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Examining Wireless Medium Access Control Schemes

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Abstract
As the technology advances and telephone, cable and data networks converges into a single network, MAC (medium access control) protocols play momentous role in WSNs. MAC protocols define rules for accessing the shared medium efficiently. MAC protocols are used for energy conservation and to avoid collisions. In this paper we describe different MAC protocols for WSN. This paper presents the comparative study of different MAC protocols. It shows which protocol will be suitable for specific application and environment. The aim of this paper is to analyze the most energy efficient protocol so that MAC protocols can be categorized and their performance can be compared. There are some problems in existing MAC protocols that is in cellular systems QOS (quality of service) is not good, bandwidth efficiency issues and network synchronisation is difficult. Bluetooth is also having short range issue.
Keywords: *Wireless Sensor Networks, Energy Efficient MAC Protocols, CDT (Continual Data Scheme).*

I. INTRODUCTION

As the need of low power microprocessor and the development of new wireless communication techniques increases so WSNs has become the most promising technologies. Designing of WSN's main aim is to minimize energy consumption and maximizing the lifetime of the networks and this can be done by using MAC protocols. The critical issue in wireless sensor networks is energy efficiency and sources of energy loss are idle listening, collision, overhearing etc [11]. In this paper we have compared the different MAC protocols which are suitable for different applications.

II. Related Work

In this section different energy efficient protocols are presented which are energy efficient. These protocols are categorized in to contention based and TDMA based protocols. Contention based MAC protocols are based on CSMA or CSMA/CA (carrier sense multiple access/collision avoidance). These protocols assigned time slot to each node dynamically. The main concept is to transmit when channel is idle. A ready to send(RTS) and clear to send(CTS) packets are used so that transmission can be collision free. TDMA based protocols allocate a time slot to each node for data transmission. These protocols are generally more energy efficient than contention based protocols. This MAC can achieve good performance because during the idle times radio transmitter can be turned off in order to conserve energy. As TDMA assign different time slot to each sensor so latency increases with the increase in number of sensors sharing the channel.

S-MAC: S-MAC protocol in [1] combination with energy efficient protocols that are used in WSNs. In this nodes have periodic listen-sleep schedule. And nodes turned off their transmitter during sleep period so that energy can be saved. Focus is mainly on improving the power consumption of S-MAC protocol, by using OLSR routing protocol. Improvement in S-MAC protocol results in increase of sensor nodes lifetime and in further, network connectivity and survivability. In this paper use of S-MAC protocol in combination with OLSR, AODV, DSR and DSDV protocols is evaluated with the aim to reduce energy consumption and thus increase connectivity and survivability of ad-hoc WSNs and by the experimental results it is verified that sensor node lifetimes, using the routing protocol OLSR is longer than remaining schemes using the routing protocols AODV, DSR, DSDV.

Timeout MAC [7]: As the traffic load fluctuates S-MAC protocol does not work properly so the T-MAC protocol is used to finish the time period of active node. When all the network traffic has finished, T-MAC[6] allows the node to go into sleep mode. Timeout (TA) duration is given to each node. If no transmission occur for TA duration then node switch off its radio so that energy can be saved and move into sleep state. The timeout should be more enough so that it can overcome the early sleeping problems. T-MAC also introduces flow control in data flow by using FRTS (future request to send).

D-MAC: It is also an energy efficient protocol and it uses a staggered wake up pattern to transmit data to the base station. It considered the nodes at different level of tree. The nodes which are at same level of tree would wake-up simultaneously to receive data. The nodes which are at next level would wake-up just after the lower level's receiving period. And this data transfer forms staggered pattern and the data packet reaches from root to leaves in one cycle. It also adopts prediction method [5] when multiple child nodes want to send data to one parent in one cycle only.

I-MAC: Intelligent MAC is having intelligent sleep and wake-up schedule. It is based on CSMA/CA (carrier sense multiple access with collision avoidance) and consist of BEB (binary exponential back-off) algorithm to reduce the collisions. Each slot is assigned time duration of σ seconds. When a station transmits data, it initialize its back-off counter [10]. The counter is decreamented, froze or resumed if medium is idle for σ seconds, busy or idle for σ seconds after the last transmission finishes respectively. The station transmits when the back-off counter reaches to zero. The receiver will wait for σ/2 seconds when there is successful reception of packets and then an ACK will be send to the transmitter. If it will not get any ACK then packet will be retransmitted. It is necessary that as soon as the transmission finished its next slot should synchronize with the slot boundary of all idle nodes.

TEEM[3]: Traffic aware energy efficient MAC protocol is contention based protocol. This protocol is similar to S-MAC. In TEEM, the durations of sleep/listen modes are adaptive by utilizing traffic information of each node. When the nodes have no data traffic to, they are put into sleep state. TEEM is more energy efficient than all other because it is having shorter and adaptive listen period and it saves more energy than S-MAC.

R-MAC[9]: Receiver driven TDMA based MAC not only eliminates the need to wake-up a receiver node by sensor node but also reduces collision among sensor node. In this the receiver node assigns its timeslot to the neighbour sender nodes and thus forms clusters of sender and receiver nodes in the network. Receiver nodes only wake-up to listen the transmission during their assigned time slot otherwise asleep for all other time slots. If any sender will not use its assigned time slot, the receiver node can go back to sleep after its timeout period of no-channel activity so that idle listening overhead may be reduced.

G-MAC [9]: Energy adaptive WSN MAC protocol i.e. Gateway MAC (G-MAC) which gives centralized function of cluster management to distribute cluster energy resources and extend network lifetime. G-MAC achieves energy saving by performing all required traffic scheduling operations while most of the nodes are sleeping in both heavy and light density traffic environments. G-MAC dynamically proposed TDMA slots according to the demand of network traffic without imposing any cluster wide message overhearing and increase the network lifetime by 250% for unicast network GMAC cluster centering functions offers significant energy savings by considering the advantages of both contention and contention-free protocol.

AEEMAC[2]: Adaptive energy efficient MAC protocol, the available energy efficient medium access control protocols for WSNs focusing on their energy conserving methods and present AEEMAC as a simple but effective energy[14] efficient MAC protocol as an optimization over SMAC. AEEMAC incorporates three additional optimizations to improve energy efficient at MAC layer are:

1. Adaptive sleeping and reusing of channel
2. Use of combined 'SYNC-RTS' control packet
3. Use of 'ACK-RTS' control packet in bidirectional and multihop data transmission.

Adaptive sleeping and reusing of channel scheme and two 'combined transmission' schemes are proposed, where control messages can be piggybacked in the messages with reservation slots. Collision probability of RTS can be reduced by this scheme as it save slots resource. The simulation studies show that AEEMAC achieves better energy performance than SMAC. AEEMAC reduces energy consumption while providing good end-to-end delay, packet delivery ratio and throughput in comparison to SMAC.

ALLEE-MAC[12]: An adaptive low latency and energy efficient MAC protocol. Energy efficient is a critical issue in WSNs. To reduce energy consumption periodic listen/sleep mechanism is used. But if fixed listen/sleep scheme is used it introduces additional latency in packet delivery and energy wastage for unnecessary idle listening. This paper proposed a low latency and energy efficient MAC protocol with an adaptive listen/sleep mechanism, named ALLEE-MAC. Cross layered design approach is adopted in ALLEE-MAC for achieving two novel schemes. These are continual data scheme and early- sleep scheme. To evaluate the performance of proposed new protocol simulations have been done, through which we get ALLEE-MAC can really reduce packet end- to- end delay in case of heavy traffic and save more energy compared with S-MAC/AL.

PW-MAC[8]: Predictive wake up MAC. It is based on asynchronous duty cycle. It enables senders to predict receive wakeup time that could minimize energy consumption, although facing the challenges of OS delay, clock drift and unpredictable network. Even in the presence of wireless collisions, it achieves high energy efficiency by an efficient prediction based retransmission mechanism. To evaluate the performance of PW-MAC with Wise MAC, R-MAC and X-MAC, experiments are conducted on a testbed of MICAZ notes.

III. Comparison of Different MAC Protocols

MAC Protocol/ type	Protocol Quality	Drawbacks
T-MAC	It introduce the timeout window to finish the active period of a node so that energy can be saved.	The major problem is that nodes sleep in accordance to their activation time and for long messages data may get lost.
D-MAC	It adds dynamic duty cycle to decrease the latency for delay sensitive applications[6].	It does not utilize collision avoidance methods. Due to which, when nodes with same schedule transmit simultaneously, collision occurs.
I-MAC	The major quality is its intelligent sleep and wake-up procedure[15]	It is limited in the real time test bed.
TEEM	It is more energy efficient due to shorter and adaptive listen period.	Collision may occur if a node transmit RTS/CTS when neighbour node is also switching its transmitter to listen in sending mode.
R-MAC	It uses scheduling to transmit control and data packets to avoid collisions.	It is not robust in error prone transmission channel.
S-MAC	It gives good scalability and collision avoidance by combined scheduling and contention scheme.	It does not work well when traffic load fluctuates.
G-MAC	Ability to schedule heavy and light density traffic to achieve significant energy saving and eliminates network wide idle listening.	It requires delicate tradeoff in energy, latency and throughput.
AEEMAC	Improves energy efficiency by adaptive sleeping and reusing of channel, combined SYNC-RTS and ACK-RTS control packets.	The three optimization schemes used makes it more complex.
ALLEEMAC	To save more energy and short end to end delay it uses two novel schemes i.e CDT and early –sleep.	End-to-end delay of ALLEE-MAC is always a bit larger than that of SMAC when the interval of message is larger than two seconds.
PW-MAC	The main concept is for sender to wake up just before receiver is ready[11]. For this every node uses pseudo random wake up schedule.	In some applications accurate prediction is not possible.

IV. Conclusion

This paper gives the different MAC protocols used in WSN. TMAC introduce the timeout window to finish the active period of a node so that energy can be saved. But it is not suitable for long data length. DMAC adds dynamic duty cycle to decrease the latency for delay sensitive applications. It does not consider collision avoidance methods. Intelligent wake up and sleep schedule are used in I-MAC. In TEEM, the durations of sleep/listen modes are adaptive by utilizing traffic information of each node. RMAC uses scheduling to transmit control and data packets to avoid collisions. In SMAC nodes have periodic listen-sleep schedule. And nodes turned off their transmitter during sleep period so that energy can be saved. But it does not work when traffic fluctuates. In GMAC ability to schedule heavy and light density traffic to achieve significant energy saving and eliminates network wide idle listening. AEEMAC improves energy efficiency by adaptive sleeping and reusing of channel, combined SYNC-RTS and ACK-RTS control packets. ALLEEMAC save more energy and short end to end delay it uses two novel schemes i.e CDT and early –sleep. The main concept in PW-MAC is for sender to wake up just before receiver is ready.

This paper gives a detailed view of various protocols. In future further detailed study on protocols could be done revealing other important properties.

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