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Hierarchical Energy Efficient Clustering Algorithm for WSN

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Abstract: The Wireless Sensor Network (WSN) is the collection of large no of low-cost micro-sensors which are used to collect and send various kinds of messages. Energy is the most important aspect of the WSNs because it determines the aliveness of wireless sensor node. In this paper we propose Hierarchical Energy Efficient Clustering Algorithm (HEEC) for WSN. HEEC achieves good performance in terms of reducing high energy consumption and increasing life time of WSN. It also minimizes the load evenly among all the nodes. HEEC introduces a new clustering algorithm and head node selection, which can handle the different energy capacity sensor nodes. And also, HEEC introduces the re-electing cluster head node concept; this method is simple and efficient approach which can avoid data loss and delay of access problem. Simulation results show that HEEC has a better performance than other energy efficient protocols in balancing load and reducing high energy consumption.

Key words: Energy efficient · Routing tree · WSN · Cluster · Cluster head

INTRODUCTION

Wireless Sensor Network: WSNs consists of more than hundreds of small spatially distributed autonomous devices using sensor called sensor nodes to monitor the physical and environmental situations such as sound vibration, temperature, pressure, motion and intensity of light at various place. Energy is most concentrate term in WSNs because it determines the aliveness of wireless sensor node. One of the most design objectives of WSNs is to minimizes node energy consumption and maximize the network life time [1].

So preserving the consumed energy of each node is an important objective. In WSNs each node tries to perform computation on data locality, so data to be forwarded and grouped because computations are less expensive than data transmission. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, control, machine health monitoring and so on. The main task of wireless sensor network is to periodically collect the information about the target region

Energy Efficiency in WSN: Energy efficiency is the important consideration in WSN. Each sensor node directly transmits data to the base station. However when base station is located far away from the target area, the sensor nodes will die quickly due to much energy consumption.

On the other hand since the distances are twines each node and base station (BS) is different, direct transmission leads to unbalanced energy consumption. To overcome the energy efficiency problems in wireless sensor network several algorithms and protocols are proposed.

Clustering: Cluster is a group of sensor nodes and connected with dedicated network. In large wireless sensor network, the sensor nodes that work together so that in many respects it can be grouped into clusters. Each cluster has a root node to organize the nodes in the cluster. Cluster structure can increase the lifetime of the network. In cluster data collection is carried out by cluster head, here CH collects data from base station and aggregate afterwards forward data to target node.

There are two techniques used in cluster formation process, the head node first and cluster construction first approach. In the head node selection first approach the CH is selected first and then cluster is constructed. In the cluster first approach the cluster is constructed first and then the CH is selected.

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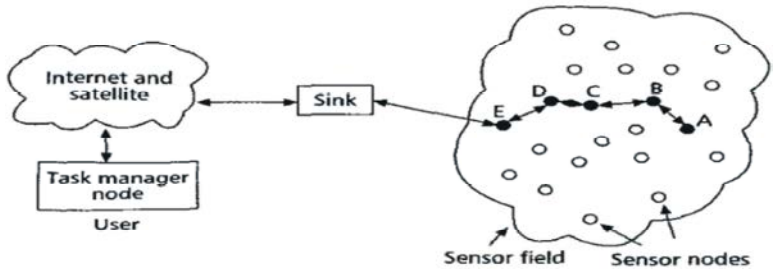

Fig. 1: Structure of the Wireless Sensor Network

Network Simulation: NS2 (Version 2) are an open source of network simulation tool. Ns2 is written in C++ and Otcl languages. The primary use of NS is in network researches to simulate various types of wired/wireless local and wide area networks; to implement network protocols such as transfer control protocol, traffic behavior such as file transfer protocol, Router queue management mechanism such as Drop, routing algorithms like Dijkstra algorithm can be used.

NS2 is written in C++ and Otcl to separate the control and data path implementations. The network simulator supports a class hierarchy in C++ (the compiled hierarchy) and a corresponding hierarchy within the Otcl interpreter. This is the reason ns2 uses two languages are that different tasks have different requirements: For example simulation of protocols requires efficient manipulation of bytes and packet headers making the run-time speed is a very important one here. In network studies the aim may vary some parameters and to quickly examine a number of scenarios the time to change the model and run it again is more important.

Related Works: A main task of WSN is to periodically collect information about the target area and transmit the information to base station [2]. Each sensor node transmits data to BS. However, when BS is located far away from the target area, the sensor nodes will die quickly due to much energy consumption. On the other hand, since the distances between each node and BS are different, direct transmission leads to unbalanced energy consumption. To avoid these problems, many protocols have been introduced. Those protocols such as LEACH, TBC and EAP can achieve satisfactory solutions.

Low Energy Adaptive Cluster Head (LEACH) is traditional kind of energy efficient protocol [3]. The activity of LEACH is classified into two phases they are setup and steady phase. In setup phase root node selection is carried out. After election of root node rest of the sensor node joins to root node and update their neighborhood table. In steady method, root node stores the data received from the BS after setup method root node transfers the data to corresponding target node. It adopts spin technique to select root node, for each round it rotates the cluster group and elects new root node.

Tree-Based Clustering (TBC) [4] is modified method of LEACH. It also uses the clustering technique. It mainly focus on the routing or optimal path construction to target node, for that TBC uses distance information between sensor node, based on that it selects optimal path from source to target node. Cluster is divided into specified level, to calculate the distance information. The node which one is having higher energy level and also nearer to source node is named as root node, after wards data communication starts. But the root node requires high energy consumption to transfer the data.

In Energy Efficient Zone Division Multihop Hierarchical Clustering Algorithm for Load Balancing in Wireless Sensor Network here [5] Cluster based routing algorithm is used to balance the energy in WSN. Here network region is divided into equal no of groups. Based on sensor node density the groups may be divided further. Here it uses middle point method. The middle point is used to select the super node (or) head node. Afterwards data communication starts. Energy level of the root node is measured by data delay and receiving signal. But choosing center point is a difficult process.

In Energy Aware routing Protocol (EAP) is another energy efficient protocol also initiate a concept of intra sensor node coverage.[6] In EAP sensor nodes are joined and builds the routing tree construction from base station to target node, it ideally minimize high energy consumption. EAP avoids the area reportage problem by introducing intra-cluster coverage, which holds the diverse energy network effectively.

PEDAP (Power efficient data gathering and aggregation in wireless sensor networks) [7] is a one of the tree-based routing protocol that makes all the nodes form a minimum spanning tree, which costs minimum energy for data transmitting. It also has another version

named as PEDAP-PA which slightly increases energy for data transmitting but balances energy consumption per node. However, both PEDAP and PEDAP-PA are protocols that need BS to build the topography which will cause a large amount of energy waste. It will leads to BS have to send lot of information to the sensor nodes, including Time Division Multiple Access (TDMA) slot, who are their child nodes and who are their parent nodes. This kind of information exchanging will cause a lot of energy to be wasted.

The main aim of GSTEB (General Self Organized Tree Based Energy Balanced Routing Protocol) [8] is to achieve a longer network lifetime for different applications. In each round, BS assigns a root node and broadcasts its ID and its coordinates to all sensor nodes. Then the network computes the path either by transmitting the path information from BS to sensor nodes or by having the same tree structure being dynamically and individually built by each node. For both cases, GSTEB can change the root and reconstruct the routing tree with short delay and low energy consumption. The operation of GSTEB is divided into Initial Phase, Tree Constructing Phase, Self-Organized Data Collecting and Transmitting Phase and Information Exchanging Phase. When Initial Phase begins, BS broadcasts a packet to all the nodes to inform them of beginning time, the length of time slot and the number of nodes N. When all the nodes receive the packet, they will compute their own energy-level (EL). EL is a parameter for load balance and it is an estimated energy value.

Proposed System: The main aim of the HEEC is to maximize lifetime of WSN, it can be achieved by minimizing high energy consumption and balancing the load evenly among all the sensor nodes. In HEEC clustering concept is introduced to group all the sensor nodes. Here CH selection is carried out by base station and then CH constructs routing tree to destination node, re-electing cluster head concept is also introduced to avoid the data loss and data fusion problem and all.

Cluster Formation for WSN: To group the sensor nodes in HEEC, clustering concept is introduced. WSN consists of millions of sensor nodes in it, these sensor nodes are moving and not structured in nature i.e. they periodically moves from one place to another place. While transferring data through these unstructured sensor nodes creates lot of problem are i.e. delay of access, high energy consumption. To avoid this clustering concept is introduced, clustering method groups all the sensor nodes and then sensor nodes are connected with dedicated network. It is fault tolerant one.

Cluster Head Selection: The head node selection is carried out by the BS (base station). Initially BS analyze the energy level sensor nodes, the sensor node which one is having high residual energy and also located nearer to the base station is selected as the CH and broadcasted. Here CH selection also depends on aliveness of the sensor node, whether the node have enough energy to transfer data packets from source to destination. CH selection is more important and crucial task in WSN. CH is responsible for optimal path selection, coordinating sensor nodes and balances the load evenly among all the sensor nodes.

Routing Tree Construction: After selection of CH next step is the routing tree construction, routing tree is method of selecting optimal path from source to destination; path selection is carried out by CH. Destination-Sequenced Distance-Vector Routing (DSDV) method is adopted to choose optimal path, CH analyze all the path and select the appropriate one, to transfer the data packets to the destination node optimal path consumes less amount of energy to transfer the data packets also reduces delay of access increases network performance. Fig. 2 shows Architecture diagram of HEEC.

Re-Electing Cluster Head: In HEEC re-electing CH concept is introduced, here each round BS analyze energy level of each sensor nodes, checks the previous round CH whether it has enough energy to transfer the data packets. If it is not means, BS again analyze the energy level, distance and aliveness of nodes based on that active high energy node is elected and broadcasted as CH. All the sensor nodes update their neighborhood table and selects new CH as the parent node. Re-electing CH concept reduces the data loss and data fusion problem and also optimally increases system performance.

Data Transfer: Important task of the WSN is to transfer the data packets, to achieve this task here clustering, re-electing cluster head and also routing tree method and all used. These methods are mainly to reduce high energy consumption and also balance the load evenly among all the sensor nodes. Based on the above strategy data is transferred securely from source to destination.

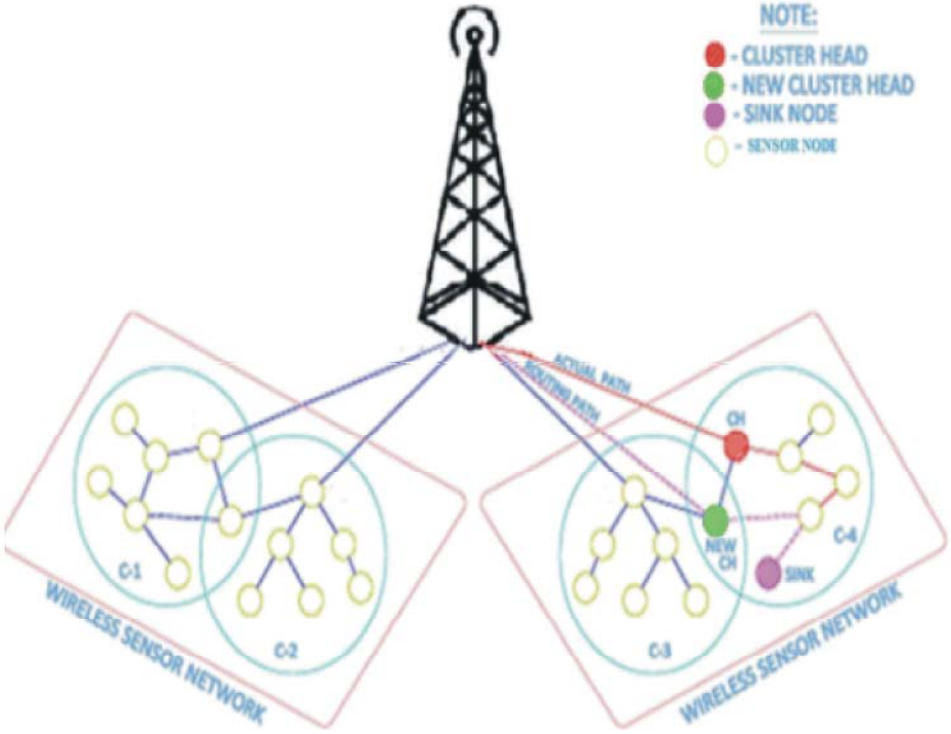

Fig. 2: HEEC (Hierarchical Energy Efficient Clustering algorithm) Architecture

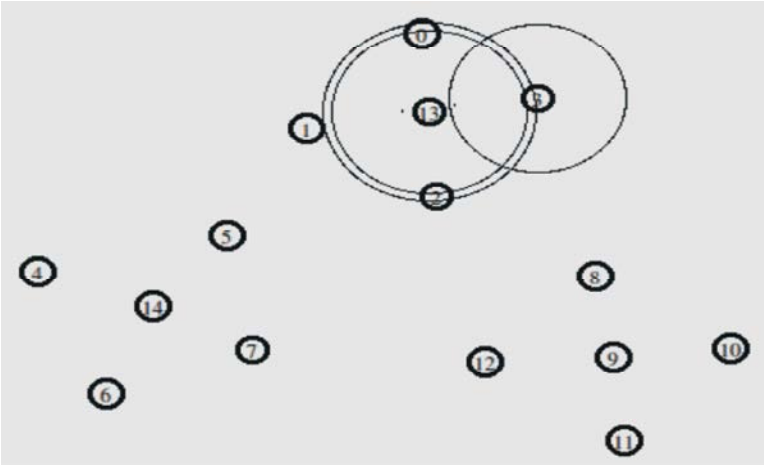

Fig. 3: Cluster formation

Implementation: Since wireless technology and the protocols used are very complex and costly they can't be tested in a reality. In order to overcome this problem we are using network simulation-2 software (ns2). With the help of this simulation software we can find out the problems in design, we can find out the capacity, few new ideas and different approaches. For WSN design we need three components they are Network, source and destination. In HEEC, ns2 simulator generates required realistic network performance.

In HEEC, initially all the sensor nodes are moving in nature, by using the ns2-simulator frequency has been set to construct the cluster group. Based on the frequency all the sensor nodes try to create a cluster group, based on the range all the sensor nodes joins particular cluster group. No of cluster group may vary on the basis of network size.

Cluster formation reduces energy consumption to transfer data packets from source to destination Fig. 3. shows cluster formation in WSN by using ns2-simulator.

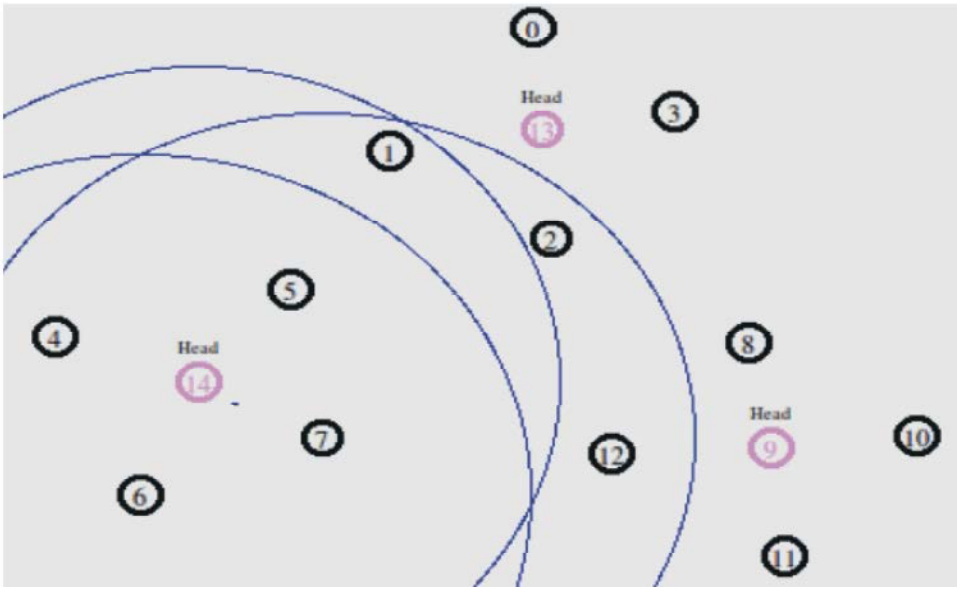

Fig. 4: Cluster head selection

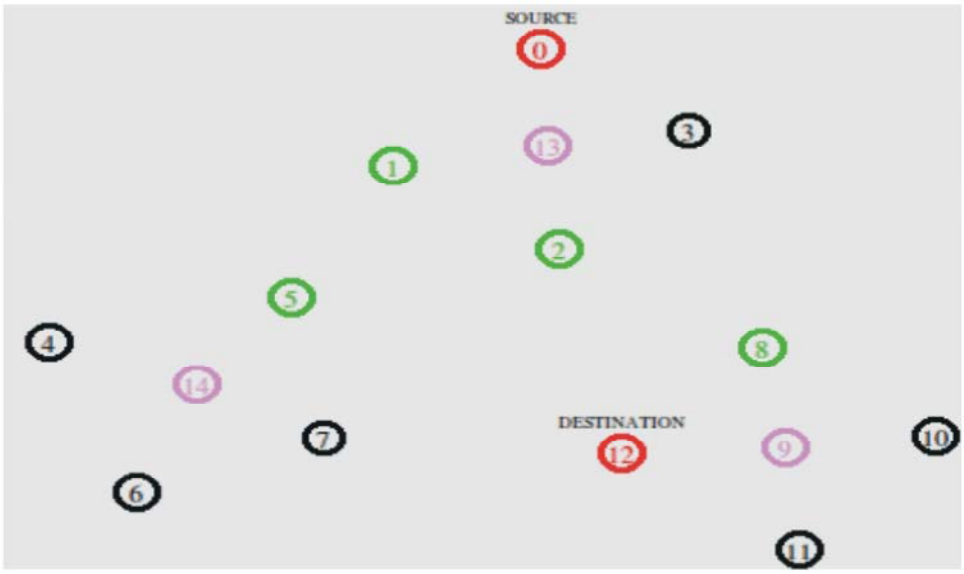

Fig. 5: Routing tree construction

After formation of cluster, CH is elected and named as root node, based on the sensor node which one with standing for n-no of requests and located far nearer to BS. CH is responsible for data transfer, node coordination and path selection. Fig. 4 shows CH selection for each cluster group.

Routing tree construction is carried out by CH using the DSDV method to choose optimal path from source to destination. CH analyze all the optimal path and the path which requires minimum cost and energy to transfer data packets is elected as routing path. Fig. 5 shows routing tree construction in WSN using DSDV method. Fig. 6 and Fig. 7 shows re-electing cluster head. Finally data transfer is carried out from source to destination.

Simulation Results

Performance Evaluation: The performance of HEEC is much better when compared to other energy efficient protocols, here HEEC reduces energy consumption by introducing concept of clustering and balances the load by electing cluster head for each cluster group, routing tree method improves the network performance by

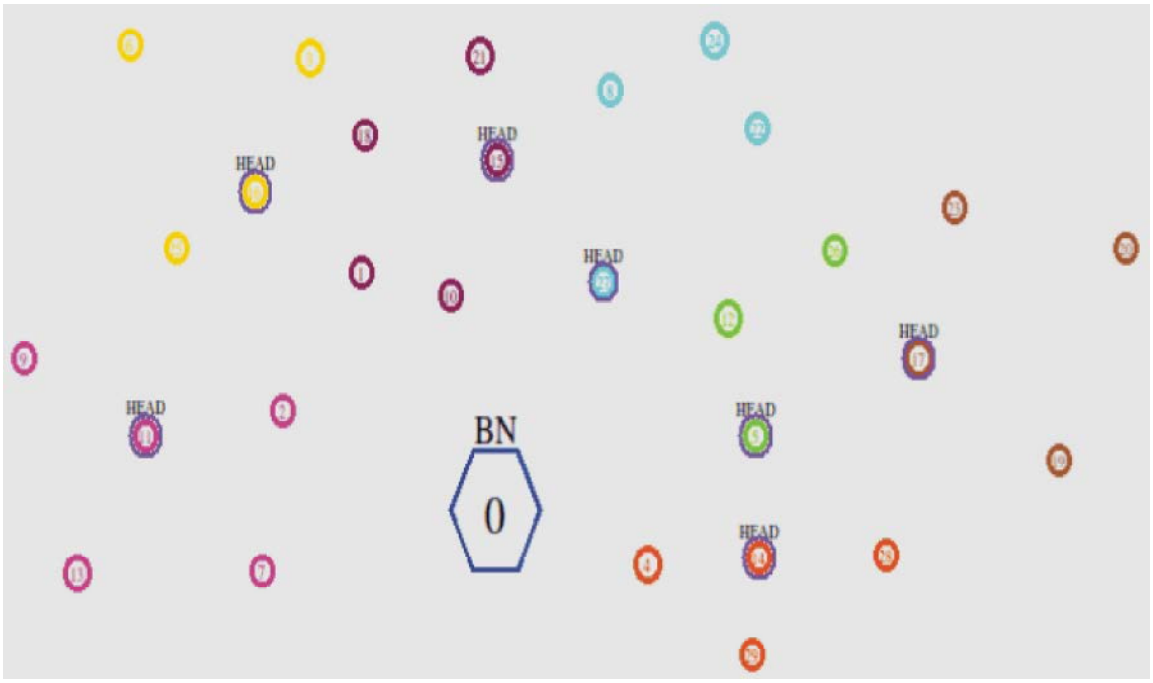

Fig. 6: Re-electing cluster head

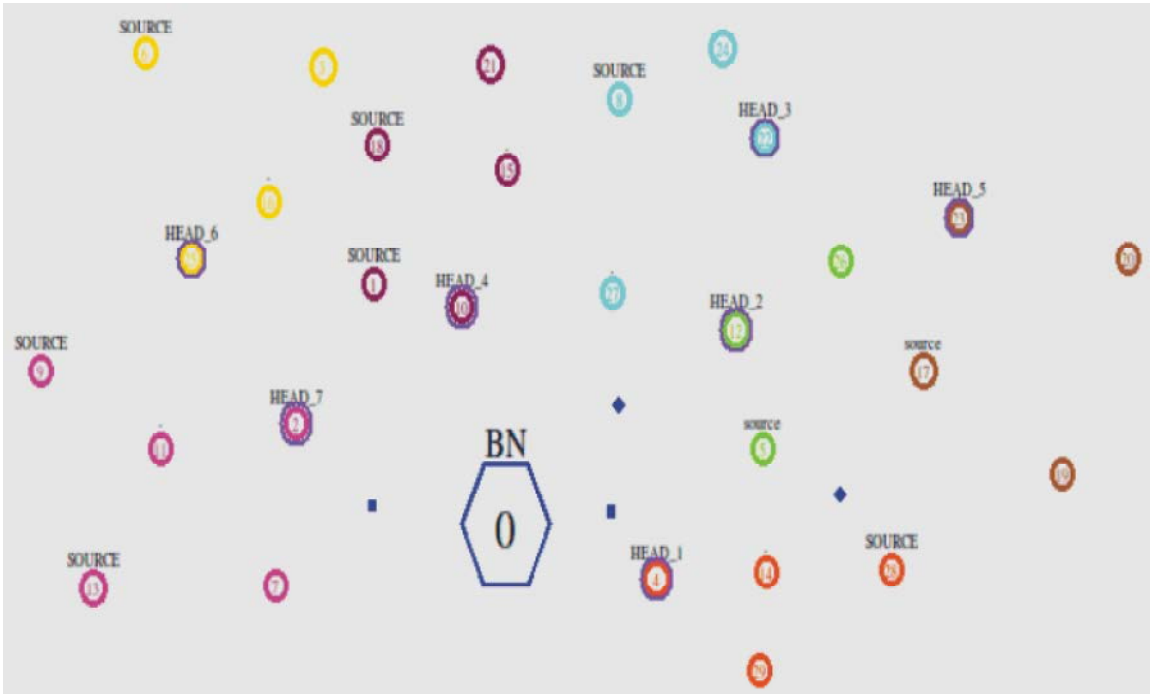

Fig. 7: Re-electing cluster head

choosing optimal path from source to destination. Also Secure data transmission is achieved using minimal cost and energy. Re-electing CH method avoids data loss, delay access etc. HEEC performs far better than GSTEB, LEACH, TBC and EAP protocols.

RESULTS AND DISCUSSION

The details of simulation parameters are as follows: In an area of 50x50 ns2 sensor field, 75 sensor nodes are located arbitrary. Sensors are having a limited

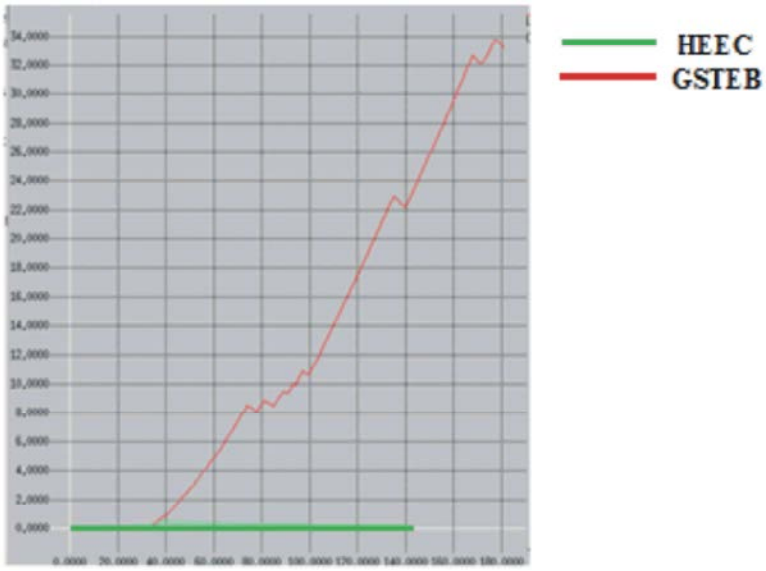

Fig. 8: Delay measurement

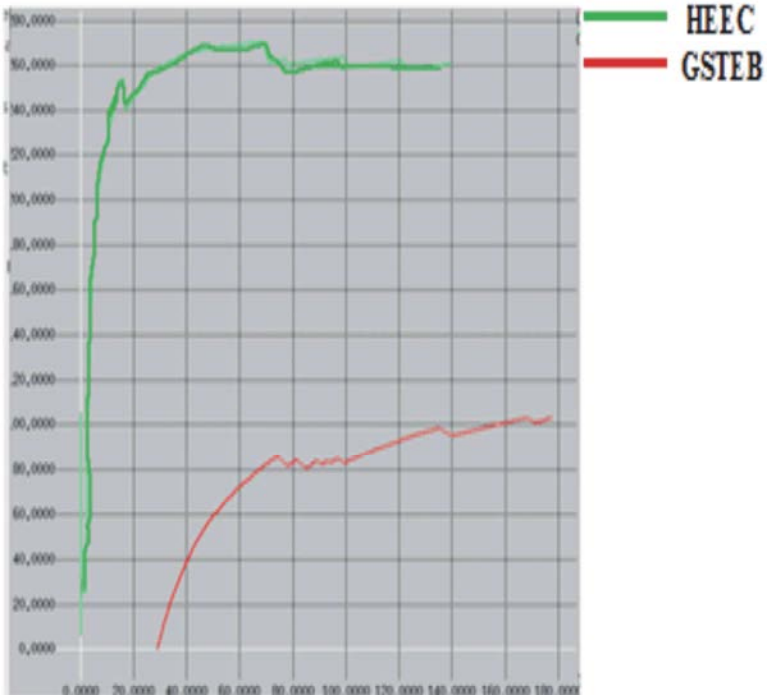

Fig. 9: Throughput Measurement

transference scale of 10 m. The aliveness of a WSN is forced by the limited energy and processing capabilities of its nodes. To increase the aliveness of the sensor nodes it is very important to have high energy efficiency at all the processing nodes.

The performance of HEEC is compared with the existing energy efficient protocol GSTEB. It is calculated by following factors they are, delay measurement, throughput signal strength, packet drop measurement, load balancing. Fig. 8 shows delay measurement is compared with existing GSTEB and proposed HEEC protocols.

Delay Measurement: The delay is unavoidable in WSN. Delay leads to poor network performance. And also reduces the efficiency of the network activities.

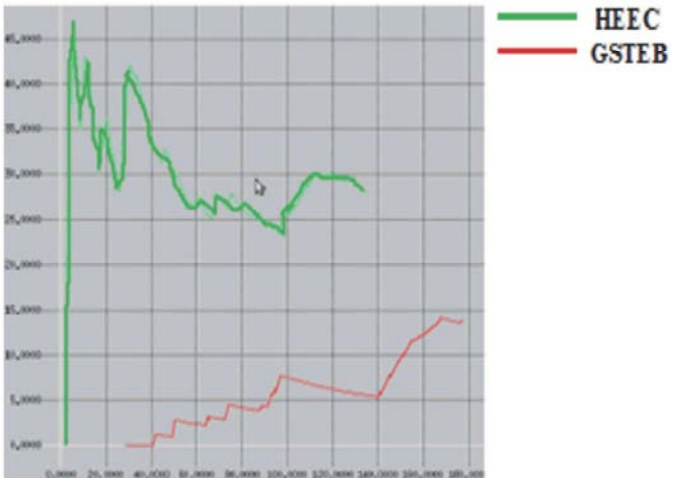

Fig. 10: Source signal frequency

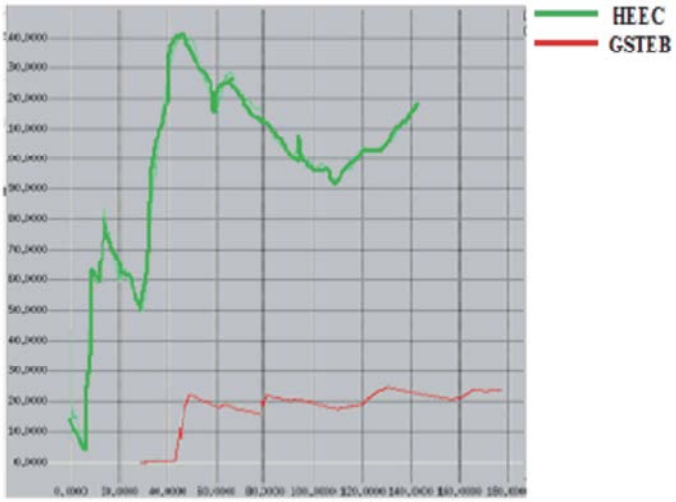

Fig. 11: Destination signal frequency

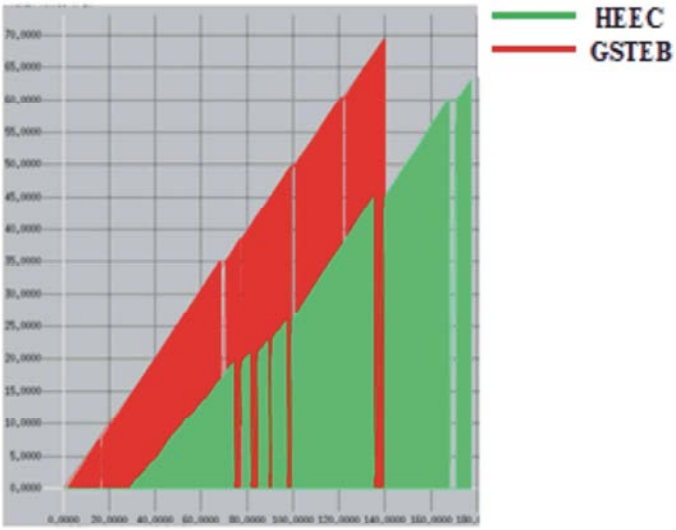

Fig. 12: Packet Drop measurement

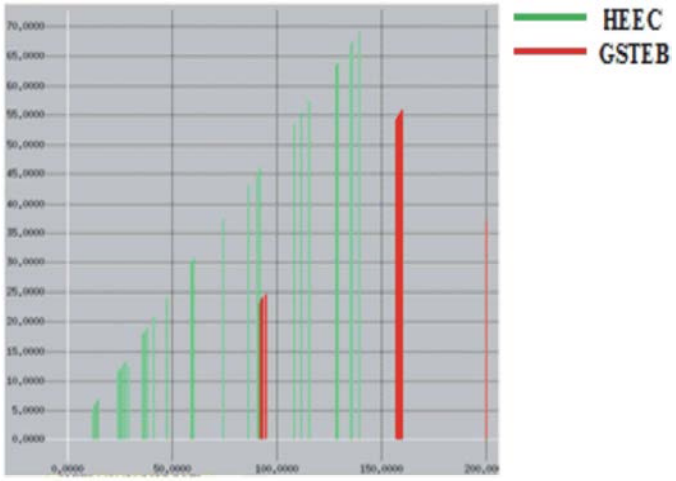

Fig. 13: Load balancing ratio

Fig. 8 clearly shows comparison factor in between GSTEB and HEEC protocols, here HEEC reduces high delay ratio by introducing concept of re-electing cluster head and routing tree construction method.

Throughput Measurement: The throughput shows no of successful packet delivery over a communication channel. Here HEEC achieves good performance in terms of packet delivery. Fig. 9 shows throughput comparison factor between existing and proposed protocols.

Signal Strength: The signal strength refers to the magnitude of the electric field at a reference point that is at a significant distance from the transmitting antenna. The source and destination signal strength are good for this HEEC method. Fig. 10 and 11 show source and destination signal frequency.

Packet Drop Measurement: The packet drop is the most usual thing in the WSN. The important characteristic of energy efficient protocol is to reduce the packet dropping and transmission of packets to the right destination place in efficient manner, the HEEC achieves good performance then compared to the existing energy efficient protocol.

Load Balancing: In WSN load is defined by no of sink or destination node handled by the particular base station. Fig. 13 shows load balancing comparison factor in between existing and proposed protocols. Here HEEC method achieves good performance in terms of handling destination node also has high load balancing factor

The performance of HEEC is much better when compared to other energy efficient protocols, here HEEC reduces energy consumption by introducing concept of clustering and balances the load by electing cluster head for each cluster group, routing tree method improves the network performance by choosing optimal path from source to destination. Also Secure data transmission is achieved using minimal cost and energy. Re-electing CH method avoids data loss, delay access etc. HEEC performs far better than GSTEB, LEACH, TBC and EAP protocols.

CONCLUSION

It is clear from the simulation results, that the HEEC improves the network life time and also efficiently balances the load and energy across the network. HEEC maintains the uniform energy level among all the sensor nodes. It is far better and also efficient than the existing energy efficient protocols also enhances the network performance in terms of secure data transmission, reducing high energy consumption and balancing load.

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