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EXPANDED DISTANCE BASED MULTI SINGLE HOP LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY (EMSLEACH) ROUTING PROTOCOL IN WIRELESS SENSOR NETWORK

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ABSTRACT

The principal targets of the Wireless sensor network (WSN) are to enhance the lifetime of the sensor network and also to use the sensor energy efficiently. To increase the life time of the network, network routing protocols is also one of the very important aspects. In this paper, Expanded Distance based Multi Single Hop Low Energy Adaptive Clustering Hierarchy(EMSLEACH) for wireless sensor network which is an enhancement of the Distance based Multi Single HOP Low Energy Adaptive Clustering Hierarchy(MSLEACH) is being considered and the said protocol is made to compare with multiple other existing clustering protocols based on multiple parameters. The paper also takes into consideration of different data sets for different multiple protocols and compared to know the reliability of the system. Finally, the simulation result shows that EMSLEACH outperformed the other multiple existing systems.

Keywords: wireless sensor network, network life time, clustering, cluster head, stable period.

1. INTRODUCTION

WSN is composed of number of small sensor that is limited power of battery and energy resource. Sensor node can sense, store transmit and receive the data and connected with each other through wireless medium such as radio wave to communicate to the base station. High power-consumption, lower energy efficiency, memory constraints and difficulty in recharging or replacing batteries pose many challenges to the effortless development & application of WSNs.

A sensor node also has the capability of routing. Due to the remote nature of wireless sensor networks deployment, sensor nodes face energy optimization and quick route discovery problems, different routing techniques have been proposed to address these issues efficiently.

Since a sensor node has a limited power, a sensor node has no identity when its battery dies. For efficient utilization of energy resources. The cluster-based technique is one of the good approaches to reduce energy consumption in wireless sensor networks. The lifetime of wireless sensor networks is extended by using the uniform cluster location and balancing the network loading among the clusters.

To validate our mathematical framework, we perform analytical simulations in MATLAB. Different performance parameters such as number of alive nodes, number of dead nodes, residual energy are selected for multiple existing protocols and compared to see the reliability of EMSLEACH.

Almost all the clustering techniques consist of two phases, i.e. setup phase and steady phase. In setup phase, election of CH and formulation of cluster is performed, while in steady state, data is transmitted from node to CH, CH then aggregate this data and transmit to the base station.

The main objectives of this paper is to extend MSLEACH protocol and compare with the other multiple existing systems such as “Low energy adaptive clustering hierarchy (LEACH)”, “power efficiency data gathering and aggregate in sensor information system (PEGASIS)”, “Stable election protocol (SEP)” and “Distance Based Cluster Protocol (DBCP)” to see the reliability and accuracy of the EMSLEACH system.

The remaining part of the paper is organized as follows. In part II, we highlighted about the related work with respect to EMSLEACH protocol. In part III, we highlighted about the MSLEACH protocol description. The part IIIA describes about the EMSLEACH protocol description and its expansions over the MSLEACH. The part IV shows the comparison table of EMSLEACH protocol with multiple other protocols based on certain properties and attributes-.

The part V shows the performance evaluation of EMSLEACH protocol by simulation through many parameters and compared it with LEACH, PEGASIS, SEP and DBCP protocols in many aspects. Finally, the part VI presents the concluding and future scope remarks.

2. RELATED WORK

Wendi B. Heinzelman *et al* [1] propose the micro sensors which are designed with low-power electronics and low-power radio frequency (RF). The limitation of resources like communication bandwidth and energy in micro sensors are an important challenge in the design of such networks. This paper proposes LEACH, a clustering based routing protocol that utilizes randomized rotation of CHs to evenly distribute the energy load among the sensors in the network. Timothy J. Shepard [2] discusses about the two parameters of the transmitted signal that are important for understanding system performance i.e. the transmitted signal’s power level and its bandwidth. Successful reception of the message at the receiver will depend upon receiver performance, the power level of interfering signals at the receiver and the received power level of the signal containing the message. E.J. Duarte-Melo. *et al* [3] state that there are three common types of communications in a wireless sensor network: Clock-driven, Event-driven and Query- driven. This paper examines sensors which are equipped with different battery power in a Clock-driven sensor network and consider a field randomly deployed with sensors that gather data and transmit it back to a remote receiver which is assumed to be located away from the sensing field sensors. This paper considers maximizing the lifetime of the network while minimizing the number the number of clusters (q) in order to be scalable .Therefore, the optimal average number of clusters is determined.

K. Kalpakis *et al* [4] discuss about the wireless networks that consist of hundreds of inexpensive nodes that can be deployed in physical environment to collect information. Information is collected from each node and data aggregation is done and then sends it to the sink.

Huseyin Ozgur Tan *et al* [5] introduce two algorithms: PEDAP (Power Efficient Data Gathering and Aggregation Protocol) and PEDAP-PA (Power Efficient Data Gathering and Aggregation Protocol-Power Aware) which are based on minimum spanning tree routing scheme, where one of them is the power aware version of the other. They perform well in both systems where base station is far away from the nodes or inside the field.

W. Steven Conner *et al* [6] introduce two energy saving protocols that work together to allow sensor network nodes to conserve energy by sleeping. This paper describes several applications deployed throughout a building monitoring conference room occupancy and environmental statistics and thus provides access to room reservation. The two protocols are: Relay Organisation (ReOrg) and Relay Synchronization (ReSync).

I.F. Akyildiz *et al* [7] describe the concept of sensor networks that has been made viable by the convergence of micro electro-mechanical systems technology, wireless communications and digital electronics. Here, the sensing tasks and the potential sensor networks applications are explored, and a review of factors influencing the design of sensor networks is provided so that the communication architecture for sensor networks is outlined.

Vivek Mhatre *et al* [8] discuss about homogeneous vs. heterogeneous LEACH system. A single-hop homogeneous network system ensures that relatively complete utilization of overall network energy distributed among all nodes but each sensor node must be designed with necessary hardware capabilities to act as a CH in this network. In the case of heterogeneous sensor network, all the sensor nodes except cluster head can be designed with simple hardware that enables short range communication but the sensor nodes near the periphery of the cluster expend more energy than those near the CH. Lindsey *et al* [9] proposed a protocol called Power Efficiency Data Gathering and Aggregate in Sensor Information System (PEGASIS). It is also the one of the well-known chain base routing protocol for improving energy efficiency, builds a chain based on the greedy algorithm. Each node communicates only with a close neighbor and takes turns transmitting to the base station, thus reducing the amount of energy spent per round. Stable election protocol (SEP) [10] is one of the heterogeneous-aware and descendent protocol of LEACH protocol. In SEP, few nodes are randomly selected as cluster heads in a distributed fashion in two-level hierarchical wireless sensor networks. Unlike LEACH, election probabilities of nodes as cluster heads are weighted by the initial energy of a node relative to that of other nodes in the network. SEP maintains clustering hierarchy and the clusters are re-established in each round and as a result the load is well distributed and balanced among the nodes of the network. In MSLEACH [11], we break the rule that only the cluster head (CH) has to report to the sink. In set-up phase of cluster formation, each node that elects itself as a cluster-head for current round, broadcasts advertisement message to rest of the nodes. All the cluster heads transmit advertisement message using same energy level. Non-cluster head nodes must keep receivers on during this phase to get this message. After this, they decide which cluster to belong to for the round by choosing cluster-head that requires minimum communication energy. The proposed system adds an intermediate step of comparing two distances before deciding which cluster head has to be chosen by a non-cluster head node. After identifying the nearest cluster head of a non-cluster head node for dissipating minimum intra-cluster communication energy, we compare the distance between the sink and the non-CH, and the distance between that non-cluster head and the nearest CH before taking membership to that particular CH. If the distance between the non-CH node and the sink is shorter, then the non-CH node is independent of that CH and will not be the member of any CH for the current round. Such node is named as independent node. Otherwise, that non-CH node acts as a member of the CH. Independent nodes for a round are eligible to send reports for itself to the sink with compressing its own sense data. In Distance based Cluster Protocol(DBCP),the objective is to increase the stable lifetime of the wireless sensor network and ultimately to increase its lifetime based on the method of taking membership during cluster formation to minimize energy dissipation among the sensor networks. Our method introduces an independent node, which is nearer to the sink, and such independent nodes can transmit their own sensor data after compressing directly to the sink. In DBCP, we break the rule that only the cluster head (CH) has to report to the sink. In set-up phase of cluster formation, each node that elects itself as a cluster-head for current round, broadcasts advertisement message to rest of the nodes. All the cluster heads transmit advertisement message using same energy level. Non-cluster head nodes must keep receivers on during this phase to get this message. After this, they decide which cluster to belong to for the round by choosing cluster-head that requires minimum communication energy. The proposed system adds an intermediate step of comparing two distances before deciding which cluster head has to be chosen by a

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non-cluster head node. After identifying the nearest cluster head of a non-cluster head node for dissipating minimum intra-cluster communication energy, we compare the distance between the sink and the non-CH, and the distance between that non-cluster head and the nearest CH before taking membership to that particular CH. If the distance between the non-CH node and the sink is shorter, then the non-CH node is independent of that CH and will not be the member of any CH for the current round. Such nodes are independent nodes. Otherwise, that non-CH node act as a member of the CH. Independent nodes for a round are eligible to send reports for itself to the sink with compressing its own sense data.

3. MSLEACH PROTOCOL

The principal aim of the protocol is to elongate the system life and efficient energy utilization in each of the nodes. Here 2 tier energy level are being used. In 2 tiers energy level routing protocol, 2 groups of nodes i.e. advanced nodes and normal nodes are available. Advance nodes are assumed to possess more energy level than normal nodes.

In this system, multi-hop LEACH inter cluster communication is done through CH which are at intermediate location to communicate if the CH and sink's distance scattered is greater than CH and sink's average distance. Otherwise, CH communicate to sink directly. LEACH multi-hop selects the best path with the minimum hop count between CH and sink directly i.e. single hop. Then the CH which are far away from sink (the distance between that particular CH and sink) analyze and identify the nearest CH which communicate to sink at single hop and used this CH as its intermediate node for inter cluster communication.

From all these, we conclude that MSLEACH heterogeneous nodes system of LEACH can survive longer than LEACH homogeneous LEACH.

3.1 THE EXPANDED MSLEACH (EMSLEACH) Protocol

The EMSLEACH system is proposed to increase the overall life time of the network. It is an expansion and analysis of MSLEACH in details taking into consideration of more parameters and attributes while evaluating the performance of the network and is made to compare with more existing systems by considering the multiple data sets for each existing systems unlike in MSLEACH to assess the more reliability of the system.

3.1.1 Algorithm for cluster formation and data transmission in EMSLEACH heterogeneous network

1. Set up phase

Step 1. CN(a) =) r
Step 2. If r < T(s),
CH = CN(a),
else,
CN(a) = CN(a) + 1
Goto step 1
Step 3. CN(b) =) r
Step 4. If r < T(s),
CH = CN(b),
else,
CN(b) = CN(b) + 1
goto step 3
Step 5. CH =) G:
Id(CH), joint-advertisement
Step 6. NCH(i) →CH(k):
Id(NCH(i)), Id(CH(k)), joint_request
Step 7. CH →NCH(i)
Id(CH(k)), <ts(i), Id(NCH(i))>

2. Steady phase

Step 1. For j=1 to n do
tot_d = tot_d + DN_BS(j)
Step 2. Avg_d = tot_d/ n
Step 3. NCH → CH(k): id(N(i)), id(CH(k)), data
Step 4. If DCH_BS < = Avg_d:
CH_S = CH
CH_S = CH
CH_S →BS: id(CH_S), id(BS), aggregate_data
Step 5. If DCH_BS >Avg_d:
CH_M = CH
Step 6. If IN(CH_M) ↔ nearest(CH_S), then
CH_M =>BS: id(CH_M), id(BS), aggregate_data
Step 7. If IN(CH_M)↔ NULL, then
CH_M →BS: id(CH_M), id(BS), aggregate_data

The symbols used in the algorithm are:
CN(a): cluster normal node to become the cluster head
CN(b): cluster advance node to become the cluster head
r : random number (0<r<1)
T(S): threshold value
Id : identification number
CH: cluster head
G : all nodes in the network
joint_advertisement: advertisement message to join the cluster
NCH: Non cluster head node
joint_request : request message to join the cluster
ts: time slot to send the sense message
DN_BS: distance between the node and base station
tot_d: total distance between all nodes and base station
avg_d: average distance between node and base station
DCH_BS: distance between cluster head and base station
CH_S: cluster head that adopts single-hop
BS: base station or sink
CH_M: cluster head that may adopt multi-hop
IN: intermediate node for hopping
=) : broadcast
→ : unicast through single-hop
=>: unicast through multi-hop
↔: select

3.1.2 Heterogeneous Network Configuration

Here we have considered a heterogeneous network. A heterogeneous network is one in which all the nodes doesn't have equal energy. Let us assume that m fraction of the nodes has α times more energy than the

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other nodes and the total number of nodes be n. They are called advanced nodes. Therefore, number of normal nodes = (1-m)× n
Energy per normal node=e
Number of advanced nodes = m × n
Energy per advanced node= e × (1+α)
Hence the total energy of the network is equal to ((1-m) × n) × e ÷ (m × n) × (e × (1+α))

The network configuration for the simulation is as follows:
Field size =100m*100m
Number of nodes =100
Sink nodes located at (50, 50)
Initial energy per (normal) nodes = 0.5J

Election probability for a node to become cluster-head= 0.1
Message size=4000bits
Maximum round= 4000

Energy consumed by the amplifier to transmit at a short distance Efs= 10pJ/bit/m^2

Energy consumed by the amplifier to transmit at a longer distance Emp=0.0013pJ/bit/m^2

Data aggregation Energy E_{DA} =5nJ/bit/signal

4. COMPARISON

Here, the comparison between different routing protocols is being presented based on certain properties and attributes-

Table 1: Comparison of different routing protocols

PROTOCOL	LEACH	EMSLEACH	PEGASIS	SEP	DBCP
Classification	**Hierarchical / Node-centric**	**Hierarchical**	**Hierarchical**	**Hierarchical**	**Hierarchical**
Network Lifetime	Good but lower than SEP	Better than LEACH	Better than LEACH	Better than PEAGSIS	Better than SEP
Type	Homogeneous	Heterogeneous	Homogeneous	Heterogeneous	Heterogeneous
Energy Efficiency	Very high	Very high	Very high	Good	Moderate
Data Aggregation	Yes	Yes	No	Yes	Yes

5. RESULT

5.1 RESULT FOR COMPARISONS

Figures 1, 2, 3, 4 and 5 show the initial distribution of the network, where the comparison of the five routing protocol such as LEACH, PEGASIS, SEP, EMSLEACH and DBCP are implemented. Here, 100 nodes are randomly distributed in 100 *100 meter area. The sink or base station is denoted by X and Y, is placed at the centre of the field (0.5, 0.5), and its number of round is 5000. In these five protocol system, 20% of nodes are having more initial energy than the others nodes in the wireless sensor network, which are called advanced nodes. In this case 20 advance nodes are having 2 joule of initial energy out of 100 nodes in the network. The remaining 80 normal nodes are having 0.5 joule of initial energy. The advance nodes are represented by plus symbol (+) and the normal nodes are represented by circle symbol (o). In Figures 1, 2, 3, 4 and 5 all the nodes are found to be alive in the network. Figure 1.1, 2.1, 3.1, 4.1 and 5.1 show the simulation result after 5000 rounds in LEACH, PEGASIS, SEP, EMSLEACH and DBCP respectively.

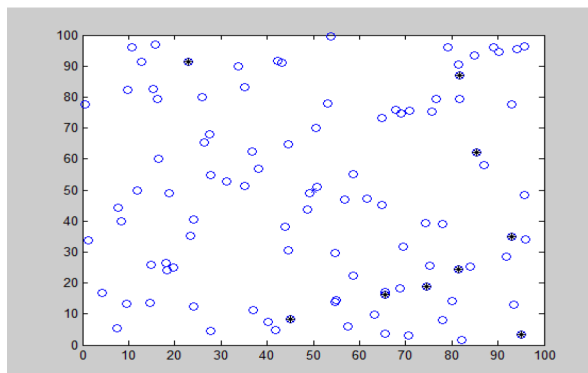

Figure-1. Initial setup phase of LEACH.

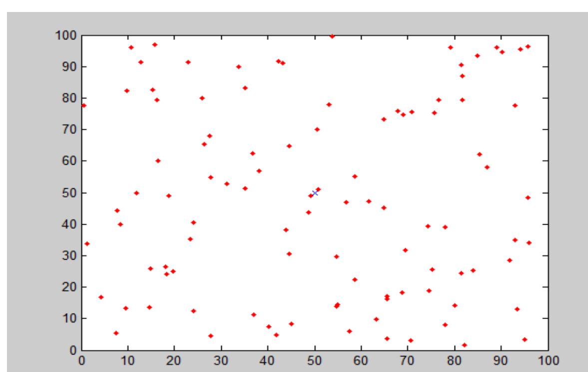

Figure-1.1. Simulation result after 5000 rounds in LEACH.

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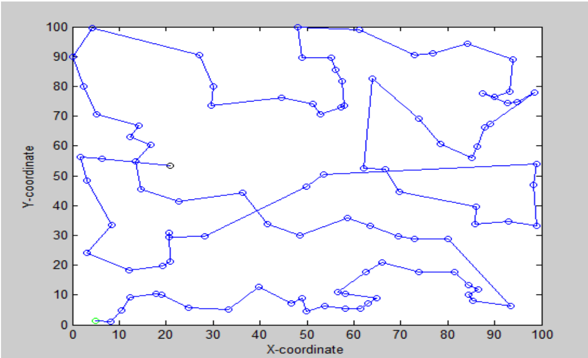

Figure-2. Initial setup phase of PEGASIS.

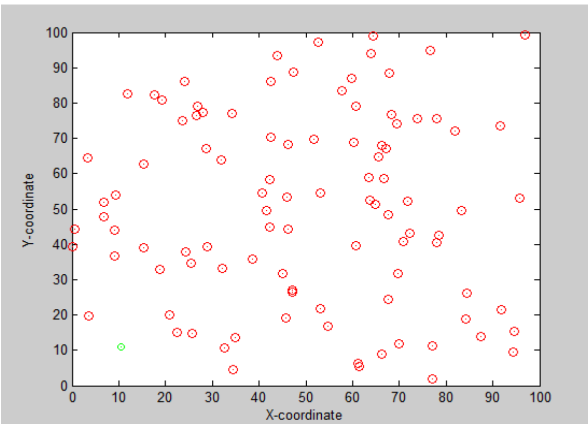

Figure-2.1. Simulation result after 5000 rounds in PEGASIS.

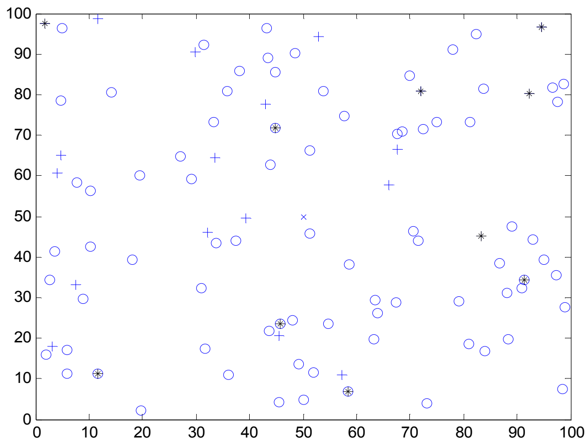

Figure-3. Initial setup phase of Stable election protocol (SEP) system.

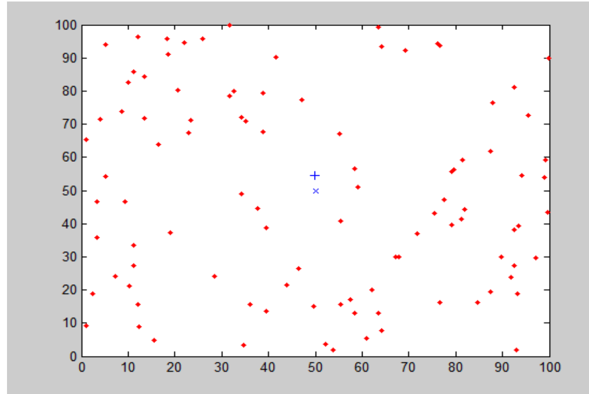

Figure-3.1. Simulation result after 5000 rounds in SEP.

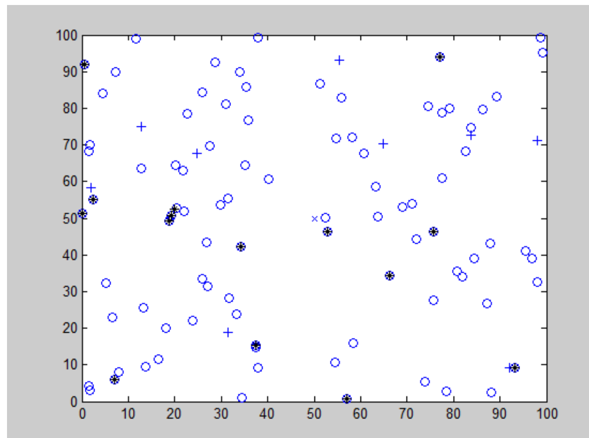

Figure-4. Initial setup phase of EMSLEACH.

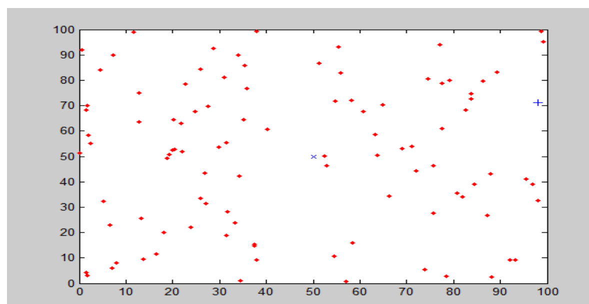

Figure-4.1. Simulation result after 5000 rounds in EMSLEACH.

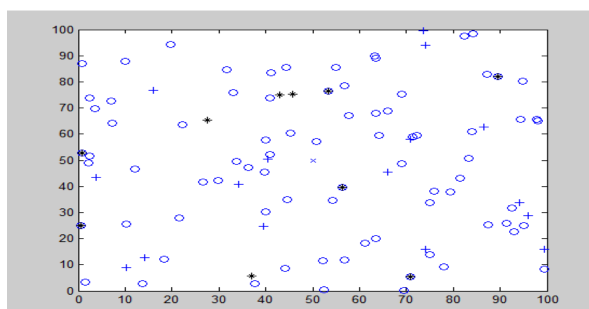

Figure-5. Initial setup phase of DBCP.

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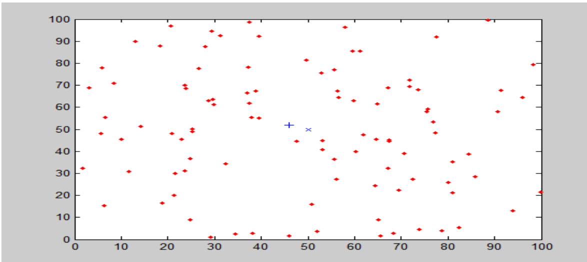

Figure-5.1. Simulation result after 5000 rounds in DBCP.

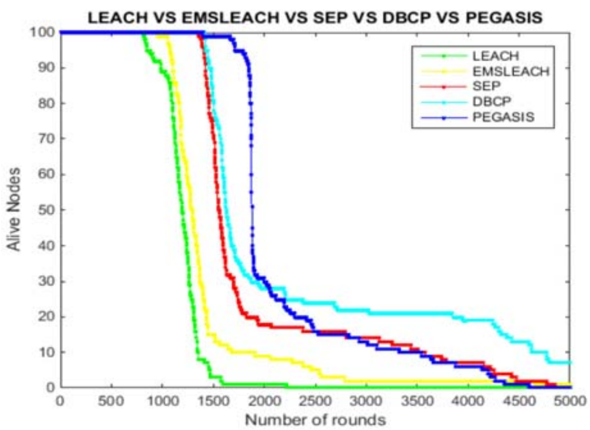

Figure-6. Number of alive nodes vs Number of rounds in LEACH, PEGASIS, SEP, EMSLEACH and DBCP system.

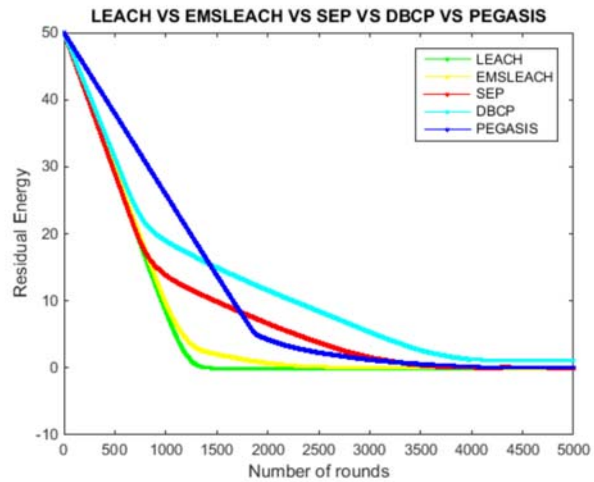

Figure-7. Residual energy vs Number of rounds in LEACH, PEGASIS, SEP, EMSLEACH and DBCP system.

Table 2: Alive Nodes Comparison of LEACH, PEGASIS, SEP, EMSLEACH AND DBCP

Rounds	LEACH	PEGASIS	SEP	EMSLEACH	DBCP
1	100	100	100	100	100
500	100	100	100	100	100
1000	89	100	100	99	100
1500	3	99	70	15	81
2000	1	31	18	9	28
2500	0	16	16	5	24
3000	0	13	14	2	22
3500	0	10	11	1	21
4000	0	6	7	2	19
4500	0	1	2	2	13
5000	0	0	0	1	7

Table 3: Residual Energy Comparison of LEACH, PEGASIS, SEP, EMSLEACH AND DBCP

Rounds	LEACH	PEGASIS	SEP	EMSLEACH	DBCP
1	50	50	50	50	50
500	29.00377	37.95846	29.01462	29.75421	31.36321
1000	8.435153	25.88572	13.85055	9.66746	18.97833
1500	-0.06359	13.82039	9.940346	2.092376	15.02042
2000	-0.10287	4.30331	6.678861	0.776749	11.62874
2500	-0.10793	2.352501	3.844219	0.166877	8.501121
3000	-0.10793	1.298257	1.647492	0.083679	5.384587
3500	-0.10793	0.629569	0.344778	0.032612	2.680242
4000	-0.10793	0.195844	-0.01745	-0.02064	1.300194
4500	-0.10793	-0.00112	0.046761	-0.07338	1.086261
5000	-0.10793	-0.01339	-0.04155	-0.07755	1.086261

CONCLUSION AND FUTURE WORK

In this paper, we have described about low energy adaptive clustering (LEACH), power efficient data gathering and aggregate in wireless sensor networks (PEGASIS), stable election protocol (SEP), expanded distance based multi single hop low energy adaptive clustering hierarchy (EMSLEACH) and distance based cluster protocol (DBCP). And discussed about the differences and the similarities between them based on the different parameters.

In LEACH, heterogeneity level is not present, cluster stability is lower than SEP, energy efficiency is lower as compare to SEP, cluster head selection criterion is based on initial and residual energy, and the network lifetime is lower than SEP.

In PEGASIS, heterogeneity level is two, clustering stability is moderate, energy efficiency is also moderate, cluster head selection criterion is based on initial and residual energy, and the network lifetime is moderate.

In SEP, heterogeneity level is multi-database management system, clustering stability is most stable, energy efficiency is reduceamount of energy spent per round, in this, data is passed through the nearest neighbour, and the network lifetime is moderate.

In EMSLEACH, heterogeneity level is present, energy efficiency is greater as compared to LEACH, cluster head selection criterion is based on initial and residual energy, and the network lifetime is better than LEACH.

In DBCP, heterogeneity level is multi-database management system, energy efficiency is moderate, and the network lifetime is greater than SEP. In the future, we may come up with better approach to make the MSLEACH more efficient and reliable.

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