ISSN:0975-9646

Pramatha.S et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (3) , 2014, 4665-4668

A Comparative Study: Efficient Multihop Broadcast Protocol and Receiver Initiated-Medium Access Control Protocol

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***Abstract*— In this paper, we propose the comparison of an Efficient Multihop Broadcast Protocol for Asynchronous Duty-Cycled Wireless Sensor Networks (EMBA) and Receiver Initiated-Medium Access Control (RI-MAC) protocol. EMBA comprises two techniques for asynchronous mode broadcast of messages namely the forwarder's guidance and the overhearing of broadcast messages and ACKs. Receiver initiated MAC broadcast for sparse and dense networks attempts to minimize the channel utilization requirements compared to other existing asynchronous scheduling approaches. We implement EMBA and conventional protocols of RI-MAC broadcast in *ns-2* simulator to compare and contrast their performance.**

***Keywords*—Wireless Sensor Networks; asynchronous sleep scheduling; synchronous scheduling; multihop broadcast; X-MAC; B-MAC; DW-MAC; EMBA; RI-MAC**

I. Introduction

For the conservation of energy wireless sensor networks adopts sleep scheduling algorithms. The sleep scheduling approaches enables the sensor nodes to alternate between sleep and wake up states. The energy is consumed only when the nodes are active. Thereby minimize the energy utilization for sensor networks. For the purpose of limiting the energy usage the sensor nodes are supposed to operate in any of the three modes: *sleeping mode, wakeup mode,* and *tracking mode*. A node in active mode would remain active till the termination of an event, whereas a node in wakeup node can itself immediately go to sleep when the time slot allotted expires.

The sleep scheduling algorithms can be of two types: synchronous and asynchronous. In synchronous approach each node do synchronise its neighbours prior to broadcast. In asynchronous sleep scheduling each node wakes up and go to sleep independently according to its own schedule. The asynchronous sleep scheduling is made possible by means of low power listening (LPL). In LPL each node periodically samples the medium to check whether there is the presence of long preambles intended for it.

II. Problem Definition

The synchronous sleep scheduling approach minimizes the energy consumption whereas the complexity of synchronization and overheads makes it less liable to be adopted for scheduling. The asynchronous sleep scheduling algorithms do support efficient sleep scheduling but the sleep scheduling schemes for multihop broadcasting is only little in number.

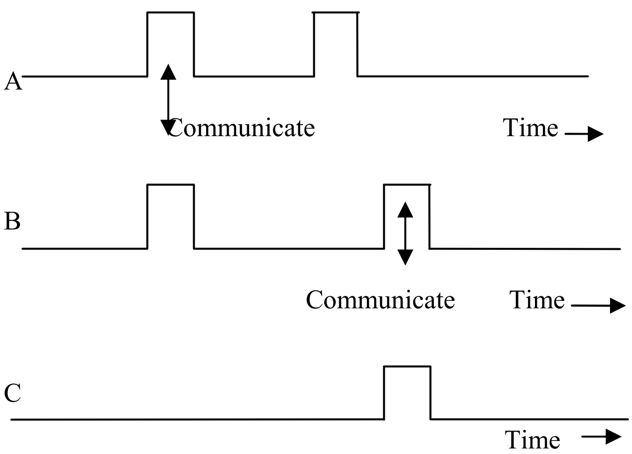


Fig 2. The Sleep Scheduling for three nodes A, B and C

The node do communicate only when both the sender and the receiver is in wake up state at the same time. Since in asynchronous scheduling the nodes do wake up independently, achieves the same through LPL.

III. Related Works

A sender, in B-MAC [2], starts to transmit data after sending a long preamble which lasts at least as long as a sleep period of a receiver. When the receiver wakes up and detects the preamble, it stays awake to receive data following the preamble. However, a node may unnecessarily stay awake to receive data destined to other nodes.

Algorithm 1 B-MAC

```
sender (starts)
   sender (preamble)
      {
         preamble length ≥ sleep period of the receiver
      }
while receiver (starts) then
      if receiver (detects preamble) then
            receiver (waits)
                  if target address==receiver address
                        accept
            else receiver (sleeps)
```

The low power listening approach called X-MAC [3], employs a short preamble to reduce energy consumption and to reduce latency. The first highlight is that it embed address information of the target in the preamble so that non-target receivers can quickly go back to sleep. This addresses the overhearing problem. The second feature is that it uses a strobed preamble to allow the target receiver to interrupt the long preamble as soon as it wakes up and determines that it is the target receiver. This short strobed preamble approach reduces the time and energy wasted waiting for the entire preamble to complete.

DW-MAC [4] which is one of synchronous sleep scheduling protocols supports multihop broadcast by using multihop forwarding. An operational cycle in DW-MAC is divided into three parts: Sync, Data, and Sleep. Each node synchronizes its clock with its neighbor nodes during the Sync period. During the Data period, a sender that wants to broadcast transmits a scheduling frame (SCH) which indicates the starting point for the broadcast transmission that will be performed within a following Sleep period.

The asynchronous duty cycle MAC protocol, called Receiver-Initiated MAC [5], attempts to minimize the time a sender and its intended receiver occupy the medium for them to find a rendezvous time for exchanging data, while still decoupling the sender and receiver's duty cycle schedules as B-MAC and X-MAC do. RI-MAC differs from prior work in asynchronous duty cycle MAC protocols in how the sender and receiver reach a rendezvous time. In RI-MAC, the sender remains active and waits silently until the receiver explicitly signifies when to start data transmission by sending a short beacon frame. As only beacon and data transmissions occupy the medium in RI-MAC, with no preamble transmissions as in LPL-based protocols, occupancy of the medium is significantly decreased, making room for other nodes to exchange data

ADB [6] has been proposed to support multihop broadcast for asynchronous duty-cycled sensor networks. ADB is designed based on RI-MAC. Suppose node *S* is a source node and node A wakes up earlier than node B. Upon receiving node A's beacon, node S sends A, a broadcast message including an ADB footer that indicates the broadcast progress and the link quality information of S. Looking into the footer, node A recognizes that the quality of the link between nodes S and B is poorer than that of link between itself and B. Node A decides to forward the broadcast message to node B and inform node S of this fact by sending ACK with a new footer. Upon receiving this ACK, node S delegates handling of node B to node A.

In efficient multihop broadcast protocol for asynchronous duty-cycled wireless sensor networks [1], each node independently wakes up according to its own schedule. EMBA adopts two techniques of the forwarder's guidance and the overhearing of broadcast messages and ACKs. A node transmits broadcast messages with guidance to neighbor nodes. The guidance presents how the node forwards the broadcast message to neighbor nodes by using unicast transmissions. This technique significantly reduces redundant transmissions and collisions. The overhearing of broadcast messages and ACKs helps to reduce the number of transmissions, thus it minimizes the active time of nodes. The flow chart for EMBA system can be depicted as shown in figure 1.

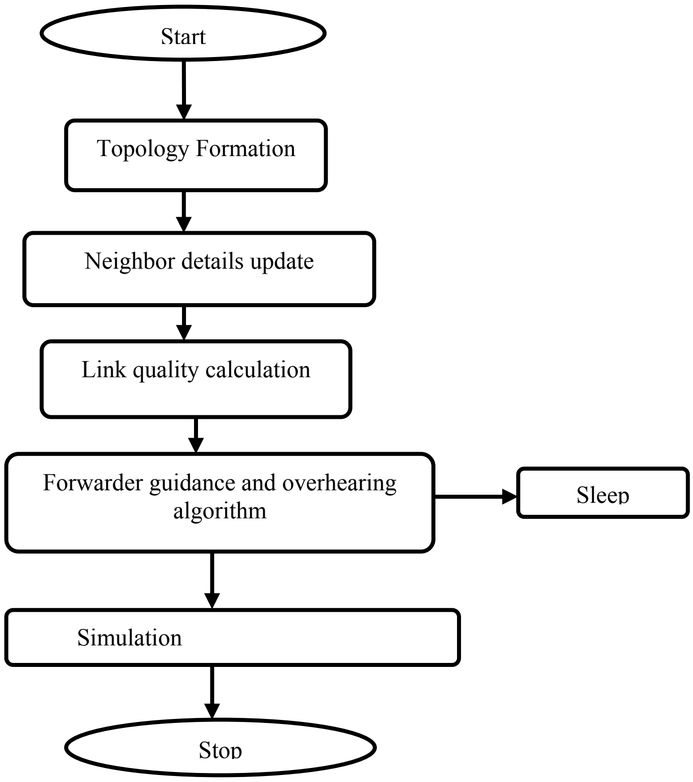


Fig.1. EMBA System

Fig 2.Summary Table for Existing System

Existing Systems	**Scheduling Method**	**Advantage**	**Disadvantage**
B-MAC	Asynchronous approach	Efficient in light loads.	A Node may unnecessarily stay awake to receive data destined to other nodes.
X-MAC	Asynchronous approach	Each preamble contains the TA. Allows nodes not involved in the communication to go to sleep immediately.	Less efficient in busty traffic
W-MAC	Synchronous sleep scheduling approach	Has operational cycle divided into three parts: sync, data and sleep.	Synchronization of the clocks with the neighbor nodes creates overhead.
RI-MAC	Asynchronous approach	Reduces the amount of time the sender and receiver occupies the wireless medium.	Chances for overhearing of messages.
ADB	Asynchronous approach	Avoids redundant transmissions.	Doesn't support MH broadcast in polygonal topologies.
EMBA	Asynchronous approach	Energy consumption low.	More overhead.

The classification tree for sleep scheduling algorithms is shown in figure 3.

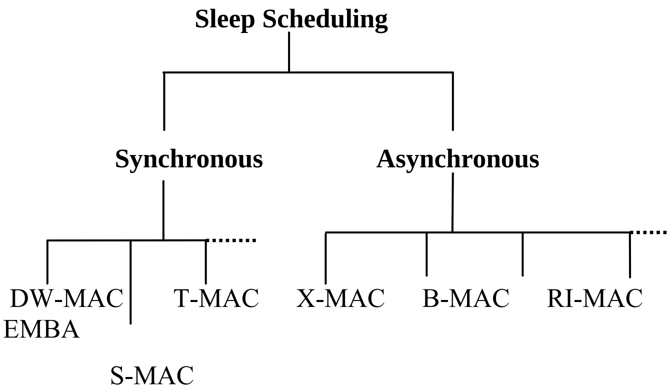


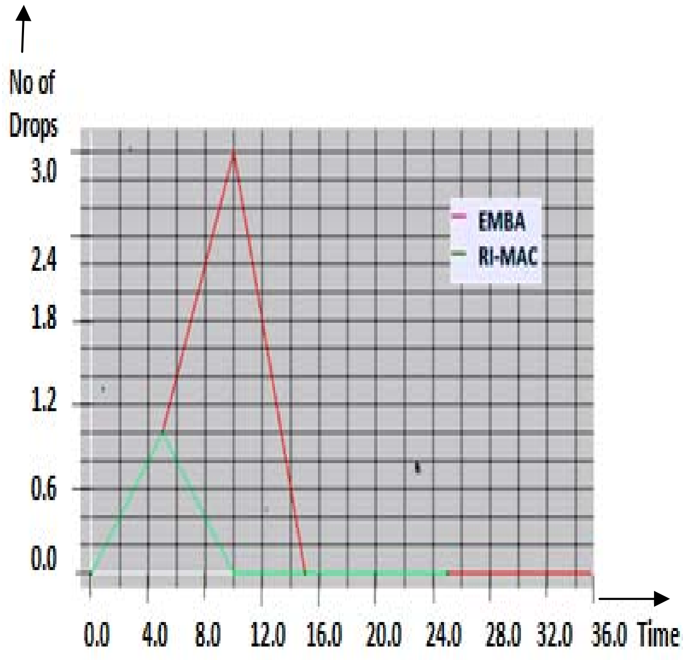
Fig. 3.Classification Tree

IV. EVALUATION RESULTS

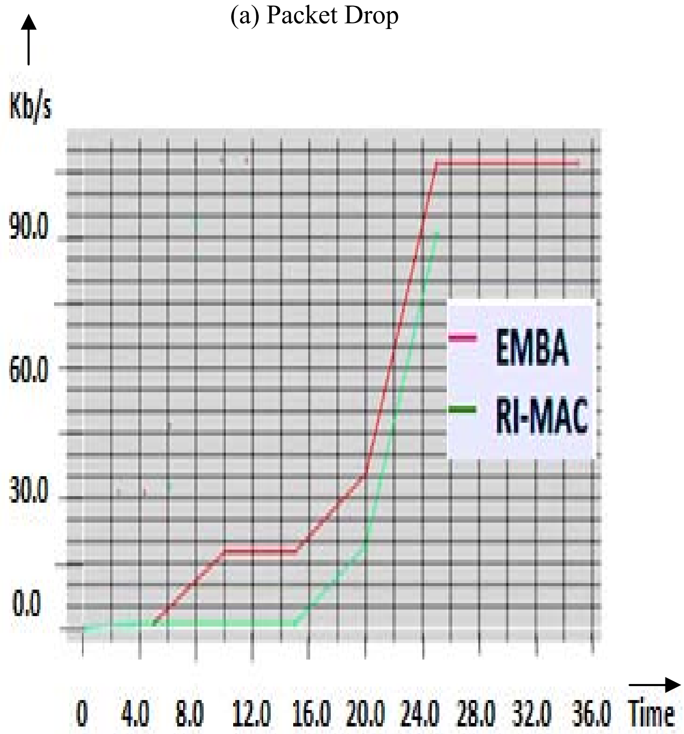
The figure 4(a) depicts the packet drop in EMBA and RI-MAC. Both give a unit triangle up thrust in which the up thrust generated by RI-MAC is more than EMBA. In RI-MAC the packet drop is nearly double as that of EMBA. Figure 4(b) shows the average energy consumption of EMBA and RI-MAC. Average energy consumption graph depicts the average amount of energy being utilized during particular time duration. The average energy consumption of RI-MAC is higher compared to EMBA. EMBA reduces consumption of energy by minimizing redundant transmission and collisions. It is achieved by means of the techniques of forwarder's guidance and overhearing of messages. Figure 4(c) shows the throughput graph for EMBA and the conventional RI-MAC protocol. EMBA achieves improved throughput compared to RI-MAC.

The figure 4(d) shows the packet delivery ratio of EMBA and RI-MAC for the same number of the packets that are being transmitted. The PDR of EMBA is slightly higher than the RI-MAC. The PDR plots to be a constant on exceeding the threshold time. The packets lost during the transmission either due to heavy traffic congestion or network failures per unit time is termed as packet drop.

We use ns-2 simulator to evaluate the performance of RI-MAC network model and the EMBA protocol by randomly deploying 45 static sensor nodes.The performance comparison is done in terms of four parameters such as throughput, average energy consumption, PDR and packet drop.

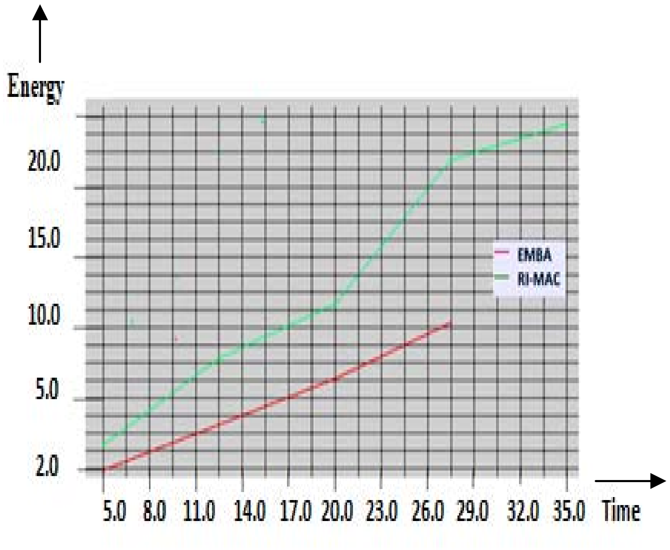


(a) Packet Drop

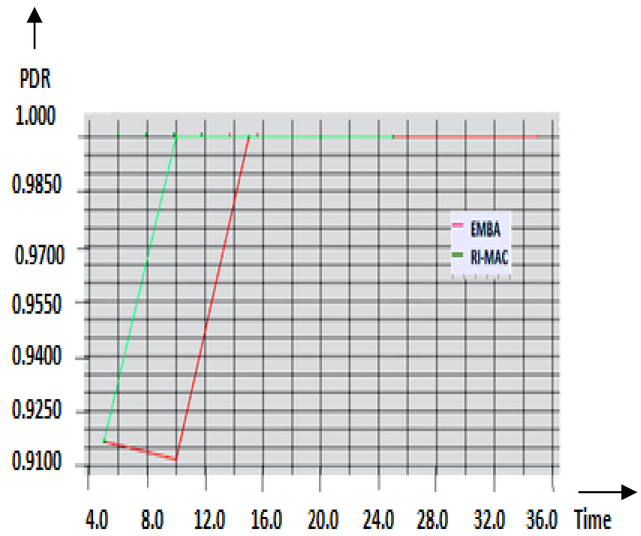


(c) Throughput

Fig.4.The results of performance comparison in simulations



(b) Average Energy Consumption



(d) Packet Delivery Ratio

V. Conclusions & Future Work

In this paper, we have done a comparison between two existing asynchronous sleep scheduling techniques EMBA and RI-MAC. The simulation results show that EMBA achieves improved performance in terms of throughput, average energy consumption, PDR and packet drop than RI-MAC. As though EMBA is a proactive multihop broadcast approach for asynchronous wireless sensor networks. It fails to focus on Link Reliability, Channel Quality, Latency and Load Balancing. These QoS parameters have to be focused to improve the performance of Sensor Networks. To address these identified issues, it is essential to propose a much more efficient multihop broadcast protocol, which will achieve lower message cost than the conventional protocols and significantly improves the energy efficiency in terms of both duty cycle and energy consumption along with the above parameters.

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