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Performence Enhancement of WSN Lifetime Using C-STEB

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Abstract: ***Wireless Sensor Network (WSN) is the infrastructure less network used to collect the data from sensor nodes and forward it to Base Station (BS). WSN consists of large number of low-cost nodes, which are battery constrained i.e. they have limited battery power. As WSN may be employed in human inaccessible areas or in extreme conditions the battery replacement is not easy for WSN with thousands of physically embedded nodes. For better performance and long lifetime of the network, the energy efficient routing protocols should be employed, making routing one of the key issues that WSN has to deal with. To achieve this aim, researchers have studied and implemented various techniques and proposed many energy efficient routing protocols out of which STEB (Self-Organized Tree-Based Energy Balance routing protocol) protocol works better. In this work, we are working on a STEB protocol which is basically used for routing with help of a root node and parent nodes selection mechanism by which data reaches its destination after it leaves the source node. The problem with STEB is the energy consumption is more than required due to excessive broadcast of data. The STEB protocol is improved using the clustering concept of the nodes in which clusters of equal size and strength are made and the cluster heads are used for better energy consumption. We name this enhanced protocol as C-STEB (Clustered-Self-Organized Tree-Based Energy Balance routing protocol). The performance analysis of C-STEB protocol is done using MATLAB and from the simulation result it is observed that C-STEB performs better than STEB protocol.***

Keywords: WSN, STEB, C-STEB, Routing, Base Station

I. INTRODUCTION

A basic understanding of networking is important for anyone managing a server. Not only is it essential for getting your services online and running smoothly, it also gives you the insight to diagnose problems. In networking, a connection refers to pieces of related information that are transferred through a network. This generally infers that a connection is built before the data transfer (by following the procedures laid out in a protocol) and then is deconstructed at the end of the data transfer. A packet is, generally speaking, the most basic unit that is transferred over a network. When communicating over a network, packets are the envelopes that carry your data (in pieces) from one end point to the other. Packets have a header portion that contains information about the packet including the source and destination, timestamps, network hops, etc. The main portion of a packet contains the actual data being transferred. It is sometimes called the body or the payload..

Wireless Sensor Network (WSN) is the infrastructure less network that is being considered as one of the most important technology of modern times. Wireless Sensor Network is used to collect and send the information from the sensor nodes to the base station commonly known as sink. WSN typically consists of large number of nodes, mainly thousands in number, which communicate between them to perform the task. These nodes are deployed in the target area and this node deployment is usually done in ad hoc manner i.e. without proper planning and engineering. The nodes of WSN are energy constrained as the power is supplied by the battery attached to them. As WSN may be employed in the extreme conditions which are inaccessible by the humans like in the military areas or in areas where environmental conditions are too harsh and so on, the battery replacement or battery recharging is not possible in most of the cases. Due to the energy constrained nature of WSN, the traditional routing protocols employed fail to perform in the efficient manner making routing as one of the key issues which is to be dealt seriously by the researchers. To solve this problem, the researchers have studied and implemented various techniques and protocols that aim at reducing the energy consumption on the part of the nodes. One such concept is grouping of the nodes into clusters which reduces the energy consumption in wireless sensor networks drastically.

Leach is clustering protocol that has been widely used in the recent past to organize the network into clusters and then start the data transmission. Since then many advancements have been made in the clustering protocols that outperform the leach and reduces the energy consumption of the wireless sensor nodes even more. One such technique has been defined by authors is STEB which has been compared with Leach and has successfully outperformed it. The problem with STEB protocol is that energy consumption is more than required due to excessive broadcast of data. The STEB protocol is improved. Hence an attempt has been made to optimize STEB protocol, using the clustering concept of the nodes in which clusters of equal size and strength are made and the cluster heads are used for better energy consumption, and develop a new protocol known as Clustered-Self-Organized Tree-Based Energy Balance routing protocol (C-STEB).

II. PREVIOUS WORK

Performance Analysis of Self-organized Tree Based Energy Balance (STEB) Routing Protocol for WSN by Dasari Raja, P.Samundiswary[1]. In this paper the authors proposed a routing protocol known as Self-organized Tree Based Energy Balance (STEB) Routing Protocol for WSN. This protocol is based on the construction of routing tree using a process where, for each round, BS assigns a root node and broadcasts this selection to all sensor nodes. Subsequently, each node selects its parent by considering only itself and its neighbors' information. Thus making STEB is considered to be a dynamic protocol. The performance analysis (Residual energy, Dead Nodes) of Self-Organized Tree-Based Energy Balance Routing Protocol (STEB) for WSN is done by using MATLAB. From the simulation results, it is observed that STEB outperforms LEACH in terms of rounds and remaining energy.

A clustering algorithm based on cell combination for wireless sensor networks by L. Chang-RI, Z.. Yun, Z. Xian-ha, and Z. Zibo[2]. In this paper authors proposed a clustering algorithm which based on cell combination for the networks. Sensor nodes are distributed densely and the energy of sensor nodes is always limited. In this clustering algorithm, the monitoring region is divided into hexagonal cells by considering the geographic location information of nodes. Each cluster consists of at least seven hexagon cells. Nodes with the same cluster identity form a cluster and the cluster head in each cluster is elected from the central cell of each cluster. The shape of the cells consider nearly circular in order to improve channel reuse and energy efficiency.

A clustering algorithm based on virtual area partition for heterogeneous wireless sensor networks by R. Wang, L. Guozhi, and C. Zheng[3]. In this authors proposed an energy efficient clustering algorithm which based on virtual area partition in heterogeneous networks environment where the maximal transmission power of each node may be different. Authors found that VAP-E can balance the load between clusters, enhance the energy efficiency of sensor nodes, prolong the lifetime of networks, and improve the efficiency of communications. Authors also compare this algorithm with respect to LEACH and LEACH-E and found that VAP-E can enhance the stability period and network life time with the same simulation condition.

Power-efficient zoning clustering algorithm for wireless sensor networks by F. Bai, H. Mu, and J.Sun[4]. Authors proposed a Power-Efficient Zoning Clustering Algorithm (PEZCA) which uses two algorithms: classical LEACH (Low-Energy Adaptive Clustering Hierarchy) and PEGASIS (Power-Efficient Gathering in Sensor Information Systems). In this algorithm, base station consider at a centre of the scenario and the scenario area is divided into multiple fan shaped regions and the clusters closer to the base station have smaller sizes than those farther away from the base station. Thus CHs (cluster heads) nearest to the BS (base station) can preserve more energy for inter-cluster data transmission. PEZCA provide more balance in energy consumption and life time of network comparisons to LEACH.

Voting-on-grid clustering for secures localization in wireless sensor networks by W. Yang, and W.T. Zhu [5]. In this authors combined voting method and clustering algorithm, and developed new clustering schemes for secure localization of sensor networks. Authors also found that the newly proposed approaches have very good performances on localization accuracy and the detection rate of malicious beacon signals. In this scheme, malicious beacon signals are filtered out according to the clustering result of intersections of location reference circles. Authors used a voting-on-grid (VOGC) method instead of traditional clustering algorithms to reduce the computational cost and found that the scheme can provide good localization accuracy and identify a high degree of malicious beacon signals.

Node clustering based on overlapping FOVs for wireless multimedia sensor networks by D. C. Hoang, P. Yadav, R. Kumar, and S. Panda[6]. This is music based meta heuristic optimization algorithm which is analogous with a music improvisation process where musician continue to polish the pitches in order to obtain better harmony. By which it optimizing the energy consumption and minimizing intra-cluster distance of the network. In this the base station computes and allocates nodes into clusters according to the information of their residual energy and location. The operation has two phases: clustering setup and data transmission. This algorithm provides improvement in term of power consumption and network life time over LEACH protocol. With a small network diameter, energy consumption of the network is almost same when using different clustering protocols.

PEGASIS: Power efficient gathering in sensor information systems by S. Lindsey And C.S. Raghavendra[7]. Here Authors proposed algorithm PEGASIS that is a chain based protocol provide improvement over LEACH algorithms. In PEGASIS, each node communicates only with a close neighbour and takes turns transmitting to the base station, thus reducing the amount of energy spent per round. Using greedy algorithm, the nodes will be organized to form a chain, after that BS can compute this chain and broadcast it to all the sensor nodes. Energy saving in PEGASIS over LEACH takes place by many stages: First, in the local data gathering, the distances that most of the sensor nodes transmit are much less compared to transmitting to a cluster-head in LEACH. Second, only one node transmits to the BS in each round of communication. PEGASIS outperforms LEACH by limiting the number of transmissions, eliminating the overhead of dynamic.

Max-min d-cluster formation in wireless ad hoc networks by A. D. Amish, R..prakash, T. vuong, and D. Huynh[8]**.** Authors proposed a clustering algorithm in which no nodes are more than d-hops away from the cluster head. The cluster head selection strategy developed, by having each sensor node initiate a 2d round of flooding, from which results are considered. In order to select the cluster head nodes, follow a set of rule in which 1std round called flummox, used to propagate largest node IDs and after completion of this round 2ndd round start which is called flagmen. This algorithm is applicable only when two assumptions are made: all nodes that survive the flood max elect themselves cluster heads. During flooding, no node ID will propagate further than d-hops from originating node. This algorithm provides load balancing among the cluster heads.

EECS: An energy efficient clustering scheme in wireless sensor networks by Y. Mao, L. Chengfa, C.Guihai, and J. Wu[9]. Authors proposed an algorithm in which cluster formation is different from LEACH protocol. In LEACH protocol cluster formation takes place on the basis of a minimum distance of nodes to their corresponding cluster head. In EECS, dynamic sizing of clusters takes place which is based on cluster distance from the base station. The results are an algorithm that addresses the problem that clusters at a greater distance from the sink requires more energy for transmission than those that are closer. Ultimately it provides equal distribution of energy in the networks, resulting in network lifetime. Thus main advantage of this algorithm is the full connectivity can be achieved for a longer duration. So we can say it provides reliable sensing capabilities at a larger range of networks for a longer period of time. It provides a 35 percent improvement in network life time over LEACH algorithm.

An energy-efficient unequal clustering mechanism for wireless sensor networks by C. Li, M. Ye, G. Chen and J. Wu[10]. This scheme is distance based scheme similar to EECS and it also required that every node has global identification such as its locations and distances to the base station. Hotspot is the main problem in WSNs because of multi hopping that occurs when CHs closer to the sink tend to die faster compare to another node in the WSNS, because they relay much more traffic than remote nodes. This algorithms partition the all nodes into clusters of unequal size, and clusters closer to the sink have smaller sizes than those farther away from the sink. Thus cluster heads (CHs) closer to the sink can conserved some energy for the inter cluster data forwarding. Energy consumed by cluster heads per round in EEUC much lower than that of LEACH standard but similar to HEED protocol.

BARC: A battery aware reliable clustering algorithm for sensor networks by K. Watfa, O.Mirza, and J. Kawtharani[11]. In this clustering algorithm authors used mathematical battery model for implementation in WSNs. With this battery model authors proposed a new Battery Aware Reliable Clustering (BARC) algorithm for WSNs. It improves the performance over other clustering algorithms by using Z-MAC and it rotates the cluster heads according to battery recovery schemes. A BARC algorithm consists of two stages per round for selection of cluster heads: initialization or setup and steady state. In this formation of cluster, take place by electing a set of CHs. BARC enhances the network lifetime greatly compare to other clustering algorithms.

III. PROBLEM FORMULATION

In STEB the concept of the tree construction is used to transmit the data from the nodes to the base station. Four types of nodes have been classified : root nodes, parent nodes, child nodes and leaf nodes. The root node is selected by the Base Station on the basis of highest residual energy and it performs the task of collecting the data from the parent nodes in the network. Each node which is not a root node can be classified as parent, child or leaf node. A leaf node is one which is starting point of the path to the root node. It does not bear any child node. The leaf nodes start the data transmission process, forwards the data to the parent node. A node having leaf nodes connected to it is classified as the parent node. And if the parent node is connected to the root node via other nodes, it becomes the child node. The whole concept revolves around the formation of the tree from the leaf nodes to the root nodes.

However, in this the Base Station has to broadcast twice to all the nodes in the network in each round. Firstly the base station broadcasts about the starting time and length of the time slot to all the nodes in the initialization phase and secondly when the base station chooses node with the highest remaining energy as the root node, it has to inform to all the nodes about the root node ID and its location coordinates. This process tends to consume more energy on the part of the nodes which have to receive the packets over a larger distance from the base station. Since the base station chooses only one root node, the root node chosen can be located at any part of the network. In the case if it is located at the opposite portion of the network with reference to the location of the base station, for example, the base station is located at the north end of the network and the root node gets chosen at the south end then in this case the nodes have to first forward the data via the parent nodes to the root node at the southern end. After collecting the data from the sensor nodes the root node will have to transmit the data over the longer distance all the way to the northern end. This will consume a lot of energy of the network. Hence the root node choosing process needs to be optimized so that energy can be saved in the network. Also the selection of the parent nodes can be taken into account. The selection of the parent nodes require the broadcasting of the messages on the part of the nodes when they inform each other about the neighbor information. This broadcasting can be quite energy consuming process in the network.

IV. METHODOLOGY

In order to reduce the energy consumption of the nodes in the wireless sensor networks, our proposed work tends to use the concept of the clustering along with the root nodes as defined by STEB. Our proposed scheme works in the following way:

- The base station will first divide the network into clusters of equal size.
- The base station will select the cluster heads on the basis of the highest residual energy and smaller distance from root node.
- Once the clusters have been formed, next step is the selection of the root node. The base station will select the node with highest energy and one that is located closer to it as the root node.
- Instead of broadcasting the ID and location coordinates of the root node to all the nodes in the network, the base station will broadcast this information to the cluster heads along with the information about the starting time and the length of the time slots.
- The cluster heads will now inform the member nodes about the starting time and the length of the time slots.

- The cluster heads elected by the base station will act as the parent nodes to the member nodes which will act as the child nodes.
- Unlike in STEB where each node chooses its parent node to reach to the root node, in the proposed scheme, the cluster heads will now choose their parent nodes to reach to the root node.
  The cluster heads exchange the information about their neighbour nodes with its one hop nodes. The parent for the cluster head will be chosen on the basis of the following criteria:
  1. The distance between its parent node and the respective root should be shorter than that between itself and the root.
  2. Each node chooses a neighbour as its parent. And if the node can't find a neighbour then, it selects the root as its parent.
- After the parent nodes have been selected for the cluster heads the data transmission will start from the member nodes.
- The cluster heads will aggregate the data from the child member nodes and transmit the data to the root node via chosen parent node. The root node will forward this data to the base station.

V. RESULTS

The results of our proposed protocol (C-STEB) are taken and compared with the existing STEB protocol. Following are the comparison results shown graphically under several parameters:

1. ***Energy left in the network:*** The graph below is the comparison of energy left in the network. From the graph it is clear that more energy is left in nodes in case of our implemented protocol (C-STEB) compared to the STEB protocol. The energy left in the network is calculated as

   EL=EI-EC

   Where EL is the energy left in the network, EI is the initial energy and EC is the energy consumed.

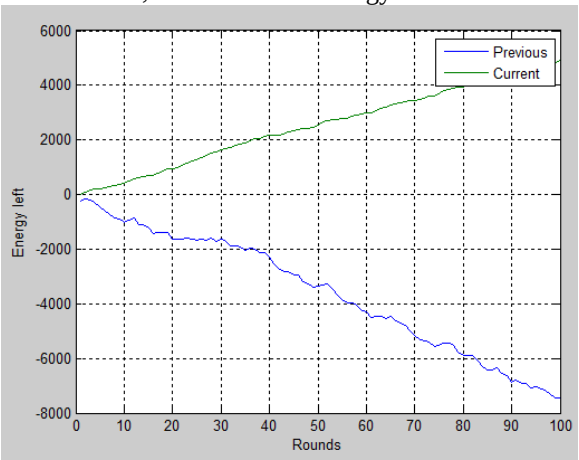


Figure 1: Graph between the Energy left and the Rounds.

2. ***Number of Dead nodes in the network***: The graph below is the comparison of number of dead nodes in the network. From the graph it is clear that C-STEB has less number of dead nodes compared to STEB thus enhancing the protocol.

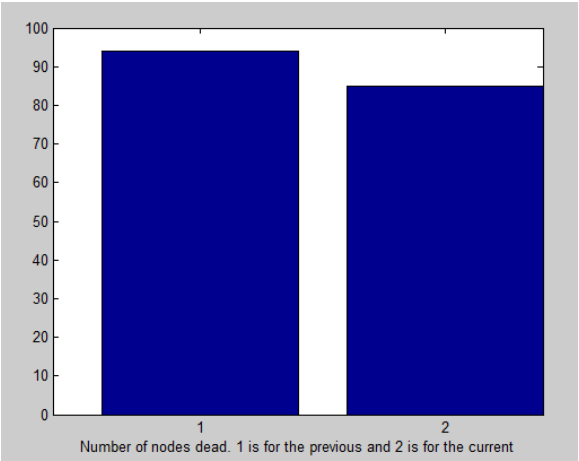


Figure 2: Bar graph between the STEB and C-STEB on the basis of dead nodes.

3. ***Throughput Comparison:*** Throughput means the number of packets delivered per unit time. In the below graph the comparison between STEB and C-STEB is shown. Hence in case of C-STEB the number of packets delivered is more compare to STEB.

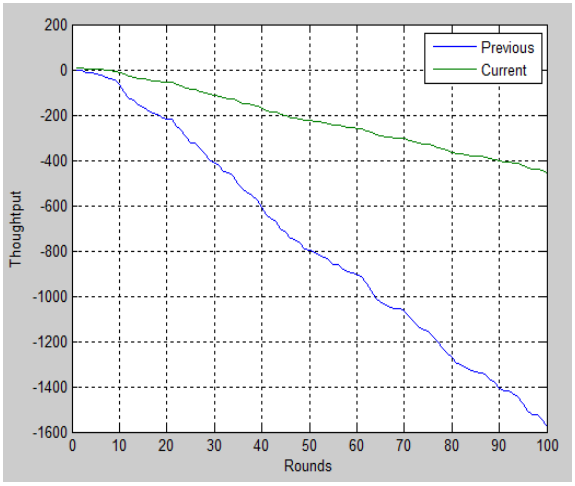


Figure 3: Graph of throughput versus rounds.

4. ***Energy consumption comparison:*** The graph below shows the comparison between STEB and C-STEB on the basis of energy consumption. From the graph it is clear energy consumption is less in C-STEB than STEB, thus enhancing the protocol.

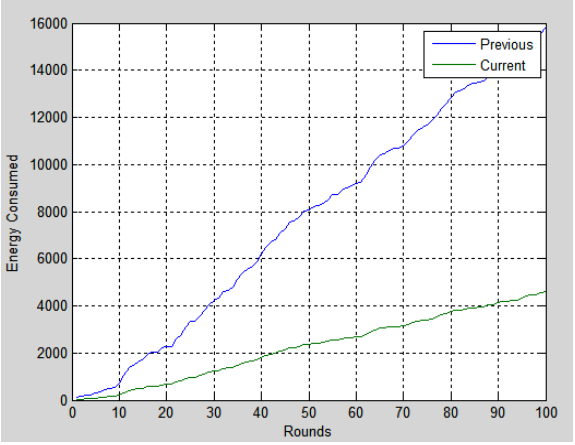
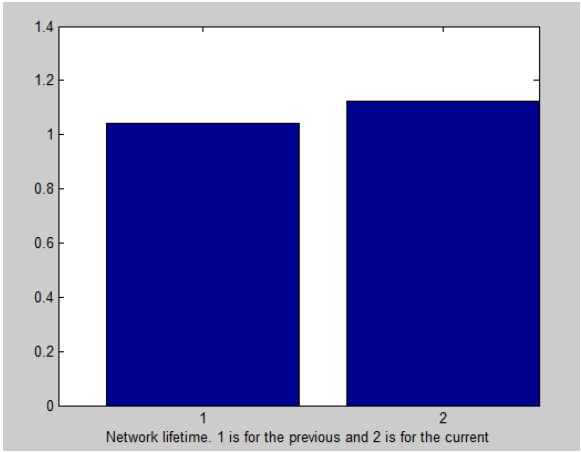


Figure 4: Graph between the Energy consumed and the Rounds.

5. ***Network Lifetime Comparison:*** Network lifetime means the time that a wireless network would be operative. The below graph clearly shows that C-STEB has higher network lifetime compared to STEB. The network lifetime is calculated as

NL=ROUNDS/ND

Where ND is the number of dead nodes.



Network lifetime graph.

VI. DISCUSSION AND CONCLUSION

This work is an enhancement of the previous work done on the STEB protocol with clustering. In this we have simulated STEB protocol in MATLAB with the concept of clustering. In the process we are making the main idea of routing by firstly deploying the 504 nodes in a network of 9 clusters and the main objective of the clusters is to reduce

the unhealthy energy consumption of the network. The cluster heads are selected on the basis of the smallest distance from the base station and the highest residual energy and the root node is also selected on the basis of highest energy and the smallest distance from the base station.

The route selection process starts from the source node which selects the parent node which is its cluster head and then it selects the next cluster head for the next link. Further the cluster head which has the data sends the data to the closest cluster head to the root node and the root node is reached. Then the root node is responsible for sending the data to the base station.

The future scope of this work is the use of more intelligent clustering protocols like pegasis or Eleach. This work can be further extended by incorporating security algorithm in C-STEB to prevent network attacks and also to enhance the performance of the network.

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