ENERGY EFFICIENT MECHANISMS FOR CLUSTER HEAD SELECTION IN WSN

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ABSTRACT

The evaluation and up gradation of wireless sensor Network(WSN) requires transfer of data from source to destination. Nodes within wireless network are sensors having limited energy associated with them. Nodes collaborating together form clusters. Data transmission takes place from distinct clusters towards base station. Energy of sensors needs to be preserved in order to enhance lifetime of network. This paper presents various techniques used to enhance lifetime of network. Lifetime of network ensures degradation in terms of packet drop ratio. Comparative analysis of techniques is also presented to determine approach that can be used for future enhancements.

Keywords

WSN, Clusters, Lifetime, Packet drop ratio

1. INTRODUCTION

[1]Wireless sensor network consist of spatially distributed devices used to maintain physical or environmental conditions. Nodes used within WSN could be of distinct configuration. These nodes form heterogeneous environment. [2], [3]Heterogeneous environment requires protocols in order to establish communication among distinctly configured nodes. IEEE 802.11 standards established for Wi-Fi connectivity is commonly used protocol for transmission within WSN. Nodes following common protocols form clusters.

[4]Clustering in WSN is formed so that minimum energy is consumed during transmission of data. Formed clusters consist of large number of nodes which may have same or distinct configuration. The nodes within the clusters if belongs to same configuration then homogeneous clusters are formed. In case nodes are of distinct configuration then heterogeneous clusters are formed.[5] Nodes selection from clusters is critical that leads to selection of cluster head.

Cluster head from particular cluster is node having maximum energy. [6]All the nodes from a distinct clusters transfer the data towards selected cluster head from their cluster. Data then is transmitted from one cluster head to another cluster head until destination node i.e base station is reached. Packet drop ratio is considerably reduced as maximum energy node is selected for transmission of information. [7]As energy decays, sensors unable to hold the packet and hence packet is dropped. As more and more packets arrive at the sensor having minimum energy, packets are dropped. This enhances packet drop ratio considerably. Within clustered environment techniques were researched over to enhance performance in terms of packet drop ratio during degradation of sensor energy. This paper presents comprehensive analysis of techniques used to enhance lifetime and decrease packet drop ratio. Highlights of this paper is listed as under

- Energy efficient protocols in WSN for enhancing lifetime of networks are discussed.
- Techniques used to minimize packet drop ratio are identified.
- Cluster head formation techniques are discussed in detail.

- Comparative analysis of various protocols is presented for determining best possible protocols out of available protocols.

2. ENERGY EFFICIENT CLUSTERING TECHNIQUES IN WSN

Large number of protocols researched over a decade to enhance lifetime associated with the network. This section discusses various protocols falls under energy efficient category.

2.1 LEACH

[4], [8]Low Energy Adaptive Clustering hierarchical protocol is used to enhance energy efficiency associated with transfer process. Time division multiple access protocol is integrated within LEACH. Cluster head selection is a problem within LEACH. In fact cluster head selection does not take place and data is transmitted from transmitter towards random selection of node selected as head. Aggregation is performed at cluster head and when threshold value is reached, packets are transmitted forward. In case cluster head energy dissipated completed, all the packets aggregated at node will be lost. Properties associated with LEACH are listed as under

- Hierarchical in nature
- Random Cluster Head Selection is involved
- Adaptive membership of cluster
- Aggregation of data at cluster head
- Communication involves nodes and cluster head
- Threshold values involve during transmission

2.2 DEEC

This protocol is advancement associated with LEACH. [9], [10]Cluster head selection is complex in case of DEEC. Maximum energy nodes are elected among available nodes. The node with the highest probability of conserving energy is selected as cluster head. A distributed multilevel clustering algorithm for heterogeneous wireless sensor networks is considered with following characteristics

- The cluster head is elected by a probability based on the ratio between the amount residual energy present at each node and the average energy of the network.
- The lifetime of a cluster head is decided according to its initial energy and residual energy. So always the nodes with high initial and residual energy have a better chance to become a CH.
- DEEC is implemented based on the concepts of LEACH algorithm. The role of cluster head is rotated among all nodes of the network to make energy dissipation uniform.
- Two levels of heterogeneous nodes are considered in this algorithm to achieve longer network lifetime and more effective messages than other classical clustering algorithms.
- It also works better for multilevel heterogeneous networks.

In DEEC, all the nodes must have the idea about total energy and lifetime of the network. Average energy of the network is used as the reference energy.

2.3 SEP

[10]SEP concentrate the effect of heterogeneity of Clusters, as far as their vitality, in remote sensor arranges that are progressively bunched. Following properties are considered

- In these systems a portion of the nodes progressed toward becoming bunch heads, total the information of their group individuals what's more, transmit it to the sink.
- It accept that a rate of the populace of sensor hubs is outfitted with extra vitality assets which is a wellspring of heterogeneity which may come about from the underlying setting or as the operation of the system advances.
- It additionally consider the sensors are arbitrarily (consistently) appropriated and are not versatile, the directions of the sink and the measurements of the sensor field are known.
- It is assumed in SEP that nodes cannot take full favorable position of the nearness of hub heterogeneity.
- SEP, a heterogeneous-mindful convention to draw out the time interim before the passing of the principal hub (we allude to as strength period), which is pivotal for some applications where the criticism from the sensor organize must be solid.
- SEP depends on weighted race probabilities of every hub to end up bunch go to the rest of the vitality in every hub.

[11], [12]SEP is advancement associate with DEEC. Energy is conserved and lifetime of network is improved considerably by the use of this protocol.

2.4 EDEEC

[13]–[15] Remote Sensor Networks (WSNs) comprises of across the board arbitrary sending of vitality obliged sensor hubs. Following properties exists of EDEEC.

- Sensor hubs have distinctive capacity to detect and send detected information to Base Station (BS) or Sink.
- Detecting and in addition transmitting information towards sink requires substantial measure of vitality.
- In WSNs, save vitality and delaying the lifetime of system are incredible difficulties. Many directing conventions have been proposed with a specific end goal to accomplish vitality productivity in heterogeneous condition.
- EDEEC for the most part comprises of three sorts of hubs in amplifying the lifetime and solidness of system.

Enhanced distributed energy efficient clustering protocol is advancement of DEEC that conserve energy and reduce packet drop ratio considerably. Further enhancement in DEEC can be made to enhance performance DEEC by reducing distance between nodes in which data is being transmitted.

Today's world needs some technologies to fulfil their routine work. [16]WSN is that technology which fulfills the routine work of the society. Wireless sensor network senses the physical world whether it is temperature, pressure, humidity and some other environment activities. WSN is used in an environment where the wires or cable are not possible to reach. It is easy to install compared with the other cables network. Now, these day's WSN are using mainly for the data transfer purpose. [17]Sensor nodes in the wireless network transfer the data packets from source to destination. Wireless sensor network includes sensors nodes and a base station (sink) and there are so many sensors which create a network. All the sensor nodes in a network communicate with each other and transfer the data packet from source node to the sink. Sensor nodes can communicate directly with the base station. Sensor nodes consume a lot of energy while data transfer. On the other hand, sensor nodes also consume energy after transferring the data packets. Due to this consumption, the lifetime of the network also gets reduced. This is the major issue of the sensor network. [18]There are more issues of the network but energy consumption and improve the lifetime of the network. Taking these issues in concern, there is one method which is very much useful to resolve these problems called clustering. Clustering, the technique in which large network region is divided into smaller one. With this technique, sensor nodes do not require direct communication with the base station. In every cluster, there is a cluster head which collects the data from all the network nodes and then transmits that data to the base station. The cluster head is elected on the basis of maximum energy of the node. The node which has highest energy is selected for cluster head. Basically only cluster head is responsible for the communication in the network. Cluster head needs more energy for the data aggregation and transmitting the data. So after transmission of the data, its energy reduces and the node which has second highest energy is selected for cluster head. There is so many clustering protocols which not only reduces the energy consumption but also enhance the network lifetime. These protocols are LEACH, HEED, DEEC, EDEEC, SEP etc. These protocols are cluster-based protocol and a lot of work has been done with these protocols. LEACH is the first protocol which came into the existence in the clustering protocol. DEEC is also a cluster-based protocol in which cluster head is selected based on the residual energy of the sensor nodes and the average energy of the network. EDEEC is the enhanced version of the DEEC protocol and requires a heterogeneous network. LEACH is the homogeneous network.

Next section describes background analysis or literature survey to determine best possible protocol for future enhancement.

3. LITERATURE SURVEY

Techniques have been devised for improvement of performance in WSN. The WSN performance is critically analysed using this paper. The worth of study is proved using this literature survey. [19] proposed distance and energy aware LEACH. The cluster head selection in this approach was adaptive and allow packet drop ratio to reduce considerably. The aggregation mechanism was the drawback associated with this approach. In case cluster head go down,

every packet aggregated at source could be lost. [20]proposed EAP for conserving energy during transmission of data from source to destination. Inter cluster coverage was introduced in this approach. Data gathered at particular cluster was according to probability distribution factor that reduces energy consumption and enhances lifetime of network. [8] discussed energy efficiency achieved through LEACH protocol. Time division MAC was integrated to achieve energy efficiency and lifetime within the WSN. [21]proposed a mechanism to analyse energy dissipation through Multi-Chain PEGASIS. This protocol constructs a chain of routing path. Multi hop routing was used under PEGASIS. Overall protocol was energy and power efficient but complex. In other words time and space complexity was enhanced using PEGASIS. Future modifications required in order to enhance performance of examined system. [22] proposed LEACH, a hierarchical protocol for achieving energy efficiency within WSN. Adaptive cluster head selection allow performance enhancement however aggregation mechanism used within WSN has merits and demerits associated with it. Energy conservation was achieved with the risk of enhancement of packet drop ration in case of cluster head failure.

[23] Proposed energy efficient DEEC protocol. DEEC protocol uses probability distribution function to determine cluster head out of number of nodes available within WSN. Probability assigned with each node within WSN was analysed for selection of cluster head. Probability associated with nodes varies during each round. Higher the probability more will be chance of node being selected as cluster head. DEEC performance decreases by the application of aggregation mechanism leading to increase in packet drop ratio. [13]proposed enhancement in DEEC protocol to achieve more energy efficiency. Lifetime of network significantly improved by the application of E-DEEC. As packets moved from one node to another, energy associated with nodes will be analysed. Node having highest energy will be selected as cluster head. Packet being received by node having highest energy. Lifetime of network was considerably enhanced but packet drop ratio increases hence requires improvement. [9]proposed a sleep awake protocol for WSN data transmission. Node being idle was set to sleep and energy conservation was achieved. The problem of topology breakage occurred as node was made to sleep. In order to wake the node sufficient amount of energy was required to be dispensed with. [15]discussed a super energy aware protocol by accomplishing modifications to the existing DEEC protocol. Modified mechanism of electing cluster head was proposed. Node selected as cluster head was evaluated against several criteria's before electing it as cluster head. Complexity in terms of cluster head was extremely high.

[24]Proposed a priority based application specific congestion control algorithm. Packets can be initiated through any node and hence traffic could be a problem. To handle traffic, congestion control mechanism was proposed by maintaining priority queue. Packets from distinct nodes were maintained within queue. As congestion becomes high, enqueue operation takes place. As traffic becomes moderate dequeue operation takes place. This mechanism results in decreasing packet drop ratio. But energy consumption in this mechanism still requires improvement. [25]advised gateway based energy routing protocol (M-GEAR) for WSN. Depending on their location in the sensing area, they divided the nodes into four zones. In this protocol, they placed the base station out of the sensing zone and placed a gateway at the middle of the sensing area. The node uses the direct communication if the distance of the sensing node from the base station or gateway is less than the prescribed distance. They also divided the remaining nodes into equal zones. Selected cluster heads in each zone are independent of each other. They compared the performance of proposed protocol with LEACH. Analysis results show that their assigned protocol perform greatly basis on the consumption of energy and lifespan of the network. [26]said that in the upcoming time, WSNs require a great need of spreading the nodes and also enhance its applications in all fields because in the future most of the devices will be connected to each and everything. So spreading of these nodes is the greatest challenge, keeping this in mind a new protocol is given called TDEEC used for the heterogeneous network. TDEEC protocols use three levels of heterogeneity. It is a reactive protocol and used basically for reactive

networks. Reactive networks are those which react quickly to any change arise in any parameter.

The comprehensive literature survey conducted in this paper suggest, considerable improvement in terms of energy efficiency and packet drop ratio within WSN is required. Some techniques suggested such as DEEC provides efficient low complexity mechanism to accomplish the same but distance based criteria's are absent within DEEC. To improve the performance of DEEC, distance between nodes must be considered. This could be the future course of action.

4. COMPARISON OF ENERGY AWARE SCHEMES WITHIN WSN

Comparison of energy aware schemes presented in this section provides clear and concise view of optimal technique within WSN during data transmission.

Protocol	Merits	Demerits	Parameter Energy Load Algorithm Efficiency Balancing Complexity	Remarks
Leach	• Each node has equal chance to become cluster head but cannot be selected as cluster head in subsequent round so load is shared between nodes • Leach uses TDMA so it keeps CHs from unnecessary collisions	• Leach use single hop communication so it cannot used in large scale networks. • CHs are elected on the basis of probability so uniform distribution cannot be ensured and it cannot provide load balancing	Very low Medium Low	Earliest protocol associated with clustering
HEED	• Fully distributed routing scheme • Requires only local communication • Achieves load balancing	• The random selection of the cluster heads, may cause higher communication overhead. • The periodic cluster head rotation or election	Medium Medium Low	Better connectivity of cluster heads
	and uniform CH selection. • Achieve high energy efficiency and scalability by communicating in multi-hop way.	needs extra energy to rebuild clusters		
Ucs	• Unequal size clusters are formed • Nodes in cluster can be variable	• It is limited by assumptions that CHs are predetermined as well as network is not homogeneous. • Residual energy of node is not considered and not sufficient for large range networks.	Very low Bad Medium	Commonly used protocol in unequal cluster sized environment
EECS	• EECS constructs more balanced network in term of energy consumption and communication load • Use dynamic sizing of clusters	• Lot of overhead due to global information for communication • Single hop communication consume lot of energy	Medium Medium Very High	Energy efficient protocol used commonly at media access control layer within data link layer
CCM	• Less energy consumption compared with leach	• Chain head selection criterion	Very low Medium Medium	Mixture of flat, hierarchical and location based routing is combined
LEACH-VF	• Solve the problem of area with overlapped sensing coverage and sensing hole • In LEACH-VF some nodes can be moved to coverage inside the cluster are	• Poor energy efficiency • Load balancing is not up to the mark	Medium Medium Medium	Area independence is achieved

TEEN	• Data transmission can be controlled by varying two thresholds • Well suited for time critical applications	• Whenever thresholds are not meet, the node will not communicate • Data may be lost if CHs are not able to communicate with each other	Very High Good High	Hierarchical routing protocol that is used to minimize energy consumption of clustering algorithm		• formation • Decrease number of data transmission	varying topologies		
					PCS	• Energy consumption is reduced • Reduced data flow from BS in CCS	• Unbalanced energy consumption • Large delay due to long chain	Low Very bad Medium	It is network coding based protocol for energy efficiency
PANEL	• Panel is energy efficient that ensure load balancing and long network lifetime • Supports asynchronous applications	• Clusters are predetermined • To determine geographic position information, special conditions are needed, which is not always available	Medium Good High	This is efficient node selection algorithm for handling cluster	TSC	• TSC reduces redundant data transmission in network by breaking long chains into smaller chains	• Node distribution is unbalanced	Medium Medium Medium	Modularity is provided by dividing the network into concentric circles hence better energy consumption is achieved
					DEEC	• Dynamic in nature • Better than Leach in terms of energy consumption	• Complex in nature • Lifetime can be further improved	High High High	Better as compared to LEECH
GAF	• GAF increase the network lifetime by saving energy • Routing fidelity is maintained	Large traffic injection and delay is not predictable	Medium Medium Medium	It is a location based least energy consumption protocol	SEP	• It is better in terms of packet drop ratio	• More complex as compared to leach	Medium High Low	Energy consumption is less as compared to previous algorithm
TTDD	• Resolve the numerous mobile sinks and moving problem of sink in large scale WSNs • Suitable to event detecting WSNs among irregular data traffic	• Large latency • Low energy efficiency • TTDD require sensor nodes to be stationary and location aware	Very low Good Low	It is a two tier energy consumption minimization protocol	PASCC	• Priority based data transformation • Packet drop ratio is low	• Energy consumption is high	High Low Low	Priority is assigned but starvation problem can be present
					TDEEC	• Modified DEEC Clustering protocol provides better performance in terms of energy consumption then DEEC	• Slotting is used hence it is more complex	Low Low High	DEEC with time division is considered hence overall operation is faster
SLGC	• Lower energy consumption in SGLC compared to LEACH	• Large overhead due to complex data communication	Medium Medium Medium	It is distributed efficient energy consumption and distribution protocol.					
PEGASIS	• Energy load is distributed uniformly • Reduce overhead due to dynamic cluster	• Long delays cause a node to become bottleneck • Network is not very scalable • Not suitable for time	Low Medium High	Load balancing is handled efficiently in this protocol as compared to LEACH					

Table 1: Comparison of Techniques of Clustering used within WSN

From comparison table it is concluded that techniques associated with clustering algorithm within WSN requires considerable improvement in terms of energy conservation and packet drop ratio. Distance handling among WSN is critical for this purpose.

5. CONCLUSION AND FUTURE SCOPE

This paper present comprehensive survey of techniques used within WSN to achieve increase in lifetime of sensor within WSN. Enhancement in lifetime involves mechanism such as sleep and wake up protocol but has demerits associated with it. The idle nodes are made to sleep but topology breakage is the result. In order to restore the nodes to their initial state sufficient energy is required leading to loss of packets. From analysis of existing techniques it is identified that there exist a trade off between energy and packet drop ratio.

In future this tradeoff between energy and packet drop ratio is to be eliminated by considering distance between nodes before selection of cluster head. Use of priority queue can also be merged within existing approach for enhancing performance of WSN.

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