Study on Wireless Sensor Networks Challenges and Routing Protocols

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ABSTRACT: Wireless Sensor Networks (WSNs) consist of many number of sensor nodes which usually releases in the inaccessible environment. WSNs are usable in many areas including: military, medical, environmental and etc. In this paper we review basic characteristics and challenges of WSNs. According to this problem that routing protocol plays an important role in the increase efficiency and life time of WSN, in this paper we review and analyzes some of the routing protocols which presented for WSNs. Study of advantages and disadvantages of protocols can help to provide more efficient protocol.

Keywords: WSNs, Routing Protocol, Network Lifetime, Wireless Communications.

INTRODUCTION

Due to technological advances in processor and wireless communication, wireless sensor networks everywhere will be usable in the future applications. WSNs consist of many number of sensor nodes which usually releases in the inaccessible environment. WSNs are usable in many areas including: military, medical, environmental and domestic. But in all fields, energy consumption has an important role in the performance of a WSN. Energy consumption in sensor nodes is done for three operations, sensing, data processing and wireless data transfer. So, one of the operations that consume the energy in WSN is communications and routing. How to routing data and transmit it to the base station is important. Due to the fact that sensor nodes are usually battery-powered and energy power of sensors is limited, a routing method with energy efficiency and of selecting the shortest path between source node and destination node for data transmission can be effective in saving energy (Zheng and Jamalipour, 2009; Akyildiz and Vuran, 2010; Akyildiz et al., 2002; Al-Karaki et al., 2005). Due to resource constraints on nodes, using resources optimally to provide reliability, extensibility, and quality of service in these networks is very important. Most protocols that presented at recent years are based on studied protocols and improve some disadvantages of studied protocols. Study of advantages and disadvantages of protocols can help to provide more efficient protocol.

Characteristics of WSNs

Important characteristics of WSNs that make it distinctive from other networks may include (Akyildiz et al., 2002 and Yaghmaee, 2008):

- Very large number of nodes, often in the order of thousands.
- Asymmetric flow of information, from the observers or sensor nodes to a command node.
- Communications are triggered by queries or events.
- At each node there is a limited amount of energy which in many applications is impossible to replace or recharge.
- Almost static topology.
- Low cost, size, and weight per node.
- Prone to failures.
- More use of broadcast communications instead of point-to-point.
- Nodes do not have a global ID such as an IP number.
- The security, both physical and at the communication level, is more limited than conventional wireless networks.
**Important Factor in the Design of WSNs**

The design of a sensor network is influenced by several parameters including: fault tolerance, scalability, cost of production, working environment, network topology, hardware limitations, transmission environment and energy consumption (Akyildiz et al., 2002 and Yaghmaee, 2008). These factors have been studied in many researches and in any research; researchers have tried to optimize these factors. These factors are having great importance. Because considered as principles of algorithms and protocols design in sensor networks. Also these parameters can be used to compare different works. In general, for design of efficient protocols for wireless sensor networks attention to these parameters are important:

Fault tolerance: The failure of nodes should not severely degrade the overall performance of the network.

Scalability: The mechanism employed should be able to adapt to a wide range of network sizes (number of nodes).

Cost: The cost of a single node should be kept very low.

Power consumption: Should be kept to a minimum to extend the useful life of network.

Hardware and software constraints: Sensors, location finding system, antenna, power amplifier, modulation, coding, CPU, RAM, operating system.

Topology maintenance: In particular to cope with the expected high rate of node failure.

Deployment: Pre-deployment mechanisms and plans for node replacement and/or maintenance.

Transmission media: ISM bands, infrared, etc.

**Routing Protocols**

In general, routing protocols in the WSNs can be classified into four categories: Data Centric Protocols, Hierarchical Protocols, Location-Based Protocols and Network Flow & QoS (Quality of Service) Aware protocols. Data centric protocols are based on request from Base Station (BS). These protocols are query-based that means sink node sends a query to certain region and nodes in this region sends response to sink node (Krishnanamachari et al., 2002). Some of the data centric protocols include: Flooding, Gossiping, SPIN (Sensor Protocols for Information via Negotiation), Directed Diffusion, Energy-aware Routing and GBR (Gradient-Based Routing). In the hierarchical protocols, network is divided into various subsections named cluster. Each cluster has a Cluster Head (CH). In each cluster, the cluster head duties such as data aggregation, eliminating redundant data. These type of protocol Maintain energy consumption of sensor nodes via multi-hop communication within a particular cluster and data aggregation and fusion to decrease the number of the total transmitted packets in the network. Some of the hierarchical protocols include: LEACH (Low-Energy Adaptive Clustering Hierarchy), PEGASIS (Power-Efficient Gathering in Sensor Information Systems), TEEN (Threshold sensitive Energy Efficient sensor Network protocol). Most of the routing protocols for sensor networks require location information for sensor nodes. Location information can be utilized in routing data in an energy efficient way. In the location based protocols, information about the location of sensors are used to optimize the transfer of information obtained through its paths. Some of the location based protocols include: MECN (Minimum Energy Communication Network), GAF (Geographic Adaptive Fidelity) and GEAR (Geographic and Energy Aware Routing). Network Flow & QoS Aware protocols are based on general network-flow modeling and protocols that strive for meeting some QoS requirements along with the routing function. Some of the Network Flow & QoS Aware protocols include: MLER (Maximum Lifetime Energy Routing), MLDG (Maximum Lifetime Data Gathering) and MCF (Minimum Cost Forwarding).

The simplest solution to solve the routing problem is transfer information through flooding protocol (Akyildiz et al., 2002 and Yaghmaee, 2008). In this protocol, each sensor node after receiving a packet, send this packet to all sensor nodes except sender. Each node receives a packet and sends this information to its neighbors. To avoid sending a packet to a node more than once, a sequence number is used for each packet. Thus, the receiver controls the packet sequence number and if it was non-repetitive, it sends the packet to its neighbors. The main advantage of this method is easy to implement in the first and second packets reach the destination safely. The main disadvantages of this scheme are implosion and overlap problems. Implosion refers to this problem that a sensor node may be receiving a same data from two or more path. This problem shows in fig. 1. Overlap refers to this problem that two or more neighbor sensor nodes send a same data to a sensor node. This problem shows in figure 2.
Gossiping protocol is improved state of flooding (Akyildiz et al., 2002 and Yaghmaee, 2008). In this protocol each sensor node that receive a packet, send this to only one of its neighbors and randomly. It will continue to do so until the data reaches its destination. In the gossiping there is no implosion problem because always a neighbor is selected for data. But the main problem in gossiping is delays.

In the SPIN protocol addition to data messages, other messages are used and thus reduce the overall data transfer volume (Intanagonwiwat et al., 2000; Al-Karaki et al., 2005). Messages in SPIN are advertisement message (ADV), request message (REQ) and data message (DATA). In the SPIN protocol, each sensor node after receiving a new data send a ADV message to its neighbors, if an its neighbor require this data, send a REQ message to sender and finally sender after receiving REQ message, starts to send data to its neighbor only. Example of this operations shows in fig. 3. The advantage of this protocol is that the protocol changes in the network topology can be only locally. In fact, each sensor needs only to know their next-door neighbors. The problem of SPIN is that no exists guarantee to delivery of transmitted data from source sensor node to destination sensor node.
LEACH is one of the most famous hierarchical protocols for wireless sensor networks (Heinzelman et al., 2000; Heinzelman et al., 2002; Al-Karaki et al., 2005). In this protocol, first network is divided into various clusters. Each cluster has a CH. CHs periodically and using TDMA technique, received the data from sensor nodes belonging to its cluster and after aggregation, directly or via indirectly (multi hop) sends data to BS. CH in this protocol periodically changed. This work helps to network load balancing. LEACH have … phase include: CH selecting, make clusters, Scheduling and stability state respectively. LEACH completely distributed and increase the lifetime of the network. LEACH in base state uses from single-hop routing and not applicable to networks in large regions and dynamic clustering in LEACH brings extra overhead to the network. Characteristics of studied protocols show in the table. 1.

<table>
<thead>
<tr>
<th>Protocol name</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooding</td>
<td>Guarantee to delivery of packets</td>
</tr>
<tr>
<td></td>
<td>Useful for transfer control signals and packets</td>
</tr>
<tr>
<td></td>
<td>Easy logic and simplest implementation</td>
</tr>
<tr>
<td></td>
<td>Implosion and overlap problems</td>
</tr>
<tr>
<td></td>
<td>Increase network load</td>
</tr>
<tr>
<td>Gossiping</td>
<td>Improved state of flooding</td>
</tr>
<tr>
<td></td>
<td>Delay to packet delivery</td>
</tr>
<tr>
<td>SPIN</td>
<td>Reduce the overall data transfer</td>
</tr>
<tr>
<td></td>
<td>Locally protocol changes in the network topology</td>
</tr>
<tr>
<td></td>
<td>No exists guarantee to delivery of transmitted data</td>
</tr>
<tr>
<td>LEACH</td>
<td>Divide network to various clusters</td>
</tr>
<tr>
<td></td>
<td>Help to network load balancing</td>
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<tr>
<td></td>
<td>Increase the lifetime of the network</td>
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<tr>
<td></td>
<td>Uses from single-hop routing in base state</td>
</tr>
<tr>
<td></td>
<td>Overhead to clustering</td>
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</tbody>
</table>

CONCLUSION

Routing is one of the key issues in wireless sensor networks. Wireless communications and environment may be destroying paths between sensor nodes. For this reason, the routing techniques that used for wired networks can’t be used for WSN. Also, due to resource constraints on nodes, using resources optimally to provide reliability, extensibility, and quality of service in these networks is very important. Most protocols that presented at recent years are based on studied protocols and improve
some disadvantages of studied protocols. Study of advantages and disadvantages of protocols can help to provide more efficient protocol.

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