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# A Detailed Survey on Energy Efficient WSN Routing Protocols

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## ABSTRACT
Energy-efficient (EE) designs are now essential requirements for the near future as the wireless sensor network (WSN) expands in popularity. The EE of WSN networks has undergone significant improvement efforts. Transmission of data at high speeds may result in increased energy consumption. As a result, enhancing the EE of WSN routing protocols remains an important area of study. We have looked at various WSN clustering protocols in our paper. It explains the Energy Efficient Sleep Awake Aware (EESAA) Protocol in detail. The EE WSN routing protocols' applications are also discussed here. The majority of these applications use more energy because they require high data transmission rates. In order to achieve the EE for WSN in these applications, a variety of protocol designs have been proposed and developed over time. A comprehensive summary of a study on energy-efficient (EE) routing protocols is provided in this article. Additionally, it addresses the burning issues regarding WSN lifetime enhancement based on the EE routing design.

## Keywords
Wireless Sensor Network, Energy Efficiency, Routing Protocols, Clustering, Set up, Steady State.

## 1. INTRODUCTION
A Wireless sensor network is a collection of numerous, spatially dispersed wireless sensing nodes in a sensor field [1]. Sensor nodes can sense (measure), process data, communicate with other sensor nodes, and serve as data generators and network relays. The administrators or end users of the data may then be able to observe and respond to events in a specific environment [2]. Wireless sensor nodes are extremely small and inexpensive. They are able to send information about environmental conditions, such as air quality, temperature, sound, pressure, and humidity, to a common base for proper processing [3]. The typical environment could be a biological structure, the real world, or the information technology (IT) background. Mesh topology's advanced networking protocols allow sensing nodes to create a large connectivity area and link cyberspace to the real world. The sensor module estimates natural boundaries that encompass the sensor and changes the surrounding energy into electric signs. The processor module processes the data to obtain information about events that are taking place close to the sensor. The data are then sent to a destination node via a radio transmitter [4] As a result of technological advancements, the size and cost of sensors have decreased, increasing interest in the use of large sets of disposable, unattended sensors. In recent years, extensive research has been conducted on the possibility of sensor collaboration in data collection and computation, sensing activity control and administration, and data flow to the destination node. Ad hoc networks can be formed by sensors communicating via wireless communication links, which is a natural design for distributed collective sensors [5]. A wireless sensor network, also known as a WSN, ought to be able to set up a large number of very small nodes that are able to join together and set up for a common goal.

A typical Wireless Sensor Network (WSN) with several sensor nodes and a sink node is depicted in Figure 1. The sink node receives environmental data continuously from the sensor nodes. In many situations, tens to upwards of thousands of such sensor hubs are conveyed all through a locale of interest, where they self-sort out into an organization through remote correspondence and team up with each other to achieve a typical undertaking [6]. All of the sensed data from these sensor nodes is received by the sink, processed, and delivered to the end user.

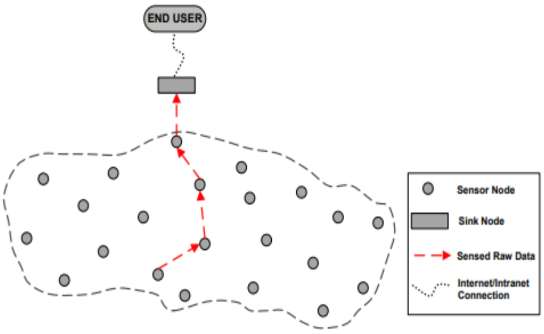



**Fig 1: Wireless Sensor Network**

WSNs are used for a variety of applications, including but not limited to battlefield surveillance, environmental monitoring, disaster detection and rescue, precise and intelligent agriculture, medicine and health care, eco-friendly buildings, traffic control, and object tracking. Monitoring underground mines for any trends in order to guarantee the safety of miners and their constant location are examples of environmental monitoring and object tracking [7].

The various components that make up a wireless sensor node are depicted in Figure 2.

The most important components of a wireless sensor network are listed below.

- **Sensor module-** The detecting unit is made out of a gathering of sensor, which are gadgets that produce an electrical reaction to an adjustment of a state of being. There are numerous types of sensors, including magnetometers, accelerometers, light sensors, temperature, pressure, and humidity sensors. Since the application will determine the type of sensors used in a sensor node, this paper will not go into greater detail on this topic.
- **Processor module-** Sensor nodes require processing units because they are expected to communicate, process, and collect sensor data. The computational capabilities and energy consumption of a sensor node are significantly influenced by its central processing unit. This paper goes

over a wide range of CPUs that can be incorporated into a sensor node.

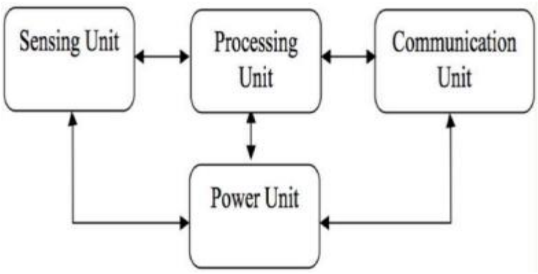



**Fig 2: Components of Sensor Node in WSN**

- **Power source module-** The power supply block is made up of a battery and a dc-dc converter. Its purpose is to power the node because the sensor node needs energy to monitor the environment. There are a lot of commercially available microcontrollers, microprocessors, and field programmable gate arrays (FPGAs).
- **Communication module-** The transceiver is a single device that combines the transmitter and receiver. The ISM (Industrial, Scientific, and Medical) band is frequently used by sensor nodes. The ISM groups are characterized by ITU-R (Worldwide Telecom Association Radio correspondences). Due to differences in national radio regulations, different nations may use these bands in different ways. This gives free radio, range portion and worldwide accessibility.

A remote correspondence network is framed in an impromptu way where sensor hubs can sort out themselves with no legitimate coordination; this is found in many WSNs applications. The sensor nodes get their power from a battery, which is usually not re-chargeable or replaceable [8]. This is especially true when the sensor nodes are expected to work without human intervention for a longer period of time during the application. The design of wireless sensor networks places a significant emphasis on careful resource management. Radio optimization, data reduction, sleep or wake-up methods, energy-efficient routing protocols, and energy harvesting are all ways to save energy [9].

When compared to conventional wireless networks, WSNs are limited in terms of bandwidth, power, storage, and processing power [10]. The application and the environment that will be monitored determine the WSN design constraint. Three fundamental characteristics are required for any application to enable WSN implementation. These are minimal expense, lesser power and ongoing help. WSN networks are used for a wide range of applications, including time-sensitive, event-detection, and constant monitoring ones. For this kind of application, data reporting is done on a regular basis, based on any event, or only in time-sensitive situations.

## 2. COMMUNICATION ARCHITECTURE

There are typically hundreds or thousands of sensor nodes in a WSN. These sensor nodes can gather data and send it back to a base station (BS), and they are frequently spread out in a sensor field. There are four main components to a sensor: a power unit, a transceiver unit, a processing unit, and a sensing unit [11]. As depicted in figure 3, it may also contain additional application-dependent components like a power generator, mobilizer, and location finding system. There are typically two subunits that make up sensing units: analog-to-digital converters (ADCs) and sensors based on the observed phenomenon, the ADCs transform the analog signals generated by the sensors into digital signals. The handling unit, which is for the most part connected with a little stockpiling unit, deals with the methodology that causes the sensor hub to team up with different hubs. The node is connected to the network by a transceiver unit. The power unit is one of the most critical components. Power scavenging devices (like solar cells) or a finite power unit (like a single battery) can support a power unit. A location finding system provides the location-related information that is required for the majority of sensing and routing techniques for sensor networks. Lastly, depending on the application, moving the sensor node may require a mobilizer at times.

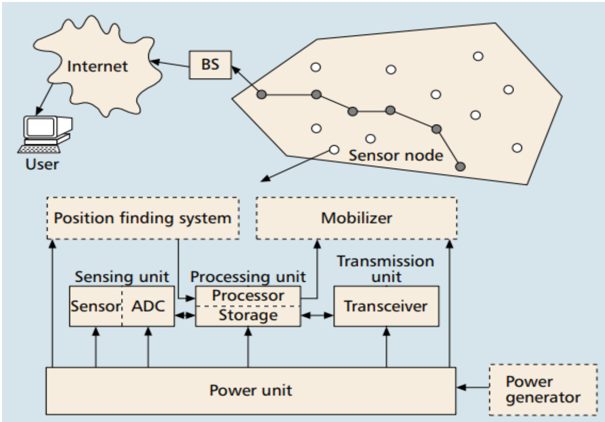



**Fig 3: Communication Architecture of WSN**

The physical, data link, network, transport, and application layers of the sensor node protocol stack are defined as follows [12]:

**Physical Layer-** Data encryption, signal deflection, modulation, and frequency selection are all performed by the physical layer.

**Data link layer-** It is in charge of multiplexing data streams, data frame detection, medium access, and error control. As well as ensuring that point-to-point and point-to-multipoint connections are reliable.

**Network layer-** It is in charge of specifying how addresses are assigned and how packets are forwarded.

**Transport layer-** It is in charge of specifying how packets will be reliably transported.

**Application layer-** It is in charge of specifying how data are requested and provided for individual sensor nodes as well as interactions with the end user.

## 3. ADVANTAGES OF WSN

WSNs have changed the world around us due to their wide range of uses. They are gradually becoming an essential part of our lives. The advantages of wireless sensor networks are listed below [13].

**Robustness to withstand harsh environmental conditions-** Because of their shrinking size, sensor nodes can communicate with a wide range of materials and are built to withstand harsh weather. WSNs can be used for a wide range of environmental tasks, including monitoring seismic activity and detecting forest fires.

**Simplicity of Sending-** In a sensor network hundreds or thousands of hubs can be conveyed in remote or risky climate. Throwing hundreds or thousands of these nodes from a plane over a remote or dangerous area makes it possible to extract information in a way that would not have been possible otherwise due to their small size and low cost.

**Fault Tolerance-** In wireless sensor networks, multiple sensor nodes are placed in close proximity to one another. They simply use a different routing path to get around node failures caused by dead or destroyed nodes. For instance, in a conflict, if an adversary destroys a surveillance sensor node, the network as a whole will not be affected.

**Capability to Cover Wide and Dangerous Areas**- Wired networks aren't used in many places because of infrastructure and economic conditions. On a battlefield, for instance, establishing a wired network would be impossible. Due to their low setup costs and lack of infrastructure, wireless sensor networks can fill this gap.

**Self-Configurable**- When sensor nodes are placed in the field, they can self-configure network discovery and multihop broadcast in a short amount of time.

**Mobility of Nodes**- In recent years, the event's mobility has been used for permanent tracking. Real shifting can be handled by recently developed protocols and architectures to maintain further routing.

**Unattended Operation**- WSNs can operate unattended, reducing the amount of work required to administer these systems and the amount of time spent working on them. Home appliance control, industrial monitoring and control, and other applications benefit from this.

**Increased durability**- As a result of the sensor nodes' close proximity to one another They can be put in groups. Only one node from this group can be used to collect data and send it to the base station in a round-robin fashion. It will make the life better.

**Better Accuracy**- in WSNs, the close proximity of the sensor nodes that are sensing and collecting data about the same event will improve accuracy and cut down on uncorrelated noise.

## 4. APPLICATIONS OF WSNs

The following are the main features of WSN: energy collecting, capacity to adapt to hub disappointment, portability of hubs, heterogeneity of hubs, versatility to huge scope organization, capacity to endure brutal natural circumstances and convenience [14]. Sensor networks can be used in a variety of ways because of the aforementioned features. Figure 4 depicts the primary application areas of a wireless sensor network, which can be divided into the following categories:

**Precision agriculture-** The goal is to make cultural operations more resourceful and less harmful to the environment. The data gathered by sensors is used to figure out the best sowing density, how much fertilizer and other inputs are needed, and how accurately crop yields can be predicted. The use of WSN in agriculture is unavoidable. The architecture consists of a number of wireless sensor nodes in the field that are used to collect and monitor data like temperature, humidity, levels of carbon dioxide gas, soil moisture, and so on [15].

**Environmental Monitoring**- The utilization of remote sensor networks in climate broadens its application in coal mining, earth tremors, torrent, flood discovery, timberland fire forecast, gas spillage, typhoons, precipitation range, water quality, and volcanic ejection, etc. The network enhances a safety measure to a certain extent because it provides early detection and prediction of all of these environmental disasters. The master station receives the data via the Internet after it is sensed by the sensors. This helps to alert people to the impending disaster and assists in taking precautions.

**Catastrophe Management**- The early admonition framework in light of WSN can be dependably conveyed in regions with high gamble of calamities. The use of a WSN promises to give rescue teams information about the disaster area in real time, making planning and coordination easier. The location information of victims, rescuers, and disaster-related objects is crucial to rescue efforts. Sensing, monitoring, and decision-making ought to be seamlessly integrated for disaster management to be operationally effective, it has long been recognized.

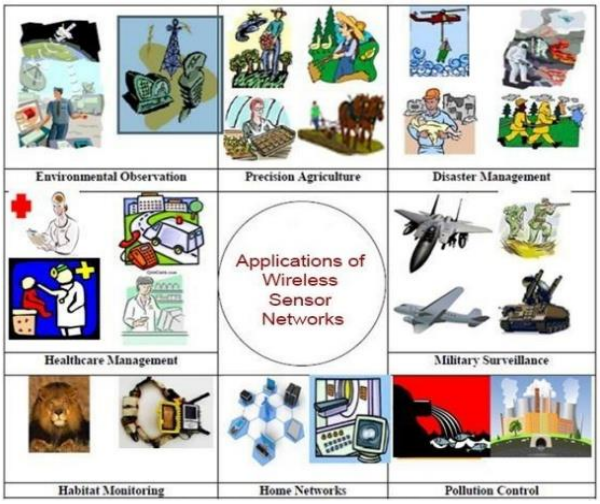



**Fig 4: Applications of WSN**

**Military Applications**- WSN is an essential component of armed C4ISRT (command, control, communications, computing, intelligence, surveillance, reconnaissance, and targeting) systems. Military applications Sensor networks are an extremely promising sensing method for military C4ISRT due to their rapid exploitation, self-organization, and error acceptance characteristics. Since sensor networks are built on the intensive use of low-cost, non-reusable sensor nodes, the destruction of some nodes by aggressive actions has less of an impact on a military operation than the destruction of a typical sensor, making sensor networks an improved strategy for battlefields.

**Health care monitoring-** The use of WSNs in the medical field is now a necessity. There are sensors in the system that can detect various physiological parameters. The practitioner receives the sensed parameters for further examination and diagnosis. WSN has been used in many projects. A few examples of WSN applications in health care are presented here, drawn from various papers.

**Smart Buildings-** An intelligent building is able to monitor and control its own functions in accordance with the structure of the building and the environment inside and outside. The building scope is directly connected to the functionalities and their characteristics. Somebody has likewise planned and fostered a brilliant checking and controlling framework for family electrical machines continuously.

**Animal tracking-** It is another use for wireless sensor networks. In animal tracking, a sensor is attached to the animal's body to determine how it is moving and where it is. Zebra Net, which is used to track zebras in the field, is an illustration of the application of wireless sensor networks in animal tracking. In order to monitor the animal's position, location, and food type, the sensors are attached to the animal's body.

**Vehicle tracking-** It is another use for WSN in smart transportation. Networked cameras and other sensors that are used to track vehicles in the city for traffic violations, monitor traffic flow to reduce congestion, and detect illegal activities around critical infrastructure like airports and railway stations The use of WSN in smart transportation has been detailed by one researcher.

## 5. ROUTING IN WSN

The power, communication, and sensing capabilities of a sensing element node are limited. These nodes can talk to each other directly or through other intermediate nodes to get information. As a result, in a highly sensing element network, each node acts as a router within the network [16]. Each sensing element node can communicate directly with the base station in direct communication routing protocols. The base station can communicate with the end user directly or through a network that is already in place. The sensing element network's topology fluctuates frequently. Since there is a significant distance between the base station and the sensing element nodes in the event of direct communication, sensors use up energy quickly and stop working. Because the possible routes can change, dynamic routing makes it possible to use routing tables in routers. Because nodes can change their positions and die at any time, dynamic routing is typically used in wireless sensing element networks.

## 5.1 Design Constraints for Routing in WSN

The following requirements are expected to be met by routing protocols in wireless sensor networks because of the sensors' limited computing, radio, and battery resources [17].

**Autonomy-** In wireless sensor networks, the idea that a dedicated unit controls the radio and routing resources is not true because it could be an easy target. The routing procedures are delegated to the network nodes because there won't be a centralized decision-making body.

**Energy Efficiency-** In order to facilitate communication between nodes, routing protocols ought to extend the lifespan of the network while also preserving a high degree of connectivity. It is essential to note that the majority of the sensors are arranged haphazardly, making it impossible to replace their batteries. In some cases, the sensors cannot even be reached. In wireless underground sensor networks, for instance, some devices are buried to sense the soil.

**Scalability**- Since a hundred nodes make up a wireless sensor network, routing protocols should be able to handle this many nodes.

**Resilience-** Sensors may suddenly stop working due to battery drain or environmental factors. In the event that a current-in-use node fails, routing protocols should be able to find an alternate route.

**Gadget Heterogeneity-** Albeit the majority of the common utilizations of remote sensor network depend on homogenous hubs, the presentation of various types of sensors could report huge advantages. The network's characteristics may be enhanced by using nodes with different processors, transceivers, power units, or sensing components. The network's scalability, energy drainage, and bandwidth, among other things, could all benefit from the diversity of nodes [7].

**Mobility Adaptability-** The various uses of wireless sensor networks may necessitate that nodes adapt to the sink's or event's mobility, as well as their own. These movements should receive the necessary support from routing protocols.

# 6. ROUTING TECHNIQUE IN WSN

There are three categories of routing protocols based on how a message sender obtains a route to the receiver. These include location-based architecture, flat routing architecture, and hierarchical routing architecture.

**Flat Routing Architecture**- Multi-hop flat routing protocols are the first type of routing protocols in the flat routing architecture category. In flat routing, sensor nodes work together to complete the sensing task, and each node typically plays the same role. It is not possible to give each of these nodes a unique global identifier due to the large number of them. Data-centric routing, in which base stations (BS) send queries to specific regions and wait for data from sensors in those regions, is the result of this consideration. Attribute-based naming is required to specify the properties of data because queries are used to request it [18].

**Hierarchical Routing Architecture**- Progressive Directing Design Various leveled or group based steering techniques, initially proposed in wire line networks are the notable strategies with unique benefits connected with versatility and proficient correspondence. As a result, energy-saving routing in WSNs also makes use of the concept of hierarchical routing. Each sensor node in a WSN is grouped with other nearby nodes to form a specific cluster, which is the central concept of this group of protocols. The base station does not receive the data directly from the sensor nodes in a cluster. Instead, these data are collected and sent to the base station by a cluster head node, which may have already carried out the necessary data aggregation.

**Location Based Routing Architecture**- Based Routing: In this type of routing, sensor nodes are contacted based on where they are. The strength of the incoming signal can be used to estimate the distance between adjacent nodes. By exchanging this information between neighbors, relative coordinates of neighboring nodes can be obtained.

## 6.1 Hierarchical Network Routing Protocols

Hierarchical protocols group nodes into clusters, in contrast to flat protocols, where each node has its own global address and all nodes are peers. The selection of a cluster head is based on a variety of election algorithms for each cluster. By utilizing the cluster heads for higher-level communication, traffic overhead is reduced. The concept of communication can be shared by all levels of clustering, rather than just two levels. There are numerous benefits to using a routing hierarchy. It improves scalability by making routing tables smaller [19].

The LEACH protocol is a hierarchical protocol in which the majority of nodes transmit to cluster heads. There are two phases to how the LEACH protocol works:

- **Setup Phase-** The clusters are arranged and the cluster heads are chosen during the Setup Phase. The data is compiled, compressed, and sent to the base station by the cluster heads. Each round, a stochastic algorithm is used by each node to determine whether it will become a cluster head. On the off chance that a hub turns into a group head for one time, it can't become bunch head again for P adjusts, where P is the ideal level of bunch heads.
- **Steady State Phase**- In the Consistent Stage, the information is shipped off the base station. In order to reduce overhead, the steady state phase takes longer to complete than the setup phase. Besides, every hub that isn't a group head chooses the nearest bunch head and joins that bunch. The cluster head then establishes a transmission schedule for each cluster node.

In terms of energy dissipation, ease of configuration, and system lifetime/quality of the network, LEACH outperforms conventional communication protocols [20]. In a WSN, supplying such a low-energy wireless distributed protocol will assist in paving the way. LEACH, on the other hand, employs single-hop routing, allowing each node to transmit directly to the sink and cluster head. As a result, it should not be used for networks that cover large areas. Additionally, dynamic clustering may result in additional overhead, such as head changes and advertisements, which might reduce the increase in energy use.

## 6.2 Cluster Based Routing Protocol

When a large number of sensors are used for sensing, cluster-based routing techniques are essential for sensor network applications. If every sensor begins to communicate and transmit data over the network, there will be a lot of congestion and data collisions, which will use up the network's limited energy. These problems will be solved by node clustering. Nodes can be divided up into a number of smaller groups called clusters in clustered networks. Each group has a facilitator, alluded to as a bunch head (CH), and various sensor hubs (SNs). CHs make up the higher tier of the cluster hierarchy, while SNs make up the lower tier. A clustered network's data flow is depicted in Figure 5.

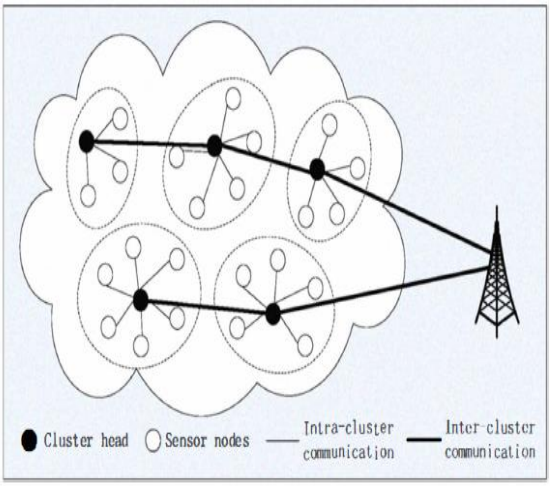



**Fig 5: Architecture of cluster-based routing protocols**

The data are sent to the appropriate CHs by the SNs. The data are aggregated by the CHs, who either directly or through other CHs send them to a central base station (BS). By creating a hierarchical WSN, clustering makes it easier to make efficient use of the sensor nodes' limited energy and thus extends the lifetime of the network.

Common definitions of "network lifetime" include the time until the first or last node in the network exhausts its energy and the time until a node is disconnected from the base station. The sensor network is broken up into various clusters during clustering. Each bunch has a delegate hub known as CH and other are group individuals. The sink node and BS do not communicate directly with member nodes. The CH must receive the compiled data from them. The data that has been received from member nodes will be compiled by the CH and sent to the BS. Assume that a field contains N scattered nodes. Finding a set of CHs that effectively cover the entire network is our objective. There is only one cluster to which each node is connected. The node and its CH can talk to each other directly [21].

The following conditions must be met:

- Clustering occurs entirely randomly.
- Clustering ought to be finished after a predetermined number of iterations. There is either a CH or a cluster member at the end of each node.
- The clustering algorithm ought to be effective in terms of the number of message exchanges and processing complexity.
- CHs are effectively dispersed throughout the network to cover the entire network.

The four stages of cluster-based routing protocols are as follows: data aggregation, data communication, cluster head selection, and cluster formation Figure 6 depicts the setup state, which begins with the cluster head selection stage and continues with the construction of clusters. The steady data transmission state comes after the setup state and is broken up into the data aggregation and transmission phases.

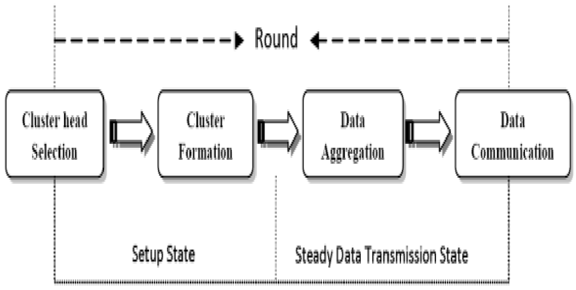



**Fig 6: Composition of one round of the clustering process**

A cluster-based protocol is run in one round, with the setup and steady data transmission states iterating throughout the protocol's or network lifetime. Sensor nodes in clustering algorithms can be categorized into four groups based on their role:

**Cluster head (CH)** - The primary responsibilities of a cluster head (CH) are to coordinate a group of nodes within the boundaries of the cluster, aggregate the cluster members' sensed data, and transmit the aggregated data to the next hop.

**Base station (BS):** Due to its high processing capabilities and unlimited energy supply, BS may serve as the network coordinator or as the sink node where all aggregated data are processed depending on the application and end user requirements.

**Transfer hub (RN)-** Gatherings of hubs in multi-jump information transmission plans answerable for handing-off detected or accumulated information by different hubs towards the objective

**General hub (GN)-** Greater part of hubs in the organization, which just give the detected information in view of the sort application.

## 6.3 Energy Efficient Sleep Awake Aware (EESAA) Protocol

EESAA [22] convention diminishes the use of energy and gives the solidness in network lifetime and deals with matching where adjoining hubs makes the pair for information transmission and further correspondence. Additionally, this protocol improves cluster head formation for increased data packet transmission. The advance coupling network model, commonly referred to as ACNM, is utilized in this protocol. In this model, nodes use GPS to estimate their location, and nodes transmit their node identification, application type, and location to the base station. This allows for communal distances between nodes to be calculated and paired based on minimum distances with the same application; however, some nodes are left out of the pairing process because they are outside of sensing range. Nodes in EESAA switch between sleep and awake. If a node is within a reasonable distance of the base station and wishes to transmit some information to the base station, it enters the active mode known as awake mode, and if there is no activity, it enters the sleep mode in order to conserve energy. Avoids excessive hearing and minimizes power consumption when nodes are in sleep mode.

**Coupling in the network-** In the network, coupling occurs when nodes transmit their location information, which includes the application type and node identifier, to the base station (BS). The base station then uses GPS to determine the nodes' mutual distance from one another. BS couples nodes that are of the same application type and have a minimum distance between them. The matching data is then distributed to each network node by the base station. During a single communication interval, nodes transition from "Sleep" mode to "Awake" or "Active" mode.

**Network configuration-** During this phase, a distributed algorithm is used to determine the best number of CH. At first, the network's energy is uniform and all nodes have the same amount. The remaining energy of each node informs the selection of CHs following the first round. The CH selection process is carried out by active nodes.

**Data Transmission-** All active mode nodes transmit their detected data to CH during their TDMA assigned slots in the first round, when all nodes have the same initial energy $E_0$. This is done based on the probability of selecting CH using a distributed algorithm. The transmission phase has no effect on sleep mode nodes. The CH totals get information from every hub and communicate it to BS. A signaling method for compressing data is data aggregation. This method has the potential to save a significant amount of energy. To achieve an acceptable signal-to-noise ratio (SNR), a non-CH node dissipates the ETX in the transmitter circuits and the Eamp in transmission amplification in order to transmit data.

# 7. BRIEF SUMMARY OF REVIEW OF ENERGY EFFICIENT (EE) ROUTING PROTOCOLS

Abu Salem,et al. [1] have presented the application of WSN in the environmental monitoring and proposed the EE sensors network design. Alkhatib et al. [2] have adopted the WSN for application in Forest Fire detection. Difallah, et al. [3] have presented a work for designing smart irrigation system for agriculture using WSN network. Dominguez et al. [4] have used sensors for monitoring. Bandyopadhyay et al. [5] have recently used WSN for the patient health monitoring application. N. Ha et al. [6] have used WSN for the structure health monitoring for concrete compressive strength sensing application. Paresh et al. [7] presented various applications of WSN in IOT uses. First time in 2012 T. Shah et al. [8] had proposed a fresh strategy of an EE routing protocol that employs a sleep awake and awareness (EESAA) to enhance overall effectiveness. For clustering and CH selection, the protocol makes use of residual energy of nodes and Euclidian distance measurements among nodes. Ansam Ennaciri et al. [9] proposed a load balancing based sleep aware and awake (EESAA) protocol that improves conventional algorithm of CH’s selection by selecting CHs based on the residual energy of nodes. They have designed the efficient energy balancing based method using the EESAA methods. Priyanka Chourey et al. [10] have significantly improved the speed of existing EESAA protocol by considering the modified distance measure. They have scaled energy for increasing the life of network. Optimum parameter based design approach is adopted for performance enhancement. O. Singh et al. [11] has proposes and assesses the Balancing EE Clustering (I-DEEC) method. The system is modeled on MATLAB using various network sizes (100–500 nodes) as test its efficacy on various parameters, and then it is contrasted with available protocols (DEEC as well as EESAA). Gaurav et al. [12] presented the new approach of EE routing with the help of a tree and an energy-conscious based routing protocol. Protocol combined tree with the suggested sleep scheduling mechanism and thus in turn provide a new technique for scheduling the regular sleep order of the sensors network nodes. Sleep awake-based WSN protocol was created employing thresolding by Kavita Sharma et al. [13]. For homogeneous WSN, Akshay Verma et al. [14] have proposed (FLEC)'s technique of fuzzy clustering routing with successful clustering has indeed been developed for Mobile Sink. To enhance the network's lifespan, a fuzzy-based protocol is employed. R. Saxena et al. [15] has offered a customized version of a standard SEP termed TSEP that outperforms EESAA and LEACH. They have shown an evaluation of excellent performance assessment of 3 alternative routing WSN protocols. A traffic- as well as energy-aware SAA based clustered routing protocol again for WSN have been suggested by the authors in the Nura Modi et al. [16]. The review of alternative routing algorithms for the WSN architecture, especially tend to clustering dependent protocols, has been presented by Amee Vishwakarma et al. [17]. Another approach that uses EE routing based on SAA has been presented by Gulnaz Ahmeda et al. [18]. For just a sleep-aware based strategy, authors Parvat et al. [19] had devised heterogeneous routing. The comprehensive assessment of LEACH-based EE techniques was presented by Tyagi S. et al. [20]. Additionally, L. H. Al-Farhani et al. [21] recently have implemented an updated SAA dependent EE routing. Still there is lot of scope of improvement in EE of these protocols.

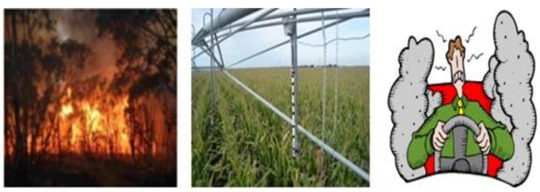
Table 1 has presented the summary of the literature review. The goal of the current paper is to improve the existing EESAA protocol and make it more energy-efficient and durable.

**Table 1: Brief Summary of Literature Review of Protocols**

| Authors and Year | Methodology | Description |
|---|---|---|
| T. Shah et al. in [8] | Proposed first time EE protocol EESAA for improving life time overall effectiveness. | For clustering and CH selection, EESAA makes use of residual energy of nodes and the distance among nodes |
| Ansam Ennaciri et al. in [9] | A load balancing based (EESAA) protocol that improves CH’s selection algorithm | Enhance CH’s selection based on residual energy of nodes. They designed energy balancing based algorithm using the EESAA methods. |
| Priyanka Chourey, et al. in [10] | Proposed sigh speed HSO-SAA protocol by considering the modified distance measure. | They scaled energy for increasing network life. Optimum parameter approach is adopted for EE improvement |
| R. Saxena et al. in [15] | Proposed the TSEP protocol outperforms other clustering-based methods. | Performance evaluation protocol based on probable stable selection. |

# 8. APPLICATIONS OF ENERGY EFFICIENT (EE) WSN

Figure 7 depicts various instances of frequent EE WSN applications. The present research is primarily motivated by these potential uses of WSN. The armed services, urban surveillance, health services and clinical, industrial WSN enabling inventories as well as industrial automation, environmental controls, environmental management as in forest management [2].




f) Habitat monitoring of animals

**Fig 7: Most frequently used applications of the EE WSN**

Other applications are weather forecasting and smart irrigation [3], WSN deployment can be seen in intelligent monitoring networks including the Fauna and Flora network and traffic monitoring [4]. Because of the low-power utilization sensing and registration devices, the major advancement in CPU technology made it simple to install the WSN. Health care is the most emerging field of the sensors network used for patient health monitoring [5]. With the expansion of the digital imaging and visual sensory devices has significantly become important to design the EE solutions while routing the data.

Thus this paper is focused to improve the EE of the traditional routing protocol based on the optimum parametric selection methodology. Most of these applications require high data rates of transmission and thus consumes more energy. With the time, various protocols designs have been proposed and designed for achieving the EE for WSN in these applications. The data is transmitted from nodes to CH and CH's to base station (BS). Thus energy is required to save during transmissions. So, to improve the speed of execution, the distance between CH and nodes is proposed to model with modified absolute distance measure as proposed by [10].

## 9. PERFORMANCE EVALUATION MATRICES OF WSN ROUTING PROTOCOLS

### *7.1 Network Lifetime*

The duration of a network from the time a node is deployed until the network ceases to function is known as the network's lifetime. Depending on the application, this can be viewed from a variety of angles. It can be thought of as the rounds of communication until the first node dies or until a certain percentage of nodes die, or it can be thought of as the rounds of communication until the last node exhausts its stored energy. We examine network lifetime from three distinct perspectives in this study.

### *7.2 First node died (FND)*

The time it takes for the first node in the network to run out of energy during sensing and communication rounds is known as the first node died (FND).

$$\left(\sum_{r=1}^{r_{\max}} \sum_{i=1}^{N} \begin{matrix} (Node(i).E \leq 0, (dead = dead + 1; \\ if(dead == 1, first\_dead = r))) \end{matrix}\right)$$

### *7.3 Fifty percent nodes died (TND)*

The time taken in detecting and correspondence adjusts until half of hubs drained their whole energy put away.

$$\left(\sum_{r=1}^{r_{\max}} \sum_{i=1}^{N} \begin{matrix} (Node(i).E \leq 0, (dead = dead + 1; \\ if(dead == 0.5 * N, half\_dead = r))) \end{matrix}\right)$$

### *7.4 Round until last node died (LND)*

It is the number of rounds that passed before the last node in the network ran out of energy.

$$\left(\left(\sum_{r=1}^{r_{\max}} \sum_{i=1}^{N} \begin{matrix} (Node(i).E \leq 0, (dead = dead + 1; \\ if(dead == N, last\_dead = r))) \end{matrix}\right)\right)$$

### *7.5 Number of alive nodes*

This number represents the number of alive nodes for each round.

### *7.6 Number of dead nodes*

The number of dead nodes in a round is the number of dead nodes.

### *7.7 Throughput*

It is the total number of successful bits that can be sent to the destination over the course of a given time period. The efficiency of the capacity in the network is shown by the throughput. Where (NR) is the total number of packets received by the destination and (NS) is the total number of packets transmitted by the source, the network throughput can be calculated as follows.

$$Throughput = \frac{NR}{NS}$$

### *7.8 Remaining Energy*

It is another name for the same thing. The capacity of the protocol to make maximum use of network energy is reflected in the remaining energy. The equation below can be used to calculate the average residual energy, where (E0) is the average initial energy and (CE) is the average amount of energy consumed.

$$RE = \frac{E_0 - CE}{E_0}$$

## 10. CONCLUSIONS

The limited available energy of the nodes is the WSN's primary limitation. WSN nodes are typically battery-operated sensor nodes with limited energy resources; therefore, replacing these sensor nodes' batteries is out of the question. However, we can save energy from individual nodes by utilizing effective energy management strategies. It can be concluded that extending the network's lifespan necessitates the creation of an energy-efficient (EE) routing protocol. By routing based on sleep awareness and wakefulness (SAA), the sensing device's low battery power can extend the WSN's life span. To increase EE, a conventional protocol's life, stability, and computation times must have been extended. The paper basically has reviewed the research done for WSN routing protocol based on the EE clustering SAA algorithm. Previous researches are deeply related to how to manage the energy utilized by the network's nodes. The EESAA protocol has saved energy from networks by keeping nodes not used in sleep modes.

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