INTERNATIONAL JOURNAL OF RESEARCH IN COMPUTER APPLICATIONS AND ROBOTICS
ISSN 2320-7345

A NEW MAC PROTOCOL IN WIRELESS SENSOR NETWORKS FOR ENERGY PRESERVING

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Abstract: - A New MAC Protocol in Wireless Sensor Networks (WSN) for Energy Preserving is a research based project in the field of wireless sensor networks. The literature survey on WSN results in understanding the working of wireless sensor networks on various applications. We studied the various available MAC protocols in wireless sensor networks, and the applications of the protocols, along with their implementations in the layered architecture of WSN. In our study we observed that, the wastage of energy in wireless sensor networks is high due to communication overhead between nodes. In wireless sensor networks energy plays a most important role for the sensing, processing and communication at node level. The nodes in the wireless sensor networks have their own power source, but it is very limited. However, the sensor nodes do not get replaced or recharged after their deployment. Hence energy preservation is the most important feature in wireless sensor network. Our review paper introduces WSN introduction, its applications, protocol stack and various MAC protocol in wireless sensor networks.

Keywords*:* Wireless Sensor Network (WSN), Energy Preservation, MAC Protocol.

1. Introduction to Wireless Sensor Networks:

A Wireless Sensor Network [1] is a combination of various distributed autonomous sensors (nodes) to monitor physical or environmental conditions like pressure, sound, temperature etc. The field of Wireless Sensor Networks includes sensing & computation of gathered information and a communication system in a single small device [5].

A wireless sensor network is sometimes also called as wireless sensor and actor network as it collects the data and further transfers the data to the main location where the main server of the sensor is located. The new modern sensor networks support the bidirectional working of the sensor; it also enables us to control the sensor activity. Basically the development of wireless sensor networks was motivated from the technique of battlefield surveillance in military applications. Today wireless sensor networks are used in several consumer and industrial based applications where the information has to be monitored for security purposes.

The Wireless Sensor Networks are built of multiple 'nodes', these nodes may vary from a few to hundreds or thousands in numbers, each node is connected to one or several other sensors for transfer of information. Each such sensor network nodes typically have several parts i.e. a radio transceiver with an internal antenna or connection to an external antenna, a micro-controller and an electronic circuit used to interface with an energy source and the sensors, usually a battery or an embedded energy harvesting form. A sensor node might vary in size from that of a shoe box down to the size of dust grains, although functioning "motes" having genuine microscopic dimensions have yet to be created.

The cost of sensor nodes is correspondingly variable, ranging from a few to hundreds of dollars, depending on the complexity of the different sensor nodes. Cost and size constraints on sensor nodes result in corresponding constraints on resources like memory, energy, communications bandwidth and computational speed. The network topology used in WSNs may be a simple start or may be advanced up to multi-hop wireless mesh network. The propagation technique in WSNs may be routing or flooding depending upon the complexity of the network.

Along with the sensors and radio transceiver each node of the WSN consists of a processor, GPS, local memory and a power source. The GPS helps us to identify the node of the WSN as per its location, the processor processes the gathered information, the local memory stores the gathered information for its further transmission to the main location and the power source provides the energy to the nodes of WSNs for their working. The power sources should be so made that they can maintain and recharge the power and energy automatically using natural sources of energy.

The power of a Wireless Sensor Network lies in the accuracy of the information gathered by different nodes of the WSN. All the nodes of the WSN should work properly and accurately, if any of the nodes fails to gather or transfer the correct information then the problem of inaccurate data is faced by the whole system. The size of the nodes of WSNs is very much small thus a major issue faced by the WSNs is power/energy consumption, as the size decreases so as the energy capacity of the nodes. These energy consumption issues led to lack of computation and storage of information which further leads to new architectural issues.

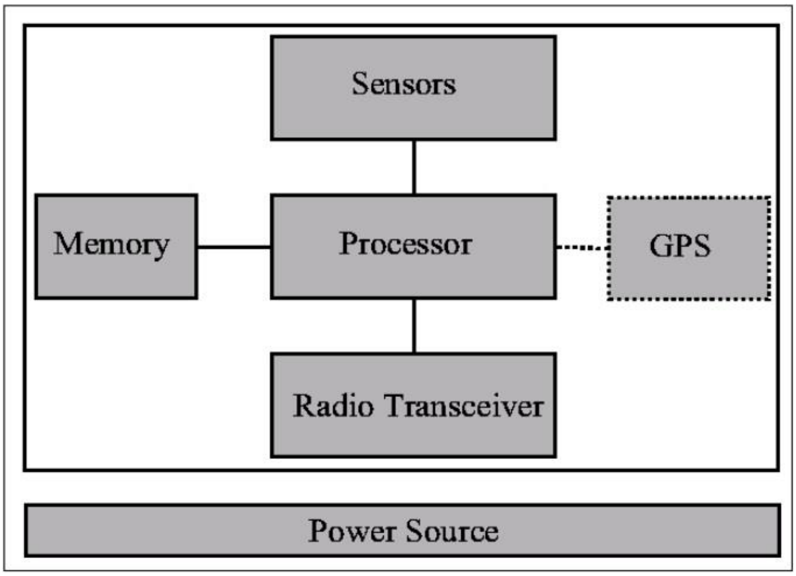

Figure 1.1 - Block Diagram of Node of WSN

2. Architecture of Wireless Sensor Networks:

The basic architecture of the wireless sensor network[2] consists of two major regions first is the main station where the user sits and monitors the changes experienced by the sensor, and second one is the field where the wireless sensor network has been set up. The basic architecture of WSN looks as follows:

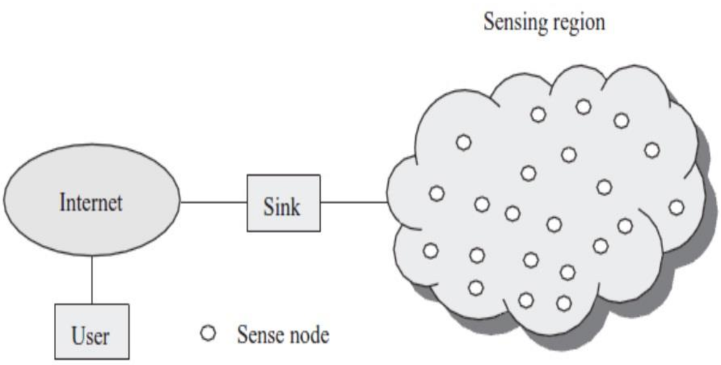

Figure 2.1 – Field Architecture of WSN

The main user station and the WSN are connected to each other through a wireless media. Generally internet is taken up as the wireless media between the main station and WSN. The nodes of the WSN are also connected to each other with internally enabled communication devices which consist of internal antennas or externally connected antennas. These antennas help the nodes of the WSN to communicate with each other and are responsible for the transfer of information between the different nodes of the Wireless Sensors Network. The sensing nodes are installed at different locations into the sensing region using a network topology. These sensing nodes records and stores the changes found at small distances in the sensing region and this information is shared with all the nodes using the inbuilt communication device of the node. The information found by all the nodes is transferred to the sink which collects the information recorded by all the nodes and then further transfers it to the main station and using the information of all the nodes a conclusive result is found out about the sensing region. The nodes of the WSNs have further smaller units called motes. These motes are microscopic functional units which record the slightest changes sensed by them and then transfer this information to their corresponding nodes. The general node architecture of Wireless Sensor Network looks as follows:

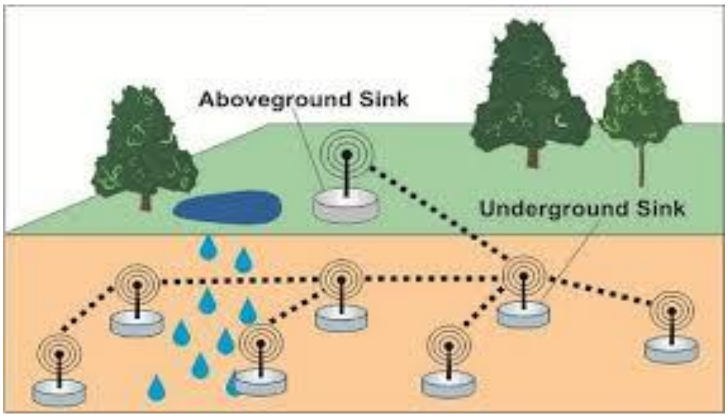

Figure 2.2 – Node Architecture of WSN

The architecture of WSNs can also be categorized into two types:

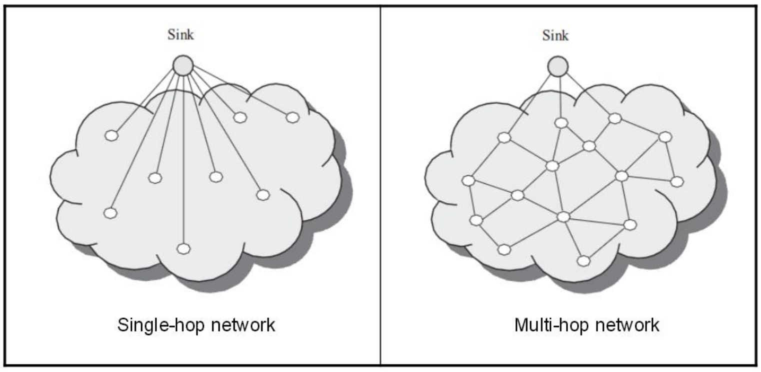

Figure 2.3 – Networks of WSN

- **Single Hop Network:**

In the single hop network the main sink which collects the information gathered by all the nodes is directly connected to all the nodes of the WSN, but the nodes are not connected to each other directly [5].

- **Multi Hop Network:**

In the multi hop network the main sink which collects the information gathered by all the nodes is directly connected to all the nodes of the WSN, but the nodes are also connected to one another directly [5].

3. Applications Areas of Wireless Sensor Networks [1]:

The Wireless Sensor Networks are widely used for different industrial, domestic and governmental monitoring of different natural or unnatural phenomenon. The application areas of Wireless Sensor Networks are:

3.1 Environmental Monitoring:

Environmental monitoring describes the processes and activities that need to be taken place to characterize and monitor the quality of the environment. Environmental monitoring is used in environmental impact assessments and in many circumstances in which human activities carry a risk of harmful effects on the natural environment. There is different monitoring which fall under environmental monitoring.

- **Air Quality Monitoring:** Air quality is monitored by wireless sensor networks by monitoring the temperature of the surface, as the temperature of the surface definitely gets affected by the quality of the air the temperature of the surface normally be cool when the air is not polluted but when the air pollution is high the temperature of the surface increases. The quality of the contents present in air is also checked and monitored by the nodes of the WSNs.

- **Water Quality Monitoring:** Water quality is also monitored by the wireless sensor networks. The wireless sensor network is set up under water sources like rivers, lakes etc. If the water is polluted then the quality of the minerals found in water also gets affected. Thus the sensors continuously keeps on monitoring the content value and quality of minerals found in water and the gathered information is compared to the required content value of the minerals in the water. If the values differ from each other then it is considered that the water is polluted. The monitoring of the content values of the minerals found in water is done at the main station. Except the minerals other quantities in the water are also monitored such as chemicals, radio contents etc.

- **Weather Monitoring:** Wireless Sensor Networks are also used to monitor the weather conditions in different geographical areas. The sensors sense the temperature, moisture etc. to show the weather conditions in that particular area.

- **Disaster Relief Operations:** Wireless Sensor Networks are used in monitoring the areas affected by natural or unnatural disasters. For example if there is some place on fire then the nodes of the WSN are dropped at different locations at that place these sensors records the temperatures and a temperature graph can be generated with the help of the gathered information.

3.2 Military Monitoring:

Wireless Sensor Networks are also widely used to monitor various military conditions such as battlefield surveillance, intelligent guiding, remote sensing etc. The WSNs are established in the battlefield area and the required data information is continuously monitored.

- **Battlefield Monitoring:** In the battlefield wireless sensor networks are widely used. The WSN is established under the land in the battlefield so that any troop or vehicle movements can be detected. WSNs are also used to detect the targets at far distances and to detect the magnetic and acoustic signals in the battlefield.

- **Intelligent Guiding:** Intelligent guiding by the wireless sensor network is done by monitoring the traffic conditions or movements of vehicles or people. In the battlefield intelligent guiding by the WSNs helps the military to choose the path where the number of enemy troops is less.

3.3 Health Care Applications:

Wireless Sensor Networks are used in a variety of medical instruments to be used at hospitals, homes and clinics. The healthcare providers and their patients, with the help of WSN, get to have an insight into physiological and physical health states that are critical in detection, diagnosis, treatment and management of ailments.

- **Monitoring the Patients:** Now a day's wireless sensor networks are being used in medical area too. The sensors are used to monitor the medical condition of the patients. WSNs are also being used for different body checkups, the nodes of the WSN are put inside the patient's body at different parts and the internal body phenomenon is monitored.

3.4 Agricultural Monitoring:

In the field of agriculture the wireless sensors are used to monitor various factors. The WSNs are used to monitor the green houses in the field of agriculture, the sensors are placed into the green houses and the energy stored in the green houses is monitored and graphical analysis report is generated on the basis of the monitored information. The WSNs are also used to monitor the fields, the fertilizer and pesticides levels can also be monitored using the WSNs so that the fertilizers and pesticides shall be sprayed only where needed to be.

4. Characteristics of Wireless Sensor Network (WSN):

Wireless Sensor Network (WSN) have replaced the traditional wireless networks for communication like "Mobile Ad hoc Network" (MANET), cellular systems as it poses some unique characteristics. These characteristics are:

- **Battery Powered Sensor Nodes:** The sensor nodes are powered with battery of good capacity as they need to be deployed to the harsh and hostile environment where it is extremely difficult to replace or recharge the battery.

- **Self Configurable:** The wireless sensor networks are deployed randomly, to configure themselves into a communication network.

- **Resilience:** The wireless sensor network has the ability to cope with the node failures, energy depletion and damage.

- **Application Specific:** The sensor network is usually designed for a specific application, and the requirements for the sensor network changes with its applications.

- **Data Redundancy:** The wireless sensor network is usually deployed to harsh environment for generating and measuring of sensing data. The redundancy is maintained by the WSN's.

- **Many To One Pattern:** The data or information sensed by the sensor nodes usually flow from multiple sources to a particular sink, which exhibits many to one pattern.

- **Frequent Change in Topology:** When node failures, physical damage, addition, channel fading the change in topology occurs frequently which is adapted by the WSN's.

5. Challenges in Wireless Sensor Networks:

The wireless sensor network face many challenges as it deals with the real time or say real world environments. In case of sensor data it is mandatory to provide data at correct instance of time so that correct observations can be made. But very less real time data is in existence. Most existing protocols ignore the real time or the simply process the data fast to meet the deadlines but it's not enough. Although there are several protocols available which could deal with real time for e.g. the RAP protocol, it suggests a new policy called Velocity Monotonic Scheduling.

The packets have a deadline and a distance to travel. Using these parameters a packet's average velocity requirement are computed and at each hop the packets are scheduled for transmission. The transmission is based on the highest velocity requirement for any packet at this node. Since this protocol addresses real time, no guarantee is given.

Another protocol available for routing which addresses real-time issues is called SPEED. This protocol uses feedback control which guarantees that each node maintains an average delay for each packet transiting a node. It can be determined whether a packet meets its deadline or not. But this guarantee becomes limited due to message loss, transient behaviour, noise, congestion and few more.

The main challenge for the WSN's is to meet the real time constraints including the data fusion, data transmission, event detection and classification. WSN's should deal and overcome with the solution of lost messages, noise and congestion. The dealing with real time helps to identify the needs for differentiated services. It should differentiate between classes of traffic and guarantees the important traffic and less importance to least important traffic. There is a need to develop new protocols for the WSN's along with the associated analysis techniques.

The power management is also one of the challenges for the wireless sensor networks. However the WSN's has low deployment cost but limited processor and less memory space are the arguable constraints for the WSN's. But soon with efficient fabrication techniques the WSN's will overcome these problems. The energy constraint is unlikely to be solved sooner due to slow progress of high capacity battery development. It seems that replacing battery is an easier way to make WSN's work on continuously but in harsh sensing environments it is very difficult to replace batteries frequently. So it's a very important issue to provide an energy efficient surveillance service for geographical area.

The current research focuses on the purpose of providing full or partial coverage for sensing in the context of energy conservation. In many scenarios we cannot rely on sensor nodes in certain geographic conditions of high security. However, we argue that, in most scenarios like battlefields, there are certain geographic sections. It is not possible to rely on one single sensor to provide safeguard to critical areas. So in this case we need to provide a higher degree of coverage with multiple sensors to monitor a single location. At the same time we need to decrease the energy consumption for less critical area.

6. Need of Energy Preservation in Wireless Sensor Networks [8]:

Over the last years the wireless sensor networks has gain attention from the research community and actual users. Usually the sensor nodes are battery powered devices so the main point of concern is that how to reduce the power consumption of these devices so that network lifetime can be extended. A typical sensor node consists of several components which consumes energy. Although many solutions have been suggested for the energy saving but yet not achieved.

A wireless sensor network consists of sensor nodes deployed over a geographical area to monitor physical phenomenon like temperature, humidity, vibrations, seismic events etc. Simply a sensor node is just a small device which includes three basic components: a sensing subsystem for data asset from the surrounding environment, a subsystem for local data processing and storage, and a wireless subsystem for data transmission. And a power source supplies the energy needed by the device for performing a programmed task. This power source generally consist a battery with a limited energy budget. And it would be impossible or difficult to recharge the battery, as the nodes can be deployed in a hostile or harsh environment. The sensor network should also have a lifetime long enough to fulfil the application requirements.

In some cases it is possible to get energy from external environment such as solar energy but the external power source show a non-continuous behaviour so a energy buffer is needed as well in order to maintain the continuity of the power.

Several experiments have proved that the data transmission consumes more energy than data processing comparatively. The energy cost for transmitting a bit of information is approximately the same as that needed for processing thousands of operations in a typical sensor node. The energy consumption of the sensing subsystem relies on a specific sensor type. In many cases it is almost nil with respect to the energy consumed by the processing. The energy expenditure for data sensing may be comparable to, or even greater than the energy required for data transmission. The energy-saving techniques focus on two subsystems: the networking subsystem, and the sensing subsystem.

The lifetime of a sensor network can be extended by jointly applying different techniques like energy efficient protocols focus to minimize the energy consumption during network activities. A large amount of energy is consumed by node components like CPU, radio etc. Even if they are idle. Thus power management techniques are used for switching off node components that are not temporarily needed.

7. Layer Architecture in Wireless Sensor Network (WSN) [2]:

The popularity of the wireless sensor network is increasing day by day, so to understand and get a brief view of how the WSN work we need to understand the architecture of WSNs. The most common architecture of WSNs follows the OSI model. The WSN architecture basically has five layers namely physical, data-link, network, transport and application layer along with three cross layers namely task management plane, power management plane and mobility management plane. The architecture can be diagrammatically shown as below:

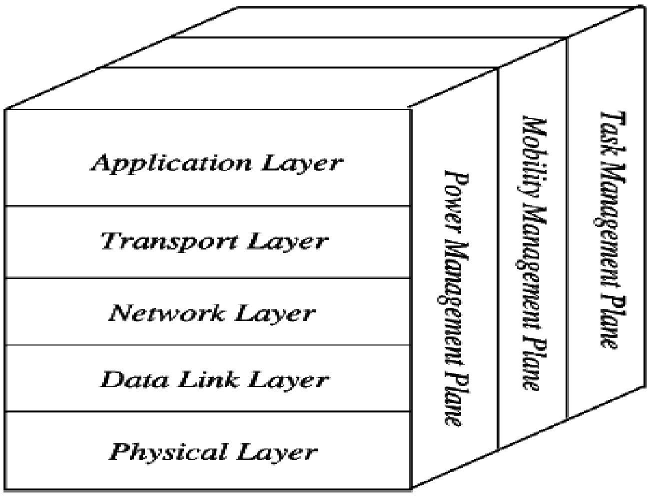

Figure 7.1 - WSN Layered Architecture

The WSN layers and their functions are:

- **Physical Layer:** This layer provides a physical medium for transmission of data bits or data stream. This layer is responsible for connection establishment, data rate, data encryption, signal detection, modulation and frequency generation.

- **Data link Layer:** In data link layer the main task is to insure and maintain the data interoperability amongst communication between nodes to nodes. It is responsible for multiplexing data streams, MAC and error control. The problems like shadowing and fading which occur at physical layer is solved at data link layer by using ARQ (automatic repeat request) and FEC (forward error correction). The co-channel interference problem at the MAC layer is solved by MAC protocol. Although the ARQ is not commonly used in WSN as it will increase overhead retransmission and cost. Hence ARQ is not efficient for frame error detection. The retransmission problem of ARQ is overcome by the FEC as it decreases the retransmission by adding redundant data on each message such that the receiver can detect and correct errors.

- **Network Layer:** Routing is the major function of this layer. The network layer finds the best and efficient path for routing mechanism. The routing may be from node to node, node to base station, node to cluster head. There are many protocols available for routing, they can be divided in two categories namely the flat routing and hierarchical routing. Also we can divide the routing protocols as time driven, query driven and event driven protocols. In time driven protocol the data is sent periodically and it needs periodically monitoring whereas in the data driven and query driven protocol the sensor responds according to action or user query.

- **Transport Layer:** The main objective of the transport layer is to establish a communication for sensor network connected to internet. This layer should also provide reliability and congestion avoidance service. This layer uses different mechanism for loss detection and loss recovery. This layer is needed when a system is organized to access other networks. For loss detection mechanism used are ACK, NACK and sequence number and for loss recovery mechanisms user are end to end or by hop to hop mechanisms. The reliable hop to hop mechanism is more efficient than the end to end mechanism, that's the reason that TCP is not suitable for WSNs.

  There are some of the popular protocols of the transport layer:

  (a) **STCP (Sensor Transmission Control Protocol):** It is an upstream protocol which provides reliability, congestion detection and congestion avoidance [2]. The STCP function at the base station. The node at the base station sends a packet to the sink in order to initiate the session for transmission. The packet consist information of transmission rate, required reliability, data flow. After sending the initiation packet the sensor node waits for the acknowledgement from the sink sp that transmission can be started.

The base station estimates the arrival time of packet as well as the reliability requirement during the failure in packet delivery. If the current reliability is less than the required reliability the sink send NACK for retransmission of the packets.

(b) PORT (Price –Oriented Reliable Transport Protocol): It is a downstream protocol which ensures that the sink receives enough information from physical phenomenon [2]. To increase sink information from specific region PORT uses two methods for this purpose:

Method 1**-** Node price is the total number of transmissions before the first packet arrives at the sink and is used to define the cost of communication. Each packet is encapsulated and sent with source price then the sink adjusts the reporting rate according to node price.

Method 2**-** Use end to end communication to reduce congestion. The congestion increases the communication cost therefore the sink reduces the reporting rate of the sources and increases the rate of those sources which have lower communication cost.

(c) PSFQ (Pump Slow Fetch Quick): It is reliable, scalable and robust. There are three main functions of PSFQ,

- Pump uses two timers T (min) and T (max), where the node waits T (min) before transmission, for the recovery of missing packets and removal of redundant broadcast. Node waits for T (max) if there are any packets or multiple packets lost.
- Fetch operation requests a retransmission for the missing packets from neighbor.
- Finally reports the operation to give a feedback to the user.

- **Application Layer:** The main objective of the application layer is to present the final output after ensuring the error free transmission from below layers. This layer is responsible for collection, management and processing of data through application software to generate reliable results. The wireless sensor networks are deployed in various applications and in various fields.

8. Importance of MAC Layer for Energy Saving:

MAC layer is a major reason to provide the reliability and efficiency for WSN. MAC is responsible for access policies, scheduling, buffer management and error control. In WSN we need a MAC protocol to consider energy reliability, efficiency, high throughput and low access delay as major priorities to accommodate with limited resources of the sensor to avoid redundant power consumption. A major reason for energy wastage in WSNs is collision, when a receiver node receives more than one packet at the same time; these packets are called collided packets even if they coincide partially. All packets that cause the collision have to be discarded and the re-transmission of these packets is required which increase the energy consumption. Next reason of energy consumption is overhearing. Overhearing means a node receives some packet which is destined for some other node. Another reason for wastage of energy in WSNs is idle hearing, which means listening to the receiver node continuously which again leads to excess of energy consumption. Last reason for energy wastage is over-emitting, which means sending the packet when the receiver node is not ready which results in failing of communication and that packet has to be sent again which results in energy wastage. MAC layer is very much important for the preservation of energy in WSNs, as there are various MAC protocols which help in solving the issues which cause the wastage or over consumption of energy in WSNs.

Sensor MAC (S-MAC) protocol [2] synchronizes the duty cycle of the nodes and also schedules the periodic sleep and wake up time of the neighbor nodes which helps in improving the transmission synchronization between the nodes. In this technique the receiver nodes have the transmitter node address and next sleep time which improves the transmission. S-MAC also helps in reducing the idle listening which helps in reduction of excess energy consumption. S-MAC is a medium-access control (MAC) protocol which is designed exclusively for WSNs. Wireless sensor networks use battery-operated computing and sensing devices. A network of these devices collaborates for common applications such as environmental monitoring. We expect sensor networks to be deployed with individual nodes remaining largely inactive for long periods of time, but then to be active suddenly when something is detected. Such characteristics of sensor networks and applications encourage a MAC which is different from traditional wireless MACs.

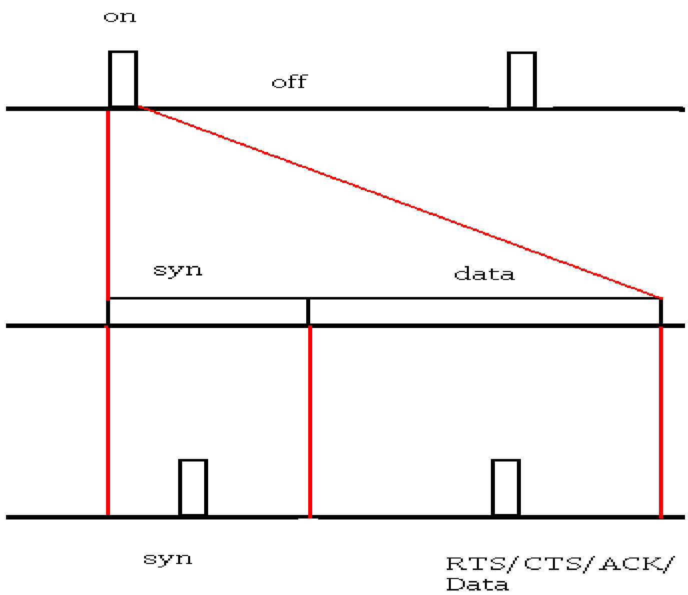

Figure 8.1 - SMAC Protocol

Time-Out MAC (T-MAC) [2] uses sleep/active duty cycle for transmission of packets between the nodes of the WSNs but ends dynamically. The nodes send or receive data only during the active period and if there no action for a long time then the active period ends automatically. This protocol increases the efficiency of algorithm for variable traffic loads.

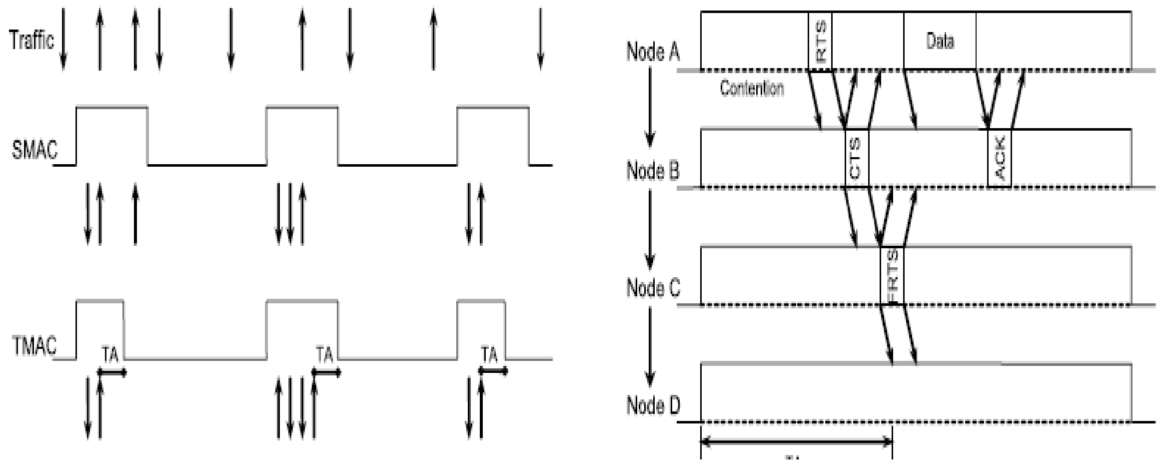

Figure 8.2 - TMAC Protocol

Traffic Adaptive MAC (TRAMA) [2] uses the technique of single slotted channel access divided into random and scheduled access period between the nodes of the Wireless Sensor Networks. TRAMA consists of scheduling exchange protocol (SEP), neighbor protocol (NP) and adaptive election algorithm (AEA). NP: uses the random access period for signaling, synchronizing and updating two hops neighbor information. It uses the target node schedules for future transmission. Here the node schedule is established according to its current traffic and neighbors. AEA: use the information from SEP and neighbors' information to elect transmitter, receiver and standby nodes for active time slot and deselected for Trans/Receive data. This data is removed from election and goes to sleep.

9. Various Protocols in Wireless Sensor Network for Energy Preservation [2]:

- ***S-MAC(Sensor-MAC):***

S-MAC (Sensor-MAC) protocol is a MAC protocol which is used in WSNs for energy conservation. It retains the flexibility of ion-based protocols similar to IEEE 802.11[3]. There are three major energy consumptions in S-MAC that are identified. These are:

(a) Collision this result in waste of energy when the collided packets are retransmitted.
(b) Overhearing that occurs when a node hears to the transmissions not intended for it.
(c) Idle listening which occurs when a node listens for receiving any possible data that is not transmitted.

The communication between nodes takes place when S-MAC protocol exchanges Carrier Sense (CS) packets to avoid collision.

Advantages:

By using this proposed Uni-Scheduling algorithm, the nodes do not take longer time for synchronization. This is because all the nodes run under a single schedule and transmit data at the same time. Thus the delay time eliminated as stabilization in schedule is solved by synchronizing the network. There is no generation of isolated schedule cluster due to Uni-Scheduling process. When a new node wants to add to the network, it can receive the Uni-Scheduling packets in the awake state and quickly change to the run state and the network can be expanded easily without any problem. Therefore, all the nodes in the network are unified under the same schedule and the energy consumption in the idle state is reduced.
When all the nodes get synchronized under a single schedule after receiving the Uni-Scheduling packets, the drifting of clock between two nodes are minimized. This clock drift error is reduced because all the nodes perform their transmission work at the same time. The error in synchronization in the WSN is also reduced and this effect is clearly visible when the network size increases.

Disadvantages:

- Delay Time In Synchronization Of Schedule:
  S-MAC scheduling mechanism works when the mode of self-configuration is set. In the listen period, a node senses its neighbor nodes and transmits synchronized packets that contain randomly generated schedule. Therefore a long time is taken by each node to get synchronized. For example, when 10 nodes are implemented in the network, they have to wait 100 seconds to setup the schedule and for 20 nodes the time is increased to 200 seconds. Thus a longer time for stabilization takes place in proportion to the number of nodes in a network.

- Isolated Schedule Cluster:
  The virtual clusters are formed when some nodes have a common schedule. When the individual cluster has one neighbor node or more is overlapped with another cluster of different period get to be synchronized. However in some cases the clusters can fail to acknowledge one another and no communication takes place between them, even though all the nodes are active. The S-MAC's solves this problem by making all nodes to work in the listen state for a given time.
  In implementation, all nodes sense synchronized packets and seek neighbor nodes while they are in the in the listen state for 10 seconds per 2 minutes. This process goes against the purpose of S-MAC, which states reduction of energy in listening in the idle state. A lot of energy is consumed while locating a hidden schedule cluster node.

- Data Transmission After Synchronization Of Border Node:
  The scheduling mechanism of S-MAC defines that each node has its own schedule generated randomly. Then it waits for a given time and if it fails to receive a SYNC packet, it will set its own schedule and broadcasts its synchronized packet to neighbor nodes. These neighbor nodes will receive the synchronized packet and use that schedule to get synchronized, even though the whole network is not unified under same schedule. Thus an independent schedule cluster having an independent schedule is made and a node between heterogeneous schedules gets to receive synchronized packets which are different from each other and work as border node. The border node handles and adopts both the schedules and creates a link between the virtual clusters. Thus it has to be in the listen state twice and power consumption will be twice the general node. And if the border node dies out quickly, the clusters will not be able to interact with one another and no transmission of data will take place between them. Thus the power consumption of the border node increases in proportion to number of multiple schedules adopted by it. In the existing S- MAC code, this problem is somewhere at minimized as the border node will only adopt one schedule depending upon the SYNC packet received first. But this does not change the longevity of the border node as it stays in the listen state for a longer time.

- Error Develop During Synchronization:

When the neighbor nodes synchronize their sleep schedule, the clock drift between each node may cause errors in synchronization. This error takes place when SYNC packets are broadcasted periodically. Presently two techniques are in S-MAC protocol code to minimize this error.

(a) All exchanged timestamps are relative rather than absolute.
(b) The listen period is significantly longer than clock drift rates.

- ***XMAC:***

XMAC builds upon the foundation provided by asynchronous duty cycled MAC protocols. This protocol improves the problems of overhearing, excessive preamble and low power listening. Asynchronous protocols like BMAC and Wise-MAC, rely on LPL (low power listening) also called preamble sampling. This uses strobe preamble which allows interruption and wake up faster. XMAC uses short preamble embedded with information related to the address of the target and retains the advantages of low power listening, simplicity, namely low power communication, and a decoupling of transmitter and receiver sleep schedules [3].

Advantages:

It is energy-efficient and has low latency (reduced preamble length). It does not need synchronization thus it has low overheads. So it is less complex.

Disadvantages:

It avoids the overhearing by embedding the node-id of the receiver. This makes broadcasting and multi-casting difficult. It is unable to schedule sufficiently small listening periods.

- ***DMAC (Dense-MAC):***

Converge cast is the mostly observed communication pattern within sensor networks. These unidirectional paths from sources to the sink can be represented as data gathering trees. The principal aim of DMAC is to gain a very low latency and to be energy efficient. DMAC could be summarized as an improved Slotted Aloha algorithm where slots are duly assigned to the nodes based on a data gathering tree. Hence, during the receiving period of a node, their children nodes consist transmit periods and contend for the medium.

Advantages:

DMAC achieves very good latency compared to other methods. The latency of the network is crucial for certain scenarios, where DMAC could be a strong competitor.

Disadvantages:

Methods for collision avoidance are not used; hence when the nodes that have the same schedule try to send to the same node, collisions occurs. This scenario is possible in event-triggered sensor networks. Besides, the data transmission paths may not be known, which precludes the data gathering tree formation.

- ***UMAC (Universal Mac Protocol):***

The concept of a universal MAC (UMAC) protocol is that it can be configured either automatically or manually, as per the application requirements, deployment scenarios and device capabilities. UMAC protocol can be configured to work on sensor nodes in WSNs, and also to work on mobile devices in MANET [3].
UMAC concept is based on the idea that the MAC protocol takes advantage of available context sensitive information related to QoS requirements, application characteristics, device capabilities and channel conditions. In this way, the UMAC protocol using such a MAC would be flexible enough to be molded as per the aforementioned context sensitive information [6].

10. Deployment Model of Wireless Sensor Networks [4]:

- ***Heterogeneous Deployment Model:***

Wireless sensor network is a key element of the ubiquitous computing, with the advancement of manufacturing and wireless technologies. The heterogeneous WSN consist of sensor models with different abilities, such as various sensor types and communication sensing range. There are two type of sensor node. First is high end ones have higher process throughput and lower communication range; and second is low end ones much cheaper and with limited computation.

To achieve a satisfying performance, the deployment of wireless sensor network is more complicated than homogeneous wireless sensor network. However, the behavior of WSN correctly is a major challenge of sensor mode deployment simultaneously. Moreover, node deployment is heterogeneous WSN has to consider the topology control between different type of sensor node.

The benefit of heterogeneous WSN has been study in many research books. Heterogeneous WSN that consist of three types of nodes: sink node, high end sensor node (NH), low end sensor node (NL). Each node the same communication model and two type of sensor node have the same sensing model. The difference between NH and NL is that the predefined communication and sensing range are different.

Conclusion: Heterogeneous WSN development method based on irregular sensor model. It aims to deal with development problem of heterogeneous sensor models with different communication and sensing range. The development process is starting from sink node and new nodes are deployed to the region centered with it. At least new sensor node is placed to the position with the most coverage gains while maintaining the communication connectivity to centre node.

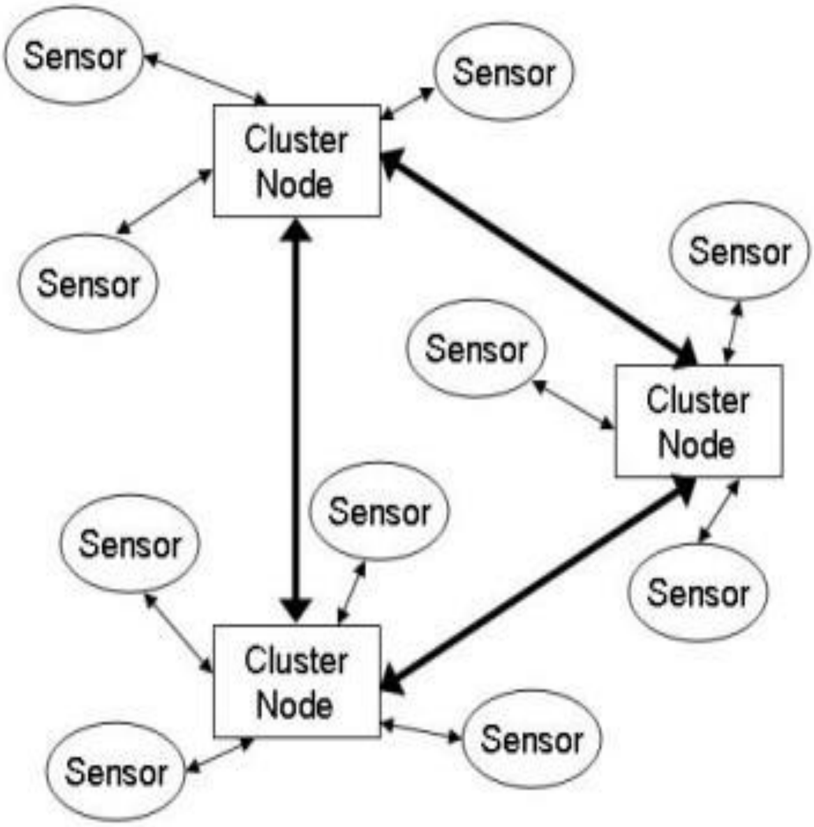

Figure 10.1 – Heterogeneous Deployment Model

- ***Node Deployment Model:***

Node deployment model is a good network model. It cannot only reduce the network costs and noise redundancy, since also can prolong the service life of the network. For example: in the building of traffic warning system, the collection of all kind of transportation information which affects the traffic control is the foundation of getting better effect of control. Thus, in order to achieve the collection of traffic information using wireless sensor network. An integrated evaluation function is presented based on coverage, conservation and connectivity [4].

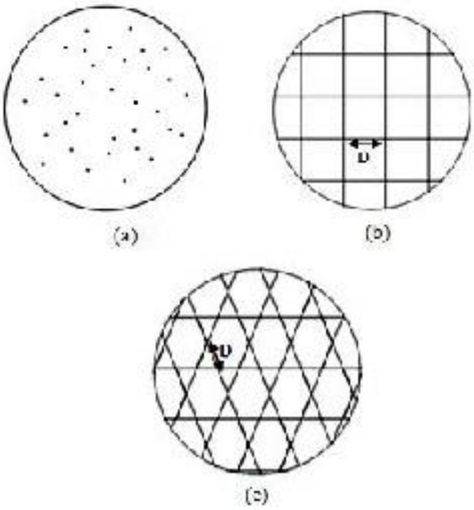

Figure 10.2 – Node Deployment Model

There are two classification first is that static deployment and other dynamic deployment,

Static Deployment: The static deployment chooses the best location according the optimization strategy, and location of sensor nodes have no change in the lifetime of the WSN. Today, static deployment includes the deterministic deployment and randomly deployment. The method of deterministic deployment is firstly to do the surveyed area and then carries on the network.

Dynamic Deployment: The dynamic deployment can be compared to the deployment of the robot. In order to make the sensor network get the maximum performance. Sensor node needs automatically move to proper location, and then start to work. Random deployment, as the name suggests it randomly throw nodes firstly and then using a variety of optimization algorithm for deployment optimization.

- ***Grid Deployment Model:***

It is also a model of wireless sensor network. A new key management scheme based on equilateral triangle network deployment model in wireless sensor network is proposed. It combines the t-order binary polynomial model with the node deployment. So the entire network is divided into several mutually non overlapping equilateral units and each pair of adjacent units adopts the same key allocation algorithm. Wireless sensor network has been regarded as one of the most important technique of the century. Since the wireless sensor network adopts wireless channels, has limited communication power. This deployment is used in distributed management. The node can easily be controlled by attacker and the data stored in the node [4].

The key management scheme utilizing the grid deployment model is an improvement of that based on geographical position. The approach is to divide the network into a number of seamless. Grid unit is none overlapping. When the network is deployed, any two adjacent nodes in a unit can establish a pair wise key, which realizes the secure communications of the network.

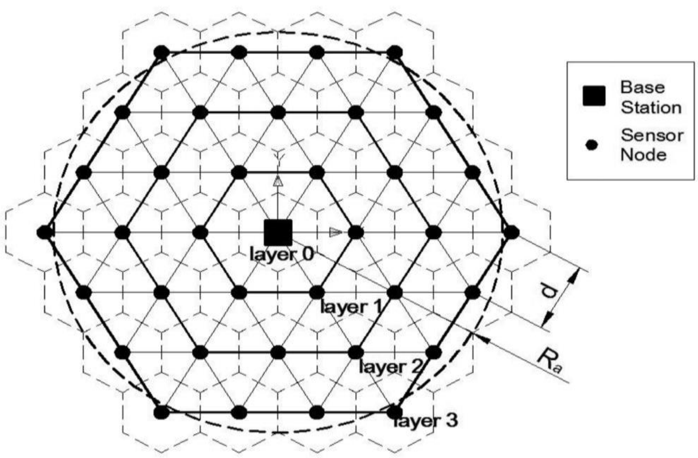

Figure 10.3 – Grid Deployment Model

- ***Random Deployment Model:***

It is also a model of wireless sensor network. This deployment is also called systematic random deployment model. Wireless sensor nodes could be generally placed in three methods including random deployment, regular deployment and customize deployment. The agricultural scenario, sensors could be mostly possible installed during terrain preparation. It is good choice for sensor node deployment referring to traditional sampling method [4].

The most commonly used sampling design for spatial data is systematic sampling in agricultural experiments because it is easy to implement. A square grid, an equilateral triangle, or a regular hexagonal grid is commonly chosen in systematic sampling. But systematic sampling does have a few disadvantages for spatial collaboration analysis. There is a danger that the systematic grid might coincide with a systematic features of the landscape.

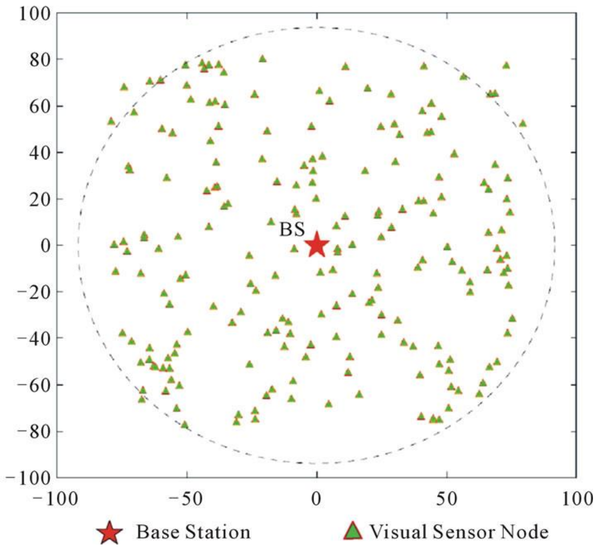

Figure 10.4 – Random Deployment Model

11. Need of MAC Protocol for WSN:

Use of Wireless sensor networks has been widely seen in environmental monitoring, industrial process monitoring, tracking of targets and tactical systems. In wireless sensor networks nodes work with a limited power source. The energy efficient operations are an important factor of the nodes in wireless sensor network. Energy conservation is an important aspect in different layers of the TCP/IP protocol suit, and for MAC layer it is the effective part. Thus, in wireless sensors network, we use MAC protocol which improve energy efficiency by decreasing idle listening and overhearing, increasing sleep duration and eliminating hidden terminal problem or collision of packets [7].

12. Energy Wastage in Mac Protocol:

The reasons of wastage of energy in a MAC protocol for wireless sensor networks are the following,

Collision: Some time the packet gets corrupted during transmission these packets need to be discarded and re-transmitted, this lead to increase in energy consumption.

Control Packet Overhead: Energy is also required for Sending and receiving packets due to these less useful data packets can be transmitted.

Idle Listening: Extra energy is also consumed in listening to receive possible traffic which is not sent.

Overhearing: Sometime nodes can pickup which is destined to other nodes. This also leads to unnecessary consume of energy. Reducing the energy wasted idle listing protocols like SMAC, TMAC and CMAC can be used.

13. Conclusion and Future Work:

We are proposing a new MAC protocol exclusively for wireless sensor networks to achieve better energy preservation at node level and network lifetime. The better network lifetime can be achieved only if the node level battery can be preserved. So we conclude that, the energy preservation of sensor node is one the important aspect in wireless sensor network. We studied the existing MAC protocols in WSN environment. Afterwards, we designed a new MAC protocols for WSN environment at node level energy preservation. In our future work, we will develop our proposed protocol and conduct the simulation experiments for testing its performance. In our further work, we will conduct simulation testing of proposed protocol with various simulation parameters.

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