# Wireless Sensor Networks: Coverage, Issues/Challenges and Applications

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***Abstract*- In recent years wireless networks has emerged as a field with variety of applications that are being developed where socio-economical industrial use of such applications is a major objective. Wireless sensor network is a type of network consisting of spatial devices that are capable of operating without human control in a network. Wireless sensor network functions by collecting information from the devices and process the same information to the network server. This paper presents a comprehensive study of wireless sensor networks, coverage of WSN, challenges and issues faced in WSN and its applications. Considering the large area of future prospects this study will present the wide scope in the field of wireless sensor networks.**

***Index Terms* – Wireless Sensor Networks (WSNs), Coverage, Region of Interest (ROI), Point of Interest (POI)**

## I. INTRODUCTION

Wireless technology has become prevalent in our day-to-day communication activities. The data communication that does not need any wired connection between the sending and receiving end is known as wireless communication. Mobility, flexibility and accessibility are the main attributes of wireless communication. Wireless communication uses electromagnetic waves for transmitting and receiving the data. It does not require a transmission medium to travel from one point to another and can communicate in vacuum.

Wireless sensor networks has become a widely accepted technology in past few years because of its far-ranging variety of technological advances in various fields such as structural health monitoring, industrial and civil applications, railways, disaster relief operations, early warning and detection, biodiversity mapping, agricultural, medicinal and healthcare services, etc. to name a few. For all these applications different types of sensors are required such as Temperature Sensor, IR Sensor (Infrared Sensor), Pressure Sensor, Light Sensor, Ultrasonic Sensor, Touch Sensor, Color Sensor, Humidity Sensor, Tilt Sensor, Flow and Level Sensor, Proximity Sensor, Accelerometer, Smoke, Gas and Alcohol Sensor, etc. depending upon the type of application and usage. A sensor is the simplest form of wireless tool that analyze and measure different attributes of the surrounding area where they are fixed or deployed and sends the collected information to the base station. These sensors are deployed within a network field to cover the region of interest [1]. Sensors collect the information while monitoring the region in which they are deployed and senses the environment around them, communicates with other sensors and computes the data to the sink node [2].

There are a number of challenges that arise in WSN such as localization, power consumption, limited storage, deployment, reliability, interference, node failure, transmission delay, mobility that we will discuss in other section.

## II. COVERAGE

In WSN coverage is the region of interest to which a sensor node can actively communicate. There are two types of ranges that a sensor node has i.e., a sensing range and a communication range. Sensing range is up to the region a sensor node is capable of monitoring the environment while the communication range is the region to which the sensor node can communicate with other sensor nodes in a network.

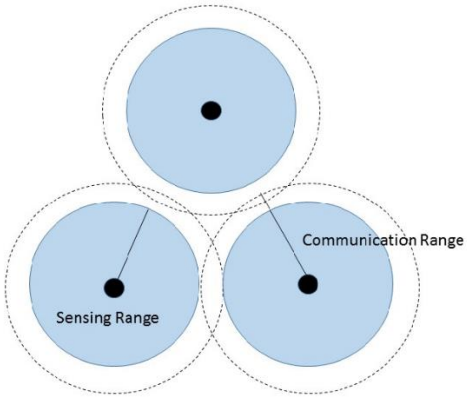
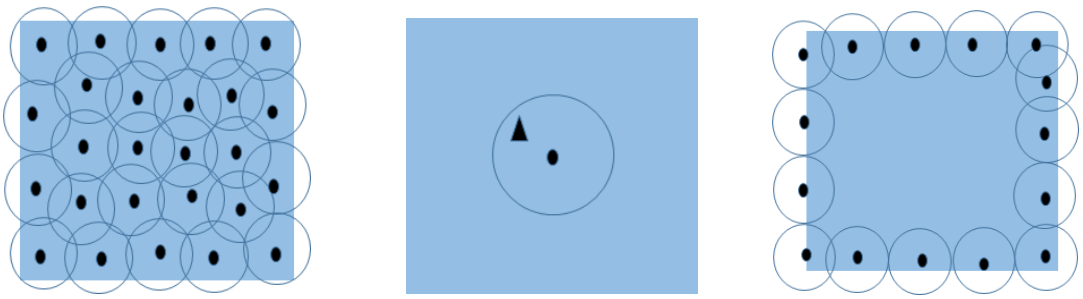



FIGURE 1. **Coverage of sensor nodes**

Coverage is one of the important issue in WSN as it affects the energy consumption and the lifetime of the sensor node. Coverage is practically related to the efficiency of the sensor node. In order for a sensor to communicate with other sensor node, the distance between them should be less than the communication range of both the sensors [3]. Common coverage problems can be categorized into continuous coverage [1] and sweep coverage when monitoring the frequency of the node. Continuous coverage is the coverage of region where the network field is required to be monitored continuously and the sensor nodes acquire the data while in sweep coverage area is not monitored continuously or all the time. The sensor nodes in sweep coverage collects the data in a network field at a time and sends it to the processing unit that functions to manage the collected data. It may use static stationed sensor nodes or the mobile sensor nodes for covering the POIs.
While monitoring the region continuously by sensors, coverage can be categorized as area coverage, point coverage and barrier coverage.

Table 1. **Types of coverage with description**

| Type | Description |
|---|---|
| Area Coverage | Concerned with covering the area (full or partial area) according to the requirement |
| Point Coverage | Concerned with the specific point or target which is called point of interest (POI) |
| Barrier Coverage | Concerned with covering the border of specific area |



(a) (b) (c)

FIGURE 2. **Categories of coverage: (a) Area coverage, (b) Point coverage, (c) Barrier coverage**

## III. ISSUES AND CHALLENGES IN WSN

There are various challenges that comes in the way of deployment and effective working of the sensor nodes.

**1. Deployment**

Deploying a sensor node is the first major issue that arises in the WSN. The sensor nodes should be deployed in such a way that they cover the entire target area in network field which could be indoor (structure/building) or outdoor (environment). The design of the nodes must be apt according to the environment. Deployment is based on three factors i.e., coverage, connectivity and power consumption. Coverage is further classified into classical deployment technique, metaheuristic and self-scheduling technique.

**2. Localization**

Localization is important to find out the current location of sensor nodes for better network management and monitoring. It also enhances the security of the sensor nodes. A WSN may consists of many sensor nodes and installing and enabling GPS hardware on each sensor node is not economical. Also configuring the location reference of sensor nodes manually is not possible when the network is dense [4]. Therefore, localization must be carried out by using the senor nodes only which may affect their other performance.

**3. Fault tolerance**

A WSN must not be affected and remains fully functional and adapt the changes in connectivity in case of any fault occurrence in any sensor node. There can be three approaches of fault diagnosis in WSN i.e., centralized, distributed and hybrid [5]. In centralized approach one sensor node has the responsibility of taking care of the fault that occurs in rest of the sensor nodes attached with it. In distributed approach each sensor node can resolve its problem at certain level. And in hybrid approach the problem of one sensor node can be resolved by any other sensor node within a network. For these, an apt routing algorithm must be used according to the design and structure of WSN.

**4. Data storage and energy**

One of the biggest limitation in WSN is the storage of data. The storage capacity in WSN is usually low because of the increase in processing time of the sensors for better and fast communication. As the number of devices increase in the network, the energy consumption also gets alleviated, the data rate will also be influenced and the QoS will be degraded. Therefore, energy harvesting is a big challenge in WSN.

**5. Routing**

Routing in a network is important to communicate between the sensor nodes and base station. The main challenge of routing protocol is to manage and utilize the energy and bandwidth as many sensor nodes can generate same data which will create redundancy [6]. Therefore the routing protocol must acquire the useful data and save energy and use the bandwidth in an efficient way. When the data is routed, it is important to use such routing protocol which balances with transmission energy, bandwidth, storage, capacity and power consumption [7]. And most of the routing techniques do not offer such kind of balance to a wireless network.

**6. Power consumption**

Wireless sensor nodes are battery driven and are deployed in an area which is vulnerable and the conditions are hostile where humans cannot reach [8]. Therefore it becomes difficult to replace a sensor with a new battery. Hence the sensor nodes are supposed to function for a long time (months or years) without any human intervention on the same initial power source. Therefore, it is important to conserve power of a sensor node in order to maintain the Quality of Service (QoS). And the sensor nodes must be designed such that they can use the residual energy in some or the other way.

**7. Quality of Service (QoS)**

QoS is the combination or set of service requirements that are needed to transmit the data packets by working more effectively and efficiently within a network by sensors [9]. WSN has a wide variety of usage as real time socio-economic industrial applications, hence it is important to have a high standard of QoS in a network but it becomes difficult due to the constant change in network topology, unbalanced traffic in WSN, incompetent energy efficiency because of the delivery of the packets in required time, variance of number of nodes which may affect QoS [10].

**8. Physical attacks and security**

The wireless sensors are mostly deployed in an open area that is prone to bad weather or the surroundings that could affect them physically, therefore, the probability of getting them affected is much higher in comparison to the other devices that

are in much secure surroundings [10]. Moreover, the attackers may use them in an unauthorized way and manipulate the information that the sensors are collecting by breaching the network security [11]. They could also hinder the process of routing in sensor nodes and may affect the communication within the sensor nodes or between the nodes and the server.

### 9. Reliability

In WSN, the reliability of sensor node depend on various factors. While in communication, there must be no or minimal noise in the network and optimum signal strength must be released by the sensor in order to collect the data in the field and send it to network server. And the sensor must live up to its lifespan.

### 10.Scalability

It is important for a WSN to be scalable. The challenge here is to maintain the efficiency and QoS of the sensor nodes in order to yield better results whenever the network topology changes or there is any variance in the number of sensor nodes [5] [12].

## IV.APPLICATIONS

The evolution of WSN was primarily motivated by military surveillance during wartime. With time, WSN is being used in large scale commercial and industrial applications with wide variety of functionalities and due to its low cost, easy deployment, high sensing capabilities among several other benefits. The application domain of WSN is diverse due to the fact that it performs many tasks such as data logging, event detection, control, object classification and tracking. These tasks may or may not work altogether depending upon the surrounding environment. In data logging, sensor node measures the physical conditions such as temperature, pressure, humidity, sound, luminance or light etc. the sensor node measure it when any kind of change occur. A sensor can monitor and detect an event whenever it triggers such as if anything around it moves. A sensor node controls the events by itself if it is self-automated of by user command. Whenever an object moves in range of sensor node, it can determine the type of object whether it is a human, vehicle or an animal, trace the path, direction or speed. Based on the task and functionality of sensor node, the applications may be summarize as follows:

- **Military surveillance:** the main purpose of using WSN in military is that it reduces the physical presence of human in monitoring the area [13]. Earlier, the submarines were detected by sound surveillance system which comprised of acoustic sensors. Sensor nodes can detect chemical, biological and explosive vapor [14]. Sensors are deployed on land to possibly identify the certainty of enemy and their movement on terrestrial planes. Automatic Identification System (AIS) is used in military that comprise of Very High Frequency Transceiver (VHF), GPS and electronic navigation sensors to track marine vessels.
- **Health care:** Health of a living being is amongst the major concern these days and with the rapid population growth, environmental changes, natural and man-made disasters, frequent changes in lifestyle of people, and low immunity, the demand of technology increases so as to decrease the threats to a living being. The average lifetime of a person is approximately 70 years. We need technology that can ease the home healthcare facility for everyone. With the advent of WSN and its contribution in early detection and warning, it is now being used in healthcare system. WSN is used for monitoring the patient without intervening the natural life of the patient, and helps in connecting the doctor and patient wirelessly in less time and with more accurate way. WSN based healthcare system provides anyone's physical, cognitive and physiological condition. This system not only benefits the patient but also decreases the healthcare workforce and their time. To monitor the glucose level of a diabetic patient, a sweat based glucose monitoring system is proposed by the researchers from Korea. A smart bra for early detection of breast cancer is designed by a Mexican named Julian Rios with his friends. This smart bra uses around 200 bio sensors which monitor the temperature changes and measures the blood flow of the body with other parameters. Many other applications such as Living sensors on finger tips that glows when it detects certain chemicals on the body and its surroundings, Autism diagnostic and observation sensor that detects and monitor heart rate, physical movements, psychological changes of autistic patients, Autism Glass Project that monitor and recognize facial expressions of autistic patients made with the help of Artificial Intelligence which

is based on machine learning along with WSN, and Smart Garments that contains biosensors with WSN technology to monitor and extract vital signs for a human body and deliver it to the healthcare experts [15].

- **Industrial sector:** As WSN is more reliable to use and in demand due to the miniaturization of sensor nodes, wireless technology and efficiency of the network, and is now making its way to the industrial sector with manufacturing, machine health, remote sensing, inventory management, vehicle management, and condition based monitoring.
- **Area monitoring**: Area monitoring is done to extract information from the surrounding environment in which different type of sensors are deployed in Region of Interest (RoI) to gather up the data and sending it to the sink node. Different types of WSNs being used for the purpose are terrestrial, underwater, underground, multimedia, and mobile WSN [16].
- **Environment monitoring**: There are a variety of sensors used to sense and monitor environmental parameters such as temperature, pressure, light, noise, humidity, concentration of gases, etc. Application area of environmental monitoring includes agricultural monitoring, greenhouse monitoring, indoor monitoring, habitat monitoring, climate monitoring and forest fire detection and monitoring [17].
- **Disaster Management:** WSN is widely being used in early detection and warning for natural calamities. It helps in preparedness for a havoc caused by disasters whether natural or man-made. A variety of sensors are used for earthquake sensing, tsunami sensing, forest fire detection, flood and water level detection [18]. WSN is also integrated with various technologies such as Internet of Things (IoT) for early warning system.
- **Vehicle Detection:** It is a very common application of WSN where any type of vehicle can be detected and monitored with sensor technologies such as Inductive loop, magnetometer, microwave radar, active laser infrared radar, passive infrared, ultrasonic and acoustic sensors, video image processors [19].
- **Flare Stack Monitoring:** It is largely used in chemical and petrochemical industries to dump the excess waste and inflammable gases that could harm the environment. Infrared sensors with pressure transducer are mounted with a good distance to determine the levels and flow of such gases [14].
- **Landfill Ground Well Level Monitoring and Pump Counter:** This is one of the important application concerning to our environment. Underwater WSNs are used to monitor the water levels and extracts and monitor the leachate level accumulation and removal in the liquid for harmful substances. It uses submersible sensor nodes and pressure transmitter [20].

## V. CONCLUSION

Wireless sensor network is growing rapidly these days due to a number of applications in almost every field. Due to the sensor node's miniaturization, cost effectiveness and efficiency, they can be integrated with other technologies as well. This paper reviews coverage, issues and application of wireless sensor networks. There are many challenges while dealing with WSN. Power consumption and quality of service being the major challenges that may degrade the performance of the entire network. To make better applications, we need to consider these issues and try to improve the functioning of WSN.

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