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An Energy Efficient Routing Protocol in Wireless Sensor Networks

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***Abstract*—The popularity of Wireless Sensor Networks has increased tremendously due to the Vast Potential of the sensor networks to connect the physical world with the virtual world. Since these devices rely on battery power and may be placed in hostile environments replacing them becomes a tedious task. Thus, improving the energy of these networks becomes important. The main concern in Wireless Sensor Network technology is to increase the network lifetime and to reduce the energy consumption of the sensor network. Wireless sensor nodes are dispersed typically in sensing area to monitor earthquake, battlefield, industrial environment, and habitat monitoring agriculture field, physical atmosphere conditions, and smart homes. Sensor nodes sense the environment, gather information and transmit to BS through the wireless link. The objective of the work, we advise cluster based energy-efficient routing protocol (LEACH) for Wireless Sensor Networks (WSNs).**

This work provides methods for clustering and cluster head selection in WSN to increase energy efficiency and network lifetime. It compares different methods on the basis of network lifetime. In this work, we develop and analyze low-energy adaptive clustering hierarchy (LEACH), a protocol architecture for both homogeneous WSNs and heterogeneous WSNs that combines the idea of energy-efficient cluster-based routing and media access together with data aggregation to achieve good performance in terms of system lifetime, latency, and application-perceived quality. Further, we modify the LEACH protocol that is one of the most prominent WSN routing protocol. LEACH protocol enhanced as modified LEACH (MODLEACH) by introducing an efficient cluster head replacement scheme and dual transmitting power levels. MODLEACH, in comparison with LEACH, outperforms it by using metrics of cluster head formation, throughput, and network life.

Index Terms— Wireless Sensor Network, Clustering, Energy Efficiency, LEACH, MODLEACH, Network Lifetime

I. Introduction

A usual WSN system is formed by combining autonomous devices, or nodes with routers and a gateway. The dispersed measurement nodes communicate wirelessly to a central Gateway, which provides a connection to the wired world where you can collect, process, analyse, and present your measurement data. A wireless sensor network (WSN) is a wireless network consisting of spatially dispersed and dedicated autonomous devices that use sensors to monitor physical or environmental conditions. You can use routers to gain an additional communication link between end nodes and the gateway for extending distance and reliability in a wireless sensor network. The wireless sensor is networked and scalable, require very little power. It is also smart and software programmable, and also capable of fast data acquisition, reliable and accurate over the long term, but costs little to purchase and install, and requires nearly zero maintenance A Wireless Sensor Network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. However, wireless sensor networks are now used in many civilian application areas, including environment and habitat monitoring, healthcare applications, home automation, and traffic control.

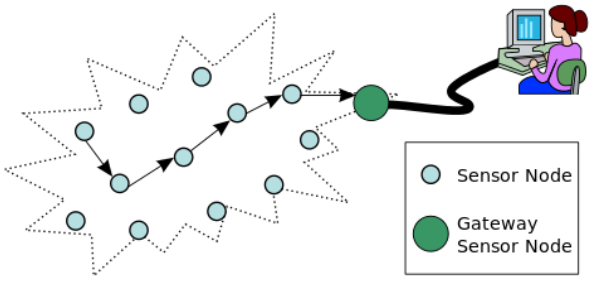

Fig. 1. Wireless sensor network

In addition to one or more sensors, each node in a sensor network is typically equipped with a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, usually a battery. The size of a single sensor node can vary from shoebox-sized nodes down to devices the size of a grain of dust. They consist of a large number of sensor nodes and one or more Base Stations. The nodes in the network are connected via Wireless communication channels. Each node has the capability to sense data, process the data and send it to the rest of the nodes or to Base Station. These networks are limited by the node battery lifetime. The development of wireless sensor networks was originally motivated by military applications such as battlefield surveillance. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and bandwidth. In computer science and telecommunications, wireless sensor networks are an active research area with numerous workshops and conferences arranged each year. WSN is used to collect data from the environment. The cost of sensor nodes is similarly variable, ranging from hundreds of dollars to a few cents, depending on the size of the sensor network and the complexity required of individual sensor nodes. Wireless Sensor Network is different from a traditional network.

- Wireless Sensor Network is a Single-purpose design means serving one specific application whereas traditional network general-purpose design means serving many applications.
- Energy is the main constraint in the design of all node and network components in wireless sensor network whereas in traditional network typical primary design concerns are network performance and latencies, energy is not a primary concern.
- Sensor networks often operate in environments with harsh conditions whereas in traditional network devices and networks operate in controlled and mild environments.

II. Motivation

LEACH gives birth to many protocols. The procedure of this protocol is compact and well coped with homogeneous sensor environment. In this protocol, a new cluster head is elected for every round. This cause unnecessary routing and uses excessive energy. In the cluster head selection process there is always a probability that some low energy node may replace it as a cluster head in the next cluster head selection process if a cluster head has not utilized much of its energy during the previous round. Thus the change of cluster head in every round considering the residual energy of the existing cluster head. There is a need to conserve this energy by an efficient cluster head replacement algorithm. For preserving energy there should be a mechanism for transmission that specifies required amplification energy for communicating with cluster head. e.g. using the same energy for transmitting data to the farthest end of the network as the base station results in wastage of energy. To solve this problem there should be global knowledge of the network and nodes decide how much energy they required to amplify the signal. Locating and calculating distances in full network topology needs a lot of routing and so, this process does not work for saving energy. To solve this problem we have two techniques, first is an efficient cluster head replacement and second is dual transmitting power level.

III. Related Works

A. *Sensor Nodes*

A mote and sensor together form a Sensor Node. A mote consists of processor, memory, battery, A/D converter for connecting to a sensor and a radio transceiver for forming an ad hoc network. The MEMS-based sensor has found good use in sensor nodes. Each sensor node can support a multi-hop routing algorithm and function as a forwarder for relaying data packets to a base station. A sensor network is a wireless ad- hoc network of sensor nodes. Sensors nodes are typically built with few sensors and a mote unit as shown in Fig. blood pressure and heartbeat Sensors are typically used to measure the changes in physical environmental parameters like temperature, pressure, humidity, sound, vibration, and changes in the health parameter of a person e.g. A Sensor is a device which senses the information and passes it on to the mote.

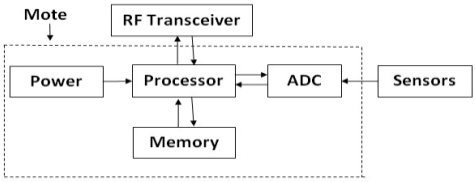

Fig. 2. Block diagram of sensor node

B. *Base Station*

Generally, base stations are assumed static in nature but in some scenarios, they are assumed to be mobile to collect the data from sensor nodes. A BS links the sensor network to another sensor network. Deployment of the base station in a wireless sensor network is very important as all the sensor nodes handover their data to the base station for processing and decision making.

It consists of a processor, radio board, antenna, and USB interface board. It is preprogrammed with low-power mesh networking software for communication with wireless sensor nodes. Energy conservation, coverage of sensor nodes and reliability issues are taken care of during deployment of a base station in a sensor network.

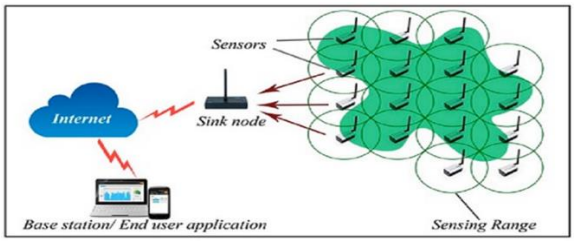

Fig. 3. A base station node

C. *Radio Model*

In the radio model, the transmitter consumes energy to run the transmitter radio and power amplifier, and the receiver consumes energy to run the receiver radio as shown in Fig. As the scenarios described in this project work, both the free space (d2 power loss) and the multi- path fading (d4 power loss) channel models were used depending on the distance between the transmitter and the receiver. If the distance is less than a threshold, the free space (FS) model is used; otherwise, the multipath (MP) model is used. We have assumed the same radio model which has been used in earlier works.

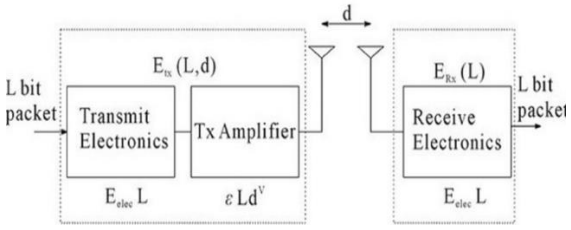

Fig. 4. Radio model

IV. Energy Efficient Routing Algorithms

An algorithm uses the method to find the best route between the source to destination with regards to some parameters of sensor nodes such as residual energy, packet reception rate, and node buffer state. In order to find the optimal path, the sink node should be aware of the criteria of each node. Thus, at the initial state, each node must send its information to the sink node. In the remaining round, if the sensor node has data to send towards the sink node, it will append its parameter to the data packet. Depend on the gathered information, the sink node determines and send the routing schedule to each sensor node. If the residual energy of sensor node is less than the energy threshold value, that node cannot participate in the routing process and hence will not send its parameters to the base station. The network load will be balanced with regard to the threshold value of the energy, and as a result, the network lifetime will be enhanced. Then, an algorithm will search for the optimal path from the source node to the destination node.

Energy efficient routing algorithm can be categorized into three categories, such as:-

- Data centric
- Location based
- Hierarchical

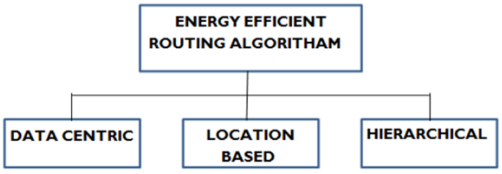

Fig. 5. Classification

A. *Data Centric*

SPIN was the first data-centric protocol. The base station sends queries to a certain area for information and waits for the reply from the nodes of that particular region. e.g. Depending on the query, sensors collect a particular data from the area of interest and this particular information is only required to transmit to the base station and thus reducing the number of transmissions. Since data is requested through queries, attribute-based naming is required to specify the properties of the data. Data-centric protocols are query based and they depend on the naming of the desired data, thus it eliminates much redundant transmission.

B. *Location Based*

Location-based routing protocol depends on the location of the sensor node. The location information of the sensor node is obtained from the GPS system. After obtaining location it is easy to find the distance between nodes and finding the shortest path between them. By using this technique the best route can be found without coding. E.g. Geographic and Energy-Aware Routing.

C. *Hierarchical*

Hierarchical routing is based on energy efficient routing. In this technique the work of nodes depends on the energy that they have like for the purpose of transmission higher energy nodes are used and for sensing purpose lower energy nodes are used. E.g. LEACH, TEEN, APTEEN.

V. Leach Algorithm

Lower Energy Adaptive Clustering Hierarchy (LEACH) protocol is a grade routing protocol. Main techniques of LEACH protocol include algorithms for distributing cluster forming, adaptive cluster forming and cluster header position changing. The technique of distributing cluster forming ensures the self-organization of most target nodes. The adaptive cluster forming and cluster header position changing algorithms ensure to share the energy dissipation fairly among all nodes and prolong the lifetime of the whole system in the end. Leach protocol provides a conception of the round. LEACH protocol runs with many rounds and each round contains two states. First is cluster setup and second is a steady state. In cluster setup state, it forms a cluster in a self-adaptive mode in a steady state, it transfers data. The time of the second state is usually longer than the time of the first state for saving the protocol payload. Fig. 6. Shows the process.

Fig. 6. Operation time of LEACH

Operation:

LEACH arranges the node into small clusters in a network and chooses one of them as a cluster head. In such an arrangement, cluster members sense their target and send this information to its cluster head. After receiving information from nodes cluster head transmits these data to the base station after compression and amplification. Cluster head consumes more energy compared to another node because it sends data to the base station which may be located far away. TDMA or CDMA MAC is used to reduce inter-cluster and intra-cluster collisions. This protocol is used where a constant monitoring by the sensor nodes are required as data collection is centralized and performed periodically.

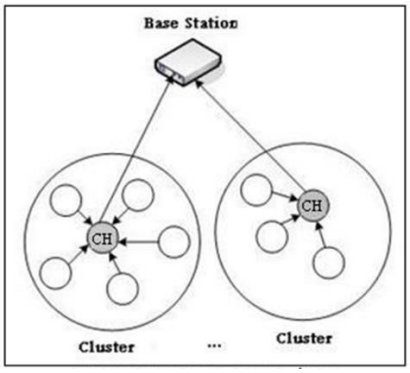

Fig. 7. Clustering in LEACH protocol

A. Setup Phase

This is the initial phase of LEACH. In setup phase clusters are formed and cluster-head is chosen for each cluster. According to the threshold value, T(n) some predetermined nodes, p choose themselves as a cluster head. The threshold value depends upon the desired percentage to become a cluster-head p, current round r and the set of nodes that have not become the cluster head in the last 1/p rounds, which is denoted by G.

$T(n) = p/1-p\{r \bmod(1/p)\}$ if $n=G$;
$T(n) = 0$ otherwise

Every node in the cluster which wants to be cluster-head chooses a value in between 1 and 0. If this chosen value is less than the threshold value T (n) then that node becomes the cluster-head for the current round. After becoming a node as a cluster head, each cluster-head broadcast an invitation message in a network to other nodes to join their clusters. On the basis of invitation signal strength nodes in the network decides to join cluster-heads. The non-cluster-head node then informs their respective cluster heads that they will be under their cluster by sending an acknowledgment message. After receiving an acknowledgment message, cluster-head creates a TDMA schedule and assigns each node a time slot in which it can transmit the sensed data. If the size of any cluster becomes larger, the cluster-head may choose other cluster head to lessen the size of a cluster. The head in the cluster does not become the cluster-head until all the nodes become the cluster-head once.

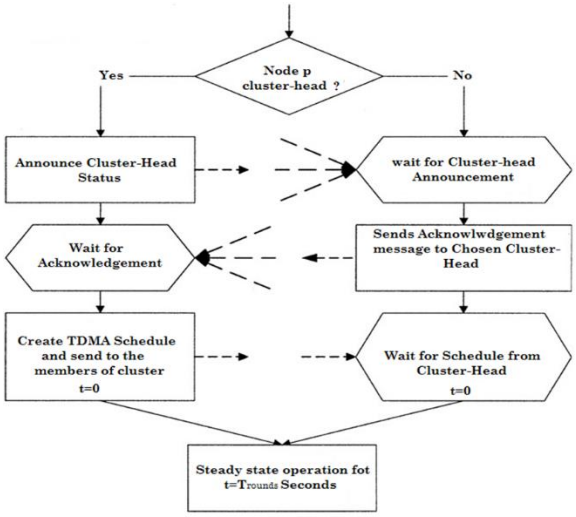

Fig. 8. Flowchart of the set-up phase of the LEACH protocol

B. Steady Phase

In this phase, the sensing process is done by non-cluster head nodes. In the cluster non- cluster head nodes sense data and send this data to the relative cluster head node according to the TDMA schedule given by cluster head. After receiving sensed data from all nodes of a cluster, cluster head node aggregates this data and sends to the base station. After completion of this process (first round) network again goes back into the setup phase and new cluster heads are chosen. This process repeated again and again until all nodes of cluster become the cluster head. In order to reduce interference from the nodes of other cluster nodes use CDMA technique for communication.

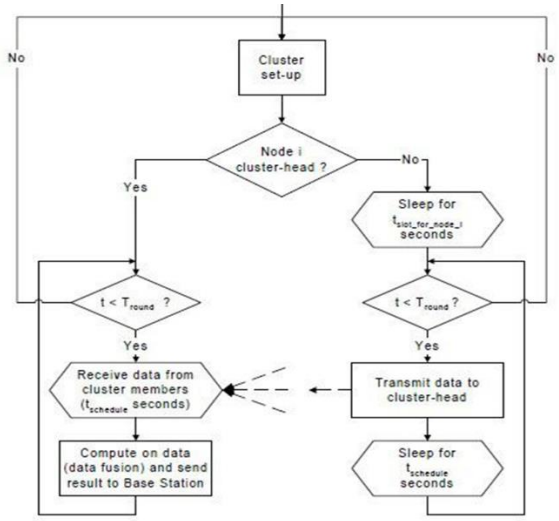

Fig. 9. Flowchart of the steady phase of the LEACH protocol

Algorithm:

Setup phase:

- CN=>
- If r >T(n), CH=CN else go to step 1
- CH=>G : id(CH) ,join adv
- X(i)->CH(j) : id{X(i)} , id{CH(j)}, join ack
- CH(j)->X(i) : id{CH(j)} : id{CH(j)}, <t(i) ,id{X(i)}

Steady phase:

- X(i)->CH(j) : id{X(i)} , id{X(i)}, info
- CH->BS: id(CH) , id(BS) , aggr info

CN = Cluster node
r = Random variable (0<r<1)
T(n) = Threshold value
CH = Cluster head
G = All nodes of network
Id = Identification no.
Join adv = Advertisement to join cluster
X = Normal node of cluster
Join ack = acknowledgment of join
t = time slot given by cluster head
=>: Broadcast
->: Unicast

Modification in LEACH:

LEACH has many drawbacks therefore many kinds of research have been done to make this protocol performs better, some of them are as follows:

LEACH-B (Balanced Low Energy Adaptive Clustering Hierarchy):

A Decentralized algorithm of cluster formation is used In in LEACH-B in which sensor the node knows only its own position and final receiver position and does not know the position of other nodes of a cluster. Sensor node chooses the CH on the basis of energy being dissipated in the transmission path between its own and final receiver. CH selection, Cluster formation and data transmission with multiple access techniques are used in LEACH-B. The efficiency of LEACH-B is better than LEACH.

LEACH-C (Centralized Low Energy Adaptive Clustering Hierarchy):

LEACH-C uses a centralized clustering algorithm and the same steady-state phase as LEACH. LEACH does not offer guarantee about the placement and/or a number of cluster heads In an enhancement over the LEACH protocol LEACH-C protocol was proposed. LEACH-C protocol is able to produce better performance than LEACH by dispersing the cluster heads throughout the network. In LEACH-C each node sends its location (Maybe using GPS) and residual energy level to the sink during the set-up phase. Then, sink determines the good clusters and ensure that the energy load is evenly distributed among all the nodes. To do this, sink computes the average node energy and determines which nodes have energy below this average. Sink broadcast a message that obtains the cluster head ID for each node after the cluster heads and nodes are found. If a cluster head ID matches its own ID, the node is a cluster head; otherwise, the node follows the TDMA slot given by CH to transmit data and goes to sleep until it's time to transmit data.

LEACH-E (Energy Low Energy Adaptive Clustering Hierarchy):

Same as LEACH protocol, E-LEACH is divided into rounds, in the first round, every node has the same probability to turn into cluster head that means node is randomly selected as cluster heads, in the next rounds, the residual energy of each node is different after one round communication and taken into account for the selection of the cluster heads. That mean nodes have more energy will become a cluster head rather than nodes with less energy. It makes the residual energy of the node as the main metric which decides whether the nodes turn into a cluster head or not after the first round. Energy-LEACH protocol improves the cluster heads selection procedure.

LEACH-F (Fixed Low Energy Adaptive Clustering Hierarchy):

LEACH-F is the further development of LEACH, which is based on clusters that are formed once and then fixed. Then, the cluster head position rotates among the nodes within the cluster. The advantage with this is that, once the clusters are formed, there is no set-up overhead at the beginning of each round. To decide clusters, LEACH-F uses the same centralized cluster formation algorithm as LEACH-C. The fixed clusters in LEACH-F do not allow new nodes to be added to the system and do not adjust their behavior based on nodes dying.

Multihop LEACH:

In LEACH protocol, EACH Cluster-Head directly communicates with Base Station regardless of the distance between CH and BS. This consumes more energy if the distance between the CH and BS is too long. MULTIHOP LEACH is an enhancement on this drawback of LEACH protocol. MULTIHOP LEACH protocol selects an optimal path through Cluster Heads between CH and BS. CHs are used as a relay station to transmit data through them. First, multi-hop communication is adopted among CHs. Then, according to the selected path, these CHs transmit data to the corresponding CH which is nearest to BS. Finally, this CH sends data to BS.

TL-LEACH (Two-Level Low Energy Adaptive Clustering Hierarchy):

In LEACH protocol, the CH collects and aggregates data from sensors in its own cluster and passes the information to the base station. CH might be located far away from the BS, so it uses most of it will die faster than other nodes. To overcome this, a new version of LEACH was proposed called TWO LEVEL LEACH. TL-LEACH is an extension of LEACH protocol. In this protocol, CH collects data from the nodes of cluster same as Leach protocol, but not transmit data directly to the base station, instead of it, it uses an another CH called secondary cluster head that lies between the CH and BS as a relay.

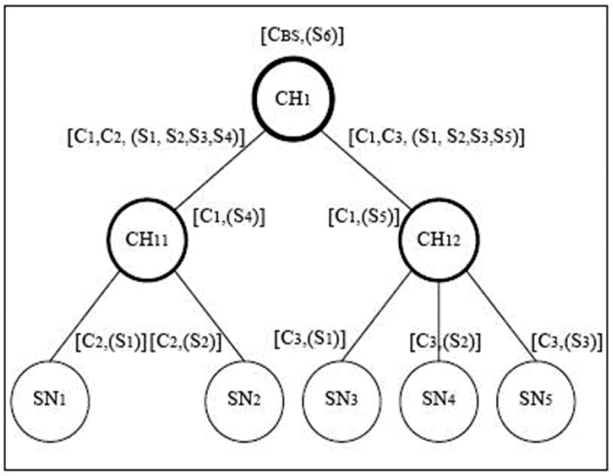

Fig. 10. TL-LEACH

V LEACH (Vice CH Low Energy Adaptive Clustering Hierarchy):

In LEACH, the cluster head always receives sensed data from cluster nodes, aggregates these data and sends to the base station that might be located far away from CH. The cluster head performs two operations sending and receiving so it will

die earlier than other nodes of a cluster. If the cluster head dies the cluster will become useless because without the cluster head data will not reach to the base station. In V-LEACH protocol, a cluster has; CH (only send sensed data received from cluster nodes to BS), VICE-CH(The node that will become cluster head in case CH dies), cluster nodes(sense data and send to the CH) In V-LEACH, besides having a CH in the cluster, a VICE-CH is there that becomes the CH in case of CH dies. In this technique data always reaches to BS and there is no need to elect a new CH in every round. This increases the lifetime of the network.

VI. MODLEACH: Proposed Scheme

This project work is based on LEACH protocol that is modified to a new version of LEACH protocol. Here, we introduced two schemes to robust network lifetime and throughput. To cognize proposed algorithm, we need to carefully understand mechanism used in LEACH protocol. In LEACH protocol cluster head replaces in every round and once a cluster head is formed, this does not replace until the completion of 1/p rounds. In LEACH after each round, cluster head is changed and in such manner, the whole process repeated again and again. In this work, we are going to modify the LEACH protocol by cluster head replacement scheme. It is a threshold in CH formation for the next round. If the selected cluster head has not spent much energy during its time period and has more energy than required then the current cluster will remain cluster head for the next round as well.

In this way, the energy of the network is wasted in routing packets for new cluster head and cluster formation can be saved. If cluster head has less energy than required threshold, it will be replaced according to LEACH algorithm. According to the nature of transmission, we introduced two different levels of power to amplify signals for limiting energy utilization in cluster formation. There are three modes of transmission in a cluster based network.

- Intra cluster Transmission
- Inter cluster Transmission
- Cluster Head to Base Station Transmission

Intra Cluster Transmission: In which all the communication take place inside cluster i.e. Sensor node sense data and send sensed data to cluster head.

Inter Cluster Transmission: In which communication take place between two cluster heads instead of cluster head transmitting its information directly to base station.

Cluster Head to Base Station Transmission: In which cluster head directly communicate with base station.

Minimum amplification power required to communicate within the cluster while its required high amplification power to transmit the data from cluster head to base station communication, therefore amplification energy required for intra cluster and inter cluster communication cannot be same. In LEACH, amplification energy required for all kinds of transmissions is set same. If the low energy level is used for intra cluster transmission with respect to cluster head to base station transmission leads in saving much amount of energy. Moreover, multi power-level also the packet drop ratio and collisions for other signals. In this context, we assume that a cluster at maximum may spread into an area 10 x 10 m^2 in a field of 100 x100 m^2. An energy that is enough to transmit at far ends of a field of 100 x100 m^2 must be lowered 10 times for intra-cluster transmission. When a node becomes a cluster head, routing protocol informs it to use high power amplification and in next round, when that node acts as a cluster member, routing protocol switches it to low-level power amplification.

Modified Protocol Functioning:

Below, the following modifications have been done in the LEACH protocol to enhance the efficiency and network lifetime.

At the end of every round, the protocol will check the energy level of CH, if the energy level has fallen below a defined threshold then only CH will be replaced. Else same CH will continue operation.

In this way, much of energy will be saved that is wasted in the cluster head formation process. Moreover, control overhead is also within a limit.

Three types of communications are there with respect to distance in an adaptive clustering hierarchy.

1) Inter Cluster Communication.
2) Intra Cluster Communication.
3) Cluster Head to Base station Communication.

There is no need to set equal amplification energy level for all kinds of communication. Therefore multi power levels are adjusted for all types of communication to save the energy.

VII. Results and Discussion

As already discussed, energy efficient wireless sensor network deployment is not an easy task because of a numerous parameters, i.e. energy parameters of a network and CH selection and then their data transmission process. MATLAB programming platform is used for coding of LEACH and MODLEACH. Comparative performance of all algorithms is explained.

The parameters considered during simulation have their own significance for the better performance of the network. The important definitions in the WSNs related to this project are:

Packet delivery ratio: The ratio of a number of packets sent from the source to the number of packets received at the destination. The greater the value of PDR means the better performance of the protocol.

Network Lifetime: The time for the first node or a certain percentage of sensor nodes to run out of power or it is the time interval from the start of operation (of the sensor network) until the death of the first alive node.
Throughput: An average rate of successful packet delivery. The throughput is the most important parameter to analyze the performance of the network, to get better through-put the error should be corrected, instead of retransmitting the packet. If the error is corrected there is no need of retransmitting the packet. If the retransmission traffic is reduced the congestion will not occur. If there is no congestion there is no packet loss that is an error. If there are a number of packets in the network the performance of the network degrades which leads to congestion, which leads to packet loss. If there is an error correction technique which corrects the error instead of going for retransmission, it improves throughput. There is no need to set equal amplification energy level for all kinds of communication. Therefore multi power levels are adjusted for all types of communication to save the energy.

A) Experiments and Graphs:

1) Number of Alive Nodes:

In this subsection shown a comparison between the number of alive nodes in Homogeneous LEACH and MODLEACH. The evaluated results are shown below:

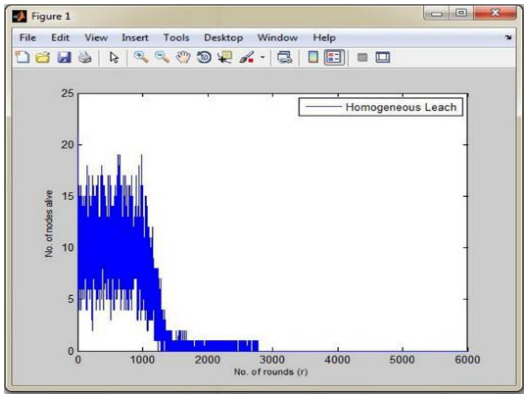

Fig. 11. No. of Alive nodes in homogeneous LEACH

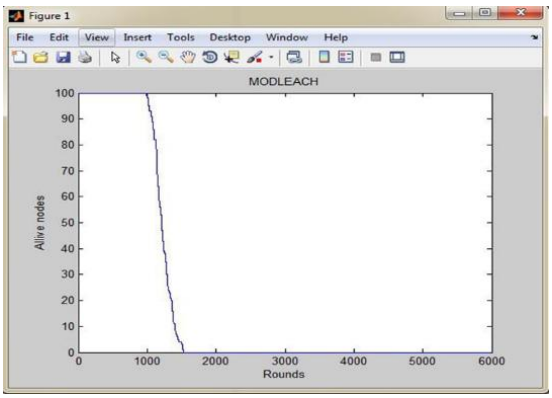

Fig. 12. No. of Alive nodes in homogeneous MODLEACH

2) Number of Packets Transmitted to Base Station:

Besides network lifetime, another metric to judge the efficiency of a routing protocol is its throughput. A base station receiving more data packets confirms the efficiency of a routing protocol. Throughput depends on network lifetime in a sense but not always. Considering the simulated results as shown in below figure, we deduce that, maximum throughput is achieved by MODLEACH.

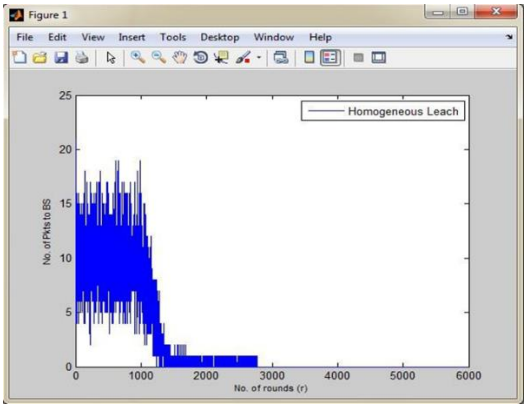

Fig. 13. No. of Packets transmitted to base station in homogeneous LEACH

3) Number of Packets Transmitted to Cluster Head:

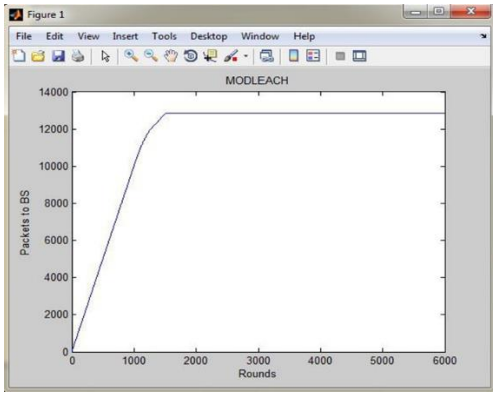

Fig. 14. No. of packets transmitted to base station in MODLEACH

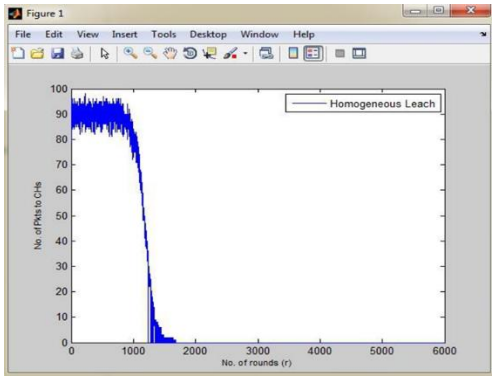

Fig. 15. No. of packets transmitted to cluster head in homogeneous LEACH

In this subsection, the following figure presents a comparison of the number of packets transmitted to the cluster heads nodes

through non-cluster head nodes by all the simulated protocols. When non-cluster head nodes transmit data to the cluster head nodes then the transmission is called intra cluster communication. MODLEACH differs from both homogeneous leach and heterogeneous leach in the following sense:

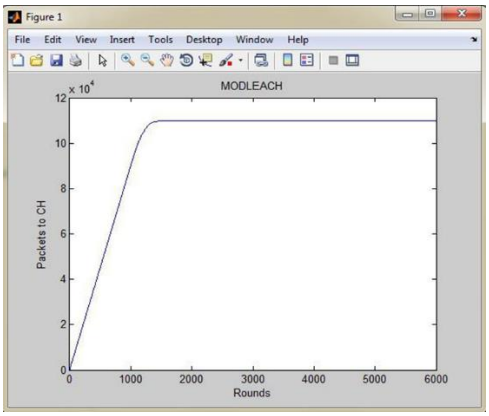

Fig. 16. No. of packets transmitted to cluster head in MODLEACH

Comparison among different protocols and Different amount of Initial Energy for the sensors:

The following Table-1, shows the better comparison of Homogeneous Leach, Heterogeneous Leach and modified leach (MODLEACH). All the protocols are compared with varying number of nodes on the basis of Network lifetime, packets transmitted to the base station and packets transmitted to the cluster head.

TABLE I
COMPARISON WITH DIFFERENT NO. OF NODE

Parameters	No. of Nodes	Network Lifetime	Packets to BS	Packets to CHs
Homogeneous Leach	n=100	756	21	99
	n=200	850	34	191
	n=300	771	47	289
	n=400	736	58	387
	n=500	794	71	471
Heterogeneous Leach	n=100	967	21	99
	n=200	991	31	191
	n=300	1008	50	284
	n=400	1010	59	377
	n=500	1042	73	486
Modified Leach	n=100	941	13103	109542
	n=200	1003	24980	220546
	n=300	1017	37555	331083
	n=400	1091	49770	442539
	n=500	981	62066	553076

In this subsection, the following table presents a comparison of the network lifetime with different amount of initial energy of sensor nodes by all the simulated protocols. For the first set of experiments, each node of the homogeneous leach, heterogeneous leach, and Mod-leach begins with only 0.25 J of initial energy and compare the 1st node dead and last node dead of all protocols and then repeated the same simulation for 0.5 J and then 1.0 J of initial energy.

TABLE II
HOMOGENEOUS LEACH

Initial Energy (J/Node)	Protocol	Round	
		1st node dies	Last node dies
0.25	Homogeneous leach	476	800
0.5	Homogeneous leach	756	1556
1.0	Homogeneous leach	1528	3603

TABLE III
MODLEACH

Initial Energy (J/Node)	Protocol	Round	
		1st node dies	Last node dies
0.25	MODLEACH	448	778
0.5	MODLEACH	1004	1556
1.0	MODLEACH	2041	3201

VIII. CONCLUSION

In this work, we considered a well-known protocol for wireless sensor networks called LEACH protocol which is the first and the most important protocol in wireless sensor network which uses the cluster based broadcasting technique. Followed by an overview of LEACH protocol implementation, then we proposed a new version of LEACH called MODLEACH protocol. MODLEACH tends to minimize of consumption energy in the network by efficient cluster head replacement after the first round and dual transmitting power levels for intra cluster and cluster head to base station communication. In MODLEACH a CH is only replaced when its energy falls below a certain threshold level minimizing the routing load of a protocol. Simulation results show that MODLEACH has better performance over LEACH protocol.

IX. FUTURE WORK

1. Implementation of Improved MODLEACH protocol on wireless sensor networks.
2. Next improvement might be possible by considering sink mobility and to ensure successful transmission/reception of data packets.
3. The process of data aggregation and fusion among clusters is also an interesting Problem to explore.
4. Design of a better routing protocol in the case when CH lost its energy before sending the data to the BS.
5. The factor affecting cluster formation and CH communication is an open issue for future research.

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