Advances in Computer Science and Information Technology (ACSIT)
p-ISSN: 2393-9907; e-ISSN: 2393-9915; Volume 4, Issue 2; January-March, 2017, pp. 95-98

http://www.krishisanskriti.org/Publication.html

# Studies in Energy Efficeint Routing Protocols of WSNs: A Review

**Urvashi Sharma**

*Department of Comp. Sc. Hans Raj Mahila Maha Vidyalaya, Jalandhar*
*E-mail: urvimishra@gmail.com*

**Abstract—***Recent advances in wireless sensor networks have led to many new routing protocols that are energy efficient. The main aim of these routing protocols is to increase the overall lifetime of network by reducing the energy consumption of nodes. In this paper we have examined various routing protocols that maximise the sensor network lifetime and tabulate the comparative study based on different parameters like their category to which they belong, data aggregation, power usage, scalability, data delivery model etc. it reveals that LEACH, TEEN and APTEEN requires more power usage whereas its need is limited in DD and maximum in PEGASIS which does not use data aggregation. Also almost all protocols have good scalability but it is limited in case of DD which is a query based routing protocol. The present study will help in making right choice of routing protocol for Wireless sensor networks.*

## 1. INTRODUCTION

Wireless Sensor Networks (WSNs) is the network of nodes that can sense the environment with limited energy resources. It communicates the information through wireless links gathered from the monitored field. Then, the data is forwarded (possibly via multiple hops relaying) to a sink which uses it locally or is connected to other networks through the gateway. Basically, these nodes are tiny sensors that can be stationary or moving; homogeneous or heterogeneous. These sensors are low price devices and a large number of nodes can easily be deployed to monitor a large area. Size and cost constraints result in corresponding constrains on resources such as energy, memory, computational speed and communication bandwidth.

In many WSNs, recharging the batteries or even replacing them becomes infeasible due to the number and location of nodes. Because of which, the energy consumption is a major design issue for WSNs. The efforts have been done to minimize the energy dissipation at all the levels of system design, including the hardware, protocols and the algorithms. To make the best use of this limited energy available to the sensor nodes, it is important to set the parameters of the protocols appropriately in the network stack. Sensor nodes have limited energy supply and bandwidth. Their constraints of this energy supply and bandwidth and of their deployment in large number have posed many challenges to the design of sensor networks and its management. This necessitates energy awareness at all the layers of protocol stack of networking. The two main objectives of the network layer are: i) to look for ways for energy efficient route setup and ii) reliable relaying of data from the sensor nodes to the sink to maximize the lifetime of the network.

The routing in wireless sensor networks is more challenging as compared to contemporary communication and wireless ad hoc networks because of the following reasons:

- Global addressing scheme is not possible for the deployment of sensor nodes due to which we cannot apply classical IP based protocols to sensor networks.
- The multiple sensors can generate same data within the vicinity of the phenomenon thus causing redundancy in the data traffic which should be removed with the help of routing protocols so that the energy utilization can be improved.
- Sensor nodes require careful management of resources as they are tightly constrained in terms of transmission power, processing capacity, on-board energy and storage.
- The flow of sensed data from multiple sources to a particular sink is required by many applications of sensor networks.

Due to the above differences, many protocols have been designed for the routing of data in sensor networks. In this paper I have discussed and compared various routing protocols of WSNs.

## 2. ROUTING TECHNIQUES

Routing protocols in wireless sensor networks emphasize on various constraints like limited battery power, data dissemination and bandwidth in order to facilitate the efficient working of the network to increase the lifetime of the network. Routing techniques can be classified as direct communication (DC) techniques, Minimum Transmission Energy (MTE) techniques and Cluster based techniques. DC and MTE routing techniques are not as energy efficient as cluster based technique.

In Direct Communication (DC) technique, each node send its sensed data directly to the base station and nodes which are far from the base station die out more quickly thereby reducing the lifetime of the network.
Minimum Transmission Energy (MTE) is better than DC because in this technique, nodes communicate with their nearest neighbours. The battery power of nearest nodes drain out more quickly where as far nodes are penalised by DC.
Cluster based Routing techniques minimize the energy consumption. Here all nodes are deployed in the cluster. A cluster head is selected in each cluster who receives data of all nodes and transfers it towards the base station in the form of packets from where user can access it easily. Data aggregation is performed by CH to reduce the exhaustion of energy. Using this technique more data packets are transmitted to base station and network's lifetime is enhanced.

## 3. ROUTING PROTOCOLS

As in WSNs, routing protocols are application specific, thus the energy efficient routing techniques can be classified as under, based on the underlying network structure:

### 3.1 LEACH

LEACH (Low-Energy Adaptive Clustering Hierarchy), designed for the periodical data gathering applications, is the first clustering protocol of WSNs in which the **hierarchical** routing approach is used. It is the self-organizing, adaptive clustering protocol that reduces the energy significantly. LEACH assumes that there is a single hop communication of sensor nodes with each other and the data can be transmitted directly to the base station by these nodes.. The complete operation is divided into various rounds where each round has further two phases: cluster formation phase and data transmission phase.

In the **Cluster Formation Phase (or Setup Phase)**, the sensor nodes organize themselves into local clusters. For each cluster, cluster head is elected, whose role is to aggregate the data collected from the nearby nodes, compress the data and forward the compressed data to the base station. The remaining sensor nodes choose the appropriate cluster to join according to their signal strength from the cluster heads. The clusters are formed in a rotation. For N nodes, if a particular node becomes a cluster head, it cannot become cluster head again for next N rounds. Thus, the possibility of a node to become a cluster head in each round is 1/N. This rotation of cluster head leads to balanced energy consumption to all nodes which results in a longer lifetime of the network.

In the **Data Transmission Phase (or Steady State Phase)**, the data is aggregated by the cluster heads from their members, and then this aggregated data is sent to the base station using single-hop communication. The load is balanced to a certain extent as the cluster heads rotate in each round. The lifetime of the data transmission phase is longer than the lifetime of the cluster formation phase in order to minimize overhead.

### 3.2 PEGASIS (Power Efficient Gathering in Sensor Information Systems)

PEGASIS falls in a greedy chain protocols category. This protocol is much similar to LEACH protocol but it requires less energy per round. In this protocol, aggregated information is received and forwarded by each node to a nearby neighbour in the form of a chain. The PEGASIS protocol obtains upto 100% of energy cost improvement per round in comparison to LEACH. Various mechanisms are presented by PEGASIS that allow the variation of different energy parameters of radio communications. PEGASIS outperforms LEACH by eliminating the overhead of dynamic cluster formation, minimizing the distance of transmission and reception among all nodes.

### 3.3 Direct Diffusion (DD)

It is a **data centric protocol** in which the nodes are addressed by the monitored data and not by their network addresses. The main idea behind the data diffusion protocol is to diffuse the data, as the name suggests, through sensor nodes by using the naming scheme. The purpose of using this scheme is to save the energy as it avoids unnecessary operation of network layer routing. In this protocol, the network is queried for a specific phenomenon value. Sensor nodes satisfying the specific query start transmitting their data.

### 3.4 Stable Election Protocol (SEP)

SEP is a heterogeneous protocol to prolong the stability period and average throughput. SEP is based on weighted election probabilities of nodes to become cluster head according to the residual energy. Nodes are divided into two categories: advanced nodes and normal nodes. Advanced nodes are based on the energy, thus, the probability to become the cluster head of advanced node is more than the normal nodes.

### 3.5 TEEN

In TEEN (Threshold-sensitive Energy Efficient Sensor Network protocol) algorithm, during the time of cluster change, the cluster head, broadcasts not only attributes but also two values – hard and soft threshold values.

***Hard Threshold Value(HT):*** This threshold value is used for sensed attribute. It is the absolute value of the attribute. The node that senses this value must switch on its transmitter and should report to its cluster head.

***Soft Threshold (ST):*** This is a change in the value of the sensed attributes which is very small and that through which the node is triggered to switch on its transmitter and transmit.

The environment is sensed by nodes continuously. As the parameter from the attribute set reaches its hard threshold value; the transmitter is switched on by the node and then it

sends the sensed data. The value is then stored by the node in an internal variable, which is called the sensed value (SV).

This scheme is best suited for time critical data sensing applications like explosion detection, intrusion detection, etc. This scheme is also quite efficient in terms of energy consumption and response time. No doubt the nodes sense continuously, but still in this scheme the energy consumption can potentially be much less than in the proactive network, as the data transmission is less frequent. The user can control the trade-off between energy efficiency and accuracy.

The main disadvantage of this scheme is that, if the thresholds are not reached, the nodes will never communicate, and the user will not be able to get any data from network. Also it will not come to know even if all the nodes die. Thus, this scheme is not well suitable for applications where the user needs to get data on a regular basis. Another disadvantage is that its practical implementation would have to ensure that there are no collisions in the cluster. To avoid this problem, TDMA scheduling of the nodes can be used which will introduce a delay in the reporting of the time-critical data. Another possible solution to this problem is CDMA.

### 3.6 APTEEN (Adaptive Threshold sensitive Energy Efficient sensor Network) Protocol

APTEEN is a hybrid routing protocol that allows for comprehensive information retrieval. In this network, the nodes not only react to time-critical situations, but the overall picture of the network is also given at periodic intervals in an energy efficient manner. Thus, the user is enabled to request past (historical), present (one-time) and future (persistent queries) data from the network. TEEN & APTEEN outperform existing protocols in terms of energy consumption and longevity of the network.

In APTEEN, when the cluster heads are decided in each cluster period, the cluster head first broadcasts the following parameters:

***Attributes:*** Attributes are set of physical parameters about which the user is interested to obtain the data.

***Thresholds:*** It consists of both threshold values i.e. hard threshold and soft threshold values.

***Schedule:*** This is a TDMA schedule assigning a slot to each node.

***Count Time (TC):*** The maximum time period between two successive reports those are sent by a node.

This scheme gives the user a complete picture of the network by sending periodic data. It also responds immediately to drastic changes, thus making it responsive to time critical situations. Thus, it combines both proactive and reactive policies. The user can set the threshold values for the attributes and the time interval (TC). The energy consumption can be controlled by the count time and the threshold values.

The major drawback of this scheme is that it requires the additional complexity to implement the threshold functions and the count time. However, this is a reasonable trade-off and it provides an additional flexibility and versatility.

**Hybrid protocol APTEEN**: It combines the best features of both proactive and reactive networks to provide periodic data collection as well as near real-time warnings about critical events.

### 3.7 TPC (Two Phase Clustering):

Two Phase Clustering in WSN is the energy saving and delay-adaptive data gathering scheme. In the first phase, the network is partitioned into clusters. For this, each node advertises for cluster head with a random delay. The node who overhears others' advertisement will give up its own advertisement. In the second phase, each node searches for a neighbour node that is close to the cluster head, within the cluster. This is done to set up an energy-saving and delay-adaptive data relay link. This advantage of chain topology helps TPC in achieving a great trade-off between cost, energy and delay.

**3.8 EECS (Energy Efficient Clustering Scheme)**: Energy Efficient Clustering Scheme is similar to LEACH clustering scheme, in which the network is partitioned into different sets of clusters each having one cluster head. There is direct communication between this cluster head and its base station i.e. communication is done in single-hop. In the deployment phase of network, a "hello" message is broadcasted by the base station to all the nodes in the network at a certain power level. An approximate distance between the node and its base station can be computed based on the signal strength received by each node. By this the nodes can properly select the power level used to communicate with the base station. This distance is helpful to balance the load among cluster heads in the cluster formation phase. During the election phase of cluster head, those cluster heads are elected that are well distributed with a little control overhead.

**3.9 EEABR (Energy Efficient Ant-based Routing):** This energy efficient protocol is based on Ant Colony Optimization metaheuristic. In this, the colony of artificial ants travels through the Wireless Sensor Networks and search for paths between the sensor networks and a destination node that are not only energy efficient and short in length but also maximize the lifetime of WSN. Each ant in the colony selects the neighbouring node to go with a probability which is a function of the node energy and of the amount of pheromone trail present on the connections between the nodes. After reaching the destination node, the ant travels in the backward direction with the help of the path constructed. The pheromone trail will be updated by an amount that is based on the quality of the energy and the number of nodes of the path. After some iteration, this protocol of energy efficiency will be able to build a routing tree with optimised energy branches.

**3.10 HEEC (Hierarchical Energy Efficient Clustering Algorithm):** The main aim of HEEC protocol is to maximize

the lifetime of WSN that can be achieved by minimizing high energy consumption and balancing the load evenly among all the sensor nodes. Clustering is used to group all the sensor nodes. Cluster head is selected by base station. The cluster head constructs the routing tree to destination node. The cluster head is re-elected to avoid the problems of data fusion and of data loss. Cluster head is responsible for the transfer of the data, for the co-ordination of nodes and for selecting the path. The construction of Routing tree to choose the optimal path from source to destination will be carried out by the cluster head using DSDV method. All the optimal paths will be analysed by the cluster head and the path that requires minimum energy and cost to transfer data packets will be selected as the routing path.

The performance of HEEC is much better than LEACH, GSTEB, TBC and EAP protocols. It reduces energy consumption using clustering. It balances the load by electing cluster head for each cluster. The Routing tree method improves the performance of the network by choosing the optimal path. Secure data transmission is achieved using minimal cost and energy. This method of Re-electing Cluster Head avoids data loss, delay access, etc.

**Table 1: Comparison of Energy Efficient Routing Protocols**

| Energy Efficient Routing protocol | Category | Data Aggregation | Position Awareness | Power Usage | Scalability | Over head | Query Based | QoS | Data Delivery Model |
|---|---|---|---|---|---|---|---|---|---|
| LEACH | Hierarchical/ Node Centric | Yes | NO | High | Good | High | No | No | Cluster head |
| PEGASIS | Hierarchical | No | NO | High | Good | Low | No | No | Chain based |
| DD | Flat/Data Centric | Yes | No | Ltd | Ltd | Low | Yes | No | Demand Driven |
| TEEN | Hierarchical | Yes | No | High | Good | High | No | No | Active Threshold |
| APTEEN | Hierarchical | Yes | NO | High | Good | High | No | No | Active Threshold |

## 4. CONCLUSION

Routing is an important concept in wireless sensor networks which is growing rapidly with the research results. In this paper, we have presented the survey of some common routing protocols like LEACH, PEGASIS, TEEN, APTEEN, SEP, EEABR and DD through the literature survey. The three routing techniques – DC, MTE and Cluster based routing is also discussed. The comparative study of LEACH, PEGASIS, DD, TEEN and APTEEN has been done in the tabular form. The studies reveal that all these routing protocols work on the same objective of increasing the lifetime of the network. They are all energy efficient routing protocols and fall in the category of Hierarchical routing protocols except DD which is the flat data centric protocol. Data aggregation is done in all these except in PEGASIS but they are not position aware protocols.

## REFERENCES


*[1]* Arati Manjeshwar, Dharma P. Agrawal, *"TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks";* Parallel and Distributed Processing Symposium, International Vol. 3, IEEE Computer Society, OH 45221-0030

*[2]* S. Lindsey, C.S. Raghavendra, *"PEGASIS: Power Efficient gathering in sensor information systems"*, Aerospace Conference Proceedings, 2002, IEEE, vol3, doi:10.1109/AERO.2002.1035242

[3] Debnath Bhattacharyya, Tai-hoon Kim, S. Pal, *"A Comparative Study of Wireless Sensor Networks and Their Routing Protocols"*, Sensors 2010, 10, 10506-10523; doi:10.3390/s101210506

[4] Pantazis, Nikolaos A., Stefanos A. Nikolidakis, Dimitrious D. Vergados. *"Energy Efficient Routing Protcols in Wireless Sensor Networks: A Survey", IEEE* Communications Surveys & Tutorials, 2012.

*[5]* Arati Manjeshwar, Dharma P. Agrawal, *"APTEEN: A Hybrid Protocol for Efficient Routing and Comprehensive Information Retrieval in Wireless Sensor Networks";* Parallel and Distributed Processing Symposium, International Vol. 3, IEEE Computer Society,

*[6]* Ridha Soua, Pascale Minet, *"A Survey On Energy Efficient Techniques in Wireless Sensor Networks"*, INRIA 78153, Le Chesnay cedex, France, IFIP WMNC' 2011

[7] Samira Yessad, Louiza Bouallouche-Medjkoune, Djamil Aissani,*"Comparison of Routing Protocols in Wireless Sensor Networks"*, VECoS, 2014 – Citeseer

[8] Tiago Camilo, "An Energy-Efficient Ant-Based Routing Algorithm for Wireless Sensor Networks", 2006

[9] Claudia Barenco Abbas, "A Proposal of a wireless sensor network routing protocol", Telecommunication Systems, 06/2008

[10] Shamsad Parvin, Muhammad Sajjadur Rahim, *"Routing Protocols for Wireless Sensor Networks: A Comparative Study"*, International Conference on Electronics, Computer and Communication, ICECC

[11] J.N. Al-Karaki. *"Routing techniques in wireless sensor networks: a survey"*, IEEE Wireless Communications, 12/2004