An Intrinsic Study on Wireless Sensor Networks and its Issues

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Abstract

Wireless sensor networks are one of the most interesting and challenging research domains of our time. They have a great potential to be deployed in wide critical applications, such as military monitoring, health care as well as civilian applications. The highly sensitive nature of collected information makes security in these special networks a crucial concern. Owing to the hostile nature of their deployment environments, the wireless medium and the constrained nature of resources on the tiny sensor devices used in such networks, security poses more severe challenges compared to the traditional networks. As attacks to any part of the hardware or software may gives significant damages to these networks. Indeed, the development of effective and efficient defense mechanisms to those attacks must be addressed at every stage of the system design. Wireless sensor networks have attracted a wide range of disciplines where close interactions with the physical world are essential. The distributed sensing capabilities and the ease of deployment provided by a wireless communication paradigm make WSNs an important component of our daily lives. Energy conservation emerges as one the most critical aspect in hardware and software related design issues. Also other related main issues include specialized hardware, software and operating system, synchronization, QOS, security, architecture and data collection related aspects with minimum communication and computation costs. This paper provides an overall view of various such issues for the better understanding of this field for the overall benefit of the research community working in this area.

Keywords: Wireless Sensor Networks, Sensor Networks, Sensor Node

I. INTRODUCTION

In computer networking there is a great value of wireless networking because it has no difficult installation, no more expenditure and has lot of way to save money and time. In the field of wireless networking there is another form of networking which is called as wireless sensor network. A type of wireless networking which is comprised on number of numerous sensors and they are interlinked or connected with each other for performing the same function collectively or cooperatively for the sake of checking and balancing the environmental factors. This type of networking is called as Wireless sensor networking.

A wireless sensor network is a group of specialized transducers with a communications infrastructure for monitoring and recording conditions at diverse locations. The main work of the sensors is to translate sensing and identification activities into services. Also to Embed, Network and disseminate to provide services to different clients. Commonly monitored parameters are temperature, humidity, pressure, wind direction and speed, illumination intensity, vibration intensity, sound intensity, power-line voltage, chemical concentrations, pollutant levels and vital body functions.

Total working of wireless sensor networking is based on its construction. Sensor network initially consists of small or large nodes called as sensor nodes. These nodes are varying in size and totally depend on the size because different sizes of sensor nodes work efficiently in different fields. Wireless sensor networking have such sensor nodes which are specially designed in such a typical way that they have a microcontroller which controls the monitoring, a radio transceiver for generating radio waves, different type of wireless communicating devices and also equipped with an energy source such as battery.

A sensor network is composed of a large number of sensor nodes, which are densely deployed either inside the phenomenon or very close to it. The position of sensor nodes need not be engineered or pre-determined. This allows random deployment in inaccessible terrains or disaster relief operations. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing capabilities. Another unique feature of sensor networks is the cooperative effort of sensor nodes. Sensor nodes are fitted with an on-board processor. Instead of sending the raw data to the nodes responsible for the fusion, sensor nodes use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data.

II. SENSOR NODE

A sensor node is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. The main components of a sensor node are a microcontroller, transceiver, external memory, power source and one or more sensors.

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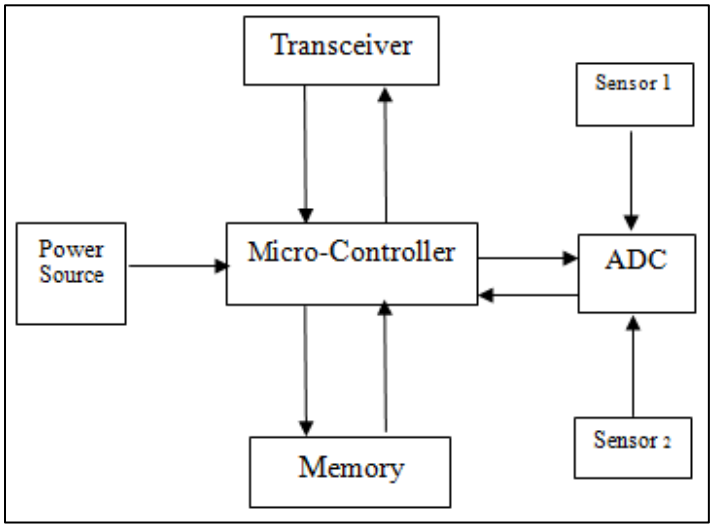

Fig. 1: Block Diagram of a Sensor Node

III. COMPONENTS OF SENSOR NODE

The controller performs tasks, processes data and controls the functionality of other components in the sensor node. The functionality of both transmitter and receiver are combined into a single device known as a transceiver. Transceivers often lack unique identifiers. The operational states are transmit, receive, idle, and sleep. Current generation transceivers have built-in state machines that perform some operations automatically.

Memory requirements are very much application dependent. Two categories of memory based on the purpose of storage are: user memory used for storing application related or personal data, and program memory used for programming the device. An important aspect in the development of a wireless sensor node is ensuring that there is always adequate energy available to power the system. The sensor node consumes power for sensing, communicating and data processing. More energy is required for data communication than any other process. Power is stored either in batteries or capacitors. Batteries, both rechargeable and non-rechargeable, are the main source of power supply for sensor nodes.

Sensors are used by wireless sensor nodes to capture data from their environment. They are hardware devices that produce a measurable response to a change in a physical condition like temperature or pressure. Sensors measure physical data of the parameter to be monitored and have specific characteristics such as accuracy, sensitivity etc.

Sensors are classified into three categories: passive, unidirectional sensors; passive, narrow-beam sensors; and active sensors. Passive sensors sense the data without actually manipulating the environment by active probing. They are self powered; that is, energy is needed only to amplify their analog signal. Active sensors actively probe the environment and they require continuous energy from a power source. Narrow-beam sensors have a well-defined notion of direction of measurement, similar to a camera. Unidirectional sensors have no notion of direction involved in their measurements.

IV. FEATURES OF WIRELESS SENSOR NETWORKS

- Readiness for field deployment: measures maturity for field deployment in terms of economic and engineering efficiency.
- Scalability: a sensor's scalability to distributed environmental monitoring tasks requires that the sensors be small and inexpensive enough to scale up to many distributed systems.
- Cost: Sensors are deployed in thousands. It is expected that cost will drop but current generation sensors are still expensive to allow wide deployment.

A. Potential Applications of Wireless Sensor Networks

WSN applications are created for areas including health care, utilities, precision agriculture and remote monitoring. In health care, wireless devices make less invasive patient monitoring and health care possible. For utilities such as the electricity grid, streetlights, and water municipals, wireless sensors offer a lower-cost method for collecting system health data to reduce energy usage and better manage resources. Remote monitoring covers a wide range of applications where wireless systems can complement wired systems by reducing wiring costs and allowing new types of measurement applications. Remote monitoring applications include:

- Environmental monitoring of air, water, and soil
- Structural monitoring for buildings and bridges
- Industrial machine monitoring
- Process monitoring in Disaster relief operations and agriculture

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- Asset tracking
- Biodiversity Mapping

B. Issues in Wireless Sensor Networks

Major issues that affect the design and performance of a wireless sensor network are as follows:

1) Energy

Sensors require power for various operations. Energy is consumed in data collection, data processing, and data communication. Sometimes it becomes difficult to recharge or change the batteries because of demographic conditions. The most crucial research challenge for the WSN researchers is to design, develop and implement energy efficient hardware and software protocols for WSNs.

2) Self-Management

Wireless sensor networks once deployed should be able to work without any human intervention. It should be able to manage the network configuration, adaptation, maintenance, and repair by itself.

3) Hardware and Software Issues

Sensor Networks consists of hundreds of thousands of nodes. It is preferred only if the node is cheap. The central processing unit of sensor node determines energy consumption and computational capabilities of a node. For saving of power, microcontroller should have three states-active, sleep, idle. Software in WSN should be hardware independent besides being light and less energy consuming.

4) Operating System

Operating System for WSNs should be less complex than the general operating systems. It should have an easy programming paradigm. Application developers should be able to concentrate on their application logic instead of being concerned with the low level hardware issues like scheduling, preempting and networking.

5) MAC Layer Issues

Medium Access Control (MAC) solutions have a direct impact on energy consumption, as some of the primary causes of energy waste are found at the MAC layer: collisions, control packet overhead and idle listening.

6) Quality of Service (QoS)

Quality of service is the level of service provided by the sensor networks to its users. WSN are being used in various real time and critical applications, so it is mandatory for the network to provide good QoS.

7) Architecture

Architecture can be considered as a set of rules and regulation for implementing some functionality along with a set of interfaces, functional components, protocols and physical hardware. Lack of Sensor Network architecture is limiting feature and hampers the progress in this field. Sensor network architecture should be durable and scalable.

8) Data Collection and Transmission

Data gathering is the main objective of sensor nodes. The sensors periodically sense the data from the surrounding environment, process it and transmit it to the base station or sink. Data gathering involves data collection and transmitting data to the sink node.

9) Calibration

Calibration is the process of adjusting the raw sensor readings obtained from the sensors into corrected values by comparing it with some standard values. Manual calibration of sensors in a sensor network is a time consuming and difficult task due to failure of sensor nodes and random noise which makes manual calibration of sensors too expensive.

10) Deployment

Deployment means implementing the wireless sensor network in real world location. It is very laborious and cumbersome activity and depends on the demographic location of the application that how network will be deployed. Deployment of sensor networks results in network congestion due to many concurrent transmission attempts made by several sensor nodes.

11) Limited Memory and Storage Space

A sensor is a tiny device with only a small amount of memory and storage space for the code. In order to build an effective security mechanism, it is necessary to limit the code size of the security algorithm.

12) In-network Processing

To reduce communication costs some algorithms remove or reduce nodes redundant sensor information and avoid forwarding data that is of no use. As nodes can inspect the data they forward they can measure averages or directionality for example of readings from other nodes.

13) Decentralized Management

The large scale and energy constraints of many WSNs make it infeasible to rely on centralized algorithms to implement network management solutions such as topology management or routing. While the decentralization may lead to non-optimal routes, the management overheads can be reduced significantly.

14) Fault Tolerance

Sensor network should remain functional even if any node fails while the network is operational. Network should be able to adapt by changing its connectivity in case of any fault. In that case, well- efficient routing algorithm is applied to change the overall configuration of network.

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15) Robustness

In order to support the lifetime requirements demanded, each node must be constructed to be as robust as possible. To achieve this, the system must be constructed so that it can tolerate and adapt to individual node failure. Additionally, each node must be designed to be as robust as possible.

16) Interpreting Data and Formation of Knowledge

Main challenges for data interpretation and the formation of knowledge include addressing noisy, physical world data, and developing new inference techniques. Uncertainty in interpreted data can easily cause users not to trust the system. It is necessary to develop techniques that convert this raw data into usable knowledge in an energy efficient manner.

17) Heterogeneity

It is a group in which all the nodes are not identical and do not have same capability i.e. some node are more powerful than others. Example of heterogeneous group is cluster architecture in which node form a cluster head and gather data from less powerful node. Heterogeneity arises when two completely different WSNs need to communicate with each other. Unified communication interfaces will be required to enable efficient information exchange across diverse systems and nodes.

18) Multimedia Communication

Multimedia information is collected and communicated by the sensor network. In addition to data delivery modes typical of scalar sensor networks, multimedia data include snapshot and streaming multimedia content. Processing and delivery of multimedia content are not independent and their interaction has a major impact on the achievable QoS. They demand high bandwidth for transmission.

19) Real Time Operation

Many real-time wireless sensor networks must achieve real-time performance over extremely long lifetimes. While energy harvesting has shown promise as an enabling technology for long-running wireless sensor networks, it also introduces new challenges to real-time processor scheduling due to fluctuating energy sources and limited capacity of energy storage.

20) Synchronization

Time Synchronization in a sensor network aims to provide a common timescale for local clocks of nodes in the network. A global clock in a sensor system will help process and analyze the data correctly and predict future system behavior. Sensors need to be synchronized with each other, as it may lead to inaccurate data estimation. Some synchronization protocols have high accuracy so they need more resources which results in energy loss. So, synchronization needs to be implemented correctly based on the application.

21) Secure Localization

Often, the utility of a sensor network will rely on its ability to accurately and automatically locate each sensor in the network. A sensor network designed to locate faults will need accurate location information in order to pinpoint the location of a fault. Unfortunately, an attacker can easily manipulate non secured location information by reporting false signal strengths, replaying signals, etc.

While the set of challenges in sensor networks are diverse, we also focus on fundamental networking challenges. The key networking challenges in sensor networks that are present are: (a) supporting multi-hop communication while limiting radio operation to conserve power, (b) data management, including frameworks that support attribute-based data naming, routing and in-network aggregation, (c) geographic routing challenges in networks where nodes know their locations, and (d) monitoring and maintenance of such dynamic, resource-limited systems.

V. CONCLUSION

Wireless Sensor Networks have created wide range of challenges that still needs to be addressed. This paper concentrates on the Wireless Sensor Network (WSN) and the Sensor node along with its components. Various Issues faced by the researchers and the difficulties regarding the issues are also discussed in this paper. The issues regarding the networking and how it is essential for the researchers to overcome these problems are also discussed. After overcoming the challenges faced by the researchers, the efficiency and the capability of the WSN will be enjoyed by all the end-users. This field is surely going to give us tremendous opportunity to change the way we perceive the world today.

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