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Power Efficient Advanced Node Clustering Hierarchical Protocol for Wireless Sensor Networks

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Abstract *: In this paper, a new power efficient advanced node clustering hierarchical (PEANCH) algorithm for wireless sensor networks is developed and analyzed. In this algorithm we introduce the concept of advanced nodes and normal nodes, where the advanced nodes are given with double the initial energy as of the normal nodes. Advanced nodes are acting as cluster heads and assigned with fixed coordinates, whereas the normal nodes are deployed randomly. Parameters such as first node death, last node death, total network lifetime, energy consumption, latency and throughput are considered for the analysis. It is observed that the network life time is 1.33 times more efficient than widely accepted and popular protocol such as low energy adaptive clustering hierarchy (LEACH).*
Keywords: *Wireless Sensor Networks, energy efficiency, routing protocols, LEACH, throughput, network lifetime.*

I. Introduction

Unprecedented growth has been seen in the wireless sensor networks (WSN) in past few years [1]. They have large number of applications in industries and even in domestics from health monitoring of a building to monitoring of dangerous chemicals, leakage from nuclear plants and industrial automation [2]. Such application growth has resulted in many technological developments and improvements in this type of networks. Key design requirements for the WSNs include cost, weight, battery life, efficient node placement and coverage area [2]. More researches are being undertaken to improve the performance.

In major applications like military and health care monitoring, the nodes deployed in a WSN have limited power levels and thus with periodic transmission of data, they spend some energy and eventually drain out of the energy completely. Transmission of data packets can be easily performed from one node in the network to any distant node, if the node is having sufficient energy levels. If a node has to transmit its data to a node which is located far away, then a large amount of transmission energy is needed. Since all nodes spend some energy in each round of transmission, they will slowly start dying eventually. The time till the node one (first) in the network dies is known as the network lifetime [2]. So, in order to maximize the lifetime of a network, routing of data should be done in such a way that a path is chosen based on the energy levels remaining in the nodes.

WSN routing protocols are normally classified into network architecture based routing protocols and operation based routing protocols [3]. Apart from these, we also have proactive, reactive and hybrid routing protocols. A number of protocols are developed and implemented in the real time [4]. With the increase in technology, the algorithms are more optimized than the existing protocols. Some of the existing protocols are low energy adaptive clustering hierarchy (LEACH), energy aware multi-hop multi-path hierarchical (EAMMH), power efficient gathering in sensor information networks (PEGASIS), modified low energy adaptive clustering hierarchy (MOD-LECH), low energy adaptive clustering hierarchy centralized (LEACH-C) [5-7]. For instance, the use of sensor networks in medical field for monitoring a patient health and the surrounding conditions is growing [8]. In health care applications, large amount of data like blood pressure, heart beat and oxygen level has to be collected and analyzed even from remote location. During this time more amount of energy levels will get drained from the batteries of wireless Internet of things (IoT) modules resulting in the network failures. Thus, an optimized algorithm is needed to reduce power consumption by the sensor nodes in the entire sensor network and to ensure that network is always up and running.

In this paper, we have developed a protocol called power efficient advanced node clustering hierarchical (PEANCH) algorithm which is energy efficient for WSN. It is cluster based where we introduce the concept of advanced nodes and normal nodes. The advanced nodes (ANs) are supplied more initial energy than the normal nodes (NNs). ANs are acting as cluster heads and assigned with fixed coordinates, whereas the NNs are deployed randomly. It is observed that the lifetime of the network has increased significantly. Apart from this, the performance in respect of other performance parameters such as power consumption, latency has also improved. We have compared this developed protocol with some of the popular and known power efficient algorithms and PEANCH performance is found to be better.

Rest of the contents of the paper is given as follows. In section II, we discuss the system architecture and related works. Details of the proposed algorithm is discussed in section III. Section IV presents the performance of the protocol while section V, concludes the paper.

II. System Architecture and Related Works

The working of WSNs at very broad level mainly reckon upon three devices equipped in the nodes namely sensors, central processing unit (CPU), and the radio. These devices' functionalities are combined depending on the use of the sensor. The sensors are used for sensing different types of data, CPU for processing the data sensed and the radio transceiver to transmit the processed data to the next node or receive the data from another node [2].

The architecture of WSN comprises of sensor nodes and base station or sink node as shown in Fig.1. Based on the application, the sink node may be connected to the cloud and then to the Internet. The function of the node is to make distinct, local analysis about the phenomenon in the area where sensors are placed by creating a wireless network, then to broadcast over a wireless medium to the another node or directly to the sink node. In addition to that, a node also functions as gathering data from different nodes, aggregating and then sending the same data to the sink node at once in the form of packets. The data recovered from the field is routed back to the sink either by single hop or multi hop routing protocols especially when the network size is large. For the large network, sensor nodes are divided logically into clusters.

Related Works:

Clustering based protocols are suitable for heterogeneous WSN [9-10]. In this paper for the heterogeneous WSNs, two new clustering- based protocols namely single-hop energy-efficient clustering protocol (S-EECP) and multi-hop energy-efficient clustering protocol (M-EECP) have been proposed. In S-EECP, the cluster heads (CHs) were selected based on the ratio between the remaining energy of each node and average energy of the network. The nodes having higher initial energy and the residual energy become the CHs. In fact M-EECP CHs transmit the data packets to the base station through the hop (relay) communication approach. Simulation results showed that the protocol prolonged the network lifetime. Furthermore, the load balancing is also achieved among the CHs, which is better than the existing clustering protocols such as LEACH, EAMMH. However, issues regarding bandwidth and power efficiency were not addressed.

LEACH protocol is an energy efficient protocol developed by Heinzelman [5]. In LEACH, a medium access control (MAC) protocol [6] based on time division multiple access (TDMA) is combined with a clustering and a simple "routing" protocol. In this, the entire network is detached into clusters where each cluster has a single CH. This CH gathers the data from the other nodes within the cluster for transmission. The CH energy would die sooner than the other nodes and communication stops. It is for this reason that the cluster heads need to be assigned periodically among the selected one. A new cluster heads is selected in each round in each cluster. Each round is splitted into a setup phase and a steady-state phase. The set up phase starts with the cluster heads election. All the nodes in the cluster can become the cluster head if they wish on the basis of a certain probability.

Energy aware multi-hop multi-path hierarchical (EAMMH) [7] routing protocol is one of the recent power efficient algorithms. Similar to LEACH, EAMMH will divide the whole network into clusters, and CHs are elected from each cluster for every round. However, unlike in LEACH, the CHs aggregate all the sensed data and send them to the sink node via multi-hops. The path is chosen in such a way that the overall energy consumed in that path is the least. The nodes in that path should have minimum threshold energy. If one of the nodes in that path does not possess the minimum threshold energy, it chooses a different path. An improved LEACH, the PEANCH is developed in our work. We discuss this in the following section.

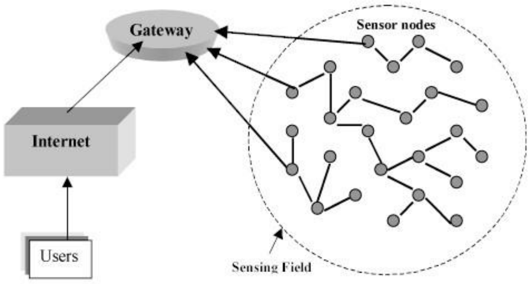

Fig. 1. Wireless sensor network.

III. Proposed Protocol

The PEANCH is an optimized version of LEACH. In this, the sensor nodes are divided in to normal nodes and advanced nodes. These are categorized based on their initial energies. The ANs are chosen as CHs. In each round, one AN from each cluster is elected as the CH of the respective cluster for that particular round. The measure of power drained by each cluster head in one round is calculated by:

$$CH_{ec} = N * (E_{elec} * cpkt * (a-1) + E_{mp} * cpkt * BS_{dist} + a * cpkt * E_{DA} + E_{elec} * cpkt \quad (1)$$

where N is the number of frames, Eelec is the transmitter or receiver electronics, cpkt is the packet length i.e., 4000bits. a denotes the number of alive nodes and it is (a-1) because the cluster head is excluded. Emp is the energy consumed by the amplifier in the transmitter. A BSdist is the distance from the cluster head to the base station. EDA is the energy consumed for data aggregation.

The operation of the PEANCH protocol is detached into two phases namely, setup phase and steady phase. Procedure for the setup phase is as shown in the Fig. 2:

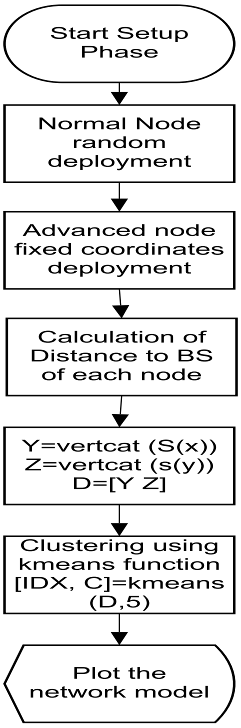

Fig.2: Setup Phase Flowchart.

The NNs are supplied with initial energy of 0.5J and deployed randomly whereas the ANs with initial energy of 1J are given fixed coordinates.It uses k-means function to divide the whole network into 5 clusters.The identification number of the node (IDX) indicates the member of a cluster. For example, IDX (1) = 3 means the node with the identification number (ID) 1 belongs to cluster number 3. Therefore IDX value assigns the node to the respective cluster. Once the nodes are assigned, the total number of nodes in each cluster is calculated. The setup phase completes with clustering and deployument. Next is the steady phase where the nodes transmit the sensed data to the sink node through a number of steps which are as shown in the Fig. 3.

i. All the information about a node i.e., the ID number, the status of the node (dead or alive), the distance of the node to base station and its *x* and y-coordinates is copied to the cluster array of that node.
ii. Each node is chosen one by one and the distance between that node and other nodes is calculated and added to the distance of the node from the base station. Same is repeated for other nodes in the cluster.
iii. After calculation in the cluster, the overall distance is divided by the number of nodes in that cluster. This is the average distance the data has to be transmitted from the sensor node to CH and to base station.
iv. This is repeated for other cluster and the steady phase round begins. The AN in each cluster is elected as cluster head for that particular round.
v. At the start of each round the number of ANs is calculated because only ANs are eligible to become the CH until all of them are dead in the respective cluster.
vi. Energy of each node is calculated and if it is less than or equal to 0, the status of the node is considered to be ‘dead’.
vii. Number of dead and alive nodes is calculated after each round.

viii. Energy of the node divided by distance, a parameter to check if the node is capable to become a CH. This is termed as EbyD.
ix. The ANs with the highest EbyD value is chosen as the CH of that cluster for that particular round.
x. Once the node becomes the CH for a particular round, it cannot be the CH for the next round.
xi. Once the CH is elected, the other cluster members send the data to the cluster head through a single hop. All the data received by the CH are aggregated into packets and these packets are sent to the base station through a single hop.
xii. As the simulation runs, the ANs slowly start dying. After the death of ANs the network becomes useless as there is no transmission of data. For this reason, the PEANCH algorithm ensures the NNs take the role of CHs after all the ANs in that cluster are dead.
xiii. At the end of each round, the number of dead nodes, number of alive nodes, total amount of data sent to base station and total energy consumption are plotted in different figures.

In PEANCH algorithm the first node dies around 900th round whereas in the LEACH, the first node dies around 100th round. In EAMMH, the first node dies around 150th round. It shows that PEANCH is 9 times better than LEACH and 6 times better than EAMMH. Performance analysis of these protocols is explained in next section.

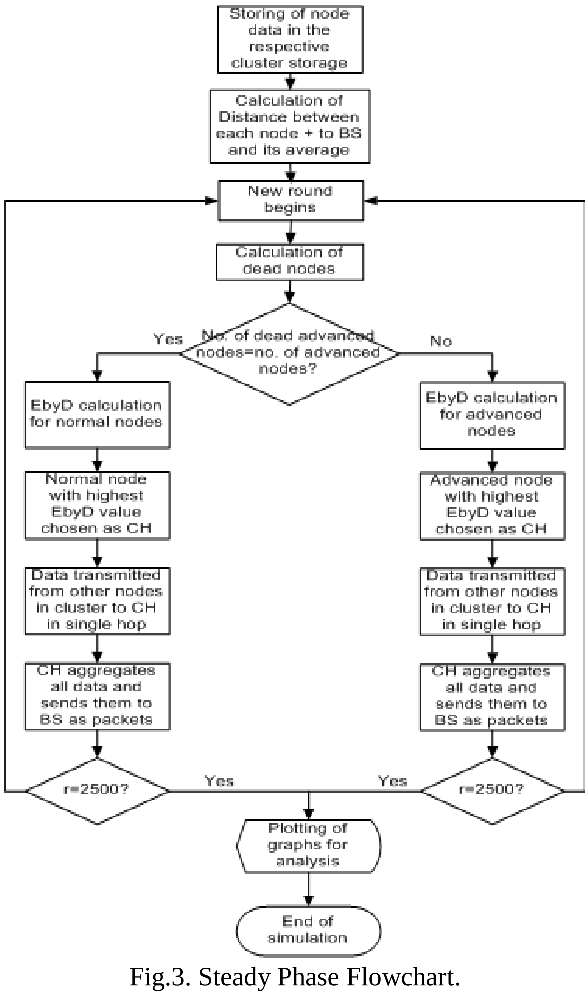

Fig.3. Steady Phase Flowchart.

IV. Results and Discussion

The PEANCH algorithm is simulated and tested using the MATLAB simulation software. 100 nodes are deployed in a 100m x 100m area, where there are 20 ANs and 80 NNs. The ANs acts as CHs and are placed at fixed coordinates, whereas the NNs are randomly distributed in the network. ANs are allocated the fixed coordinates so as to increase the probability of having equal number of nodes in each cluster. The ANs are given double the initial energy, as of the NNs. The simulation specifications are shown in Table1. As the ANs have to receive the data from the other nodes as well as they have to transmit the aggregated data to the sink node, the receiver and transmitter electronics contribute to the energy consumed by a cluster head whereas only transmitter electronics contributes to the energy consumed by a normal node.

The network model is shown in the Fig.4, where the ANs are depicted as larger nodes and the NNs are smaller in size. On an average in each cluster there are 4 ANs. In the above diagram there are 5 clusters with each cluster having 20 nodes. Each cluster is differentiated by various symbols.

Table I. Simulation Specifications of PEANCH Protocol.

PARAMETER	VALUE
Network size	100*100
Number of nodes	100
Packet size	4000 bits
Number of normal nodes	90, 85, 80, 75 &70
Number of Advanced Nodes (AN)	10, 15, 20, 25 & 30
Initial energy of normal nodes	0.5J
Initial energy of advanced nodes	1J
Number of rounds	1000, 2000 & 3000
Transmitter electronics(ETX)	50nJ/bit
Receiver electronics(ERX)	50nJ/bit
Data aggregation energy	5nJ/bit

Table II. Comparison between leach and peanch for first node death.

No: of Rounds	**LEACH**	**PEANCH No: of Advanced Nodes**				
		10 AN	***15 AN***	***20 AN***	***25 AN***	***30 AN***
1000	214	650	935	840	0	0
1500	200	550	760	920	1160	1300
2000	195	640	810	820	1100	1460
3000	20	520	800	950	850	1000

For the experiments, we have considered a WSN with number of nodes as N=100 of which ANs are varied from 10 to 30 in multiples of 5 in an area of 100m x 100m field. Results have been taken by fixing the packet size to 500bytes for various rounds such as 1000, 2000 and 3000. To get better performance of the developed algorithm, we have allocated 1J of energy for ANs and half of the AN energy is distributed to normal nodes.

The following parameters are considered for evaluating the performance analysis of PEANCH and LEACH protocols.

Number of rounds at which one node death occurred
Network lifetime
Latency
Throughput
Energy Consumption

Fig. 5 shows the plot of number of rounds vs the round at which the first node death occurred and Table II shows the comparison between the PEANCH and LEANCH protocols for the parameter of first node death. It can be seen from the Fig. 5 and Table. II, that in the LEACH algorithm, the first node death is occurring at 214 rounds for 1000 iterations, and thereafter we can see that there is a drastic decrease in first node death as the number of rounds linearly increased i.e. for 3000 iterations first node death occurred at 20th round where as in PEANCH, the experiments were carried out by taking maximum of 5 clusters, and in each cluster we have fixed the coordinates of advanced nodes. The first node death is occurring at 650 rounds for 1000 iterations, and when we compare with LEACH, the developed algorithm is three times better than LEACH. We can also see that there is a zero first node deaths as the number of rounds linearly increased i.e. for 2000 & 3000 iterations there is no occurrence of first node death. This is because of the advanced nodes in the PEANCH are given the opportunity to become cluster heads, whereas in LEACH all nodes get an opportunity to become cluster heads.

Fig. 6 and Table-III show the plot of number of rounds vs number of dead nodes i.e. network lifetime. It is seen that in

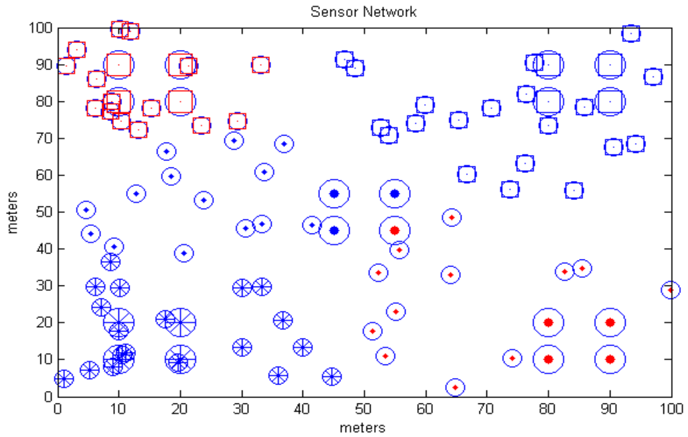

Fig.4: Arrangement of advanced and normal nodes.

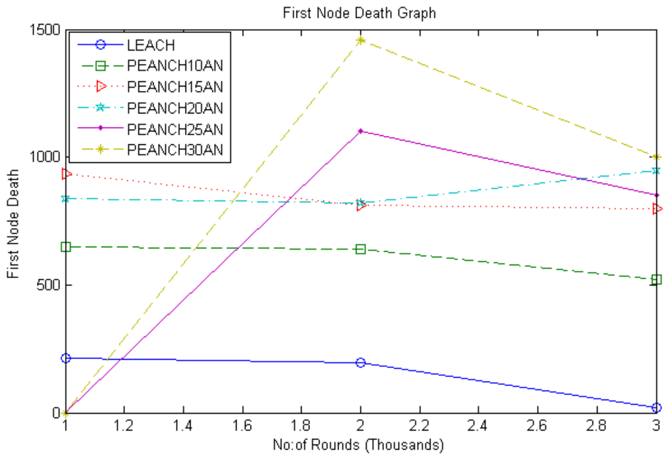

Fig.5: Number of rounds vs round at which first node death Occurred

LEACH, from 2000 rounds, all the nodes are died while in PEANCH, at 3000 rounds, the nodes are still alive except for the 10AN. From this we can conclude that the lifetime of a network is less in LEANCH when compared with PEANCH.

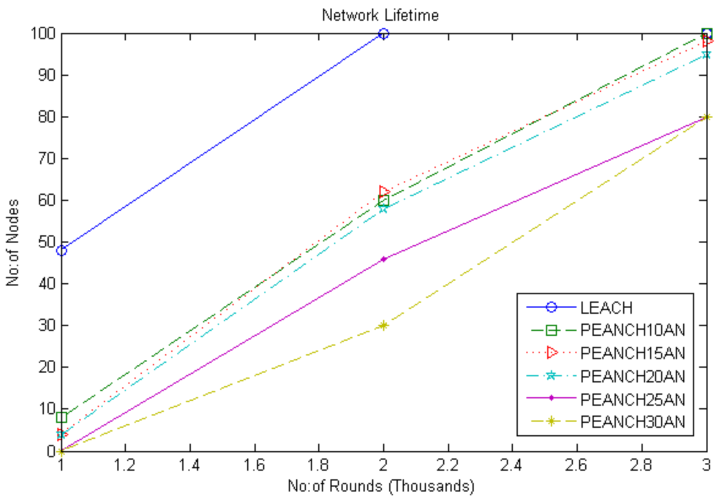

Fig.6: Number of rounds vs number of dead nodes.

Table III. Comparison between leach and peanch for network lifetime.

No: of Rounds	LEACH (100)	PEANCH No: of Advanced Nodes

		10 AN	*15 AN*	*20 AN*	*25 AN*	*30 AN*
1000	48	08	04	04	0	0
2000	100	60	62	58	46	30
3000	100	100	98	95	80	80

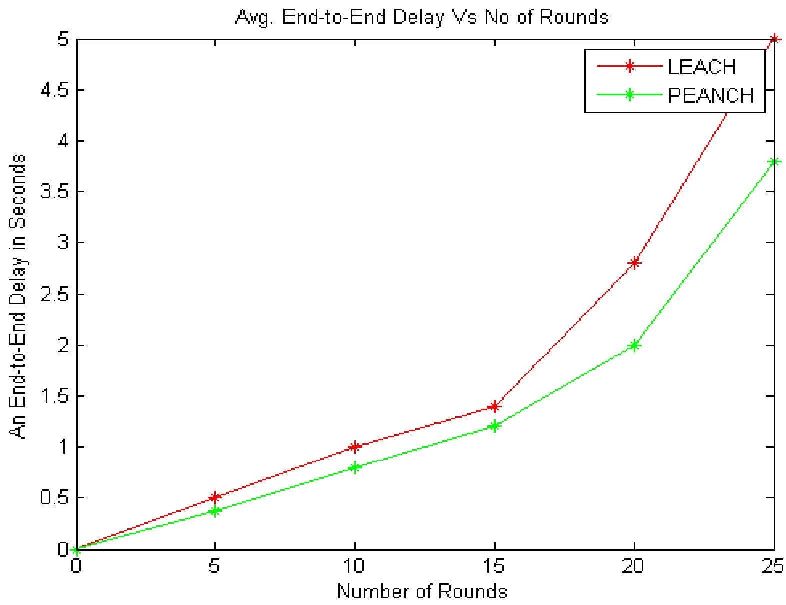

Fig.7: Number of rounds vs Delay

Fig.7 shows the plot of number of rounds to delay. It is observed that the end to end delay is also reduced as compared to the LEACH. The average end to end delay of a packet depends on discovery of route latency, transmission delay, the delay that is occurred during the propagation of packets, delays occurring at each hop and the total number of hops. In LEACH algorithm, end to end delay depends upon number of nodes and data traffic. The end to end delay increases rapidly when there is an increase in number of nodes and data traffic. It can be seen that the end to end delay is 5sec in LEACH after 25 rounds where as it is 3.5sec in PEANCH after the same no. of rounds. With increase in simulation time, the end to end delay in LEACH is 20sec after 100 rounds while it is 14sec in PEANCH. After 1000 rounds the end to end delay in LEACH is 200sec whereas in PEANCH the end to end delay is 140sec. As we considered the total number of rounds as 3000, then the end to end delay in LEACH at the end of simulation is 500sec, whereas in PEANCH the end to end delay at the end of simulation is 350sec. Thus for all the cases, the delay performance is better.

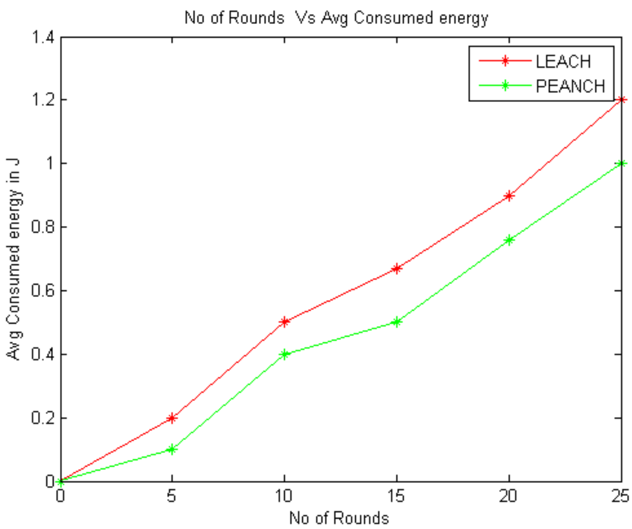

Fig.8: Number of rounds vs average energy consumed

Fig.8 shows the energy performance. Total energy consumption is defined as the amount of energy consumed during the process of transmission, reception, idle time and sleep time by the nodes. In idle mode, the amount of energy consumed is ignored in PEANCH algorithm. It is observed that energy consumption is more while transmitting the data packets than receiving the data packets. The nodes do not consume energy during their sleep state. When there is an increase in the number of nodes or traffic load, the energy consumption in LEACH as well as in PEANCH increases. But the performance of PEANCH is better than LEACH due to its low routing overhead at all the specified number of nodes variation. It can be seen from the Fig.8 that the average energy consumed by each node in LEACH is 1.2J after 25rounds, where as it is 1J in PEANCH. With increase in simulation time, the average energy consumed by each node in LEACH after 1000 rounds is 48J, whereas it is 40J in PEANCH. At the end of simulation i.e., after 3000 rounds the average energy consumed by each node in LEACH is 120J, whereas it is 100J in PEACH. It shows that PEANCH protocol is more power efficient than LEACH protocol.

Fig.9 shows the average throughput performance. We notice that the throughput attained in PEANCH is better than the LEACH especially when the nodes begin to die. This is because advanced nodes are cluster heads in PEANCH which have a larger initial energy than the cluster heads in LEACH. It can be seen that the throughput of PEANCH protocol after 200ms is 180, whereas it is 160 in LEACH.

In PEANCH, the energy consumed by nodes per 100 rounds is reduced by approximately 1J per 100 rounds. The average end-to-end delay per 100 rounds in LEACH and PEANCH is 20sed and 14sec respectively. Thus, the delay produced in PEANCH per 100 rounds is reduced by 6sec. And there after the delay is increasing linearly with a linear increase in number of rounds. Similarly, the average throughput for LEACH and PEANCH per 200ms is 160 and 180 respectively. Thus, the throughput of the PEANCH protocol is better than that of LEACH.

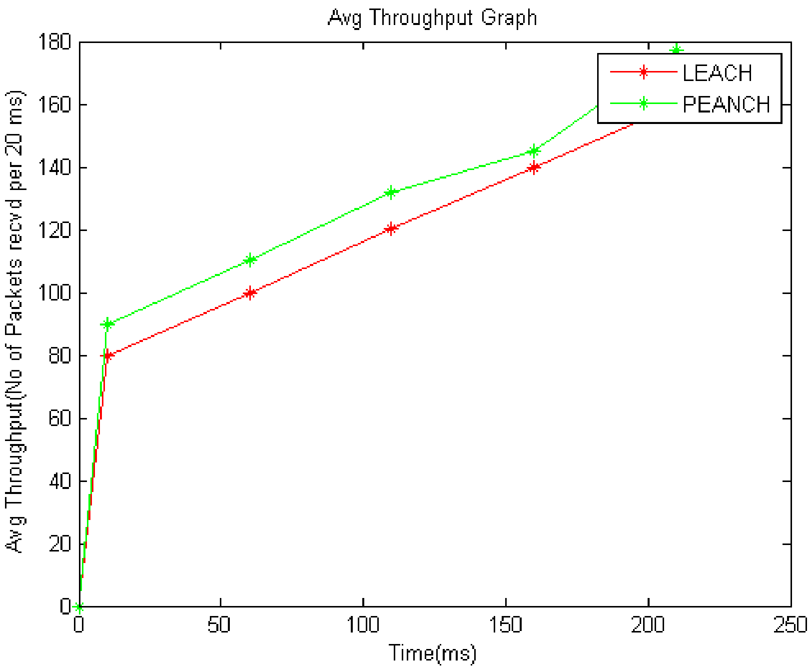

Fig.9: Time (ms) vs. average throughput

V. Conclusion

A new clustered hierarchical power efficient algorithm is developed and analyzed. It is observed that the developed algorithm has longer life time when multiple advanced nodes are considered to be cluster head. The protocol performance in a small area of 100 sqm is considered and simulation is performed. However, the applicability of this algorithm needs to be verified for larger area and for more number of sensor nodes.

References

[1]. C. Chong, S. P. Kumar. Sensor Networks: Evolution, Opportunities, and Challenges, Proceedings of the IEEE. 91(8):1247-1256, Aug. 2003.

[2]. F. Akyildiz, W. Su, Y.Sankrasubramaniam, and E. Cayirci. A Survey on Sensor Networks, IEEE Communications Magazine, 40(8):102-1 14, Aug. 2002.

[3]. Akkaya, Kemal, and Mohamed Younis. A survey on routing protocols for wireless sensor networks, Ad hoc networks 3.3 325-349, (2005).

[4]. Karl, Holger, and Andreas Willig, Protocols and architectures for wireless sensor networks, (John Wiley and Sons, 2007).

[5]. Wendi R Heinzelman, A Chandrakasan, and H Balakrishnan, Energy-Efficient Communication Protocol for Wireless Microsensor Networks, IEEE Proc.of the 33rd Hawaii International Conference on System Sciences – 2000.

[6]. Ye, Wei, John Heidemann, and Deborah Estrin. An energy-efficient MAC protocol for wireless sensor networks, INFOCOM 2002. Twenty- First Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings. IEEE. Vol. 3, 2002.

[7]. Kumar, D., Performance analysis of energy efficient clustering protocols for maximizing lifetime of Wireless Sensor Networks, Wireless Sensor Systems, IET, ISSN: 2043-6386, Mar. 2014.

[8]. Ahmed Lounis, Abdelkrim Hadjidj, Abdelmadjid Bouabdallah and Yacine Challal, Secure and Scalable Cloud-based Architecture for e-Health Wireless sensor networks, International Conference on Computer Communication Networks (ICCCN), Jul 2012, Munich, Germany. pp.1, 2012.

[9]. Xuxun Liu, A Survey on Clustering Routing Protocols in Wireless Sensor Networks, Sensors 2012, 12, 11113-11153.

[10]. Said, Jihed Eddine, Lutful Karim, Jalal Almhana, and Alagan Anpalagan, Heterogeneous mobility and connectivity-based clustering protocol for wireless sensor networks, In Communications (ICC), 2014 IEEE International Conference on, pp. 257-262. IEEE, 2014.