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Performance Evaluation of T-MAC Protocols for Wireless Sensor Network

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Abstract—: A Key Challenge in wireless sensor networks is the power efficiency as sensor nodes are small sized, low power, low cost micro electro mechanical system (MEMS) which is capable of Sensing, Computing and Communicating. In this paper on the basis of different T-MAC protocols like B-MAC, SPEC-MAC-D, X-MAC the protocol MIX-MAC is analyzed on the basis of power used and network delay, so that life time of nodes can be enhanced. As "LPL MAC protocols" impose a significant drain on the transmitting node, the schedule used for probing as well as the particular probing technique should be well matched to the current network conditions. On the basis of simulation (MATLAB) results, the burden of the receiver for schedule selection overhead is reduced, events are found chronologically and scenario is also created dynamically.

Index Terms- B-MAC, LPL, MAC, T-MAC, WSN.

1 INTRODUCTION

Energy is Primary Concern, (Sensor nodes are limited in power, computational capacities and memory).Architecture of a Sensor Node shown in Figure below [1]:

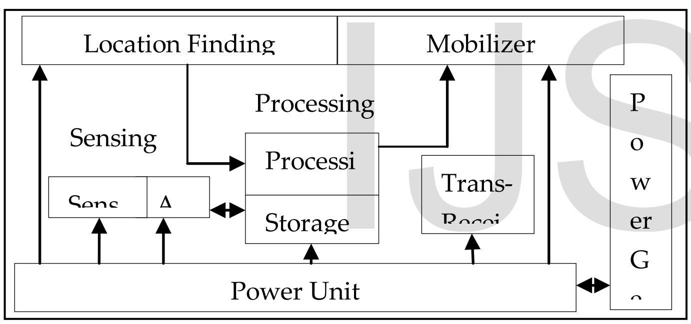

Fig1. Architecture of a Sensor Node

In Sensor-MAC (S-MAC) protocol basically we define schedule for nodes wakeup and sleep schedule and we try that wake up time should be kept smallest and sleep time should be larger This is known as duty cycle so smallest the duty cycle more energy will be saved. So it was fixing in S-MAC it didn't vary with Traffic Load. As Duty cycle is wakeup to sleep period ratio and in sleep mode a sensor node consumes lesser energy because Power is consumed in sensing, data-processing, communication (Transmission), Reception (Rx), Idle and sleep (very low) Timed out MAC protocol was an enhancement of S-MAC protocol in sensor MAC when node kept in sleep period it could not send information and it increases the packet delay. When data is not available for a particular threshold then only node should go in sleep mode. So after many advances in MAC layer protocols a new generation of Low-Power-Listening (LPL) MAC protocols were introduced. B-MAC [2] and X-MAC [3], transmitting node occupies the medium for long intervals of duration ti(s) to signal its imminent packet transmission. Receiving nodes are thus allowed to sleep for at most the duration of this preamble (ti), and they must stay awake when they sense a busy medium until the packet transfer is complete. the receiver does not need to know what specific schedule is being used, as it always wakes up every ti (s) to sense the medium, regardless of which schedule is selected by the transmitter. As a consequence, this protocol called Reconstructed-MiX-MAC, requires no overhead, and our implementation of this approach shows that total Energy Consumption and Packet delay can be decreased

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2 RELATED WORK

A considerable research effort has been devoted to wireless sensor network protocols in the last few years. Many new researches have been proposed and various simulators are being used for simulation and performance analysis.

In this paper a protocol named S-MAC has been proposed. S-MAC uses three novel techniques to reduce energy consumption and support self-configuration. To reduce energy consumption in listening to an idle channel, nodes periodically sleep. Finally, S-MAC applies message passing to reduce contention latency for sensor-network applications that require store-and forward processing as data move through the network. [4].

In this paper an investigation has been made on the node level power control scheduling on densely deployed sensor networks. It has been proved that given homogeneous Poisson sensing traffic in a sensor network, the routing traffic is heterogeneous. Further a well defined power control model to adapt to heterogeneous traffic, and propose a data-centric energy efficient scheduling protocol under the power model [5].

In this a MAC protocol for wireless sensor networks to monitor manufacturing equipment and processes has been developed. It is also being explained a single machine defect may trigger multiple sensors to respond and transmit a string of defect data to the central control station, leading to high network collision rate, which in turn consumes power on the side of the sensors. For battery-driven, miniaturized sensors, such an energy-inefficient mode of operation may severely reduce the effectiveness and efficiency of the entire sensor network. Realistically, the number of the fault-registering sensors is not a constant, but various continuously, corresponding to the ad hoc nature of the defect generation [6].

In this paper an asynchronous energy-efficient MAC protocol, ASCEMAC, is proposed for wireless sensor networks. In ASCEMAC, by applying free-running method and fuzzy logic rescheduling scheme, time synchronization which is necessary in existing energy-efficient MAC protocols is not required any more. Moreover it is also being presented that a traffic-strength- and network-density-based model to determine essential algorithm parameters, such as power on/off duration, interval of schedule broadcast and super-time-slot size and order [7].

In this paper an energy efficient MAC protocol for wireless sensor networks has been proposed since sensor nodes are equipped with a limited energy of batteries, reducing energy consumption is a critical issue for extending network lifetime. To resolve this issue, a listen-sleep cycle as in S-MAC [8], allowing sensor nodes to turn their transceiver off during a sleep period has been proposed [9].

3 WIRELESS COMMUNICATIONS

Wireless communication enables greater flexibility for sensor placement, but also constrains the node design due to the energy consumption associated with wireless data transmission.
There are two kinds of wireless networks [10]:

1) An ad-hoc or peer-to-peer wireless network consists of a number of computers each equipped with a wireless networking interface card. Each computer can communicate directly with all of the other wireless enabled computers. They can share files and printers this way, but may not be able to access wired LAN resources, unless one of the computers acts as a bridge to the wired LAN using special software. This is called "bridging" [11]. Each computer with a wireless interface can communicate directly with all of the others.

2) A wireless network can also use an access point, or base station. In this type of network the access point acts like a hub, providing connectivity for the wireless computers. It can connect (or "bridge") the wireless LAN to a wired LAN, allowing wireless computer access to LAN resources, such as file servers or existing Internet Connectivity.
The use of MAC protocols organizes transmissions in a standard format to streamline data transmission, preventing collisions and network failure. Typical 802.11 uses an Exponential Binary Backoff (EBB) mechanism to detect when the channel is free to send data. Alternatively, a more graceful coordination function is shown to improve network performance in an environment with high data transmission rates. This is achieved by using a protocol with the AIMD mechanism, which maintains better network stability when large data transfer rates are encountered [12]. Dispatch of data packets in a network is controlled by MAC. Most of the current Wireless Local Area Networks use the Distributed Coordination Function (DCF) defined in the 802.11 standard [13].

3 MAC PROTOCOLS

In a sensor node, most energy consumption occurs in a radio transceiver whose utilization is controlled by a medium access control (MAC) protocol. The MAC protocol coordinates accesses among competing nodes for the shared medium and tries to minimize interference through the control of transmissions among nodes. In the MAC layer, there are several major sources of energy waste. The first one is idle listening, which occurs when a node still turns its radio transceiver on even though there is no data to transmit or receive. It has been studied that the energy consumption during the idle listening state is comparable to that during the receiving state. The second one is overhearing, which occurs when a node receives and decodes packets that are not destined to it. The third one is over emitting, which occurs when the transmitter node transmits a packet while the receiver node is not ready to receive. The last major source of energy waste is collision, which occurs when there are simultaneous transmissions from several nodes that are within the interference range of the receiver node. Since the collided packets must be retransmitted, it also causes unnecessary energy waste.

To alleviate those energy wastes, several MAC protocols for wireless sensor networks have been proposed. These protocols can be classified into either scheduling based or contention based protocols. Scheduling based protocols are usually TDMA-based protocols in which each sensor node is assigned one of time slots and can communicate only in the assigned time slot. TDMA-based protocols are naturally contention-free, and hence, there is no energy waste caused by collisions. However, in general, it is not easy to design a simple algorithm for time slot assignment, due to a large number of sensor nodes and lack of the central controller. In addition, elaborate time synchronization is required to correct timing error caused by clock drift. Contention based protocols are not collision-free. However, due to its simplicity and scalability, in practice, contention based protocols are preferred for wireless sensor networks. Thus far, many contention based protocols that aim to reduce energy consumption are proposed. It is an adaptive energy-efficient MAC protocol for wireless sensor networks that minimizes idle listening, while considering wireless sensor communication patterns and hardware limitations [14].

1) SENSOR MAC (S-MAC)

S-MAC is a contention-based protocol that reduces energy consumption by means of several mechanisms. Periodic listen and sleep forces nodes to activate periodically for a small time interval (the listen period); the rest of the time the nodes turn off their radio and sleep (the sleep period). A listen/sleep cycle is also called a frame. The ratio of the listen interval to the sleep interval is the duty cycle. Neighbors achieve and maintain a coordinated sleeping time, synchronizing their listen/sleep schedules by means of the short Synchronization (SYNC) packet. SYNC packets correct clock drifts and are used to discover new neighbors. In a stationary situation, each node broadcasts a SYNC packet after a fixed number of frames (NC) to maintain synchronization. Within a frame, the listen interval is subdivided into SYNC period (for SYNC packets) and data period (for data packets); Nodes perform carrier sense during a random number of slots (contention) before transmitting SYNC.

2) TIMEOUT MAC (T-MAC)

In T MAC every node periodically wakes up to communicate with its neighbors, and then go to sleep again until the next frame. Meanwhile, new messages are queued. Nodes communicate with each other using a Request-To-Send (RTS), Clear-To-Send (CTS), and Data, Acknowledgement (ACK) scheme, which provides both collision avoidance and reliable transmission.

A node will keep listening and potentially transmitting, as long as it is in an active period. An active period ends when no activation event has occurred for a time TA.

An activation event is:

- the firing of a periodic frame timer;
- the reception of any data on the radio;
- the sensing of communication1 on the radio, e.g. during a collision;
- the end-of-transmission of a node's own data packet or acknowledgement;
- The knowledge, acquired through overhearing prior RTS and CTS packets that a data exchange of a neighbor has ended.

A node will sleep if it is idle and not in an active period. Note that TA is an upper bound on the idle listening time per frame at the end of the active time.

The described timeout scheme moves all communication to a burst at the beginning of the frame. Since messages between active times must be buffered, the buffer capacity determines an upper bound on the maximum frame time [15].

Various other Mac protocols are also exist which more and less comes under the above two mentioned categories. B-MAC [16] with LPL was the first MAC protocol to introduce LPL schedules for recent radios. Polastre et al. provide a model for LPL with strong consideration for the target radio. Post-B-MAC protocols include X-MAC [17] and Speck-MAC-D [13]. Both protocols are of the channel-probing family and tried to improve the LPL scheme presented by B-MAC.in [13] MX-MAC is reconstructed and compared with X-MAC, B-MAC and Speck-MAC D etc. On

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the Basis of above work done we proposed a protocol which selects flow events of nodes randomly.

5 SIMULATION SETUP AND RESULTS DISCUSSION

In this section we have discussed the simulation setup for performance evaluation of proposed protocol. Simulation is done in MATLAB.

A) Simulation Setup

Serial Number	Parameter Name	Value
1.	Number of nodes	10
2.	Transmission Range	30 mt
4.	Antenna	Omni Antenna
5.	Packet size	40 Byte
6.	Simulation Time	200 sec
7.	Topology	Flat-greed
8.	Queue Size	20
9.	Time To Send 1Byte	31.89 µS
10.	Probing Time	9.67 mS
11.	Probing Energy	142.64 µJ
12.	Power Down	0.000892587 Per Second

B) Result Discussion

The goal of this paper is to propose a WSN MAC protocol to reduce the average Energy consumption of nodes, packet delay is also reduced than earlier used MAC protocols. In the given scenario, simulation time is set to 500 sec Average Delay is 3.431 s and average energy consumption is 1.8736 j. 10 nodes were taken, placed at a distance of 30 meter from each other. The parameters were set according to the table.

1. First node was made source and 10th as destination. Events are found chronologically and simulation is done according to the events found results are shown below. When parameters are set as above table:

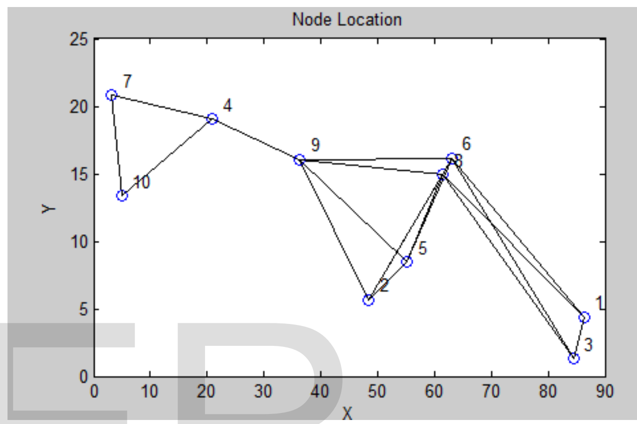

Fig2. Randomly Generated Scenario.

During the simulation the area 30 by 100 meter is covered and sensor nodes deployed randomly on the basis of the range of the antenna then we find the neighbors of each node at the end we create a shortest path from source to destination and nodes are plotted then one by one links are plotted between nodes to show the path.

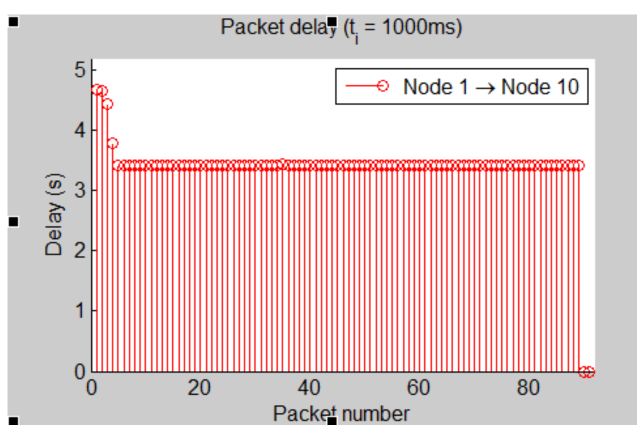

Fig3. Packet Delay in ms

In Figure 3 Source to destination packet delay in milliseconds is shown we took five milliseconds as delay and for 90 packets the delay is shown and delay for approximately first 10 packets is above 4 but after that it is less than 4. So average delay packet delay is 3.4576 ms

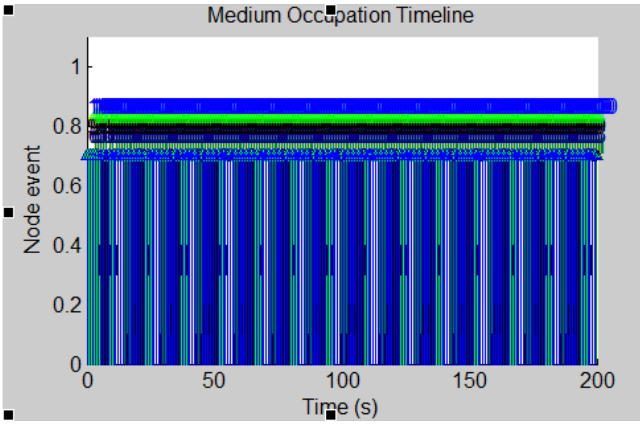

Fig4. Medium Occupation

In Fig 4 during the time of 200 ms nodes occupy the medium at different time slots and the this graph just consider only the x-axis because only the time line shows the time at which the medium is occupied.

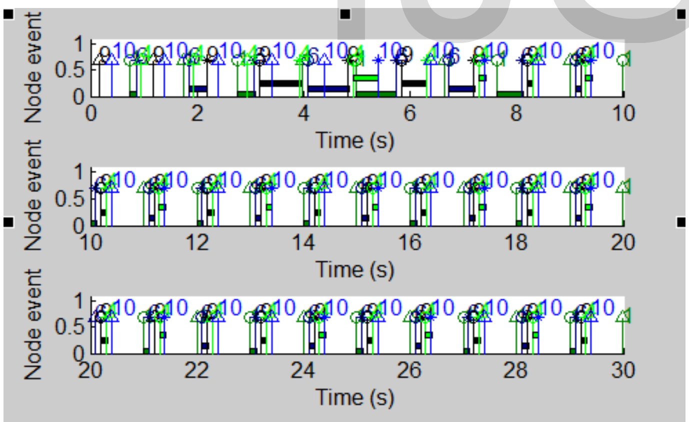

Figure 5 Node Event

Figure 5, as events are found chronologically so randomly events and flow events are found according to found events the simulation is done four first 30 ms for the best visibility of the figure different events are shown with different colors and also as a label node which hire the event is plotted on the Top of the plotted event. As events are found so a node may find feedback, flow update, Next Wakeup Time Mode, probe end of Transmission Mode, end of Receiving Mode etc.

6 CONCLUSION

In WSN to increase the network lifetime the MAC layer protocol plays an important role. T-MAC is an energy efficient MAC layer protocol for wireless network. Being MAC layer protocol, it provides a batter utilization of the network by using randomly selection of the adaptive schedule by the sender so that receiver can adopt the schedule selected by the sender and energy can be saved as shown above the total energy consumption is approximately 0.77497 μJoule, the average packet delay is 3.4576 ms. We have also reduced the number of probes which is also energy consuming in the verification of channel either it is free or not hence in other protocols problem of synchronization occurs which is energy consuming due to the loss of packets as our results shows efficiency of the network as 97 percent data is received successfully.

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