A STUDY ON ROUTING TECHNIQUES IN WIRELESS SENSOR NETWORK

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ABSTRACT

Wireless Sensor Network (WSN) is built with group of sensors. These nodes lead to a number of advanced protocols especially developed for battery life conservation. Routing is used to establish a connection in the sensor network. Primary task of routing algorithm is to transfer data from sensors to sink. Building an efficient routing protocol, increasing the lifetime of the sensor nodes, dealing with packet loss are all some of the most difficult tasks in WSN. This paper discusses about the hierarchical routing algorithm and also presents the classification of those protocols. This paper also gives the clear view to select an appropriate routing protocol for efficient routing.

Keywords: Wireless Sensor Network, Routing Protocol, Cluster head.

INTRODUCTION

In present years, there is a rapid technological advancement in Wireless Sensor Networks. It typically consists of a large number of low-cost, low-power and multifunctional wireless sensor nodes with sensing, wireless communication and computation capabilities [1]. A WSN is made of sensor nodes and has a wide area of usage including military and civil applications, each includes every aspects of our daily life, like as medical monitoring, industrial plant monitoring and building structures monitoring [2]. Sensor network have constrained energy, power supply, life time, throughput etc. Routing is a challenging issue in Wireless sensor network.

Architectural requirement of a network is measured with respect to the routing requirements of that network. Routing algorithm can be classified into three: Hierarchical scheme, Location scheme and Flat scheme routing protocol. This paper talks about all these three routing methodologies, mainly focusing on Hierarchical routing algorithms. Architectural overview of Wireless Sensor Network can be listed as [3]:

1. *Source node*: initial node in the sensor network. The data is transferred from the source to the sink.
2. *Cluster*: Nodes with similar parameters are grouped to form clusters.
3. *Cluster head*: Initiator in the cluster. It contains the detailed information about the nearby nodes.
4. *Gateway*: Intermediate between the two cluster.
5. *Sink*: Terminator

To establish the communication between these nodes, routing becomes an essential mechanism. Various routing mechanism rely on routing protocols [4].

1

Routing path can be categorized into two types:

1. Multipath path
2. Single path

A Single path routing is the Routing technique where the direct connection is established between the source and destination. It is simple as well as scalable. The selection of intermediate node from the source node in the network becomes an effortless task. On the other hand, this technique may deplete more power from the sensor nodes, and the lifetime becomes too short due to network partition. The flat scheme routing comes under the Single path. The harmful issues in WSN are insufficient power, limited memory, unreliable network communication and unpredictable environmental interference which cannot be overcome by this technique. An alternative technique that can overcome these issues is the multipath routing technique.

In Multipath routing technique, multiple paths deliver data from source to sink. Single path routing issues can be replaced by multipath, since it relies on redundant path. Multipath routing is reliable and secure. Both Hierarchical and Location based schemes belong to Multipath Routing.

ROUTING TECHNIQUES IN WSN

Though sensor networks are basically used for sensing and communicating events, they depend on the application. So, a single routing algorithm cannot work efficiently for sensor networks for all applications.

Routing protocols in wireless sensor network is used to minimize the energy consideration along with battery power saving. Energy awareness is a main issue in routing protocol. Based on the network structure, routing algorithm in WSN is classified into three types [5][6]:

1. Flat-scheme routing
2. Hierarchical-scheme routing
3. Location-scheme routing

2.1 Flat scheme routing:

In flat scheme routing, each and every node has equal preference. The Collaboration is made between the sensor nodes to sense data. Data centric algorithm comes under the flat based routing. The query message is transferred between the sensor nodes to establish a connection. Here, the sink node communicates the query messages to the nearby nodes and waits for the related data in response. Based on the above mechanism, SPIN(Sensor Protocols for Information via Negotiation) was developed as the first data centric protocol. It eliminates redundant data by considering the data negotiation between group of nodes. The advantage is, it saves the energy. Directed Diffusion (DD) is our targeted area. This concept aims to diffuse data along the sensor nodes using naming schema for data. An importance is defined and analyzed by using those pairs. Rumor routing(RR) is one type of Direct Diffusion. This is mainly used for applications where routing with respect to geographical constraint is not possible. In a random way, the Query and Event flooding protocols can be combined. And it has some assumptions, the network is comprised of distributed nodes, bidirectional links only can be allowed, transmission can be occurred between only the short distance.

2.2 Hierarchical scheme routing:

The Hierarchical routing protocol [7] considers energy consumption as a major issue in Wireless Sensor Network. Several clusters can be formed based on this technique. To implement the routing mechanism, the sensor network is grouped to form a clusters. The Cluster Head (CH) is assigned for all clusters. Cluster heads plays the role as an initiator of the group. The Cluster head has various responsibilities such as data aggregation, collection and also diminish the number of communications to sink. The data aggregation in these nodes significantly reduces the energy that help as to increases the life of the network. Clusters formed are dependent on the nodes initial energy and nodes proximity of hops to the CH. The hierarchical protocols are.

2.2.1 LEACH:

"Low-energy adaptive clustering hierarchy" (LEACH) is an important hierarchal routing protocols [8]. Idea behind LEACH is to form clusters which depend on the signal quality and proximity of nodes to CH. Because of this consideration, energy spent in communication with BS gets reduced. Randomized rotation of CH is achieved by this technique. To protect the battery life of a single node, normalization technique is used. Here CH also does aggregation of data to reduce the number of communications to BS [3].

$$T(n) = \begin{cases} \dfrac{Per}{1-p*(cr \bmod {}^1/p)} & \text{if } n \in G0 \\ \\ 0 & \text{otherwise} \end{cases}$$

Where: per- % of cluster heads,

cr -present round and

G_0 –non CH nodes in the last 1/p rounds .

2.2.2 PEGASIS:

PEGASIS(Power-Efficient Gathering in Sensor Information Systems)[8]. Power-Efficient Gathering in Sensor Information Systems (PEGASIS) is an enhanced version of the LEACH algorithm. As an alternative for multiple clustering, this algorithm form chain of nodes, so that every node communicates to a neighbor and only one node is responsible for communication with the Base Station (sink). Communicated data gets aggregated at the CH and gets communicated to BS. This type of chain of nodes construction is considered in a greedy way [3].
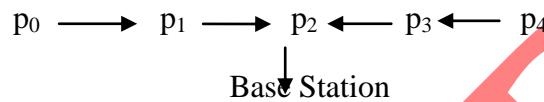
$$p_0 \longrightarrow p_1 \longrightarrow p_2 \longleftarrow p_3 \longleftarrow p_4$$

Base Station

Fig.1: Chain Formation in PEGASIS

The Fig.1shows, node n_0 forwards data received by node p_1. p_1 aggregates p_0's information and then communicates to CH. Afterwards, p_2 passes that token to p_4, node p_4 forwards its data to node p3.p3 aggregates p4's information with its own and then transmits to the leader. Node p_2 waits until it receives the data from all neighbors and then aggregates the content with all neighbor nodes data. Finally, p_2 transmits single packet to the base station.

2.2.3 TEEN:

"Threshold sensitive Energy Efficient sensor Network protocol(TEEN)" is permutation of both data-centric and hierarchical clustering protocols [15] .This supports critical applications. Methodology can be used when abrupt events occurs. TEEN uses a combination of both hierarchical and data centric applications. After the cluster formation, both thresholds value are broadcasted from the CH to members on clusters. Hard threshold(HT), which is the least probability of an aspect to build a sensor to switch data from its transmitter and transmitter to CH. Softer threshold(ST), is a variation in the sensed attribute value. It stimulates the node to which it switches and then transmits the sensed data, only when this obtained value exist beyond the harder threshold, the node reports to sink

2.2.4 APTEEN:

The "Adaptive Threshold sensitive Energy Efficient sensor Network" protocol (APTEEN)" is an enhancement of TEEN, which targets both sensing cyclic collection and also aggregation, then reacts to the time-specific events. When the clusters can be formed by the base station, and then CH broadcasts the attribute identifier, the threshold and scheduled transmission to all nodes[16]. CH can also perform the data aggregation, nodes conserve battery life. Algorithm supports three types of queries: historical scheme: analyzes the past values; one-time scheme: takes a snapshot of the network and persistent scheme: monitors events for a period of time.

2.2.5 HEED:

"Hybrid Energy-Efficient Distributed Clustering(HEED)" is a multiple-hop clustering algorithm for WSN, and aims at efficient clustering by efficient CH [18]. Depending on the distance of nodes, the CH can be selected.

Most important objective of HEED is,

1. Increase network lifetime by Distribute energy consumption
2. Reduce energy during CH selection phases
3. Reduce overhead of a network.

Main feature of HEED is CH selection methods. CHs are found based on two basic metrics: Remaining energy and Inter cluster communication. The remaining energy of each sensor is used to elect the preliminary group of CH. Many other clustering schemes use this parameter. Cost of Intra-cluster communication is utilized by sensors to establish the cluster to be connected. This parameter can be particularly used in the case of node drops into a cluster, which has more than one cluster head.

2.2.6 EARP:

An EARP is Energy-aware routing protocol [19]. This algorithm is mainly designed for hierarchical networks, a three tier architecture. There exists some assumption: clusters are formed based on prior knowledge. The algorithm employs CH and GW, which proves to be energy efficient. GW maintains the states of the nodes and set up multiple-hop path for gathering sensors data.

The command node communicates with GW. A TDMA based MAC is used by nodes to send data to the GW. The GW informs the timeslots, when it must communicates to other sensors slots, where sensors can be used for its own transmission. The sensor is considered that it is able to operate in an active or standby mode. The processing and sensing circuits can be done when power is off or on.

The Nodes in a cluster is four types, namely:

1) Sense state: Period when sensors probes the network and produces constant data

2) Relay state: When the sensors do not sense the destination, but its transmitting circuitry is ready to forward data from all other active nodes.

3) Sense-relay state : Sensor does sensing and transmitting

4) Inactive state: State when node does not do any activity

2.3 Location Scheme Routing:

Location information is the basic requirement for this kind of routing protocol. This calculates the node distance by means of which energy consumption is predicted. It is an energy efficient protocol, Since the location information is used for routing, addressing scheme like, IP addresses are not required. To sense the location, the queries are diffused to the particular region instead of transmitting all over the network. It is mainly designed for adhoc network. They are not energy aware due to which is not applicable for sensor network [24].

2.3.1 MECN and SMECN:

In "Minimum Energy Communication Network", smaller power GPS is used to maintain lowest energy in the wireless network. It is applicable for the static network. Master node is found for the station that includes minimum power topology. Assumed as a master site that contains the information about the sink.

Another possible approach called SMECN is introduced. The possible obstacle between the pair of nodes is considered, whereas in MECN, each and every node can transmit to every other nodes. Network is assumed to be connected in all cases. Minimum energy relaying is probably smaller for the network constructed by SMECN than by MECN. In this case, the broadcasted message is able to reach the sensors in the round fashion.

2.3.2 GAF:

"Geographic Adaptive Fidelity" is abbreviated as GAF. It is a location scheme based algorithm for mobile ad-hoc network as well as sensor network. It considers energy by disabling the unwanted sensor in the network, without disturbing the routing process. It creates a virtual- grid. Every node utilizes GPS to locate their points on grid. Nodes of the same grid are considered in terms of the packet routing rate. In order to save energy, these equivalents are exploited to keep certain nodes in the sleeping state. Thus, GAF has the capability to boost the network life time as the number of sensor increases.

2.3.3 GEAR:

"Geographically Energy Aware Routing" which utilized geographically inform neighbor selection heuristic and energy aware mechanism to communicate a packet towards the sink. The main aim of the GEAR is to limit interest in DD, by allowing the particular region than transmitting to the entire network. Thus, GEAR in comparison with the DD conserves energy.

COMPARATIVE STUDY

The table given below gives a comparative study about the Routing protocols which depends upon the different parameters based on their performance [27]:

Routing protocol	Energy Consumption	Lifetime	Scalability	Classification	Data Aggregation	Query Based	Technique
SPIN	Limited	Good	Limited	Flat	Yes	Yes	Multipath
DD	Limited	Good	Limited	Flat	Yes	Yes	Multipath
RR	Very limited	Better	Good	Flat	Yes	Yes	Single path
LEACH	Maximum	Better	Good	Hierarchical	Yes	No	Single path
PEGASIS	Maximum	Better	Good	Hierarchical	No	No	Single path
HEED	Maximum	Better	Good	Hierarchical	Yes	No	Single path
TEEN	Maximum	Better	Good	Hierarchical	Yes	No	Single path
APTEEN	Maximum	Better	Good	Hierarchical	Yes	No	Single path
EARP	Maximum	Better	Good	Hierarchical	Yes	No	Single path

MECN & SMECN	Maximum	Good	Low	Location	No	No	Single path
GAF	Limited	Good	Good	Location	No	No	Single path
GEAR	Limited	Good	Limited	Location	No	No	Single path

Table.1: comparative study of Routing Techniques

The study can be determined according to the lifetime of the network, scalability, energy consumption, data aggregation, Query based and its technique. According to this comparative study, LEACH, TEEN, APTEEN, HEED all are having similar functions. The performance of these protocols are different. The protocols can be classified as clustering based and chain based protocols. Here, the protocols like LEACH, HEED, TEEN, APTEEN are clustering based, whereas protocol like PEGASIS are chain based protocol. The technique for these protocols are classified into single path and multipath. The technique for both hierarchal and location scheme based protocol are single path whereas, protocols like SPIN and DD are considered as Multipath technique. The function of APTEEN is similar to LEACH and TEEN, in terms of energy consumption and lifetime. In the case of critical time transmission, it can only be transmitted by TEEN, whereas periodic transmission can be performed by APTEEN. APTEEN is better than LEACH, according to transmissions. i.e, APTEEN transmits data depends on threshold value but LEACH transmits data continuously. HEED is considered as a multihop clustering which gives efficient clustering. PEGASIS avoids the overhead of cluster head formation in LEACH.

CONCLUSION

In Recent years, Routing has become an interesting mechanism in Wireless Sensor Network. To transfer a data efficiently from the source to the Destination, routing plays a major role. In this paper, different concepts of routing are explained in various topological view. It focuses on the hierarchical routing and its function in detail. Also a comparative analysis of the routing techniques is given for better understanding of the concepts.

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7

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8

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9