A COMPARATIVE STUDY OF NETWORK STRUCTURED HIERARCHICAL ROUTING PROTOCOL IN WIRELESS SENSOR NETWORK

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Abstract

Wireless sensor Network is a system consists of a group of sensor nodes to transmit information as packets to the Base station. For the reason of limited processing capability and energy resources, designing of energy efficient routing protocols which are responsible for maintaining the routes in the network are essential in WSN. Basically, the important feature of routing protocol is to reduce the energy consumption of the sensor node and prolong the lifetime of the network. The network structured routing protocol in WSN is classified into three categories: Flat, Hierarchical and Location based. In this paper the theoretical approach to give survey on Hierarchical routing protocol for WSN & also discuss about their performance.

Index Terms: *Routing protocol, Network Lifetime, Hierarchical Routing, Wireless Sensor Network.*

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1. INTRODUCTION

Due to recent technical advances, Wireless Sensor Networks have emerged as an new research area which senses and monitor physical or environmental conditions such as Humidity, pressure, etc[1]. A WSN is a collection of large number of sensor nodes which have the ability to communicate either among each other or directly to an external base-station (BS). They are self-organize and are connected with each other through wireless links. The important features of sensor networks are data aggregation, self organization, low power consumption and multi-hop routing [2][3].The strength of wireless sensor network lies in their flexibility and scalability.

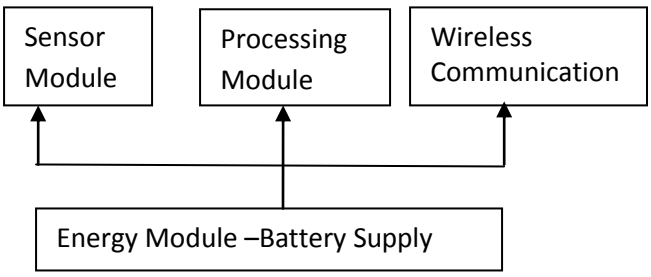

Fig-1: ***Wireless Sensor Network Structure.***

Routing protocols in charge of discovering and maintaining the routes in the network is challenging research area in wireless sensor networks. The problem behind of the routing strategies is to efficiently deliver the packets to their BS. Sensor nodes are Energy Constrained [4].It is very difficult and even impossible to change or recharge batteries for the sensor nodes. In WSN networks, the hierarchical routing strategy should ensure the consumption of energy and hence maximization of the lifetime of the network. Conventional routing protocols like flooding technique in which a node stores the data item it receives and then sends copies of the data item to all its neighbours could not be used in sensor networks due to the energy constrained nature of these networks.

Flooding has several deficiencies such as implosion which is a situation where duplicated messages send to the same node and unawareness about resources available .Moreover, it is not possible to build a global addressing scheme for the deployment of a large number of sensor nodes. To overcome these limitations, routing mechanisms designed for WSNs is to consider the inherent features of networks along with the application and architecture requirements. In the past few years, many new algorithms have been proposed for the routing problem in wireless sensor networks.

This paper is organized as follows: In section 2, Route Selection Strategies of WSN are described. In section 3,

Hierarchical routing techniques are discussed. In Section 4, the comparison of hierarchical routing protocols is given. Finally, in section 5, we conclude the paper.

2. ENERGY EFFICIENT ROUTE SELECTION STRATEGIES

The goal of WSN [3] is not only to transmit data from a source to a BS, but also to boosting the lifetime of the network structure which can be achieved by employing aggressive energy efficient routing techniques. The design of routing protocols in WSNs is influenced by many important parameter. In the following category, we discuss some of the routing challenges and design issues that affect routing process in WSNs [4].

Energy consumption without losing accuracy: sensor nodes can use up their limited supply of energy performing computations and transmitting information in a wireless environment. As such, energy-conserving forms of communication and computation are essential.

Scalability: The number of sensor nodes deployed in the sensing area may be in the order of hundreds and above. Any routing scheme must be able to work with this huge number of sensor nodes.

Transmission Media: In a multi-hop sensor network, wireless medium act as a transmission medium. Related to the transmission media is the design of medium access control (MAC).

Connectivity: Priority node density in sensor networks to be considers them from being completely isolated from each other.

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

Data Aggregation: sensor nodes may generate significant redundant data thus making similar packets from multiple nodes can be aggregated .so that the number of transmissions is reduced.

3. HIERARCHICAL ROUTING PROTOCOL

In WSNs, sending message is the important process for data transmission, where as data sending is the process in which a source node transmits a message to all other nodes in the network. Hierarchical routing protocols are designed to reduce energy consumption by localizing communication within the cluster and aggregate data to reduce transmissions to the BS. A hierarchical approach groups nodes into clusters with single cluster head that has the responsibility of routing from the cluster to the other cluster heads or base stations. Here, some of the hierarchical routing protocols are reviewed.

LEACH

Low-Energy Adaptive Clustering Hierarchy (LEACH) [5][8]is the first hierarchical cluster based routing protocol that give the guarantee about the allocation of energy in the sensor nodes homogeneously in wireless sensor networks. In LEACH, sensor nodes are organized into local clusters in which one node in each cluster is elected as cluster head. The cluster head receives data from all other sensors in the cluster[7] .LEACH uses rotation of the cluster head in order to evenly distribute the energy load. Thus LEACH is suitable for networks where every node has data to send at regular intervals.

The operation of LEACH is done into two different steps. That is setup and steady state phase[6]. In setup phase, the nodes are organized into clusters and CHs are selected. The cluster-head receives all the messages sent by the nodes that would like to join in the group of sensor nodes to confirms them as one of the cluster nodes, then joins them in the routing table and allocates TDMA table of slots for the cluster members telling each member when it can transmit data.

In the steady state phase, Steady-state phase: members of the cluster send data to the cluster-head in the way of single-hop during the allocated slot according to the TDMA table, the CHs receives all the data from each node in the cluster nodes, fuses all the data into a single signal, after that the fusion signal is transmitted to the base station by CHs. Data sending lasts a certain time, and then the entire network comes into the next round.To minimize overhead the duration of the steady state phase should be longer than the duration of the setup phase[7]. Many improved versions of LEACH protocol (like LEACH-C, VLEACH, E-LEACH etc) are proposed.

HEED

H*ybrid* E*nergy* E*fficient* D*istributed* C*lustering* (or HEED) is a multi-hop clustering algorithm for WSNs to choose an efficient clustering by proper selection of cluster heads based on the physical distance between nodes. The main objectives of HEED are to [9]:

1. To increase the network lifetime.
2. Minimize energy consumption during the cluster heads selection phase.

The most important aspect of HEED is the method of cluster heads selection. Cluster heads are determined based on two important parameters [10][11]:

1. The residual energy of each node is used to probabilistically choose the initial set of cluster heads.
2. Intra-Cluster Communication Cost is used by nodes to determine the cluster to join. This is especially useful if a given node falls within the range of more than one cluster head.

PEGASIS

PEGASIS (P*ower* E*fficient* G*athering* in S*ensor* I*nformation* S*ystems*).This protocol becomes to form a chain structure by connecting sensor nodes[12]. The sensor nodes which are closest to each other will be considered to form the chain and this chain is responsible for communicating with the BS. Initial node becomes CH and nearest node become child node. Similarly the process continue to till reach BS. Each and every node will fuses its own information with the information of the neighbouring node and this will form a one information packet. This information packet will be of the same length and transmit the fused information to the neighbour's node. In PEGASIS [13], signal strength is considered to measure the distance to all the neighbouring nodes. Chain construction process continues till the sensor node in the chain dies due to low energy backup. The main drawback of Greedy chain construction approach of PEGASIS protocol is that whenever a single node dies the whole chain has to be constructed as it becomes non-functional.

COSEN

Chain Oriented Sensor Network (COSEN)[19] protocol is a hierarchical chain based two layer protocol. Sensors are grouped into one higher level chain and several lower level chains. In every chain, one sensor is elected as a chain-leader based on the residual energy and this node remains as a chain-leader for an optimal number of rounds. One higher level leader is selected among all lower level leaders based on some measures at every round. All nodes in a lower level chain send messages to the lower level COSEN leader. Besides, all lower level leaders send the information to the higher level leader. The higher level leader is the node that sends the data to the BS. Further completion of optimal rounds new chain leaders is selected. Due to multiple chains and hierarchical structure, COSEN require much lower time and energy as compared to other protocols of WSN for data collection.

TEEN

T*hreshold sensitive* **E***nergy* **E***fficient sensor* **N***etwork (*TEEN)[21] *protocol* is a reactive protocol which provides responses to drastic and sudden changes in the network. Closer nodes form clusters, with cluster heads to transmit the collected data to one upper layer. Forming the clusters, cluster heads broadcast hard threshold and soft threshold; it is minimum possible value of an attribute to trigger a sensor node. Hard threshold allow the nodes to transmit the data. Therefore a reduction of the transmission delay occurs. But when an soft threshold occurs, the nodes don't send a new packet of data. Employing soft threshold prevents from the redundant data transmission. It is suitable for time-critical applications.

APTEEN

A*daptive* T*hreshold* S*ensitive* E*nergy* E*fficient* S*ensor* N*etwork* (APTEEN) [22] Protocol is an extension of TEEN aiming to capture both time-critical events and periodic data collections. Once the clusters formed then the CHs broadcast threshold values, transmission schedule to all nodes. CHs used for data aggregation in order to decrease the size data transmitted so energy consumed. The main drawbacks of TEEN and APTEEN are difficulty to forming clusters in multiple levels and implementing threshold-based functions and dealing with attribute based naming of queries.

PEDAP

A new minimum spanning tree based protocol called PEDAP [14][17][18](Power Efficient Data gathering and Aggregation Protocol) and its power-aware version. PEDAP prolongs the lifetime of the last node in the system while providing a good lifetime for the first node. With its power-aware version provides optimal lifetime for the first node although slightly decreasing the lifetime of the last node. Another advantage of our protocols is they improve the lifetime of the system even if the base station is inside the field, whereas LEACH and PEGASIS cannot.

TBC

Tree-based clustering (TBC)[26] is a Novel approach for energy efficient wireless sensor networks. A cluster tree can be formed using both top down and a bottom up approach. In an top down approach designated root node first forms its own cluster. It then selects some of its neighbours (as CHs) to form their own clusters and the process continues until the entire sensor field is covered. The cluster tree is formed by considering the parent-child relationship between CHs and it is assured to connect as new child CHs are selected from neighbours of existing CHs. In bottom-up approach [20], individual clusters are formed independently and later combined together to form a higher-level structure. For example, nodes probabilistically elect themselves as CHs at different levels of the hierarchy and form their own clusters.

TREEPSI

Tree-based Efficient Protocol for Sensor Information (TREEPSI) [25][27] is tree structure routing protocol. TREEPSI protocol, WSNs will select a root node in all the sensor nodes. Two ways are used to build the tree path. One is computing the path centrally by sink and broadcasting the path information to the network. The other can be the same tree structure locally by using a common algorithm in each node. Initially, root nodes create the data gathering process to the neighbour's node. All the leaf nodes will start sending the sensed data towards their parent nodes. The parent nodes will collect the received data with their sensed data. Then the transmission process will be repeated until all data the received by the root node. The data aggregation will be takes place at the root node, after aggregating the data, it send data to the BS. The process will go around until the root node dead.

GSTEB

General Self-Organized Tree-Based Energy-Balance routing protocol (GSTEB)[23][24] which builds a routing tree using a process where, for each round, BS assigns a root node and broadcasts this selection to all sensor nodes. Subsequently, each node selects its parent by considering only itself and its neighbours' information, thus making GSTEB a dynamic protocol.

IV. COMPARISON OF HIERARCHICAL ROUTING PROTOCOL

Routing Protocol	Data Aggregation	Type of network	Hierarchical level	Topology
LEACH	CH-Centralized	fixed	Single level	cluster
HEED	CH-Centralized	fixed	Single level	cluster
PEGASIS	CH-Distributed	fixed	Multilevel	chain
TEEN & APTEEN	CH-Centralized	fixed	Single level	cluster
PEDAP	CH-Distributed	fixed	multilevel	tree
TBC	CH-Centralized	fixed	Single level	tree &cluster
TREEPSI	CH-Distributed	fixed	multilevel	tree
COSEN	CH-Distributed	fixed	multilevel	chain
GSTEB	CH-Distributed	fixed	multilevel	tree

Table- I: Performance comparison of Hierarchical

Routing Protocol

4. CONCLUSION

The ultimate objective of the routing protocol designed for WSN should be as energy efficient as possible to prolong the lifetime of individual sensors and hence the network lifetime. In this paper, we have described energy efficient routing protocol that has been developed for WSN. The network structured routing protocol in WSN is classified into three categories: Flat, Hierarchical and Location based. Hierarchical routing protocols are designed to reduce energy consumption by localizing communication within the cluster and aggregate data to reduce transmissions to the BS. A hierarchical approach groups nodes into clusters with single cluster head that has the responsibility of routing from the cluster to the other cluster heads or base stations. Finally, comparison of the Hierarchical routing protocol is given.

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