

# A SURVEY ON COMPARISON OF HIERARCHICAL ROUTING TECHNIQUES IN WIRELESS SENSOR NETWORKS

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## ABSTRACT

*Wireless sensor networks have brought a new wave in the technology today as a result of advancements in the micro electro mechanical systems technology, integrated circuit technology, microprocessor and Nano technology, wireless communications etc. They find a wide range of applications in areas like military, health care sector, chemical industry, agriculture, security surveillance and so on. But since sensor nodes are small devices with limited resources, careful utilization of their capabilities become important especially to conserve energy and extend the network lifetime. Many routing strategies have been proposed in order to minimize the usage of energy in WSNs. This study is an attempt to provide a wide comparison on various routing protocols used in hierarchical WSNs focusing mainly on hierarchical routing protocols so that it would help in choosing the most suitable one based on the network requirements.*

**Keywords:** *Energy Efficiency, Hierarchical Protocols, Network Lifetime, Routing Protocols, Wireless Sensor Networks.*

## I INTRODUCTION

Wireless sensor networks can be defined as a collection of wireless nodes which are deployed randomly in a dynamically changing environment for the purpose of monitoring and detecting events such as temperature or humidity changes, movement, seismic events etc. These wireless sensor nodes are usually battery-powered devices with limited resources and capabilities. So it becomes necessary that these resources should be carefully used for the longer existence of the network. Hence conserving the energy and extending the network lifetime are the core challenges in WSNs.

Wireless sensor nodes are very tiny, low powered devices with limited capabilities [1]. They are deployed in the area of the phenomena to sense or detect events that might occur in the area under the surveillance. These nodes form a network by communicating with each other either directly or via other nodes. One or more than one amongst these nodes will act as sink(s) that are capable of communicating with the user either directly or through the existing wired networks.

There are four basic components of a sensor node [1] [2]. A sensing part for sensing and acquiring the data, a control system for the local data processing and storage, a communication subsystem for transmission and

reception of data and a power source that supplies the required energy for performing the desired tasks. Since sensor nodes are tiny devices, the battery equipped along with each of them is also small with limited energy. Although there have been several propositions to recharge these batteries, it is almost impossible when they are deployed in larger numbers randomly over the area of phenomenon. Finding out those nodes whose batteries have reached a low level and replacing them manually becomes a gigantic task, especially when they are deployed in a vast environment. Also there have been some propositions where in the idea of recharging the batteries using solar energy has been thought of. But again, this is not implementable practically because the nodes may be deployed in regions where there is no continuous availability of solar energy. Hence spending the available energy in the batteries efficiently is the only feasible choice as of today.

Once the data is sensed and processed by the nodes they are sent to the sink node by multiple hops via other nodes that come along the way. Since data transmission also takes up most of the energy it is necessary that the use of a routing strategy to transfer the data from the nodes to base station would help in a way to reduce the energy spent for it.

Further this survey is organized as follows:

Section 2 contains applications of sensor networks, section 3 contains classification of routing protocols based on network structure, section 4 contains design issues of routing protocols, section 5 contains comparison of hierarchical routing protocols, and finally section 6 contains conclusion.

## **II APPLICATIONS OF WIRELESS SENSOR NETWORKS**

Wireless sensor networks have made their mark in the technology industry with their extraordinary ability and have found its way into wide areas of applications. They could be easily deployed into a variety of scenarios based on the system and application requirements.

It has been deployed in areas ranging from agriculture, manufacturing, chemical industries to military, monitoring, surveillance and health care sectors.

Following is a brief section summarizing the various fields in which the WSNs have been successfully implemented.

In Military sectors, for monitoring the areas at the country borders in order to have knowledge about the positions of the fellow soldiers, for sensing intruders on basis of their movement, in the detection of enemy unit movements on land as well as under the sea and also in the battle field surveillances [3]. It would be even helpful in finding the positions of the land mines etc.

In times of natural calamities, it can be used for disaster management like detecting forest fires, for sensing seismic activities, tornados, measuring high level of poisonous chemical substances in water, soil as well as air [4]. All the sensing and detections of such disasters and timely notifications could help in relocating people to a safer place and save millions of lives.

In agriculture industry, for detecting soil composition to know which crop grows best in a particular area, to monitor the soil humidity for healthy growth of crops, detecting the increased amount of pesticides, insecticides in the soil, also detection of rodent presence to take necessary action to protect the crops from their attacks.

In medicine and health care, for monitoring a patient's condition remotely by a doctor so that immediate care can be taken if there is an emergency [3], for critical measurements of blood flow, respiration rate, ECG(electrocardiogram), blood pressure and oxygen measurement.

In monitoring environmental components, like monitoring of water level and soil composition [5], habitual monitoring which involves monitoring of animals in wildlife sanctuaries to ensure their safety, for observation of biological and artificial systems such as in museums to safeguard precious artifacts from intrusion and also in security systems.

They have also found to be employed in automotive industries for coordinated vehicle tracking, in home networks for location awareness, in manufacturing for factory process control and industrial automation etc.

### **III CLASSIFICATION OF ROUTING PROTOCOLS BASED ON NETWORK STRUCTURE**

Several routing protocols have been put forth proposed depending on different criteria like based on the structure of the network, location of the nodes, whether the nodes are proactive or reactive, whether they are source-initiated or destination-initiated, whether the nodes are stationary or mobile etc.

But here our interest lies in the classification of protocols based on network structure [6]. Based on the network structure, they can be categorized into flat routing protocols and hierarchical routing protocols. In some networks, all the nodes deployed perform the same type of tasks, such nodes are called homogeneous nodes and the networks consisting of these nodes usually make use of flat routing protocols. In such networks, all the nodes are treated equally and usually deployed in large numbers. When a node needs to send data, it may find a route that consists of several hops to the sink. Every node trying to send its sensed data using many hops will result in energy wastage. Because the number of sensor nodes is very large it is not possible to assign a particular identification (Id) to each and every node. This leads to data-centric routing approach in which Base station sends query to a group of particular nodes performing similar kind of task in a region and waits for their response.

Hierarchical routing protocols are considered to be a better approach for heterogeneous networks where some of the nodes are more powerful than the other ones and perform more number of tasks compared to others. In hierarchical protocols, also known as clustering protocols nodes are grouped into clusters with a node having better capabilities than the other nodes in the group chosen as the cluster head node(CH). This node is assigned to perform additional tasks like accumulation of data from all the nodes in the group and passing it on to the sink node. Since the nodes in the group require just one hop to send their data to CH, their energy expenditure is reduced greatly. Also because localized algorithms within a cluster can function without the wait for the control messages from the sink node, delay or waiting is reduced. These distributed protocols can be a good solution in handling the failures in a better way also. So compared to flat routing protocols the clustering protocols have several advantages like scalability, ease management, energy efficient in finding routes and can achieve more stability and throughput.

### **IV DESIGN ISSUES THAT HAS TO BE CONSIDERED FOR ROUTING PROTOCOLS**

The main idea behind using a routing protocol is to efficiently transfer the sensed data from the nodes deployed in the area of the phenomenon to the sink node in such a way that the energy consumed for the whole process is minimized in turn increasing the network lifespan. This being the main issue there are several other design issues [7] that have to be considered while choosing or designing a routing protocol for a particular application or based on the required specification. Some of them are discussed below.

#### **4.1 Quality of Service**

This refers to efficiency with which the sensor networks will be able to fulfill the purpose of an application for which it is deployed. It all depends on the type of application for which the routing protocol is being chosen or designed. Also it refers to the timely transfer of sensed useful data to the appropriate destination in a timely manner for example when monitoring a patient's condition, if there occurs an emergency situation, immediate notification of the emergency would help to take necessary measures to save the patient's life.

#### **4.2 Node Deployment**

Deployment of the sensor nodes within the area under observation depends on the application and its requirements. Some applications require static nodes where nodes once deployed and configured at a location won't be moved or relocated unless they are damaged or need to be updated. Whereas some applications require nodes which can be dynamically configurable based on the changes in the environment. In such situations, based on the application criteria, the nodes reconfigure their positions. But in such cases, if the nodes aren't distributed uniformly then the cluster head's position will vary and might result in energy wastage.

#### **4.3 Data Latency and Overhead**

Transfer of sensed data involving multi-hops induces latency in the arrival of data at the sink in the network. Also routing protocols whose algorithms require acknowledgements from the base station also induce latency because the nodes have to wait for the control messages to arrive from the base station. Also too many control messages add unnecessary overhead to the network thus resulting in energy wastage because transmission of control messages also consume considerable amount of battery power.

#### **4.4 Data Aggregation**

Data from the nearby nodes can be collected by a node whose distance is approximately the same from those nodes so that the energy consumption due to data transfer by individual nodes to the same destination can be reduced using data aggregation. Several routing protocols support this feature in their algorithms and this will also help in eliminating the redundant data i.e similar data coming from different nodes.

### **V HIERARCHICAL ROUTING PROTOCOLS**

The following hierarchical routing protocols have been considered for comparison in this study.

#### **5.1 LEACH (Low Energy Adaptive Clustering Hierarchy)**

LEACH is a hierarchical routing protocol which is adaptive and self-organizing. Here most of the nodes communicate to the cluster head (CH) for transmission of information to the base station. Proposed by Heinzelman et al [8] it is considered as one of the first hierarchical routing approaches for WSNs. The main idea here is to select sensor nodes as CHs by rotation, so the high energy consumption for communicating with the BS is equal to all sensor nodes in the network.

LEACH involves of two phases:

Setup Phase: This is the first phase where in cluster formation takes place followed by cluster head selection. The CH is selected among the sensor nodes at a time with a certain probability. A random number between 0 to 1 is generated by each node and if this number is lower than the threshold node  $T(n)$  then this particular node becomes a CH.

$T(n)$  is given by:

$$T(n) = \begin{cases} \frac{p}{1-p} [r \bmod 1/p] & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

where  $p$  is the percentage of nodes that are CHs,  $r$  refers to the current round and  $G$  represents the set of those nodes that have not been elected as cluster head in the past  $1/p$  rounds. When a node is elected as CH successfully, an advertisement message is sent to the other nodes by this newly elected CH and based on the received signal strength of this advertisement, other nodes will decide to which cluster they will join for current round and send a membership message to its CH. Time slots will be assigned to nodes during which they can transmit data to CH. At each round the CH will be rotated so that those nodes which haven't been chosen as CH yet can become CH and hence all nodes will have equal energy expenditure.

Steady State Phase: Communication of the sensed data takes place in this round. The nodes in a cluster send their sensed data to their respective CHs during the time slots allocated to them. The CHs aggregate the data obtained from various nodes fuse them and sends them to the BS. The positions of CHs play an important role here because if they are located far away from the BS, then lot of energy is consumed in transmission of data.

### 5.2 LEACH-C (Low-Energy Adaptive Clustering Hierarchy Centralized)

LEACH-C [9] is reinforcement to the traditional LEACH protocol. In LEACH, the nodes self configure themselves into clusters. But in LEACH-C, the base station is used for cluster formation.

Initially the Base Station (BS) receives information regarding the position and energy level of every node in the network. Based on this information, the BS calculates a predetermined number of cluster heads that should be there in the network and configures the network into clusters.

The cluster groupings are done in such a way as to minimize the energy required for non-cluster-head nodes to transmit their data to their respective cluster heads.

The improvements in LEACH-C compared to LEACH are:

- The BS can make use of its knowledge of the entire network under it for cluster formation in a way that requires less energy for data transmission.
- In LEACH-C the number of cluster heads in each round equals to a predetermined optimal value which is calculated at the beginning. Whereas in LEACH, the number of CHs elected varies from one round to another because the nodes in the network do not have complete knowledge of and coordination with other nodes in the network.

### 5.3 PEGASIS (Power-Efficient Gathering in Sensor Information Systems)

PEGASIS [10] protocol is an improvement of the LEACH protocol. This protocol is said to be chain based where in each node communicates only with its nearby neighbor to directly send or receive information thereby

reducing the energy spent by each node if they had to send their individually. Here, the nodes are organized in a way as to form a chain. There are two ways in which the chain can be formed. One way is where the sensor nodes can make use of greedy algorithm to form the chain by themselves starting from some node. Another way is that the BS can compute the chain and broadcast it to all the sensor nodes. In order to construct the chain, all nodes need to have global knowledge of the network and that a greedy algorithm is employed for minimum cost route calculation. Thus, the construction of the chain will start from a node that is far away to the node that is the closest. If a node dies in the chain, the chain is reconstructed in the same manner to bypass the dead node. A node, after receiving data from its neighbor node will add its own sensed data and forward it to its next neighbor. At each round a leader node is chosen which would be responsible for collecting data from all the nodes in the chain and passing it on to the BS.

It has been proved that the PEGASIS protocol presents twice or more performance in comparison with the LEACH protocol. Unlike LEACH, the transmitting distance for most of the nodes is reduced in PEGASIS. The “PEGASIS” protocol has a serious problem that is the terminated broadcasting of the data. If an aggregator node is far away from the BS and does not have enough energy to transmit the data to BS then it results in terminated broadcast. The reason for this difficulty is that there is no thought on the BS’s location for the energy of nodes when one of nodes is nominated as head node.

#### **5.4 TEEN (Threshold sensitive Energy Efficient sensor Network)**

TEEN [11] is a hierarchical routing protocol which is usually used for time-critical systems where responsiveness is very important. It is based on the LEACH protocol. It is designed for the conditions like sudden changes in the sensed attributes such as temperature [64]. Here it is assumed that the BS and all the nodes have the same initial energy and the BS can transmit data to all the nodes directly.

TEEN uses the same strategy as LEACH’s for cluster formation. Closer nodes form hierarchy of clusters and this process goes on the second level until the sink is reached. After the clusters are formed and cluster heads are elected, the CHs broadcasts two types of thresholds to its member nodes. One is called as the Hard Threshold(HT) value for the sensed attribute which is the absolute value. So if a sensed value goes beyond this HT then the node that has sensed this value must switch on its transmitter and report to its cluster head. Another one is the Soft Threshold(ST) which refers to the small change in the value of the sensed attribute occurring upon which the node has to switch on its transmitter to transmit. In this protocol, nodes sense the medium continuously, but the data transmission is done less frequently. The main advantage of TEEN is that it is very well suited for time-critical applications where sudden changes have to be sensed. But it also has its share of drawbacks.

One of the drawbacks is that the CHs always keep their transmitters on in order to receive the sensed data. This is because the changes may occur at any time in time-critical environment. Because of this the CHs lose their energy very soon. Also in large networks, when the number of layers in the hierarchy is small, it leads to large consumption of energy because of long distance transmissions.

#### **5.5 APTEEN (Adaptive Threshold sensitive Energy Efficient sensor Network)**

APTEEN [12] is an improvement to TEEN protocol. Unlike TEEN which is mainly designed to sense time-critical and periodic data APTEEN aims at collecting periodic data as well as reacting to time-critical events. So it was developed for hybrid networks.

The BS forms the clusters and in each round after the cluster heads are elected, the cluster heads broadcast the attributes, the Soft and Hard threshold values and the transmission schedule to all nodes.

The main advantage of APTEEN, compared to TEEN, is that nodes consume less energy because of data aggregation. But the main drawbacks of APTEEN are the complexity related to the thresholds and that it results in longer delay times.

### 5.6 HEED (Hybrid Energy-Efficient Distributed clustering)

HEED[13] is a multi-hop WSN clustering algorithm. It is an energy-efficient clustering algorithm mainly concentrating on reducing the energy expenditure of the network. One of the main goals of HEED is to evenly-distribute CHs throughout the network. It differs from LEACH in the way of CH election and does not select nodes as CHs randomly. In HEED, elected CHs have relatively high average residual energy compared to regular nodes.

In HEED, CHs are periodically elected based on two important parameters: One parameter is the residual energy and second parameter is the intra-cluster communication cost of the candidate nodes. Each node goes through several iterations until it finds the CH. If it does not hear from any CH, the node elects itself as a CH and sends an announcement message to its neighbors. Each node doubles its  $CH_{prob}$  value (where  $CH_{prob}$  is the probability of a node becoming a CH ) and goes to the next iteration. This process continues until its  $CH_{prob}$  reaches 1. Therefore, there are two types of statuses that a sensor node could announce to its neighbors: tentative status and final status. If the  $CH_{prob}$  of a node is less than 1, the node becomes a tentative CH. if it finds a lower cost CH than itself at a later iteration it can change its status to a regular node. On the other hand if a node's  $CH_{prob}$  has reached 1, the node permanently becomes a CH. CHs send the aggregated data to the BS in a multi-hop fashion to the BS.

The advantages of the HEED protocol are:

- It is a fully distributed clustering method, provides uniform CH distribution across the network and load balancing.
- Communicates in a multi-hop fashion between CHs and the BS promote more energy conservation and scalability.

However, there are some limitations with HEED as follows:

- The use of tentative CHs that do not become final CHs leave some uncovered nodes. As a result, more CHs are generated than the expected number accounting for unbalanced energy consumption in the network.
- Significant overhead in the network due to clustering in each round causing noticeable energy dissipation thus decreasing the network lifetime.

Several iterations are required to form clusters because of which there is consequent overhead. At each iteration, a lot of packets are broadcast. Some CHs, especially near the sink, may die earlier because these CHs have more work load.

### 5.7 DWEHC (Distributed Weight-based Energy-efficient Hierarchical Clustering protocol)

DWEHC [14] is a distributed clustering protocol. Both HEED and DWEHC have similarities in ways that they don't have assumptions on the network size and density. Both take into account the residual energy of the nodes



in the process of CH election. But the main objective of DWEHC is to improve HEED. DWEHC does so by building balanced cluster sizes and optimize the intra-cluster topology using location awareness of the nodes. In DWEHC, every node implements the algorithm individually and it ends after several iterations that are implemented in a distributed manner. DWEHC creates a multi-level structure for intra-cluster communication and limits a parent node's number of children.

Once every node determines the location of the neighboring nodes in its area, it calculates its weight. The node with largest weight would be elected a CH and the other nodes become members. At this stage, the regular nodes are considered as 1-level nodes and communicate directly with the CH. Since node has knowledge of the distance to its neighbors, it can determine whether it is better to stay a 1-level member or become a  $h$ -level one where  $h$  is the number of hops from the CH to itself. If a regular node can save energy while reaching its CH with more than one hop, it will become a  $h$ -level member.

This is actually done to achieve the most energy efficient intra cluster topology and the process continues until all nodes achieve this. A cluster range is usually set to limit the number of levels every cluster should have.

TDMA is used for Intra-cluster communication and each parent node polls its direct children and forwards the data to its parent node until the data reaches the CH. The parent node aggregates several data packets from its children together with its own data into one packet. For inter-cluster communication, the CHs poll their first-level children, including their own data, and transmit to the BS.

The advantages of DWEHC are:

- CHs are elected by making use of the knowledge of every node's residual energy along with their location and hence results in more well-balanced CHs distribution and significant lower energy consumption in intra-cluster and inter-cluster routing than HEED.
- The clustering process of DWEHC terminates in a few iterations, and does not depend on network topology or size.

Some disadvantages of DWEHC are:

- Because it uses single-hop inter-communication, i.e CHs using a single hop to send data to the BS it results in significant amount of energy consumption in case of large-region networks.
- The iterative nature in both DWEHC and HEED during cluster formation results in a relatively high control message overhead compared to other protocols.

## VI COMPARISON OF HIERARCHICAL ROUTING PROTOCOLS

**Table 1 shows the comparison of hierarchical protocols discussed above based on few metrics**

| Protocol | Advantages                                              | Drawbacks                                                                            | Scalability | Mobility | Overhead | Energy Efficiency | Robust |
|----------|---------------------------------------------------------|--------------------------------------------------------------------------------------|-------------|----------|----------|-------------------|--------|
| LEECH    | Low energy, ease of configuration, distributed protocol | Single hop from CH to BS, not applicable for large networks, overhead due to dynamic | good        | Fixed BS | high     | low               | good   |



|                |                                                                                         | clustering                                                                                                                                 |      |          |          |          |         |
|----------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|------|----------|----------|----------|---------|
| <b>LEECH-C</b> | Uses less energy for data transmission than LEECH, fixed no. of CHs every round         | Overhead                                                                                                                                   | good | Fixed BS | high     | moderate | good    |
| <b>PEGASIS</b> | Reduced transmitting distance for most nodes                                            | Terminated broadcast problem because of no thought on BS's location for the energy of nodes when one of nodes is nominated as head of node | good | Fixed BS | low      | low      | good    |
| <b>TEEN</b>    | Works well for time-critical environment involving sudden changes in sensed attributes. | Lot of energy consumption and overhead in case of large networks for long distance transmissions                                           | good | Fixed BS | high     | High     | limited |
| <b>APTEEN</b>  | Low energy consumption, suitable for time-critical and periodic data collection         | Complexity, longer delay                                                                                                                   | good | Fixed BS | high     | High     | good    |
| <b>HEED</b>    | Uniform CH distribution, multi hop, load balancing, energy efficiency                   | Uncovered nodes, Overhead due to need for several iterations to form clusters                                                              | good | Fixed BS | moderate | moderate | good    |
| <b>DWEHC</b>   | Fully distributed                                                                       | Single hop inter communication                                                                                                             | good | Fixed BS | High     | High     | limited |

|  |                                                                                  |                                                                            |  |  |  |  |  |
|--|----------------------------------------------------------------------------------|----------------------------------------------------------------------------|--|--|--|--|--|
|  | clustering, well<br>balanced CH<br>distribution,<br>reduced no. of<br>iterations | not suitable for<br>large networks,<br>High control<br>message<br>overhead |  |  |  |  |  |
|--|----------------------------------------------------------------------------------|----------------------------------------------------------------------------|--|--|--|--|--|

## VII ADVANTAGES OF CLUSTERING

As said before there are several advantages of clustering/hierarchical routing. The following gives a summary of some of the important advantages.

### 7.1 Fault-Tolerance

Since sensor nodes are deployed in hostile environments for sensing different type of changes such as in warfare, to detect seismic events it is obvious that they are prone to failures/destructions. In such situations it often becomes necessary that the sensed data is not lost and the network is up. Thus, fault-tolerance is an important challenge in WSNs [15]. Although some nodes are lost clustering routing protocols can help to keep the network up by using dynamic clustering. Re-clustering is done to make it up for those nodes which are destroyed in order to avoid the loss of significant data from key sensor nodes especially the CHs. Also using backup for CHs data is a good option for recovering from node failures thus providing fault tolerance to some extent.

### 7.2 Load Balancing

Load balancing is said to have considerable impact on lifetime of a WSN. When nodes are randomly deployed in the area of phenomenon especially if the area that has to be kept under surveillance is large, then it is possible that some CHs may be positioned at a far away location with respect to the BS. These CHs when they have to transmit their data to the BS, more energy is consumed which subsequently leads to early death of the nodes. Clustering routing protocols mainly aim at even distribution of sensor nodes among the clusters where CHs are placed evenly and perform the task of data processing and intra-cluster management. Thus in general, constructing equal-sized clusters is adopted for prolonging the network lifetime since it prevents the premature energy exhaustion of CHs. Multi-path routing is also a method to achieve load balancing.

### 7.3 More Scalability

In clustering routing scheme, sensor nodes are grouped into clusters where some nodes act as regular nodes which perform sensing tasks and some are elected as CHs for performing data aggregation and network management tasks. This introduces hierarchy into the cluster. With such a setup it is easy to expand or reduce the network by adding or deleting nodes. Clustering topology can localize the route set up within the cluster and thus reduce the size of the routing table stored at the individual sensor nodes [16] [17]. Compared with a flat topology, this kind of network topology is easier to manage, and more scalable to respond to events in the environment.

### 7.4 Maximizing of the Network Lifetime

For continuous surveillance of phenomena, the network should be up and running for longer duration of time. Hence network lifetime becomes an inevitable consideration in WSNs. Because sensor nodes are constrained in power supply, processing capability and transmission bandwidth, care has to be taken for careful expenditure of the battery power of the nodes. Usually it is indispensable to minimize the energy consumption for intra-cluster communication by CHs which are richer in resources than regular nodes. When compared to the conventional routing protocols, hierarchical/clustering routing protocols contribute more to conserving the energy of WSNs by choosing those nodes to be CHs whose energy reserve is more and are equally closer to most of the nodes in the cluster. Additionally, they also aim to select those routes that are expected to prolong the network lifetime in inter-cluster communications, and the routes composed of nodes with higher energy resources preferred.

### **7.5 Reduced latency and collision avoidance**

When a WSN is divided into clusters, only CHs perform the task of data transmissions out of the cluster, thus collisions between nodes that might occur during data transmission to BS are reduced. Data aggregation within a cluster is taken care by the respective CHs without the need to wait for control messages to arrive from the BS, hence latency is reduced. In flat routing scheme, data transmission is performed hop by hop usually using flooding but in case of clustering routing scheme, only CHs perform the task of data transmission, which can decrease the number of hops from data source to the BS, accordingly decrease latency.

## **VIII CONCLUSION**

Energy efficiency is a very most important issue for the networks particularly for WSNs which are described as “limited battery capabilities”. WSNs involve complex operations and what is required is the use of energy-efficient routing techniques and protocols, which will assure the network connectivity and routing of information with less required energy. In this survey the focus was on the energy efficient hierarchical protocols that have been developed for WSNs. In case of a large network, the flat protocols become “infeasible” because of link and the processing overhead. The hierarchical protocols try to solve this and as a result produce scalable, efficient and effective solutions. They split the network into “clusters” to proficiently maintain the energy consumption of sensor nodes and also perform “data aggregation and fusion” to lessen the number of transmitted messages to the sink. The clusters are arranged based on the energy backup of sensors and sensor’s nearness to the CH. Thus, we can conclude that the hierarchical protocols are appropriate for sensor networks with the heavy load and wide coverage area. So in order to develop a scheme that will prolong the lifetime of the WSNs, it is needed to decrease the energy consumption of the sensors within the network. Here we have compared and analyzed different hierarchical routing protocols based on some metrics like overhead, network lifetime, data aggregation and energy efficiency etc with aim of helping the readers to choose a wise protocol based on application requirement. Therefore, the application of the appropriate routing protocol will enhance the lifetime of the network and at the same time it will guarantee the network connectivity and effective and efficient data delivery.

## **REFERENCES**

- [1] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, “Wireless Sensor Networks: A survey,” *Computer Networks*, Volume 38, N. 4, March 2002.

- [2] Fundamentals of Wireless Sensor Networks: Theory and Practice, Waltenegus Dargie and Christian Poellabauer© 2010 John Wiley & Sons, Ltd.
- [3] Elaine Shi, Adrian Perrig: Designing Secure Sensor Networks IEEE Wireless Communications (December 2004).
- [4] Sarjoun S. Doumit, Dharma P. Agrawal: Self-Organizing and Energy-Efficient Network of Sensors, IEEE.
- [5] Al-Karaki, J.N., Al-Mashagbeh: Energy-Centric Routing in Wireless Sensor Networks Computers and Communications, ISCC 06 Proceedings, 11th IEEE Symposium (2006).
- [6] Al-Karaki, A. Kamal, "Routing Techniques in Wireless Sensor networks: A Survey," *Security and Networks*, 2004, Vol. 11, Issue 6.
- [7] R. V. Biradar, V. C. Patil, S. R. Sawant, R. R. Mudholkar, "Classification and Comparison of Routing Protocols in Wireless Sensor Networks," *Special Issue on Ubiquitous Computing Security Systems*, 2009, Vol. 4, Issue 2.
- [8] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient routing protocols for wireless microsensor networks," *In Proceedings of 33rd Hawaii International Conference on System Sciences (HICSS)*, HI, USA, 2000, Vol. 8.
- [9] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "An application Specific Protocol Architecture for wireless sensor networks," *IEEE trans. Wireless commun.*, 2002, Vol. 1, Issue 4.
- [10] S. Lindsey and C. S. Raghavendra, "PEGASIS: Power-efficient gathering in sensor information systems," *In Proceedings of the IEEE Aerospace Conference*, USA, Montana, March 2002, Vol. 3.
- [11] A. Manjeshwar, D. Agrawal, "TEEN: A routing protocol for Enhanced Efficiency in Wireless Sensor Networks," *In Proceedings of 15th International Parallel and Distributed Processing Symposium (IPDPS'01) Workshops*, USA, California, 2001.
- [12] A. Manjeshwar, D. Agrawal, "APTEEN: A Hybrid Protocol for Efficiency Routing and Comprehensive Information Retrieval in Wireless Sensor Networks," *In proceedings of International Parallel and Distributed Processing Symposium*, Florida.
- [13] Younis, O.; Fahmy, S. HEED: A hybrid, energy-efficient, distributed clustering approach for *ad-hoc* sensor networks. *IEEE Trans. Mobile Comput.* 2004.
- [14] Ding, P.; Holliday, J.; Celik, A. Distributed Energy Efficient Hierarchical Clustering for Wireless Sensor Networks. *In Proceedings of the 8th IEEE International Conference on Distributed Computing in Sensor Systems (DCOSS)*, Marina Del Rey, CA, USA, 8–10 June 2005.
- [15] Chitnis, L.; Dobra, A.; Ranka, S. Fault tolerant aggregation in heterogeneous sensor networks. *J. Parallel Distrib. Comput.* 2009.
- [16] Abbasi, A.A.; Younis, M. A survey on clustering algorithms for wireless sensor networks. *Comput. Commun.* 2007.
- [17] K. Akkaya, M. Younis, "A Survey on Routing Protocols for Wireless Sensor Networks," *Ad Hoc Network, Elsevier*, 2005, Vol. 3, Issue 3.