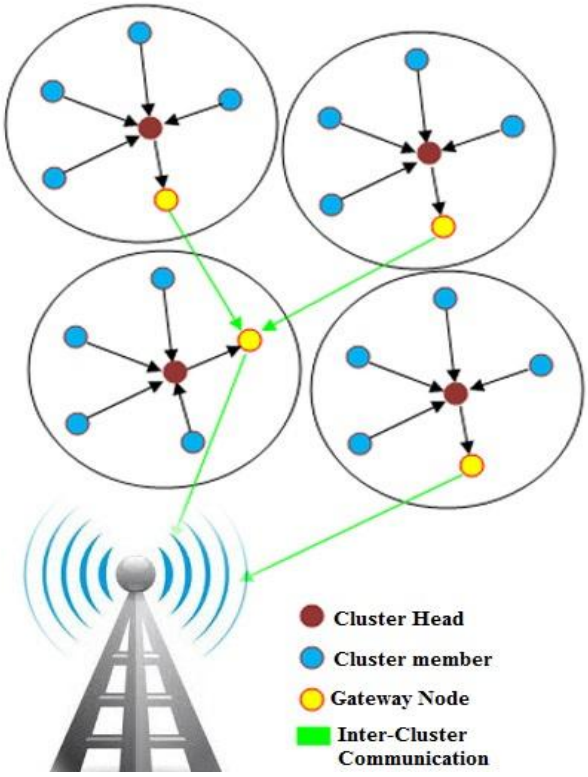

Figure 1. Proposed Clustering Structure

Advantages:

- The energy Efficiency of the network is increased.
- The energy consumption of the network is reduced.
- The reliability of the network is reduced. The data loss is highly reduced.

IV. CONCLUSION

Hybridization of two medium access control techniques such as TDMA and CSMA/CA based scheduling for the communication synchronization in cluster based WSNs. It can solve communication overhead. When communicating between the clusters if traffic is low, it works as CSMA/CA and if traffic is intense it acts as TDMA. We can achieve both inter-cluster and intra-cluster communication with less overhead. Gateway node remove heavy burden of packet relaying on CHs. Hybridization approach gives WSNs as fundamental network in cyber physical system.

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