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# Study Of WSNs: Its Application and Types

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## ABSTRACT

**Recent years have witnessed the power of WSNs as a most secure network communication medium. Among that a wide varieties of sensor networks and their variants have found their application and uses. The development of wireless sensor networks was motivated by a number of military applications such as battlefield surveillance along with a lot more areas of life. The design of a WSN depends significantly on the application, and it must consider factors such as the environment, the application's design objectives, cost, hardware, and system constraints. There are many Size and cost constraints on sensor nodes that result in constraints on resources such as high speed. energy, good memory, and communications bandwidth. This has been enabled by the availability, particularly in recent years, of sensors that are intelligent and cheaper. These sensors are made with wireless interfaces through which they can communicate with one another to form a network. The goal of our survey is to present a comprehensive review of lot of works done on Wireless Sensor Networks.**

## 1. Introduction:

A wireless sensor network (WSN) (sometimes called a wireless sensor and actor network (WSAN)) are spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location.

Smart sensor nodes are low power devices equipped with one or more sensors, a processor, memory, a power supply, a radio, and an actuator.[1] A variety of mechanical, thermal, biological, chemical, optical, and magnetic sensors may be attached to the sensor node to measure properties of the environment. Since the sensor nodes have limited memory and are typically deployed in difficult-to-access locations, a radio is implemented for wireless communication to transfer the data to a base station (e.g., a laptop, a personal handheld device, or an access point to a fixed infrastructure). Battery is the main power source in a sensor node. Secondary power supply that harvests power from the environment such as solar panels may be added to the node depending on the appropriateness of the environment where the sensor will be deployed. Depending on the application and the type of sensors used, actuators may be incorporated in the sensors.

A WSN typically has little or no infrastructure. It consists of a number of sensor nodes (few tens to thousands) working together to monitor a region to obtain data about the environment. There are two types of WSNs: structured and unstructured. An unstructured WSN is one that contains a dense collection of sensor nodes. Sensor nodes may be deployed in an ad hoc manner[2] into the field. Once deployed, the network is left unattended to perform monitoring and reporting functions. In an unstructured WSN, network maintenance such as managing connectivity and detecting failures is difficult since there are so many nodes. In a structured WSN, all or some of the sensor nodes are deployed in a pre-planned manner.[3] The advantage of a structured network is that fewer nodes can be deployed with lower network maintenance and management cost. Fewer nodes can be deployed now since nodes are placed at specific locations to provide coverage while ad hoc deployment can have uncovered regions.

WSNs have great potential for many applications in scenarios such as military target tracking and surveillance and natural disaster relief , biomedical health monitoring and hazardous environment exploration and seismic sensing .In military target tracking and surveillance, a WSN can assist in intrusion detection and identification. Specific examples include spatially-correlated and coordinated troop and tank movements. With natural disasters, sensor nodes can sense and detect the environment to forecast disasters before they occur. In biomedical applications, surgical implants of sensors can help monitor a patient's health. For seismic sensing, ad hoc deployment of sensors along the volcanic area can detect the development of earthquakes and eruptions.

Unlike traditional networks, a WSN has its own design and resource constraints. Resource constraints include a limited amount of energy, short communication range, low bandwidth, and limited processing and storage in each node. Design constraints are application dependent and are based on the monitored environment. The environment plays a key role in determining the size of the network, the deployment scheme, and the network topology. The size of the network varies with the monitored environment. For indoor environments, fewer nodes are required to form a network in a limited space whereas outdoor environments may require more nodes to cover a larger area. An ad hoc deployment is preferred over pre-planned deployment when the environment is inaccessible by humans or when the network is composed of hundreds to thousands of nodes. Obstructions in the environment can also limit communication between nodes, which in turn affects the network connectivity (or topology).

Research in WSNs aims to meet the above constraints by introducing new design concepts, creating or improving existing protocols, building new applications and developing new algorithms. In this study, we present a top-down approach to survey different protocols and algorithms proposed in recent years. Our work differs from other surveys as follows:

- While our survey is similar t, our focus has been to survey the more recent literature.
- We address the issues in a WSN both at the individual sensor node level as well as a group level.
- We survey the current provisioning, management and control issues in WSNs. These include issues such as localization, coverage, synchronization, network security, and data aggregation and compression.
- We compare and contrast the various types of wireless sensor networks.

Finally, we provide a summary of the current sensor technologies.

## 2. Overview of key issues

Current state-of-the-art sensor technology provides a solution to design and develop many types of wireless sensor applications. Available sensors in the market include generic (multi-purpose) nodes and gateway (bridge) nodes. A generic (multi-purpose) sensor node's task is to take measurements from the monitored environment. It may be equipped with a variety of devices which can measure various physical attributes such as light, temperature, humidity, barometric pressure, velocity, acceleration, acoustics, magnetic field, etc. Gateway (bridge) nodes gather data from generic sensors and relay them to the base station. Gateway nodes have higher processing capability, battery power, and transmission (radio) range. A combination of generic and gateway nodes is typically deployed to form a WSN.

To enable wireless sensor applications using sensor technologies, the range of tasks can be broadly classified into three groups as shown in Fig. 1. The first group is the system. Each sensor node is an individual system. In order to support different application software on a sensor system, development of new platforms, operating systems, and storage schemes are needed. The second group is communication protocols, which enable communication between the application and sensors. They also enable communication between the sensor nodes. The last group is services which are developed to enhance the application and to improve system performance and network efficiency.

From application requirements and network management perspectives, it is important that sensor nodes are capable of self-organizing themselves. That is, the sensor nodes can organize themselves into a network and subsequently are able to control and manage themselves efficiently. As sensor nodes are limited in power, processing capacity, and storage, new communication protocols and management services are needed to fulfill these requirements

The communication protocol consists of five standard protocol layers for packet switching: application layer, transport layer, network layer, data-link layer, and physical layer. In this survey, we study how protocols at different layers address network dynamics and energy efficiency. Functions such as localization, coverage, storage, synchronization, security, and data aggregation and compression are explored as sensor network services.

Implementation of protocols at different layers in the protocol stack can significantly affect energy consumption, end-to-end delay, and system efficiency. It is important to optimize communication and minimize energy usage. Traditional networking protocols do not work well in a WSN since they are not designed to meet these requirements. Hence, new energy-efficient protocols have been proposed for all layers of the protocol stack. These protocols employ cross-layer optimization by supporting interactions across the protocol layers. Specifically, protocol state information at a particular layer is shared across all the layers to meet the specific requirements of the WSN.

As sensor nodes operate on limited battery power, energy usage is a very important concern in a WSN; and there has been significant research focus that revolves around harvesting and minimizing energy.

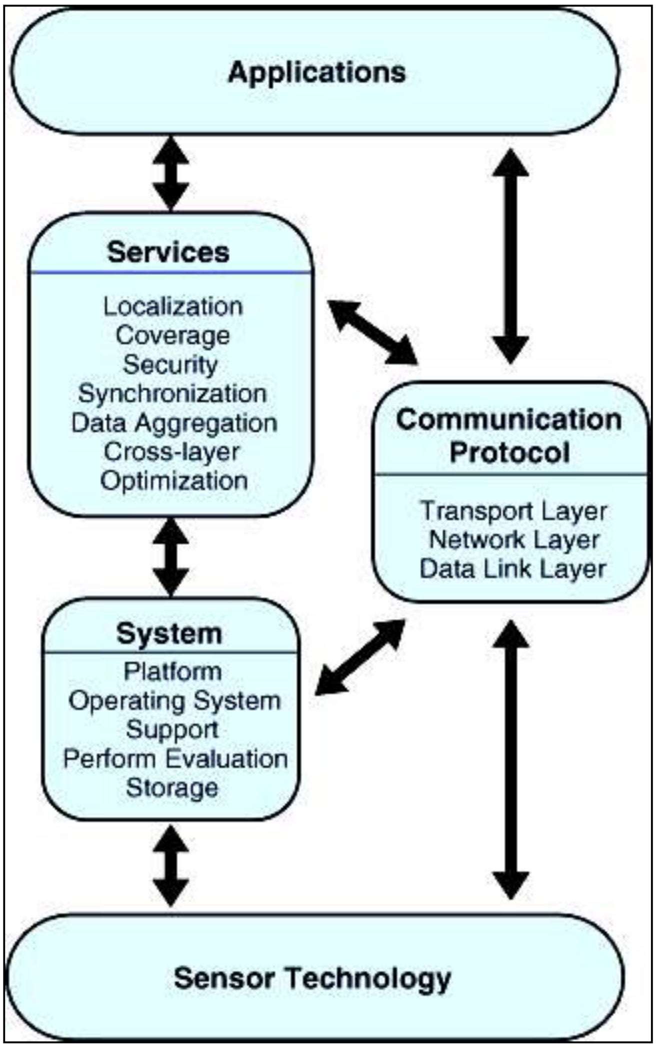

Figure 1. Broad classification of various issues in a WSN.

When a sensor node is depleted of energy, it will die and disconnect from the network which can significantly impact the performance of the application. Sensor network lifetime depends on the number of active nodes and connectivity of the network, so energy must be used efficiently in order to maximize the network lifetime.

Energy harvesting involves nodes replenishing its energy from an energy source. Potential energy sources include solar cells and vibration, fuel cells, acoustic noise, and a mobile supplier. In terms of harvesting energy from the environment, solar cell is the current mature technique that harvest energy from light. There is also work in using a mobile energy supplier such as a robot to replenish energy. The robots would be responsible in charging themselves with energy and then delivering energy to the nodes.

Energy conservation in a WSN maximizes network lifetime and is addressed through efficient reliable wireless communication, intelligent sensor placement to achieve adequate coverage, security and efficient storage management, and through data aggregation and data compression. The above approaches aim to satisfy both the energy constraint and provide quality of service (QoS) for the application. For reliable communication, services such as congestion control, active buffer monitoring, acknowledgements, and packet-loss recovery are necessary to guarantee reliable packet delivery. Communication strength is dependent on the placement of sensor nodes. Sparse sensor placement may result in long-range transmission and higher energy usage while dense sensor placement may result in short-range transmission and less energy consumption. Coverage is interrelated to sensor placement. The total number of sensors in the network and their placement determine the degree of network coverage. Depending on the application, a higher degree of coverage may be required to increase the accuracy of the sensed data.

## 3. Characteristics

The main characteristics of a WSN include:

Power consumption constraints for nodes using batteries or energy harvesting

- Ability to cope with node failures (resilience)
- Mobility of nodes
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Ability to withstand harsh environmental conditions
- Ease of use
- Cross-layer design

## 4. Types of sensor networks

Current WSNs are deployed on land, underground, and underwater. Depending on the environment, a sensor network faces different challenges and constraints. There are five types of WSNs: terrestrial WSN, underground WSN, underwater WSN, multi-media WSN, and mobile WSN.

1.Terrestrial WSNs typically consist of hundreds to thousands of inexpensive wireless sensor nodes deployed in a given area, either in an ad hoc or in a pre-planned manner. In ad hoc deployment, sensor nodes can be dropped from a plane and randomly placed into the target area. In pre-planned deployment, there is grid placement, optimal placement 2-d and 3-d placement and models.

Underground WSNs and consist of a number of sensor nodes buried underground or in a cave or mine used to monitor underground conditions. Additional sink nodes are located above ground to relay information from the sensor nodes to the base station. An underground WSN is more expensive than a terrestrial WSN in terms of equipment, deployment, and maintenance. Underground sensor nodes are expensive because appropriate equipment parts must be selected to ensure reliable communication through soil, rocks, water, and other mineral contents. The underground environment makes wireless communication a challenge due to signal losses and high levels of attenuation. Unlike terrestrial WSNs, the deployment of an underground WSN requires careful planning and energy and cost considerations. Energy is an important concern Underwater WSNs consist of a number of sensor nodes and vehicles deployed underwater. As opposite to terrestrial WSNs, underwater sensor nodes are more expensive and fewer sensor nodes are deployed. Autonomous underwater vehicles are used for exploration or gathering data from sensor nodes. Compared to a dense deployment of sensor nodes in a terrestrial WSN, a sparse deployment of sensor nodes is placed underwater.

Multi-media WSNs have been proposed to enable monitoring and tracking of events in the form of multi-media such as video, audio, and imaging. Multi-media WSNs consist of a number of low cost sensor nodes equipped with cameras and microphones. These sensor nodes interconnect with each other over a wireless connection for data retrieval, process, correlation, and compression. Multi-media sensor nodes are deployed in a pre-planned manner into the environment to guarantee coverage.

Mobile WSNs consist of a collection of sensor nodes that can move on their own and interact with the physical environment. Mobile nodes have the ability sense, compute, and communicate like static nodes. A key difference is mobile nodes have the ability to reposition and organize itself in the network. A mobile WSN can start off with some initial deployment and nodes can then spread out to gather information. Information gathered by a mobile node can be communicated to another mobile node when they are within range of each other.

## 5. Applications

WSN applications can be classified into two categories: monitoring and tracking. Monitoring applications include indoor/outdoor environmental monitoring, health and wellness monitoring, power monitoring, inventory location monitoring, factory and process automation, and seismic and structural monitoring. Tracking applications include tracking objects, animals, humans, and vehicles. While there are many different applications, below we describe a few example applications that have been deployed and tested in the real environment.

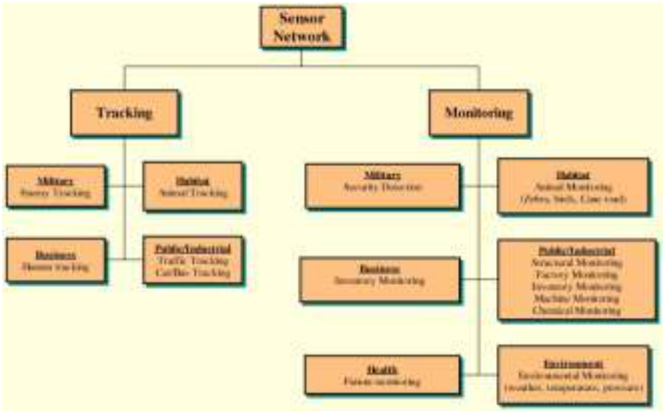

Figure 2. Overview of sensor applications.

*WSN in a petroleum facility* can reduce cost and improve efficiency. The design of this network is focused on the data rate and latency requirement of the plant. The network consists of four sensor node and an actuator node. The sensor nodes are based on T-mote sky devices . Two AGN1200 pre-802.11N Series MIMO access points are used to create an 802.11b 2.4 GHz wireless local area network. In this multi-hop WSN, the T-mote sky devices send their radio packets to the base station which is forwarded to a crossbow stargate gateway.

*Volcanic monitoring* with WSN can help accelerate the deployment, installation, and maintenance process. WSN equipments are smaller, lighter, and consume less power. The challenges of a WSN application for volcanic data collection include reliable event detection, efficient data collection, high data rates, and sparse deployment of nodes.

*Health monitoring applications* using WSN can improve the existing health care and patient monitoring. Five prototype designs have been developed for applications such as infant monitoring, alerting the deaf, blood pressure monitoring and tracking, and fire-fighter vital sign monitoring. The prototypes used two types of motes: T-mote sky devices and SHIMMER (Intel Digital Health Group’s Sensing Health with Intelligence, Modularity, Mobility, and Experimental Re-usability).

LISTSENse enables the hearing impaired to be informed of the audible information in their environment. A user carries the base station T-mote with him. The base station T-mote consists of a vibrator and LEDs. Transmitter motes are place near objects (e.g., smoke alarm and doorbell) that can be heard. Transmitter motes consist of an omni-directional condenser microphone. They periodically sample the microphone signal at a rate of 20 Hz. If the signal is greater than the reference signal, an encrypted activation message is sent to the user. The base station T-mote receiving the message actives the vibrator and its LED lights to warn the user. The user must press the acknowledge button to deactivate the alert.

Other applications include

- Industrial monitoring
- Data logging
- Water/Waste water monitoring
- Structural Health Monitoring
- Music Technology
- Landslide detection
- Chemical agent detection
- Forest fire detection
- process management
- area monitering
- Environmental/Earth sensing
- Air pollution monitoring
- Water quality monitoring
- Natural disaster prevention

## 8. Conclusion

Unlike other networks, WSNs are designed for specific applications. Applications include, but are not limited to, environmental monitoring, industrial machine monitoring, surveillance systems, and military target tracking . Each application differs in features and requirements. To support this diversity of applications, the development of new communication protocols, algorithms, designs, and services are needed.

We have surveyed in this paper issues on three different categories: (1) internal platform and underlying operating system, (2) communication protocol stack, and (3) network services, provisioning, and deployment issues. We have summarized and compared different proposed designs, algorithms, protocols, and services. Moreover, we have highlighted possible improvements and research in each area. There are still many issues to be resolved around WSN applications such as communication architectures, security, and management. By solving these issues, we can close the gap between technology and application.