International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 5, Issue 5, May 2016 **ISSN 2319 - 4847**

Overview of Issues and Challenges in Wireless Sensor Networks

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ABSTRACT

Wireless Sensor Networks have attracted many researchers due to their capability to connect to the real world. The network finds application from military to medicine and is customized according to the task to be performed in the applications. The significant tasks performed by the network includes sensing, monitoring, target tracking and event sensing. Being one of the prominent futuristic technology, wireless sensor network needs to be addressed from different perspectives from design to development to application. With a need to unleash the unlimited potential of Wireless sensor networks along with addressing the challenges posed. In this paper we resent a comprehensive review of work published in wireless sensor networks recently. Hence making our survey unique providing a direction to the future research work in wireless sensor network domain.

Keywords: Wireless Sensor Networks, Mobility, Clustering, Security, heterogeneity.

1. INTRODUCTION

Wireless Sensor Networks (WSN) became a reality due to tremendous advancements in Micro-Electrical-Mechanical systems and radio communication technologies [1]. WSNs are made up small devices deployed in large scale that run autonomously. These small devices are embedded with sensors termed as 'nodes' with capability to feel the real world. The main task of WSN is to sense and monitor the physical phenomenon in the environment, reporting back the same to Base station for further processing. The Base Station (BS) is a node that controls and coordinates the activities of the networks and takes decisions, assigns tasks and also can query the network for data or any information. The size and design of the node pose some potential energy issues with communication capability, computation capacity, storage capacity and battery operated. The deployed environment also pose potential security issues in the WSN. With this background, in this paper we try to put light on various existing schemes and issues associated, and also provide directions to novice researchers in WSN domain.

The organization of the paper is as follows: section 2 gives brief overview of WSN, Section 3 we confine our discussion to the 4 major issues in WSN to be addressed at appropriate level. Section 4 enlists the future work that can be focused on. Section 5 concludes the paper.

2. WSN BASICS

2.1WSN Applications

Due to their capabilities WSN finds its applications in many domains. Continuous advancements to the technology and with the development of appropriate algorithms WSN can be made accessible to even more domains. WSN can be used for continuous or intermittent sensing, target tracking and event detection in the deployed area. Applications based on their functions can be summarized as follows:

Table 1: Summary of WSN Applications

Application	Function	Description
Military Applications	Sensing , Target Tracking and Event Detection	WSN is used to monitor the resources, track enemies and targets, to assess the damage , detection of attacks such as nuclear, biochemical etc.
Environmental Applications	Sensing, Event Detection	WSN is used to monitor the weather conditions, soil conditions, in precision agriculture, forest fire detection, and Volcano, Flood and pollution detection.
Home Applications	Sensing, Event Detection	Sensors are buried in the appliances to help automate. Aids in ease to manage and monitor these appliances locally or remotely

Vehicle Tracking	Target Tracking	Location estimation of the vehicles
Structural and Industrial Monitoring Applications	Sensing, Tracking, Event Detection	To monitor the condition of the structures, bridges, tunnels, machinery used in industry. To estimate wear and tear.
Business and Inventory Control Applications	Sensing, Tracking, Event Detection	Inventory monitoring, to keep track of the items in the inventories. To check the supply chain system
Medical Applications	Sensing, Tracking, Event Detection	The Sensors can be implanted or attached to the patient to observe the physiological parameters and other conditions and provide appropriate treatment at the right time.

2.2Architecture and organization of WSN

WSNs are networks for real time applications, made up of numerous number of nodes [2-5]. The function of these nodes if to sense the environmental parameters such as temperature, pressure, humidity etc. having sensed these nodes need to store the data in their memory and pass on this data to the BS for further processing. The BS processes the data, draws conclusions an pass the results to any user querying the network through the internet. This scenario is depicted in figure 1

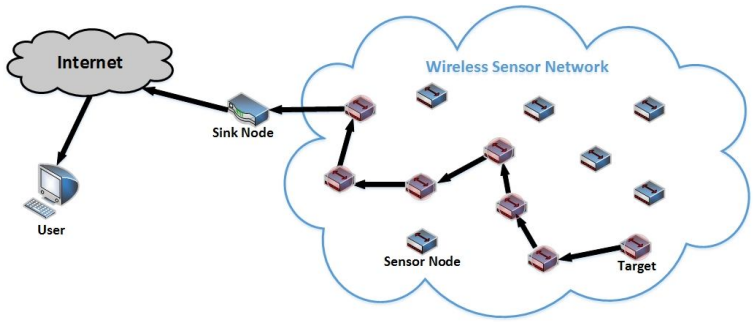

Figure 1: A Simple Wireless Sensor Network Scenario

Any device to connect itself to the other devices needs the protocol stack. The protocol stack of sensor nodes include 5 layers, (from Bottom to Top) 1: Physical Layer: manages transmission, reception and modulation of data, 2: Data Link Layer: Manages noise, collision, mobility etc, 3: Network Layer: Routes the data supplied by the layer above, 4: Transport Layer: Maintains and manages the flow of data in the network and 5: Application Layer: various Application software's are built based on the sensing capabilities.

These 5 layers are surrounded by 3 planes, 1: The Power Management Plane: Since the node is battery operated and not re-chargeable, this plane helps utilize the node power in optimal manner. 2: The Mobility Management Plane: Manages the movement of nodes along with tracking the neighbors and 3: The Task Management plane: this plane balances and schedules the sensing tasks in a specific region of the network.

The organization of the sensor node is given in figure 2. The node is battery operated with Position finding system that helps node to locate itself in the deployed area. The Mobilizer is used to detect the movement of the node, the sensor senses the environment and the sensed data is then converted into transmittable form by ADC, the data can be processed by a microprocessor mounted on the node. The sensed data can be immediately passed to BS through a transceiver or it can be stored in the node memory and can be used when required.

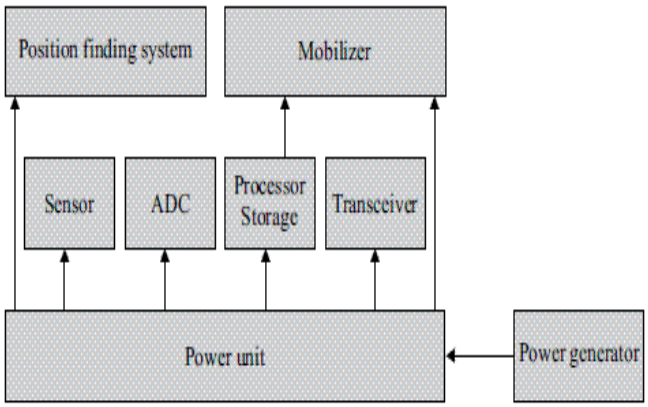

Figure 2: Sensor Node Organization

2.3Classification and Constraints

WSN can be classified based on network organization into 1: Flat topology: in this organization all nodes perform same task.2: Hierarchical topology: assigns different roles to nodes. These topology can further be clustered to obtain energy efficiency.

2.3.1Influencing factors in WSN

Topology: maintenance of the way the nodes are deployed and how network evolves over time is very challenging. The network is more vulnerable to tampering and failure of nodes and hence this leads to frequent changes to the topology. The issues that need to be addressed are: pre-deployment. Deployment, post-deployment, re-deployment phases.

Power Consumption: the nodes in the network are battery operated and hence possess finite amount of energy. Methods for replenishment have to be sought to enhance the lifetime of the network. Other factors that leads to power consumption are sensing, communication, mobility, location detection and processing of data.

Transmission Medium: the communication medium for WSN is Wireless and hence prone to many attacks.

Fault Tolerance: the WSN is vulnerable to node failure and hence the network should function normally even in presence node failures.

Scalability: with the increase in the number of nodes the network should still be functioning appropriately.

Operating Environment: the WSN can be deployed in sea bed, on floating ocean waters, near volcanos, in machinery, on humans, on animals, vehicles etc. seeing the diversity of applications, we can conclude that different applications need to be approached in different ways.

2.3.2WSN Constraints

The constraints of WSN are classified into three

1) **Deployment Constraints:** The WSN nodes are ad-hoc in nature and once deployed the nodes self-organize. The nodes are deployed in unattended environment and managed remotely. The deployment can be fixed or random. In fixed deployment the position or location of node placement is predetermined and in random deployment the nodes are deployed randomly in the network and location is not predetermined.
2) **Communication constraints:** The WSN links have limited bandwidth and due to its wireless channels they are unreliable and prone to attacks. The links due to dense deployment of nodes will have more collisions and more delay.
3) **Device Constraints:** The device has limited memory storage, limited power as they are battery operated and limited processing capability.

3. FOUR MAJOR WSN ISSUES

We have discussed the factors influencing the WSN design, our discussion will revolve around those issues to achieve efficiency.

3.1 Heterogeneity: There are two types of WSN networks, homogeneous and heterogeneous [6]. In homogeneous WSN all nodes have same capability and the network is very simple. All the nodes drain their energy uniformly and also the cost of hardware is low. In heterogeneous WSN, nodes with different capability with respect to battery, storage, mobility and processing are used. The advantage of such heterogeneity is that the life of network can be drastically increased. The control and coordination roles of the network can be handled by nodes with high energy and nodes with low energy can be used for sensing the environment, hence making the network more efficient in terms of energy.

Future research directions for heterogeneity: with heterogeniety of links and nodes the schemes proposed for homogeneous sensor network are not applicable as their energy drainage and their working differs completely. Further research involving WSN should imbibe heterogeneity for routing, clustering, localization, target tracking. Since the advantage of heterogeneity in WSN prolongs the life of network.

3.2 Mobility: The nodes in WSN can move from one location to another [11-12]. This movement of nodes help in effectively avoiding the network disconnection due to node failures making the network fault tolerant. The mobility of nodes helps achieve scalability and energy efficiency. Mobility can be associated with sinks and nodes. When sink moves around in the network, the data collection from nodes will be easy and increases the efficiency of the network.

Mobile nodes can replace the nodes dead due to exhaustion of battery. The mobility in WSN is deliberate and hence the movement of nodes can be controlled and coordinated.

The mobility is an issue that is not addressed to an appreciable level in WSN. As many of the proposed schemes use only static WSN where all nodes have fixed location after deployment. But introduction of mobility in turn introduces a great challenge of localizing the nodes. In a Clustered WSN environment, the nodes movement causes the nodes leaves and enters into a new cluster.

Future research directions for mobility: New adaptive schemes have to be developed that consider the network dynamics, with appropriate procedures for nodes leaving and joining the clusters. The evaluation metrics used for static WSN have to be revived to cater to the mobile WSN.

3.3 Clustering: For effective management of WSN nodes can be grouped into non overlapping groups and each of these groups are led by a Cluster Head that manages the activities and scheduling of the nodes that are members of the cluster [7-10]. The cluster head is selected or predetermined. In heterogeneous WSN the nodes with high energy is considered as a CH candidate and nodes with less energy for sensing.

Future research directions for Clustering: Adaptive Clustering schemes are required where the clustering is done on demand, but whole of the network is clustered. A part of the network may be actively sensing and involved in communication and in rest of the network not much activity is seen, in such scenario provisioning clustering schemes should be developed. Provision clustering refers to clustering only in the active regions of the network. This will improve the energy utilization in the network and reduce the number of messages exchanged to set up clusters.

3.4 Security: Due to their communication media, environment and nodes vulnerability WSN are more susceptible to security breaches called attacks [13-15]. Security attacks can be active: here the adversary tries to modify, fabricate the nodes and data content, these attacks leave traces in the network and hence can be detected or passive: here the adversary eavesdrops the communications in the network, based on these communications active attacks can be launched. The other attacks in WSN are Node based attacks: attacks dealing with the maneuver of nodes such as node compromise misbehavior and node replication, Message based attacks: attacks dealing replay of messages and Network based attacks: deals with attacks during routing and time synchronization. These attacks can be overcome by encryption, authentication, trust setup, key establishment, group management, security routing etc

Future research directions for Securing WSN: Adaptive security schemes to support different types of network. Develop light weight key management schemes and authentication to support resource constrained WSN. Techniques to provision security based on need and level of compromise. Security schemes for mobile WSN to support encryption and authentication.

4. CONCLUSION

Wireless Sensor Networks is a real time network with very high potential to deal with critical environment. The unique properties of WSN its size, environment, capability etc. This paper summarizes the basics of WSN, significant issues affecting the design of WSN for widening the applicability, challenges faced by WSN, future research directions in each of these issues. This survey will hopefully motivate the future researchers to develop smart, robust and scalable schemes to make the network more efficient in terms of energy and performance.

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