

A Survey on Energy Efficient Routing Protocols in WSN

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Summary

Wireless Sensor Networks (WSNs) consist of large number of tiny, battery powered sensor nodes with sensing, computation, and wireless communications technologies. These Nodes sense and send their reports towards a centralized node which is called —sink or base station. This transmission and reception process consumes lots of energy as compared to data processing, all sensor nodes are processed by limited capacity battery resources which are difficult to replace or recharge due to the unsuitable nature of located nodes. Therefore, to increase the life time of the nodes in WSN, the designing of energy aware routing protocol is vital to increase the life time of the sensor node in WSN. An Energy Efficient Routing is a significant issue in the designing of Wireless Sensor Network (WSN) protocols. This paper presents the list of various type of energy efficient protocols have been studied having classified them into proper categories

Keywords:

WSN, EER, LEACH, PEGASIS and DREAM.

1. Introduction

A WSN typically consists of a large number of sensor nodes that are deployed in an area of interest [1]. These nodes are low-power, low-cost devices. These nodes are small in size, but are equipped with embedded microprocessors, radio receivers, and power components to enable sensing, computing, communication, and actuation. These components are integrated on a single or multiple boards, and packaged in a few cubic inches. These sensor nodes sense the information and transmit it to the base station [2]. Base station analyses the received data and computation is performed, which gives the human understandable result. The Base station is having unlimited battery power. Since the entire sensor nodes are battery powered devices, energy consumption of nodes during transmission or reception of packets affects the life-time of the entire network. Due to the factors mentioned above, researchers have designed various routing protocols especially for WSNs due to the differences between routing in WSNs and other wireless networks. Almost all applications of sensor networks require the flow of sensed data from multiple regions (source nodes) to a particular sink. Generated data traffic has significant redundancy in it since multiple sensors may generate the same data within the near-by region. Such redundancy needs to be exploited by the routing protocols to improve energy and bandwidth

utilization. So it should implement the algorithm and protocols by which it can enhance the life time of the sensor node as well as save the battery power. In this paper section 2 describes the strategies of Routing protocols, section 3 gives an overview of some existing protocols to improve the energy efficiency in wireless sensor networks.

2. Routing Strategies

A number of routing protocols have been developed for the WSN till today. Due to its constraints in the processing power and limited battery power, the routing protocols for the wired networks cannot be used here. These protocols can be categorized into the following ways:

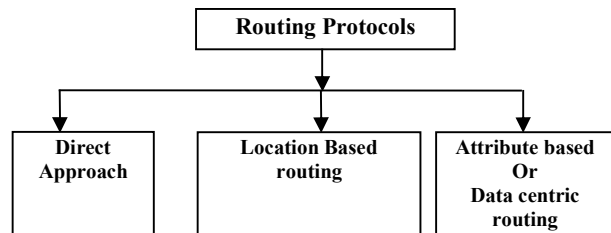


Figure. 1 Classification of wireless sensor networks

2.1 Direct Approach

The simple flooding type routing protocols will be coming under the direct approach. Though it is simple in its implementation, it is not an energy efficient protocol for the sensor networks.

2.2 Location Based routing

The routing of data to the nodes is done by the geographic location of the nodes (i.e.) nodes are identified by its location only. The location information of the individual nodes is obtained by the low power GPS receivers embedded in the nodes. The following picture

shows the different types of protocols falls under the location based routing.

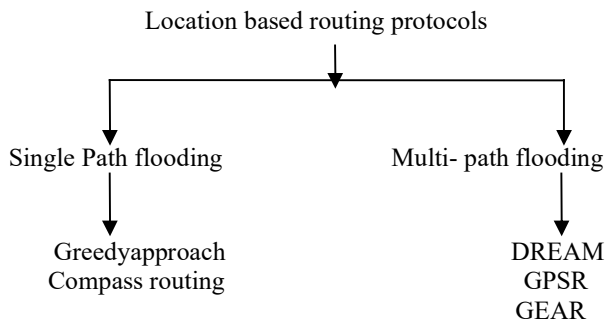


Figure. 2 Location based Routing protocols

a. Greedy approach

In this protocol, neighboring node Y which is closer to the destination node D from the source or intermediate node S conducts the packet to the destination. The data flows through the intermediate nodes like this until it reaches the destination node D.

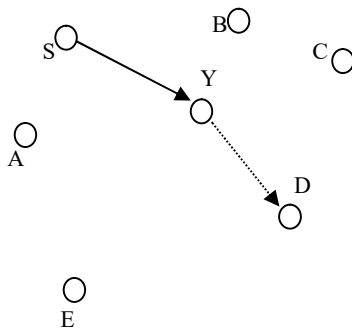


Figure. 3 Implementation of Greedy approach in WSN

b. Compass routing

In this protocol, the source node S calculates the direction of the destination D and the neighboring node Y which is having closest direction to the destination than SD is selected as the next eligible intermediate node to route the data from the source node.

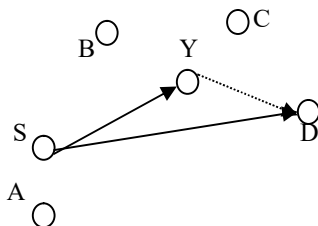


Figure. 4 Implementation of Compass routing approach in WSN

c. DREAM

A Distance Routing Effect Algorithm for Mobility proposed the model of flooding packets to all the neighboring nodes of node x, here a different approach was taken. The data is only flooded to the limited number of nodes which is coming under the area when the tangents are flowing between the node x to the circle centered at destination D. Since we are forwarding data to limited number of nodes, it is a better one than its predecessors.

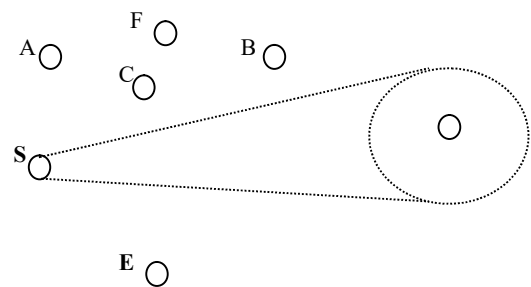


Figure. 5 Implementation of DREAM Protocol in WSN

Here in the above diagram the dotted nodes which fall under the tangents connecting the circle and the source node is only receiving the data.

d. GPSR

Greedy Perimeter Stateless Routing, the modified version of greedy-face-greedy algorithm is the Greedy perimeter stateless routing [14]. Here the combination of greedy and perimeter approach is taken. Initially the data is forwarded by using greedy approach and if the packet gets stuck at any point, perimeter approach comes to rescue of the situation. But this perimeter approach is followed till a node closer to the destination was found than the node at which the packet got stuck. It ensures the guaranteed delivery of packets to the destination.

e. GEAR

Geographic & Energy Aware Routing takes the different approach than its previous protocols by considering the least cost path to route the packets to the destination node which is identified by its location information.

f. GAF

Geographic Adaptive Fidelity proposed that the nodes coming under the particular geographical range will

be associated with a particular grid. The communication cost of nodes coming under the same grid will be same. During the routing decision any one node from the particular grid will wake up and takes part in routing and all other nodes in the same grid will go to the sleeping state to avoid unnecessary energy depletion.

2.3 Data centric routing

The basic view which separates the sensor network from the other wireless networks is the distinction between the address of the node and the content of the node. Here in the above said "Location based routing" strategy the entire sensor nodes in the particular region are viewed as the system rather than as the separate nodes. This lead the sensor network to take routing decisions based on data held by the nodes in the network rather than its destination address or geographic location. Some of the protocols which follow the data centric routing are,

- Directed diffusion
- SPIN
- Rumor routing

3. Energy Efficiency In Routing

Since energy efficiency is more important for wireless sensor networks than any other networks, more research works have already been done in routing in WSN. In general, data transmission in wireless communication takes more power than data processing. Whenever the nodes are transmitting more number of data proportionately their battery power also get reduced. To reduce the data size we can go for data fusion or aggregation techniques. Data fusion is that in which the sensed data from different nodes are fused at certain point suitable for the transmission in its reduced size.

Even in the data aggregation concept there are two types of aggregation. The first type of data aggregation fuses the data gathered from different sources and sends the final fused data in reduced size. But the problem behind this approach is it lacks in accuracy and precision of data from various sensor nodes. The second approach combines the data from different sources under the the single header and forward it to the base station. Here header packets consolidates and pass it to the base station without any modification to the original data from the sensors. Hence accuracy is improved. Study on energy efficient routing in WSN brings this two broad classification of approaches.

- Clustering or Hierarchical approach
- Tree based approach

3.1 Clustering approach

It is an important factor in achieving energy efficient routing of data within the network. Splitting the sensor networks into small manageable numbers is called as clustering. As such, the nodes in WSN are classified into two categories. One is the group of high energy nodes – these can be used to process and send the information. And the another one is the group of low engery nodes – these can be used to perform sensing in the targetted location. This type of Clustering reduces the communication overhead for both single and multipath routing. Apart from achieving scalability of the network it has more advantages like conserving communication bandwidth within the clusters, avoiding redundant message transfer between the sensor nodes, localizing energy efficient route setup within the clusters.

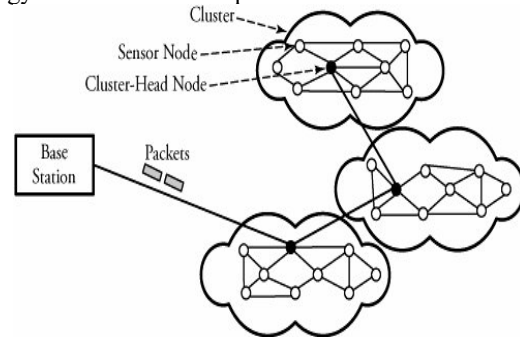


Figure. 6 Structure of Clustering in WSN

Fig.6 shows the structure of Clustering technique in wireless sensor networks. In this method some of the sensor nodes grouped together to form a cluster and each cluster having cluster head and cluster head is responsible for sending the aggregated data from its cluster members to the base station. Cluster head selection is based on the threshold value of the sensor node in each sensor. Some of the energy efficient routing protocols based on clustering are LEACH, HEED, etc...

- a. **LEACH** (Low-energy adaptive clustering hierarchy) LEACH [13] is a cluster-based wireless sensor networking protocol. LEACH adapts the clustering concept to distribute the energy among the sensor nodes in the network. LEACH improves the energy-efficiency of wireless sensor networking beyond the normal clustering architecture. As a result, we can extend the life time of our network, and this is the very important issue that is considered in the wireless sensor networking field. LEACH Protocol has 2 phases. Namely,
 - a. Setup phase
 - b. Study - State Phase
- b.

During the setup phase of the LEACH Protocol Cluster head are chosen. During the Study state phase data is transmitted between nodes and nodes in the cluster are maintained in the following ways.

In LEACH protocol, wireless sensor networking nodes divide themselves to be many local clusters. In each local cluster, there is one node that acts as the base station (or we can call it “cluster-head”). Hence, every node in that local cluster will send the data to the cluster-head in each local cluster. The important technique that makes LEACH be different from the normal cluster architecture is that LEACH uses the randomize technique to select the cluster-head depending on the energy left of the node.

After cluster-head is selected with some probability, the cluster-heads in each local cluster will broadcast their status to the sensor nodes in their local range by using CSMA MAC protocol. Each sensor node will choose a cluster-head that is closest to itself to join that cluster because each sensor node will try to spend the minimum communication energy with it cluster head. After the clustering phase is set up, each cluster-head will make a schedule for the nodes in its cluster. In LEACH, TDMA is used. For more efficiency, each sensor node could turn-off waiting for their allocated transmission.

Cluster-heads will collect the data from the nodes in its cluster, and compresses that data before transmits the data to the base station. Although LEACH protocol prolongs the network lifetime in contrast to plane multi-hop routing and static routing, it still has problems. The cluster heads are elected randomly, so the optimal number and distribution of cluster heads cannot be ensured. The nodes with low remnant energy have the same priority to be a cluster head as the node with high remnant energy. Therefore, those nodes with less remaining energy may be chosen as the cluster heads which will result that these nodes may die first. The cluster heads communicate with the base station in single-hop mode which makes LEACH cannot be used in large-scale wireless sensor networks for the limit effective communication range of the sensor nodes [14,].

- c. **HEED** (Hybrid Energy Efficient Distributed) protocol is the clustering protocol. It uses using residual energy as primary parameter and network topology features (e.g. node degree, distances to neighbours) are only used as secondary parameters to break tie between candidate cluster heads, as a metric for cluster selection to achieve load balancing. In this type all sensor nodes are equipped with same initial energy.

We assume that a percentage of the node population is equipped with more energy than the rest of the nodes in the same network - this is the case of heterogeneous sensor networks. As the lifetime of sensor networks is limited there is a need to re-energize the sensor network by adding more nodes. These nodes will be equipped with more energy than the nodes that are already in use.

d.

3.2 Tree Based Approach

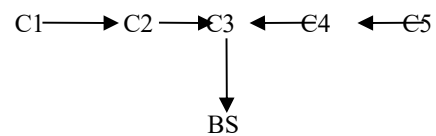


Figure. 7 Packet passing approach in PEGASIS

Apart from clustering techniques in WSN, another energy efficient way of routing the data over the network is tree based approach. In this approach a hierarchical manner of aggregation points are formed which resembles the tree structure. The leaves are the source nodes and the root is the sink node. The data when travelling gets aggregated in the intermediate nodes itself. The most successful energy efficient routing protocol which follows the tree based approach was PEGASIS.

- a. PEGASIS Though the Cluster based protocols like LEACH have shown a factor of 8 improvements when compared with its previous protocols further improvements were done by forwarding the packets to only one neighbor of the node. This method had been named as “Power Efficient Gathering in Sensor Information System”[6]. Instead of forwarding the packets from many cluster heads as like in LEACH protocol here in PEGASIS each node will form a chain structure to the base station through which the data would be forwarded to the BS node.
- b. Here in PEGASIS energy efficient is achieved by transmitting the data to only one of its neighbor node. There the collected data is fused and the fused data will be forwarded to its immediate one hop neighbor. Since all the nodes are doing the data fusion at its place there is no rapid depletion of power for the nodes present near the Base station. Also in this method each node will be getting the chance to forward the gathered data to the base station. But when the sensor measurements are aggregated to be a single packet, only fraction of the data generated by

the sensor is given to the base station. In some applications when the particular sensor measurement is needed it fails to give it to base station. But apart from the function of the routing protocol we can make the sensor network database to follow the multi resolution scheme where the aggregated data will be present in the root node and the finer data can be obtained by further tree traversal mechanism. Though the Directed Diffusion [8] and Rumor routing [7] techniques comes under tree based approach in terms of energy efficiency it lacks behinds PEGASIS model.

4. Proposed model

The existing energy efficiency model for the sensor network shows considerable improvement in one or more objectives to suite the specific application, still there needs a lot of work to be done on energy efficient model in terms of low clustering overhead, distributed cluster heads, continuous packet delivery, reduced data fusion cost. In future, proposing a new hybrid protocol model which considers all these factors in the routing mechanism for the wireless sensor network.

5. Conclusion

Thus, the existing routing strategies in the wireless sensor networks and their corresponding protocols had been explained. Though the protocol like LEACH, HEED, DECA, SPIN, and PEGASIS are proved to be energy efficient than its previous models the main pitfalls in these protocols are that nodes are assumed to be static and stationary. The energy efficiency model is untested while the sensor nodes exhibit mobility. Future works may concentrate on achieving better energy efficiency in routing mechanism for mobile wireless sensor nodes.

6. References

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