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Novel Energy Efficient Dynamic Routing Protocol for Wireless Sensor Networks

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Abstract: Tiny sensor nodes with limited energy sources and connected wirelessly are widely used for real time applications. Long distance data transmission towards base station with number of hops reduces overall wireless sensor energy consumption in the network. Here it is propose a dynamic routing protocol with hopping for better energy management as well as reducing delay in packet data transmission. Leveling, clustering and dynamic routing issues are considered for better performance. In our proposed solution to energy management and attempt to develop an intra cluster rotation scheme with hierarchical hop based routing. In this process random and non-hopping methods are compared with hierarchical hopping. Results show that this novel protocol is more efficient than the conventional protocols like LEACH, Multihop LEACH, and TEEN in dynamic routing based data transmission.

Keywords: sensor node; cluster head; base station; levelling; intra cluster; dynamic routing;

I. INTRODUCTION

In general for area monitoring, intruder monitoring etc, various types of sensors are deployed over a geographical area. These sensors are connected together to form a network called a wireless sensor network. If the area to monitor increases, the range over which the nodes should transmit also increases. This results in dissipating more energy as they have to transmit using more power. As they use a large amount of power, their internal battery drains quickly as in [1]. Alternative approaches are derived by various authors for problems employing an energy efficient algorithm to enhance the efficiency of the network as in [2]. Instead of all the nodes communicating at a time, allow them to communicate with only a single gateway node called cluster head as in [3]. The cluster head in turn communicates with the nearest gateway node and thereby it communicates with the base station as in [4].

Wireless sensor networks are deployed in a wide range of fields like fire department, forest department, communication sector, government and private security systems like thermal scanning and infiltration scanning systems. In all these systems the sensing devices are randomly placed and will detect whatever they are programmed to detect, and transmit the data to the base station according to the algorithm chosen. Various routing protocols have been developed depending on the requirement. These protocols are advantageous in aspects such as network traffic reduction, energy conservation etc as in [5]. However they also have limitations which depend on their design. Some of the commonly developed routing protocols are LEACH, TEEN which are discussed as in [6,7 and 8]. When the network geographical area is increased beyond certain level, distance between cluster-head and base station is increased enormously.

In this paper authors aim to develop an energy efficient algorithm for routing in WSNs. Randomly deployed nodes are grouped to form various clusters. Instead of all the nodes communicating to the base station, and appoint a node in a cluster as the cluster head and it handles the data transfer of that cluster. Dynamic routing with an efficient way of data transfer takes place between cluster heads of different levels and data finally reaches the base station as in [9]. In this paper graphical comparisons are takes place for energy efficiency and other parameters. Section II represents system model with leveling and clustering. Section III mention represents the previous works. Section IV describes the system for effective routing which includes cluster rotation scheme. Simulation results are discussed in V and section VI describes the conclusions.

II. SYSTEM MODEL

Sensing range of each sensor node is different. Base Station placement in the sensor field plays a key role in data receiving processes as in [9]. We consider two key processes for implementation of the algorithm more efficiently. One is leveling and the other is clustering. With this algorithm, divided the entire field into levels based on their distance from base station i.e. nodes which are equidistant from base station come under same level. The cluster head of a level transmits the information to its nearest cluster head of lower level and in this way routing is accomplished. Initial cluster head selection is based on the probability with maximum energy. Here it is introduced and implemented the concept of intra cluster communication and formed clusters in which every node of a cluster transmits the information to its cluster head as in [10]. The cluster head fuses the data and sends them to next lower level cluster head. The selection of cluster head is based on its energy. Periodically the energies of all the nodes in a cluster are monitored and the node with the highest energy is chosen as cluster head of that cluster as in [11]. This is called cluster head rotation. As the cluster head involved in communication is changed frequently, the algorithm is energy effective.

III. RELATED WORKS

The goal of LEACH is to lower the energy consumption required to create and maintain clusters in order to improve the life time of a wireless sensor network. Low Energy Adaptive Clustering Hierarchy ("LEACH") is a TDMA-based MAC protocol which is integrated with clustering and a simple routing protocol in wireless sensor networks (WSNs). Features of LEACH are:

1) Reducing the number of transmissions to sink using cluster head.
2) LEACH increases the life time of all nodes through random rotation to select cluster head.
3) LEACH allows non-cluster head nodes to keep sleeping except for specific time durations.
4) In LEACH, routing protocols, nodes die randomly and clustering enhances network life time.
5) LEACH routing protocol makes WSN scalable and robust.
6) The main draw backs of LEACH:
   Hinder its efficiency, Cluster formation is not dynamic as in [6].

Multihop LEACH is also complete distributed cluster based routing protocol. Like LEACH, multihop LEACH also cluster head formation is done in setup phase. In steady state, cluster head collects data from all nodes of its cluster and transmits to base station through cluster heads. Inter-cluster and intra cluster communication are carried out in multihop LEACH. In this nodes communicate to cluster head through one hop only as in [7].

TEEN: The nodes sense the data continuously, but data transmission is done less frequently. The main drawback of this scheme is that, if the threshold value is not reached, nodes will not communicate. This scheme is not well suited for real time updates as in [8].

IV. EFFECTIVE ROUTING

Wireless sensors are deployed in several walks of life and these consume a lot of energy. It can minimize the amount of energy that's being consumed and also reduce the time it takes for a message to reach its destination. Considering that the position of base station is at the middle of the sensor field for better communication. The cluster based routing algorithms and data fusion techniques have an array of advantages as in [10]. Instead of each node communicating with the base station, they instead communicate with their respective cluster head. And these cluster heads in turn communicate with the cluster head of the lower level, and they in turn finally deliver the messages to the base station. Also low transmitting powers can be used since the nodes are only transferring data over smaller distances. This energy saved is reflected in the prolonged life of the nodes as in [11].

Initially specify 'S_{ni}' sensor nodes in a particular level to form clusters. L_i is the number of levels in the sensor field and 'n_i' lies between 0^{th} level and Li-1. In case any nodes are left out they are automatically appended to the nearest formed cluster. As mentioned earlier a node becomes a cluster head. This is done randomly. Opted for 't' seconds time frame, and once every second the cluster head changes. Every node has the layout of the entire network, so after every second the node with the highest energy of a cluster automatically broadcasts a message stating that it is the new cluster head and all the nearby nodes receive this signal. Since in a particular level there is more than one cluster head, every node receives the broadcast message of two or more cluster heads. They compare the strengths of the signals received. As high signal strength corresponds to a nearer cluster head, they automatically associate themselves with this cluster head and form a new cluster. In this way dynamically the cluster formation varies once every second. When a cluster is formed the nodes automatically broadcast the new layout of the network and each node has its information updated.

Nodes of a cluster transmit the sensed data to the cluster head with its identification. User Datagram Protocol (UDP) as the transmission protocol used in this paper. Using UDP, data transfer takes place in the form of packets called as datagrams. UDP uses a simple transmission model with no handshake signals. Also UDP provides checksums for data integrity. Hence it is suitable where error checking and correction are not required. Thus it enables data fusion and Constant Bit Rate (CBR) as the application type in this.

The cluster head fuses the data received from each node and sends it to the Base Station (BS). In case of multiple levels the cluster head transfers the data to the lower level's cluster head. There are also instances in which the lower level's cluster head is farther when compared to the BS. In this case the cluster head directly transmits to the base station, rather than sending to the lower level's cluster head, thus saving energy and reducing traffic. Above is the scenario in multi-level. A similar situation occurs within the same level wherein a node of a cluster is farther to the cluster head when compared to the base station and in this case also the node directly sends the data to the BS rather than sending it to the cluster head as in[9]. In this protocol every node within its life time becomes a cluster head and that too not more than once, thus enhancing the efficiency by involving every node. Figure1. gives the routing techniques of the proposed algorithm.

Table1. Node parameters

S.No	Parameter	Type/Value
1	Channel propagation	TwoRayGround
2	Queue	Droptail, Priority
3	Antenna	Omini directional
4	Routing Protocol	DSDV
5	Initial Energy to node	100J
6	Transmitting energy	5J
7	Receiving power	1.5J
8	Sleep power	0.001J
9	Average energy	6.5J
10	Packet size	1500 bits

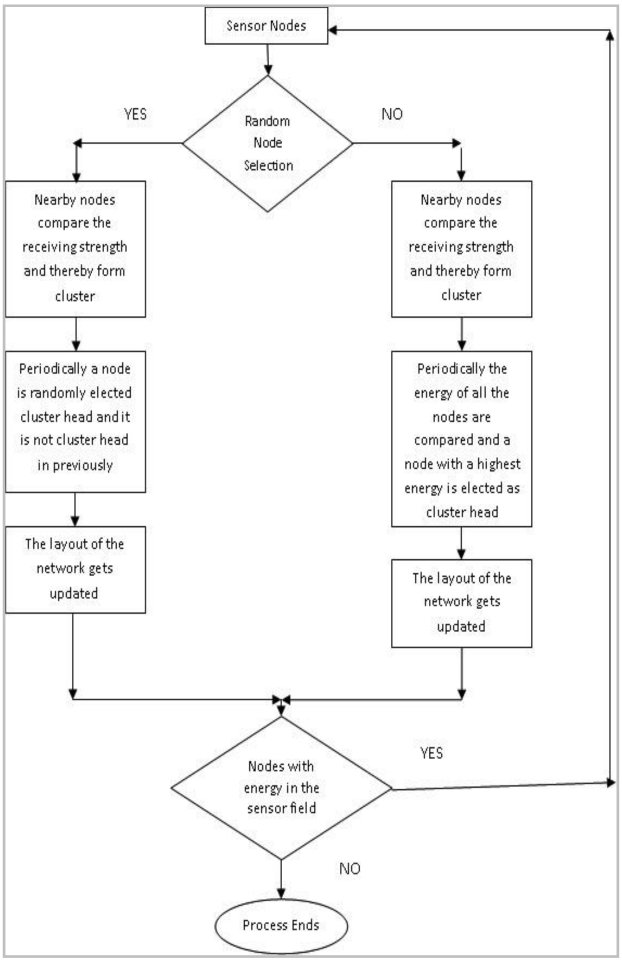

Figure1. Flow chart for the algorithms

V. SIMULATION RESULTS

In Fig2 the central node represents the base station and it is surrounded by two levels of nodes which transmit the data sensed in that particular region, as initially all the nodes have maximum energy. Figure 3 represents the node coverage range and cluster formation as in [13]. Fig 4 and Fig5 represent the cluster head and recluster heads formation process, as nodes transfer the information to the nearest. Every node will be elected as cluster head at least once in its life span.

In the simulation process, consider the number of nodes and the packet sizes, overhead, amount of energy remaining after transmission of packets in the node and delay in data transmission. With the help of NS-2, X-graph graphical simulation as in [12], compared the results of random data transmission towards base station vs hierarchical hop and non-hopping data transmission vs hierarchal method. If the number of nodes increases, normally packet size and node overhead also increases. However this new algorithm reduces the number of packets per node as well as node overhead in non-hop vs hierarchal as well as random vs hierarchal methods. Simulation results are shown in Fig 7, Fig 8, Fig 9 and Fig 10.

Fig 11 and Fig 12 represent the simulation results of residual energy. The algorithm performance is good for both the cases. If the number of nodes increases, the amount of energy remaining in a cluster decreases as in [14] as the cluster head of higher level has to transmit to base station directly. In contrast our algorithm uses concept of hopping and hence energy remaining is high compared to conventional method. This difference is high, particularly when the number of nodes increases. Simulation results of Fig 13 and Fig 14 represent the delay due to packet transmission. Due to hopping and energy based cluster head selection the congestion is less and hence causes less amount of delay in data transmission. On the other hand due to low congestion, delay is high in non-hopping and random routing algorithms. All simulation processes are carried out in through Network Simulator (NS-2) software as in [12].

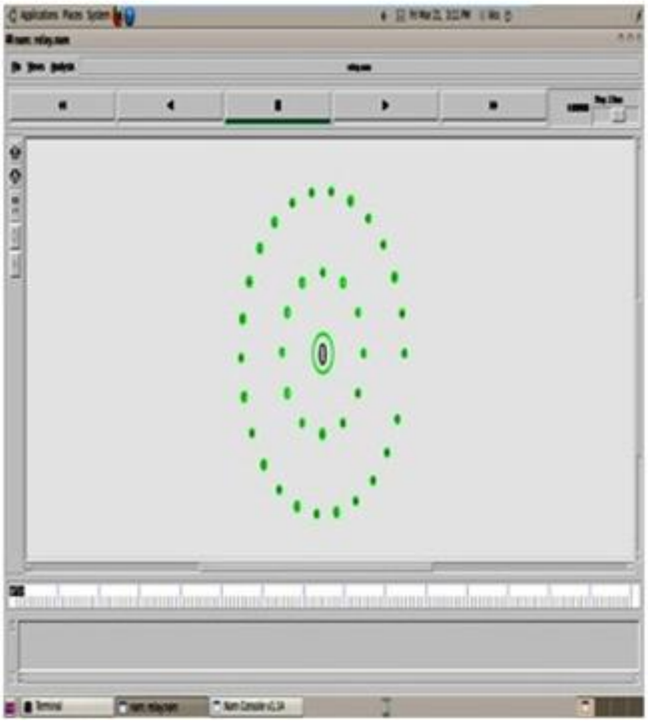

Figure2. Placement of nodes in sensor field

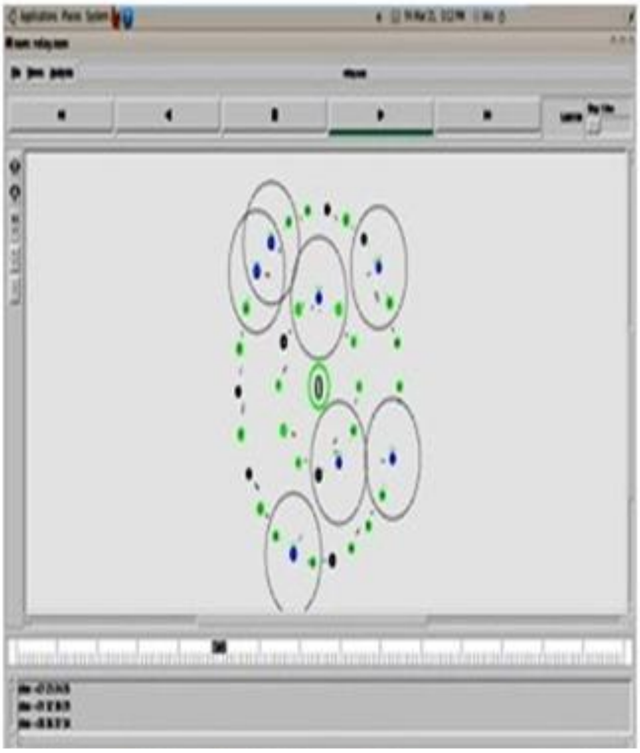

Figure3. Nodes sharing its energy information

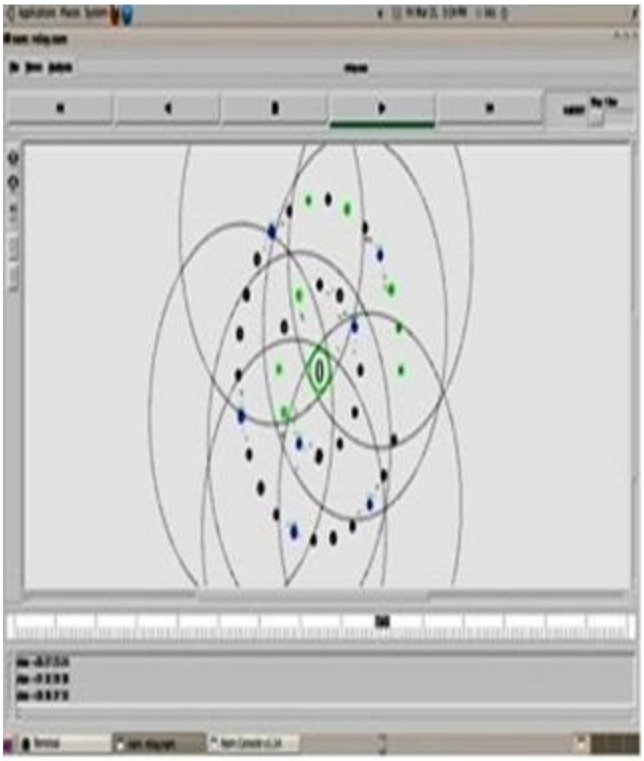

Figure5. Clustering and Re-clustering

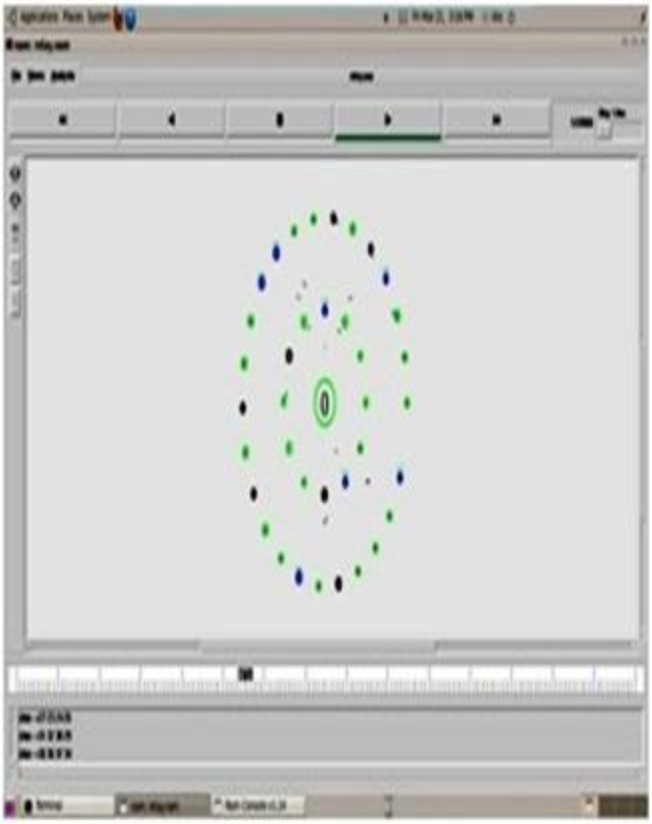

Figure4. Cluster formations

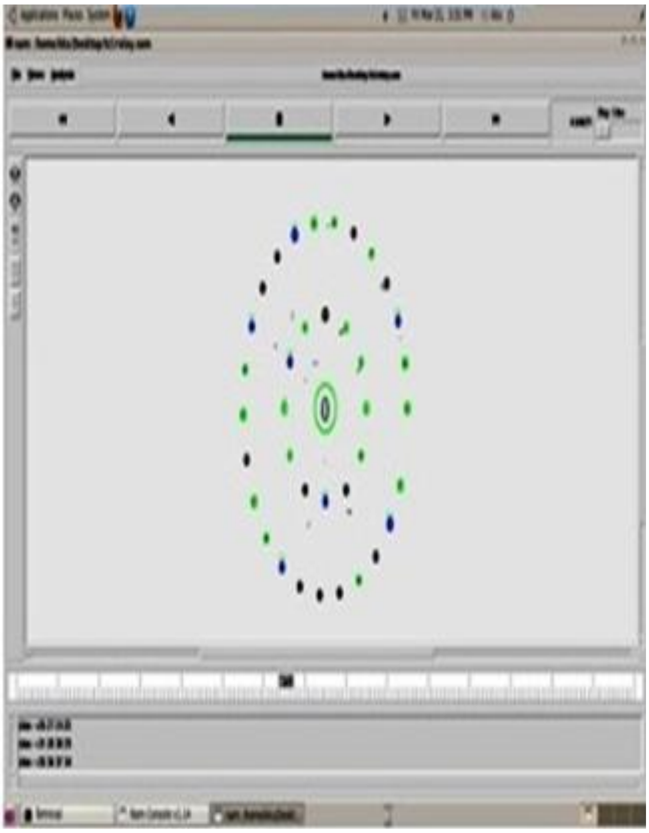

Figure6. Energy dissipation in the field

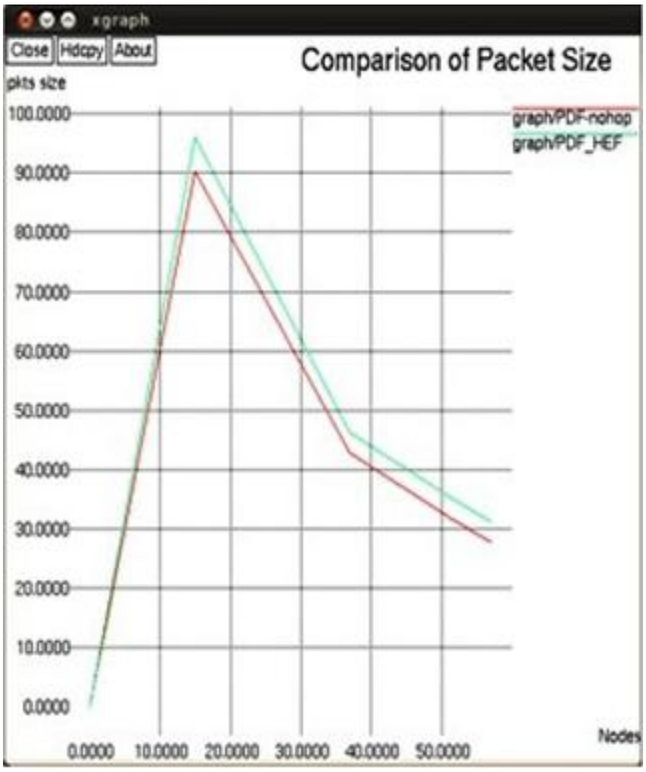

Figure7. Hopping and non hopping comparison with packet Sizes

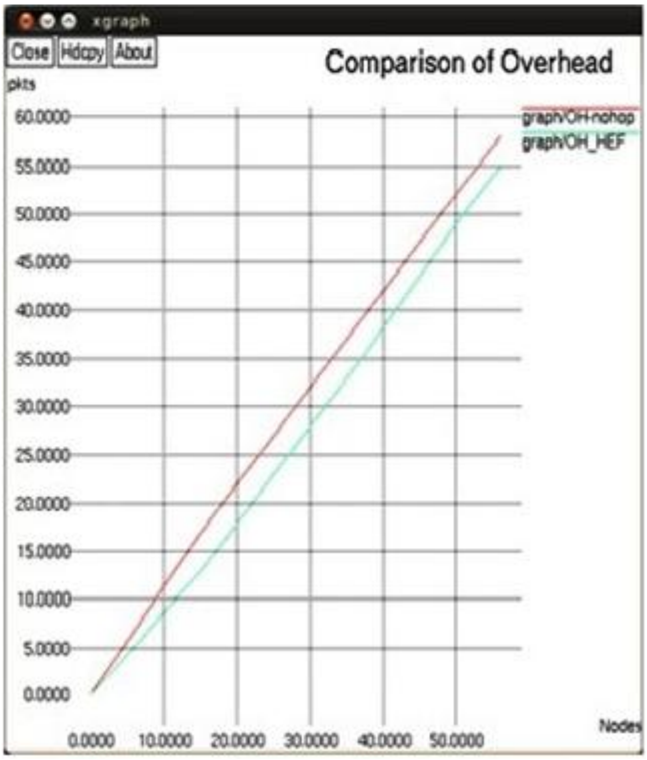

Figure9. Hopping and non-hopping comparison in terms of node over head

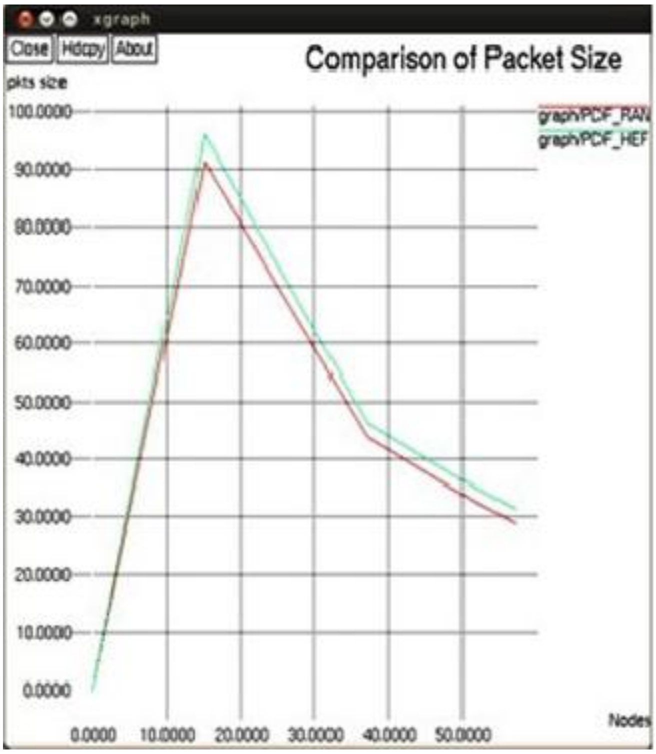

Figure8. Hopping and Random comparison in terms of node handling packet sizes

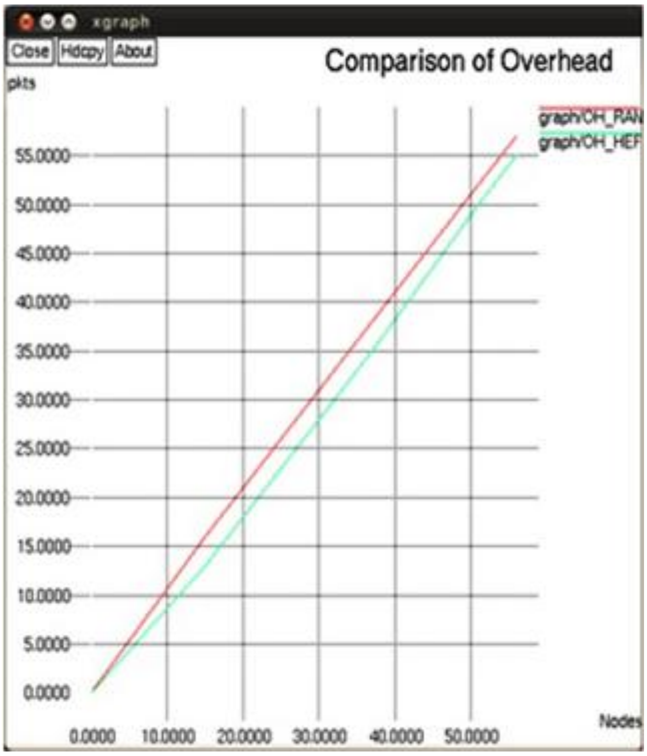

Figure10. Hopping and random comparison in terms of node over head

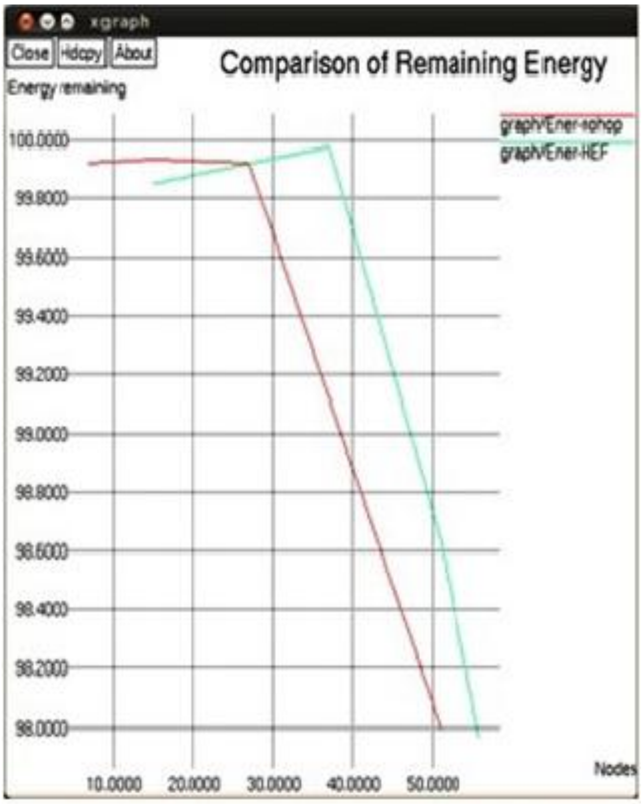

Figure11. Hopping and non-hopping comparison in terms of energy remaining in node

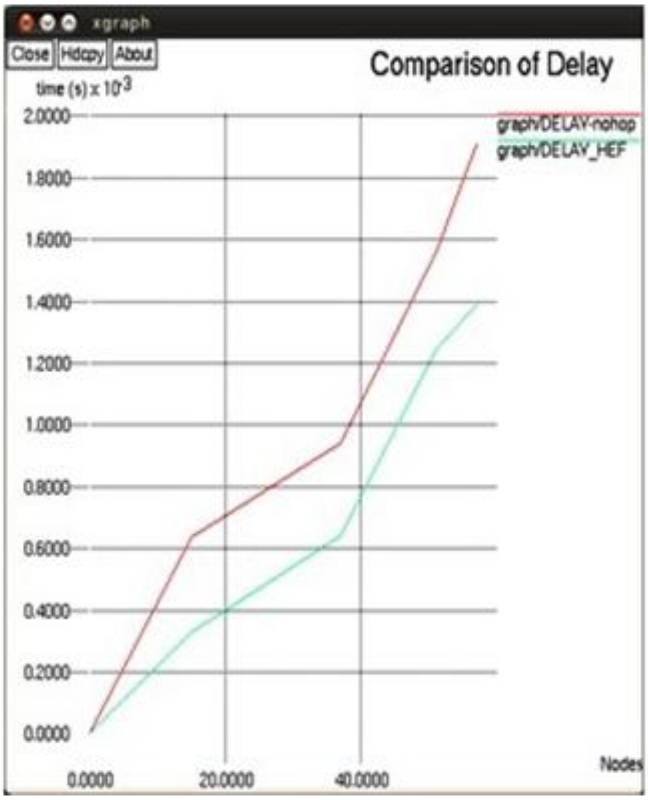

Figure13.Hopping and non-hopping comparison in terms of packet delay

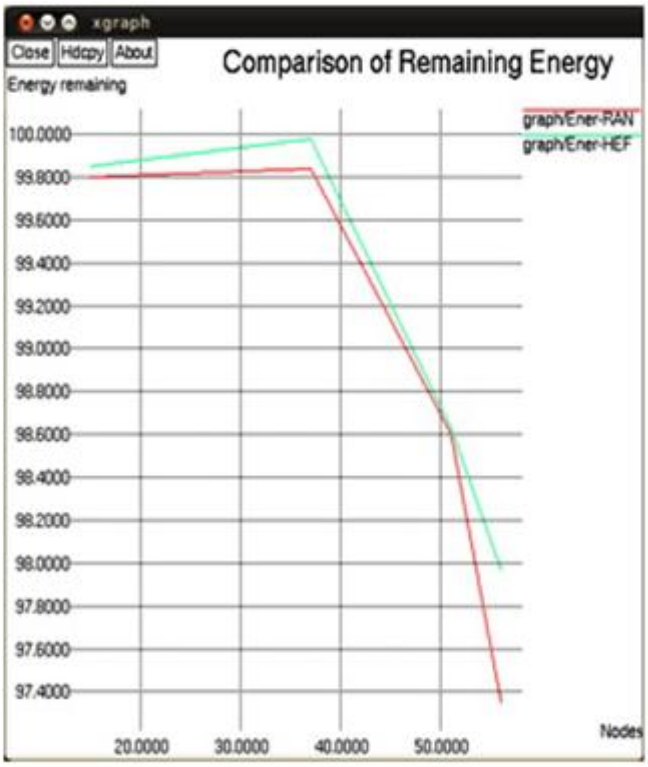

Figure12. Residual energy with random and hierarchical hop

Figure14.Hopping and random comparison in-terms of packet delay

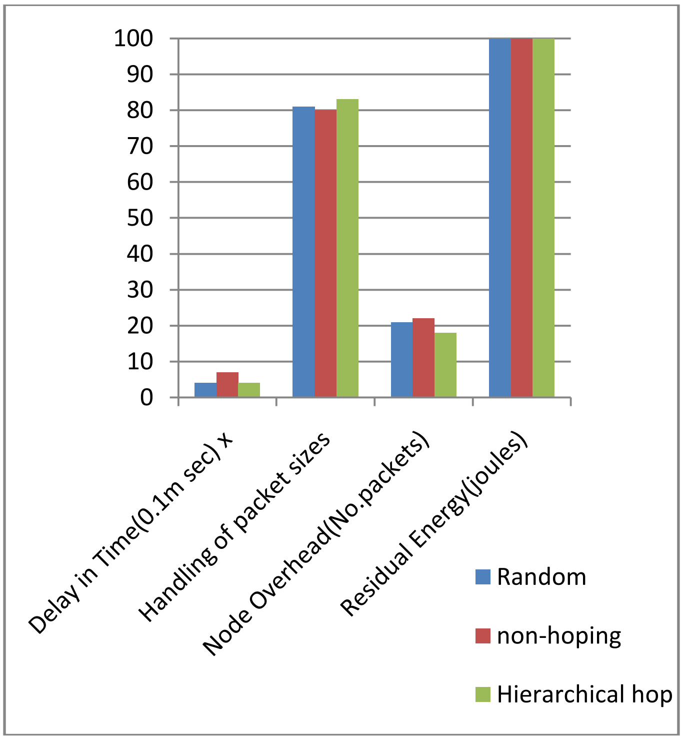

Fig 15. 20 number of nodes in sensing process

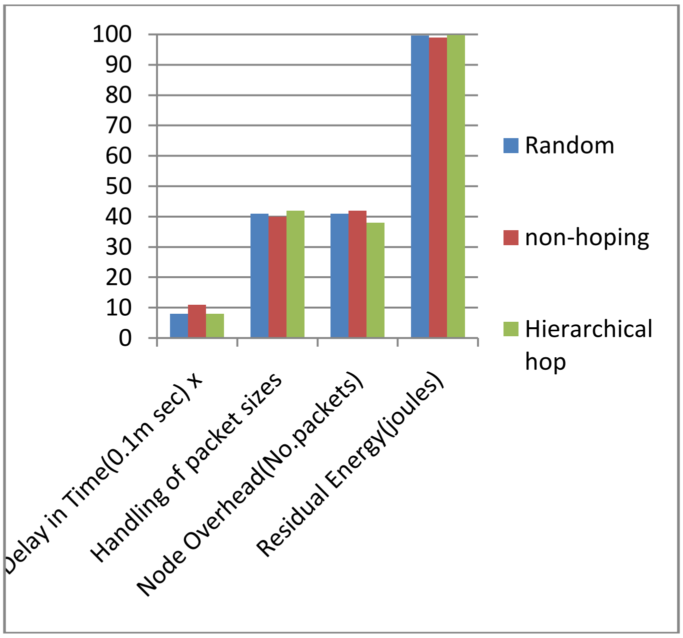

Fig 16. Results of large number of nodes in sensing process

VI. CONCLUSIONS

Here it is developed and simulated an energy efficient algorithm for in wireless sensor networks wherein conserve the energy of the nodes by involving less number of nodes in data transmission. Here it is compare the results of our protocol with the conventional non hopping protocols, and from the results and observations, the residual energy remaining increases, node overhead, delay and the packet size decrease. The results are also compared with number of nodes presents in the sensing process. Irrespective of the node number, hierarchical hop routing protocol is energy efficient than the others.

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