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An overview of Wireless Sensor Networks

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ABSTRACT

Wireless Sensor Networks are the infrastructure based sensing, computing and communication element which provides its controllers the ability to measure, to collect and to react to the occurrences in the monitored environment. Wireless sensor networks can be considered as the interfaces between the physical and the virtual worlds. WSNs are the one of the most rapidly developing information technologies over the last few years because of their widespread applications. This paper gives an overview on the field of Wireless Sensor Networks and it focuses on outlining general ideas behind WSNs and the technology being used to implement these ideas.

Keywords: Mesh Network, Star Network, Industrial Automation

INTRODUCTION

Wireless sensor networks (WSN) are currently receiving significant attention due to their unlimited potential. A wireless sensor network is a collection of nodes organized into a cooperative network. The sensor nodes can communicate among themselves using radio signals. Wireless Sensor Networks are wireless networks that usually consist of a great number of far distributed devices that are equipped with sensors (instruments that measure quantities in our environment) to monitor physical or environmental phenomenon.

These devices work autonomous and are logically linked by self-organizing means. A wireless sensor node is equipped with sensing, radio transceivers and power components and computing devices. Individual nodes in wireless sensor network (WSN) are resource constrained as they have limited storage capacity processing speed, and bandwidth.[1]
The emerging wireless sensor networks combines computation, and communication sensing, into a single tiny device. Through mesh networking protocols, these devices form a channel of connectivity that extends the reach of cyberspace out into the physical world. Then the onboard sensors start collecting information of interest. The Wireless sensor devices respond to queries sent from a “control site” to perform specific instructions or provide sensing signals. The working of the sensor nodes may be either continuous or event driven.

The power of the wireless sensor networks lies in the ability to deploy large numbers of tiny nodes that can assemble and re configure themselves. Usage of all these devices range from real-time tracking, to monitoring of environmental conditions, and the to ubiquitous computing environments

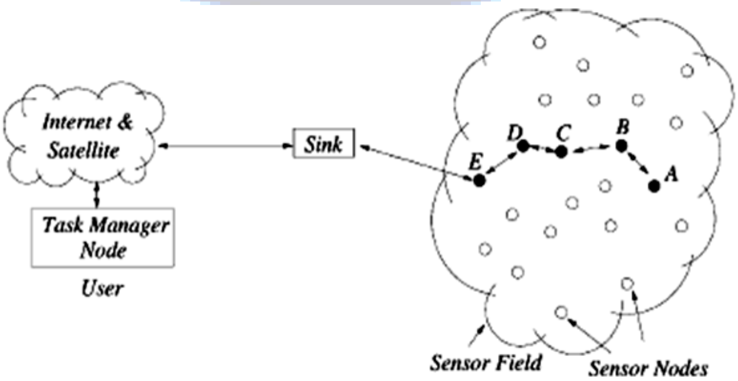

Figure 1: A typical Wireless Sensor Network

The most common application of wireless sensor network technology is to monitor remote environments for low frequency data trends. For instance in case of monitoring a chemical plant could be easily done for any of leakage by hundreds of sensors that can automatically form a wireless interconnected network and then immediately reports to the detection of any chemical leakage to the control room.

Wireless sensor networks (WSNs) enables new applications and requires non-conventional steps for protocol design due to several constraints. The requirement for an energy efficient network (i.e. long network lifetime), there must have to be a proper balance between the signal and data processing capabilities communication and must be available.

This requirement motivates a need of huge effort in research activities, adaptation mechanisms and standardization process, and this can respond to the changes in the network topologies or it can causes the network to shift drastically between different modes of operation.[2] Current wireless communication systems only touches the surface of the possibilities emerging from the integration of these sensing, energy storage low power communication, and the computation. [3]

THEORITICAL BACKGROUND

A wireless sensor network is composed of a very large number of nodes which are being deployed densely very close to the phenomenon being monitored. These nodes collect data and then route this information back to the sink. The wireless sensor network must possess the self-organizing capabilities as the positions of individual nodes are not determined prior. Cooperation among nodes is the highly desired and the dominant feature of these of network,
as the various nodes in a group cooperate with each other nodes to disseminate the information

The basic differences between the wireless sensor and ad-hoc networks are:

- The number of nodes can of extremely orders of magnitude
- WSNs have a Limited processing and power capabilities
- In WSN there is broadcast type of communication
- WSN Sensor nodes are more prone to failure.
- In WSN there is a frequent topology change
- All the Sensor nodes are very densely placed

There are a large number of challenges in the deployment of sensor networks which are very large as compared to those found in wireless ad hoc networks. Wireless sensor nodes can communicate over lossy lines and wireless networks without infrastructure. [4]

Fault Tolerance: In WSN the Individual nodes are more prone to failures with a high probability than the other types of networks. It is desired that the network should sustain the information dissemination irrespective of failures. Wireless Sensor nodes are more vulnerable and these are more frequently deployed in dangerous environments. Any of the sensor nodes can fail either due to hardware problems or any physical damage or by exhausting their energy supply.

Scalability: the WSN protocols should be able to scale to such high degree and should be able to take advantage of the very high density networks. Wireless Sensor networks vary in scale from several nodes to potentially several thousand. Thus for collecting high resolution data, node density might reach the level where a node has several thousand neighbours in their transmission range. Thus the protocols deployed in sensor networks must be able to scalable to these levels and side by side maintaing adequate performance

Production Costs: Because of many deployment models considered sensor nodes to be disposable devices. Wireless sensor networks can compete with traditional information gathering approaches only if the individual sensor nodes can be produced very cheaply. The cost of a single node must be low, much less than a dollar..

Hardware Constraints: A sensor node is comprised of many sensing, processing, communication, power, location Finding system, power scavenging and mobilizing units. All these units combined together must consume extremely low power and be contained within an extremely small volume.

Sensor Network Topology: Must be maintained even with very high node densities.

Environment: wireless sensor nodes operates in inaccessible locations because of the hostile environment

Transmission Media: The communication between the nodes is normally implemented using radio communication. However, some sensor networks may use optical or infrared communication, the latter having the advantage of being robust and virtually interference free.

Power Consumption: Power conservation and power management are primary design factors. The size of the nodes limits the size of the battery. The software and hardware design needs to carefully consider the issues of efficient energy use. The energy policy also depends on the application; in some applications, it might be acceptable to turn off a subset of nodes in order to conserve energy while other applications require all nodes operating simultaneously.

WIRELESS SENSOR NETWORKS ARCHITECTURE

There are a number of different topologies for radio communications networks. A brief discussion of the network topologies that apply to wireless sensor networks are outlined below.

A. Star Network (Single Point-to-Multipoint)

A star network is a communications topology where a single base station can send and/or receive a message to a number of remote nodes. Remote nodes can only send or receive a message from the single base station and they are not permitted to send messages to other nodes. The advantage of this type of network is in its simplicity and the ability to keep the remote node's power consumption to a minimum.

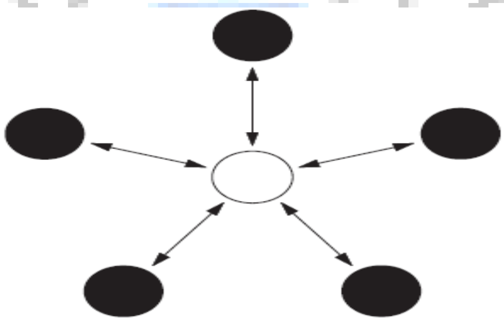

Figure 2: Star Network

It also allows low latency communications between the remote node and the base station. Disadvantage of such a network is that the base station must be within radio transmission range of all the individual nodes and is not as robust as other networks due to its dependency on a single node to manage the network.

B. Mesh Network

A mesh network allows any node in the network to transmit to any other node in the network which is within its radio transmission range. This is the desired feature of multi-hop communications, in which if any node wants to send a message to another node that is out of radio communications range, it uses an intermediate node to forward the message. This mesh network topology has the advantage of redundancy and scalability. In case of failure of an individual node, any remote node still can communicate to any other node in its range, which in turn, can forward the message to the desired location

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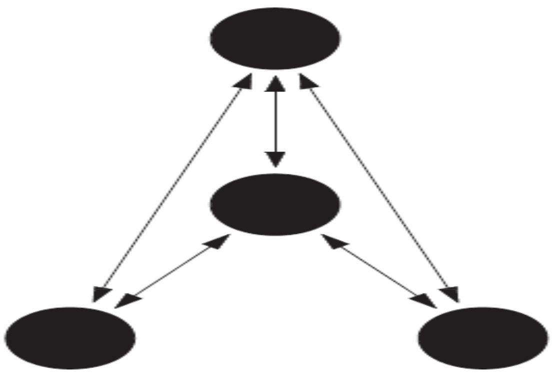

Figure 3: Mesh Network

Moreover, the range of the network is not limited by the range in between single nodes; range can simply be extended by adding more nodes to the system.. Additionally, as the number of communication hops to a destination increases therefore the time to deliver the message also increases, especially when low power operation of nodes is a required. The disadvantage of this type of network is in power consumption for the nodes that implement the multi hop communications are generally higher than for the nodes that don't have this capability and this often limits the battery life.[7]

C. Hybrid Star – Mesh Network

A hybrid between the star and mesh network provides a robust and versatile communications network, while it maintains the ability to keep the power consumption wireless sensor nodes to a minimum.

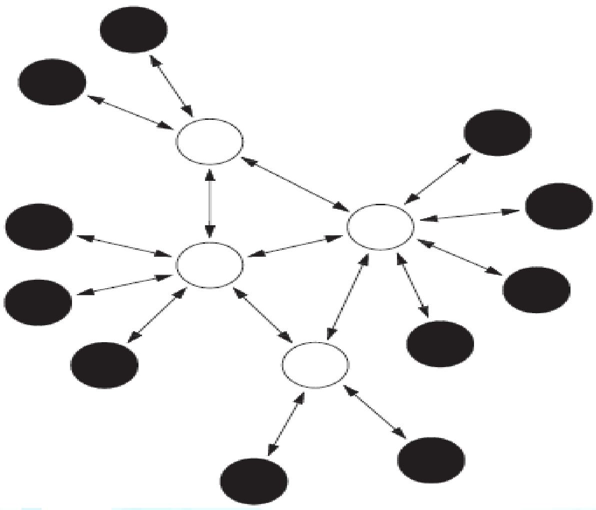

Figure 4: Hybrid Star-Mesh Network

In this network topology, the lowest power sensor nodes are not enabled with the ability to forward messages. It allows the requirement for minimal power consumption to be maintained. Other nodes on the network are enabled with multi-hop capability that allows them to forward messages from the low power nodes to other nodes on the network. The nodes with the multi-hop capability are higher power, and are often plugged into the electrical mains line.

APPLICATIONS OF WIRELESS SENSOR NETWORKS

A Structural Health Monitoring – Smart Structures

Sensors embedded into machines and structures enable condition-based maintenance of these assets. The structures or machines are inspected at regular time intervals, and components may be repaired or replaced based on their hours of usage in service not on their working conditions. Although this method is expensive if the components are in good working order, also in some cases, the scheduled maintenance will not protect the asset if it was damaged in between the inspection intervals. The wireless sensing will allow assets to be inspected when the sensors indicate that there might be a problem, thus reduced cost of maintenance and preventing catastrophic failure in the event that damage is detected [6]

In some cases, wireless sensing applications demand the elimination of not only the lead wires, but also the elimination of batteries as well, because of the inherent nature of the machine, structure, or materials under test. Most of these applications include sensors mounted on continuously rotating parts, within concrete and composite materials and within medical implants

B. Industrial Automation

In addition to being expensive, lead wires can be constraining, especially when moving parts are involved. There the use of wireless sensors allows for rapid installation of sensing equipment and allows access to locations that would not be practical if cables were attached previously, the use of wired sensors was too cumbersome to be implemented in a production line environment. The usage of wireless sensors in this application is to enable and to allow a measurement to be made that was not previously practical. Other applications include energy control systems, location-based services for logistics, and health care. Security, wind turbine health monitoring environmental monitoring.

C. Civil Structure Monitoring

One of the most recent applications sensor networks is structural health monitoring of large civil structures, , The wireless sensing nodes were packaged in environmentally sealed NEMA rated enclosures. And the strain gauges were also suitably sealed from the environment and were spot welded to the surface of the bridge steel support structures. The transmission range of the sensors on this star network was approximately 100 meters.[5]

CONCLUSION

Wireless sensor networks are enabling applications that previously were not practical. As new standards based networks are released and low power systems are continually developed, widespread deployment of wireless sensor networks. In telecommunications, wireless sensor networks are an active research area. All of this sensor network research is generating a new technology which is already appearing in many practical applications. In recent future an accelerated pace of adoption of this technology would be seen.

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