

A Survey Of Mac Protocol For Broadcast Problem In Wireless Sensor Network

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Abstract: One of the most active research areas for computer science and telecommunication researcher is the wireless sensor networks. Usually after the deployment of sensor nodes in the hazardous, hostile or remote areas, these nodes work on their own. These sensors nodes will have to perform their function with scarce and non-replenishable power resources. One of the main design objectives for these networks is Energy efficiency. This paper presented the obstacle and challenges in the design and development of power aware medium access control protocol for wireless sensor networks.

Keywords: Energy Efficiency, Medium Access Control, Wireless Sensor Network.

I. INTRODUCTION

The Potential usages of the Wireless Sensor Networks (WSNs) in scientific and defence applications have proved it to be as one of the dominant technology trends of this decade. The applications of these WSNs is not limited to only military, or surveillance but it serves different purposes such as target tracking, intrusion detection, wildlife habitat monitoring, climate control and disaster management [10]. A common node of a Wireless Sensor Network consists of a sensor, a processing module, small amount of processing memory, transmitter / receiver module and a power source. There are a lot of resource constraints for these Sensors, and energy must be conserved in order to function properly when needed. The most energy consuming task or operation in sensor networks is when they coordinate among themselves i.e. communication or data transmission. Most the research is focused on the design of low power electronic devices so that the energy consumption the sensors should be minimized. In order to overcome the limitations in the hardware, further efficiency can be achieved through the design of energy efficient communication protocols.

II. DESIGN MATRICES FOR MAC PROTOCOLS

The medium access control protocol must achieve the following two challenges;

- i. The creation of the sensor network infrastructure.

A large number of sensor nodes are deployed and the MAC scheme must establish the communication link between the sensor nodes.

- ii. To share the communication medium fairly and efficiently.

2.1 Characteristics of Efficient MAC Protocol

The following attributes are to be considered, while design a good MAC protocol for the wireless sensor networks.

- i. **Energy Efficiency:** The sensor nodes are battery powered and it is often very difficult to change or recharge batteries for these sensor nodes.
- ii. **Latency:** Latency requirement basically depends on the application. In the sensor network applications, the detected events must be reported to the sink node in real time so that the appropriate action could be taken immediately.
- iii. **Throughput:** Throughput requirement also varies with different applications. Some of the sensor network application requires sampling the information with fine temporal resolution.
- iv. **Fairness:** In many sensor network applications when bandwidth is limited, it is necessary to ensure that the sink node receives information from all sensor nodes fairly.

2.2 Major Causes of Energy Wastes in Wireless Sensor Network

Major causes of energy waste in wireless sensor network are basically of four types.

- i. **Collision:** The first one is the collision. When a transmitted packet is corrupted due to interference, it has to be discarded and the follow on retransmissions increase energy consumption.
- ii. **Overhearing:** The second is overhearing, meaning that a node picks up packets that are destined to other nodes.
- iii. **Packet Overhead:** The third cause is control packet overhead. Sending and receiving control packets consumes energy too and less useful data packets can be transmitted.
- iv. **Idle listening:** The last major source of inefficiency is idle listening i.e., listening to receive possible traffic that is not sent. This is especially true in many sensor network applications.

2.3 Performance Matrices for MAC Protocol

The research community consider the following matrices in order to evaluate and compare the performance of energy conscious MAC protocols.

- i. **Energy Consumption per Bit:** The energy efficiency of the sensor nodes can be defined as the total energy consumed / total bits transmitted. The unit of energy efficiency is joules/bit. The lesser the number, the better is the efficiency of a protocol in transmitting the information in the network.
- ii. **Average Delivery Ratio:** The average packet delivery ratio is the number of packets received to the number of packets sent averaged over all the nodes.
- iii. **Average Packet Latency:** The average packet latency is the average time taken by the packets to reach to the sink node.
- iv. **Network Throughput:** The network throughput is defined as the total number of packets delivered at the sink node per time unit.

III. CATEGORIES OF MAC PROTOCOLS

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

3.1 Contention Based

The contention based protocols on the other hand relax time synchronization requirements and can easily adjust to the topology changes as some new nodes may join and others may die few years after deployment. These protocols are based on Carrier Sense Multiple Access (CSMA) technique and have higher costs for message collisions, overhearing and idle listening.

3.1.1 IEEE 802.11

The IEEE 802.11 [19] 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. The Power Save Mode (PSM) of the IEEE 802.11 protocol reduces the idle listening by periodically entering into the sleep state. This PSM mode is for the single-hop network where the time synchronization is simple and may not be suitable for multi-hop networks because of the problems in clock synchronization, neighbour discovery and network partitioning.

3.1.2 Sensor – MAC (S – MAC)

Sensor – MAC [2] a contention based MAC protocol is modification of IEEE 802.11 protocol specially designed for the wireless sensor network in 2002. In this medium access control protocol the sensor node periodically goes to the fixed listen/sleep cycle. A time frame in S-MAC is divided into two parts: one for a listening session and the other for a sleeping session. Only for a listen period, sensor nodes are able to communicate with other nodes and send some control packets such as SYNC, RTS (Request to Send), CTS (Clear to Send) and ACK (Acknowledgement). By a SYNC packet exchange all neighboring nodes can synchronize together and using RTS/CTS exchange the two nodes can communicate with each other.

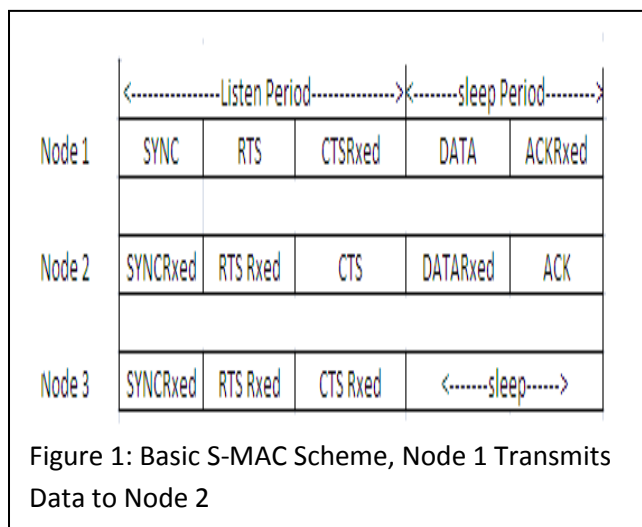


Figure 1: Basic S-MAC Scheme, Node 1 Transmits Data to Node 2

3.1.3 Time Out MAC (T – MAC)

Timeout T-MAC [3] is the protocol based on the S-MAC protocol in which the Active period is pre-empted and the sensor goes to the sleep period if no activation event has occurred for a time. The event can be reception of data, start of listen/sleep frame time etc. The time 'Ta' is the minimal amount of idle listening per frame. The interval $T_a > T_{ci} + T_{rt} + T_{ta} + T_{ct}$ where T_{ci} is the length of the contention interval, T_{rt} is the length of an RTS packet, T_{ta} is the turnaround time (time between the end of the RTS packet and the beginning of the CTS packet) and T_{ct} is the length of the CTS packet.

3.1.4 Berkeley Media Access Control (B-MAC)

The Berkeley Media Access Control (B-MAC) [10] is a contention based MAC protocol for WSNs. B-MAC is similar to Aloha with Preamble Sampling [11], 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.

3.2 Scheduled Based

The schedule based protocol can avoid collisions, overhearing and idle listening by scheduling transmit & listen periods but have strict time synchronization requirements.

3.2.1 Traffic Adaptive Medium Access Protocol (TRAMA)

The traffic adaptive medium access (TRAMA) [6] is a Contention based protocol that has been designed for energy efficient collision free channel in WSNs. In this protocol the power consumption has been reduced by ensuring collision free transmission and by switching the nodes to low power idle state when they are not transmitting or receiving. This protocol consists of three main parts:

- i. The Neighbor Protocol is for collecting the information about the neighboring nodes.
- ii. The Schedule Exchange Protocol is for exchanging the two – hop neighbor information and their schedule.
- iii. The Adaptive Election Algorithm decides the transmitting and receiving nodes for the current time slot using the neighborhood and schedule information. The other nodes in the same time slot are switched to low power mode.

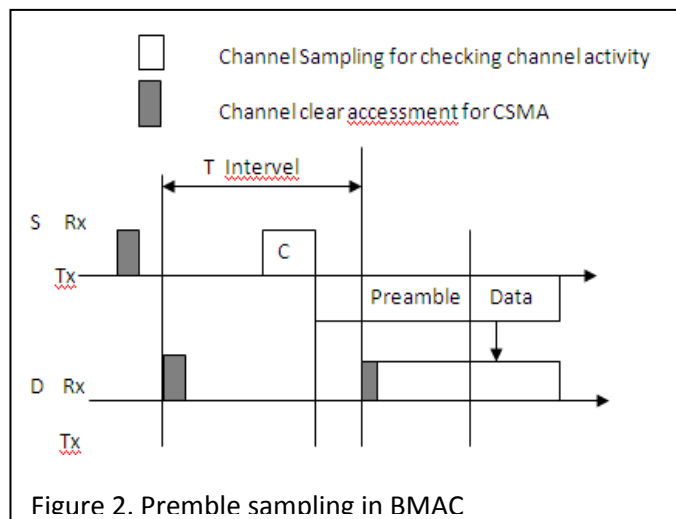


Figure 2. Preamble sampling in B-MAC

3.2.2 Self Organizing Medium Access Control for Sensor Networks (SMACS)

SMACS [9] is a schedule based medium access control protocol for the wireless sensor network. This MAC protocol uses a combination of TDMA and FDMA or CDMA for accessing the channel. In this protocol the time slots are wasted if the sensor node does not have data to be sent to the intended receivers. This is one of the drawbacks of this MAC scheme.

3.2.3 Wise MAC

Wise MAC [10] 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 [9] 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 [8] 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 neighbors.

3.2.4 Low Energy Adaptive Clustering Hierarchy (LEACH)

Energy Aware Scheduled Based MAC [16] 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.

3.2.5 Data Gathering MAC (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 (converge cast communication) in wireless sensor network. The main objective of this MAC protocol is to achieve low latency and still maintaining the energy efficiency. In this protocol the time is divided in small slots and runs carrier transmit/receive one packet. The sensor node periodically executes the basic sequence of 'l' transmit, 'l' receive and 'n' sleep slots. In this approach a single packet from a source Transmitting Node Receiving Node Preamble Message node at depth 'k' in the tree reaches the sink node with a delay of just 'k' time slots.

IV. 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. The Frequency Division Multiple Access (FDMA) scheme also allow collision free access to the media but the extra circuitry required to dynamically communicate with different radio channels increases the cost of the sensor nodes This contradicts the main objective of the wireless sensor networks (WSNs).

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