A Survey on Various Routing Protocols In Wireless Sensor Network

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Abstract: Wireless sensor networks have advanced so much in the recent times that they have led to the development of many protocols, whose utmost concern is the energy efficiency of the sensor nodes. A Wireless sensor network (WSN) is a collection of various low cost sensor nodes which communicate through radio interface. They sense, compute, and transmit information to the base stations. But they have limited energy, capability, and storage. This paper is based on a survey of the various types of WSNs, their applications and the various routing protocols being used.

Keywords: Wireless Sensor Networks, Location-based Protocols, Data-centric Protocols, Hierarchical Protocols.

I. INTRODUCTION

A Wireless Sensor Network is a group of low-cost, low-powered, multi-sensing nodes. They are randomly distributed in the system. They sense data process it and transmit it to the base stations. The positions of these nodes can be located using GPS (Global Positioning System) [1]. A WSN typically consists of tens and thousands of these sensing nodes which communicate & share information. WSNs can be deployed for environmental sensing, study of habitat, or they can be deployed on battle fields for military surveillance, in factories, buildings, even in bodies for patients monitoring. The most important feature of this network is the cooperation among nodes. The nodes cooperate among themselves to spread the data collected by them in the region of their deployment [4]. A Base Station provides a link to the world, where this collected data is processed & made useful in various applications [3].

II. APPLICATIONS

WSNs provide science of monitoring; it has led to the development of wide variety of applications. The applications are related to security, military, medical and environment monitoring. These applications help in improving the accuracy and density of measurements used in science for measuring physical phenomenon as large number of sensor nodes can be deployed where the experiments fail. Some examples are:

2.1 Military applications: To track the enemies, sensor networks help to monitor them. The activities of the opposing forces are closely monitored in the battle fields.

2.2 Environment monitoring: Environment monitoring means to forecast the physical conditions like pollution, forest fire detection, Tsunamis, earthquake detection etc. The sensor nodes may be densely deployed which transfer the sensed information to the base stations in a predetermined format.

2.3 Medical applications: Bio-sensors are placed inside the human body to check the patients physiological parameters like pulse rate, blood pressure, etc. The sensed data is sent to the doctor concerned so that immediate action could be taken if any anomaly is detected. The bio-sensors are capable of sensing allergies correctly.

Various other applications of WSNs include habitat monitoring, disaster management, fire detection, home automation, and more [3].

III. TYPES OF WIRELESS SENSOR NETWORKS

There are five types of Wireless Sensor Networks deployed on land, underground, underwater and so on, depending upon the environment and different challenges and constraints of a sensor network.

3.1 Terrestrial Wireless Sensor Network: Terrestrial WSNs consist of hundreds or thousands of inexpensive wireless sensor nodes. These nodes can be deployed in an ad hoc and in a pre-planned manner [8]. The nodes are distributed randomly in an ad hoc manner and kept within the target area. In terrestrial WSN the sensor nodes must communicate with the base station, while the battery power of these nodes is limited. So it is essential for sensor nodes to conserve energy.

3.2 Underground Wireless Sensor Network: Underground WSNs are more expensive than the terrestrial WSNs in terms of deployment, maintenance and equipment cost considerations.
There is a number of hidden sensor nodes are buried underground to monitor underground conditions [9]. In addition sink nodes are located above the ground for communication between hidden sensor nodes to base station. The underground environment makes wireless communication a challenge due to signal losses and high levels of attenuation.

3.3 Underwater Wireless Sensor Network: Underwater WSN embody of a number of sensor nodes and vehicles deployed underwater. These sensor nodes are more costly and less dense than the terrestrial WSN nodes. Underwater wireless communications are established through transmission of acoustic waves [9]. It is a challenge in underwater WSN due to limited bandwidth, long propagation delay, and signal fading problem.

3.4 Multi-Media Wireless Sensor Network: Multi-Media WSNs have propounded to enable tracking and monitoring of events in the form of multimedia. These networks consist of low-cost sensor nodes accorded with microphones and cameras. These nodes are interconnected with each other for data retrieval, process, and compression over a wireless connection. Challenges in this WSN accommodate high bandwidth demand, high energy consumption, data processing and compressing techniques [9].

3.5 Mobile Wireless Sensor Network: Mobile WSN is a mass of sensor nodes that interact with the sensing environment. Mobile nodes have the endowment of sensing, computing, and communication like static sensing nodes. Mobile nodes communicate some other mobile nodes to gathered information within the range of each other. The mobile WSNs are more dexterous as compared to the other static sensor network system.

IV. CHALLENGES FACED BY WSNs

There are some challenges that need to be understood prior designing any routing protocol. The major challenges are:

4.1 Limited Capabilities: A sensor node has limited storage for storing the data. This limits the various other functions of the sensor nodes like processing and transmitting. Therefore, a good protocol must be designed taking into consideration the limited functional capabilities of the nodes.

4.2 Limited Energy: A sensor node has limited amount of energy and because of this, it is important to take care of the efficient use of energy while designing various applications.

4.3 Network Dotage: Due to the limited functionality and limited energy, the sensor nodes have limited lifetime. The other challenges include Scalability, Duplicate data, fault tolerance, and more[3].

V. ROUTING SCHEMES OF WSNs

Routing is basically a method to find the path between the source node and the base station for data transfer [1]. There are various routing algorithms for WSNs which are categorized into three parts:

- Location-based protocols
- Data-centric protocols
- Hierarchical protocols

VI. LOCATION-BASED PROTOCOLS

In this type of protocols, the addressing of the sensor nodes is done through their locations. The sensor networks require the information about the locations of the sensor nodes so that they can estimate the actual energy consumption by calculating the distance between two particular nodes.

Various types of protocols under this category are:

6.1 Geographic Adaptive Fidelity (GAF): This protocol [2, 10, 11] was mainly made for MANETS (Mobile Ad-Hoc Networks), but they can be used in WSNs because of the factor of energy conservation which is favoured by GAF. It works by turning off the unimportant nodes without affecting the routing fidelity level in the sensor network. This helps in energy conservation. In this protocol, the sensor nodes are divided into grid squares and each of the sensors utilises their location information provided by the GPS (Global Positioning System), so that they can associate themselves with the grid in which they reside. This type of association is used by this protocol to identify the sensors that are equivalent from the point of view of packet forwarding. It has three states and they are discovery, active, and sleeping. The discovery state is to find out about the neighbouring sensors in the same grid. The active state broadcasts its messages on a regular interval so that the other nodes are informed about its state. In the sleep state, the sensor turns off its radio to conserve energy. GAF’s main goal is to maximize the network lifetime, which it does by reaching a state where every grid has only one active sensor based on sensor ranking. The amount of energy left will decide the rank of the sensors. A sensor with longer lifetime has the higher rank.

6.2 Geographic and Energy Aware Routing (GEAR): It [2, 16] is an energy-efficient routing protocol proposed for routing queries to target regions in a sensor field. In GEAR, the sensors are supposed to have some location systems equipped like the GPS or any other localization system so that they are able to know their current positions. Additionally, the sensors are aware of their leftover energy as well as the locations and the remaining energy of its neighbouring nodes. GEAR uses energy aware heuristics that are based on geographical information to select sensors to route a packet toward its destination region.
6.3 Trajectory-Based Forwarding (TBF): This routing protocol [2, 15] requires a densely deployed network and also a localization system or a coordinate system like a GPS for positioning themselves and for calculating the distance with their neighbouring nodes. The trajectory in a packet is specified by the source, but it does not explicitly direct the path on a hop-by-hop basis. On the basis of the location information of the neighbours, a forwarding sensor takes a greedy approach to determine the next hop that will be closest to the trajectory fixed by the source sensor. To increase the reliability and strength of the network, it is possible to implement multi-path routing in this protocol where an alternate path will be just another trajectory. Its applications include securing the perimeter of the network and also can be used for resource discovery.

7.1 Sensor Protocols for Information via Negotiation (SPIN): This protocol [6] was designed to solve the problem of flooding and jamming attack. It transmits the information by the procedure called negotiating. For this goal, Spin uses high-level descriptors and meta-data. There are two key mechanism of spin protocols namely negotiation and resource adaptation. Spin’s meta-data negotiation solves the typical problems of flooding such as redundant information passing, overlapping of sensing areas and thus achieves a lot of energy efficiency. There are two protocols of Spin have been developed SPIN-1 uses a negotiation mechanism to reduce the consumption of sensor, SPIN-2 uses a resource aware mechanism for energy savings.

7.2 Direct Diffusion: Direct diffusion is a data centric protocol. It consists of several key elements namely data naming, interests and gradients, data propagation and reinforcement. The idea targeted at diffusing data through sensor nodes using a naming scheme for the data. The main idea behind using such a scheme is to get rid of unnecessary operations in order to save energy. It meets the main requirements of WSNs serving as energy efficiency, scalability and robustness.

7.3 Cougar: Cougar is a data centric protocol that views the network as a huge distributed database system. This concept provides a user and application programs with declarative queries of the sensed data generated by the source sensors. Its approach uses a layer of query where each sensor is coupled with a query proxy that lies between the network and application layer of the sensor. In addition, cougar procedure employs in-network processing to minimize the consumption of total energy and increase the network lifetime. Based on the database approach it faces less challenges.

VIII. Hierarchical Routing Protocols

Sensor nodes [7] are small devices used for communication and processing of collected information. There are various limitations faced by the sensor networks like the limited storage, limited energy. Due to these conditions, the main factor to keep in mind is the network dotage. This factor should be kept in mind while developing routing protocols. Among all the protocols, [10] hierarchical protocols are the one that are being used worldwide. These protocols are good in communication and help to solve the scalability issue. The creation of cluster and cluster based in these protocols helps in efficient communication. The various types include:

8.1 LEACH (Low Energy Adaptive Clustering Hierarchy): LEACH [5, 10] is an energetic and cluster-based routing protocol. Clustering helps in the reduction of energy consumption by sensor nodes. In this type of protocol, all the nodes deployed are homogenous and they have limited battery power so, to improve their lifetime, clusters are formed. Each node is given a chance to become a cluster head at least once. A node which has become a cluster head once will again become cluster head after all other nodes have become cluster head. This process of cluster head election is a random process. The whole task under the LEACH protocol is done in the following two phases, the setup phase and the steady phase. In the setup phase, the clusters are formed and the random election of cluster head is done in this phase. In the steady phase the data transfer takes place from the nodes to the cluster head and from the cluster head to the base station.

8.2 PEGASIS (Power-Efficient Gathering in Sensor Information Systems): This protocol [2, 14] is an improvement in the LEACH routing protocol. It forms chains of sensor nodes so that one node will transmit the data collected to its immediate neighbour node and after that only one node will be selected from the chain to send the data to the base station. PEGASIS is different from LEACH in various ways like in PEGASIS, there is no such thing like cluster formation as it is their in LEACH. The data is sent to its neighbouring nodes instead of sending to the cluster head directly as in LEACH.
PEGASIS is more advantageous than LEACH because it helps to reduce the overall energy used in data transmission thus improving the lifetime.

8.3 HEED (Hybrid Energy Efficient Distributed Clustering): HEED [2, 10, 12, 13] continues the fundamental scheme of LEACH by utilizing leftover energy and node degree or density as a metric for cluster election to achieve power balancing. It is operated in multi-hop networks which uses an adaptive transmitting power in the inter-clustering transmission. HEED had mainly four main goals and they are extending network lifetime by distributing energy consumption, breaking off the clustering process within a constant number of iterations, lowering control overhead, and producing well-distributed cluster heads and dense clusters. HEED selects cluster heads according to a combination of two clustering parameters. The main parameter is the leftover energy of every sensor node and the subordinate parameter is the intra-cluster communication cost as a function of cluster density or node degree. The first parameter selects an initial set of cluster heads using probability while the second parameter is used to break the ties. The HEED clustering helps in improving network lifetime over LEACH clustering because LEACH randomly selects cluster heads, which may result in speedy death of some nodes. All the finally selected cluster heads in HEED are well distributed across the network and the transmission cost is minimized.

IX. CONCLUSION

This paper explains the concept of WSN, its applications, the various challenges faced by them and the different types of Routing Protocols designed for meeting its various limitations. There are a lot of challenges but the main challenge of WSNs is the energy efficiency of the sensor nodes. This limitation should be kept in mind during the design of the routing protocols. The main goal behind the design of the protocol should be the long life of the sensor nodes.

REFERENCES