A Comparative Study on Various Routing Protocols of Wireless Sensor Network

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---ABSTRACT--
Wireless Sensor Networks consist of small nodes with sensing and computation, communication capabilities. Wireless network are highly dependent on specific application and are constrained by energy, storage capacity and power. To increase the lifetime of networks, energy awareness is essential consideration if we analyze routing protocols. Routing protocols of sensor networks are responsible for maintaining the routs in the network. In this paper, we analyze the wireless sensor network routing protocols are hierarchical, flat and location based routing protocol on the basis of network structure.

Keywords: **Hierarchical, Protocols, Routing, Sensor, Wireless sensor network**
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1. Introduction

Wireless sensor networks is widely considered as one of the most important technologies. A WSN consists of a large number of low cost, low powers. The main goal of WSN is detect the occurrences of events, classify a detected object and track an object. These sensor nodes communicate over short distance via a wireless medium [1]. In sensor networks, energy is a critical resource, while applications exhibit a limited set of characteristics.

Wireless sensor networks have found their way into a wide variety of applications and systems with vastly varying requirements and characteristics[2-3]. The routing protocols used in several applications are following:

Military: The sensor network can be used in military situation awareness, basis of sensing intruders detection of enemy unit movements on land and sea, battle field surveillances.

Emergency situations: In Emergency situations, Wireless sensor network used in disaster management, fire/water detectors, hazardous chemical level and fires.

Medical and health: The sensor network used in medical and health for measuring blood flow, respiratory rate , ECG(electrocardiogram),pulse oxymeter and blood pressure and oxygen measurement and also monitoring people's location and health condition.
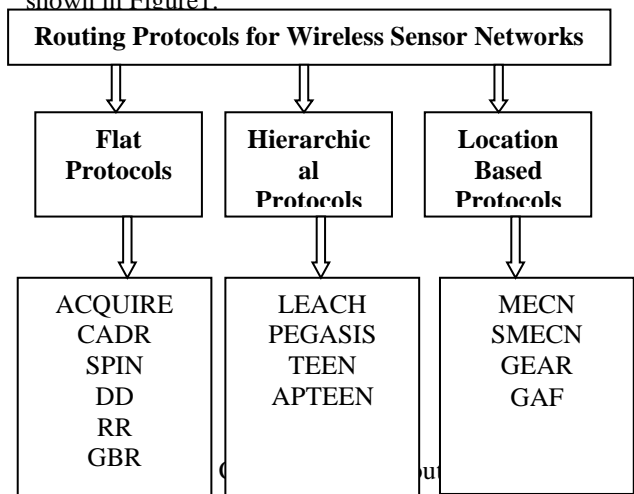
Industrial: In Industries, sensor networks are used in factory process control and industrial automation and monitoring and control of industrial equipment.

Home networks: In Home appliances, sensor network used in location awareness (blue tooth) and Person locator.

In this paper, we discuss about routing protocols and classify them into three categories on the basis of network structure are flat routing, location based routing and hierarchical routing. Then we discuss the design issues of routing protocols. Then we compare the routing protocols and at last we conclude this paper.

2. Classification of routing protocols in WSN

In general, routing in WSNs can be classified into flat based routing, hierarchical based routing, and location-based routing depending on the network structure. In flat-based routing, all nodes are typically assigned equal roles or functionality. In hierarchical-based routing, however, nodes will play different roles in the network. In location-based routing, sensor nodes' positions are exploited to route data in the network. The classification of routing protocols are shown in Figure1.

Routing Protocols for Wireless Sensor Networks		
Flat Protocols	**Hierarchical Protocols**	**Location Based Protocols**
ACQUIRE CADR SPIN DD RR GBR	LEACH PEGASIS TEEN APTEEN	MECN SMECN GEAR GAF

2.1 Flat routing protocol

In Flat routing, all nodes plays same role. Each node distributes data to other reachable node and sensor nodes collaborate 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.

2.1.1Sensor Protocols for Information via Negotiation (SPIN)

SPIN [4] protocol was designed to improve classic flooding protocols and overcome the problems they may cause, for example, implosion and overlap. The SPIN protocols are resource aware and resource adaptive. The sensors running the SPIN protocols are able to compute the energy consumption required to compute, send, and receive data over the network. Thus, they can make informed decisions for efficient use of their own resources. The SPIN protocols are based on two key mechanisms namely negotiation and resource adaptation. SPIN enables the sensors to negotiate with each other before any data dissemination can occur in order to avoid injecting non-useful and redundant information in the network.

2.1.2 Rumor Routing

Rumor routing is a logical compromise between query flooding and event flooding app schemes [5]. Rumor routing is an efficient protocol if the number of queries is between the two intersection points of the curve of rumor routing with those of query flooding and event flooding. Rumor routing is based on the concept of agent, which is a long-lived packet that traverses a network and informs each sensor it encounters about the events that it has learned during its network traverse. An agent will travel the network for a certain number of hops and then die. Each sensor, including the agent, maintains an event list that has event-distance pairs, where every entry in the list contains the event and the actual distance in the number of hops to that event from the currently visited sensor.

2.2 Location based Routing

In location-based protocols, sensor nodes are addressed by means of their locations. Location information for sensor nodes is required for sensor networks by most of the routing protocols to calculate the distance between two particular nodes so that energy consumption can be estimated. Some real time application to know about location of node before communication. This routing protocol find the geographical position of node and then transmit the packets.

2.2.1Geographic and Energy Aware Routing (GEAR)

In this algorithm, each node keeps an estimated cost and a learning cost of reaching the destination through neighbors. The estimated cost is a combination of residual energy and distance to destination. Hole occurs when a node does not have any closer neighbors to the target. If there are no holes, the estimated cost is equal to the learned cost. The learned cost is propagated one hop back every time a packet reaches the destination so that route set up for next packet will be adjusted.

2.2.2 Geographic Adaptive Fidelity (GAF)

GAF [6] is an energy-aware routing protocol primarily proposed for MANETs, but can also be used for WSNs because it favors energy conservation. The design of GAF is motivated based on an energy model that considers energy consumption due to the reception and transmission of packets as well as idle (or listening) time when the radio of a sensor is on to detect the presence of incoming packets. GAF is based on mechanism of turning off unnecessary sensors while keeping a constant level of routing fidelity (or uninterrupted connectivity between communicating sensors). In GAF, sensor field is divided into grid squares and every sensor uses its location information, which can be provided by GPS or other location systems, to associate itself with a particular grid in which it resides.

2.2.3 Small Minimum-Energy Communication Network (SMECN)

SMECN [7] is a routing protocol proposed to improve MECN, in which a minimal graph is characterized with regard to the minimum energy property. This property implies that for any pair of sensors in a graph associated with a network, there is a minimum energy-efficient path between them; that is, a path that has the smallest cost in terms of energy consumption over all possible paths between this pair of sensors. Their characterization of a graph with respect to the minimum energy property is intuitive. In SMECN protocol, every sensor discovers its immediate neighbors by broadcasting a neighbor discovery message using some initial power that is updated incrementally.

2.3 Hierarchical Routing

Hierarchical routing is to efficiently maintain the energy consumption of network. Clustering is an energy efficient communication protocol that can be used by the sensors to report their sensed data to the sink. This provides inherent optimization capabilities at the cluster heads. A network is composed of several clusters. Each cluster is managed by a special node, called cluster head, which is responsible for coordinating the data transmission activities of all sensors in its cluster.

2.3.1 Low Energy Adaptive Clustering Hierarchy (LEACH)

Low energy adaptive clustering hierarchy (LEACH) is most popular hierarchical routing protocol for sensor networks. LEACH is a hierarchical protocol in which most nodes transmit to cluster heads, and the cluster heads compress and aggregate the data and forward it to the base station. LEACH assumes that each node has a radio powerful enough to directly reach the base station or the nearest cluster head, but that using this radio at full power all the

time would waste energy. Nodes that have been cluster heads cannot become cluster heads again for P rounds. At the end of each round, each node that is not a cluster head selects the closest cluster head and joins that cluster to transmit its data.

2.3.2 Power-Efficient Gathering in Sensor Information Systems (PEGASIS)

Power Efficient Gathering in Sensor Information Systems, which is near optimal for this data gathering application in sensor networks. In PEGASIS is to form a chain among the sensor nodes so that each node will receive from and transmit to a close neighbor gathered data moves from node to node and a designated node transmits to the base station[8]. For collecting data in each round, each node receives data from one neighbor, fuses with its own data and transmit to other neighbor on the chain.

2.3.3 Threshold-sensitive Energy Efficient Protocols (TEEN and APTEEN)

In TEEN, sensor nodes sense the medium continuously, but the data transmission is done less frequently. A cluster head sensor sends its members a hard threshold, which is the threshold value of the sensed attribute and a soft threshold, which is a small change in the value of the sensed attribute that triggers the node to switch on its transmitter and transmit. Thus the hard threshold tries to reduce the number of transmissions by allowing the nodes to transmit only when the sensed attribute is in the range of interest[9]. The soft threshold further reduces the number of transmissions that might have otherwise occurred when there is little or no change in the sensed attribute.

In APTEEN, the cluster-heads broadcasts the following parameters.

1. **Attributes (A)**: This is a set of physical parameters which the user is interested in obtaining information about.

2. **Thresholds**: This parameter consists of the Hard Threshold (HT) and the Soft Threshold (ST).

3. **Schedule**: This is a TDMA schedule, assigning a slot to each node.
4. **Count Time (CT)**: It is the maximum time period between two successive reports sent by a node.

The node senses the environment continuously, and only those nodes which sense a data value at or beyond the hard threshold transmit. Once a node senses a value beyond HT, it transmits data only when the values of that attribute changes by an amount equal to or greater than the ST. If a node does not send data for a time period equal to the count time, it is forced to sense and retransmit the data. A TDMA schedule is used and each node in the cluster is assigned a transmission slot. Hence, APTEEN uses a modified TDMA schedule to implement the hybrid network. The main features of the APTEEN scheme include the following. It combines both proactive and reactive policies. It offers a lot of flexibility by allowing the user to set the count-time interval (CT), and the threshold values for the energy consumption can be controlled by changing the count time as well as the threshold values.

3. Comparison of Routing Protocols

Flat routing is simple protocol but it suffers large amount of control packet overhead and lack of scalability. In recent year, researches are moved to Hierarchical routing. Compared with all routing protocols in WSN, Hierarchical routing protocols has many advantages like more scalability, consume less energy and more robustness [10-11]. This section summarizes the advantages of hierarchical routing.

➢ **More Scalability**
   Scalability refers to the performance of communicating system won't be degraded when number of nodes will increases. In WSN, there may be thousand of nodes. It can be achieved by localize the interaction among the communicating nodes, which can be done through hierarchical routing. Compare to flat routing it can be easily manageable.

➢ **Less Energy**
   In hierarchical routing Cluster head performs data aggregation and data transmission. This will lead save great deal of energy compare to flat and location based routing. In addition to that clustering with inter and intra cluster communication reduces the node to communicate with node present in long distance. This will also help to consume less amount of energy.

➢ **More Robustness**
   The topology of a WSN may change due to alternative state of sensor node from sleep node to active node. Hierarchal routing is highly suitable for topology control and network management. It is work well in large-scale scenario compared to flat routing.

Routing Protocols	Classification	Merits
LEACH	Hierarchical	Scalable in order to maximize system lifetime and robust to node failures
PEGASIS	Hierarchical	Reduce the overhead and minimize the delay.
Rumor Routing	Flat	Save energy and reduce the redundant element.
SPIN	Flat	Reduces the overlaps and extends the lifetime
SMECN	Flat	Overall energy consumption is reduced
GAF	Location	Good in scalability and use minimum power.

Table1: Classification and merits of routing protocols in wireless sensor networks.

Merits of routing protocols in wireless sensor networks are given in above table. Moreover Hierarchical routing is reservation-based, collisions avoided, Fair channel allocation, Reduced duty cycle due to periodic sleeping of node, simple but not a optimal routing and energy dissipation is uniform. It has two main drawbacks. First overhead of cluster head formation throughout the network and second it require global and local synchronization.

4. Conclusion

In this paper we made a survey about wireless sensor network and its protocols such as flat routing, location based routing and hierarchical routing. In future, we provide an efficient protocol by choosing best features of above comparison merits. Sensor networks have a lot of promise in applications where gathering sensing information in remote locations is required. It is an evolving field, which offers scope for a lot of research.

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