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# A Review Study on Various Hierarchical Routing Protocols in Wireless Sensor Network

**Nishu Sethi**
Assistant Professor, Computer Engineering Department, Amity University, Gurgaon, India
E-mail- sethinishu@gmail.com

***Abstract:*** ***Wireless sensing technology is ubiquitous these days. The tremendous growth in the sensor network has been due to the demanding solutions for the limited energy constraints on WSN. In due prospect, various routing protocols have been designed to efficiently utilize those energy resources. Hierarchical routing is one of the best routing strategy which deals with the evenly distribution of load in the network, leading to the lifetime enhancement of the network. This paper focus on the introducing the WSN in brief along with its applications then the major portion of the paper is intended to review the advancement in the hierarchical routing protocols which aim to enhance network lifetime. Then the study done on the clustered protocols is recapitulated by giving the tabular comparison for some of the most recent routing protocols. It has been found that clustering protocols are with consummate potential to enhance the network lifetime.***

***Keywords: Review, Wireless sensor network, Hierarchical routing, clustering protocols, sensor node.***

## 1. Introduction to architecture of WSN and sensor node

Since the technological advancement, it has become feasible to develop the small and low-cost sensors which measure ambient conditions in the physical form that can be converted into further operating mode.

A WSN can be defined as the network consisting of various nodes connected together to accumulate data from the network and thereafter processing it for the further operations. The data from the network is being forwarded to the Base Station after removing the redundant data. Afterward the alarm is sent to the user via internet so as the required rescue operations can be performed. The architecture of WSN is shown in the figure 1. It is basically applicable in large scale areas [1].

A general sensor node is made up of four basic components as shown in figure 2: a sensing unit, a processing unit, a transceiver unit and a power unit. They may also have application dependent additional components such as a location finding system, a power

 

generator and a mobilizer. Sensing units are usually composed of two subunits: sensors and analog to digital converters (ADCs). The analog signals produced by the sensors based on the observed phenomenon are converted to digital signals by the ADC, and then fed into the processing unit.

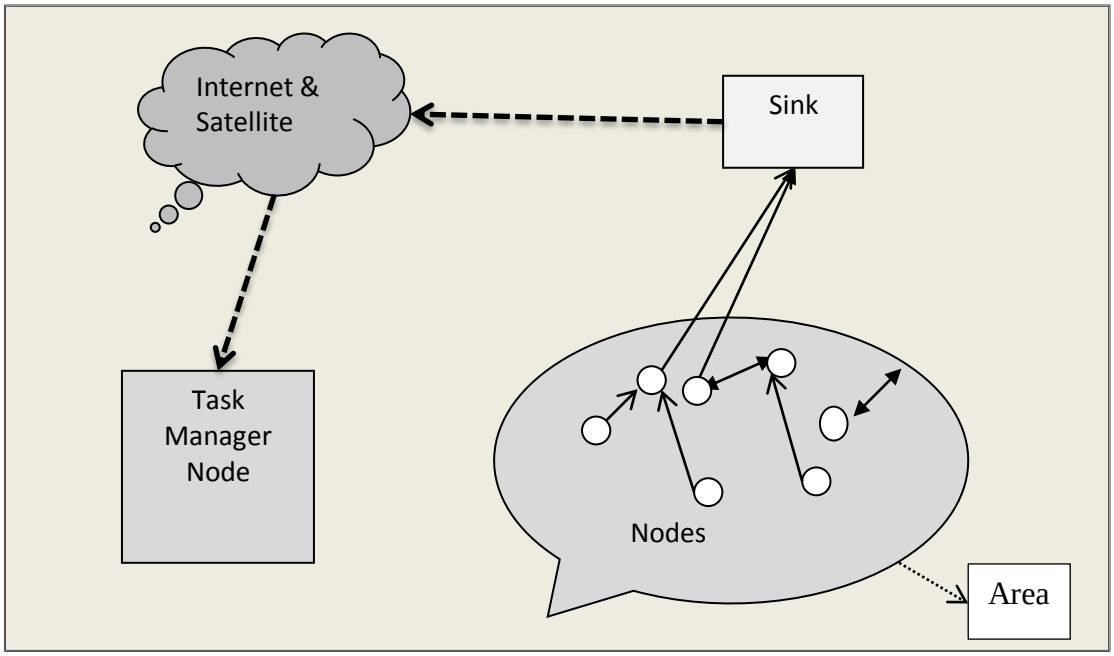


Figure 1. Architecture of WSN

The processing unit, which is generally associated with a small storage unit, manages the procedures that make the sensor node collaborate with the other nodes to carry out the assigned sensing tasks.

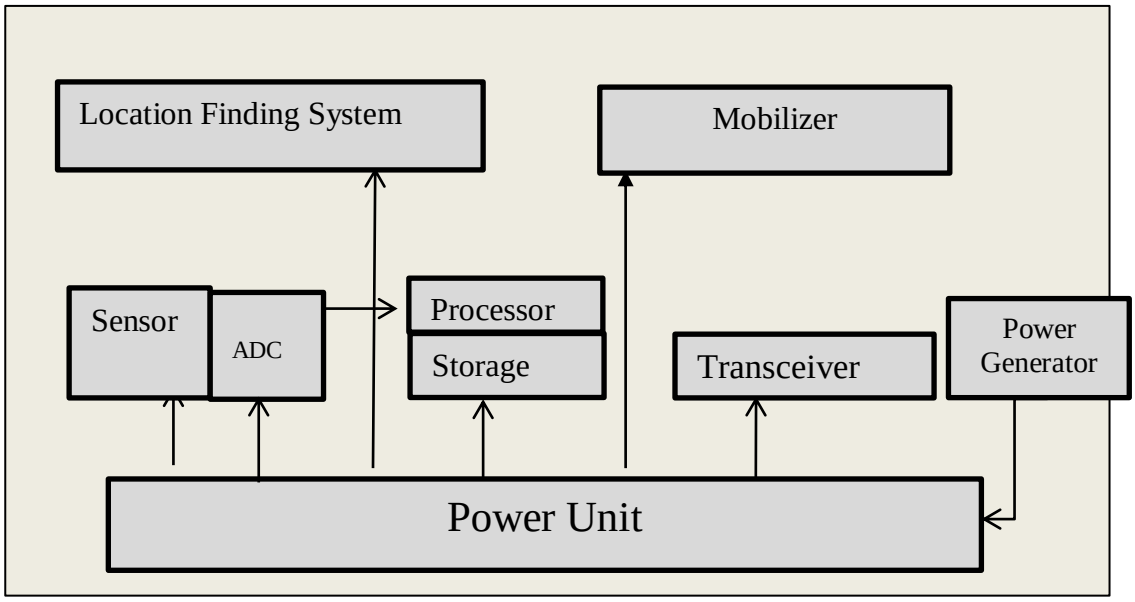


Figure 2. Architecture of sensor node

 

## 2. Applications of WSN

There is huge number of applications of WSN which makes it the one among the favorite to be used for real time purpose. Basically, the sensor network is classified into two main categories, Tracking and Monitoring. Under tracking category, mainly military, habitat monitoring, business and industrial concerns are dealt. Monitoring activities involve the military surveillance, health applications etc. explained as following:

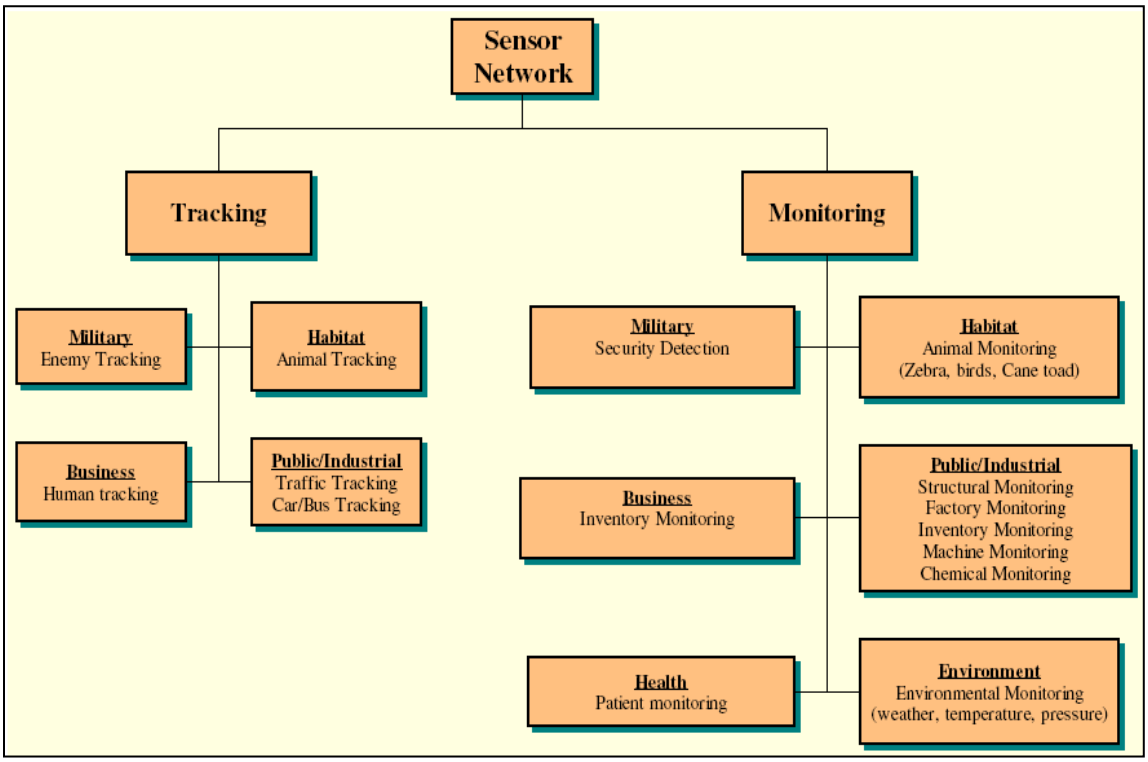


Figure 3. Applications of WSNs [1]

i. ***Battlefield surveillance***: Critical terrains, approach routes, paths and straits can be rapidly covered with sensor networks and closely watched for the activities of the opposing forces. As the operations evolve and new operational plans are prepared, new sensor networks can be deployed anytime for battlefield surveillance.

ii. ***Targeting***: Sensor networks can be incorporated into guidance systems of the intelligent ammunition. Battle damage assessment: Just before or after attacks, sensor networks can be deployed in the target area to gather the battle damage assessment data

iii. ***Environmental applications***-There are applications like environmental monitoring in marine, soil, and atmospheric contexts; forest fire detection; meteorological or geophysical research

iv. ***Forest fire detection***: Since sensor nodes may be strategically, randomly, and densely deployed in a forest, sensor nodes can relay the exact origin of the fire to the end users before the fire is spread uncontrollably. Millions of sensor nodes can be deployed and integrated using radio frequencies/ optical systems. Also, they may be equipped with effective power scavenging methods such as solar cells, because the sensors may be left unattended for months and even years. The sensor

 

nodes will collaborate with each other to perform distributed sensing and overcome obstacles, such as trees and rocks that block wired sensors' line of Sight.

## 3. Routing in WSN

Routing in sensor networks is very challenging because of the wireless communication which suffers from various signal losses. The other challenges that includes are [2]:

i. It is not possible to build a global addressing scheme for the deployment of sheer number of sensor nodes. Therefore, classical IP-based protocols cannot be applied to sensor networks.
ii. In contrary to typical communication networks almost all applications of sensor networks require the flow of sensed data from multiple regions (sources) to a particular sink.
iii. Generated data traffic has significant redundancy in it since multiple sensors may generate same data within the vicinity of a phenomenon. Such redundancy needs to be exploited by the routing protocols to improve energy and bandwidth utilization.
iv. Sensor nodes are tightly constrained in terms of transmission power, on-board energy, processing capacity and storage and thus require careful resource management.

### *3.1 Types of routing*

There are basically three types of routing, flat routing, hierarchical routing and location based routing.
Flat routing doesn't follow any specific topology for data transmission. Hierarchical routing is destined to perform data transmission in the level of clusters. Location based routing deals with the GPS installed nodes. Hierarchical routing is explained as following:

#### *3.1.1 Hierarchical Routing:*

In this routing technique of wireless sensor network all the sensors nodes in the network are clustered and among them a cluster head is selected based on some criteria and then cluster head collects and aggregates the data from the nodes and checks for redundancy of the data and then it is sent to the sink [3-4]. This save processing work and also saves energy consumption.

**I. Low Energy Adaptive Clustering Hierarchy (LEACH)**

LEACH is the first and most popular energy-efficient hierarchical clustering based routing algorithm for WSNs that was proposed for reducing the power consumption in the network [5]. In LEACH, the clustering task is rotated among all the nodes, based on duration. In this the nodes select their cluster head based on some criteria. Direct communication is used by each cluster head (CH) of the network to forward the data directly to the base station (BS).

 

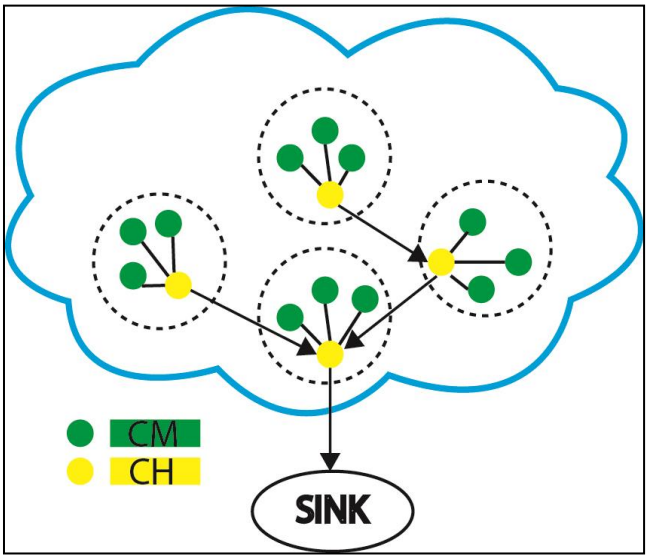


Figure 4: Cluster-based Hierarchical Model [5]

LEACH protocol divides the network into several clusters, each containing a number of sensors; these are constructed by using localized coordination of the nodes. LEACH uses a randomize rotation of high-energy CH position rather than selecting CH in a static manner, in order to give a chance to all sensors to act as CHs and avoid the battery depletion of an individual sensor. The operation of LEACH is divided into rounds which are having two phases each namely as a setup phase: To divide the network into clusters. A steady-state phase: for aggregation, compression, and transmission of data packets to the sink.

***Disadvantages***

LEACH assumes all nodes to be homogeneous which is practically not usual as heterogeneity in energy is the most common case. Random generation of CH leads to energy hole problem. Single Hop Communication leads to hot spot problem.

**II. PEGASIS**

Power-Efficient Gathering in Sensor Information Systems (PEGASIS) is an improved algorithm of the LEACH protocol. Unlike LEACH it avoids cluster formation and selection of one node is done to transmit data to sink rather than doing it by multiple nodes. So a chain is formed and only one node performs the task of transmission to the sink. PEGASIS uses a greedy approach and in case if there is any node failure than it bypass that node. So in each round node selection is done randomly thus reducing the per round energy consumption compared to LEACH [6].

 

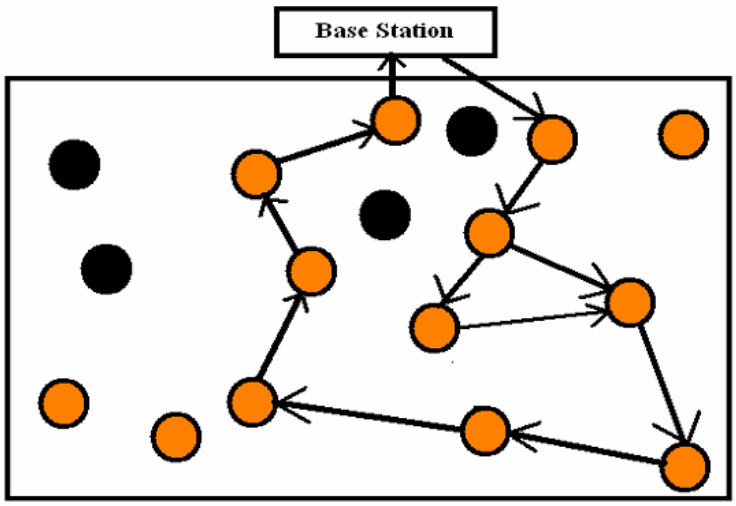


Figure 5. PEGASIS Chain Based Protocol [6]

***Advantages***

(i) Increases Life Time of network twice as compare to LEACH.

(ii) It decreases the number of transmission and reception by using data aggregation. Clustering overhead is avoided.

***Disadvantages***

It needs dynamical topology adjustment which causes significant overhead. It assumes every node to be of same energy which is not practically possible. Delay involved is concerning issue here.

### III. TEEN

TEEN is a clustering communication protocol. When clusters are formed, the CH broadcasts two thresholds to the sensor nodes namely (i) hard threshold (*HT*), and (ii) soft threshold (*ST*). Hard threshold gives the minimum value of an attribute after which sensor should turn on its transmitter to give information about sensed data to its CH. So transmission of data is made dependent on location of sensed attribute.

When value is greater than hard threshold, it will allow the node to transmit but it has to further check that if there is change in sensed attribute beyond the value of soft threshold. So in this way number of transmission are reduced [7].

***Advantages***

Adjustment can be made in the value of hard and soft threshold values in order to control the number of packet transmissions. Suitable for time critical application

***Disadvantages***

It is not suitable for applications where periodic reports are required

 

**IV.APTEEN**

Adaptive Threshold sensitive Energy Efficient sensor Network protocol (APTEEN) performs both capturing periodic data collections and also reacting to the time-critical events [8]. After the formation of cluster, CH broadcast the attributes, the threshold values, and the transmission schedule to all nodes and it also perform data aggregation. Three types of query are supported by APTEEN: historical, which analyze past data values; one-time, which take a snapshot view of the network and persistent which monitor an event for a period of time.

***Advantages***

APTEEN guarantee lower energy dissipation and a larger number of sensor alive. The performance of APTEEN is between LEACH and TEEN in terms of energy dissipation and network lifetime

***Disadvantages***

Complexity is involved in forming clusters in multiple levels and also in implementation of threshold based function.

**V. HEED**

Hybrid, Energy-Efficient Distributed Clustering (HEED) is implemented in multi-hop networks, with the use of an adaptive transmission power in the inter-clustering communication [9]. There are some major goals for which HEED was proposed, they are following

(i) Prolonging the network lifetime by distribution of energy consumption.

(ii) Termination of the clustering process within a constant number of iterations.

***Advantages***

(i) Communication cost in minimized.

(ii) Automatic updating of neighbor sets in multi-hop environment by periodically transmitting and receiving messages.

***Disadvantages***

It is not suitable for the specific requirements of WSN.

**3.1.2 Tabular comparison of hierarchical routing protocols**

| **Protocol Name** | **Cluster-Based/ Chain Based** | **Single Hop/ Multi-Hop clustering** | **QoS parameter considered** | **Drawback** |
|---|---|---|---|---|
| LEACH | Cluster-Based | Single Hop | Network Lifetime | Random selection of Cluster Head |
| PEGASIS | Chain Based | Multi-Hop | Network Lifetime, Delay | Non-optimized leader node selection |
| TEEN | Cluster-Based | Single Hop | Network Lifetime | No information if the threshold is not reached |
| APTEEN | Cluster-Based | Single Hop | Network Lifetime | CH selection is not efficient |

 

| | | | | |
|---|---|---|---|---|
| HEED | Cluster-Based | Multi-Hop | Network Lifetime | Node degree is ignored while CH selection |
| EEZECR [10] | Cluster-Based | Multi-Hop | Network Lifetime/ Load Balancing | CH selection is inefficient avoiding distance parameter |

## 4. Conclusion and Future Work

Wireless sensor network has been limited in performing due to its limited battery resources. In order to cope with this scenario, various energy efficient routing protocols have been developed. In this paper, various hierarchical routing protocols have been discussed by mentioning their advantages and disadvantages. A tabular comparison is listed to show the performance evaluation of the different routing protocols. Some of the introductory portion regarding architectures of WSN and sensor node and applications of WSN has also been discussed. It can be concluded that there is requirement of energy efficient cluster head selection in the clustering protocols to achieve enhanced network lifetime. Future work will be focusing on the evaluation of these routing protocols by performing the simulation in MATLAB.

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