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Survey on Wireless Sensor Network, Its Applications, and Issues

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Abstract : *. This work explores the WSN architecture according to the OSI model with some protocols in order to achieve good background on the wireless sensor network. The wireless sensor network is a combination of sensing, computation, and communication into a single tiny device. A Wireless sensor network consists of an array of several sensor networks of different types interconnected by a wireless communication network. Sensor data is shared between these sensor nodes. The system extracts relevant information from the available data. It acts as information source, sensing and collecting data samples from the environment. Node can also act as information sink, receiving dynamic configuration information from other nodes or external entities. The end portion of a node can be an antenna. The WSNs need not communicate directly with the nearest high-power control tower or base station, but only with their local peers. The main objectives is to improve energy efficiency, network life time and to reduce delay time. These sensors are used to collect the information from the environment and pass it on to base station. A base station provides a connection to the wired world where the collected data is processed, analysed, and presented to useful applications. The cluster-based technique is one of the good approaches to reduce energy consumption in wireless sensor networks., Wireless Sensor Network can be used as a tool to bridge real and virtual environment.*

***Key words* – Wireless Sensor Network (WSN), Sensor nodes, Protocol, CH-Cluster Head, BS-Base Station**

I. INTRODUCTION

A computer network is an interconnection of computers which are connected to each other through some communication medium or protocol. The medium and protocol can have different architectures for communication due to which a variation in speed and reliability is observed. Broadly the network is being categorized in two segments namely wired and wireless network [1]. The word "wired" is any physical medium having cable. The cables can be of copper, twisted pair or fibre optics. In wired network, the various signals transfers in the form of current through some medium. Only one internet connection is used and one device is connected through which data is shared among different devices through wired network. "Wireless" means data transfer through electromagnetic waves or infrared waves. Wireless devices have sensors or antennas embedded in them. Few examples are mobiles, TV remote, Laptop etc. Instead of using wires for connecting devices, radio waves, fibre optic and broadband ADSL are used [2][3].

Wireless Sensor Network (WSN) comprises of small nodes that have certain components as in Fig(1) 1) Power unit 2) Sensing unit 3) Micro Controller 4) Radio Tran-Receiver. WSNs have two broad categorical applications i.e., monitoring and tracking. In the current scenario, these WSNs operate on power sources like battery and hence organized energy consumption is highly required. These networks are highly reliable and are advantageous over conventional sensing devices. Also, they offer a very low-cost network deployment solution [4][5].

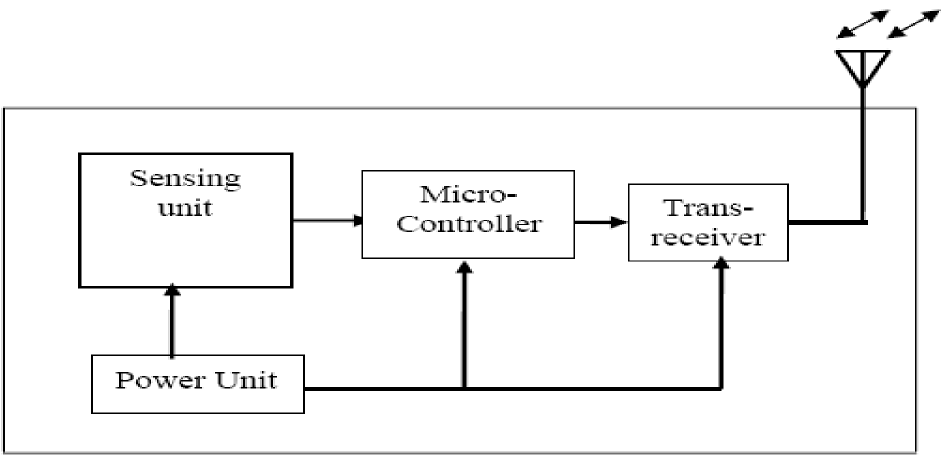

Fig (1) internal block diagram of a WSN Nodes

II Wireless Sensor Network (WSN) Architecture

Due to the advancement in wireless communication technology, wireless sensor networks (WSNs) It consists of multitudinous wireless nodes having the potential of sensing, processing, and communicating with a restricted power source (battery). These sensor nodes play vital roles as coordinator, router, and end devices. The architecture of a clustered WSN and its individual node is shown in Fig. 2. In the clustered architecture of WSN, nodes are subdivided into a small group, which is known as a cluster. After cluster formation, any one node of a particular cluster is chosen for transmission of signals to the base station (BS). The selection of nodes depends on some criteria and that node is known as cluster head (CH) . It collects the data from various nodes of the cluster and sends it to the BS. However, sensor network still suffers from extensive constraints such as limited memory, complex computing ability, inadequate energy, random deployment, and erratic environment. Wireless sensor nodes are placed randomly for monitoring of hazardous or suspicious locations, in those locations where replacement of power source (battery) is not possible easily. Hence, it is mandatory to develop an energy- efficient algorithm to minimise energy consumption.

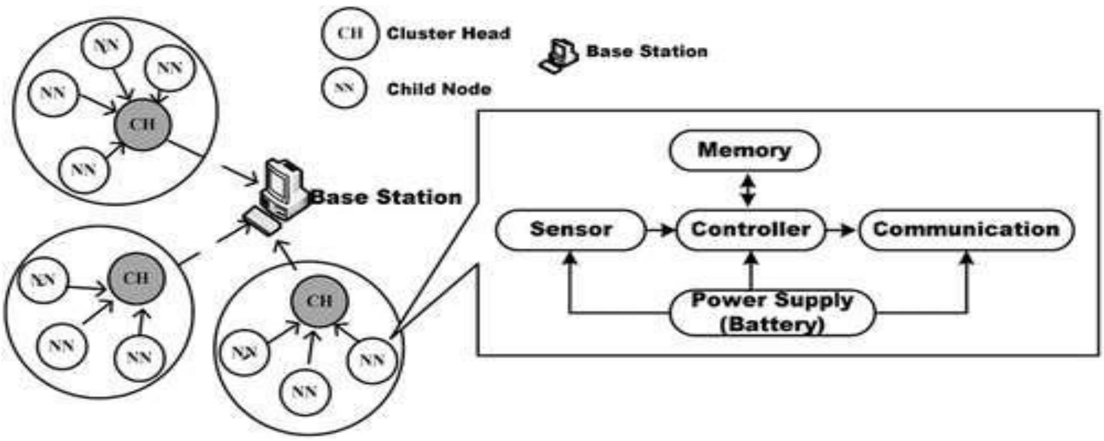

Fig (2) WSN Architecture

Characteristics of Wireless Sensor Network

Some basic characteristics of Wireless Sensor Networks are as follows:

Power consumption constraints for nodes using energy harvesting or mainly batteries are used.

Having the ability to deal with node failures (resilience)

Having some mobility of nodes (for highly mobile nodes see Mobile Wireless Sensor Networks)

Scalability to the large scale of deployment, Ability to resist harsh environmental conditions

Heterogeneity of nodes, Homogeneity of nodes, Easy to use, Cross-layer optimization

Issues in Wireless Sensor Networks

Various issues are occurring in wireless sensor networks WSNs such as design issues, topology issues, and other issues.
The complications in design in different types of wireless sensor networks include:
Low latency, Transmission Media, Fault, Coverage Problems, Scalability,
The complications in the topology of wireless sensor networks include the following.
Sensor Holes Coverage Topology Geographic Routing

The big issues of a wireless sensor network WSNs include the following. These issues mainly affect the design and performance of wireless sensor networks. Operating System & Hardware for WSN, Schemes for Medium Access, Deployment, Middleware, Characteristics of Wireless Radio Communication, Architecture, Calibration, Database Centric and Querying, Network Layer, localization, Sensor Networks Programming Models, Synchronization, Transport Layer, Data Dissemination & Data Aggregation

The Advantages of wireless sensor networks:

Flexibility and Mobility: WSNs are highly flexible and can be deployed in a wide range of environments. They are also mobile and can be easily moved from one location to another as required.

Low Cost: WSNs are often more cost-effective than traditional wired networks. They require less cabling, no complex wiring infrastructure, and can be easily scaled up or down as required.

Energy Efficiency: Sensor nodes in WSNs are designed to be energy-efficient, which allows them to operate for extended periods of time on a single battery charge. This is particularly important in applications where nodes are deployed in remote or hard-to-reach locations.

Scalability: WSNs can be easily scaled up or down to meet the needs of the application. Additional nodes can be added as required to increase coverage and improve network performance.

Real-Time Monitoring: WSNs allow for real-time monitoring of the physical environment, such as temperature, humidity, and pressure. This information can be used to make informed decisions and improve operational efficiency.

Easy Installation: WSNs are easy to install and maintain, with minimal configuration required. This makes them an ideal solution for applications where quick deployment is required.

It is suitable for non-reachable places like over the sea, mountains, rural areas, or deep forests. It avoids lots of wiring. It might accommodate new devices at any time. It can also be accessed by using a centralized monitor. Flexible if there's a random situation when the additional workstation is required. Implementation pricing is affordable. It's flexible to undergo physical partitions.

The disadvantages of Wireless sensor networks:

Limited Range: The range of communication between nodes in a WSN is limited due to the low power of the nodes. This means that multiple nodes may be required to ensure that data can be transmitted across the entire network.

Interference: WSNs operate in a shared frequency band, which can lead to interference from other wireless devices. This interference can result in data loss or delays in transmission, leading to reduced network performance.

Security: WSNs are susceptible to security threats, including eavesdropping, tampering, and data interception. The use of encryption and other security measures can help to mitigate these risks, but they can also add complexity to the network.

Scalability: While WSNs are scalable, adding more nodes to the network can increase congestion and reduce network performance. This means that careful planning is required to ensure that the network can accommodate additional nodes without impacting performance.

Limited Processing Power: Sensor nodes in WSNs typically have limited processing power, which can limit the types of applications that can be run on the network. This can be addressed by using more powerful nodes or by offloading processing tasks to other devices in the network.

Battery Life: Sensor nodes in WSNs are typically powered by batteries, which have a limited lifespan. This means that batteries will need to be replaced periodically, which can be difficult in applications where nodes are deployed in remote or hard-to-reach locations.

Overall, WSNs have several limitations that need to be taken into consideration when designing and deploying a network. These limitations can be addressed through careful planning, the use of appropriate hardware and software, and the implementation of effective security measures.

III Applications of wireless sensor network

Wireless sensor networks have gained considerable popularity due to their flexibility in solving problems in different application domains and have the potential to change our lives in many different ways. WSNs have been successfully applied in various application domains such as:

Military applications: Wireless sensor networks be likely an integral part of military command, control, communications, computing, intelligence, battlefield surveillance, reconnaissance and targeting systems.
Area monitoring: In area monitoring, the sensor nodes are deployed over a region where some phenomenon is to be monitored. When the sensors detect the event being monitored (heat, pressure etc), the event is reported to one of the base stations, which then takes appropriate action.
Transportation: Real-time traffic information is being collected by WSNs to later feed transportation models and alert drivers of congestion and traffic problems.
Health applications: Some of the health applications for sensor networks are supporting interfaces for the disabled, integrated patient monitoring, diagnostics, and drug administration in hospitals, tele-monitoring of human physiological data, and tracking & monitoring doctors or patients inside a hospital.
Environmental sensing: The term Environmental Sensor Networks has developed to cover many applications of WSNs to earth science research. This includes sensing, oceans, glaciers, forests etc. Some other major areas are listed below: Air pollution monitoring, Forest fires detection, Greenhouse monitoring, Landslide detection
Structural monitoring: Wireless sensors can be utilized to monitor the movement within buildings and infrastructure such as bridges, flyovers, embankments, tunnels etc enabling Engineering practices to monitor assets remotely with out the need for costly site visits.
Industrial monitoring: Wireless sensor networks have been developed for machinery condition-based maintenance (CBM) as they offer significant cost savings and enable new functionalities. In wired systems, the installation of enough sensors is often limited by the cost of wiring.
Agricultural sector: using a wireless network frees the farmer from the maintenance of wiring in a difficult environment. Irrigation automation enables more efficient water use and reduces waste.

Emergency Alerting: Proactive monitoring of the causes of natural disasters, can help to avoid these disasters or/and heir cost. WSNs can be utilized for monitoring common disastrous causes in real time to provide proactive alerts in order to lower damage or even prevent disaster. Typical examples described in the rest of this subsection, are related to the monitoring of seismic activity, volcanic activity, forest fires, and tsunamis.

Seismic Activity Monitoring: Earthquakes can cause enormous damage to an occupied region where they take place. WSNs can be utilized to monitor seismic activity in real time in order to take precautionary measures and enable the authorities to act in advance. A real time seismic activity monitoring system is presented. In [24], the authors designed a warning system for earthquakes in order to increase the time before an earthquake so as to take precaution measures. The authors deployed a WSN in the island of Mauritius, which has high seismic activity. The system monitors seismic activity by utilizing primary waves (P-waves) and estimates local velocity and the hypocentre's location according to time delays in the arrival of the P-waves at the sensors.

Volcanic Activity Monitoring: Volcanoes can cause enormous damage to nearby towns or cities when they are tivated. Before a volcano erupts, there are many signs that a WSN system can measure, proactively, in order to inform nearby citizens about the eruption. When such a system is applied, citizens can protect their families and belongings by transporting them outside of the area of the eruption, preventing further damage. Below is an example of such a system. In [25], a WSN based system to monitor volcanic activity components is proposed. The system is low cost, flexible, and easy to deploy and to maintain for remote locations. The users of the system can choose GPS data synchronization when the sensor nodes have signal reception, or a specific algorithm when they have not, to collect accurate timestamps of each sample. Pieces of the equipment used,

Logistics Management: The domain of logistics is an area of interest where WSNs can be applied, because many logistics systems need real time monitoring of various environmental parameters and better handling of packages. These requirements can be fulfilled by combining the logistics systems with WSNs. The transport logistics sector requires low cost and high-quality during deliveries. The deployment of a WSN based system for monitoring transportation conditions, such as temperature and humidity, within a cargo container travelling via both a trans-Atlantic cargo vessel and a lorry is described. It is shown that the use of a system of this kind, can increase quality better supervision and lower the cost by reducing losses during transportation environmental conditions. According to the authors this system, by the aforementioned parameters, can be used to prevent diseases, determine environment pollution, and inform on food safety issues.

Industrial Applications: WSNs can be applied in various industrial applications to solve many related problems., the main subcategories of industrial applications of WSNs namely logistics, robotics, and machinery health monitoring are illustrated. These specific categories of applications are studied in the rest of this subsection. The subcategories of the industrial applications of WSNs and the types of the sensors used in them.

IV Survey on different Wireless Sensor Network Routing protocols

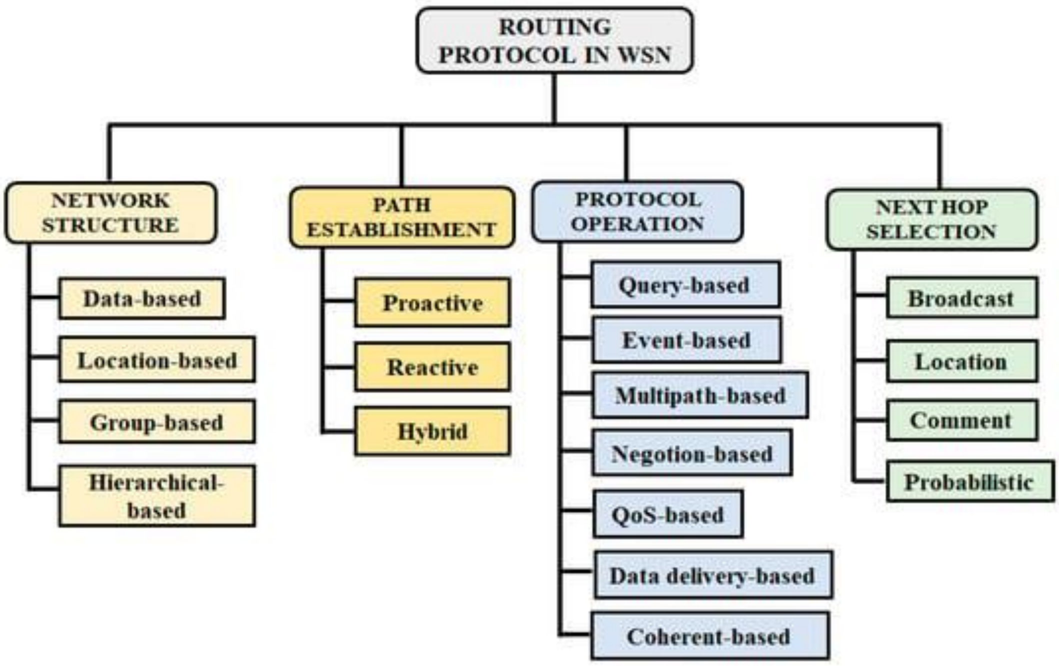

Fig (2) Different Routing protocols in WSN Architecture

Different Wireless Sensor Network Routing protocols in use

Protocols	Abbreviations
Improved LEACH Protocol	I-LEACH
Intra-Balanced LEACH Protocol	IB-LEACH
Energy Consumption and Lifetime analysis in Clustered Multi-hop Protocol	ECLCM
Energy-Efficient Cluster-Based Data Aggregation Protocol	ECBDA
Density Control Energy Balanced Clustering Protocol	DCEBC
Fault-Tolerant Energy-Efficient Distributed Protocol	**FEED**
Location-Based Clustering Protocol	LBC
Node Degree Based Clustering Protocol	NDBC
Voting-On-Grid Protocol	VoGC
Battery Aware Reliable Clustering Protocol	BARC
Energy and Distance-Based Clustering Protocol	EDBC
Distributed Clustering Algorithms with Load Balancing Protocol	DCLB
Energy Efficient Clustering Scheme with Self-organized ID Assignment Protocol	EECSIA
Virtual Area Partition Protocol	VAP-E
Unequal Multiple Hops Clustering Protocol	UMCA
Distributed Multi-competitive Clustering Approach Protocol	DMCC
Distributed Load Balancing Unequal Clustering Protocol	DUCF
Mutual Exclusive Distributive Clustering Protocol	MEDC
Two-Step Uniform Clustering Algorithm Protocol	TSUC
Hierarchical State Routing Protocol	HSR
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I-LEACH Protocol: In [9], the proposed IB-LEACH is an enhancement of LEACH where a randomize function is used to uniformly distribute workload among sensor nodes. This protocol is a self-healing and adaptive clustering technique that is designed for a heterogeneous environment. In this protocol, a special type of high energy node called a normal node/cluster head/gateway is used to take the responsibility of CH and perform all the CH's function.

IB-LEACH Protocol: In [10], an extension of LEACH named IB-LEACH was proposed. Unlike LEACH, the IB-LEACH adopts three rounds for the transmission process. The rounds are set-up phase, pre-steady and steady phase. The additional pre-steady phase calculates the workload of one frame and chooses such CM who can work as CH.

ECLCM Protocol: According to [11], the authors assigned each SN of WSN with a prior-probability function as criteria to be a CH. The theme of ECLCM is to reduce energy consumption in the multi-hop communication process. The initial assignment of CH probability enables each SN to advertise its eligibility for CH to the neighbour SN. In a particular time, span, each SN receives many advertises regarding CH but, the one with less hop-count with BS is elected as CH.

ECBDA Protocol: In [12], the creators proposed a proficient information collection algorithm to improve the soundness and lifetime of WSN. The center methodology of ECBDA is to partition the entire sensor arrange into a limited number of bunches. At that point, from each bunch, the SN with the most elevated leftover vitality has been chosen as CH. Further, for information transmission, it utilizes Time-division different access (TDMA) time planning for every SN to send their gathered information to CHS. CH total that information by evacuating repetitive data and sent to the BS.

DCEBC Protocol: In [13], the CH election process primarily focuses on enhancing the life span of heterogeneous WSN. Here, the CH election based on two factors such as; probability threshold and current residual energy. This protocol aims to enhance the network lifetime by reducing energy consumption.

FEED Protocol: In [14], the maker proposed an imperativeness beneficial clustering system, which picks reasonable CHs by contemplating extra essentialness, density, arranging, and the partition between canter points. The makers have sent an administrator center for each CH which goes about as a substitute center if there ought to be an event of CH falls dead. This property causes an augmentation in structure lifetime what's more desires the system to be inadequacy indulgent. It requires the general circumstance of sensor centers and message correspondence for CH affirmation, which is an expensive and imperativeness consumable strategy.

LBC Protocol: In [15], the creators have been proposed as a calculation to improve the lifetime of the sensor arrange. The clusters are encircled only once during the lifetime of the sensor arrange. CHS going to depend upon the rest of the vitality of CHs. The turn repeat timing of CH relies upon the vitality utilization of SNs for various assignments performed by the CH in the lifetime of the sensor arrange. This guarantees that balanced vitality usage by all SNs present in a bunch brings a deferred framework lifetime. The proposed show is static;the CH decision strategy isn't well as far as vitality usage. Burden adjusting has unevenly flowed, so all these lead to a poor relentlessness period.

NDBC Protocol: The proposed NDBC in [16], has been intended to improve the lifetime of heterogeneous WSNs. In this paper, the makers have been utilized two sorts of SNs, for instance, advanced and move centres. Advance canters are having more essentialness than hand-off canter points. The moved canters are picked as CH dependent on its imperativeness and canter degree in the framework. NDBC helped with decreasing the correspondence cost among SNs utilized for transmitting and enduring the messages for CH affirmation.

VoGC Protocol: In [17], the creators have been used the systems for casting a ballot and clustering to convey an energy gainful and secure limitation of the SNs as opposed to using a conventional grouping procedure. The reason for the VoGC technique is to reduce computational costs.

BARC Protocol: BARC in [18], incorporates with additional factor to utilize the energy efficiently. It rotates the CH to achieve the battery recovery scheme also it introduces a trust factor to gauge the reliability of CHs. The core difference between BARC and other existing protocols is the adoption of Z-MAC protocol which helps to enhance the network lifetime with any rigid constraint like other algorithms.

E-DEEC Protocol: It has been implemented on three types of the node to increase the heterogeneity and network lifetime. It is an advanced version of the E-DEEC protocol. The three types of nodes are advanced-nodes, relay- nodes, and super-nodes. Here, three different probability function has been defined for these three types of nodes.
So, according to the average energy of the network, the most suitable CH can be selected by using any one of the three probability functions [19].

ELE Protocol: In [20], a probabilistic approach had been discussed. Here, the probability has been calculated based on the ratio between residual energy of each SN and the reaming residual energy of the sensor network. The primary difference in ELE is the data transmission process which uses a 2-level hierarchy, unlike other clustering protocols.

PRODUCE Protocol: In [21], the authors have been proposed a randomized and distributed clustering protocol which consists of unequal clusters. Here, the distance between CH and BS has been considered which brings two possibilities of communication such as; inter-cluster or intra-cluster. If the distance between CH and BS is less, then the CH can participate in the inter-cluster communication and if the distance is more, then probably the CH will participate in intra-cluster communication. This mechanism helps to avoid signal attenuation and more energy.

CONCLUSION: WSN is a low-cost wireless network that can be rapidly deployed even in hard-to-reach places, such as underwater and underground environment. To understand the mechanism of this network, we presented the structure of the sensor node that is essential in the construction of WSN and its working and communication protocols. Furthermore, this paper reviewed the application of WSN in different domains using realistic examples that highlighted its importance. WSNs helps in transmission of information from sender nodes to the receiver nodes and for that purpose some routing mechanism should be available so that the data should be transmitted effectively without any loss.

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