# A Scheduled Based MAC Protocols for Wireless Sensor Network: A Survey

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**ABSTRACT**-The wireless sensor network has been gaining popularity in all fields. The applications of the WSN are traffic analysis, environmental monitoring, tactical systems, etc. Drawbacks of the WSN include limited battery power, limited bandwidth, memory constraint, etc. Hence designing an efficient MAC layer protocol for WSN is a challenging task. TDMA based MAC protocols can overcome the mentioned drawbacks. It can avoid collisions, idle listening and therefore is energy efficient. In this paper we have represented merits and demerits of different TDMA based MAC protocols for WSN.

**Keywords** - Centralized TDMA , Distributed TDMA ,Time Division Multiple Access(TDMA), Wireless Sensor Network(WSN),

## I. INTRODUCTION

Recent advancement in the technology has enabled low cost, low weight and more energy efficient sensor devices. These sensor devices include integrated sensing, onboard processing and transmission. These sensor devices also known as sensor node is capable of detecting environmental conditions and sound. Sensor nodes have limited battery power leading to less coverage WSN consists of large number of sensor nodes to perform a designated task. In most wireless networks, collision [1] is caused due to two nodes sending data at the same time on the same transmission medium. To overcome this problem, MAC protocols are employed to the sensor networks. TDMA based MAC protocols time is divided into time frames. Each time frame is divided into fixed time slots. Each node is assigned to particular time slot in which transmission occurs. TDMA based MAC protocol [2] avoids the over hearing and idle listening since energy node has a fixed time slot for transmitting and receiving. Every node after receiving or transmission of data enters sleep mode i.e., switch off, thereby saving battery power. The rest of the paper organized as follows: Section II discusses about classification of MAC protocols followed by Section III describes the Scheduled based MAC Protocols and Section IV concludes the paper.

## II. CLASSIFICATION OF WSN MAC PROTOCOLS

In WSN MAC protocol is categorized into Contention Based MAC protocols and Scheduled Based MAC Protocols .In Contention Based MAC Protocol, all the nodes share a common medium and contend for the same medium for transmission. Thus, collision may occur. To avoid collision, nodes can have arbitrary access to the shared channel. The sender listens to the shared medium before the transmission, waits for some time if the medium is busy, then tries for the transmission again. Examples of contention based MAC protocols are: Carrier Sensor Multiple Access (CSMA), Multiple accesses with collision avoidance, (ALOHA).

In Scheduled Based MAC Protocols, nodes access to the shared medium is divided with respect to time (Time Division Multiple Access), frequency (Frequency Division Multiple Access) and orthogonal pseudo codes (Code Division Multiple Access).This allows the different nodes to access the shared channel without collision. These protocols consume less energy hence they do not waste energy in collision and idle listening. Examples of Scheduled based MAC protocols are: Low energy adaptive clustering hierarchy (LEACH), Power efficient and delay-aware medium access protocol (PEDAMACS) etc.

Features of good MAC protocol

- Energy efficiency: The sensor nodes are battery charged and it has to be recharged frequently. Sometimes it‘s better to replace the sensor nodes rather than recharging.
- Latency: It refers to the time delay between time when data is sent by the sender and the time when data is received by the receiver. It depends on the application the detected quarts must be reported, so that the designed table is achieved.
- Throughput: It refers to the amount of data successfully transferred from a sender to the receiver in the given time similar to destiny. Its requirement depends on required application.
- Fairness: When bandwidth is limited, it is required to ensure that the sink nodes receive information from all sensor node fairly.

Among all the above features energy efficiency and throughput are the major aspects.

## III. SCHEDULED BASED MAC PROTOCOLS

Scheduled based MAC protocol is divided into two categories. The first one is traditional TDMA MAC protocol or centralized TDMA protocols. Second category is distributed TDMA protocols.

In centralized TDMA protocols; the nodes are scheduled centrally by different time slots. The scheduling is done by cluster head (CH) or the base station (BS). In this method

if any mode join or leave the network then once again cluster head need to re-assign the scheduling time slots for each node. Disadvantage of this method is scalability and global time synchronization is required for all the nodes in a network.

A Centralized TDMA protocols

1) Bit-map resisted MAC protocol

Bit-map resisted MAC Protocol [3] is an Intra-cluster communication MAC protocol for a large scale cluster-based WSNS.BMA operates in two rounds. Fig 1 shows a complete round. Each round is divided into set-up phase and steady state phase. During set-up phase cluster-head is elected and determined based on the energy levels. The steady state phase is divided into n-sessions with fixed time duration. Each session consist of contention period, in this period all nodes keep their radio on and cluster-head has complete information about the nodes in the network. In TDMA period, nodes send a 1 bit control message to the cluster-head. When it has data to transmit, otherwise, its scheduled slots remain empty.

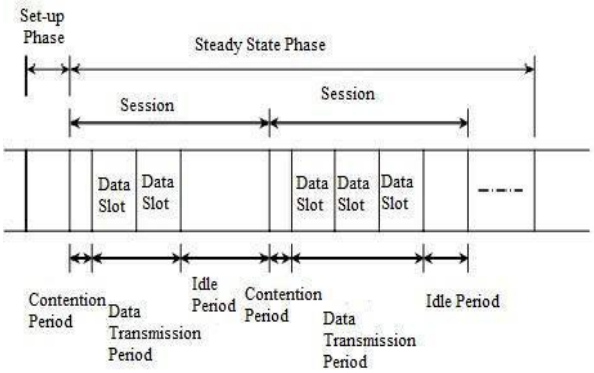


**Fig1Single Round in a BMA**

The cluster head decides the slot and broadcast to the source nodes to transmit data. During contention period slot is assigned to source node. In data transmission period, the node sends a data to cluster head during their allocated time slot and all other time node switch off the radio. When a session finishes, the next session begins with a again contention period followed by data transmission period. The same procedure repeated. The cluster head collects the data from all the node and forwards to base station.

Advantages of this algorithm is that it effectively utilizes the bandwidth, and average packet latency. Disadvantage of this algorithm is that it gives better result in low and medium traffic not for heavy traffic.

2) Self-Organized TDMA Protocol for WSN

Self-Organized TDMA Protocol [4] is a cross layer protocol to serve the application specific and data centric nature of WSN. In SOTP transmission range is very high. In this algorithm time slots divided into frames and each frame divided into time slots. Each frame consists of five types of time slots: Broadcast slot (BR), Carrier Sensing Slot (CS), Transmitting Slot (TX), Receiving Slot(RX) and Idle Slot(ID).A BR slot is always the first slot in the frame, CS is the second slot. Each node move into a one of three states: Searching synchronized or registered. When node boots up is called as node in searching state. The base station periodically broadcast the time slot, then node picks any of the broadcasted time slot then it is called node moved to synchronized state. This picked time slot need to be informed to father node then node moved to register state. In registered state can have one father node and several child nodes.

The merit of SOTP is more energy efficient due to its pure TDMA and non-clustering architecture. The main drawback of this method is that it assumes the high transmission range it covers all the nodes in the network. Data aggregation and compression is given to the upper layer.

3) Mobility tolerant TDMA based MAC protocol

Mobility tolerant TDMA based MAC protocol is used in mobile wireless sensor network. It is assured that network is static during its set-up phase. The network is divided into different clusters and each cluster will have a cluster head. The time is divided into frames and in turn frame is divided into time slots as shown in Fig (2).

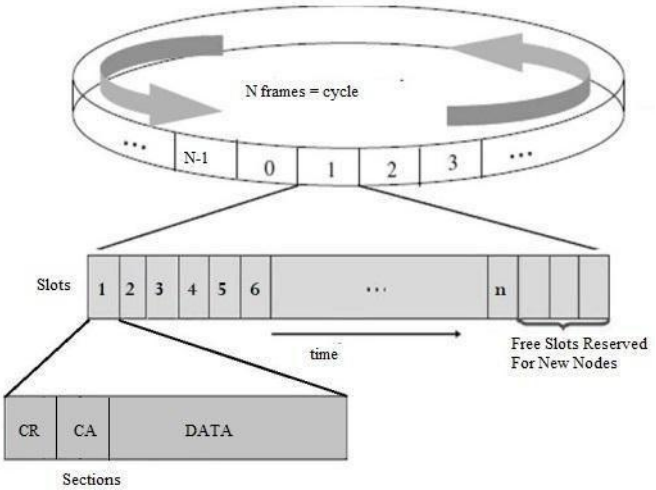


**Fig2 Slot representation in a Mobility tolerant TDMA MAC**

The cluster head allocated a time slot to every node in the cluster and X slots are made free in order to allocate for the nodes which join later part of the time frame. The 10% of total time frame is also allocated for Y. Whenever new node comes and joins the cluster, the cluster head allocates half of the free time slots (Y/2) to the new node. If another node joins to the network then cluster head allocates half of the current time slots (Y/4). Always cluster will a some free time slots to allocate to a new node that join the network.

In this method each time slot is further divided in to 3 sections: Communication request (CR), channel allocation (CA), and data section (DS). In communication request all those nodes that have data to transmit will put the request to the owner node. The owner node calculates the priority of each node. Based on the priority it allocates a time slot. In channel allocation section the packets are transmitted or received in data section. The node which is having highest priority, then owner node assigns first slot to highest priority node.

*B Distibuted TDMA Protocols*

In Distributed TDMA Protocols, nodes are scheduled by themselves. Each individual node will have the information based on these local information scheduling. The message overhead can be reduced by this method. So this method is more energy efficient. Global time synchronization is not needed. Distributed TDMA protocols are adaptive to topology changes and bandwidth adjustment. In the next subsection some of the Distributed TDMA Protocols are discussed.

*1) Distributed Neighborhood Information Based TDMA Scheduling (DNIB)*

The DNIB algorithm, composed of the following stages: Slot assignment, Update and Recovery

At initial stage nonscheduled node computes for contender rank for itself and its nonscheduled neighbors, contender rank are computed based on hop distance and the node id. A node itself as a rank 1, when it has a highest C value. The contender rank is updated each time a neighbor is scheduled. Node through the Update procedure informs to its neighbors. It sends updated message to its one-hop neighbors. Those one-hop neighbors send broadcast message to their neighbor‘s .Now the message is reached to two hop neighbors to update. The broadcast message contains node id and assigned slot. For two hop broadcast message it give slot assignment information for the one hop to reach to two hop neighbors. During this procedure, f collision may occur. The collisions between two-hop broadcast and one-hop broadcast messages may exist.so delay can be introduced for one hop message otherwise wait for a predetermined time slot m. An example is illustrated in Fig 3.

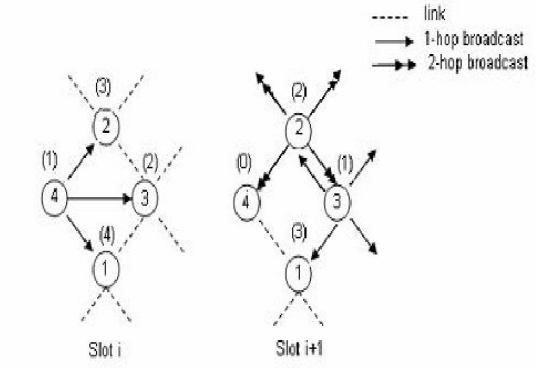


**Fig3: Collision during updated procedure**

The third procedure is Recovery procedure. This procedure is used when a node does not succeed to get scheduled for a predetermined period of time denoted Xn for node n. In this case, the node can send a ―request‖ message to its one hop neighbors. This request message is the same as that of one-hop broadcast message except the assigned slot values which is set to NULL. Node sends a message to one-hop neighbors using ―two hop broadcast‖ message with all already known scheduling information. If two nodes sending message at same time can be avoided by setting Xn.

The advantage of this algorithm is that, it is scalable. It can run parallelly in a network. It does not require whole network information, using a two hop neighbor it can perform the operation. The main demerit of this algorithm is recovery procedure is based on setting of Xn, if too small or too large time will be the problem for collision.

*2) Distributed Randomized TDMA Scheduling (DRAND)*

The DRAND is based on coloring problem. In order to assign TDMA slot assignment it uses graph coloring, where the no two adjacent nodes have the same color and vertices should use minimum color. In DRAND each node will be in a four states: Idle, Request, Grant, and Release.

Initially Node A will be in an Idle state. DRAND sends a request message based on probability, when we are tossing a coin probability of getting head or tail is ½ .The based on probability P Node A sends a request message to node B as shown in Fig (4).Node B adds node A time slot into the list.

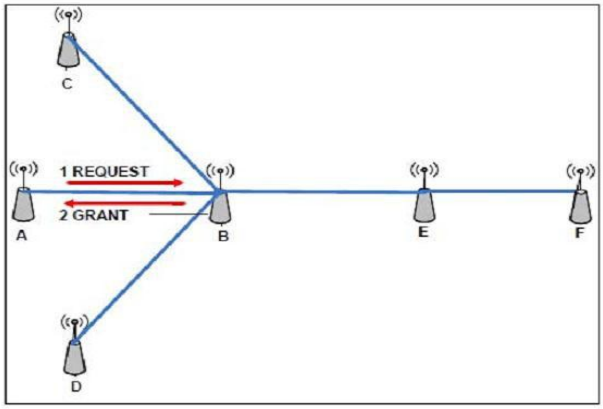


**Fig4: Sucessful slot assignment by DRAND**

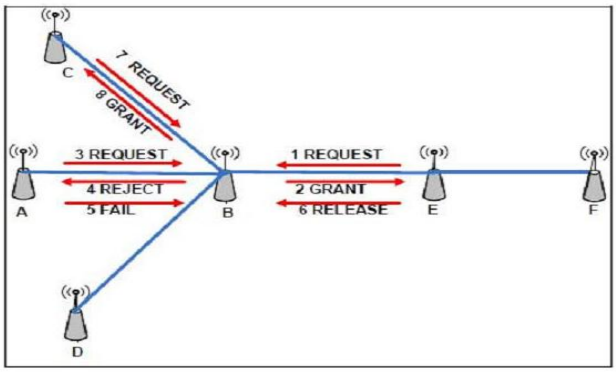


**Fig5 Unsuccessful slot assignment by DRAND**

If node B does not get a request message from any of the one-hop neighbor before node A, then node B gives a Grant message. In turn it sends a request message to two-hop neighbors. Based on node B grant message node A allocates a time slot .Node A will receive a Grant message only on node B in Idle or Release state. If node B receives Request message from one of its neighbor node D before getting a request from node A as shown in Fig (5). Nodes B send a Release message to node A, because it has already sent a grant message to some other node. In both the cases node A does

not receive Grant Message. Node A has to wait for a time period Ta (time delay node A receives response from neighbors).The node A sends a Fail broadcast message to all its neighbors and goto Idle state. After Ta period node A once again send request message.

An advantage of DRAND, scalable, slot assignment is calculated in each node locally. In large network it works efficiently. The main disadvantages of DRAND are message overhead. The energy is wasted for unnecessary message transmission.

*1) Fair Scheduling TDMA Protocols*

Fair Scheduling TDMA Protocols is a distributed slot assignment algorithm. Each Node maintains four states as that of DRAND IDLE, REQUEST, GRANT and RELEASE. Node E sends a request message to node B. If node B does not get a request message from any of the one-hop neighbor before node E, then node B gives a Grant message. In turn it sends a request message to two-hop neighbors. Based on node B grant message node E allocates a time slot .Node E will receive a Grant message only on node B in Idle or Release state. If node B receives Request message from one of its neighbor node C before getting a request from node E as shown in Fig (6). Node B store a request message in its queue and will send a WAIT message to the nodes which have sent REQUEST message as shown in Fig.6.Node B aware of REQUEST from all nodes. Node B sends a GRANT message based on priority, which node request first they will get first grant message.

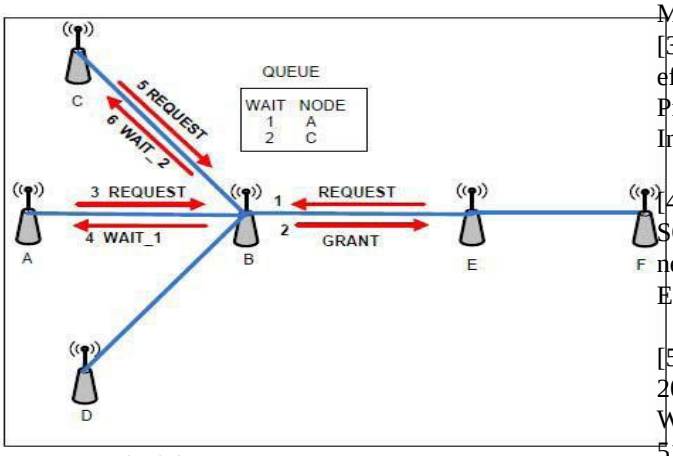


**Fig6: Fair Scheduling maintaining REQUEST in QUEUE**

The advantages of this method is that, message overhead can be reduced, more energy efficient. The main disadvantage is request message has to be stored in a node memory.

for nurses. They are used for recording home visits for the elderly. NFC is becoming widely accepted for medical devices in some markets specifically in the developed countries. Sony Corporation has developed an NFC Healthcare Library which enables communication between healthcare products embedded with the NFC Dynamic Tag (FeliCa Plug) and healthcare applications installed on smart phones. This library is available free of charge for a number of OS, including Windows, Linux and Android. Companies like Omron, Terumo and A&D are incorporating Sony‘s solution into their devices like BP monitors, pedometers, blood glucose meters, etc. Various other companies like Qolpac and Identive WPG have brought NFC into the mainstream with uses ranging from medication compliance to X-ray imagesharing.

## IV. CONCLUSION

In this Paper scheduled based MAC protocols are discussed. In all the scheduled based Protocols advantages and disadvantages are discussed, but still there is no standard protocol is defined .The scheduled based protocol is categorized into centralized and distributed. In centralized method cluster head or base station has to allocate a schedule, so cluster head or base station will have more overheads. In distributed approach each node in a network is responsible for allocating a time slot schedule. Compare to centralized one distributed gives better performance, but still some of the drawbacks were observed. Improvement need to be made in scheduled based protocols.

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