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The Architecture of Wireless Sensor Network, its Issues and Applications

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ABSTRACT: A Wireless Sensor Network (WSN) is a network formed by a large number of sensor nodes where each node is equipped with a sensor to detect physical phenomena such as light, heat, pressure, etc. One of the biggest concerns of WSNs is that they are very defenseless to security threats. As wireless sensor technology improves; an increasing number of organizations are using it for a wide range of purposes. WSNs enable new applications and require non-conventional paradigms for protocol design due to several constraints. Presently, WSNs are beginning to be organized in an enhanced step. It is not awkward to expect that in 10 to 15 years that the world will be protected with WSNs with entree to them via the Internet. This can be measured as the Internet becoming a physical network. This technology is thrilling with infinite potential for many application areas like medical, environmental, transportation, military, entertainment, homeland defense, crisis management and also smart spaces. This paper concludes the architecture, issues and applications concerning WSN.

KEYWORDS: **W**ireless **S**ensor **N**etwork; Architecture; WSN issues; WSNs Applications

I. INTRODUCTION

A sensor network consists of multiple detection stations called sensor nodes, from a few to several hundreds or even thousands, where each node is connected to one or sometimes several sensors. Every sensor node is equipped with a transducer, microcomputer, transceiver and power source. The transducer generates electrical signals based on sensed physical effects and phenomena. The microcomputer processes and stores the sensor output. The transceiver receives commands from a central computer and transmits data to that computer. The power for each sensor node is derived from a battery. The positions of sensor nodes in network need not be engineered or predetermined i.e. nodes are random deployment in inaccessible terrains or hazardous environments. The sensor node is a multi-functional, energy efficient wireless device. The applications of motes in industrial are widespread. A collection of sensor nodes collects the data from the surroundings to achieve specific application objectives. In contrast with sensor networks, Ad Hoc networks will have fewer nodes without any structure. In Wireless sensor networks there are two kinds of wireless nodes; sensor and base station nodes. The main function of the base station relies on managing the actions executed to provide reliable and efficient sensing support. It provides a gateway to other networks or acts as a data storage processing data in a powerful way. It even acts as an access point to human interface for human interaction, and is capable of broadcasting control data in the network or removes data from it. The base station node will calculate and send the even source, its position and a timestamp to the analysis centre. If an alert is received by the base station regarding a target, an identity of the target will be allocated allowing all related alerts getting appropriate management. An example of a WSN device is shown in figure 1.

II. WIRELESS SENSOR NETWORK ARCHITECTURE

The most common WSN architecture follows the OSI architecture Model. The architecture of the WSN includes five layers and three cross layers. Mostly in sensor network we require five layers, namely application, transport, network, data link & physical layer. The three cross planes are namely power management, mobility management, and task management. These layers of the WSN are used to accomplish the network and make the sensors work together in order to raise the complete efficiency of the network. Figure 2 shows a typical architecture of WSN.

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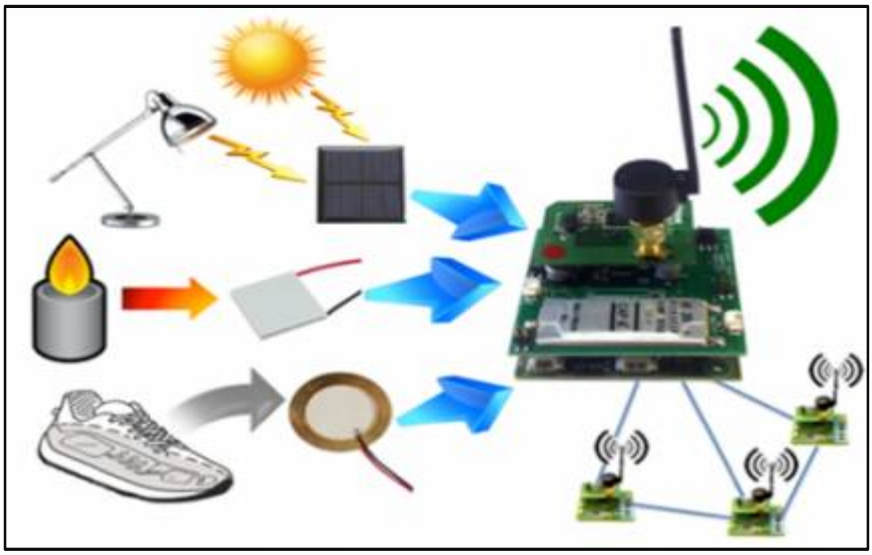

Fig1. Wireless Sensor Network

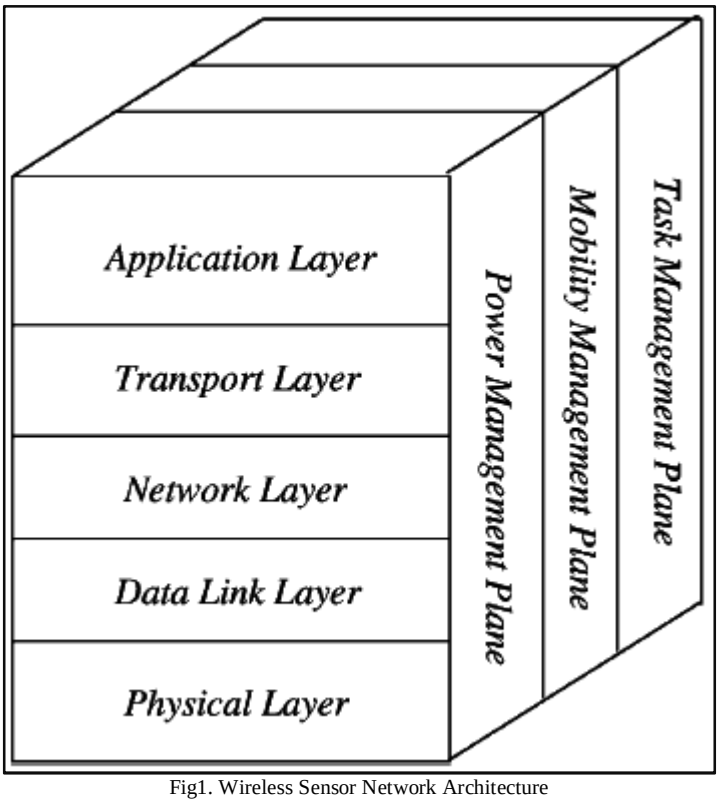

Fig1. Wireless Sensor Network Architecture

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A. Application Layer:

The application layer is liable for traffic management and offers software for numerous applications that convert the data in a clear form to find positive information. Sensor networks arranged in numerous applications in different fields such as agricultural, military, environment, medical, etc.

B. Transport Layer:

The function of the transport layer is to deliver congestion avoidance and reliability where a lot of protocols intended to offer this function are either practical on the upstream. These protocols use dissimilar mechanisms for loss recognition and loss recovery. The transport layer is exactly needed when a system is planned to contact other networks.

Providing a reliable loss recovery is more energy efficient and that is one of the main reasons why TCP is not fit for WSN. In general, Transport layers can be separated into Packet driven, Event driven. There are some popular protocols in the transport layer namely STCP (Sensor Transmission Control Protocol), PORT (Price-Oriented Reliable Transport Protocol and PSFQ (pump slow fetch quick).

C. Network Layer:

The main function of the network layer is routing, it has a lot of tasks based on the application, but actually, the main tasks are in the power conserving, partial memory, buffers, and sensor don't have a universal ID and have to be self-organized.

The simple idea of the routing protocol is to explain a reliable lane and redundant lanes, according to a convinced scale called metric, which varies from protocol to protocol. There are a lot of existing protocols for this network layer, they can be separate into; flat routing and hierarchal routing or can be separated into time driven, query-driven & event driven.

D. Data Link Layer:

The data link layer is liable for multiplexing data frame detection, data streams, MAC, & error control, confirm the reliability of point–point (or) point– multipoint.

E. Physical Layer:

The physical layer provides an edge for transferring a stream of bits above physical medium. This layer is responsible for the selection of frequency, generation of a carrier frequency, signal detection, Modulation & data encryption. IEEE 802.15.4 is suggested as typical for low rate particular areas & wireless sensor network with low cost, power consumption, density, the range of communication to improve the battery life. CSMA/CA is used to support star & peer to peer topology. There are several versions of IEEE 802.15.4.V.

III. ISSUES IN WIRELESS SENSOR NETWORKS

A. *Design Issues in WSN:*

The sensor network consists of several different kinds of nodes hence heterogeneity needs to be supported. The number of sensor nodes in the network is not constant throughout the life time of the network it may vary because of addition of senor nodes or reduction of nodes due to their death. The major factors that need to consider while designing sensor network are listed below.

- *Fault Tolerance:* Possibility of node failure and change of topology of network is quite high in case of WSN. Hence the designer of network should make the network robust and reliable even in case of node failures and topology changes. The network should function smoothly and normally irrespective of node failures and topology changes.
- *Life Time:* WSN are supposed to work for a quite long time with low power consumption. They are supposed to last at-least for 6 months to 1 year. We need to keep in mind that every node in WSN may be powered using just a 3 V battery and this should be sufficient for the entire life time of the node. The design of protocols of WSN should be such that the node consumes as less energy as possible. This will help in making the WSN last longer.
- *Scalability:* The design of WSN should support addition of new nodes any time and also the design should support large number of nodes because some applications in WSN may require quite a huge number of sensor nodes.

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- *Date Aggregation:* The sensor nodes in WSN are located close to each other hence the possibility of similar data being generated by the nodes next to each other is quite high. So the data needs to be aggregated and the duplicate data needs to be avoided because the transmission and reception data is the costliest affair in WSN. The data needs to be aggregated at different levels in WSN so that only the necessary data is transmitted and received and the redundant data is not communicated.
- *Cost:* The cost of each sensor node is supposed to be 1$, as WSN can have large number of sensor nodes the total cost of the network can become a quite expensive affair. So the designer of WSN needs to decide on the optimal number of nodes necessary for the application.
- *Environment:* The environment in which the WSN is deployed can be very demanding, so the design of WSN should be such that WSN should be able to survive regardless of the conditions in which WSN s deployed.
- *Heterogeneity Support:* The protocols designed for WSN should support different kinds of sensor nodes and also be able to support variety of applications.
- *Autonomous Operations:* The WSN should be able to organize, reorganize and operate autonomously because sometimes WSN deployed in places where human habitation is not possible.
- *Limited Memory and Processing Capability:* The sensor nodes have very limited memory, power and processing capabilities, so all designs of WSN should not be demanding in terms of processing requirements or memory requirements.

B. *Topology Issues:*

- *Geographic Routing:* Geographic routing is a routing principle that relies on geographic position information. It is mainly proposed for wireless networks and based on the idea that the source sends a message to the geographic location of the destination instead of using the network address.
- *Sensor Holes:* A routing hole consists of a region in the sensor network, where either node is not available or the available nodes cannot participate in the actual routing of the data due to various possible reasons. The task of identifying holes is especially challenging since typical wireless sensor networks consist of lightweight, low-capability nodes that are unaware of their geographic location.
- *Coverage Topology:* Coverage problem reflects how well an area is monitored or tracked by sensors. The coverage and connectivity problems in sensor networks have received considerable attention in the research community in recent years. This problem can be formulated as a decision problem, whose goal is to determine whether every point in the service area of the sensor network is covered by at least k sensors, where k is a given parameter.

C. *Other Issues:*

- The major issues that affect the design and performance of a wireless sensor network are as follows:
- Hardware and Operating System for WSN
- Wireless Radio Communication Characteristics
- Medium Access Schemes
- Deployment
- Localization
- Synchronization
- Calibration
- Network Layer
- Transport Layer
- Data Aggregation and Data Dissemination
- Database Centric and Querying
- Architecture
- Programming Models for Sensor Networks
- Middleware

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IV. WIRELESS SENSOR NETWORK APPLICATIONS

There are numerous applications of WSNs in industrial automation, traffic monitoring and control, medical device monitoring and in many other areas. Some of applications are discussed below:

- *Disaster Relief Operation:*

If an area is reported to have been stricken from some sort of calamity such as wildfire, then drop the sensor nodes on the fire from an aircraft. Monitor the data of each node and construct a temperature map to devise proper ways and techniques to overcome the fire.

- *Military Applications:*

As the WSNs can be deployed rapidly and are self-organized therefore they are very useful in military operations for sensing and monitoring friendly or hostile motions. The battlefield surveillance can be done through the sensor nodes to keep a check on everything in case more equipment, forces or ammunitions are needed in the battlefield. The chemical, nuclear and biological attacks can also be detected through the sensor nodes.

An example of this is the 'sniper detection system' which can detect the incoming fire through acoustic sensors and the position of the shooter can also be estimated by processing the detected audio from the microphone.

- *Environmental Applications:*

These sensor networks have a huge number of applications in the environment. They can be used to track movement of animals, birds and record them. Monitoring of earth, soil, atmosphere context, irrigation and precision agriculture can be done through these sensors. They can also use for the detection of fire, flood, earthquakes, and chemical/biological outbreak etc.

A common example is of 'Zebra Net'. The purpose of this system is to track and monitor the movements and interactions of zebras within themselves and with other species also.

- *Medical Applications:*

In health applications, the integrated monitoring of a patient can be done by using WSNs. The internal processes and movements of animals can be monitored. Diagnostics can be done. They also help in keeping a check on drug administration in hospitals and in monitoring patients as well as doctors.

An example of this is 'artificial retina' which helps the patient in detecting the presence of light and the movement of objects. They can also locate objects and count individual items.

- *Home Applications:*

As the technology is advancing, it is also making its way in our household appliances for their smooth running and satisfactory performance. These sensors can be found in refrigerators, microwave ovens, vacuum cleaners, security systems and also in water monitoring systems. The user can control devices locally as well as remotely with the help of the WSNs.

V. CONCLUSION

Wireless Sensor Networks must be designed to meet a number of challenging requirements. Wireless Sensor Networks are getting smaller and faster, increasing their potential applications in commercial, industrial and residential environments. As Wireless Sensor Networks are still a young research field, much activity is still ongoing to solve many open issues. In this paper the typical architecture of a WSN is defined and also the issues and applications related to WSNs are identified. The impact of wireless sensor networks on our day to day life can be preferably compared to what Internet has done to us.

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BIOGRAPHY

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