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A STUDY ON ROUTING MECHANISMS FOR WIRELESS SENSOR NETWORKS

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Abstract: *Wireless sensor network (WSN) consist of nodes with sensing, computation and wireless communication capabilities. The difference between the WSN and the traditional wireless networks is that sensors are sensitive to energy consumption. Energy saving is the essential issue in designing the wireless sensor networks, and another major issue in wireless sensor network is the limited battery power within network sensor nodes. In order to increase the lifetime of sensor nodes, it is preferable to distribute the energy throughout the wireless sensor network. So it is important to design effective and energy aware protocols in order to increase the network lifetime. Many routing protocol have been proposed for sensor network where energy awareness is an essential consideration. In this paper we give theoretical analysis of routing protocol for WSN by comparing their strengths and limitations. Three major categories explored in this survey are Data-centric approach, Hierarchical approach and Location-based approach. Routing protocols are described under one of the aforementioned category.*

Keywords: *Wireless Sensor Networks, Design issues, Routing Protocols*.

1. INTRODUCTION

A wireless sensor networks (WSNs) is a current research area [1][3][4][7]. A Wireless Sensor Networks consist of hundreds or thousands of micro sensor nodes that have ability of sensing, create wireless communication between each other and doing computational operations and processing. Sensor networks have a broad variety of functions and systems with hugely varying requirements and characteristics. The sensor networks can be applied in

Disaster management , Military environment, Medical and health care, Habitat monitoring Industrial fields, Home networks, detecting, Biological, chemical, nuclear and radiological etc. Exploitation of a sensor network in these applications can be in arbitrary fashion or can be established manually. For example, in a disaster management application, number of sensors can be dropped from a helicopter. Networking these sensors can assist rescue operations by identifying risky and locating survivors.

Fig.1 Shows diagram of sensor node components [5]. The sensor nodes comprises of sensing unit, processing unit, transmission unit, position finding system, mobilize, power unit. These sensor nodes are scattered in the sensor field. The sensor field is the area where sensors nodes are deployed. The same diagram shows the communication architecture of WSN. Every scattered sensor node has the capability to collect data and route back to the base station (BS). A BS may be fixed or mobile node and capable of connecting the sensor network to the internet where a user can have access to the reported data.

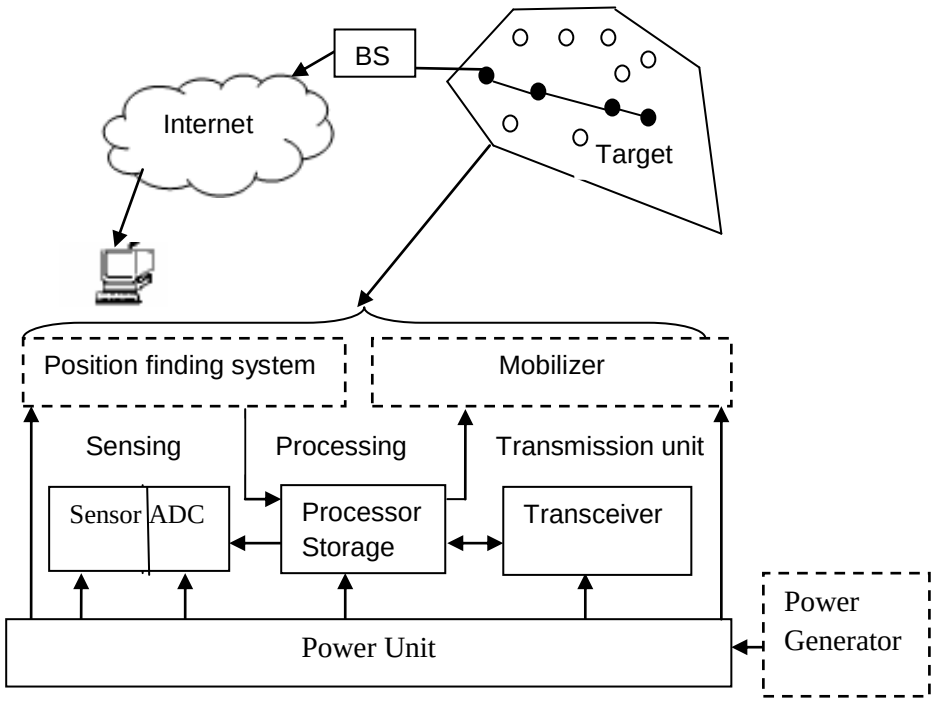

Fig.1: The component of sensor node.

In general, routing techniques in WSNs is divided into Data-centric routing, hierarchical-based routing and location-based routing depending on the network structure. In addition, the protocols can be classified into mobility-based, multipath-based, heterogeneity-based and quality of services (QoS)-based routing depending on the protocol operation. In this paper, we focus on three major routing techniques. First, **Data-centric approach**; in this category every sensor has the same role and functionality. Therefore the connections between the nodes are set in short distance to establish the radio communication. This

technique includes Sensor Protocols For Information via Negotiation(SPIN)[21], Direct Diffusion[12], Rumor Routing[8], Active Query Forwarding in Sensor Networks (ACQUIRE)[25], Gradient-Based Routing[10] protocols. Second, **Hierarchical-based approach**, in this network is divided into clusters containing number of nodes. Cluster head, which is master node, is responsible for routing the information to other cluster head. This method includes LEACH [24], PEGASIS [15], TEEN [1] and APTEEN [22]. Third, **Location-based approach**, in this category the routing protocols need node position to estimate the distance between two nodes, therefore energy utilization can be calculated in advance. This method includes Minimum Energy Communication Network (MECN)[22], Small Minimum Energy Communication Network (SMECN)[22], Geographic Adaptive Fidelity (GAF)[22], Coordination of power saving with routing [16][17], Trajectory-based forwarding [18], Geographic and Energy-Aware Routing (GEAR)[22], protocols. Out of these protocols, we have done the theoretical analysis of Rumor Routing, Active Query Forwarding in Sensor Networks (ACQUIRE), Coordination of power saving with routing, Trajectory-based forwarding, LEACH, PEGASIS, TEEN protocols.

In this paper, we will briefly describe the routing protocol for WSN. In the section 2 routing challenges and design issues are describes. In the section 3 various routing protocol are discussed and compared. Finally section 4 concludes the survey.

2. ROUTING CHALLENGES AND DESIGN ISSUES

Although the numerous application of WSNs, these networks have a number of limitations such as limited energy supply, limited bandwidth of the wireless links connecting sensor nodes and limited computing power[9]. The most important design goal of WSNs is to perform data communication while trying to enhance the lifetime of the network. The design of routing protocols is influenced by many challenges factors in WSNs. These factors have to overcome before communication can be achieved in WSNs. We describe some of the routing challenges and design issues that affect the routing process in WSNs [11].

2.1 NODE DEPLOYEMENT: Node deployment can be manual or randomized. For manual, the roots are predetermined and the sensors are manually placed. Though, in arbitrary node deployment, the sensor nodes are spread randomly, generating an ad-hoc routing infrastructure, for random deployed network route designation has been a challenging subject.

2.2 ENERGY CONSIDERATION: The energy consideration has a great influence on route design during the creation of an infrastructure. During transmission the power consumed is the greatest portion of energy consumption of any node. Multi-hop communication consumes less power than direct communication. However, multi-hop routing introduces extra topology management and medium access control.

2.3 DATA DELIVERY MODELS: Data delivery model can be, event-driven, query-driven, continuous, or hybrid. In event-driven and query driven model, the transmission is triggered by the sink when an event occurs. In continuous model, each sensor sends data periodically. Hybrid model is a combination of event driven, continuous and query-driven data delivery models.

2.4 DATA AGGREGATION: By definition, the sensor nodes are densely deployed and the data gathered by each node can be aggregated to reduce the number of transmission. Data aggregation is the grouping of data from different sources. Therefore data aggregation is referred to as data fusion which decreases the size of the data transmitted.

2.5 FAULT TOLERANCE: Some of nodes may fail or be blocked by physical damage, lack of power or environmental interference. The failure nodes should not affect the network operation. Thus, sensor nodes should be fault tolerant and have the abilities of self-testing, self-calibrating, self-repairing and self-recovering.

3. CLASSIFICATION OF ROUTING PROTOCOLS IN WSN

3.1 DATA-CENTRIC ROUTING

In data centric protocol, the data is sent from source sensor to the sink [25]. When the source sensor sends data to the sink, intermediate sensor perform some form of aggregation on data and forward the data to the sink. This process saves energy because it takes less transmission to send the data from source to the sink.

3.1.1 Rumor Routing

Rumor routing [8] is a variant of direct diffusion and is proposed for application in which geographic routing is not feasible. When there is no geographic condition to disseminate task, direct diffusion uses flooding to add the query to entire network. But in some cases the use of flooding is unnecessary because only small amount of data request from the nodes. Another approach is to flood the events, if the number of queries is large and number of events is small. To flood event, the rumor routing algorithm employs long- lived packet called agent. When a node identifies an event it adds the event to its event table and generate an agent. For an event, when a node generate query, the nodes that know the route can reply its event table. Therefore there is no need to flood the network.

As opposite to the direct diffusion, rumor routing maintains only one path between source and destination. Rumor routing does well when the number of events is tiny. The cost of maintaining agents and event-tables for large number of events becomes infeasible if there is not enough interest in these events from the BS.

3.1.2 ACQUIRE (Active Query Forwarding in Sensor Networks)

It is another direct centric querying mechanism. As in [25], the sensor network as a distributed database which consist of several sub queries and is well-suited for complex queries. The query mechanism works as follows:

The sink forwarded the query, the node receiving the query try to respond by using its pre-cached information and forward it to another sensor. If the information is not up to data, the information gathers by the nodes from its neighbor within a look-ahead of d hops. The query is transmitted back through either the reverse or shortest path to the sink once the query is completely determined. To answer precise types of queries ACQUIRE provide query optimization known as one shot complex queries for replicated data.

3.2 HIERARCHICAL-BASED ROUTING

It is a cluster-based routing method, initially proposed in wire-line network. This protocol creates clusters and head node is assigned to each cluster. The responsibility of head node is to collect and aggregate the data to the base station. This reduces energy consumption in the network by minimizing the total data message to be sent to the base station. It is a two layer routing protocol one layer is used to select cluster head and other layer is used for routing [22].

3.2.1. Low Energy Adaptive Clustering Hierarchy (LEACH)

LEACH [23][24]is designed to collect and deliver data to the destination. LEACH protocol organizes the network into set of cluster. The purpose is to randomly select sensor nodes as a cluster heads (CH). The responsibility of cluster head is to carry out several tasks. The first task is to collect the data from the member of the cluster, after that, the cluster head aggregated the collected data to remove redundancy among interrelated values. The second task is to transmit the aggregate data directly to the base station. The third task is to create Time division multiple access (TDMA) base schedule in which each node of cluster is assigned a time slot for transmission. This protocol is suitable for regular monitoring such as monitor machinery for diagnosis and fault detection. The drawback of this protocol is that it uses single-hop routing where every node can transmit to the cluster-head and the destination. So, it is not appropriate to networks deployed in large area.

The operation of LEACH is divided into 2 phases as shown in Figure 2 each namely...

1. Setup phase: It organizes the network into cluster and cluster head is selected.
2. Steady state phase: It focuses on data collection, aggregation and delivery actual data to the base station. The period of the setup phase is relatively shorter than the steady-state phase to minimize the protocol overhead.

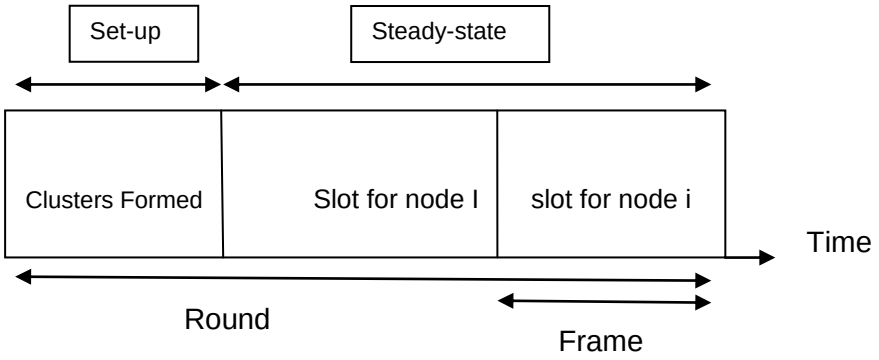

Fig.2: LEACH operation.

3.2.2. Power-Efficient Gathering in Sensor Information Systems (PEGASIS)

PEGASIS [15] is a chain based protocol. It is an extension of LEACH protocol which form a chain from the sensor node in which each node transmit and receive from a neighbor. Only one node is selected from the chain to transmit it to the base station. The goal of PEGASIS is to build up a routing structure and an aggregation method to reduce energy utilization and send the aggregated data with minimal delay to the base station. Based on the structure, node communicates to the closest neighbor. Network nodes are added to the chain, starting from the closest neighbor to the end node. Nodes that are outside the chain are added in a greedy fashion. The nodes adjust the power of their transmissions with this purpose. In every round, one node in the chain is selected to communicate with the sink. PEGASIS increases the lifetime of a network by accomplishing a high level of energy efficiency and consistent energy consumption across all network nodes. This performance is achieved through the removal of the overhead caused by dynamic cluster formation in LEACH and through minimizing the number of transmission but PEGASIS still need dynamic topology adjustment because a sensor node wants to know regarding energy status of its neighbors, to identify where to route its data. Such topology adjustment can commence large overhead mainly for highly utilized networks.

3.2.3. Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN)

TEEN [1] is hierarchical protocol for reactive networks that react immediately to changes in the significant parameters. This protocol groups sensor into the cluster with leading cluster head (CH). Here the sensor nodes sends their data to CH and CH then sends that aggregated data to the higher level of CH until the data is transmitted to the destination. Thus, in TEEN sensor network architecture is based on a hierarchical grouping where closer node form cluster and this process go on the second level until the BS is reached. TEEN uses a data-centric technique with hierarchical approach. For time critical sensing application the TEEN is best suited. The applications where periodic reports are needed cannot use TEEN.

3.3 LOCATION-BASED ROUTING

Before communication, real time application wants to know regarding the location of node in WSN. Geographic routing known as geometric, position-based or Location based routing protocols calculate the geographical position of node and then broadcast the packet [6].

3.3.1 Trajectory-Based Forwarding (TBF)

TBF [18] performs better in a sufficiently dense network, where the sensor nodes can coordinate each other's locations using GPS system. The source node specifies a certain trajectory in the forwarding packet but not the actual path to the destination node. The sensor nodes using the neighboring nodes information and the trajectory set by the source nodes forwards the packets. The sensor nodes having the value closest to the trajectory set by sensor nodes are selected to forward the packets. TBF can be used for many of the network functions such as flooding, discovery and network management.

3.3.2 Coordination of power saving with Routing

Span [17] is a routing protocol primarily planned for MANETS's, but can be relevant for WSNs. The main objective of this routing protocol is to reduce energy consumption of the nodes. As the wireless network devices are the largest consumer of power, the span protocol is introduced. Span makes a forwarding backbone topology for the sensor nodes and joins the source and destination nodes. Span checks for the sensor nodes if it is coordinate or non-coordinated node and forwards packet with the help of coordinators node which is closest to the destination, If a non-coordinator is closer to the destination node, the span selects that node to transfer packet.

	Applied Technique					
Protocols	Data Centric	Energy Efficiency	Location Based	Multipath	QoS	Hierarchy Based
Rumor	Yes					
ACQUIRE	Yes					
LEACH		Yes				Yes
PEGASIS		Yes			Yes	Yes
TEEN		Yes				Yes
TBF			Yes			
SPAN			Yes			

Table1: Characteristics of routing protocols in sensor network

4. CONCLUSION

The main challenge in the design of routing protocol is energy efficiency due to limited energy resource of sensor. The energy consumption of the sensors is subjected by data transmission and acceptance. As a result, routing protocols planned for WSNs should be as energy efficient as possible to enhance the lifetime of the network. The protocols discussed have advantages and disadvantages. The protocol and routing strategies can be applied based on the topology. Overall, the routing techniques are classified into 3 main categories namely data-centric, hierarchical and location-based. We also highlight the routing challenges and design issues of routing protocol. While various routing techniques seem to be promising but there are many challenges that have to be solved in sensor network.

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