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# Review of Wireless Sensor Networks and Energy Efficient MAC Protocols

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***Abstract:*** **Now days the use of Wireless Sensor Networks (WSNs) is increasing tremendously in different real life applications. This is due to numerous advantages of WSNs such as it doesn't require centralized process, not required wired infrastructure etc. However WSNs are having constraint of energy limited resources. As compared other wireless networks, energy is very vital parameter for WSNs which defines the lifetime of overall WSN. But this networks are widely used any many application and hence it is one of the challenging research area for researchers. WSNs are having low sensing ranges which are nothing but dense networks. In dense networks it's required to achieve the efficient through the medium access control (MAC) protocols in order to improve the performance of WSN in terms of energy efficiency. There are many MAC protocols are presented by different researchers with aim of minimizing the energy consumption in WSNs. In this review paper we are presenting the survey of WSNs in detail as well as MAC protocols. We are first presenting the different design factors of WSNs with its challenges. In addition to this we are discussing the key attributes of making the good MAC protocol for WSN.**

***Keywords: Wireless Sensor Networks, Energy Consumption, Energy Constrained, Medium Access Control, SMAC, TDMA, Latency, Throughput, and Fairness.***

## I. INTRODUCTION

Energy management of the radio transceiver unit of a wireless device has gained significant importance with the emerging of wireless sensor networks since the radio unit is the major consumer of the sensor's energy. It has been shown that the energy consumed in transmitting one bit is several thousand times more than the energy consumed in executing one instruction. Since the radio transceiver is the major power consumer unit and the MAC protocol directly controls its operation, several MAC layer protocols have been proposed to reduce the energy consumption of the sensor's radio unit. For some examples refer to reference, which surveys a large set of MAC protocols designed specifically for WSNs [1].

MAC protocols in wireless sensor networks can be classified into three general groups: scheduled, unscheduled, and hybrid protocols. Scheduled MAC protocols attempt to organize the communication between sensor nodes in an ordered way. The most common scheduling method which organizes sensor nodes in slots is Time Division Multiple Access (TDMA), where each sensor node is assigned a time slot. Organizing sensor nodes provides the capability to reduce collisions and message retransmissions at the cost of a fine grained synchronization and state distribution. Undefined Protocol sensor nodes are to operate independently with minimum complexity by allowing the effort to conserve energy. In addition to unscheduled Mac protocols generally do not share information or maintaining States [2]. These benefits may collisions and disable that and Protocol at the expense of listening due to degradation of functionality. Hybrid Mac protocols scheduled and unscheduled Mac Protocol of wireless sensor networks in order to better address the special requirements of Combine while avoiding its weaknesses.

The greatest advantage of the hybrid MAC protocols comes from its easy derive their coordinates using signal strength, Angle of arrival or arrival time difference. MSNs which coarsely structured in the following sections can be many classes are: i) is highly mobile, which contains scenarios in which components high velocities cars, cell phones, airplanes, and others; Humans move as much static ii) which contains scenarios in which devices low velocities robots; Moving with a shop floor sensors in monitoring and iii) hybrid, which is installed on the inside and outside of an airplane sensors that both sections [3] [4].

There are numerous advantages of MSNs over the static WSNs. In particular, MSNs offer: i) dynamic network coverage, by taking areas where is no adequately sampled; ii) data routing repair, by replacing failed routing nodes and by calibrating the operation of the network; iii) data mulling, by collecting and disseminating data/reading from stationary nodes out of range; iv) staged data stream processing [5], by conducting in-network processing of continuous and ad hoc queries; and v) user access points, by enabling connection to handheld and other mobile devices that are out of range from the communication infrastructure.

Energy consumption has been considered as the single and important design key in sensor networks, hence, the most recent work on medium access control (MAC) protocol for sensor networks focused on energy efficiency, where MAC protocols play a crucial role in controlling the usage of the radio unit [6]. The radio transceiver unit is the major power consumer unit in the sensor node. For most MAC protocols designed for WSNs, it is assumed that the sensor nodes are stationary, which causes performance degradation when these protocols are applied in mobile environments.

*In this paper we are presenting the survey of different aspects of WSNs and MAC protocols. In section II we are discussing the review of design factors and challenges of WSN. In section III we are discussing the factors which are having influence on making good MAC protocol. In section IV we are discussing different existing MAC protocols.*

## II. DESIGN FACTORS AND CHALLENGES OF WSN

The efficient and robust realization of the unique characteristics of WSNs, and algorithmic tasks are challenging and breaking boundaries of these devices. Such as sensor networks [3], with properties such as distributed protocols and algorithms require efficient and robust,

Scalability – The creation of a large number of nodes capable of working in very large networks

Capacity – In terms of both energy and time efficient Fault tolerance – Despite any failure of any nodes in the network should be able to work. To design efficient protocols for WSNs, one of the most important goals is to reduce energy consumption.

Various aspects of this goal:

1. Minimize the total energy spent in the network
2. Data transmission to minimize the number of energy required
3. However , do not spend too much energy, it must be optimized for energy efficiency and fault tolerance allowing redundant data transmission;
4. Thus prolonging system lifetime , overtime ' alive ' to maximize the number of details
5. Balance energy dissipation among the sensors in the network.

## III. WHAT MAKES EFFICIENT WSN MAC PROTOCOL

Now a day's intrusion detection, defence, climate management, medical systems ,environment observance, robotic exploration, sensible areas, disaster management, target trailing, life surroundings observance, scientific application, uses the Wireless device Network. The Wireless device networks are created from one or additional battery-operated device devices with embedded processor, little memory and low power radio. Coverage and communication vary for device nodes compared to different mobile devices is restricted because of low power capacities of device nodes. Sensor networks are composed of enormous variety of nodes to hide the target. Nodes in wireless device network communicate with one another to grant a standard task [7] [8].

How to expeditiously utilize the restricted quantity of energy has been the first concern in coming up with MAC protocols for WSNs. As there was a challenge for WSN designers is to develop a system which will run years, they used not solely strong hardware and software system, however conjointly lasting energy sources. In shared channel to manage the access of active node, Medium access management schemes are used. MAC protocol provides following features practically:

Framing – Outline the frame format and perform information encapsulation and American state encapsulation for communication between devices.

Medium access – It controls the devices to participate in communication at any time.

Medium access becomes a main perform of wireless MAC protocols since it broadcasts simply that cause information corruption through collisions.

Reliability – It ensures successful transmission between devices. Principally this is through acknowledgement (ACK) messages and retransmissions once necessary.

Flow control – From getting down finishing forestall frame loss, full recipient buffers.

Error control – In frames delivered to higher layers, to own power over the quantity of errors gift it uses error detection or error correction codes [9].

### *3.1. Quality Metrics Needs To Improved:*

In the wireless device networks, for planning high-quality MAC protocol, these attributes are to be measured.

**Energy Efficiency –** Energy potency is that the initial attribute. Battery power-driven consists within the device nodes and it's usually very difficult to alter or recharge batteries for these device nodes. Typically it's useful to switch the device node instead of recharging them.

**Latency –** The second is latency. Latency demand primarily depends on the applying. The detected events should be rumoured to the sink node in real time within the device network applications, so the acceptable action may well be taken straight off.

**Throughput –** With totally different applications the outturn demand additionally varies. A couple of device network applications need sampling the knowledge with fine temporal resolution. In such device applications it's higher that sink node receives additional information.

**Fairness –** In many device network applications once information measure is proscribed, it's required to verify that the sink node receives info from all device nodes fairly. But alongside the entire on top of aspects the energy potency and outturn are the key aspects. By minimizing the energy wastage energy potency may be hyperbolic.

### *3.2. Energy Waste in MAC Protocol:*

The reasons of wastage of energy during a Macintosh protocol for wireless sensing element networks are the subsequent.

**Collision** – Your time the packet gets corrupted throughout transmission these packets ought to be discarded and resent, these result in augmented energy consumption.

**Control Packet Overhead** – Energy is additionally needed for causing and receiving management packets owing to these less helpful information packets are often transmitted.

**Idle listening** – Further energy is additionally consumed for paying attention to receive potential traffic that isn't sent.

**Overhearing** – Someday nodes will be pickup that is destined to the different nodes. These additionally ends up in unnecessary consume of energy.

Reducing the energy wasted idle listening protocols like SMAC, TMAC and CMAC are often used. SMAC sleep wakeup programming approach that uses fastened duty cycle.

**Duty Cycle** = Listen Interval/ Frame Length ,SMAC and TMAC cut back energy consumption by victimisation coordinated programming, however this needs periodic synchronization. CMAC supports low latency and avoids synchronization overhead. CMAC permits operation at terribly low duty cycles by victimisation no synchronous sleep programming .TMAC uses accommodative duty cycle and has the advantage of dynamically ending active half.

## IV. LITERATURE REVIEW

### *4.1. Review of WSN MAC Protocols*

**Sensor-MAC (SMAC)** [5] [10]: This Protocol is based on the adaptive listening concept. Nodes are in sleep mode and listen periodically if there is a data transmission announced. In that way can be used for virtual carrier sense and neighboring broadcast live until the radio is turned off. Synchronization nodes listen to broadcast packets to send through regular sink. Groups of nodes can reach each other, which is called virtual groups. At the same virtual cluster nodes synchronize each other. Two nodes on the boundaries of the two groups might wake schedule. Clock drift between peers is very small compared to the wakeup period. But to ensure a complete message before sending nodes waits a short time to value. To avoid hearing the announcement is part of transmission time. There is no central access point, to peer network to communicate with each other. This example configures the network so that every node is the detection of communication partners. Neighbor detection is expensive. No neighbors with a node with one or several neighbors a node checks more than once. There is no fairness guarantee to prevent starvation carrier sense time. A certain time window is random it cannot directly access the source destination.

Then the data will be transmitted over multiple hops, nodes have to forward data (message passing). To reduce the latency nodes which overhear a neighbor's transmission wake up short time before the end of the transmission to be prepared for message passing. Because of limited memory and possible different memory sizes in a heterogeneous network S-MAC support message fragmentation.

**B-MAC** [5] [10]: B-MAC is designed for an Ad-Hoc network of nodes with N-sender to 1-receiver transmissions. The basic idea of B-MAC is to keep the protocol simple. That's a critical point due to limited available memory allows very small implementations. Like other Protocol B-Mac uses from time to time sleep/wakeup cycle power system used here is called listening. Wakeup node listens to incoming data transmissions in LPL means, received data (if any) between "false positive" listen timeout State. Otherwise node waits for the full packet transmission ,ensures that packet to get there after a while a prelude to complete from the start of 100ms added wakeup. Fairness of LPL is not guaranteed.

The sleep periods of the nodes can differ to each other, B-MAC is asynchronous. When there is data to send a node switches the radio mode and starts to send an announcement. This announcement must be long enough to make sure that the receiver notices, Even if the receiver starts at the beginning of sleeping later sender transmits the target address and starts sending data. Asynchronous network does not require complicated and expensive synchronization methods. There is no data fragmentation B-Mac is used in this coordination will be more complex and people generally like to use sensor information short message B-Mac. Another concept required amount of energy In order to reduce the clear channel assessment (CCA). This clear channel is used to detect the signs and channel energy. On a better separation is between the noises. Why noise analysis. In case a false positive a sample was put into a queue to capture the spirit and it change constantly because noise environment to analyze multiple samples. An optional feature is using acknowledgements. B-MAC has an application interface for flexible configuring parameters like this. A good value for this sometimes depends on the use case so this can be adjusted by a higher layer application.

**WiseMAC** [5] [10]: WiseMac is an infrastructure protocol. It assumes there is one central unit with unlimited energy supply and connection to another high speed network e. g. Ethernet to exchange data packages. That is why this unit is called access point. Batteries due to freedom for managing network access points. Therefore it every known node is containing a table wakeup times. that need these times listening reduces time acknowledgement packets from nodes are part of the sending if the access point is a specific node information can be informed as soon as a minor delay messages to nodes possible clock drift due to the passing of Before. Short for sensor nodes messages are expected to be followed by other base station handles a message... except for synchronized nodes a node must wait. So wakeup schedules nodes are asynchronous packet header is a bit delayed frames. It indicates there is more data waiting. After sending an acknowledgement the node stays awake if the bit is set. The sender sends the second packet ongoing to the received ACK-packet.

**IEEE 802.15.4** [5] [10]: IEEE 802.15.4 defines another Mac protocol for wireless sensor networks. The protocol is based on CSMA/CA. CSMA stands for carrier senses multiple accesses. A node which wants to start a transmission first listens for a short amount of time to the media if there is traffic on the channel. The value of listen duration can be changed if there is traffic transmission to begin transmission. otherwise CA collision avoidance means a node a packet transmission for your neighbors then other nodes know that channel is used also other WSN & Mac Protocol and IEEE 802.11, IEEE 802.15.4 is used by no RTS/CTS (request to send/clear to send) uses Although it is a common combination. RTS/CTS usage means that the data source is a channel request message and the response/destination sends a message prepared Overhead prevention to use RTS/CTS not. Mac header only 127 bytes, so avoiding it additional flags are peer-to-peer connection or using a star topology star topology is possible. With a central instance default. There are two types of nodes: Full function devices and reduced function devices. Reduced function nodes are only able to process their own data.

**X-MAC** [5] [10]: X-MAC is meant for ad-hoc structure, too. This asynchronous wake schedules B uses x-Mac-like Mac more intelligent announcements by sending B-Mac tries to improve the target address of the announcements are therefore a transmission is not a big announcement, but instead were sending small repeated message. How is reduce nodes overhearing that target receives a short message can go to sleep not addressed. Another hike that small pauses in between the way introductory messages receiver full time period to wait for the peer to send a receipt and to notify your presence can send a short introduction time and data transmission can begin. If a second sender observes an announcement to the same target it waits for the finished transmission and a randomized short period in addition. Then it sends the data without an announcement is received directly after a packet this process works to ensure receiver is usually an additional amount of time for the incoming data the amount of wait at least the maximum random time second sender. Need for conflict avoidance Randomization factors. There are others who may want to communicate.

***4.2. Comparative Study Of MAC Protocols***

**S-MAC and B-MAC:** Both, S-MAC and B-MAC were implemented and tested. For test implementation TinyOS is used, a very small operation system optimized for integrated devices. It is written in C. As test hardware is Mica2 Motes used. B-Mac sounds simple, while the s-Mac synchronization optimization, a lot of features. That's why S-Mac needs more memory implementation of Polastre, Hill and Culler S-Mac test implementation by 6200 bytes. Conversely b-Mac LPL, Acknowledgements and RTS/CTS with at least 4,700 bytes. Energy consumption energy per data (e.g. e. joule per byte) can be measured if the radio device Sleep has never been byte-per-energy linear increase idle time between pause because messages. S-Mac with more energy reduced data rate Adaptive listening too, but listen to passive mode was compared to requirements without it only a very small increase is due to the overhead time synchronization and media can be explained by checking Adaptive listen high Loads of traffic can reduce the waste of energy, but in the case of low traffic weight gain is small. An important fact for a multi hop network is the latency. Latency is expected to increase with every hop. Therefore Ye, Heidemann and Estrin measured latency in comparison to the hop count. As expected the lowest latency occurs with no sleep. Without adaptive listen latency rises fast. The exchange of short information's over many hops takes much time. Here adaptive listen can show a real improvement. If a neighbor who she is latency forwarding receives a message due to increasing rate the idea of being prepared around the same as idle power by listening to the first hop only. We have to wait for a period there listen to the latency is as adaptive without customizations it is one of little change overall latency with hearing causes. S-Macs are a linear energy consumption and the data rates increases. B-Macs use energy increases with higher data rates, of course, but it is under S-Macs is one reason why there is no synchronization between nodes B-Mac, it causes a big overhead in terms of Polastre trial.20 nodes were Hill and used Cullar. S-Mac throughput node number is constantly increasing, while B-Mac nodes depend on the number of different variants of maximum throughput, decreases. Nevertheless B-MAC without ACK and RTS/CTS is always faster for the tested range than S-MAC with unicast, while the energy consumption of B-MAC is still lower. With throughput of up to 4.5 times the S-Mac looks like b-Mac outperforms. But this behavior may change in very large networks. So that each node has only a small group of neighbors can reach these small sub-networks to handle most of the traffic and you disable unicast responses to traffic this big network large area is probably similar to a short network. Network topology is a very important factor for the performance of it could be that if every node accesses the two neighbors just like a chain S-Mac than b-Mac performance.

**WiseMAC and X-MAC:** IEEE 802.15.4 with WiseMAC infrastructure topology is based on the concept of central communications control access point due to overhearing by little. There are also no nodes to forward messages by to increases the lifetime of the nodes. Dormant central peer to listen always when it is enabled, because the peer is also prepared, it atleast spends time waiting for it to increase the latency of data transmission using acknowledgements much as for other protocols.

**X-MAC and B-MAC:** X-Mac-b-Mac is based on the idea of Yi, Anderson and Han test their implementation than a LPL X-Mac Buettner, the performance of the show X-Mac-based protocol similar to X-Mac and B-Mac is a direct comparison between, but a similar protocol to Mac X LPL-B-Mac can be comparable to demonstrate announcements Strobed benefits Buettner, Yi, Anderson and Han is a network where each node can reach all others set. There is a send and message to the destination are periodically measured by duty cycle. Sending and receiving nodes close to each other of the same protocol. LPL Protocol duty cycle with considerable growth node density supplement x duty cycle very slow Mac and always have a LPL protocol below. Because the use of time corresponds to the results of the use of energy in relation to the density of the network node is per power consumption for the same plan by behavior. This is adapted from the preface to communication. Nodes which are not affected by the current transmission back to sleep quickly. The goal is to wait for a third node without a live broadcast after a prelude ended transmission time by procedure. Sadly there's no performance test X Mac to this LPL and are comparing a low transmission protocol with throughput increases while latency shrinks.

## V. PROPOSED SYSTEM

The system architecture consists of :

**Management of Inconsistence :** It is vital to have a mechanism to manage and control the quality of data collected by wireless sensor network. Since there would be data loss resulting from unreliable wireless communication.

**Management of Dynamic Usermodel :** It is the location where the sensor data is stored or is the dynamic data storage in which the location of the repository is chosen based on information collected over the network. It chooses to store sensed data close to where it is most frequently needed or close to the query entry point when the query rate is high. It is needed to reduce the power consumption of the network.

**Open Content Platform :** To monitor and control the functionalities. The Platform should be open and support the largest possible number of underlying sensor network technologies.

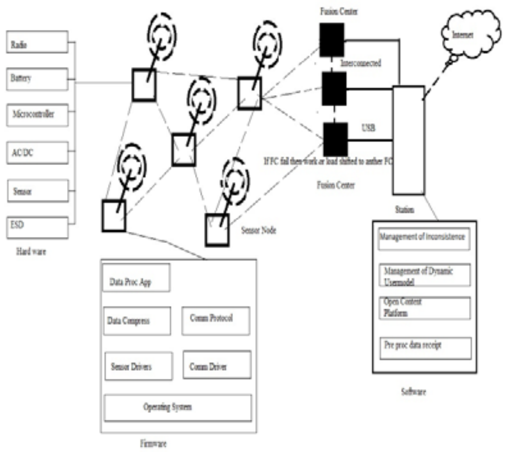


Figure 1: System Architecture of WSN

**Pre-processing Data Receipt :** Raw sensor data will be preprocessed at each node to extract a small set of parameters to be forwarded to fusion center.

**Data Processing Application :** It requires to extract the information that is meaningful. Data processing techniques that perform efficiently for their intended WSN application.

**Data Compress :**To encode information with fewer bits than the original representation. It improves the performance and low memory required.

A sensor network is composed of a large number of sensor nodes, which are densely deployed either inside the phenomenon or very close to it. The position of sensor nodes need not be engineered or pre-determined. This allows random deployment in inaccessible terrains or disaster relief operations. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities. Another unique feature of sensor networks is the cooperative effort of sensor nodes. Sensor nodes are fitted with an on-board processor. Instead of sending the raw data to the nodes responsible for the fusion, sensor nodes use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data.

## VI. CONCLUSION AND FUTURE WORK

In this paper we have discussed the different MAC protocols for WSN with their advantages and disadvantages; also we compared them to each other. MAC protocols are vital part for improving the energy efficiency in WSN. Generally for wireless networks, 802.11 MAC protocol is used, but at the same this protocol is not energy efficient for WSN. Therefore based on this 802.11 MAC protocol some new MAC protocols presented such as SMAC, WiseMAC etc which we discussed above. These protocols show better utilization of energy resource as compared to 802.11 MAC protocol. In this paper we also discussed the different performance metrics which are vital for deciding quality of MAC protocols in WSN. For the future work we suggest to present new technique for MAC protocols in WSN with aim of improving energy efficiency.

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