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A Survey on Routing Techniques in Wireless Sensor Networks

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Abstract--- The great advances made in the wireless technology have enabled the deployment of wireless communication networks in some of the harshest environments such as volcanoes, hurricane- affected regions, and underground mines. In such challenging environments there is lack of infrastructure in terms of computing and energy resources. It is well known that task of transmitting data consumes more energy than collecting it. Routing is crucial in wireless sensor networks. The tasks of routing include route selection and packet forwarding. The highly dynamic and lossy nature of the wireless medium makes routing in wireless networks a challenging problem. In this survey, we give an overview of types of wireless sensor networks and various routing techniques in same.

***Keywords**—Wireless sensor network, Types of WSNs, Routing techniques*

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I. INTRODUCTION

A WSN can be defined as a network of spatially distributed autonomous sensors called as sensor nodes, which monitors physical or environmental conditions such as temperature, pressure. The information gathered by the different nodes is sent to a sink which either uses the information locally or is connected to other networks, for example, the Internet through a gateway[1]. Fig.1 illustrates a typical WSN.

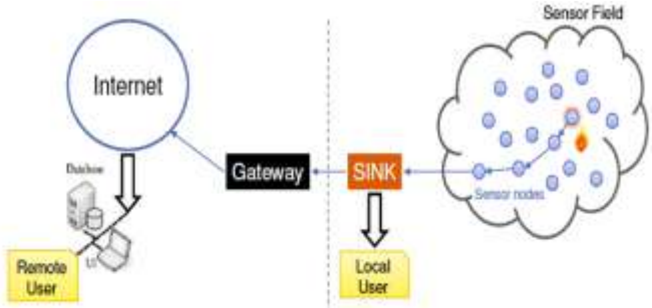

Fig. 1: Wireless Sensor Network(WSN)

A Wireless sensor network (WSN) consists of wireless sensor nodes, which are devices equipped with a processor, a radio interface, an analog-to-digital converter, sensors, memory and a power supply. The processor performs the management of node and data processing. The sensors attached to the node are capable of sensing temperature, humidity, light, etc. Memory is used to store programs (instructions executed by the processor) and data. Nodes are equipped with a low-rate and short-range wireless radio that enables communicate among themselves. Since radio communication consumes most of the power, the energy-efficient communication techniques must be incorporated. The power source commonly used is rechargeable batteries. Since nodes can be deployed in remote and hostile environments they must use little power and must employ built-in mechanisms to extend network lifetime. For example, nodes may be equipped with effective power harvesting methods, such as solar cells, so they may be left unattended for years.

II. TYPES OF WIRELESS SENSOR NETWORKS

Presently, many WSNs are deployed on land, underground and underwater. Each wireless Sensor Networks faces different challenges and constraints depending on their environment in which they are operating [1]. We present some types of WSNs as shown in Figure 2.

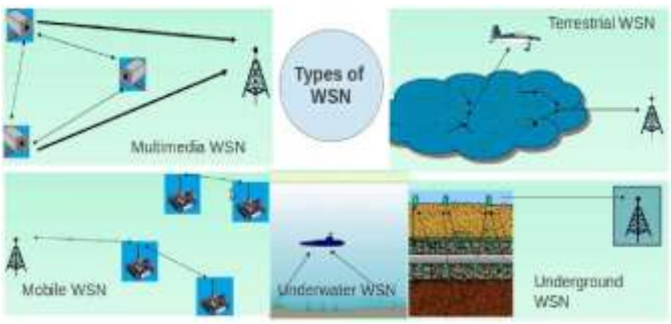

Fig. 2:Types of Wireless Sensor Network(WSN)

Terrestrial WSN: This type of WSNs consists of a large number (usually from hundreds to thousands) of low-cost nodes deployed on land in a selected area, usually in an ad-hoc manner such as, nodes dropped from an airplane. In terrestrial WSNs, sensor nodes must be able to effectively transmit data back to the base station in a dense environment. Since battery power is limited and usually non-rechargeable, terrestrial sensor nodes can be equipped with a secondary power source such as solar cells. Energy can be conserved with help of multi-hop optimal routing, having short transmission range, in-network data aggregation, and using low duty-cycle operations. Common applications of terrestrial WSNs are environmental sensing and monitoring, industrial monitoring, and surface explorations.

Underground WSN: It consists of a number of sensor nodes deployed in caves or mines or underground to monitor underground conditions. In order to relay information from the underground sensor nodes to the base station, additional sink nodes are installed above ground. They are more expensive than terrestrial WSNs as they require appropriate equipments to perform reliable communication through soil, rocks, and water. Wireless communication is a challenging in underground environment due to high attenuation and signal loss. Moreover, it is difficult to recharge or replace the battery of nodes buried underground making it important to design energy efficient communication protocol for longer lifetime of network. Underground WSNs are used in many applications such as agriculture monitoring, landscape management, underground monitoring of soil, water or mineral, and military border monitoring.

Multi-media WSN: It consists of low cost sensor nodes equipped with cameras and microphones, deployed in a pre-planned manner to guaranteed coverage. Multimedia sensor devices are capable of storing, processing, and retrieving multimedia data such as video, audio, and images. They must face various challenges such as high bandwidth demand, high energy consumption, quality of service (QoS) provisioning, data processing and compressing techniques, and cross-layer design. It is required to develop transmission techniques that support high bandwidth and low energy consumption in order to transmit multimedia content such as a video stream. Though provision of QoS (Quality of Service) is difficult in multimedia WSNs due to variable link capacity and delay, still a certain amount of QoS must be achieved for reliable content delivery. Multimedia WSNs enhance the existing WSN applications such as tracking and monitoring.

Underwater WSNs: It consists of sensors deployed underwater, for example, into the ocean environment. This types of nodes are expensive, only a few nodes are deployed and autonomous underwater vehicles are used to extract or gather data from them. Underwater wireless communication uses acoustic waves that presents various challenges such as limited bandwidth, long propagation delay, high latency, and signal fading problems. These nodes must be able to self-configure and adapt to extreme conditions of ocean environment. Nodes are equipped with a limited battery which cannot be replaced or recharged requiring energy efficient underwater communication and networking techniques. Applications of underwater WSNs include water pollution monitoring, under sea surveillance and exploration, disaster prevention and monitoring, seismic monitoring, equipment monitoring, and underwater robotics.

Mobile WSN: This type of WSNs consists of mobile sensor nodes that can move around and interact with the physical environment surrounding them. Mobile nodes can change their position and organize themselves in the network , to be able to sense, compute and communicate. A dynamic routing algorithm is must here as nodes are employed unlike fixed routing in static WSN. Mobile WSNs face various challenges such as deployment, mobility management, localization with mobility, navigation and control of mobile nodes, maintaining adequate sensing coverage, minimizing energy consumption in locomotion, maintaining network connectivity, and data distribution. Primary examples of mobile WSN applications are monitoring (environment, habitat, underwater), military surveillance, target tracking, search and rescue. A higher degree of coverage and connectivity can be achieved with mobile sensor nodes compared to static nodes.

III. Related Work

In recent years, there are several studies on routing-related parameters, such as connectivity-related parameters and density of the distributed nodes, in 1-D queue networks. There are various routing techniques in wireless sensor networks which evolved over time.

As transmitting data consumes much more energy than other tasks of sensor nodes, energy savings optimization is realized by finding the minimum energy path between the source and sink in WSNs. In [5], the theoretical analysis of the optimal power and optimal forwarding distance of each single hop is given. The energy consumption is minimized by using high power for long hop lengths and using low power and shorter hop lengths. This generally applied when each sensor node locates form one another within the optimal transmission distance in dense multihop wireless network. The most forward within range (MFR) [6] routing approach has also been considered in 1-D queue networks, which chooses the most away neighboring node as the next forwarder within range, and eventually causes less multihop delay and less energy consumption. Another approach proposed in [7] reduces the total power consumption based on two things, i.e., path selection and bit allocation. Packets with the optimal size are forwarded to node from sensor nodes in the best intermediate hops. The unreliable wireless links makes routing in wireless sensor networks a challenging problem. In order to overcome this problem, the concept of opportunistic routing was proposed in [8]. Compared with traditional best path routing, opportunistic routings, such as extremely opportunistic routing (ExOR), geographic random forwarding (GeRaF) , and efficient QoS-aware geographic opportunistic routing (EQGOR), take advantage of the broadcast nature of the wireless medium, and allow multiple neighbors that can overhear the transmission to participate in forwarding packets.

IV. Comparison of Different Techniques

This section provides a brief comparison of different routing techniques in WSNs. This comparison is summarized in Table 1[4][5][8][9][10][11][12].

Title of Paper	Findings	Drawback
[1] QoS Aware Geographic Opportunistic Routing in Wireless Sensor Networks	This paper propose an Efficient QoS-aware GOR (EQGOR) protocol for QoS provisioning in WSNs. EQGOR selects and prioritizes the forwarding candidate set in an efficient manner, which is suitable for WSNs in respect of energy efficiency, latency.	The average computation delay of EQGOR increases as the number of available next-hop nodes increases.
[2] An Energy-Balanced Routing Method Based on Forward-Aware Factor for Wireless Sensor Networks	An energy-balanced routing method based on forward-aware factor (FAF-EBRM) is proposed. In FAF-EBRM, the next-hop node is selected according to the awareness of weight of edge between nodes and forward energy density of each possible next- hop node.	The disadvantage of this protocol is more delay in data transmission and less throughput.
[3] Real-Time Implementation of a Harmony Search Algorithm-Based Clustering	Paper represents protocol designed and implemented in real time for the WSNs. It is expected to minimize the	It does not support mobility.

Protocol for Energy-Efficient Wireless Sensor Networks.	intra cluster distances between the cluster members that increases network lifetime.	
[4] Optimal hop distance and power control for a single cell, dense, ad hoc wireless network.	In this there is tradeoff to maximize a measure of the transport capacity of the network by using high power for long hop lengths and Using low power for shorter hop lengths.	The system when uses long hops results in minimizing network lifetime.
[5] On the hop count statistics for randomly deployed wireless sensor networks	The most forward within range (MFR) routing approach has been proposed in 1-D queue networks, which chooses the farthest away neighboring node as the next forwarder, and eventually results in less multihop delay	This approach solely focus on the relationship between the number of hops and the distance separating two nodes & energy efficiency and network lifetime are remained unfocused.
[6] Exor: Opportunistic multi-hop routing for wireless networks	ExOR, is an integrated routing and MAC protocol that increases the throughput of large unicast transfers in multi-hop wireless networks.	There are no acknowledge packets and did not address exploiting OR for selecting the appropriate forwarding list to minimize the energy consumption
[7] Geographic random forwarding (geraf) for ad hoc and sensor networks: Multihop performance	In this, a novel forwarding technique based on geographical location of the nodes involved and random selection of the relaying node via contention among receivers	Drawback of this is that GeRaF give no consideration to the residual energy of relay nodes as low residual energy of relay nodes would run out more quickly for transmitting large amount of data.

V. CONCLUSION

WSN has been widely used for monitoring and control applications in our daily life due to its promising features, such as low cost, low power, easy implementation, and easy maintenance. Energy savings optimization is one of major concerns in the WSN routing protocol design. This paper has presented types of wireless sensor network and survey of routing techniques in wireless sensor networks. They have the common objective of trying to extend the lifetime of the sensor network while not compromising data delivery.

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