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Review of Wireless Sensor Networks- Architecture and Applications

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Abstract
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. Each node consists of processing capability. In this Paper, I Concentrate on Architecture and the applications of Wireless Sensor Networks .I have also mentioned future scope of WSN. The network must possess self-organizing capabilities since the positions of individual nodes are not predetermined.
Keywords: *Mesh Network, Star Network, Industrial Automation.*

I. INTRODUCTION

The emerging field of wireless sensor networks combines sensing, computation, and communication into a single tiny device. Through advanced mesh networking protocols, these devices form a sea of connectivity that extends the reach of cyberspace out into the physical world. The power of wireless sensor networks lies in the ability to deploy large numbers of tiny nodes that assemble and configure themselves. Usage scenarios for these devices range from real-time tracking, to monitoring of environmental conditions, to ubiquitous computing environments.

The most straightforward application of wireless sensor network technology is to monitor remote environments for low frequency data trends. For example, a chemical plant could be easily monitored for leaks by hundreds of sensors that automatically form a wireless interconnection network and immediately report the detection of any chemical leaks. Unlike traditional wired systems, deployment costs would be minimal.

In addition to drastically reducing the installation costs, wireless sensor networks have the ability to dynamically adapt to changing environments. Adaptation mechanisms can respond to changes in network topologies or can cause the network to shift between drastically different modes of operation.
Current wireless systems only scratch the surface of possibilities emerging from the integration of low-power communication, sensing, energy storage, and computation. Unlike traditional wireless devices, wireless sensor nodes do not need to communicate directly with the nearest high-power control tower or base station, but only with their local peers. Instead, of relying on a pre-deployed infrastructure, each individual sensor or actuator becomes part of the overall infrastructure. Peer-to-peer networking protocols provide a mesh-like interconnect to shuttle

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data between the thousands of tiny embedded devices in a multi-hop fashion.

II. LITERATURE

A sensor network is de_ned as being composed of a large number of nodes which are deployed densely in close proximity to the phenomenon to be monitored. Each of these nodes collects data and its purpose is to route this information back to a sink. The network must possess self-organizing capabilities since the ositions of individual nodes are not predetermined. Cooperation among nodes is the dominant feature of this type of network, where groups of nodes cooperate to disseminate the information gathered in their vicinity to the user.
Major differences between sensor and ad-hoc networks:

- Number of nodes can be orders of magnitude higher.
- Sensor nodes are densely deployed
- Sensor nodes are prone to failure.
- Frequent topology changes
- Broadcast communication paradigm
- Limited power, processing and power capabilities
- Possible absence of unique global identification per node

The authors point out that none of the studies surveyed has a fully integrated view of all the factors driving the design of sensor networks and proceeds to present its own communication architecture and design factors to be used as a guideline and as a tool to compare various protocols. After surveying the literature, this is our impression as well and we include it in the open research issues that can be explored for future work.

The design factors listed by the authors:

Fault Tolerance:

Individual nodes are prone to unexpected failure with a much higher probability than other types of networks. The network should sustain information dissemination in spite of failures.

Scalability:

Number in the order of hundreds or thousands. Protocols should be able to scale to such high degree and take advantage of the high density of such networks.

Production Costs: The cost of a single node must be low, much less than $1.

Hardware Constraints: A sensor node is comprised of many subunits (sensing, processing, communication, power, location Finding system, power scavenging and mobilize). 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: Nodes are operating in inaccessible locations either because of hostile environment or because they are embedded in a structure.

Transmission Media: RF, Infrared and Optical.
Power Consumption: Power conservation and power management are primary design factors.

III. 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 (Figure 1) is a communications topology where a single base station can send and/or receive a message to a number of remote nodes. The remote nodes can only send or receive a message from the single base station; they are not permitted to send messages to each other. The advantage of this type of network for wireless sensor networks is in its simplicity and the ability to keep the remote node's poweatr consumption to a minimum. It also allows for low latency communications between the remote node and the base station. The disadvantage of such a network is that the base station must be within radio

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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.

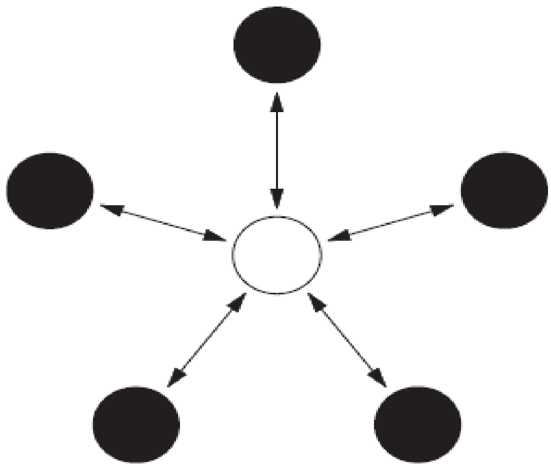

Figure 1: Star Network

B. Mesh Network

A mesh network allows for any node in the network to transmit to any other node in the network that is within its radio transmission range. This allows for what is known as multi-hop communications; that is, if a node wants to send a message to another node that is out of radio communications range, it can use an intermediate node to forward the message to the desired node. This network topology has the advantage of redundancy and scalability.
If an individual node fails, a remote node still can communicate to any other node in its range, which in turn, can forward the message to the desired location. In addition, the range of the network is not necessarily limited by the range in between single nodes, it can simply be extended
by adding more nodes to the system. 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,
often limiting the battery life. Additionally, as the number of communication hops to a destination increases, the time to deliver the message also increases, especially if low power operation of the nodes is a requirement.

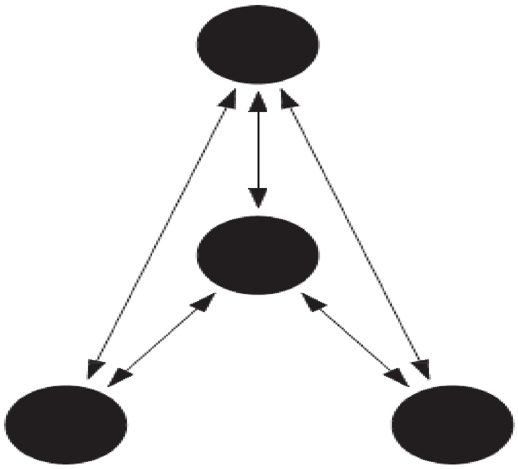

Figure 2: Mesh Network

C. Hybrid Star – Mesh Network

A hybrid between the star and mesh network provides for a robust and versatile communications network, while maintaining the ability to keep the wireless sensor nodes power consumption to a minimum. In this network topology, the lowest power sensor nodes are not enabled with the ability to forward messages. This allows for minimal power consumption to be maintained. However, other nodes on the network are enabled with multi-hop capability, allowing them to forward messages from the low power nodes to other nodes on the network. Generally, the nodes with the multi-hop capability are higher power, and if possible, are often plugged into the electrical mains line.

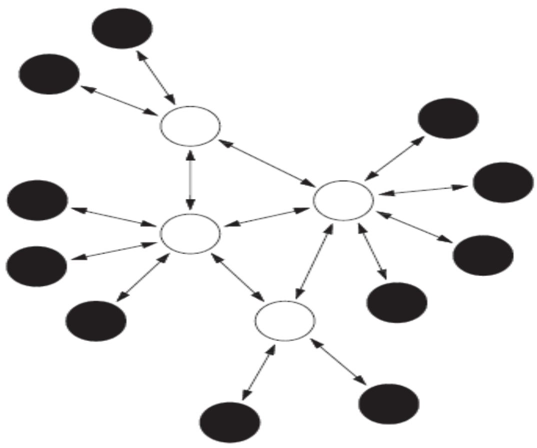

Figure 3: Hybrid Star-Mesh Network

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IV APPLICATIONS OF WIRELESS SENSOR NETWORKS

A. Structural Health Monitoring – Smart Structures

Sensors embedded into machines and structures enable condition-based maintenance of these assets. Typically, structures or machines are inspected at regular time intervals, and components may be repaired or replaced based on their hours in service, rather than on their working conditions. This method is expensive if the components are in good working order, and in some cases, scheduled maintenance will not protect the asset if it was damaged in between the inspection intervals. Wireless sensing will allow assets to be inspected when the sensors indicate that there may be a problem, reducing the cost of maintenance and preventing catastrophic failure in the event that damage is detected.
In some cases, wireless sensing applications demand the elimination of not only lead wires, but the elimination of batteries as well, due to the inherent nature of the machine, structure, or materials under test. These applications include sensors mounted on continuously rotating parts , within concrete and composite materials [5], and within medical implants

B. Industrial Automation

In addition to being expensive, lead wires can be constraining, especially when moving parts are involved. 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. An example of such an application on a production line is shown. In this application, typically ten or more sensors are used to measure gaps where rubber seals are to be placed. Previously, the use of wired sensors was too cumbersome to be implemented in a production line environment. The use of wireless sensors in this application is enabling, allowing a measurement to be made that was not previously practical.

Other applications include energy control systems, security, wind turbine health monitoring, environmental monitoring, location-based services for logistics, and health care.

C. Civil Structure Monitoring

One of the most recent applications of today's smarter, energy-aware sensor networks is structural health monitoring of large civil structures, such as the Ben Franklin Bridge (Figure 22.6.2), which spans the Delaware River, linking Philadelphia and Camden, N.J [9,10]. The bridge carries automobile, train and pedestrian traffic. Bridge officials wanted to monitor the strains on the structure as high-speed commuter trains crossed over the bridge.
A star network of ten strain sensors were deployed on the tracks of the commuter rail train. The wireless sensing nodes were packaged in environmentally sealed NEMA rated enclosures.
The strain gauges were also suitably sealed from the environment and were spot welded to the surface of the bridge steel support structure. Transmission range of the sensors on this star network was approximately 100 meters.

V. FUTURE DEVELOPMENTS

The most general and versatile deployments of wireless sensing networks demand that batteries be deployed. Future work is being performed on systems that exploit piezoelectric materials to harvest ambient strain energy for energy storage in capacitors and/or rechargeable batteries. By combining smart, energy saving electronics with advanced thin film battery chemistries that permit infinite recharge cycles, these systems could provide a long term, maintenance free, wireless monitoring solution

V. 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, we will start to see the widespread deployment of wireless sensor networks. Sensor nodes can be imagined as small computers, extremely basic in terms of their interfaces and their components. In computer science and telecommunications, wireless sensor networks are an active research area with numerous workshops and conferences arranged each year. All of this sensor network research is producing a new technology which is already appearing in many practical

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applications. The future should see an accelerated pace of adoption of this technology.

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