A Survey on Wireless Sensor Network Technologies, Recent Advances and Applications

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Abstract—*Wireless Sensor Network (WSNs) have become one of the most interesting areas of research in the past few years which provides a new paradigm for sensing and monitoring various environments. Wireless Sensor Networks are formed by a large number of sensor nodes, working together to provide a specific task in variety of field which includes military, biological, healthcare, environmental and other commercial applications. The structure of WSNs are highly application dependent. In this paper we study recent trends in WSNs and industry applications; it also includes the research challenges for WSNs.*

Keywords—Wireless Sensor Networks,Recent Advances; Application, Deployments,Protocols.

I. Introduction

To monitor and measure various physical parameters of environments like temperature, fluid levels, strain, humidity etc. in remote and hostile locations. WSNs have gained worldwide attention in recent years. Wireless Sensor Networks formed by thousands of sensors are deployed at different locations operating in different modes. These smart sensors are small, with limited processing and having capabilities of processing, sensing and storing. However nodes are constrained in energy supply and bandwidth. These constraints combined with a specific deployment of large number of nodes have faced various challenges to the design and management of networks. Recent advances in Micro Electro mechanical Systems (MEMS) design have made it possible to construct compact inexpensive wireless sensors [1].
To prolong the life of the network an efficient routing technique is required to deploy a network because in communication significant amount of battery power consume, sensor nodes should consume as little energy as possible, when receiving and transmitting data. The network life can be increased by reducing bandwidth consumption [2].

This paper continues as follows: Section II describes Applications of WSNs, Section III describes the deployment of WSNs, Section IV describes the routing protocol for wireless sensor network, Section V shows the conclusion.

II. Applications of WSNs

Wireless Sensor Networks can formed by different types of sensors such as infrared ,seismic, temperature, air pressure ,light motion or vibrations etc. which are able to monitor a wide variety of environmental conditions. A wide range of applications of WSNs in military, target tracking, environment tracking, healthcare, Disaster and public/Industrial etc.

2.1 Military Application:

Military WSNs can detect information about enemy movement, explosions and other phenomenon of interest. The rapid deployment, fault tolerance and self organization characteristics of WSNs make them promising sensing technique for military. The sensors which used in military applications are chemical, biological radiological, nuclear and explosive detectors, ranging (e.g. radar. Lidar, ultrasonic), imaging (IR. Ladar), noise (acoustic sensor producing audio stream).

2.2 Healthcare Applications:

There is long history of using sensors in medical field and public health. A variety of medical instruments which are embedded with sensors used at hospitals, clinics and homes to provide patients and their healthcare provider insight into physiological and physical health state. This has resulted in reduction of costs, improvement of equipments and better management of patients. The implementation and analysis of WSN based e-Health application [3] are used to make the treatment more effective and efficient.

2.3 Environmental tracking and Monitoring Application:

WSNs can be used to track the management of birds, small animals ,insects and other endangered species and also used to monitor regional environmental changes in plains, forests, oceans, flood levels, precision agriculture etc.Like in forest for fire detection sensor node are strategically, randomly and densely deployed and sensor nodes can relay the exact origin of the fire to end users before the fire is spread uncontrollable.

2.4 Home Application:

In home automation sensor nodes insides the domestic devices can interact with each other and with outer network through satellite or internet. This allows user to manage home devices locally or remote more easily. Managing inventory control, vehicle tracking and interactive museums could be in smart space category.

2.5 Public/ Industrial Application:

Monitoring of Structures, factory, Inventory, Machine and Chemical comes in the Public/Industrial applications .Successful use of Wireless sensors in systems such as Supervisory control and data acquisition has proved that these devices could effectively address the need of industrial applications.

III. Deployments of Wireless Sensor Networks

A WSNs consist of a number of sensor nodes spread across a geographical area. Each node has sufficient Intelligence for signal processing and networking of the data and wireless communication capability. A WSN can be deployed in remote geographical locations by two types, Structured WSNs and Unstructured WSNs. An unstructured WSN is one that contains a dense collection of sensor nodes, which are randomly placed into the field. Therefore network maintenance such as managing connectivity and detecting failures is difficult since so many nodes are used there. In Structured WSN all or some of the nodes are deployed in preplanned manner. To deploy network following network services are necessary i.e. localization of nodes, synchronization, coverage of nodes, data aggregation ,compression and security.

3.1 Localization

Randomly deployed nodes into the environment don't have prior knowledge of their location.The problem of determining the node's position (location) is called localization. Presently existing localization method uses Global Positioning System (GPS) beacon nodes. In beacon node localization method beacon nodes are those nodes which knows their own position.

3.2 Time synchronization

After localization of nodes their synchronization in WSN is important for routing and power conservation. Global time synchronization allows the sensor nodes to transmit data in proper manner. To save energy, sensor nodes could periodically turn on and off to participate in network communication [4].

3.3 Coverage

The quality of monitoring in WSN is depend upon the application. Such as target tracking may require a higher degree of coverage to track target accurately. To overcome the problem of coverage in WSN, different types of protocol can be used such as coverage configuration protocol (CCP), Minimal and Maximal exposure path algorithms, Different Surveillance Service Protocol etc. In CCP a node can be in one of the three states: Sleep, Active and Listen. In Sleep state node turn off its radio unit until its sleep time expires and then it enters in the listen state. In this state node listen the hello massages from its neighbors and collect them to determine coverage to switch state into active state [5].

3.4 Data Aggregation and Compression

To reduce communication cost and increase reliability of data transfer needs both compression and aggregation of data. For WSN applications data compression and aggregation is necessary, because WSNs have large amount of data to send across the network. In data compression technique size of data is reduced before the transmission and decompression of data perform at the base station. For data aggregation data is collected from multiple sources and combine together to transmit to base station.

3.5 Security

To distribute data in any network require adequate security measures to keep data safe in transit. For security of WSN different security routing protocols [6] for different layers like network layer and application layer are used.

IV. ROUTING PROTOCOLS FOR WSNs

For WSNs advanced and extremely efficient communication protocols are required. WSNs are application based or specific, so the design requirement of WSNs changes according to the application. Hence routing protocols requirement are changed from one application to another. All major routing protocols purposed for WSNs can be divided into seven categories

4.1 Location based Protocol:

In location-based protocols, sensor nodes already know their locations. Location information for sensor nodes is required for sensor networks by most of the routing protocols to calculate the distance between two particular nodes so that energy consumption can be estimated. Location-aware routing protocols proposed for WSNs are

- SMECN ,MECN : (Small) Minimum-Energy Communication Network
- GFA: Geographic Adaptive Fidelity
- GEAR: Geographic and Energy-Aware Routing
- SPAN
- TBF: Trajectory-Based Forwarding
- BVGF : Bounded Voronoi Greedy Forwarding
- GeRaF: Geographic Random Forwarding

4.2 Data centric Protocols:

In data-centric protocols, the sink sends queries to certain regions and waits for data from the sensors located in the selected regions. Since data is being requested through queries, attribute based naming is necessary to specify the properties of data. Here data is usually transmitted from every sensor node within the deployment region with significant redundancy. Some of the data-centric routing protocols for WSNs are

- SPIN: Sensor Protocols for Information via Negotiation
- Directed Diffusion
- Rumor Routing
- COUGAR
- ACQUIRE: Active Query Forwarding in Sensor Networks
- EAD: Energy-Aware Data-Centric Routing
- Information-Directed Routing,
- Gradient-Based Routing, Energy-aware Routing,
- Information-Directed Routing
- Quorum-Based Information Dissemination
- Home Agent Based Information Dissemination

4.3 Hierarchical Protocols:

Hierarchical or cluster based methods are well known techniques with special advantage of scalability and efficient communication. Nodes play different roles in the network. Some of the Hierarchical protocol routing are

- LEACH: Low Energy Adaptive Clustering Hierarchy
- PEGASIS: Power efficient gathering in sensor information systems
- HEED: Hybrid, Energy-Efficient Distributed Clustering
- TEEN: Threshold Sensitive Energy Efficient Sensor Network Protocol
- APTEEN: Adaptive Periodic Threshold Sensitive Energy Efficient Sensor Network Protocol

4.4 Mobility-based Protocols:

New challenges to routing protocols in WSNs are mobility. Nodes mobility requires energy-efficient protocols to data delivery originated from source sensor nodes toward mobile sink nodes. Some mobility-based routing protocols for mobile WSNs are

- SEAD: Scalable Energy-Efficient Asynchronous Dissemination
- TTDD
- Joint Mobility and Routing
- Data MULES
- Dynamic Proxy Tree-Base Data Dissemination

4.5 Multipath-based Protocols:

For data transmission between source sensors and the sink node, there are two routing type: single-path routing and multipath routing. In single-path routing, each source sensor sends its data to the sink node through the shortest path. In multipath routing, each source sensor finds the first k shortest paths to the sink and divides its load evenly among these paths. Some multipath routing protocols for WSNs are

- Sensor-Disjoint Multipath
- Braided Multipath
- N-to-1 Multipath Discovery

4.6 Heterogeneity-based Protocols:

In heterogeneity wireless sensor network, there are two types of sensors nodes namely line-powered sensors and battery- powered sensors. Line-powered sensor nodes have no energy constraint, and the battery-powered sensors having limited lifetime, and it should use their available energy efficiently by minimizing their potential of data computation and communication. Heterogeneity in WSNs to extend network lifetime and present a few routing protocols.

- IDSQ: Information-Driven Sensor Query
- CADR: Cons trained Anisotropic Diffusion Routing
- CHR: Cluster-Head Relay Routing

4.7 QoS-based protocols:

To minimize energy consumption, it is also important to consider quality of service (QoS) requirements in terms of reliability, delay and fault tolerance in routing of WSNs. Some QoS based routing protocols that help find a balance between energy consumption and QoS requirements are

- SAR: Sequential Assignment Routing
- SPEED
- Energy-aware routing

V. CHALLENGING ISSUES IN WIRELESS SENSOR NETWORKS

WSNs are application-specific, so the design requirements of WSNs change according to the application. WSN are

formed by a large number of sensor nodes working together to provide a specific duty. Typically, a sensor node is a small device that consists of four basic components
1)sensing subsystem for data gathering from its environment,
2)processing subsystem for data processing and data storing,
3)wireless communication subsystem for data transmission
4) energy supply subsystem
which is a power source for the sensor node. Due to limited computing, radio and battery resources of sensors[7][8], wireless sensor network are expected to fulfill the following requirement:

5.1 Reliability:

In network some sensor nodes may fail or be blocked due to lack of power, have environmental interference or physical damage. The failure of the sensor node should not affect the task of wireless sensor networks. This is the reliability. Fault tolerance is the ability to sustain sensor network functionalities without any interruption due to sensor node failures. The fault tolerance level depends on the application of the WSN.

5.2 Self Configuration:

Large numbers of nodes are randomly deployed over the remote areas. It is essential that the network be able to self-organize. Moreover, nodes may fail from limitation of energy, from physical destruction or any other means, and new nodes may need to join the network.

5.6 Limited Energy Capacity:

Since sensor nodes are battery powered, they have limited energy capacity. Energy poses a big challenge for network designers in hostile environments. Thus, routing protocols designed for sensors should be as energy efficient as possible to extend their lifetime.

5.7 Data Aggregation:

In network each node generates the random redundant data for sink node. This data may in huge amount and require large power to transmit it. But our sensor are battery limited so to save energy data aggregation is must to transmit data over network.

5.8 Security:

Security aspects of wireless sensor networks have received little attention compared with other aspects. The main focus of WSN security has been on centralized communication approaches; there is a need to develop distributed approaches.

VI. CONCLUSION

Unlike other networks, WSNs are designed for specific applications. Applications include, but are not limited to, environmental monitoring, industrial machine monitoring, surveillance systems, and military target tracking. In this paper we have surveyed different aspects such as how many infrastructure of wireless sensor network can form. Routing in sensor networks is a new research area, with a limited but rapidly growing set of results. In this paper, routing protocols are discussed based on seven categories. They have the common objective of trying to extend the lifetime of the sensor network. We believe that the issues described in this paper touch on several directions for required research and technologies for WSN applications.

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