Energy Efficient Routing Protocols for Wireless Sensor Network- Survey

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Abstract – Wireless Sensor gains popularity from last few decades due to their viability in hostile environment. Based on types of node sensor networks are categorized as WSN and MWSN. Wireless Sensor Network with mobile nodes faces numerous challenges in terms of energy efficient network, prolonged lifetime and network traffic. This paper gives an overview of efficient routing protocols suitable for wireless sensor network with mobile nodes.

Index Terms – Energy efficient, routing, WSN, MWSN

1. INTRODUCTION

Wireless Sensor Network consists of tiny sized sensor that have sensing capability and sense different type of according to application. These sensor nodes are battery operated and their battery level reduces with passage of time. Field of WSN in high demand and becomes popular in twenty-one century [27, 29, 47, 48, 49]. Sensor nodes are deeply deployed in that environment that was not easily reachable so it will be beneficial for critical applications like mining, military applications like battlefield surveillance, industry controlling process and environmental monitoring [28]. Initially WSN was used for military application but now WSN also used in civilian applications like habitat monitoring, health monitoring, home automation, traffic controls and environment monitoring.

Bedsides cellular and Ad-hoc network, nodes in WSN can be deployed deeply in the hostile environment, limited storage capacity; limited energy results in numerous challenges [1] in use and development of WSN. Various types of research activities have been proposed to solve design, deployment, development and application issues of WSN. A large sized WSN consist of thousand numbers of nodes with low cost, limited power and have ability to perform different type of functions depending on the type of deployed environment. These small sized sensors equipped with microprocessors, radio receivers and power components for enabling sensing, computation, actuation and communication. All these components are integrated to form a circuit on a single board.

Wireless channels are used by WSN for communicated over small distances using cooperative processing and information processing. Sensor nodes are globally deployed for environment monitoring, habitat monitoring in battle field for military surveillance and in emerging environment for rescue and search operations [50]. Depending upon factory maintenance conditions and process control, infrastructure for health monitoring these sensors are deeply deployed. After deployment these sensor nodes are self-organized as per the type of network and having multi hop connections among themselves.

These integrated sensors collecting different type of information about environment under different working modes like continuous and event driven. Location information is obtained using local positioning algorithms and global positioning system (GPS). Information is collected over the network across the network and processed for global monitoring of the object and phenomena. Every ode in WSN has its own capability in terms of battery for communicate over the network.

In typical sensor network architecture, query processing is done for information retrieval between user and network. Sensor nodes are deployed around the sink and have limited battery level, storage capacity and computational capacity. Sensor nodes are not globally recognized because these nodes are deployed in bulk.

Thus, the basic goal of a WSN is to supply data from raw native information obtained (sensed data) by individual device mode by prolonging the life time of WSN as much as attainable. The resource strained nature of device nodes creates the distinctive challenges to the look of WSNs for his or her applications. The restricted power of device nodes mandates the look of energy-efficient communication protocol. Routing in device networks is incredibly difficult because of many characteristics that distinguish them from contemporary communication and wireless ad-hoc networks [30].

The detector nodes are tightly forced in terms of transmission power, on-board energy, process capability and storage and so need careful resource management. Researchers have devised several protocols for communication, and security in wireless networks life infrastructure based mostly networks, ad-hoc networks, mobile networks, etc. a lot of analysis has been tired

recent years, investigation completely different aspects like, low power protocols, network institutions, routing protocol, coverage issues and therefore the institution of secure wireless detector networks. A spread of protocols were projected for prolonging the lifetime of WSN and for routing the right information to the bottom station [2], [3], [7], [8], [10], [11], [12], [14], [15], [16], [17], [18], [20], [21], [24], [25], [26]. However every protocol has disadvantages and isn't appropriate for space monitoring applications. These protocols cannot be used directly thanks to resource constraints of detector nodes for resources like restricted battery power, communication capability, and machine speed. Even once several efforts, there are still several style choices open for Improvement, and for more analysis targeted to the precise applications, have to be compelled to be done. Therefore, there's a requirement to check alternate and new protocol that allows additional economical use of scarce resources at individual detector nodes for an application. There are completely different routing protocols already reported for WSN applications however largely they're for static networks.

In this paper energy efficient cluster based routing protocols for wireless sensor network are discussed and compared. The paper is organized in the following way. Section 2 represent energy-efficient clustering structures of WSN. Sections 3 specify energy-efficient cluster-based routing protocols. Comparison of clustered based energy efficient protocols is represented in Section 4. Finally, Section 5 concludes the survey.

2. ENERGY-EFFICIENT CLUSTERING STRUCTURES IN WSN

Traditional protocols mentioned in literature are not suitable for wireless sensor networks. For energy efficient routing clustered network is the only key solution. Clustering is used to minimize the total energy consumption level of all nodes during aggregation along the selected path and for load balancing among the nodes for prolonging the network life time. In clustered protocol nodes are arranged in layered structure of sensor nodes. Each cluster has one header node that is called cluster head; cluster head is responsible for data transmission in its own cluster head. All the nodes within the network will only communicate to its cluster head that is also called local coordinator for inter and intra transmission and data aggregation. Sensor data sensed by sensors will be forwarded to their cluster head, because there will less distance between the cluster and member nodes as compare to distance from base station. So it becomes beneficial in terms of lesser traffic rate at low bandwidth range of network. A kind of agreement is made between cluster and sensor nodes which node is going to transmit at which time.

As shown in figure 1 Clustering specify the local routing information within the cluster and reducing the routing overhead of each node. Clustering arrangement of sensor nodes gives the compact presentation of the network. But data aggregated within cluster might have redundant information with consumes network bandwidth. Sensor nodes consumes energy with different rate during inter and intra cluster communication that reduces the interference and collision in network. But before these constraints major challenging issue is the cluster formation. Energy consumption level of CH is much higher than other member nodes. Therefore it becomes mandatory to repeat the cluster formation process periodically so as to divide the load uniformly.

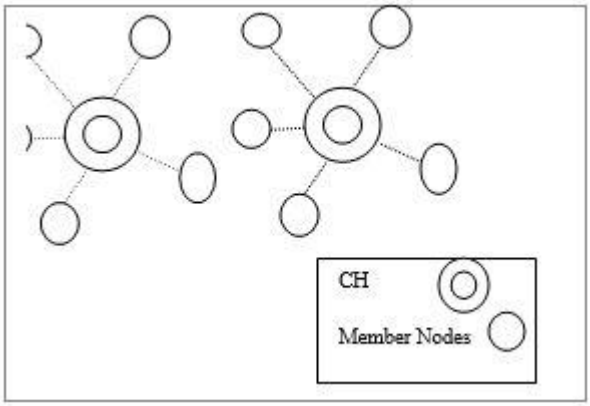

Figure 1 Clustered Network

2.1 Hierarchical Clustering Model

In hierarchical clustering model network is divided in the form cluster layers [37]. Sensor nodes at each layer are organized in the form of clusters and cluster head of one cluster is responsible for forwarding the data to its nearby cluster or to the cluster at higher level or to base station. Data moves from one level to lower level to higher level. In clustered hierarchical arrangement, aggregated data by cluster is forwarded to cluster head at higher level. In this type of arrangement data travels long distance so reduces the travelling time as compare to traditional multi hop model. As data moves at faster rate as compare to multi hop model so latency is reduced. Therefore cluster based model is highly suitable for critical time based applications. Besides these benefits of faster data travelling rate, low latency level but energy consumption rate is high (twice to square of distance) during movement from one level to next higher level. But this model offers optimal routing for sensor networks.

3. CLUSTER-BASED ENERGY-EFFICIENT ROUTING PROTOCOL IN SENSOR NETWORKS

Cluster based approach in traditional ad hoc network don’t work efficiently as desired in unique features of sensor networks [29]. Sensor Networks has the following unique features.

- In sensor networks number of sensor nodes is quite high but they have limited battery life, storage capacity and computational capacity.
- Sensor nodes are more prone to failure.
- Nodes are densely deployed in sensor networks.
- There is rapid change in topology of sensor nodes as their state changes frequently.
- Due to bulk deployment of sensor nodes their global identification is not the simple task.

Multi hop communication might be possible in sensor networks due to their bulk quantity [31,32,33,34]. In sensor networks transmission power level could be fixed to low value and also they consume less power. In previous section we already discussed that member nodes in the cluster are communicated directly to its cluster heads. CHs transmit the collected data to base station using multi hop approach. A cluster is m hop cluster if all the sensor nodes are on same path with length < m hopes [35]. To determine the optimal value of m for minimizing the energy consumption level of sensor networks, a mechanism has been developed which consider data packet size, allowable latency level, transmission frequency, database maintenance and computational processes. Clustering not only for aggregation of sensed data; it also minimizes the energy consumption level within each cluster and results in reduction of channel traffic.

4. ENERGY-EFFICIENT HIERARCHICAL CLUSTERING ALGORITHMS

In EECH algorithm cluster head is elected periodically for balancing the energy consumption level of CHs. Many researchers have been proposed various clustering mechanisms for hierarchical

Thus, the EEHC algorithm can be run periodically for load balancing or triggered as the energy levels of the CHs fall below a certain threshold. Many research projects in the last few years have explored hierarchical clustering in WSN from different perspectives. A variety of protocols have been proposed for prolonging the life of WSN and for routing the correct data to the base station. Each protocol has advantages and disadvantages. Battery power of individual sensor nodes is a precious resource in the WSN [4], [5]. Some of the hierarchical protocols are LEACH, PEGASIS, TEEN, and APTEEN.

Low Energy Adaptive Clustering Hierarchy (LEACH):

Low Energy Adaptive Clustering Hierarchy (LEACH) is one of the most common and popular cluster based algorithm proposed by [3,7] for sensor networks for energy efficiency. This proposed approach reduced energy consumption level of sensor nodes by making rotation of cluster head among the sensor nodes. Each cluster head sends the data to base station depending on the type of application. So it's application specific routing protocol uses clusters for prolonging the network life time. This protocol uses aggregation approach for collecting then sensed data in packet form. The whole network is divided in the form of clusters, where clusters are formed on the bases of coordination and distance among them so as reduce the communication overheads. This clustering approach also helps in scalable and robust routing. Energy consumption rate of sensor nodes depends upon data size and distance that have to be traversed by sensor node.

This protocol transmits the data over short distance so reduces the numbers of transmission and receiving operations. LEACH protocol merely focused on rotation of cluster head, reducing the data size for long range communication, as small sized data can travel to long distance, coordination among sensor nodes for cluster formation and communication. As already discussed energy level of CHs drains speedily as compare to other sensor nodes so LEACH proposes the rotated CH selection approach. The whole operation in this protocol divides in terms of rounds; however each round consists of two phases: setup phase and steady phase. In set up phase nodes are arranged in form of clusters and CH is selected and transmission schedule is maintained and in steady phase data aggregation, compressions and transmission of data to sink node is carried on. CSMA MAC protocol is being used by cluster heads to advertise their status. No cluster nodes keep the receiver on during communication in setup phase in order to read the status of their cluster head. The selection of cluster head is done on the basis of some probabilistic function and they broadcast their status message in the network, accordingly decision for cluster head selection is done on the basis of some desired threshold value. Any node who is not elected as cluster head since last few rounds will now be elected as cluster head. TDMA (Time Division Multiple Access) schedule is being designed for the nodes for communication i.e. for sending and receiving the data. Cluster type communication approach of LEACH protocol offers lower level of energy consumption rate as compare to direct communication. Dynamic cluster head selection of CH prolong the network lifetime.

LEACH-Centralized (LEACH-C): Centralized Clustering algorithm with same steady state phase of LEACH protocol combined to form a new protocol called as LEACH-C. In this approach each nodes sends information about its current location and current energy level to base station. Base station takes the decision about the cluster head and non cluster heads. Base station uses global information for election of cluster head that consumes less amount of energy for communication. In each round optimal numbers of cluster heads are being elected that was not there in traditional LEACH protocol.

Enhanced Low-Energy Adaptive Clustering Hierarchy (ELEACH): Enhanced LEACH protocol proposed by [7] is

the improved version of traditional LEACH protocol with two more aspects. Cluster head election algorithm proposed here will elect the cluster head to the node have non uniform energy consumption level among the sensor nodes. This algorithm assumes to have global information about the remaining energy level of all sensor nodes. This process is further carried under few assumptions like number of cluster heads elected will be square root of total number of sensor nodes in the network so as to reduce the energy consumption level of sensor nodes.

LEACH with Fixed Cluster (LEACH-F): LEACH-F is the extension protocol of traditional LEACH protocol with fixed cluster head [42]. Cluster head is selected once but its position gets rotated with in cluster. The major advantage of this proposed approach is that setup phase is not need required to be execute repeatedly in beginning of each round. Cluster head selection is need to be done in similar way to that of centralized clustering algorithm. Fixed clustering approach in LEACH-F protocol doesn't allow new nodes to get entered in the network and needs to get adjusted as per the dying modes.

Multi-hop LEACH (M-LEACH): Modified LEACH (M-LEACH) increases the energy efficiency of protocol using multi-hop communication [39]. The concept of gateways is being introduced as a way of communication within cluster or outside the cluster [40]. Multi-hop communication approach proposed here reduces the overheads of long distance communication between cluster heads and sink; however this approach is being used by sensor nodes within the clusters as well as by cluster heads outside the cluster for communicating with sink. Data fusion process accomplished by CHs reduces the amount of data transmitted in the network.

Power-Efficient Gathering in Sensor Information Systems (PEGASIS): It is the extended form of LEACH protocol, where instead of multiple clusters chain of sensor nodes are formed so that node can only transfer data to its neighbor and one node is being selected for transmitting the data to base station. Data is collected in node by node form and finally the aggregated data is sent to base station. The major difference between LEACH and PEGASIS is that there is no clustering concept and nodes are sending their data to their adjacent neighbor in place of cluster heads. This protocol assumes to have prior information about network like position of nodes. The chain of nodes is based on greedy approach and it starts with furthest node to closest node of sink. If any node dies in between due to lack of energy, it will move out from chain and new chain is formed using greedy approach. This protocol reduces the communication overhead and prolongs the network lifetime as compare to LEACH protocol. PEGASIS is an optimal chain based algorithm because it supports only the local communication.

This protocol offers few advantages like increases the lifetime of network using shared technique and allows only the local coordination among the sensor nodes. But this protocol has few limitations like it assumes that all nodes have same energy draining level and will die at same time. Location identification of sensor nodes is again a challenging issue here.

Hybrid, Energy-Efficient Distributed Clustering (HEED): It is an extended scheme of LEACH protocol based on residual energy of sensor nodes and count the node degree for election of cluster head [25,26]. HEED protocol have few major goals like prolonging the network lifetime, producing optimum sized cluster, reducing the cluster head re-election iterations so thereby reducing the overhead. Cluster head election is accomplished on the basis of two parameters; residual energy and intra cluster communication cost. Here clustering process takes several rounds to get completed and within this duration a node can receive the message from its neighboring nodes [29].

Distributed energy consumption among sensor nodes extends the life time of the network and offers a stable set of neighbors. CH selection process of HEED offers extended life time as compare to traditional LEACH protocol. The overall communication cost get reduced, so this method is suitable only for prolonging the network life not for other needs of sensor network.

Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN): TEEN protocol comes under the category of hierarchical protocols that supports clustering of nodes [45, 46]. CH is again responsible for transferring the aggregated data to sink node. In this protocol closer nodes are elected as clusters ad this process continued till it reaches to base station. Data centric approach of TEEN protocol improves energy consumption rate (decreases), accuracy of data and response time of network. A threshold parameter is being decided to make the transmission on or off. These threshold parameters are categorized as hard and soft threshold, each node sense this threshold value if this value reaches up to hard level it gets on its transmitter and start sending and receiving data.

This protocol is suitable for critical time based applications. However transmission of data takes long time as compare to sensing, so its energy consumption level is less as compare to proactive network.

Adaptive Threshold Sensitive Energy Efficient Sensor Network Protocol (APTEEN): An improved version of TEEN protocol proposed by [47] that overcomes the shortcomings of TEEN protocol. APTEEN uses hybrid clustering approach where data is collected on periodic basis and gives reaction as they observe or sense any change in the sensed data. Along with hard and soft threshold values APTEEN uses TDMA schedule for transmission. This protocol handles different scenario like analysis of old data, current view of network and regular monitoring of the network. Since APTEEN claims prolonged network life time and high rate of nodes are alive but simulation reflects that its performance lies

between LEACH and TEEN. The reason behind the less popularity of these approaches is complexity raised in cluster formation.

Protocol	Data Collection	Energy Consumption rate	Cluster Reelection
PEGASIS	Chain of nodes	Low	Chain of Nodes
EECH	Periodic	Very High	Yes
LEACH	TDMA	Low	Yes
TEEN	Hierarchical Data Centric	Average	Threshold value
Flooding	Data Centric	High	No cluster formation

5. CONCLUSION AND FUTURE RESEARCH

Due to the scarce energy resources of sensors, energy efficiency is one among the most challenges within the style of protocols for WSNs. The final objective behind the protocol style is to stay the sensors operational for as long as attainable, so extending the network period of time. In this paper we've surveyed and summarized recent analysis works centered principally on the energy economical hierarchal cluster-based routing protocols for WSNs. As this can be a broad area, this paper has coated solely few sample of routing protocols. The protocols mentioned during this paper have individual benefits and pitfalls. supported the topology, the protocol and routing methods may be applied. The factors touching cluster formation and CH communication are open problems for future analysis. Moreover, the method of data aggregation and fusion among clusters is additionally an interesting drawback to explore. For realization of detector networks, it's required to satisfy the constraints introduced by factors like fault tolerance, scalability, cost, topology modification, atmosphere, and power consumption. Since these constraints area unit extremely demanding and specific for detector networks, new wireless unplanned networking techniques area unit needed to be explored additional. Though the performance of the protocols mentioned during this paper is promising in terms of energy potency, further research would be required to deal with problems associated with Quality of Service (QoS) display by video and imaging sensors and period of time applications.

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