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An Insight into Architectural Modeling, applications and Limitations of Wireless Sensor Networks

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Abstract: ***Evolution of Wireless sensor networks brought a great revolution in the field of wireless networks. Sensor nodes are scattered over the targeted field to sense environmental activities and their characteristics. Sensor nodes in a sensor network pass the information gathered by them to each other and a collective report can be produced. WSNs are having certain architectural characteristics, based on which they have certain limitations also. In this paper architecture of WSN is discussed along with its area of applications and limitations.***

Keywords: WSN, SINK, sensor field, TMP, PMP, MMP.

1. Introduction

A Wireless Sensor Network (WSN) consists of low cost small devices with ability of sensing, storing and communicating wirelessly, called sensor nodes. WSNs can be defined as self-configured and infrastructure-less wireless networks to monitor environmental or physical conditions like - sound, volume, strain, tremor, warmth, contaminants or motion etc. and to cooperatively transmit their data through the network to a sink or a main location where this data can be monitored and analyzed [1], [2].

An interface acts between users and the network is called a base station or a sink. The necessary information needed from the network can be retrieved by putting queries to and collecting results from the sink or base station. Over thousands of sensor nodes can be contained in a wireless sensor network. Communication among these sensor nodes in a WSN is done by use of radio signals. Every individual node in a wireless sensor network has limited communication bandwidth, processing speed, and storage capacity. After the deployment of sensor nodes they automatically self-organize themselves to form an appropriate network infrastructure. In general, multi-hop communication occurs between sensor nodes. The main objective of sensor node is collecting the information of interest. There are two types of working modes of the sensor nodes i.e. it may be either event driven or continuous [2].

The sensor nodes are small and low powered devices usually scattered in a area called sensor field as shown in figure 1. The work of each sensor scattered in the sensor field is to collect data or information and route back to base station or sink [1]. The routing of data or information depends on multihop connectivity or infrastructure exist between sensor nodes. The Internet or Satellite works as an interface between sink and Task Manager Node for communication. Whenever an event is generated in the sensor fields, it detects near by sensors and communicated to the sink. The sink then communicates to the Internet & satellite then it communicate to the task manager node [1].

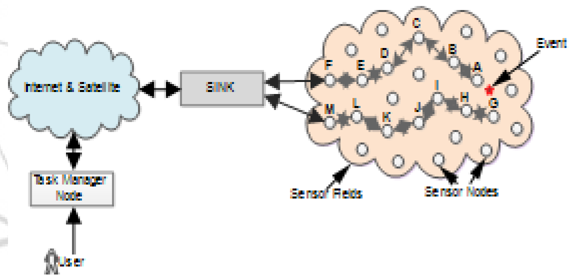

Figure 1: Illustration of distribution of sensor nodes in a sensor field and their communication with user via SINK

2. Architecture

OSI model is followed in the most common architecture of WSN, so called layered architecture of WSN which includes five layers as –Network layer (NL), Data link layer (DLL), Physical layer (PL), application layer (AL) and Transport layer (TL). Apart from these five layers there are three more layers called cross layers [3] as depicted in the figure named Task Management Plane (TMP), Mobility management Plane (MMP) and Power management plane (PMP). All these layers and cross layers have their own responsibilities and functions [3] which are discussed in this section.

2.1 Physical layer [4]

It has responsibility to provide an interface on which a stream of bits is transmitted over a physical medium. It does the selection of frequency, generates carrier frequency, detects signal, performs modulation and encrypts the data.

2.2 Data link layer [4]

This layer plays a vital role as it multiplexes data streams, detects data frames, error control and MAC, ensures the reliability of point-to-point and point-multipoint. Despite of all these, this layer may have unreliability or exception. Major reasons of such exceptions are [5], [6]:

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1. The co-channel interference which is occurred at MAC layer and this issue can be resolved by MAC protocol. Therefore, MAC protocol which is used at MAC layer is liable for resolution of co-channel interference.
2. Shadowing and multipath fading occurred at physical layer and this issue can be resolved by ARQ (Automatic repeat Request) and FEC (Forward Error Correction).

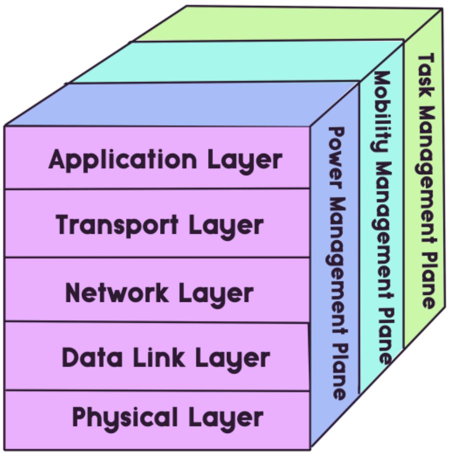

Figure 2: Layered Architecture of WSN [3]

2.3 Network Layer

Main responsibility of this layer is routing. Along with it this layer has to face the challenges like – limited buffer, limited memory and power saving and its nature should be self-organizing as sensors do not have any global ID [3]. The intrinsic idea of protocols of this layer is to identify redundant paths and reliable path according to metric (a certain scale). A variety of protocols is available in this layer and they are categorized into hierarchical and flat routing protocols or sometimes they are categorized into query driven, event driven and time driven protocols [7], [8].

2.4 Transport Layer

Major responsibilities of this layer are providing reliability and avoidance of congestion. To do so, lots of protocols are designed to be applied either on upstream (user to sink) or on downstream (sink to user). These protocols are having strength of detecting the loss or recovering the loss. This layer is specially required if the system has to communicate with other networks [4], [9].

2.5 Application layer

This layer is having responsibility of management of traffic and providing software to applications to transform data into understandable format. It facilitates sending queries to fetch specific information and thus WSNs are widely used in different fields such as – environmental, agricultural, military and medical studies [8], [10].

2.6 Cross layers

Cross layers/planes are layers those work simultaneously beside the scene to make sensor nodes work together and to manage the network so that sensor network can exhibit improved efficiency. This category includes PMP (Power Management Plane), MMP (Mobility Management Plane) and TMP (Task Management Plane). PMP is responsible for scheming the power consumption of nodes. MMP detects movement of sensors in network as well as sensors can keep track of power levels and neighbors. TMP enables nodes to sense specified region and detects which nodes in network are ON and which nodes are OFF [7], [10].

3. Life cycle of Sensor network

Lifecycle of a wireless sensor network can be characterized into four phases. The researchers generally take interest in planning and deployment phase, but customers take interest in monitoring and controlling phase of wireless sensor network. One phase called implementation phase is not illustrated in this section because the code for sensors is reused very frequently [11].

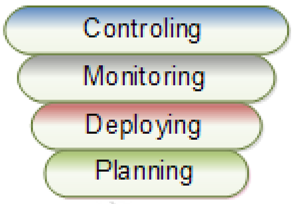

Figure 3: Wireless sensor network lifecycle [11]

3.1 Planning WSNs

This phase generally includes inspecting the area of deployment and identification of exact location for positioning the sensors so that they can achieve the desired objective. Perfect positioning for deployment is required so that targeted efficiency can be achieved. Moreover, performance measure is an issue along with cost of establishment of sensor network as objective defines the level of efficiency of network and density of sensors in network [11].

3.2 Deploying WSNs

In this phase sensor nodes continuously transmit their quality of wireless connection and route to sink/base. Transmission of such information suggests the WSN to identify nodes with high performance and their selection, based on which most promising routes can be defined and efficiency of network is not degraded [11].

3.3 Monitoring WSNs

In this phase main concern is on values examined by network sensors. Monitory issue is very important since this is what for which sensors are deployed to form a wireless sensor network. Sensor field collects the values read by sensor nodes and transmits them ahead [11].

3.4 Controlling WSNs

Commands are used to control the WSNs which are sent by applications also. Commands used in this phase command the network devices to reset the network impede sending messages and increment in time duration between messages being sent. Near in the future WSNs will be controlled by

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some hand-held devices or a web interface that will make restarting or stopping the network easier [11].

4. Applications of WSNs

In various areas WSNs can be applied for example: Military, monitoring, tracking, disaster relief, rescue operation, monitoring target, management of warehouse and building, security, industries safety and production monitoring, traffic control, health monitoring, environment monitoring, nuclear explosive detection, auto pilot mode etc. Here some areas of applications of WSNs are discussed below-

- **Intelligent Infrastructures:** By sensing their temperature, level of humidity and light requirement, facilities can be driven based on data given by sensors situated in building.
- **Disaster prevention systems:** Level of water to prevent flood impact on locality, judgment of heat in forest, pre sensing for volcanic emission and earthquakes and lot more things can be done.
- **Monitoring the Biodiversity:** Sensors can be used to monitor the wildlife and behavior of animals and nature by which a better relation with nature can be thought [11].
- **Agriculture:** Scattering sensors over agriculture fields can lead to a better crop result as they can give information about the field over which they are distributed and based on their information better decisions can be taken to take care of agricultural field.
- **Health Care:** Care of patients by analyzing their body temperature, blood pressure, pulse rate, level of oxygen in their lungs etc. Surveillance such as ECG, EEG and other diagnostic processes can be performed.
- **Industrial monitoring:** Sensors have ability to play a vital role in automation of processes and supervision of machineries so that proper maintenance and production can take place [11].
- **Defense:** WSNs help defense agencies and army to judge enemy locations and their activities so that their plan can be predicted and proper decisions can be taken in defense.
- **Domestic uses:** WSNs can be used to locate members of home inside, monitoring home appliances and in-house environment.
- **Traffic control:** Sensors can judge the traffic and congestion so that time span of a opening signal can be managed and traffic can be moved to lesser congested routes.
- **Environmental observation:** Sensors have ability to sense weather changes for better forecasting, level of air and water pollution, radiation and sun rays' impact.

5. Limitations of WSNs

This section includes the major limitations of Wireless Sensor Networks because of which efficiency and security issues are raised:

- A typical wireless sensor node is having very less processing power, storage capacity and radio frequency. Therefore, because of limited power and storage, WSNs need more number of sensors densely scattered within and hence cost increases.
- As WSNs do not have any specific physical/wired network configuration therefore they lack in network security and high network communication.
- It is not necessary that sensor nodes of a WSN must be homogenous and hence synchronization degrades the efficiency.

6. Conclusion

The presented paper provides information about architecture, lifetime of a sensor, limitations with WSN and applications in different areas. As Lifetime of sensor depends on energy so conservation and efficient use of energy is prime requirement and these can be achieved by using better congestion control methods, load balancing mechanisms and efficient routing strategies. Duplication of packets during transmission of data or information must be removed.

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