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Emerging Issues in Wireless Sensor Networks

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ABSTRACT

Wireless communication technologies have advanced over years of research work and developments. In recent times wireless sensor networks have received significant attention from researchers due to its unlimited potential. However despite all this effort at providing improved services in these areas, issues still remain unsolved and many more have emerged based on the proffered solutions. This paper is focused on presenting to the reader emerging issues in wireless sensor networks. I have concentrated on grouping emerging issues in Wireless sensor network into three broad groups namely; the system group issues, the communication protocol issues and the service group issues. By solving these issues, we can close the wide gap between Wireless Sensor Network Technology invention and its deployment on the field

1. Introduction

Wireless sensor networks (WSN) have drawn the attentions of research communities in the last few years, driven by a wealth of theoretical and practical challenges. This growing interest can be largely attributed to the proliferation of Micro-Electro–Mechanical-Systems (MEMS) [1] technology and new applications enabled by large-scale networks of small devices capable of harvesting information from the physical environment, performing simple processing on the extracted data and transmitting it to remote locations. Significant results in this area over the last few years have ushered in a surge of civil and military applications such as system tracking and environment monitoring. As of today, most deployed wireless sensor networks measure scalar physical phenomena like temperature, pressure, humidity, or location of objects [2].

WSNs host its peculiar challenges on the unique characteristics of this network which are different from the traditional already established internet protocol networks. Some of the characteristics of the WSNs include; Power consumption constrains for nodes since batteries

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are used.

- Highly prone to node failures.
- Mobility of nodes
- Changing network topology
- Communication failures
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Mostly exposed to harsh environmental conditions
- Easy of use
- Unattended operation.

These unique characteristics has formed the backbone of emerging issues in WSNs. Emerging issues are broad; however this work presents them in three groups. The first group is the *systems* which consist of sensor nodes; the sensor nodes could be termed Generic nodes or Gateway nodes. Generic nodes take measurement from monitored environments, while Gateway nodes gather data from generic nodes and convey them to the base station. Each sensor node is an individual system. In order to support different application software on a sensor system, researchers need to develop new platforms, operating systems, and storage schemes. The second group is *communication protocols*, which enable communication between the application and sensors. They also enable communication between the sensor nodes. 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, researchers must look into new energy-efficient protocols though some have been proposed for all layers of the protocol stack to meet WSN requirement. The last group is *services* which are developed to enhance the application and to improve system performance and network efficiency. Each of this group poses unique challenges to researchers. Figure 1 shows the groups. The rest of this paper is organized as follows; section two presents the research issues in the systems, while section three presents the challenges in the communication protocols stack and section four presents the research areas in the network services finally section five concludes.

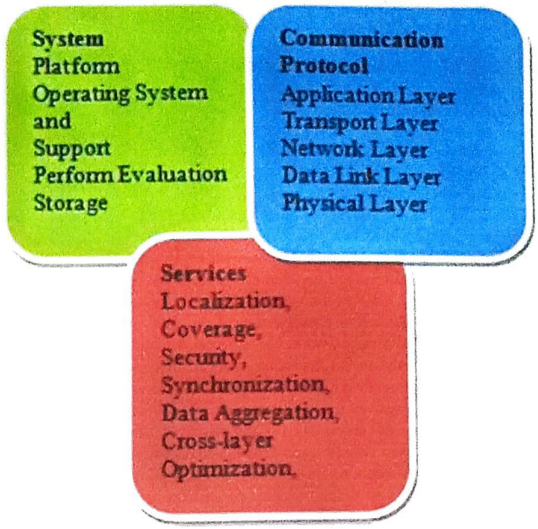

Figure 1: Broad Classification of various issues in WSN

2 Research Issues In Wsn Systems

For a sensor to operate in a WSN, there are several internal system issues that need to be addressed. This section takes a view of these issues.

i. System Platform and OS support

WSN platforms are built to support a wide range of sensor technology. Sensor products available in the markets have different radio components, processsors, and storage. It is therefore a challenge to integrate different wireless sensors on a WSN platform since sensor hardwares are different and processing raw data can be a problem with limited resources in the sensor node [3]. System software such as the OS must be designed to support these sensor platforms. Re search in this area involves designing platforms that support automatic management, optimizing network longevity, and distributed programming.

ii. Standard

A standard specifies the functions and protocols necessary for sensor nodes to interface with a variety of networks. There are a number of standardization bodies in the field of WSNs. The IEEE focuses on the physical and MAC layers; the Internet Engineering Task Force works on layers 3 and above. In addition to these, bodies such as the International Society of Automation provide vertical solutions, covering all protocol layer. Some of the already established standards include the IEEE 802.15.4 [3], ZigBee [4, 5], Wireless HART [6, 7], ISA100.11 [8], IETF 6LoWPAN [9-11], IEEE 802.15.3 [12], Wibree [13]. Several standards are currently either ratified or under development for wireless sensor networks, standards in wireless networks must bear in mind WSNs unique characteristics mentioned in section one.

iii. Storage

Conventional approaches in WSNs require that data be transferred from sensor nodes to a centralized base

station because storage is limited in sensor nodes. Techniques such as aggregation and compression reduce the amount of data transferred, thereby reducing communication and energy costs. These techniques are important for real-time or event-based applications, but they may not suffice. Applications that operate on a query-and-collect approach will selectively decide which data are important to collect.

Given that storage space is limited and communication is expensive, a storage model is necessary to satisfy storage constraints and query requirements. Though some storage models exist such as; Graph Embedding (GEM) [14], Two-tier sensor storage architecture (TSAR) [15] and Multi-resolution storage [16]. Emerging issues in storage models is anchored on the limited memory space and size as such the requirements for an efficient memory space include: (1) minimizing storage size to maximize coverage/data retention; (2) minimizing energy; (3) supporting efficient query execution on the stored data (note that in the reach back method where all the data must be sent to the observer, query execution is simply the transfer of the data to the observer)[17]; and (4) providing efficient data management under constrained storage. Several approaches to storage management have been proposed to meet the above requirements, with most approaches involving a tradeoff among these different goals.

3 ISSUES IN COMMUNICATION PROTOCOL

A network consist of several nodes, each nodes uses the protocol stack to communication with each other. Hence researchers must focus on developing a reliable and energy efficient protocol stack. It is important to optimize communication and minimize energy usage. However traditional networking protocols do not work well in a WSN since they are not designed to meet WSN requirement. Design issues still remain in each of the five standard protocol layers, this include; application layer, transport layer, network layer, data-link layer, and physical layer.

The transport layer ensures the reliability and quality of data at the source and the sink. Transport layer protocols in WSNs should support multiple applications, variable reliability, packet-loss recovery, and congestion control mechanism. Although many transport layer protocols have been proposed for WSN, such as sensor transmission control protocols (STCP) [18], price-oriented reliable transport protocol (PORT) [19], Delay sensitive transport protocol. There are still several open research problems such as cross-layer optimization, fairness, and congestion control with active queue management. The transport layer can benefit from cross-layer interactions. Cross-layer interactions can improve the performance of the transport protocol by selecting better paths for retransmission and getting error reports from the link layer. There are some researches in this area; however, cross-layer optimization across multiple layers needs to be explored more. Current congestion control mechanisms focus on monitoring of the channels and dynamically adjusting the data rate of the source when congestion occurs. There is no active monitoring of the queue to avoid congestion. Incorporating active queue management with congestion control may further reduce packet loss and increase throughput. The transport protocol should guarantee fairness among sensor nodes. One solution to this problem is to assign packets with priority. The problem of guaranteeing fairness in a frequently-changing topology has not been extensively explored.

The network layer handles routing of data across the network from the source to the destination. Routing protocols in WSNs differs from traditional routing protocols in several ways. For one, sensor nodes do not have Internet protocol (IP) addresses, so IP-based routing protocols cannot be used in a WSN. The design of network protocols in a WSN needs to be scalable. It should easily manage communication among many nodes and propagate sensor data to the base station. The protocol should meet network resource constraints such as limited energy, communication bandwidth, memory, and computation capabilities. By meeting these constraints, a sensor network's lifetime can be prolonged. Lastly, the protocol should address issues of efficiency, fault tolerance, fairness, and security.

The data-link layer is concerned with the data transfer between two nodes that shares the same link. Since the underling technology is wireless there is a need for an energy efficient medium access control and management protocol. The protocol must put in mind, frame synchronization, fairness, bandwidth utilization, flow control and error control for data communication. Although several MAC protocols have been proposed the researcher may still take a look at system performance optimization, cross layer optimization, energy optimization and improving communication reliability.

The physical layer provides an interface for transmitting bit streams over the physical communication medium. The physical layer is responsible for interacting with the MAC layer, performing transmission and reception, and modulation. The physical layer must be designed with consideration of WSN requirements. Researchers must look into design of an energy efficient radio transmitter, optimal transmission power, good modulation scheme. Other WSN requirements that should be put into considerations at the physical layer design includes; Interference, synchronization and multi -casting.

4 ISSUES IN NETWORK SERVICES

Network services include sensor provisioning, management, and control. These are developed to coordinate and manage sensor nodes. Provisioning involves coverage and localization. Management and control services play key roles in WSNs as they provide support to middleware services such as security, synchronization, data compression and aggregation cross-layer optimization, e.t.c. Provisioning, management, and control services are needed to sustain network connectivity and maintain operations. Provisioning services such as localization and coverage can improve network performance. Efficient algorithms can reduce the cost of localization while sensor nodes are able to self-organize and identify themselves in some spatially coordinated system. Localization has been studied extensively to minimize energy, cost, and localization errors. The problem of energy conservation while maintaining a desired coverage has also been studied. Coverage efficiency depends on the number of active nodes. The more active nodes there are in the network, the higher is the degree of coverage. Coverage protocols should meet different levels of coverage requirements and be energy efficient. Existing solutions have investigated different degrees of coverage along with network connectivity. Future research and development should continue to focus on optimizing coverage for better energy conservation. Management and control services include synchronization, data aggregation and compression, security, and cross-layer optimization. In a dense WSN, there is a need for network-wide time synchronization. Time synchronization eliminates event collision, energy wastage, and non-uniform updates. Proposed time synchronization protocols aim to synchronize local node clocks in the network and reduce energy overhead. Continuing research should focus on minimizing uncertainty errors over long periods of time and dealing with precision. With large amounts of data generated over time, the cost of transferring all of the sensed data to the base station is expensive. Data compression and aggregation techniques aid in reducing the amount of data to be transferred. The development of various compression and aggregation scheme for event-based or continuous data collection network is a challenging research topic. For security monitoring in a WSN, secure protocols have to monitor, detect, and respond to attacks with uninterrupted service. Many proposed secure protocols are for the network layer and data-link layer. Malicious attacks can occur at any layer in the protocol stack. Secure monitoring for different layers of the protocol stack need to be explored. Cross-layer secure monitoring is another challenging area for research.

5 Conclusion

This paper, aimed at presenting the research areas in wireless sensor networks has briefed the reader with some of the challenges in WSN in three groups; challenges in the systems, this included Platform, Operating System and Storage, we went on to show challenges in the second group, communication protocol stack as well as the research areas in the third group WSN services. However there lie a lot of research issues in WSN applications such as communication architectures, security, and management. By solving these issues, we can close the gap between WSN technology and application.

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