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# Wireless Sensor Networks - Technologies, Protocols, Applications and Simulators: A Survey

***Priyanka.P[1], Ayyappan.B[2]**
[1]Student, [2]Assistant Professor, Department of Information Technology, Jeppiaar Engineering College, Chennai.
***Corresponding author: Email: priyankapons173@gmail.com**

## ABSTRACT

Wireless Sensor Networks (WSNs) have emerged as a new research technology in the computer environment's is a multidisciplinary area of research which has generated a lot of interest from both industrial and research perspectives .It has a great potential for long term applications. Wireless sensor network (WSN) consists of widely scattered sensors to monitor physical or environmental conditions. It can also be deployed in extreme environmental conditions and may be prone to enemy attacks. Wireless sensor networks mainly use broadcast communication consisting of protocols and algorithms with self-organizing capabilities. In this paper, a survey is made on wireless sensor network research, technologies, routing protocols, simulators and applications.

**Keywords:**technology,zigbee,protocol,leach,traffic monitoring,military ,simulators.

## INTRODUCTION

Wireless Sensor networks have recently become a premier research topic having the ability to transform human lives in various aspects. A smart WSN is composed of thousands of sensing nodes deployed in a large area and one or few base stations connect a sensor network to the users through the Internet or other networks. Each sensor node consists of a CPU for processing the data, memory, a RF transceiver and a power source like batteries or solar cells. These nodes sense, process and transmit information to the base stations.

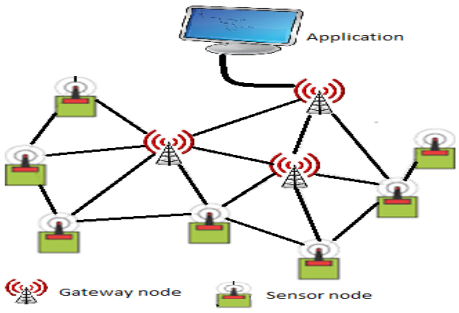


**Fig.1.Block diagram of Wireless Sensor Network**

## CHARECTERISTICS

**Sensing Accuracy:** The use of a large number of sensor nodes provides potential for greater accuracy in the information gathered as compared to that obtained from a single sensor.

**Area Coverage:** This implies that fast and efficient sensor network could span a greater geographical area without adverse impact on the overall network cost.

**Connectivity:** Many sensor networks may be connected through base stations along with internet. The clustering of networks enables each individual network to focus on specific areas or events and share only relevant information.

**Fault Tolerance:** Redundancy of device and information contribute to a good level of fault tolerance in individual sensors.

**Technologies:** In recent years research interest is growing from both industry and academia to explore the different practical applications using the emerging technologies. There are several advantages and disadvantages of state-of-the-art. The various technologies include WiFi, Bluetooth, UWB, zigbee etc.

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**Bluetooth:** The Bluetooth technology is a short-range wireless connectivity solution for electronic devices. It is known for its portability. With extensive applications of Bluetooth for wireless data communication in hand-held devices and wireless computing it is used for local positioning. Similar to Wi-Fi, Bluetooth can provide accuracies even for a longer distance based on the popular RSSI methodology. Nodes are organized in piconets. The architecture includes a master node and seven active slaves. Bluetooth technology provides the effect of full duplex transmission through the use of a time-division duplex (TDD) scheme.

**WiFi:** Wi-Fi alliance is a specification for IEEE 802.11 WLAN standards. It uses radio waves to provide wireless high-speed Internet and network connections. It provides wired LAN extension in market such as home, enterprises, institutions and many more areas some of the advantages of Wi-Fi is that it is economical covering a wide area with easy availability, stability and robustness.

**ZIGBEE:** ZigBee is an IEEE 802.15.4 technological standard created for sensor networks. It is a low-cost and low power mesh based network. Some of the important features of ZigBee are low data rate, extremely low power consumption, low complexity; and high reliability and security. ZigBee is a published specification set of high level communication protocols. Employs 64-bit IEEE & 16-bit short address. Three device types specified Network Coordinator, Full Function Device (FFD) and Reduced Function Device (RFD).

**Routing protocols:** Routing in wireless sensor networks differs from conventional routing in fixed networks in various ways. The conventional routing algorithms lacked infrastructure, they were unreliable causing the sensor nodes to fail.. Many routing algorithms were developed for wireless network in general. The commonly used protocols are

**Leach:** Low Energy Active Clustering Hierarchy (LEACH) is a clustering-based energy efficient Routing protocol. The energy consumption of nodes can be minimized by distributing the energy load uniformly to all the homogeneous and energy constrained nodes in the sensor network. LEACH operates in two different phases - the setup phase and the steady phase. In the setup phase, few Sensor nodes are randomly chosen as cluster heads and all other nodes will be advertised about these cluster heads. Based on the signal strength of the sensor nodes and the advertise message received, the nodes will themselves find Out the cluster to which they belong. In the steady phase of the LEACH, the sensor nodes are made to sense, acquire and transmit information to the cluster heads.

All these data from various sensor nodes will be aggregated and then sent to the base station. Once the Data is sent the setup phase will start to choose another set of cluster heads and so on. Though LEACH provides many good features it has some drawbacks. Some of them are Hot spot problem – wherein the nodes may drain out their batteries very soon while transmitting the data from a hotspot region to the base station and the Protocol may not be suitable for Real-time applications.

**Spin:** Sensor Protocols for Information via Negotiation is a set of protocols designed to overcome the drawbacks of flooding like the transmission of redundant data, overlapping of the sensing regions etc., by using two main features - Negotiation and adapting of resources. In Negotiation, the sensor nodes negotiate with each Other before transmitting data to overcome implosion and overlap of the classic flooding. The nodes send only the useful information instead of sending the complete data. The observed data will be described using meta-data or high level descriptors. In resource adaptation, each node will have a resource manager to update the resources. All the applications communicate with the resource manager before Transmitting and processing data. Also when the energy reduces, the sensors also reduce certain activities for energy conservation.

**Teen:** Threshold sensitive Energy Efficient Sensor Network protocol: TEEN is a cluster-based hierarchical routing protocol based on the concept of LEACH. This protocol monitors the sudden changes of sensing attributes. The two factors monitor the changes are– Hard and Soft threshold. The threshold value of the sensing attribute which when exceeded triggers the node to transmit that value is the hard threshold (HT) and the small change in the threshold value of the sensing attribute which triggers the sensing node to report the sensed

Applications:

There are various applications of Wireless Sensor Networks in the real time. Some of the applications are Traffic monitoring, smart parking, fire Detection and Agriculture.

**Military Surveillance:** Sensor Networks were initially implemented mainly for defense applications, especially the two important programs the Distributed Sensor Networks (DSN) and the Sensor Information Technology (SenIT) forming the Defense Advanced Research Project Agency (DARPA). Sensor networks were very successful in the military sensing and later have become an integral part of military commanding, control, message passing, evaluation, intelligence, surveillance and reconnaissance. In the battlefield, they provide quicker deployment, self-organization and fault tolerance and security to the network. The sensor devices or nodes should provide following services:

- Monitoring friendly forces, equipment etc.
- Location and observation of opposing forces and terrain
- Battlefield surveillance
- Nuclear, biological and chemical attack detection
- Battle damage assessment

**2. Traffic Monitoring:** A wireless sensor network is able to detect the flow, speed and the occupation of vehicles with good spatial and temporal resolutions, thus providing a solution to traffic congestion. To improve traffic monitoring and to reduce the waiting time and travel time, WSN provides a number of techniques which promise efficient road management. The use of WSN in roads is a vast domain which encompasses the following areas

- gathering information about the incoming flow of traffic
- traffic load on a particular road
- detection of an emergency situation like an accident
- Dynamic traffic light system that will minimize the waiting time as well as manage traffic load at intersection points adaptively.

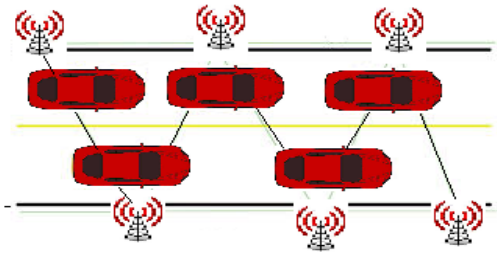

**Fig.2.Block diagram of Traffic monitoring**

**Smart vehicle parking:** The car parking monitoring system is composed of a server, a gateway, a sink node, and multiple sensor nodes. Each of the sensor nodes is equipped with a 3-axis AMR sensor and installed in the center of a parking space to detect the availability of the parking space. The sink node forms a Star-shaped wireless network along with the sensor nodes and collects information from the sensor nodes. The sink node is connected to the gateway and the information collected by the sink node is relayed to the server via the gateway. The server determines which parking space is available based on the received information and provides the availability information for drivers (e.g., using an LED display board). The sensor node remains in a sleep mode during most of the operation time to conserve battery power and wakes up at a predetermined time interval to read the AMR sensor data.

**Fig.3.Schematic diagram of Smart vehicle parking**

**Forest Fire Detection:** Forest fire detection system is made of nodes deployed in a forest area randomly. Each node is equipped with a temperature sensor. Nodes sense the temperature periodically to decide if there is fire or not. When a

significant change in temperature is detected by sensor nodes, they broadcast packets with their measurements. These packets are sent to the nodes which are present in the broadcast region of the sender and relayed to the node that acts as the Base station. Base station is a special node which forwards the received messages to the serial port. Any application will listen to the serial port and keep track of the network. Since the nodes are deployed randomly, there is no proper information about its' coordinates. In addition, an exact topological infrastructure is required for the flow of messages from nodes to the base station.

**Agriculture and Livestock:** Precision agriculture is one of the most interesting applications of wireless sensor networks which may deliver a feasible or sometimes an optimal solution. Fraunhofer IMS is carrying out a project that concentrates on monitoring micro-climates in a potato field. Fraunhofer IMS instrumented a field with sensor nodes with sensors for measuring temperature, humidity and soil moisture. The main is to indicate the farmer in case of fungal attacks on the farm.

**Fig.4.WSN in Agriculture**

A wireless measuring system, consisting of sensors nodes, helps to keep livestock healthier with limited resources. The system determines the pH level and the temperature inside the cow's rumen. This data is wirelessly transmitted to an external node through an encapsulated measuring probe called as bolus. The objective of this application is the development of a wireless rumen monitoring system for early detection of rumen acidosis by periodic measurement, transmission and indication of the pH-value of dairy cows.

**Simulation tools:** A network simulator is a software that predicts the behavior of a computer network. Here are many both free/open-source and proprietary network simulators.

**NS2:** NS-2 is an open source, discrete event. It is an object-oriented network simulator in scientific environment developed in C++. It is a widely used network simulator with a rich set of protocols which focus mainly on IP networks. It simulates the network at the packet level and allows a wide range of network configurations. It provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless networks. NS-2 is also having a few draw back besides its popularity. It does not provide detailed support for measuring the utilization of energy in the hardware, software, and firmware components of a WSN node. The interdependence between modules is caused due to its object oriented design which in turn does not allow the addition of new protocols.

**TOSSIM:** TOSSIM, like NS-2 is an open source and a discrete event driven simulator for TinyOS sensor networks. Users can compile it in the TOSSIM framework, which runs on a host PC instead of compiling aTinyOS application for a mote. This allows users to compile, debug, test, and analyze algorithms in a controlled as well as in a repeatable environment. As TOSSIM runs on a PC, users can examine their code using debuggers and other available development tools.

The algorithms used by this simulator are similar to the hardware implementations thus not allowing the development code to be repeated for hardware. The simulator runs the same code as the hardware except for a few parts. By modifying the ncc (nesC) compiler, TinyOS programs can be compiled to run in TOSSIM by using a command-line option.

**OPNET:** OPNET, a proprietary software, is a very large and a powerful software with a variety of possibilities. It enables the possibility to simulate the networks with various protocols. Originally the software was developed for military needs, but it has now grown to be a world's leading commercial network simulation tool .OPNET is quite expensive for commercial use but there are free licenses available for education purpose.OPNET is a high level network simulation tool which operates at "packet-level" and contains a huge library of accurate models available fixed network hardware and protocols which are commercial. Nowadays, the possibilities for wireless network simulations are also very wide with

greater potential but there exists a lack of the recent wireless systems. OPNET can be used as a research tool or as a network design or analysis tool. The threshold for the usage is high for the developer and low for the end user.

**NETSIM:** NetSim is a popular network simulation tool used for design, planning and for network research and development. NetSim comes with an in-built development environment serving as an interface between User's code and NetSim's protocol libraries which are available as open C code for user modification, and simulation kernel. De-bugging custom code during simulation is an advanced feature where the users are allowed to perform single step,step in and step over which is carried out at various levels. NetSim is also a proprietary software.

## CONCLUSION

Sensor nodes of wireless network are mostly used in critical environments like military, health care and fire detection. These applications demand perfect security which must be addressed at the initial phase of design itself. In case of a battle field, the nodes are prone to physical attacks .An intruder can capture a sensor node and also introduce his malicious nodes in to the existing node, tricking the network to accept his nodes as legitimates. This way the sensible information which is collected by the deployed sensor node can be used for illegal purposes.

The challenge for researchers and developers is to design resilient security protocols offering security in such a way that even when the node is attacked, it should ensure that the information stored cannot be taken off. Sometimes, the encryption key is also contained by the sensor nodes which, on attack can be taken off easily. Thus, Key agreement protocols that do not require encryption keys to be stored in the sensors must be designed. The major obstacle for developing complex security algorithms is the limited resources. Their small size might be attractable in many cases but affects resources .The sensor nodes besides holding information ,also holds encryption data, initialization and authentication data which makes the size a disadvantage. Therefore strong cryptographic algorithms and protocols must be designed in such a way that minimum number of encryption keys must be used to give necessary protection to the network. Focus should be placed on designing protocols that are flexible, fault tolerant and adaptable to dynamic changes providing an enhanced protection to the network and its information.

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