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Overview on Research Trends and Challenges in Wireless Sensor Network (WSN)

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***Abstract* – In computing, a network is a collection of two or more interconnected nodes or devices. Physical or wireless connections may be used to connect the devices or nodes in question. The important thing is that there are at least two distinct components that are linked together. A sensor network is a collection of sensors, each of which collects data from a distinct place and transmits it to a hub for archiving, viewing, and analysis. A network of tiny embedded devices known as sensors that interact wirelessly using an ad hoc configuration is known as a wireless sensor network (WSN). WSN classified as Static and Mobile WSN, Deterministic and Nondeterministic WSN, Single Base Station and Multi Base Station WSN, Static Base Station and Mobile Base Station WSN, Single-hop and Multi-hop WSN. WSN Application area includes Area monitoring, Health care monitoring, Habitat monitoring, Environmental/Earth sensing, Air quality monitoring, Forest fire detection, Landslide detection, Water quality monitoring, Natural disaster prevention, Industrial monitoring, Threat detection, Incident monitoring and Supply chain related management. WSNs measure environmental factors such as wind, humidity, temperature, sound, air, and other pollution levels. WSNs are made up of independent, spatially dispersed sensors that keep track of the physical and environmental variables. The capacity to follow systems or devices in real-time and remotely monitor and control them is made possible by wireless sensor networks. The central office must monitor and record the position and status of the equipment on the production floors in certain large companies. A detailed review of the wireless sensor network and its related future trends has also been addressed in this document.**

Keywords: Sensor Network, Wireless Sensor Network, Health Care Monitoring, Industrial Monitoring, Defense Monitoring,

I. INTRODUCTION

The creation of wireless sensor networks made up of components known as sensor nodes is now possible because to advancements in wireless communication. Low power, compact, and affordable sensor nodes are gadgets with sensing, wireless connection, and compute capabilities. The sensors organize themselves and link with one another as soon as they are placed in the network, which allows them to start collecting data and sending it to the base station.

The term "WSN" can also refer to a network of nodes, which are typically small and low-complexity devices that are able to sense their surroundings and transmit information gathered from the monitored area. The gathered data can be transmitted directly or through multiple hops to a sink, which can use it locally or connect to other networks (such as the internet) through gateway nodes.

1. Concepts of WSN

A WSN is made up of one or more sink nodes (also known as base stations) and geographically dispersed sensors. Sensors generate sensory data and continuously monitor physical factors including temperature, vibration, and motion. A sensor node may act as a data router and data originator simultaneously. On the other hand, a washbasin gathers information from sensors. For instance, in an application for event monitoring, sensors must transmit data to the sink(s) whenever they notice the occurrence of events of interest.

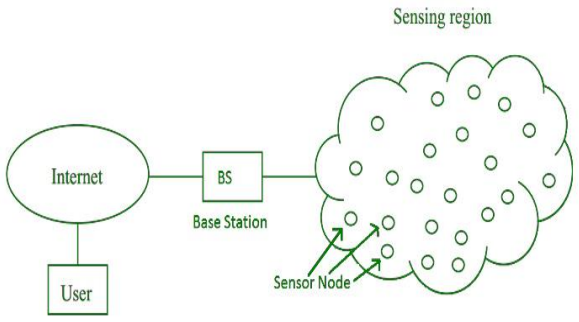

Figure.01. Architecture of WSN

Direct connections, the Internet, satellite, or any kind of wireless link are all possible methods for the washbasin and the end user to communicate. Figure One shows an example of WSN architecture. Keep in mind that there could be a number of sinks and end consumers.

2. Components of WSN

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- **Sensors**

In a WSN, sensors are utilized to both collect data and capture ambient variables. Electrical signals are created from sensor signals.

- **Radio Nodes**

It is used to take in and transmit data generated by the sensors to the WLAN access point. A microcontroller, transceiver, external memory, and power source make up this device.

- **WLAN Access Point**

It accepts information that is wirelessly transmitted by radio nodes, typically through the internet.

- **Evaluation Software**

In order to deliver the report to the users for further processing of the data that can be utilized for processing, analysis, storage, and mining of the data, the data received by the WLAN Access Point is analyzed by a programme called Evaluation Software.

3. Advantages of WSN

Compared to conventional cable-based monitoring systems, WSNs offer a number of benefits. WSNs are practical, economical, and trustworthy. A WSN is made up of geographically dispersed autonomous units that employ sensors to monitor factors such as sound, temperature, and other things in various applications. WSNs were initially created for military uses. WSNs are primarily employed today for non-military purposes like traffic control, health care, and condition monitoring.

Furthermore, car berth occupancy in parking garages can be detected using wireless sensor nodes. To determine whether a vehicle is present in the hardware node, magnetometers can be employed. Magnetometers and micro radars can also be used to track moving vehicles.

WSNs are made up of a lot of resources, particularly when low-cost sensor nodes are used to build a densely packed network using their built-in wireless communication modules. Sensor nodes can sense, analyze, and send various types of monitored data since they are each equipped with a variety of sensors, computing units, and storage devices. Video cameras and inductive loops placed along the highway can be used to gather data on motorway traffic. WSNs are affordable, dependable, precise, and simple to deploy.

Sensing accuracy, coverage area, fault tolerance, connectivity, low human intervention, operability in challenging situations, and dynamic sensor scheduling are some of the traits of WSNs.

4. Applications of WSN

Many various types of sensors, including seismic, low sample rate magnetic, thermal, visual, infrared, acoustic, and radar, may be included in wireless sensor networks. They can keep an eye on a wide range of environmental factors, such as temperature, humidity, vehicle movement, lightning conditions, pressure, soil composition, noise levels, the presence or absence of specific objects, mechanical stress levels on attached objects, and the current characteristics of an object, such as its speed, direction, and size.

The following categories can be used to categories WSN applications and also illustrated in the figure two:

- ***Military & Marine applications***

These networks can offer the military and the air force a variety of services, including data collection, battlefield observation, and attack detection. WSNs are crucial to military operations because of their real-time transmission abilities.

Water temperature, pressure, wind direction, wind speed, salinity, turbidity, pH, oxygen density, and chlorophyll levels are just a few of the physical and chemical characteristics that can be monitored and measured in a WSN-based marine environment monitoring system.

Figure.02. WSN Application Types

- ***Environmental applications***

By offering numerous crucial advantages like real-time data access, extensive coverage, long-term monitoring, and system scalability, wireless sensor networks (WSNs) enable creative and appealing solutions as well as pervasive environmental monitoring.

- ***Healthcare applications***

A WSN, also known as a wireless sensor network or WSAN, consists of wrapped sensors that monitor constant conditions or physical phenomena like weight, sound, and temperature and push their measurements over the network to a focal point. For sensor control, most current networks are bidirectional.

- ***Home applications***

A Wireless Sensor Network (WSN) is a collection of decentralized, self-contained security systems for homes, buildings, etc. that employ sensors to keep tabs on what's going on in the neighborhood. The onboard CPUs and sensors are integrated with the sensor nodes used in WSN systems.

5. Trends and Challenges in WSN

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Using aggressive energy management techniques, one of the key design objectives of WSNs is to carry out data transfer while attempting to extend the network's lifespan and prevent connectivity degradation.WSN topology control is impacted by a variety of difficult aspects. Before WSNs can achieve effective communication, several obstacles must be removed.

The following provides a summary of some of the difficulties and design considerations that affect the creation and maintenance of topologies in WSNs. The QoS related issues are illustrated in figure three.

- **Node deployment**

Application-specific node deployment in WSNs influences the effectiveness of topology control techniques. Both deterministic and random deployment strategies are possible. Deterministic deployment involves manually placing the sensors and routing the data along pre-established channels.

Nevertheless, with random node deployment, the sensor nodes are dispersed at random and an ad hoc architecture is created.

- **Energy consumption without losing accuracy**

The little energy that sensor nodes have can be depleted by computations and data transmission in a wireless setting. Therefore, energy-efficient communication and computation methods are crucial. The battery lifetime exhibits a significant reliance on the sensor node lifetime.

- **Data Reporting Model:**

The application and the degree of time criticality of the data reporting determine the data sensing and reporting in WSNs. There are four different types of data reporting: time-driven (continuous), event-driven, query-driven, and hybrid. Applications that call for routine data monitoring can benefit from the time-driven delivery approach. In order to perceive the surroundings and send the relevant data at regular intervals, sensor nodes will regularly turn on their sensors and transmitters.

- **Node/Link Heterogeneity**

Many studies made the assumption that every sensor node was homogeneous, i.e., had a same capacity for computing, communication, and power. However, a sensor node may have a distinct function or role depending on the application.

- **Fault Tolerance**

Lack of electricity, physical harm, or interference from the environment can cause some sensor nodes to malfunction or get blocked. The main goal of the sensor network shouldn't be impacted by sensor node failure. The development of new links and routes to the data collection base stations must be accommodated by MAC and topology control algorithms if several nodes fail.

- **Scalability**

There may be hundreds, thousands, or even more sensor nodes planted throughout the sensing region. With this enormous quantity of sensor nodes, any topology control strategy must be able to function. Algorithms for controlling sensor network routing should also be scalable enough to react to environmental occurrences. The majority of the sensors can stay in a condition of slumber until an event happens, with the data from the few remaining sensors having a coarse quality.

- **Reliability**

WSNs are frequently employed in crucial applications, such as managing industrial operations or monitoring the environment. A significant difficulty is ensuring that the network is dependable and capable of operating well under all circumstances.

- **Interference**

WSNs are frequently installed in settings with a lot of wireless device interference. Due to this, ensuring trustworthy communication between sensor nodes may be challenging.

- **Security**

In some applications, the nodes' communication must be sufficiently secured to maintain confidentiality. When dealing with military applications like battlefield monitoring, military operations, etc., it is mostly necessary.

Figure.03. QoS Related Issues

With regard to many applications, including climate change, environmental monitoring, traffic monitoring, and home automation, the popularity of WSN has been enormously on the rise. As a result, maintaining the WSN has always been difficult. Through the use of symmetric key, asymmetric key, and hash functions, cryptography offers security.

A lightweight cryptographic technique is needed because WSN have severe processing, communication, and battery power limitations. In a wireless sensor network (WSN), choosing a cryptographic method is crucial due to sensor node limitations. Three areas can be used to describe cryptography in WSN: hash, symmetric, and asymmetric functions

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Conclusion

WSNs have been heavily utilized in many facets of human life. Any sensor node can communicate and react to the many attributes thanks to the sensing technology. This article provides an overview of several WSN-related topics. The WSN has been briefly introduced, and the special issues have been covered. Applications and security concerns in WSN have both been identified. The research conducted for this paper leads to the conclusion that WSN has revolutionized practically every industry in the modern period. It offers tremendous potential for investigation into many facets of human life.

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