A Survey: MAC Protocols for Wireless Sensor Networks

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Abstract—Wireless sensor networks have gained increasing attention from both the research community and actual users. Sensor nodes are generally deployed in hazardous, remote, hostile area. So it is impossible or inconvenient to recharge the battery. Energy efficiency is main design criteria for WSNs. This paper presented various energy efficient MAC protocol with different objective for wireless sensor networks.

I. Introduction

A wireless sensor network highly distributed network of small and light weight nodes deployed over a geographical area to monitoring physical phenomena like temperature, humidity, vibrations and so on. The sensor networks are design and deployed with a specific application requirements. A sensor node is a small device that includes three basic components: a sensing subsystem for data acquisition from the physical surrounding environment, a processing subsystem for data processing and storage, and a wireless communication subsystem for data transmission.

Sensor nodes are battery operated device and generally deployed in hazardous, remote, hostile area. So it is impossible or inconvenient to recharge the battery. So power management is a key issue in sensor node. Therefore researches are design energy efficient mac-protocol to extend nodes and network lifetime.

Design challenges for MAC protocols

The medium access control protocols for the wireless sensor network have to achieve two objectives. The first objective is to establish the communication link between thousands of the sensor nodes. The second objective is to share the communication medium fairly and efficiently.

Characteristic to design efficient mac protocol:-

1) *Energy efficiency:*-Sensor nodes are battery operated devices. It is deployed in hazardous and hostile areas. So it is impossible and inconvenient to recharge the battery. So we design energy efficient mac protocol to extend the network life time
2) *Latency:*-Latency represent the amount time message takes to traverse the system. So latency requirement depends on the real-time application where the detected event must be reported to the sink node and action takes immediately.
3) *Throughput:*-Throughput represents the amount of data within a period of time sent from the sender to the receiver. That is varies with the application requirement.
4) *Fairness:*-In sensor network the resources are limited, it necessary to ensure that all the node share fairly.

The main goal in MAC protocol design for WSN in energy efficiency in order to increase the network lifetime of sensor. The reasons for the unnecessary energy waste in wireless communication are:

1) Ideal listening:-This type of mode most energy is wasted because node is listen or waiting for packet arrives.
2) Packet collision:-In this mode when collision occurred, so energy will consume to retransmitted the corrupted packet.
3) Overhearing:-In this mode the node are wasting energy for the packet is received that not destined for them.
4) Control overhead: - Control packet overhead for synchronization, is another sources of energy consumption.

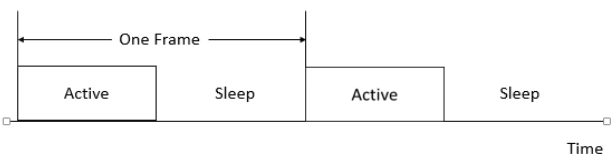
II. Types Of MAC Protocol

The medium access control protocols for the sensor networks can be classified broadly into two categories: Contention based and Schedule based

A. Contention Based

Contention-based MAC protocols can access the medium by sensing the shared channel and competing to get access to it instead of defining schedules for access. Carrier Sense Multiple Access (CSMA) is the most commonly used technique for this type of protocol. Contention-based MAC protocols are easy to implement and configure.

1) *IEEE 802.11:*-The IEEE 802.11 is a well-known contention based medium access control protocol which uses carrier sensing and randomized back-offs to avoid collisions of the data packets. It is a simple and reliable MAC protocol that is widely used in many ad hoc wireless networks. This is not suitable for sensor networks because throughput, latency, and fairness were the primary design criteria, not power consumption.
2) *S-MAC* Sensor – MAC a contention based MAC protocol is modification of IEEE 802.11 protocol specially designed for the wireless sensor network. As fig shown that in Sensor-MAC time divided into frames and each frame is divided into active and sleep periods. Data transmission occurs during in active period. Based on the application requirement Duty cycle is fixed and predefine. So a disadvantage is many nodes are idle during the listening time which can waste the energy.



3) *T-MAC* Timeout mac is another contention based mac protocol which is the modified of s-mac. In this type of protocol use adaptive duty cycle for data transmission.

Sensor nodes go to sleep mode when no event is detected. So duty is variable based on traffic level.

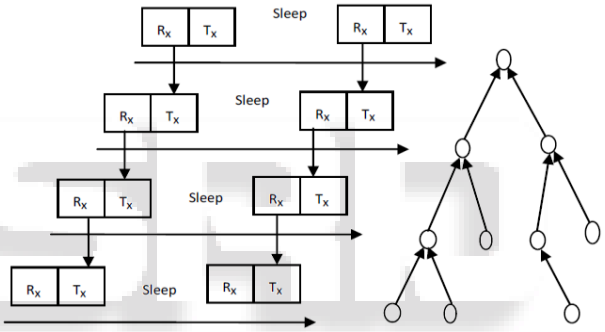
4) *PAMAS* Power Aware Multi-Access is contention based MAC protocol designed with energy aware as the main objective. In this protocol nodes are turned off their transmission or receiving to save their energy. This protocol use to separate channel for data and control packet. It required two radios for communication. The disadvantage is the additional cost for the second radio.
5) *B-MAC* The Berkeley Media Access Control (B-MAC) is a contention based MAC protocol for WSNs. B-MAC is similar to Aloha with Preamble Sampling, which duty cycles the radio transceiver i.e. The sensor node turns ON/OFF repeatedly without missing the data packets. However in B-MAC, the preamble length is provided as parameter to the upper layer. This provides optimal trade-off between energy savings and latency or throughput. The experimental results show B-MAC has better performance in terms of latency, throughput and often energy consumption as compared to S-MAC.

B. Reservation Based

In reservation-based MAC protocols, the channel or medium is reserved for a certain amount of time. Reservation-based MAC protocols have many disadvantages like exact timing, not scalable, required coordination

1) *TRAMA (Traffic-adaptive medium access protocol)* TRAMA is a reservation-based MAC protocol. It reduces energy consumption when the nodes are idle by making the nodes switch to sleep mode hence collisions are avoided. TRAMA uses a distributed election scheme. Based on information about the traffic at each node it determines which node can transmit at a particular time slot. The schedules in TRAMA are dynamic and adaptive based on current traffic patterns.

   Objective of TRAMA is to significantly save energy by reducing energy consumption from two sources: collision and idle listening.
2) *ER-MAC (Energy and rate-MAC)* ER-MAC is another reservation-based MAC protocol designed for wireless sensor networks that uses the TDMA technique. For energy saving ER-MAC periodically switches nodes to sleep. ER-MAC selects nodes to sleep based on their criticality. Criticality is a measure of the lifetime of the node, which is decided based on energy and traffic rates. If node is defined critical based on if it has more data to send. So that nodes gives more time slot to send data. Also the node has lower battery than it is critical node, to give more time to sleep. So the duty cycle is based on the criticality of the nodes.
3) *WISE-MAC* the Wise MAC medium access control protocol was developed for the "Wise NET" wireless sensor network. This protocol is similar to Spatial TDMA and CSMA with Preamble Sampling protocol where all the sensor nodes have two communication channels. TDMA is used for accessing data channel and CSMA is used for accessing control channel. However, Wise MAC needs only one channel and uses non-persistent CSMA with preamble sampling technique to reduce power consumption during idle listening. This protocol uses the preamble of minimum size based on the information of the sampling schedule of its direct neighbours. The sleep schedules of the neighbouring nodes are updated by the acknowledgement message (ACK) during every data transfer. Wise MAC is adaptive to the traffic loads and provides low power consumption during low traffic and high energy efficiency during high traffic. The simulation results show that Wise MAC performs better than S-MAC protocol.
4) *D-MAC* The Data-Gathering Medium Access Control (D - MAC) [12] is a schedule based MAC protocol which has been designed and optimized for tree based data gathering in wireless sensor network. The main objective of this MAC protocol is to achieve low latency and the energy efficiency. In this protocol the time is divided in small slots and runs carrier transmit/receive one packet. DMAC could be summarized as an improved Slotted Aloha algorithm. In DMAC based on data gathering tree slots are assigned to the sets of nodes as shown in Figure. Hence, during the received period of a node, all of its child nodes have transmit periods and struggle for the medium. By assigning subsequent slots to the nodes that are successive in the data transmission path low latency is achieved.



5) *LEACH* Energy Aware Scheduled Based MAC protocol assumes the formation of clusters in the network. Each of the cluster sensor nodes is managed by the cluster head. The cluster head collects the information from the other sensor nodes within its cluster, performs the data fusion, communicates with the other cluster head and finally sends the data to the control centre. The assignment of the time slots to the sensor nodes within its cluster is performed by the cluster head. The cluster head inform the other nodes about the time slot when it should listen to other nodes and the time slot when it can transmit own data

III. CONCLUSION

Recently several medium access control protocols for the wireless sensor network have been proposed by the researchers. However, no protocol is accepted as standard. This is because the MAC protocol in general will be application specific. Therefore, there will not be one standard MAC protocol for the WSNs.

The schedule based (TDMA) have collision free access to the medium but the synchronization is critical. Moreover, there is difficulty in adapting to the changes in the network topology because of the addition and deletion of nodes.

The contention based (CSMA) have low latency and high throughput. However, it still suffers from the collisions.

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