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Energy Efficient Clustering Algorithm for Maximizing Network Lifetime in Wireless Sensor Networks

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Abstract: A wireless sensor network is the version of adhoc networks consisting nodes with less energy power fitted with a radio transceiver. The primary constraint of a sensor node is its energy resource limitation in the form of a short battery lifetime. Energy is the critical problem while we design the algorithm for wireless sensor networks to maximize the network lifetime. Hence we have to design the algorithm for bringing down energy use and maximizing network lifetime. In this paper, we proposed energy efficient clustering algorithm for clustering in wireless sensor network to increase the energy power and maximizing the network lifetime of wireless sensor networks. In this algorithm cluster heads are chosen based on the highest residual energy from the home station. In the previous LEACH algorithm cluster heads are selected which node is the highest residual energy from the nearest neighbor nodes. The simulation results demonstrate that minimal energy is consumed compared with the previous LEACH algorithm using the NS-2 simulator.

Keywords: Clustering algorithm, Energy efficient, Throughput, Wireless sensor networks.

I. INTRODUCTION

A WSN be made up the degree of sensor nodes. Each sensor node senses the state of environs like the degree of hotness, force, dampness and light. It dispatches the sensed data to a base station (BS). Serving as a base station, a sensor node is made up of three constituent, specifically a sensing subsystem, a processing subsystem, and a communication subsystem. The sensing subsystem is relating to encompassing environs. The processing subsystem employs the local data and to store them. Data transmission is completed by wireless communication subsystem. It's powered by restricting power batteries. The extreme the limit of the network, tiny energy consumption is mandatory for sensor nodes. In accordance with, diminish the energy use of goods and services, a clustering and data accretion tactic is being practiced. In this tactic, sensor nodes are distributed as clusters. The delegate node which called cluster head (CH) that combine the entire data within the cluster and send off the data to base station. Hereby CH nodes are only necessities for long distance transmission and rest of nodes save the energy consumed and stretches the scalability and the lifetime of the network. Clustering is an indispensable thing in wireless adhoc and sensor nets. In clustered sensor networks, CH is answerable for data fusion and pass on the aggregated data to the remote base station. Due to clustering the network the payload has been taken low.... Ex: Battery energy slightly preserved. To lengthen of network lifetime, energy efficient protocols have to design for peculiar of WSN. Efficiently organizing the sensor nodes into clusters are useful in diminishing the energy consumption, according to that many protocols are developed. Bearing on the structure of clustering, the data aggregation is profitable by clustering technique and which combines data from root node into the meaningful data.

II. RELATED WORK

Low Energy Adaptive Clustering Hierarchy (LEACH) **[6]** was proposed by W. B. Heinzelman et al. first well known clustering protocol LEACH for wireless sensor networks. It is a clustering-based protocol with randomized rotation of the cluster-heads to evenly distribute the energy load among the nodes in the network evenly. It is a hierarchical protocol in which most nodes transmit the data to cluster heads. The operation of LEACH mainly consists of two phases: Setup phase & Steady phase. In the setup phase, the clusters will be organized and the cluster heads are elected based on the threshold. At every turn, a cluster-head will be elected based on the algorithm. If a node gets a cluster head in the present round than it cannot turn a cluster head again for P rounds, where P is the number of clusters-head (desired percentage of cluster heads). In the steady state phase, once the cluster is elected & cluster ate formed the nodes will sense the information to the cluster-head. The cluster - head will send the data is transmitted to the base station. The continuance of the steady state phase is much longer than the continuance of the setup phase in order to cut down the operating cost. LEACH is a one of the protocols which ends to trim down the energy use of goods and services in a WSN. However, LEACH uses single-hop routing in which each sensor node transmits information either directly to the cluster head or straight to the sink. Due to this drawback, it is not suited for networks that are deployed in large areas.

LEACH with Virtual Force (LEACH-VF) [4] was introduced by Awad *et al*. and gives the rules of virtual field force on each cluster within the network in order to run the sensor nodes to locations that maximize the sensing coverage and minimize the transmitted energy. Two cases of virtual force are used: an attractive force and a repulsive power. The attractive force moves the nodes towards the cluster head in order to reduce the energy used for communication, and the repulsive force moves the overlapping nodes away from each other so their sensing coverage is maximized. The LEACH-VF algorithm can be split into three stages. Stage 1 includes cluster formation and setup. This phase is very similar to the one in LEACH, where the network is divided into clusters via cluster-head election, except in LEACH-VF the sensor nodes report their current location to the cluster head they are associated with via the cluster-join message. In Phase 2, the virtual force computation and sensor node relocation are performed. Each cluster head applies the virtual field force principles to the sensor nodes associated with it, after which the cluster head informs the sensor nodes of the new locations to which they should be active. Stage 3 is the steady-state, or data transmission, which is the same as in LEACH.

Hybrid Energy-Efficient Distributed (HEED) [1] clustering was introduced by Younis and Fahmy. The primary goal of HEED is to prolong network life. The primary difference between HEED and LEACH is cluster head election; cluster head election in HEED is not random. The construction of clusters is based along the residual energy of the node and intra-cluster communication cost. Cluster heads have higher average residual energy than the member nodes. The communication technique of HEED is the same as LEACH.

The Unequal Clustering Size (UCS) [2] model was proposed by Soro *et al.* Clusters of equal size may have an unbalanced load on the cluster heads, but an inadequate size of clusters can provide more balanced energy consumption for cluster heads. UCS is the first unequal clustering model for WSNs. It is a two-layered network model, and the sizes of the clusters differ. The total number of nodes in each network depends on the residual energy of the cluster head. The cluster head is set up close to the base station in two bands known as strata. Data transmission is performed through multiple hops, where each cluster head chooses to forward its information to the closest cluster head in the centering of the base station. Cluster heads are more complex than the member nodes, and hence, more expensive.

The Threshold-sensitive Energy Efficient sensor Network (TEEN) [3] was proposed by Anjeshwar *et al.* And is a hierarchical scheme for reactive networks. Its primary use is in time-critical applications. TEEN is a combination hierarchical and data-centric approach. TEEN has a two-tier clustering topology. TEEN operation uses two thresholds: hard threshold (H_T) and soft threshold (S_T). H_T is used for the sensed attribute. S_T is used to show small changes in the value of the sensed attribute. In TEEN, a cluster head sends its members its H_T and S_T values. The hard threshold and soft threshold try to reduce data communication.

III. PROPOSED WORK

The proposed work developed the energy based clustering algorithm that takes the cluster head based on the highest energy from the home station (BS). Energy Efficient Clustering Scheme Algorithm is a clustering algorithm in which cluster head nodes participate in the ability to upgrade the cluster head for a given cycle. Each sensor node can calculate the closest distance to the Base Station on the received signal strength level. It provides to select the proper energy level to interact with the Base Station. This mechanism holds the two phases, one is cluster head selection phase another one is cluster formation phase. In the cluster head selection phase, several cluster heads are preferred. The node becomes the cluster head, which node is the higher energy from the base station. In one case the cluster head node is picked out, and then transmits the advertisement head messages within the wireless range. In Cluster formation phase, every cluster heads send the head advertisement messages to all non-cluster head nodes that receive head messages and non-cluster head nodes join with them. EECA is fully administered and more energy efficient and the simulation results prove that it prolongs the network lifetime as much as 135% of LEACH.

3.1 ALGORITHM FOR EECA

Step 1 After starting the network, the wireless sensor nodes will be split into several clusters in the WSN.

Step 2 Compute the highest residual energy of the node.

Step 3 One node will be chosen as the cluster head in each cluster area. This cluster head will be selected based on highest residual energy from the base station.

Step 4 After that, the cluster-heads will send the head messages within the radio range to the rest of sensor nodes in each cluster asking them to bring together the cluster-heads to form the Cluster**.**

Step 5 If the CH is already elected based on highest residual energy from the base station.

Step 6 Go to the step-2.

Step 7 Nodes send data to Cluster Head

Step 8 Cluster head received the sensed data from all neighbor nodes.

Step 9 Cluster head aggregates all the data & send to the sink with the help of another cluster

3.2 FLOW DIAGRAM FOR EECA

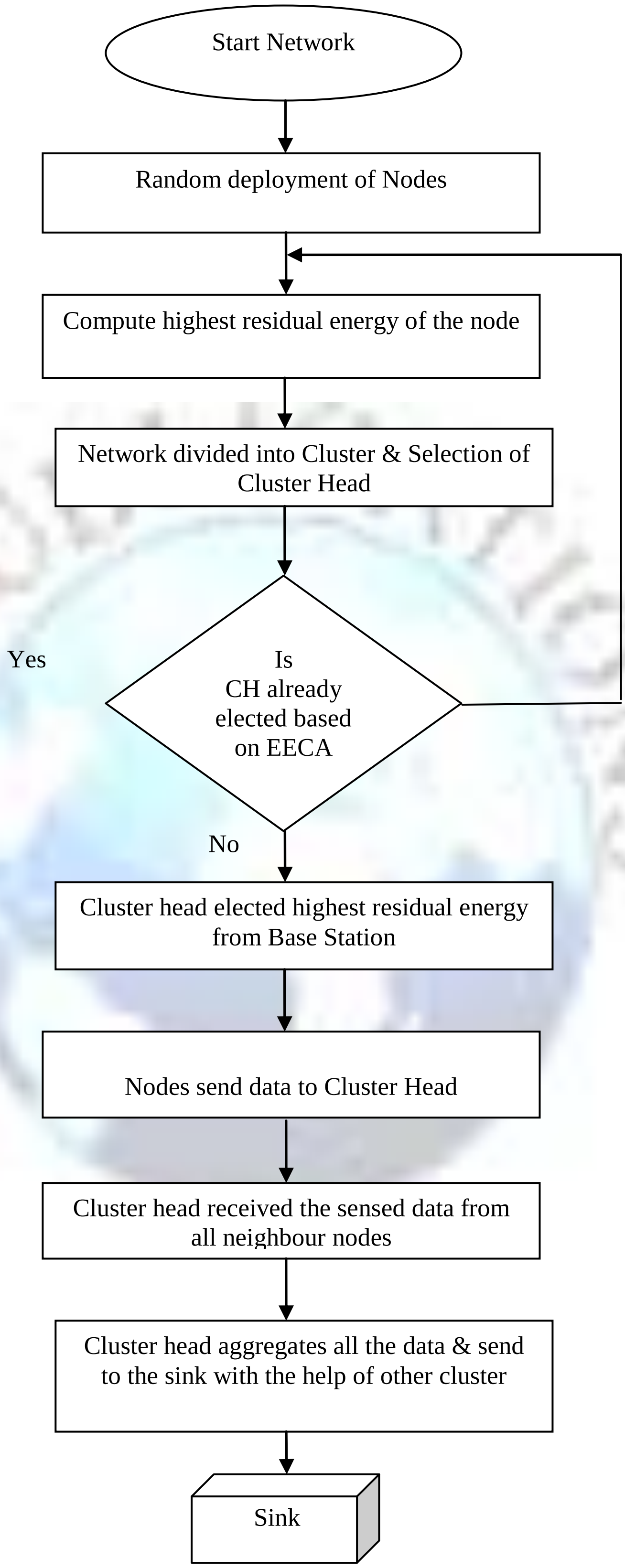

Fig. 3.2 shows the flow of the proposed mechanism

IV. RESULTS AND DISCUSSIONS

This section describes the simulation scenario that is a tool which is used to simulate the proposed algorithms and investigation of the performance evaluation between EECA-LEACH through an extensive set of simulation results.

A. Simulation Parameters

The simulation was run on a computer system, and the tool that is used to evaluate the proposed protocol is NS2 **[8].** It provides a widespread perfection environment for modeling and performance evaluation of communication networks and Distributed systems **[7].**

B. Performance Evaluation

To evaluate the performance of this proposed algorithm, performance metrics like Average Energy Consumption, Packet deliver ratio, Throughput and delay.

1) ***Average Energy Consumption (Ea)***

It measures the average difference between the initial level of energy and the final level of energy.

$$\boldsymbol{Average\ Energy\ Consumption\ (Ea)} = \frac{\sum_{k=1}^{n} (E_{ik} - E_{if})}{\mathbf{N}}$$

Where $\boldsymbol{Ei}$ = the initial energy level of a node, $\boldsymbol{Ef}$ = the final energy level of a node and N = number of nodes in the simulation.

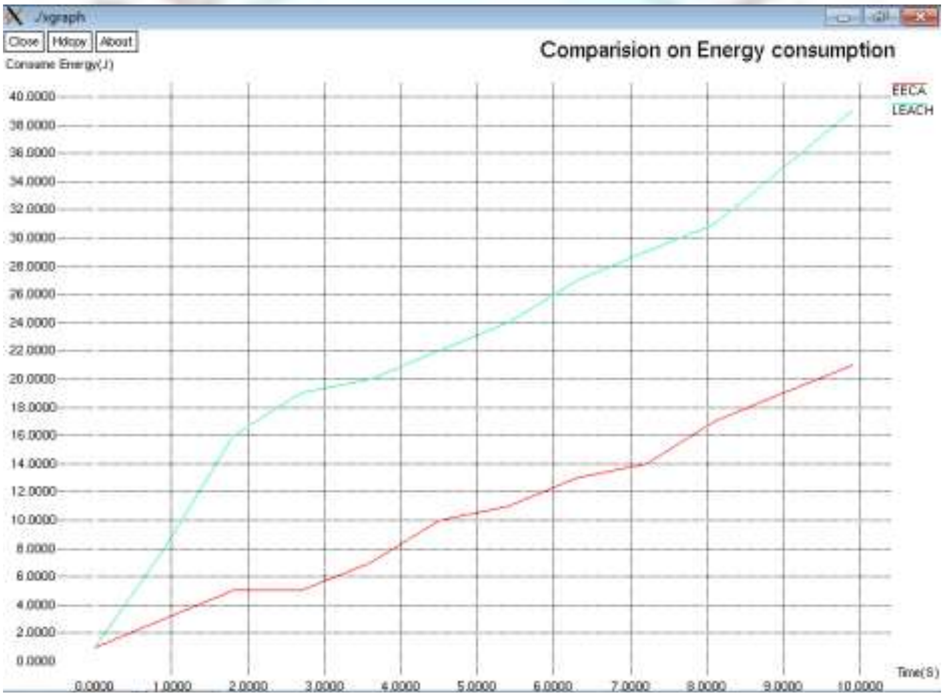

Fig 4.1 Average Energy Consumption

Figure 4.1 shows the simulation result comparison between existing LEACH and proposed EECA. As time increases the energy consumption between the nodes increases. The proposed mechanism shows less consumption of energy for data transmission by comparing with LEACH.

2) Packet Delivery Ratio

This represents the ratio between the number of data packets that are sent by the source and the number of data packets that are received by the sink.

$$\boldsymbol{Packet\ Delivery\ Ratio} = \frac{\boldsymbol{Successfully\ Sent\ Packets}}{\boldsymbol{Total\ \ Number\ of\ Received\ Packets}}$$

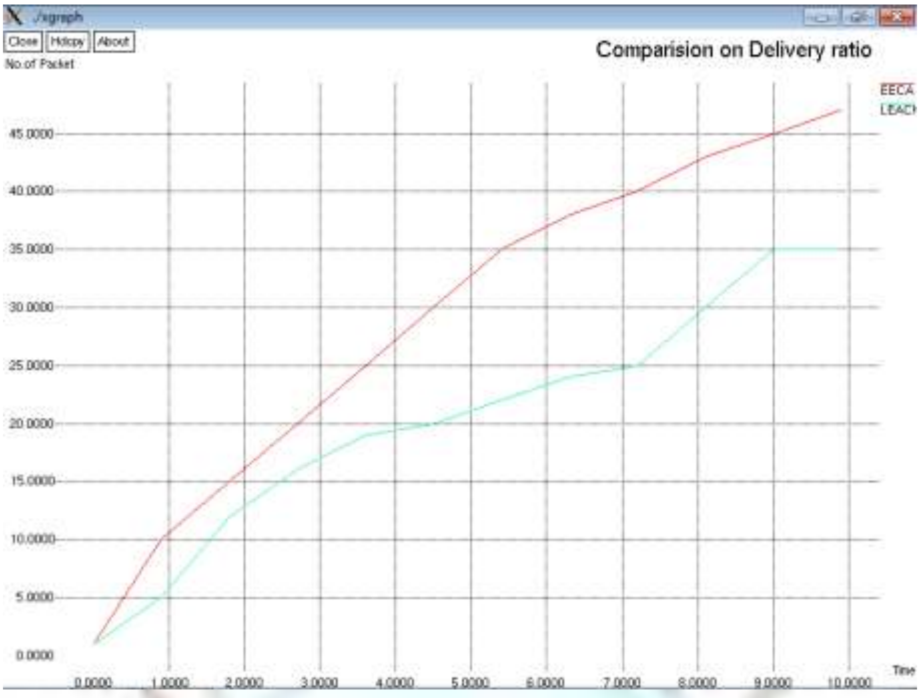

Fig 4.2 Packet Delivery ratio

Figure 4.2 shows the packet delivery ratio. In the packet Delivery ratio, number of packets successfully delivered compared with the LEAH.

3) Throughput

The ratio of total data received by a receiver from a sender for a time the last packet received by receiver measures in bit/Sec and byte/Sec. It can be expressed mathematically as

$$\boldsymbol{Throughput\ (bit/sec)} = \frac{\boldsymbol{Number\ of\ Delivered\ Packet\ * Packet\ size * 8}}{\boldsymbol{Total\ duration\ of\ simulation}}$$

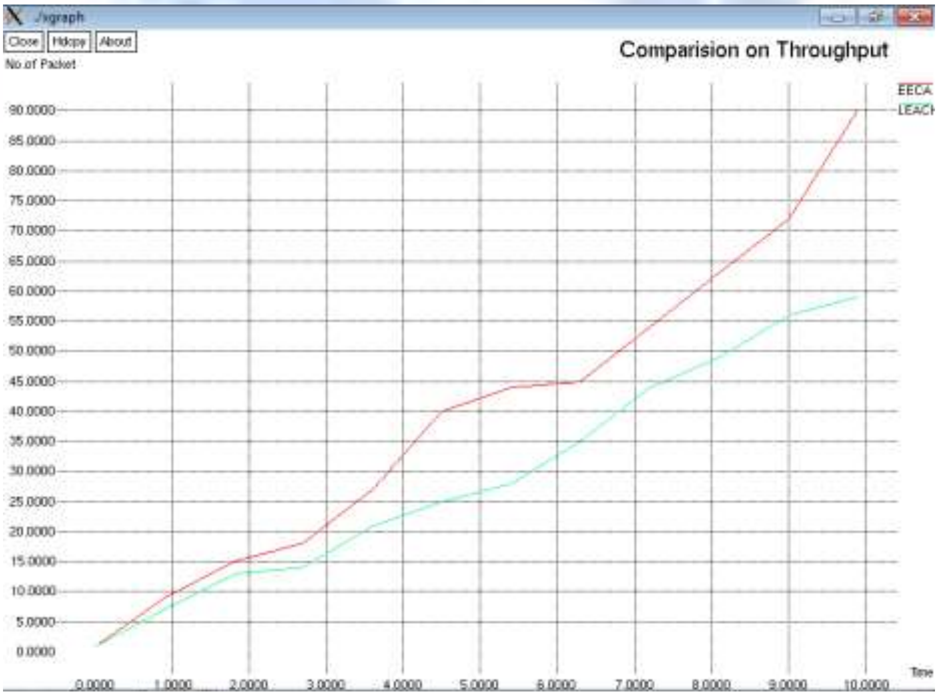

Fig 4.3 Throughput

Figure 4.3 shows that the throughput of proposed work and LEAH protocol on sensor network. Generally throughput defines the average of successfully delivering data packets in a network. The comparison shows that the throughput is

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more in the case of proposed work than LEAH.

4) Packets Delay

It is the average delay between the sending of the data packet by the source and its receipt at the corresponding receiver including the delays due to route acquisition, buffering and processing at intermediate nodes, and retransmission delays at the MAC layer.

$$\boldsymbol{Delay(D)} = \frac{\sum_{i=0}^{n} (\boldsymbol{Time\ Packet\ Received_i} - \boldsymbol{Time\ Packet\ Sent_i})}{\boldsymbol{Total\ Number\ of\ Packets}}$$

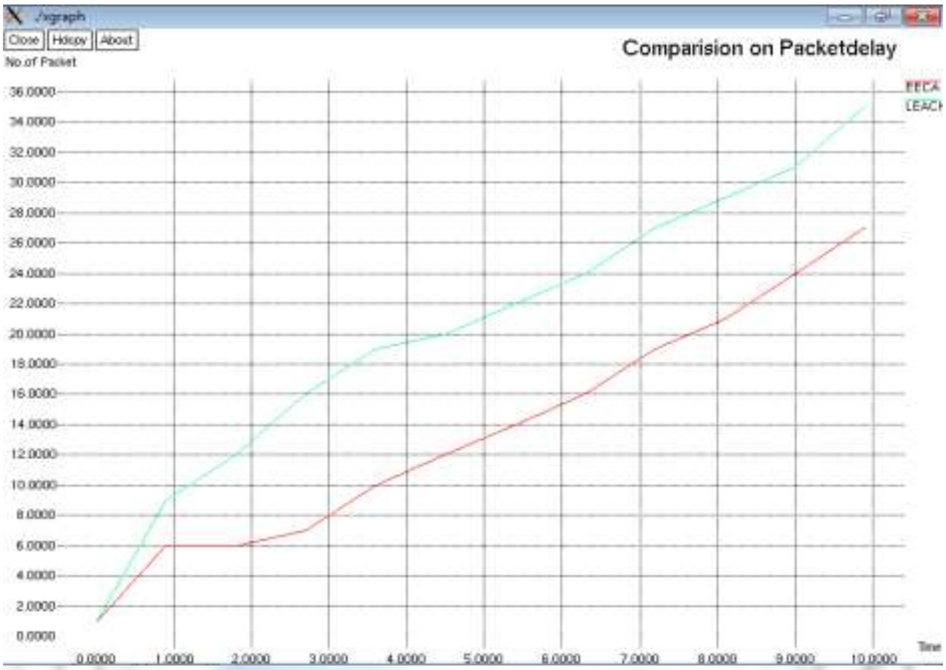

Fig 4.4 *Packets Delay*

Figure 4.4 Shows the end to end delay is minimized in the proposed algorithm by reducing it. The energy of the nodes is maintained and the lifetime of the wireless sensor network is extended.

TABLE 1 Simulation parameters and their values

Parameter	Value
Area	1000*1000
Channel	Channel/wirelessChannel
Propagation model	Propagation/TwoRayGround
Network interface	Physical/wirelessPhysical
MAC interface	Mac 802.11
Interface queue type	Queue/DropTail/PriQueue
Interface queue length	50
Routing protocol	EECP
Initial Energy	2 Joule
Data Packet Size	512 Bytes
Simulation Time	500 Sec

TABLE 2 Performances for LEACH and EECA

Algorithm	No. of Nodes	Throughput	Packet delay	Delivery ratio
LEACH	35	78%	97%	82%
EECA	35	85%	91%	89%

V. CONCLUSION

We have taken out the cluster based algorithm which provides the residual energy of nodes to extend the network lifetime. The proposed EECA provides better energy efficiency that is proven in simulation results. In the Energy Efficient Clustering Algorithm, cluster heads are selected uniformly and distributed over the network because iteration is not occurring as in the previous LEAH algorithm. Simulation results have performed that provides a more dependable result in terms of the packet delivery ratio, packet delay, throughput, energy consumption compared with LEACH algorithm.

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