

# A Survey on Hierarchical Routing Protocols in Wireless Sensor Networks

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**Abstract-** There are several issues in Wireless Sensor Networks from which routing is also a major issue which is directly related to energy consumption. In order to increase the lifetime of network energy must be consumed efficiently. This paper describes various routing protocols and their features. We first describe types of routing protocols in wireless sensor network and then explain the hierarchical routing protocols which include LEACH, PEGASIS, TEEN, APTEEN and CCPAR.

**Keywords-** Routing, WSN, Clusters, Energy Consumption.

## I. INTRODUCTION

Wireless sensor network is the collection of mobile or static nodes which are capable of communicating with each other in order to collect data accurately, autonomously. Each node deployed is capable of sensing, processing and communicating. Manufacturing of inexpensive low power sensors having computational capability is possible with the help of recent advances in field of technology. Wireless sensor network is used to collect reliable and accurate information from distant and hazardous environment such as battle field, volcano monitoring etc. Major applications of wireless sensor network is monitoring and tracking [1, 2]. In National Defense, Military affairs, environment monitoring, traffic monitoring, industry monitoring, manufacturing monitoring etc wireless sensor network is widely used.

Wireless sensor network has four basic components: processing unit, sensing unit, radio unit (communication unit), battery (power source). In order to monitoring and tracking purposes sensor nodes are expected to be deployed in large area. Data Gathering is the major application of wireless sensor network. In WSN nodes are deployed at different specified locations which continuously collect different type of data such as temperature, light and vibration at different sampling rates. Sensor nodes routes to distant locations. Life time of network is determined from energy consumption by sensor nodes. So, In order to enhance life time network, energy must be consumed efficiently by using efficient protocols in routing. Generally adaptive networks that use data aggregation and hierarchy to reduce energy consumption are used in WSN. In this paper we first describe hierarchical routing protocols used in WSN.

## II. CLASSIFICATION OF ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORKS

Routing protocols on the basis of network structure are divided into 3 main groups:-

- Flat Based Routing
- Hierarchical Based Routing
- Location Based Routing

### A. Flat Based Routing

In the Flat Based Routing all nodes are same and have same functions. In this each node collects the data and act as relay agent by relaying the information to other nodes. By flooding routing tables are build. There are three modes based on which flat-based routing can be classified:

- 1) Traditional Flooding Mode
- 2) Event Driven Mode
- 3) Query Drive Mode

### B. Hierarchical Based Routing

In Hierarchical Based Routing there are two layers in which one layer is used to select cluster heads and second layer is used for routing. In this whole sensor network is divided into different cluster and that clusters have their cluster heads which perform many operations.

### C. Location Based Routing

In flat based routing (flooding) there is problem of broadcasting storm. So, by knowing the location of destination node the data can be transmitted in particular area rather than broadcasting in whole network.

## III. HIERARCHICAL ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORK

### A. LEACH

LEACH is Low Energy Adaptive Clustering method. In this each clusters and cluster heads are formed. Clusters are collection of nodes. Clusters Heads collects data from the cluster nodes within the cluster and then forwards the collected data to Base Station as shown in figure 1. Cluster Head can be Static or Dynamic. The static Cluster Heads which does not change for different rounds it remains same and dynamic cluster head is which changes with time [3,6]. In static cluster heads scheme energy consumption of

single CH will be more because Static CH have to communicate with whole cluster nodes throughout the network life but in dynamic cluster clusters are randomly selected which leads to balanced energy dissipation. Various scheduling schemes can be adopted such as ACTIVE and SLEEP [5]. By using these scheduling schemes energy efficient is increased near to 50% than LEACH protocol.

LEACH algorithm details [3]:The steps in the LEACH are

- 1) Advertisement Phase
- 2) Cluster Setup Phase
- 3) Schedule Creation
- 4) Data Transmission

TL-LEACH is enhancements of LEACH in which primary and secondary clusters are formed. Primary cluster communicate with secondary clusters and in turn secondary cluster communicate with clusters. Primary clusters directly communicate with Base Stations (BS).

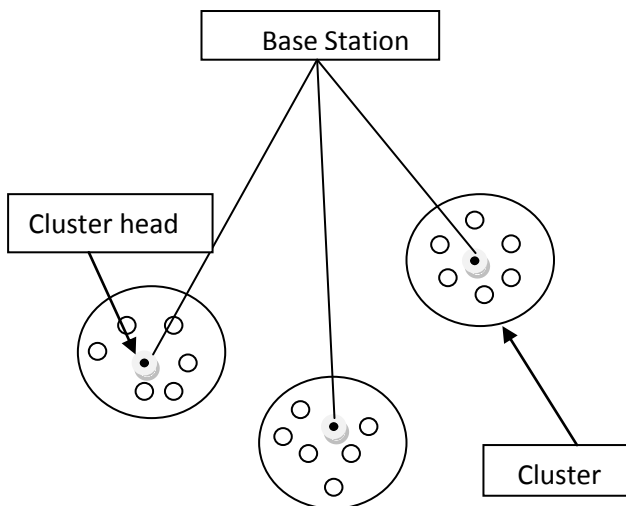


Fig.1 Leach Protocol

*Disadvantages of LEACH*

- LEACH does not provide clarity about position of sensor nodes and the number of cluster heads in the network.
- Each Cluster-Head directly communicates with BS no matter the distance between CH and BS. It will consume lot of its energy if the distance is far.
- The CH uses most of its energy for transmitting and collecting data, because, it will die faster than other nodes.
- The CH is always on and when the CH die, the cluster will become useless because the data gathered by cluster nodes will never reach the base station.

**B. PEGASIS**

PEGASIS is Power-Efficient Gathering in Sensor Information Systems. PEGASIS form open chain starting from node which is farthest from Base Station. PEGASIS assume that global information is available. This algorithm uses greedy algorithm for chain construction. Before first round of communication chain formation is done [5]. During formation of chain care must be taken so that nodes already in chain should not revisit. When a node die then chain is reconstructed by bypassing that node. In data gathering cycle each node forms a data packet of its own in network. For each data gathering cycle leader is elected among all nodes in network. Each node in network receives a data packet and fuses it with its own data and forwards it to other neighboring node. PEGASIS uses a simple token passing approach which is initiated by leader to start data transmission from ends of chain.

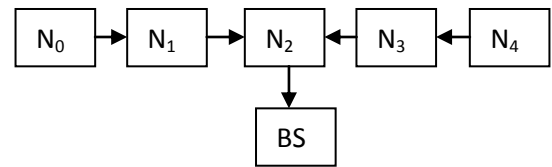


Fig.2 Chaining and token passing in PEGASIS

Let us assume that the network has only 5 nodes In Figure 2, node N<sub>2</sub> is the leader, and it will pass the token along the chain to node N<sub>0</sub>. Node N<sub>0</sub> will pass its data towards node N<sub>2</sub>. After node N<sub>2</sub> receives data from node N<sub>1</sub>, it will pass the token to node N<sub>4</sub>, and node N<sub>4</sub> will pass its data towards node N<sub>2</sub>. The leader elected in a particular cycle receives the fused data packets of the nodes in the network from its two neighbors, fuses it with its own data packet and finally this single data packet is transmitted to the base station [4,6]. In PEGASIS the nodes are successively selected as leaders. For example if there are 'N' nodes then each node will become a leader once every 'N' data gathering cycles.

**C. TEEN**

Threshold sensitive Energy Efficient sensor Network protocol (TEEN) [7], is a hybrid of hierarchical clustering and data-centric protocols designed for time-critical applications. It is a responsive protocol to sudden changes of some of the attributes observed in the WSN. The algorithm first goes through cluster formation. The CHs then broadcast two thresholds to the nodes in their clusters. Those are hard and soft thresholds for the sensed attribute

*Hard Threshold:* This is a threshold value for the sensed attribute. It is the absolute value of the attribute beyond which, the node sensing this value must switch on its transmitter and report to its cluster head.

**Soft Threshold:** This is a small change in the value of the sensed attribute which triggers the node to switch on its transmitter and transmit.

The environment continuously sensed by nodes. The first time a parameter from the attribute set reaches its hard threshold value, the node switches on its transmitter and sends the sensed data. The sensed value is stored in an internal variable in the node, called the *sensed value (SV)*. The nodes will next transmit data in the current cluster period, only when both the following conditions are true:

- The current value of the sensed attribute is greater than the hard threshold.
- The current value of the sensed attribute differs from *SV* by an amount equal to or greater than the soft threshold.

Whenever a node transmits data, *SV* is set equal to the current value of the sensed attribute. 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. The soft threshold further reduces the number of transmissions by eliminating all the transmissions which might have otherwise occurred when there is little or no change in the sensed attribute once the hard threshold.

#### D. APTEEN

APTEEN [8] is advance of TEEN and APTEEN has same structure as that of TEEN. Main task of this APTEEN is on reacting time constraint events and capturing periodic data. Clusters are formed by Base Station and Base Station transmits all transmission schedules and threshold values to all nodes. Data aggregation is performed by cluster heads in order to conserve energy.

- Three Different queries are supported by APTEEN which are: Historical is used to analyze past data values .
- One-time is used to take snapshot of the network.
- Persistence is used in to monitor any event for period of time.

#### E. CCPAR

CCPAR [9] is a clustered chain power aware routing protocol. It is based on hierarchical clustered chain scheme which reduces greater power reduction and increase lifespan of whole network. In this whole area divided into number of clusters and nodes are distributed across all clusters. The below figure 3 shows how nodes are connected in chain within a cluster.

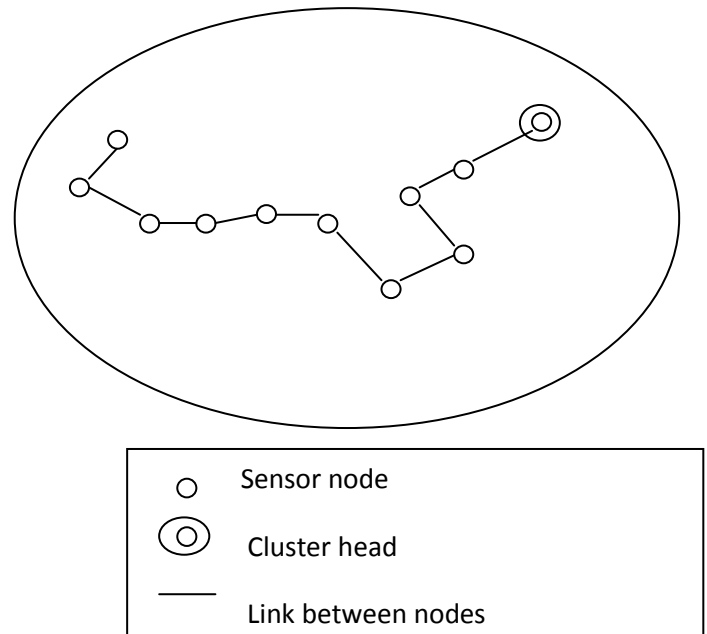


Fig.3 Chain of sensor nodes in a cluster

#### IV. CONCLUSIONS

Routing is the process of sending information from one sensor node to another node or to another part of the network in WSN. This paper describes various hierarchical routing protocols used for routing. LEACH is cluster Based, PEGASIS use chain formation for information routing, TEEN and APTEEN use threshold values in order to on transmitters.

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