Energy- Efficient Routing Protocols For Wireless Sensor Network : A Review

Pardeep Kaur, Sandeep Kad

Abstract: There has been plenty of interest in building and deploying sensor networks. Wireless sensor network is a collection of a large number of small nodes which acts as routers also. These nodes carry very limited power source which is non-rechargeable and non-replaceable which makes energy consumption an significant issue. Energy conservation is a very important issue for prolonging the lifetime of the network. As the sensor nodes act like routers as well, the determination of routing technique plays a key role in controlling the consumption of energy. This paper describes the framework of wireless sensor network and the analysis and study of various research work related to Energy Efficient Routing in Wireless Sensor Networks.

Index Terms: Energy Efficient Routing, Wireless Sensor Network, PDORP, DSR, PEGASIS, LEACH, TEEN, APTEEN

1 INTRODUCTION

Wireless sensor network gained popularity in recent years due to the advancement in wireless communication technology and a rapidly developing zone for research. WSN refers to a system of sensor hubs associated through a wireless medium [1][2]. Every hub comprises of Handling capacity (at least one CPU, DSP chips Microcontroller) may contain different sorts of memory (program, information and flash memories), have a power source (e.g., batteries and sun-powered cells), and contain different sensors and actuators [3]. Energy conservation is a big issue in WSN as sensor hubs carry limited non-rechargeable power source and it is not easy to replace the nodes which makes power saving important to increase the lifetime of nodes. Energy efficient routing protocols are required to minimize the utilization of the power resources and prolonging the network lifetime path while transferring data [4].

1.1 Wireless Sensor Network

WSN is a network of small, self-sufficient gadgets called sensors which gather distinctive sorts of Physical or Environmental Conditions e.g temperature, sound, vibration, weight, movement at various areas and process information and transmit the detected data to clients [5]. These sensors are utilized to gather the data from the environment and transfer it to the base station. A base station gives an association with the physical world where the gathered information is handled, broke down and exhibited to helpful applications [2] [6]. WSNs contain a large number of these sensor hubs, and these sensors can transmit data either among each other or straightforwardly to an outside base station . A large number of sensors can be deployed in various applications to detect various events like pressure, movement of object, fire etc. [7]. The basic design of sensor node is as shown in Figure 1.1.

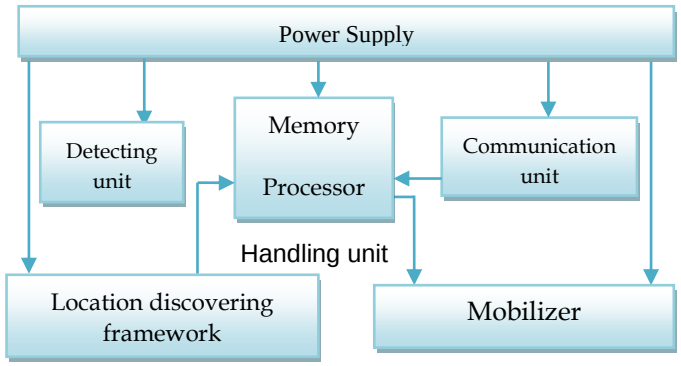

Fig.1.1. *Framework of sensor hub[1]*

The sensor hub is a self-ruling little gadget that comprises of chiefly four units that are sensing (detecting), Processing (handling), communication and power supply [1].

- *Sensing unit*: are normally made out of two subparts: Sensors and analog to digital converter(ADC). Sensor sense data in form of analog signals and these signals then converted to digital signals by ADC and then forwarded to handling unit.
- *Handling unit*: It is associated with a small memory and deals with the strategies that make the sensor hub work together with alternate hubs to complete the allocated detecting undertakings.
- *Communication unit*: It associates the hubs to the network.
- *Power source* is the most vital segments of a sensor hub. It might be upheld by sun-powered cells. There are additionally different subunits, which are application subordinate. The majority of routing procedures and detecting undertakings require the information of area with high exactness. In this way, it is normal that a sensor hub has a location discovering framework.[3]

2 ROUTING IN WSN

Routing strategies are required for transferring data between the sensor nodes and the base station [1] [2]. Routing in WSN is different than traditional IP network routing because it exhibits a number of unique characteristics such as it is unrealistic to build a global addressing scheme for a large number of sensor nodes, secondly as opposed to regular correspondence systems all utilization of sensor systems require the stream of detected information from numerous sources to a specific BS [8]. Different routing techniques are

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proposed for remote sensor network and these conventions can be classified as per different parameters. The classification of routing methods is shown in figure 1.2[1].

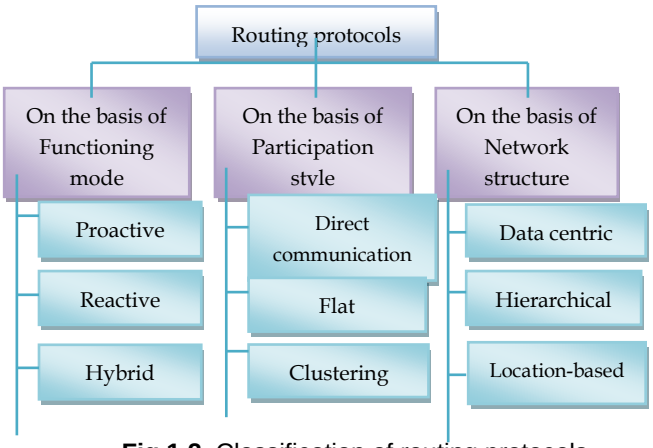

Fig 1.2. Classification of routing protocols

Functioning mode based routing protocols

The function of a wireless sensor network specifies its application. Therefore, routing protocols can be categorized according to the operation used to satisfy a WSN function as follows:

- Proactive Protocols: These protocols are also called as table-driven protocols. In Proactive, the data is transmitted to a BS through the predefined route. For example LEACH, PEGASIS.
- Reactive Protocol: In Reactive Protocol the route is established on demand. The route is established dynamically i.e.Network -based route is found when needed. TEEN, AODV, DSR are some reactive protocols.
- Hybrid protocols: All the routes are found initially and then improved at the time of sending data. These protocols possess the concepts of both reactive and proactive. For example APTEEN.

Participation style based routing protocols

Some WSNs consist of homogeneous nodes, whereas some consist of heterogeneous nodes and these nodes participate differently in every network i.e. according to remaining energy of nodes, cluster head etc. Based on this concept we can classify the protocols as:

- Direct Communication protocols: In this type of protocols the information sensed by nodes is sent directly to Base Station(BS). SPIN is this type of protocol.ˆ
- Flat protocols: In this, the nodes search for the valid path and then transmit it to BS. For example Rumor Routing protocol.
- Clustering Protocols: In this, the area is divided into clusters and Cluster heads are assigned to each cluster. All the nodes in the cluster send data to corresponding cluster heads and then cluster head sends it to Base station. For example TEEN

Network-based routing protocols

Network-based routing protocols depend on the strategy how the network is prearranged. Such protocols fall under three categories:

- Data Centric protocols: These are query based and they depend on the naming of the desired data. The BS sends queries within a certain region to get information and waits for a reply from the nodes. Nodes in a particular region collect the specific data based upon the queries. SPIN is a data-centric protocol.
- Hierarchical protocols: In this, the nodes with lower energy are used to capture information and nodes with higher energies are used to process and transfer it that is why it is used to perform energy efficient routing. TEEN, APTEEN are hierarchical protocols.
- Location Based: In these, the location of nodes must be known to find an optimal path using flooding. To get the information about location of0 node GPS is used. For example GEAR.

2.1 Energy efficient routing protocols in WSN

Energy efficiency of a network is a significant concern in wireless sensor network (WSN). These days networks are becoming large, so information gathered is becoming even larger, which all consume a great amount of energy resulting in an early death of a node. Therefore, many energy efficient protocols are developed to lessen the power used in data sampling and collection to extend the lifetime of a network. Following are some energy efficient routing protocols:

1. LEACH “Low-Energy Adaptive Clustering Hierarchy” In this type of hierarchical protocol, most of the nodes communicate to cluster heads (C.H) [1] [8]. It consists of two phases:

(i). The Setup Phase: in this phase, the clusters are ordered and then Cluster Head(CH) has been selected. The task of CH is to cumulate, wrapping, and forward the information to the base station (Sink) [2].

(ii). The Study State Phase: in the previous state, the nodes and the CH have been organized, but in the second state of “LEACH”, the data is communicated to the base station (Sink). Duration of this phase is longer than the previous state. To minimize the overhead, the duration of this phase has been increased. Each node in the network, contact with the cluster head, and transfer the data to it and after that CH will develop the schedule to transfer the data of each node to base station [8] [2].

2. PEGASIS “Power-Efficient Gathering in Sensor Information Systems”

It is a “chain-bases protocol” and an upgrading of the “LEACH”. In “PEGASIS” every node transfers only with a close neighbor to direct and obtain information. It receipts turns communicating to the BS, thus decreasing the quantity of energy consumed per round [9]. The nodes are in this way that a chain should be developed, which can be completed by the sensor nodes along with using an algorithm. On the other hand, the BS can compute this chain and transmission of it to all the sensor nodes. [10]To develop the chain, it is expected that all nodes have universal information of the system and that a greedy algorithm is engaged. Thus, the structure of the chain will begin from the remote node to the nearer node. If a node expires, the chain is rebuilt in the similar method to avoid the lifeless node [11].

3. TEEN “Threshold sensitive Energy Efficient sensor Network protocol” The TEEN is a hierarchical protocol designed for the conditions like sudden changes in the sensed attributes such as temperature. For a reactive network, the first developed

protocol was TEEN [12]. The reduction of the number of transmissions is the purpose of a hard threshold, which is done by allowing the nodes to transmit only when the sensed attribute is in the range of interest. The number of transmissions is reduced by soft threshold by avoiding all the transmissions which might occur when the sensed attribute is changed slightly or not changed. TEEN is well applicable for time important problems and is likewise quite efficient in terms of saving energy and response time. It also allows the user to manage the power utilization and accurateness to suit the application [13].

4.APTEEN “Adaptive Threshold sensitive Energy Efficient Sensor Network"

The “APTEEN” is an expansion of “TEEN” and goals at both taking episodic data gatherings and replying to time-critical events. As soon as the BS formulates the clusters, the C.H transmits the features, the values of threshold and schedule of transmission to all nodes.[12] After that, the C.H performs information accumulation, which has as a consequence to preserve power. The main advantage of “APTEEN” in contrast to “TEEN”, is that nodes utilize a smaller amount power. on the other hand, the primary disadvantages of APTEEN are the complication and that it results in lengthier deferment times [14].

5. Directed Diffusion

Directed diffusion is data-centric routing protocol for collecting and publishing the information in WSNs [15]. It has been developed to address the requirement of data flowing from the sink toward the sensors, i.e. when the sink requests particular information from these sensors. Its main objective is extending the network lifetime by realizing essential energy saving. In order to fulfill this objective, it has to keep the interactions among the nodes within a limited environment by message exchange. A localized interaction that provides multipath delivery is a unique feature of this protocol. This unique feature with the ability of the nodes to respond to the queries of the sink results in considerable energy savings [1] [15].

6. Energy-Efficient Sensor Routing (EESR)

EESR is a flat routing algorithm [16] proposed particularly to decrease the power utilization and data latency, and to give scalability in the WSN. Mainly, it consists of Gateway, Base Station, Manager Nodes, and Sensor Nodes [17] [18]. Their duties are: Gateway Delivers messages from Manager Nodes or forms other networks to the Base Station, which has extra specification than normal sensor nodes. It sends and receives messages to/from Gateway. Moreover, it sends queries and collects data to/from sensor nodes. Manager Nodes and Sensor Nodes collect data from the environment and send it to each other in 1-Hop distance till the Base Station [16].

3 LITERATURE REVIEW

Ahmad, A., Latif, K. Javaid N. Khan et. al. (2013) [20] investigated on clustering procedure which is most well recognized directing strategy in WSNs. Because of differing need of WSN application productive vitality use in directing conventions is very still a potential field of research. Authors presented new energy efficient directing technique in this research. This strategy is utilized to defeat the fundamental trouble of energy hole and coverage hole. In their strategy, they have controlled these issues by presenting density controlled uniform circulation of hubs and settled an ideal number of Cluster Heads in each round. Lohan, P. and Chauhan, R. et. al.(2012) [21] presented the Geography-Informed Sleep Scheduling and Chaining Based Routing (GSSC) algorithm in wireless sensor network. As detector nodes are power restraint, the system lifetime improved by utilizing the energy of nodes very proficiently. GSSC saves power by discovering alike nodes from routing perspective by using their geological information, it senses nearly similar information and then turning off needless nodes to eliminate data redundancy. This chaining based routing can lessen energy spending of data transferring with the help of multi-hop routing technique. Their simulation outcome (using MATLAB) demonstrate that GSSC achieved considerable increment in network lifespan than LEACH and PEGASIS. Seongsoo Jang, Ho-Yeon Kim and Nam-Uk Kim et. al. (2011) [22] worked on the development of the Wireless Sensor Network technology, ubiquitous technology comes to the fore as the core technology in the future. In the WSN, energy efficiency of the whole network is a key difficulty that has to be solved. Clustering is one of routing methods to enhance energy efficiency. The author suggests a new method, "Energy-Efficient Clustering scheme with Concentric Hierarchy (EECCH)," a centralized clustering scheme intended at overcoming shortcomings of LEACH and LEACH-C both. By drawing circles with the base station as its center, the base point separates network nodes into some levels. The clusters have different numbers of its member nodes to eliminate inequality in energy dissipation through this process; it becomes possible to improve energy efficiency. Saravana Kumar R., Susila S.G. and Raja J. et. al (2010) [23] have done research work on WSN. It consisting of a large number of sensors and as the sensor operates on a limited power source, it is challenging to design an energy efficient routing protocol that can diminish the delay while providing high-energy efficiency and extended network lifetime. Author analyzes the fundamental distributed clustering routing protocol Low Energy Adaptive Clustering Hierarchy, also proposed a novel routing method and data aggregation method in which the sensor nodes form the cluster and the cluster-head chosen based on the remaining power of the individual node calculation without re-clustering and the node scheduling scheme is adopted in each cluster of the WSN. Results using MATLAB shows that the proposed routing protocol considerably reduces energy utilization and enhance the total lifespan of the wireless sensor network compared to the LEACH protocol. Gurbinder Singh Brar et. al., (2016) [24] proposed PDORP protocol which is transmission-based energy aware routing protocol. The proposed protocol PDORP has the characteristics of both power efficient gathering sensor information system(PEGASIS) and DSR routing protocols. Hybridization of genetic algorithm and bacterial foraging optimization is associated with proposed routing technique to distinguish energy proficient ideal ways. The execution examination, correlation through a hybridization approach of the proposed routing convention, gives improved result involving less piece mistake rate, a lesser amount of postponement, reduced energy consumption, and improved throughput, which prompts to enhanced QoS and drag out the lifetime of the system. S. Lindsey, C. Raghavendra et. al. (2002) [19] proposed the Power-Efficient Gathering in Sensor Information Systems (PEGASIS), which avoids the assumption of direct communication and reduces the relatively large

overhead of the LEACH protocol. In PEGASIS, the nodes form a chain, and each node stores in its routing table the addresses of an upstream and a downstream node. The data collection process is initiated at the far end of the chain. Each intermediate node aggregates the received data with its local data before transmitting the result to its upstream neighbor. The last node in the chain is responsible for transmitting to the sink node. Liu Wenjun and Yu Jiguo et. al. (2009) [6] proposed that rather than allowing the nodes to transmit directly to the base station, a novel scheme of clustering was proposed. Clustering provides resource utilization and minimizes energy consumption in WSNs by reducing the number of sensor nodes that involve in the long-distance communication. They used an energy-efficient clustering and routing scheme for wireless sensor networks (EECR) which includes distributed nodes clustering, dynamic cluster head rotation, and inter-cluster routing selection. In clustering stage they used uneven clustering mechanism in which cluster heads (CHs) which are closer to the base station (BS) have smaller cluster size than those farther from BS, thus they can conserve some power for inter-cluster data forwarding. For the dynamic cluster head rotation mechanism, the sensor hubs perform cluster head function in turn which balances power consumption well among CHs. Gherbi Chirihane & Aliouat Zibouda et al. (2015) [25] proposed a distributed energy efficient adaptive clustering protocol with Data Gathering for WSN reduces the energy consumption and network lifetime is extended. The clustering techniques are used efficiently with distributed cluster heads. The node's ratio is turned off for fixed time period and sleep control laws are designed to reduce the cost function. The scenario displays random deployment of nodes and the total simulation time is decomposed using resource reservation. The technique distributed energy efficient adaptive clustering protocol with Data Gathering (DEACP) reduced the overall network energy consumption, balance the energy consumption among the sensors and extend the lifetime of the network by making the clustering efficient in complexity of message and time, well-distributing the cluster-heads across the network, the load balancing done well and as a result transmission power of the node is reduce which subsequently reduces the energy consumption .

TABLE I. *Comparison of various routing protocols*

	CLASS	LIFETIME	ENERGY EFFICIENT	THROUGHPUT	SCALABILITY
LEACH [2]	HIERARCHICAL	VERY GOOD	HIGH	VERY HIGH	HIGH
PEGASIS [19]	HIERARCHICAL	VERY GOOD	HIGH	VERY HIGH	GOOD
TEEN [13]	HIERARCHICAL	GOOD	GOOD	SATISFACTORY	GOOD
APTEEN [14]	HYBRID	VERY GOOD	GOOD	HIGH	GOOD
DIRECTED DIFFUSION [15]	FLAT	GOOD	HIGH	SATISFACTORY	RESTRICTED
EESR [16]	FLAT	VERY GOOD	HIGH	HIGH	HIGH

4 CONCLUSION AND FUTURE SCOPE

In addition to many applications of wireless sensor networks, it is necessary to transmit information appropriately with regard to power utilization and network lifespan as well as limited resources of such networks. The most significant difficulty in such networks is routing and transferring data to the destination node in compliance with the energy problem. Therefore, energy-efficient routing protocols have significant and effective roles in wireless sensor networks. They are divided into three major groups based on data, network structure and reliability. In this study, energy-efficient routing protocols were investigated in wireless sensor networks. Then the essential classifications were introduced and related parameters of corresponding protocols were compared to each other. Despite the fact that these protocols are performing well in terms of energy conservation but issues like quality of service (QoS) would be expected to address to ensure utilization of most energy proficient way for data transfer and in addition ensuring guaranteed data transfer rate or delay. Another interesting issue in routing is that the majority of the present routing conventions accept that the sensor hubs and the sink is stationary. In circumstances, for example, on the battlefield where the sink and maybe the sensors should be versatile. In such cases, new routing techniques are required keeping in mind the end goal to deal with the overhead of portability and topology changes in such power constrained circumstances. Integrating WSN with wired networks(i.e. Internet) is other possible future research for routing protocols .

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