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Types of Coverage in Wireless Sensor Network: A Survey

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***Abstract*—Coverage in Wireless Sensor Network (WSN) is the most important parameter and acts as the prime parameter in deciding the efficiency of the sensor network deployed. Nodes in a WSN are used for monitoring and controlling the region of interests in which they are deployed. The coverage thus depends on the communicating range of the sensor node. Therefore sensor nodes deployed in the form of a barrier will provide quality coverage by using fewer sensors when compared to full coverage. Covering every point in the region of interest will lead to redundant sensors and therefore increases the overall operating cost of the network. Barrier coverage, on the other hand, needs much fewer sensors without compromising the quality of service. This paper presents the detail about the WSN with its architecture and provide a review of different types of coverage used in WSN and its application briefly.**

***Index Terms*— coverage, sensor network, barrier coverage.**

I. INTRODUCTION

From the starting point of our modern era, Wireless Sensor Network (WSN) has become a very important part of mankind. There are so many applications based on WSN and day by day many new applications are also invented with the help of this system. The name Wireless Sensor Network suggests that the collection of nodes [1] presents in the network and the nodes are the sensor nodes that are used for sensing and controlling the environment surrounding them. Nodes are used to establish the connection between these communications. We know the sensors are used for sensing any change of environment and respond to an output. For example, a sensor might be able to sense temperature, pressure, different colors, sounds, any movement, and so on. Wireless Sensor Networks can be defined as a self-creating network with sensor nodes. Nowadays the popularity of sensor networks is increasing due to its boundless application of Wireless Sensor Network. In every sector, we can find the use of WSN such as in environmental management to controlling [5], in health care and medical sector, tracking, localization, monitoring, in the military field, for making a smart home, etc. Another important thing is the internet of things and wireless Sensor Network is involved so deeply that without any of them we can't able to make a smart home or smart city [6,7]. A typical architecture of WSN is given in figure 1.

Coverage in WSN, although is classified into many types, in this survey we classify coverage into five types viz.,

1. Strong Barrier Coverage [2]
2. Weak Barrier Coverage [2,3]
3. Local Barrier Coverage [4]
4. Global Barrier Coverage and [4]
5. Crossed Barreier Coverage. [3]

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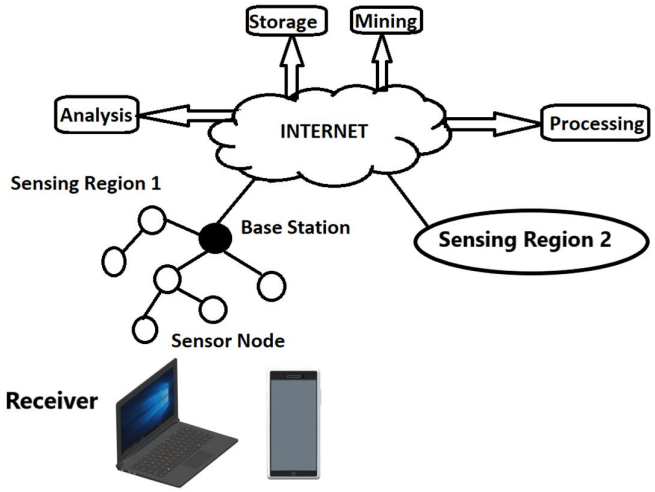

Figure 1. Components of a WSN

The rest of the paper is organized as follows, Section A gives the details of architectural components of a typical WSN, Section B describes in brief, the components of a sensor node. Section C highlights the different types of barrier coverage followed by a conclusion in section D

A. The basic architectural components of the WSN:

Figure 1 has shown the basic architecture of the WSN system, where we can see that in WSN, sensor nodes are taking the information from the environment then communicating with each other after that they send the information to the gateway and then through the internet, it is received by the users.
The basic architectural components of the WSN system are:

1. Sensor nodes
2. Gateway
3. Observer (user)

Sensor Node:
In Wireless Sensor Network the sensor node is one of the most important and main components which is small in size with low powered [8]. It has limited energy resources and is a low-cost device. Sensor nodes collect and transfer data with four components. These are-
1) Power and Power Management unit: In the base of the sensor node, the power source is present which supplies energy to different units of sensor nodes for sensing
2) Sensor unit (sensing): Sensor units are CPU and radio.
3) Microcontroller unit (computing): It is the brain of the sensor node which is composed of a microprocessor and a flash memory. It deals with the collected data and makes a decision.
4) Transceiver unit (communicating): Transceiver unit makes the communication wireless. As RF has 10s of meters indoors and 100s of meters outdoors operation frequencies of WSN so it is widely used for WSNs.

Gateway:
Gateway makes the system administrators for interfacing the nodes to Personal Digital Assistants (PDAs) and Personal Computer (PCs) [9,10]. It has three different stages, these are:
•.Active: It sends the data to the server actively.
• Passive: It sends the information to the sensor nodes to send the data.
• Hybrid: It is the combination of the active and passive gateway.

Observer (user) :
Observer received the data through the gateway server with the help of task managers like satellite links or the internet. The task manager has two sections, these are:
• Client Data Browsing/Processing
• Data Service

The task manager stores all the collected data and analyses here and then the user can collect that data locally or remotely.

B. The components of a sensor node:

The main components of sensor networks are the sensing device, processing device, transceiver unit, and power supply. The details of each are given below

1) Sensing Device: This device creates raw data by sensing events like temperature, sound, light, etc. then it sends all the data to the sink node after doing the calibration.

2) Processing Device: Mainly microcontroller works as a processing device. It collects the raw data from the sensing device and helped to make the decision based on the raw data.

3) Transceiver Device: Transceiver device transmit that collected data to the neighboring node. The power of this device determines the range of the sensing device. We know that battery consumption is directly proportional to transmission power so a high power communication range will affect the battery consumption.

4) Power Device: The power device has the most important role in the network. This gadget controls the detecting, handling, and handset gadgets [11]. The working lifetime of the whole organization relies upon the battery life of the power gadget [12,13]. Astute energy-saving methods can be applied to expand the general lifetime of the network.

Types of Coverage:

The coverage given by the Wireless Sensor Network is one the most generally acknowledged measurement for estimating the nature of administration given by the organization. To accomplish the most extreme inclusion, the key target of inclusion in WSN is to have pretty much every area of the actual space of interest under the detecting scope of in any event one sensor node [14]. The coverage given by the WSN decides how well the organization is checked by the sensor nodes. In WSN, the coverage has mainly two parts, one is full coverage and another is partial coverage. In full coverage, as shown in figure 2, every single place of the district ought to be covered which requires extra and repetitive sensor nodes whereas in halfway or partial inclusion excess are wiped out by covering just a part of the whole area [15].

In Barrier coverage, as displayed in figure 3, the way that sensors pointlessly cover the whole locale is exploited and many fewer sensors will be sent in the area. A bunch of virtual nodes, which can be named as the source and sink nodes, will be set at the left and right limits of the organization separately. In many works, barrier coverage is also defined as *k-barrier* coverage where the value of $k \geq 1$. Therefore in a barrier-covered WSN, there should exist at least one barrier from the source node to the sink node [16]. A barrier is formed by interconnecting the range of sensor nodes from left boundary to right boundary or vice-versa. A barrier can also exist from the top of the network to the bottom or vice-versa [17,18].

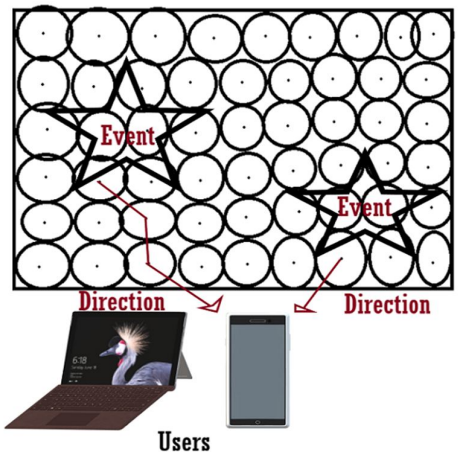

Figure 2. Full Coverage in WSN

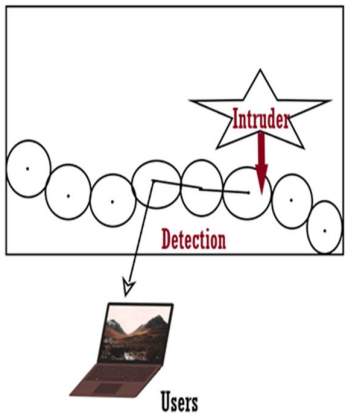

Figure 3 Barrier Coverage in WSN

C. Types of Barrier Coverage:

1) Weak Barrier Coverage: In this coverage, there is a coverage gap in the area given that the intrusion to be identified follows the course inverse to that of hindrance way. In this manner, week obstruction

inclusion recognizes occasions that occur or goes in a straight inverse to the direction of hindrance way as displayed in figure 3, this kind of barrier coverage isn't reasonable for interruption discovery as an interloper may have the insight of knowing the direction of obstruction way ahead of time. In this manner to keep away from being getting recognized will follow the way where an inclusion hole is present.

2) Strong Barrier Coverage: In strong barrier coverage, a network is one in which there exists at least one k-barrier way from one finish point to the opposite end of the network. Accordingly to this coverage, it can distinguish occasion which occurs or goes in the discretionary way independent of the direction of intrusion. Because of which the detriment of feeble hindrance inclusion is wiped out and in this manner, solid boundary inclusion is appropriate for interruption identification as displayed in figure 4.
3) Local Barrier Coverage: A Local Barrier Coverage gives N sensor nodes haphazardly sent over a rectangular locale to accomplish k-barrier coverage ($k \geq 1$), a barrier shaped at one side of the district neither can ensure that the organization is covered by the boundaries nor will have data of different coverages. Accordingly, this coverage is although gives a solid intrusion detection however has a drawback that the coverage data of the entire area isn't given.
4) Global Barrier Coverage: As the name suggests that a global barrier coverage provides all the information present in a network but it doesn't cover the whole network.
5) Crossed Barrier Coverage: A crossed barrier inclusion is given if and only if two barriers opposite to one another can be framed which will meet each other precisely in the center. Subsequently, if there exists a barrier from the left limit to the right limit of the network then one more barrier should exist from the top of the network to the base as displayed in figure 5.

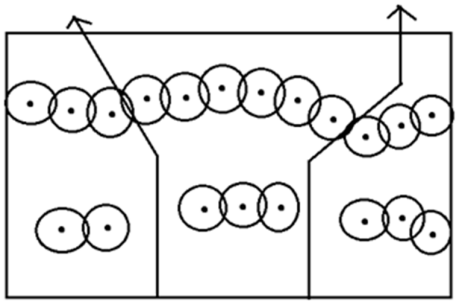

Figure 4 Strong Barrier Coverage

TABLE I. GIVEN BELOW SUMMARIZES THE TYPES OF BARRIER COVERAGE ALONG WITH THEIR APPLICATIONS

S.No	Reference	Type of barrier coverage	Applications	Probability of Detection/ Coverage
1	[2,3]	Weak Barrier Coverage	Intrusion detection	Very Less
2	[2]	Strong Barrier Coverage	Intrusion Detection, Event Detection, Information transfer from one end to another end of the network	Very High
3	[4]	Local Barrier Coverage	Point detection	High
4	[4]	Global Barrier Coverage	Full Coverage	High Coverage Probability
5	[3]	Crossed Barrier Coverage	Intrusion Detection from top to bottom and sideways	Very Less

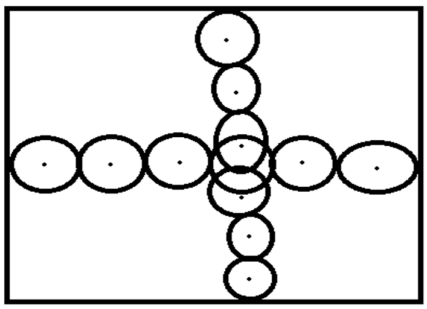

Figure 5 Crossed Barrier Coverage

II. Conclusion

In this paper, we have presented a comprehensive literature survey on types of barrier coverage and its applications. This paper also describes the architecture of a typical Wireless Sensor Network used for barrier coverage applications. This review will help researchers in finding the different types of barrier coverage in one place. It will also help in identifying the applications of different types of barrier coverage.

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