Energy Efficient Routing Protocols in WSN: A Review Paper

Vandana Katoch[1] Kamal Kumar[2]
[1,2]Department of Computer Science and Engineering
[1,2]SDDIET, Barwala

Abstract— Wireless sensor networks with hundreds of sensor nodes have emerged in recent years as important platforms for a wide spectrum of monitoring tasks ranging from environmental to military applications. A sensor network is a static ad hoc network which consists of hundreds of sensor nodes that can be deployed on the fly operation being not attended so the main design issue for a sensor network must be conservation of the energy available at each sensor node. Wireless Sensor Network depends on nodes have limited energy, computational power, memory , range and it is important to increase energy efficiency by saving the battery power so as to extend the life time of the given WSN deployment. Different protocols are used for energy consumption, in wireless sensor network. LEACH, TEEN, APTEEN, PEGASIS ,DEEC, DDEEC, EDEEC, BEENISH are energy- efficient protocols that balances the energy expense, saves the node energy and hence prolongs the lifetime of the network. This paper presents a detailed review and analysis of these energy efficient protocols.

Key words: Wireless Sensor Network, Energy Conservation, LEACH, TEEN, APTEEN, PEGASIS, DEEC, DDEEC, HEED, BEENISH, cluster head etc

I. INTRODUCTION

A wireless sensor network (WSN) (sometimes called a wireless sensor and actor network (WSAN) are spatially distributed autonomous sensors to monitor physical or environmentalconditions,suchas temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors.

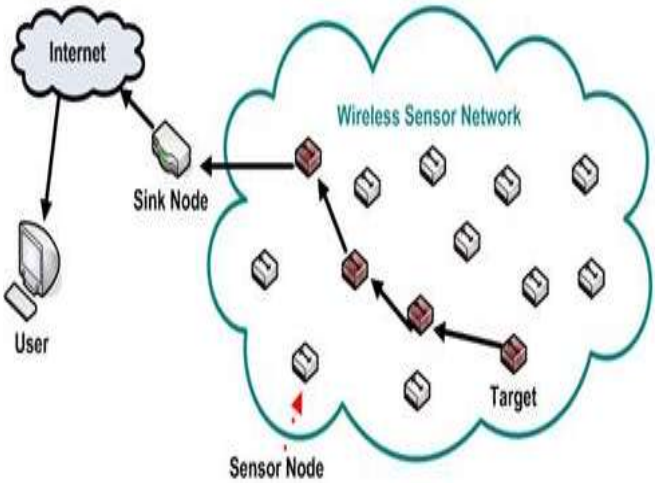

Fig. 1: Basic architecture of wireless sensor network

- A sensor node is a node in a sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network.
- Sensing is a very important technique that is used to gather information about a physical object or process including change in the state such as drop in temperature or pressure. The object that usually perform sensing task is termed as sensor**.**

A. Applications:

1) Forest Fire Detection-

A network of sensor nodes can de installed in a forest to detect when a fire has started. The node can be equipped with sensors to measure temperature, humidity and gases which are produced by fire in the trees or vegetation.

If the node detects fire, it sends an alarm message(along with its location)to the base station.

B. Air pollution monitoring

Wireless sensor networks have been deployed in several cities (Stockholm, London or Brisbane) to monitor the concentration of dangerous gases for citizens. These can take advantages of ad-hoc wireless links rather than wired installations.

C. Health care monitoring

Current healthcare applications of wireless sensor networks target heart problems cancer, asthma, glucose level monitoring, stress monitoring etc.

II. RELATED WORK

A. Leach

Low-Energy Adaptive Clustering Hierarchy (LEACH) [1], is an initial hierarchical clustering protocol that suggests both distributed and centralized schemes. The basic idea of LEACH has been an inspiration for many later clustering routing protocols. Leach utilizes the randomized rotation of cluster heads to uniformly distribute the energy consignment among the sensors in the network. The cluster heads have the responsibility of gathering data from their clusters, while also to aggregate the collected data for decreasing the amount of messages to be sent to the BS, which outcome in less energy dissipation, to enhance the network lifetime. This protocol is divided into rounds; every round consists of two phases.

- Set-up phase - organizing the cluster.
- Steady-state phase - deals with the actual data transfers to the base station.

This protocol consists of number of rounds r and each round has two phases: set up phase and steady-state phase. In set up phase Cluster Head (CH) selection is 18based on two factors. First, the percentage P of nodes in network and secondly history of nodes that has served as CH.

There are some problems associated with LEACH Protocol: The cluster head is selected randomly so each node in cluster has same probability to become cluster head. After numerous rounds, the node with high remaining energy and node with low remaining energy have same probability of becoming cluster head. If the node with low remaining energy is chosen as cluster head, it will run out of energy and die quickly which affects network lifetime.

The division of clusters is also done in random fashion which results in uneven distribution of clusters. The divided clusters have non uniformities like: one cluster has a lot more nodes than other cluster and some cluster heads are at Centre and some are at edge of cluster far from other members. These non-uniformities affect the performance of network.

1) Merits

- Accounting for adaptive clusters and rotate the cluster head periodically.
- Completely distributed. It requires no global knowledge of the network.
- Increases the lifetime of the network.

2) Demerits

- Uses single-hop routing within the cluster.
- Highly dynamic clustering brings extra overhead.
- Leach randomly select cluster head, which may result faster death in few nodes.

B. TEEN

Threshold sensitive Energy Efficient sensor Network protocol (TEEN) [2], is a hierarchical clustering protocol. It is first reactive network protocol. This protocol main goal is to manage with sudden changes in the sensed attributes such as temperature. It combines the hierarchical method in line with a Data-centric approach. TEEN, is a 2-tier clustering topology and two thresholds they are hard threshold and soft threshold, are namely.

- Hard Threshold – Threshold value for the sensed attribute. A cluster member only reports/sends data to CH by switching on its transmitter, only if data values are in the scope of interest.
- Soft Threshold – Small change in the value of the sensed attribute. A cluster member only reports/sends data to CH by switching on its transmitter, but its value changes by atleast the soft threshold.

In TEEN a CH sends its members a hard threshold and a soft threshold. This way, the hard threshold sanctions the nodes to transmit only when the sensed attribute is in the range of importance, this method reducing the number of transmissions considerably. Once a node senses a value at or beyond the hard threshold, it transmits data only after thevalue of that attribute changes by an amount equipollent to or more preponderant than the soft threshold, which point to a minute transmutation in the value of the sensed attribute and triggers a sensor to turn ON its transmitter and send it sensed data to the CH. So, soft threshold will further reduce the number of transmissions for sensing data if there is diminutive or no transmutation in the value of sensed attribute.

1) Merits

- Based on the two thresholds, data broadcast can be controlled estimable.
- TEEN has complemented for reacting to great changes in the sensed attributes.

2) Demerits

- If the thresholds do not reach, the nodes will never communicate; the user will not get any data from the network at all and will not come to know even if all the nodes die.
- It is not well suited for real time application where the user needs to get data on a regular basis.

C. APTEEN

The Adaptive Threshold sensitive Energy Efficient sensor Network protocol (APTEEN) [3], is an expansion to TEEN. It combines the best features of both proactive and reactive networks as minimizing their limits to make a new type of network called a hybrid network. APTEEN is based on a query system which allows three types of queries: historical, on-time, and constant which can be used in a hybrid network. In APTEEN the cluster head first broadcasts the following parameters:

- Attributes -interested physical parameters.
- Thresholds -hard threshold value and soft threshold value.
- Schedule -time slot using TDMA.

- Count time -Maximum time period between two successive reports sent by a node.

1) *Merits*
   - Outperform LEACH in terms of energy disappearing and total lifetime of the network.
2) *Demerits*
   - Overhead and complexity.
   - Forming multiple level clusters.
   - Implement threshold-based functions.
   - Dealing with attribute-based naming of query.

D. PEGASIS

Power-Efficient Gathering in Sensor Information Systems (PEGASIS) [4], a near best chain-based protocol that is a development over LEACH. The PEGASIS is for each node to receive from and transmit to close neighbors and take turns being the leader in transmission to the BS. It will be distributing the energy load evenly among the sensor nodes in the network. It is a data-gathering and near-optimal chain based algorithm that establishes the design that energy conservation can outcome from nodes not directly forming clusters. This PEGASIS, the nodes are organized to form a chain; they can either be concentrated assigned by the sink and broadcast to all nodes or terminated by the nodes themselves by a greedy algorithm. In the process of chain formation, it is idea that all nodes have overall knowledge of the network and the greedy algorithm is employed.

- The performance of this protocol can be better by using a greedy algorithm for chain structure.
- Not allowing nodes, which disappear more energy to become the leader.
- Applying a threshold adaptive for the remaining energy levels in nodes.

1) *Merits*
   - This protocol is able to better than LEACH for different network sizes and topologies.
   - The energy load is spread out completely in the network.
   - It increases the lifetime of network twice as much the lifetime of the network under the LEACH protocol.
2) *Demerits*
   - It is the requirement of having a complete view of the network topology at each node for chain construction.
   - The communication manner suffers from too much delay caused by the single chain of distant nodes and a high probability for any node to become a bottleneck.
   - All nodes maintain a complete database about the location of all other nodes in the network. So it takes lot of time and energy.

E. DEEC

Distributed –Efficient Energy Clustering Protocol (DEEC), DEEC uses the initial and residual energy level of the nodes to select the cluster-heads. To avoid that each node needs to know the global knowledge of the networks. The clustering Algorithm is a kind of key technique used to reduce energy consumption. It can increase the scalability and lifetime of the network. Energy-efficient clustering protocols should be designed for the characteristic of heterogeneous wireless sensor networks. We propose and evaluate a new distributed energy-efficient clustering scheme for heterogeneous wireless sensor networks, which is called DEEC.

In DEEC, the cluster-heads are elected by a probability based on the ratio between the residual energy of each node and the average energy of the network. The round number of the rotating epoch for each node is different according to its initial and residual energy, i.e., DEEC adapt the rotating epoch of each node to its energy. The nodes with high initial and residual energy will have more chances to be the cluster-heads than the low-energy nodes.

Thus DEEC can prolong the network lifetime, especially the stability period, by heterogeneous-aware clustering algorithm.

1) *Merits*
   - DEEC doesn't need any universal knowledge of energy at each election round.
   - In contrast to SEP and LEACH, DEEC will perform well in multi-level heterogeneous wireless network.
2) *Demerits*
   - Advanced nodes always punish in the DEEC, particularly when their residual energy reduced and when they come in the range of the normal nodes. During this position, the advanced nodes die rapidly than the others.

F. DDEEC

A Elbhiri et al. [5] proposed a developed distributed energy efficient clustering scheme for heterogeneous wireless sensor networks. This technique is based on changing dynamically and with more efficiency the cluster head election probability. DDEEC is based on DEEC scheme, where all nodes use the initial and residual energy level to define the cluster heads. To evade that each node needs to have the global knowledge of the networks, DDEEC like DEEC estimate the ideal value of network lifetime, which is used to compute the reference energy that each node should expend during each round. In the scheme, the network is organized into a clustering hierarchy, and the cluster heads collect measurements information from cluster nodes and transmit the aggregated data to the base station directly. Moreover, the authors have supposed that the network topology is fixed and no-varying on time. The difference between DDEEC and DEEC is localized in the expression which defines the probability to be a cluster head for normal and advanced nodes. Simulation results show that the protocol performs better than the SEP and DEEC in terms of network lifetime and first node dies.

G. HEED

Hybrid energy efficient Distributed Clustering (HEED) [6] is a multi-hop clustering algorithm for wireless sensor networks. It is considered to choose different cluster heads in a field, based on the amount of residual energy that is distributed in relation to a neighboring node. The random selection of cluster head is not suitable in HEED, because it decrease the lifetime of network.

The main goals of the network-

- Extend the network lifetime by distributing energy consumption.

- Terminate the clustering process within a constant number of cycles/steps.
- Produce well-distributed cluster heads and compact clusters.

The most important of HEED is the method of cluster head selection. Cluster head is chosen based on two important parameters. One parameter depends on the node's residual energy, and the other parameter is the intra-cluster communication cost as a function of cluster density.

1) Merits

- HEED distribution of energy; improve the lifetime of the nodes within the network this method stabilizing the neighboring node.
- Does not require particular node's ability, such as location-awareness.

2) Demerits

- The random selection of the cluster head may cause higher communication overhead.
- The cyclic cluster head rotation or election needs extra energy to reconstruct clusters.

H. BEENISH

Balanced Energy Efficient Network Integrated Super Heterogeneous (BEENISH) Protocol [7]. It assumes WSN containing four energy levels of nodes. Here, Cluster Heads (CHs) are elected on the basis of the residual energy level of nodes. BEENISH implements the same concept as in DEEC, in terms of selecting CH which is based on the residual energy level of the nodes with respect to the average energy of the network. Though, DEEC is based on two types of nodes; normal and advance nodes. BEENISH uses the idea of four types of nodes; normal, advance, super and ultra-super nodes. In this reach longer stability, lifetime and extra effective messages than Stable Election Protocol (SEP) [8], Distributed Energy Efficient Clustering (DEEC), Developed DEEC (DDEEC) and Enhanced DEEC (EDEEC). In BEENISH ultra-super nodes are mostly elected as CH as different from super, advance and normal nodes. Hence, in this way energy consumed by all nodes is equally distributed.

BEENISH is energy-aware clustering protocol for heterogenous WSNs, with the concept of four types of nodes. Election of CH based on residual and average energy of the network. So, nodes with high energy have more chances to get selected as CH, as compare to the low energy nodes. BEENISH is proved to be the most efficient protocols as compared to DEEC, DDEEC and EDEEC for all types ofWSNs in terms of stability period, network lifetime and throughput.

1) Merits

- Election of CH based on average and the residual energy of the network.
- Stability, network lifetime and throughput better than DEEC, DDEEC and EDEEC.

2) Demerits

- Difficult to recognize different levels of heterogeneous network having normal, advance, super and ultra-super nodes.
- Hard to achieve coordination among clusters.

III. CONCLUSION

In this paper, we have discuss some of the existing 'routing protocols', specifically with respect to their network lifetime and reliability requirements. In addition, we also provided a comparative study of the protocols reacting towards various networking parameters. As there are the infinite existences of routing protocols, we have considered some of routing protocols to explicate the concept with individual Merits and Demerits.

REFERENCES

[1] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy Efficient Communication Protocols for Wireless Sensor Networks", In Proceedings of the 33rd Annual Hawaii International Conference on System Sciences (HICSS), Big Island, Hawaii, USA, pp. 3005-3014,Jan-2000.

[2] A. Manjeshwar., D.P. Agrawal,. "TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks", In Proceedings of the 15th International Parallel and Distributed Processing Symposium (IPDPS), San Francisco, CA, USA, pp. 23–27, April-2001.

[3] A. Manjeshwar., D.P. Agrawal,. "APTEEN: A Hybrid Protocol for Efficient Routing and Comprehensive Information Retrieval in Wireless Sensor Networks", In Proceedings of the 2nd International Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile computing, Lauderdale, FL, USA, pp. 195–202, April 2002.

[4] Stephanie Lindsey, Cauligi Raghavendra, Krishna M. Sivalingam. "Data gathering algorithms in sensor networks using energy metrics", IEEE Trans, Parallel Distrib., pp. 924–935, Sep-2002.

[5] Elbhiri, B., Saadane, R., El Fkihi, S., Aboutajdine, D. "Developed Distributed Energy-Efficient Clustering (DDEEC) for heterogeneous wireless sensor networks", in: 5th International Symposium on I/V Communications and Mobile Network (ISVC), 2010.

[6] O. Younis, S. Fahmy," HEED: A hybrid, energy-efficient, distributed clustering approach for adhoc sensor networks", IEEE Trans, Mobile Comput, pp. 366–379, Dec-2004.

[7] Jun Yuea, Weiming Zhang, Weidong Xiao, Daquan Tang, Jiuyang Tang, "BEENISH: Balanced Energy Efficient Network Integrated Super Heterogeneous Protocol for Wireless Sensor Networks", International Workshop on Body Area Sensor Networks (BASNet-2). Vol.19, PP. 920- 925, 2013.

[8] G. Smaragdakis, I. Matta, A. Bestavros,"SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor network", in: Second International Workshop on Sensor and Actor Network Protocols and Applications (SANPA), 2004.

