A Review on Routing Techniques in Wireless Sensor Networks

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Abstract— In recent years there has been a world-wide interest in Wireless Sensor Networks (WSNs). Wireless sensor network (WSN) has emerged as one of the most promising technologies for the future. Advancement in technology and easy availability of small, smart and inexpensive sensors results in cost effective deployment of WSNs. In WSNs, thousands of physically embedded sensor nodes are distributed in possibly harsh terrain and in most applications, it is impossible to replenish energy via replacing batteries. Various routing techniques are proposed that may efficiently manage energy resources to extend network lifetime. This paper presents a review of various routing techniques in WSNs.

Keywords—*Wireless sensor network, Design Issues , 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.

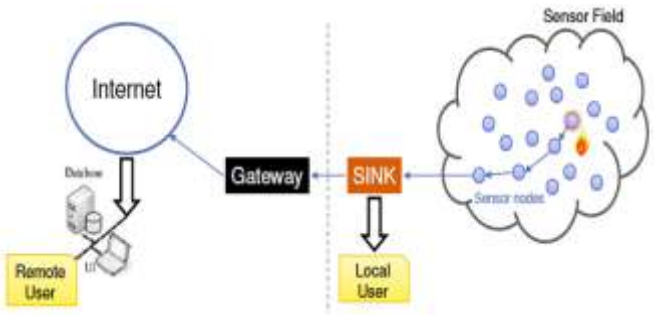

Fig. 1: Wireless Sensor Network(WSN)

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. ROUTING CHALLENGES AND DESIGN ISSUES IN WIRELESS SENSOR NETWORKS

Despite the various applications of WSNs, these networks have several limitations, such as limited energy supply, limited computing power and limited bandwidth of the wireless links connecting sensor nodes. The design of routing protocols in WSNs is influenced by many challenging factors. These factors must be overcome in order to achieve efficient communication in WSNs. Following are some of the routing challenges and design issues that affect the routing process in WSNs[3].

Node deployment: Node deployment in WSNs is application-dependent and can be either deterministic or randomized. In manual deployment, the sensors are manually placed and data is routed through predetermined paths. However, in random node deployment, the sensor nodes are scattered randomly, creating an ad hoc routing infrastructure. Inter-sensor communication is normally within short transmission ranges due to energy and bandwidth limitations. Therefore, it is most likely that a route will consist of multiple wireless hops.

Energy consumption: The main task of sensor nodes is to collect and transmit data. It is well known that transmitting data consumes much more energy than collecting data. As such, energy-conserving forms of communication and computation are essential. In a multihop WSN, each node plays a dual role as data sender and data router. The power failure of any sensor node can cause significant topological changes, and might require rerouting of packets.

Node/link heterogeneity: Mostly, It is assumed that all sensor nodes are homogeneous (i.e., have equal capacity in terms of computation,
communication, and power). However, depending on the application a sensor node can have a different role or capability. The existence of a heterogeneous set of sensors raises many technical issues related to data routing.

Fault tolerance: Some sensor nodes may fail or be blocked due to lack of power, physical damage, or environmental interference. The failure of sensor nodes should not affect the overall task of the sensor network. One of the main design goals of WSNs is to carry out data communication while trying to prolong the lifetime of the network Therefore, multiple levels of redundancy may be needed in a fault-tolerant sensor network.

Scalability: The number of sensor nodes deployed in the sensing area may be in the number of hundreds or thousands, or more. Any routing scheme must be able to work with this huge number of sensor nodes. In addition, sensor network routing protocols should be scalable enough to respond to events in the environment.

Transmission media: In a multihop sensor network, communicating nodes are linked by a wireless medium. The traditional problems associated with a wireless channel (e.g., fading, high error rate) may also affect the operation of the sensor network.

Connectivity: High node density in sensor networks prevents them from being completely isolated from each other. Therefore, sensor nodes are expected to be highly connected. However ,It may not prevent the network topology from being variable and the network size getting smaller due to sensor node failures. In addition, connectivity depends on the possibly random distribution of nodes.

Coverage: In WSNs, each sensor node obtains a certain view of the environment. A given sensor's view of the environment is limited in terms of both range and accuracy; it can only cover a limited physical area of the environment. Hence, area coverage is also an important design parameter in WSNs.

III. Routing Techniques in Wireless SEnsor Network

There are various routing techniques in wireless sensor networks, they are as follows[2][3][4][5]:

Flat Routing: The first category of routing protocols are the multihop flat routing protocols. In flat networks, each node typically plays the same role and sensor nodes work together to perform the sensing task. Due to the large number of such nodes, it is not feasible to assign a global identifier to each node. This leads to data-centric routing, where the Base Station sends queries to certain regions and waits for data from the sensors located in the selected regions. This technique focus on energy saving through data negotiation and elimination of redundant data.

Hierarchical Routing: Hierarchical routing methods which was originally proposed in wired networks, are well-known techniques with special advantages such as scalability and efficient communication. As such, the concept of hierarchical routing is also utilized to perform energy-efficient routing in WSNs. In a hierarchical architecture, higher-energy nodes are used to process and transmit the information, while low-energy nodes are used to perform the sensing data within the range of the target. The creation
of clusters and assigning special tasks to cluster heads can greatly contribute to overall system scalability, increased lifetime, and energy efficiency. Hierarchical routing is an efficient way to lower energy consumption within a cluster, performing data aggregation and fusion in order to decrease the number of transmitted messages to the BS. Hierarchical routing is mainly two-layer routing where one layer is used to select cluster heads and the other for routing. However, this routing focuses on "who and when to send or process/ aggregate" the information, channel allocation, and so on, which is helpful in the multihop routing function.

Location-Based Routing: In this type of routing, sensor nodes are addressed by means of their locations. The distance between neighboring nodes can be estimated on the basis of incoming signal strengths. Alternatively, the location of nodes may be available directly by communicating with a satellite using GPS if nodes are equipped with a small low-power GPS receiver. To save energy, some location-based schemes demand that nodes should go to sleep if there is no activity. More energy savings can be obtained by having as many sleeping nodes in the network as possible.

Multipath Routing: This routing protocols uses multiple paths rather than a single path in order to enhance network performance. The fault tolerance of Multipath Routing protocol is measured by the ability of having an alternate path between a source and a destination when the primary path fails. This can be increased by maintaining multiple paths between the source and destination at the cost of increased energy consumption and traffic generation. These alternate paths are kept alive by sending messages on periodic basis. Hence, network reliability can be increased at the expense of increased overhead in maintaining the alternate paths.

Query-Based Routing: In this kind of routing, the destination nodes propagate a query for data (sensing information) from a node through the network, and a node which has data sends the data that matches the query back to the node that initiated the query. Usually these queries are described in natural language or high-level query languages. For example, client submit a query to node and ask: Are there moving vehicles in traffic region ? All the nodes maintains tables consisting of the queries they receive, and send data that matches these queries when they receive it.

Negotiation-Based Routing: These protocols use high-level data descriptors in order to eliminate redundant data transmissions through
negotiation. Communication decisions are also made based on the resources available to them. The motivation is that the use of flooding to spread data will produce implosion and overlap between the sent data, so nodes will receive duplicate copies of the same data. This operation consumes more energy and

processing by sending the same data by different sensors. Hence, the main idea of negotiation-based routing in WSNs is to suppress duplicate information and prevent redundant data from being sent to the next sensor or the BS by conducting a series of negotiation messages before the real data transmission begins.

QoS-based Routing: In QoS-based routing protocols, the network has to make balance between energy consumption and data quality. In particular, the network has to satisfy certain QoS metrics such as delay, energy, bandwidth, etc. when delivering data to the BS. Sequential Assignment Routing (SAR) is one of the first routing protocols for WSNs with QoS-Based Routing. A routing decision in SAR is done based on three factors: energy resources, QoS on each path, and the priority level of each packet. When single route fails, a multipath approach and localized path restoration schemes are used. To create multiple paths from a source node, a tree rooted at the source node to the destination nodes is built. The paths of the tree are built while nodes with low energy or QoS guarantees are avoided. At the end of process, each sensor node will be part of a multipath tree. SAR maintains multiple paths from nodes to BS. Although this ensures fault tolerance and easy recovery, the protocol suffers from the overhead of maintaining the tables and states at each sensor node, especially when the number of nodes is huge.

Coherent-Based Routing: Data processing is a major in the operation of wireless sensor networks. Hence, routing techniques has different data processing techniques. In general, sensor nodes will cooperate with each other in processing different data flooded in the network area. Examples of data processing techniques in WSNs are coherent and noncoherent data-processing based routing.In noncoherent data processing based routing, nodes will locally process the raw data before it is sent to other nodes for further processing. The nodes that perform further processing are called aggregators. In coherent based routing, the data is forwarded to aggregators after minimum processing done. The minimum processing normally include time stamping and duplicate suppression. To perform energy-efficient routing, coherent processing is normally selected.

Opportunistic Routing: The key idea behind OR (also called opportunistic forwarding) is to overcome the drawback of unreliable wireless transmission by taking advantage of the broadcast nature of
the wireless medium such that one transmission can be overheard by multiple neighbors. The forwarding task can continue as long as at least one neighbor along a route receives the packet. OR improves performance over that of traditional best path routing.

IV. CONCLUSION

The research in wireless sensor networks is very dynamic, and expectations are high regarding applications and business potential of sensor networks. This paper has presented some challenges and design issues faced by wireless sensor network. Moreover, some routing techniques in wireless sensor networks have been presented. They have the common objective of trying to extend the lifetime of the sensor network while not compromising data delivery.

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REFERENCES

[1] Rawat, Priyanka, Et Al. "Wireless Sensor Networks: A Survey On Recent Developments And Potential Synergies." The Journal Of Supercomputing 68.1 (2014): 1-48.

[2] Sha, Kewei, Jegnesh Gehlot, And Robert Greve. "Multipath Routing Techniques In Wireless Sensor Networks: A Survey." Wireless Personal Communications 70.2 (2013): 807-829.

[3] Al-Karaki, Jamal N., And Ahmed E. Kamal. "Routing Techniques In Wireless Sensor Networks: A Survey." Ieee Wireless Communications 11.6 (2004): 6-28.

[4] Rault, Tifenn, Abdelmadjid Bouabdallah, And Yacine Challal. "Energy Efficiency In Wireless Sensor Networks: A Top-Down Survey." Computer Networks 67 (2014): 104-122.

[5] Ahmad, Ozair. "Survey Of Routing Protocols In Wireless Sensor Networks." (2014).