Energy Efficient Routing Protocols in Wireless Sensor Network

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***Abstract*—A wireless sensor network is one of the most important technology that will change the world. It consists of a large number of sensor nodes which are densely deployed in large network area. These sensor nodes are equipped with a set of limited Processor, limited memory unit, on-board sensors and battery power. WSN is basically used for tracking and monitoring the physical environment phenomenon. This paper represents energy efficient routing protocols in WSN. In WSN node require much power or energy for the transmission of data rather than sensing and capturing, so the Reliable routing of sensed data from the sensor node to its base station is the most important task. In WSN node has limited power and memory so the main concern of this research is to save power and to increase the life of sensor network. The aim of research in this paper is to cover the hierarchical routing protocol to make enhancement in lifetime of LEACH protocol and MODLEACH protocol that depends on current protocol theories and overcome the limitation of these theories. The simulation result shows the comparison of enhanced protocols with existing routing protocols, LEACH and MODLEACH based on different parameters. Different tests are performed to compare with LEACH and MODLEACH. From which the result shows that the enhanced protocols increases network lifetime as compared to LEACH and MODLEACH protocols.**

***Keywords*—Wireless sensor network, routing protocols, energy efficiency, lifetime.**

I. INTRODUCTION:

Wireless Sensor Network (WSN) consists large number of sensor nodes to monitor and record the presence of environmental and physical phenomena like wind speed, light, temperature, and humidity etc. WSN network consists of ten to thousands of small nodes having sensing, computation and communication capabilities. More energy require for the transmission of data rather than sensing and capturing .The data collected by sensor nodes are transmitted node by node to the base station using single-hop routing or multi-hop routing. The nodes in WSN are equipped with a limited battery power, limited memory, limited processor and onboard sensors. So the, main concern is to save power to increase the lifetime of sensor network.

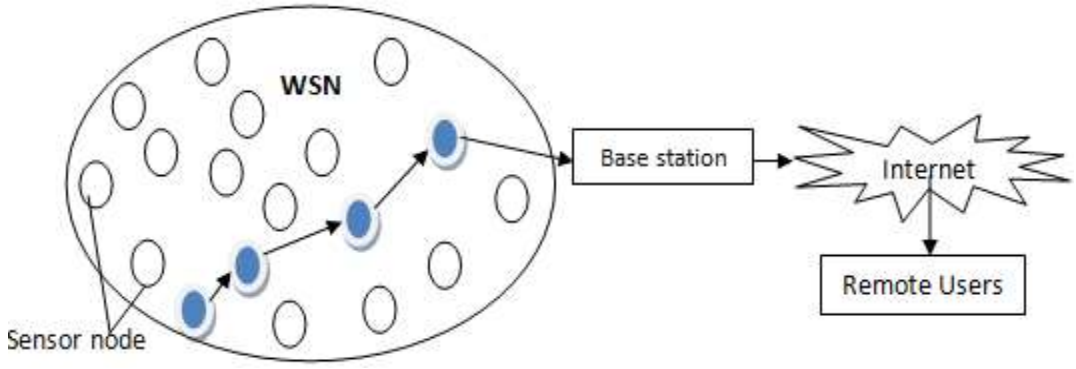

Fig.1: wireless sensor networks

Basic terminology:

a) Sensor: A sensor is a transducer which convert physical phenomenon such as heat, light, sound, motion into electrical energy or signals.

b) Sensor node: sensor node is a basic unit of the sensor network. Which contain onboard sensor, processor, and memory and power supply battery.

c) Sensor network: it is a collection of large number of sensor nodes. And these nodes deployed either inside or very closed to phenomenon. Each sensor node is capable of only a limited amount of energy. Sensors have the ability to measure a given physical phenomena in great detail.

II. APPLICATIONS OF WSN:

WSN applications can be classified into two categories.

- Monitoring
- Tracking

Monitoring applications: include environmental monitoring, health and wellness monitoring, power monitoring, inventory location monitoring, and structural monitoring.
Tracking applications: include tracking objects, animals, humans, and vehicles and categorize the applications into military, environment, health, home and other commercial areas. It is possible to expand this classification with more categories such as space exploration, chemical processing and disaster relief.

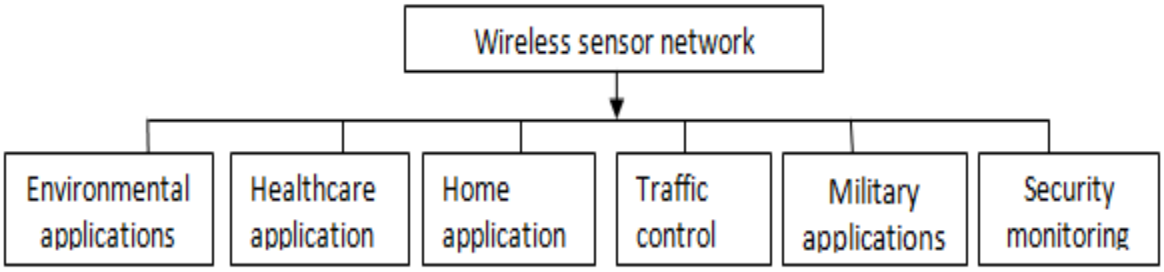

Fig.2: Applications of wireless sensor network

a) **Environmental applications**: Environmental sensors are used to study vegetation response to climate changes, and can identify, track, and measure the population of birds and other species. It monitors the environmental conditions that affect crops and livestock. Other applications of WSNs are chemical and biological detection, precision agriculture, biological, forest fire detection, volcanic monitoring, flood detection and pollution study.

b) **Healthcare applications**: WSN based technologies such as Body Sensor Networks provide dozens of solutions to healthcare's biggest challenges such as an aging population and rising healthcare costs. Body sensor networks can be used to monitor the physiological data of patients The Body sensor networks can provide interfaces for disabled, integrated patient monitoring. It can monitor and detect elderly people's behaviour, e.g., when a patient has fallen. These small sensor nodes allow patients a greater freedom of movement and allow doctors to identify pre-defined symptoms earlier on. Each patient has small and lightweight sensor nodes attached to them, which may be detecting the heart rate and blood pressure. Doctors may also carry a sensor node, which allows other doctors to locate them within the hospital.

c) **Home applications**: With the advance of technology, the tiny sensor nodes can be embedded into furniture and appliances, such as vacuum cleaners, microwave ovens and refrigerators. They provide the intelligent or smart environment. They are able to communicate with each other and the room server to learn about the services they offer, e.g., printing, scanning and faxing [3].

d) **Traffic control**: Traffic conditions can be easily monitored and controlled at peak times by WSNs. Temporary situations such as roadwork and accidents can be monitored.

e) **Military applications**: Military sensor networks can be used to detect and gain as much information as possible about enemy movements, explosions, and other phenomena of interest, such as battlefield surveillance, nuclear, biological and chemical attack detection.

f) **Security monitoring:** A key difference between security monitoring and environmental monitoring is that security networks are not actually collecting any data. This has a significant impact on the optimal network architecture. Each node has to frequently check the status of its sensors but it only has to transmit a data report when there is a security violation.

III. ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORK:

Routing protocols used in Sensor network are different from conventional networks routing protocols.

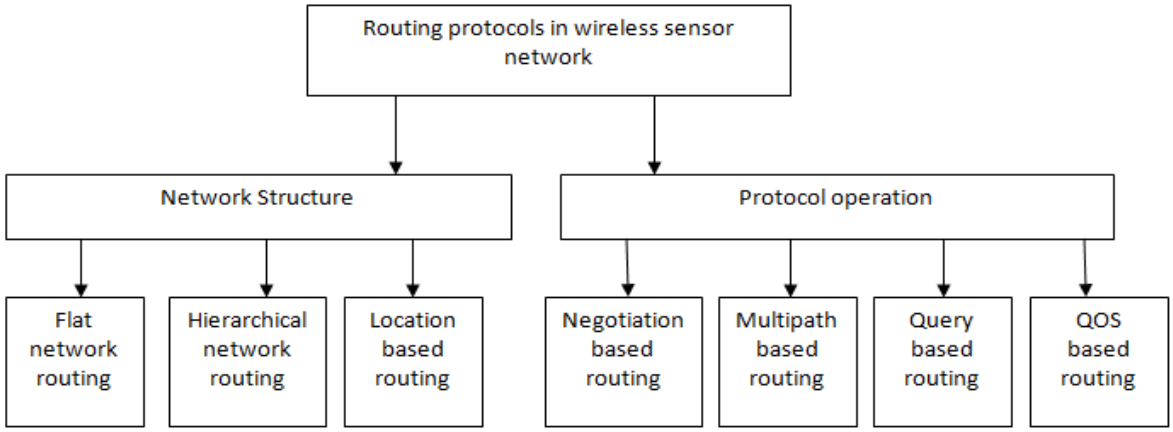

Fig.3: Taxonomy of the routing protocols in WSN

Network structure consists of different protocols are:

a) **Flat Routing:** in this routing technique all the sensor nodes play the equal or same roles, such as collecting data and communicating with the sink. Sensed data reach the base station (BS) by multi-hop routing.

b) **Hierarchical networks**: also called cluster based routing, in which nodes cannot communicate directly to the base station. They are all controlled by cluster head. Networks can be divided into clusters and interconnect through CH.

c) Location based routes: in this protocol each node knows its position in network (e.g., GPS). All the nodes in the network exchange this data in order to know about neighboring nodes. As energy is the major factor of concern in routing protocols, location-based schemes demand that nodes should change their state from active to sleep mode when there is no activity. The more nodes in sleep mode, the more energy is saved **[5].**

Protocol operation:

a) **Negotiation based routing:** These protocols uses the Meta data in order to eliminate redundant data transmission, important decisions are based on local interaction. The use of flooding produces implosion and overlap between the sent data, hence nodes will receive duplicate copies of the same data.

b) **Multipath based routing:** there is at least one alternate path for the transmission of data from sensor nodes to base station, this routing protocol uses multiple paths rather than a single path in order to enhance the network performance. The fault tolerance of a protocol is measured by an alternate path exists between a source and a destination when the primary path fails.

c) **Query based routing: in this protocol** the destination nodes propagate a query for sensed data from a node through the network and a node having this data sends the data which matches the query back to the node, which initiates the query.

d) **QoS-based routing:** in this routing protocol, the network has to balance between energy consumption and data quality. Here the network has to satisfy certain QoS metrics, e.g., delay, energy, bandwidth, etc. when delivering data to the BS **[7].**

IV. HIERARCHICAL PROTOCOLS

1) LEACH: stands for Low-Energy Adaptive Clustering Hierarchy LEACH protocol: LEACH is a cluster-based protocol, which includes distributed cluster formation. Where nodes send the sensed data to the cluster head CH, cluster head perform the data aggregation or data fusion operations and send the aggregated data to the base station. Cluster head is selected by comparing random value of nodes with threshold value T (n). If the value is less than the threshold value, it becomes the cluster head node. If a node is selected as a cluster head once, than it will not be re-selected as CH again. Otherwise it will be the non-cluster head node in the next round.

$$T(n) = \begin{cases} \frac{p}{1-p*(r \bmod \frac{1}{p})} & \text{if n} \in \text{G} \\ 0 & otherwise \end{cases}$$

Where p is the desired percentage of CHs, r is = the current round, and G is the set of nodes that have not been selected as cluster heads in the last 1/p rounds.

The operation of cluster heads is divided into rounds, and one round represent subsequently one transmission, means one round is the process to send the sensed data to the base station which includes cluster set-up phase and a steady-state phase where the cluster heads aggregate the data received from their cluster members and send the aggregated data to the base station. It uses the single hop communication for the transmission of data. After a round complete, a new node select as a CH that have never been selected as a CH [9].

a) Set-up phase:
- CHs are selected on the basis of T (n), threshold.
- All CHs broadcast ADV message to their cluster members
- All cluster members nodes select their CHs, by receiving advertisement ADV message
- cluster members sends Join-REQ back to CH Now, CHs

b) Steady-state phase:
- Sensor nodes starts sensing the physical environment
- The transmission of sensed data to CHs as per allocated TDMA Schedule.

c) Forwarding phase:
- After receiving data, CHs will compile its own message and perform the data fusion operation.
- aggregates data to send to the BS in one-hop manner, which reducing the no. of transmissions & hence saving energy
- After certain time, N/W goes back to set-up phase again & start another round

2) MODLEACH: it stands for modified LEACH Here the role of the CH is rotated and randomized to distribute the energy requirements among the nodes of the network. To reduce the total amount of data transmission, local compression techniques are used in the CH. initially In MODLEACH the number of cluster heads remains stable and cluster head formation is similar to LEACH. MODLEACH is further improved by using the concept of soft and hard threshold. In the leach protocol for every new round we chooses a new cluster head thus in new cluster head formation required energy that will result in the energy loss. If cluster-heads energy is within the threshold limit than there is no need to create the new CH thus it reduces the energy usage for the cluster head formation. If the CH energy is not within the threshold limit than new cluster-head will be selected by Leach protocol.

3) Enhanced protocol: It solved the energy utilization problem of Original LEACH. Here we make the enhancement during the cluster head formation. The threshold value to select the cluster head during setup phase is enhanced in the way to increase the network lifetime and reduce the power consumption.

- Cluster formation is based on information received on signal strength of nodes and total energy of the network. Cluster head formation can be increased by modifying the threshold value T (n).
- All CHs broadcast advertisement ADV message to their cluster members.
- All cluster members send the reply message when they receive ADV message, this message contains the node id and nodes energy.
- After then, CHs create TDMA schedule & send it to the all cluster members. Collection of data is done in a reserved time slot and it follows multi hop routing for data transmission from sensor nodes to cluster head.
- Our Simulations result shows it clearly that such a modification of the cluster-head formation threshold can increase the lifetime of a LEACH and MODLEACH.

V. SIMULATION AND RESULT: To test the overall network lifetime, a simulation is performed on the network size of 100 nodes. Initial energy of the nodes is 0.5.

1) Calculate the Number of dead nodes: this test shows the round that the first node, half node and last node expired in the network.

2) Number of packet transmission to the base station: the amount of data received by the base station tells the rate of the accuracy of the nodes, throughput.

3) Number of cluster head formation: Cluster head selection algorithm depends on the random number which is generated by the sensor node. The figures represent the count of cluster heads with the variation.

4) Life time of network: lifetime of the sensor network is the lifetime of the network from the startup of the network to the end of the network. The network lifetime is measured in two ways alive nodes and dead nodes.

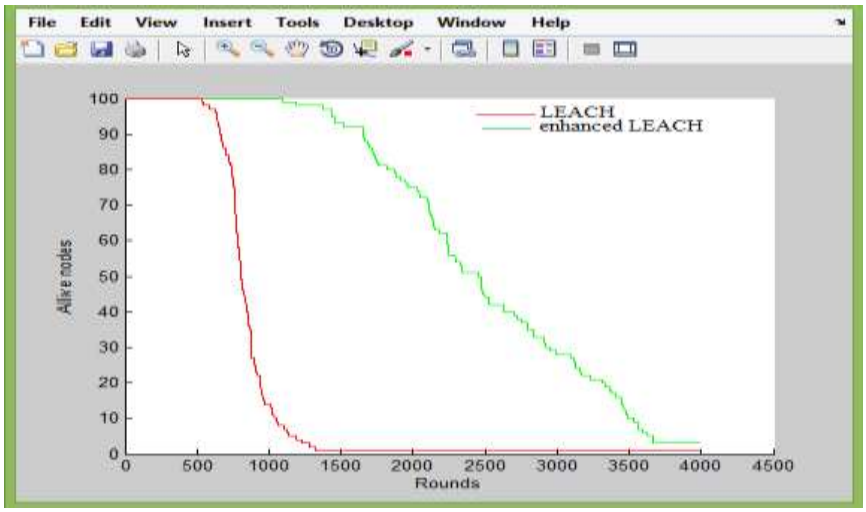

Fig.4: Number of dead nodes per round for both LEACH and enhanced LEACH

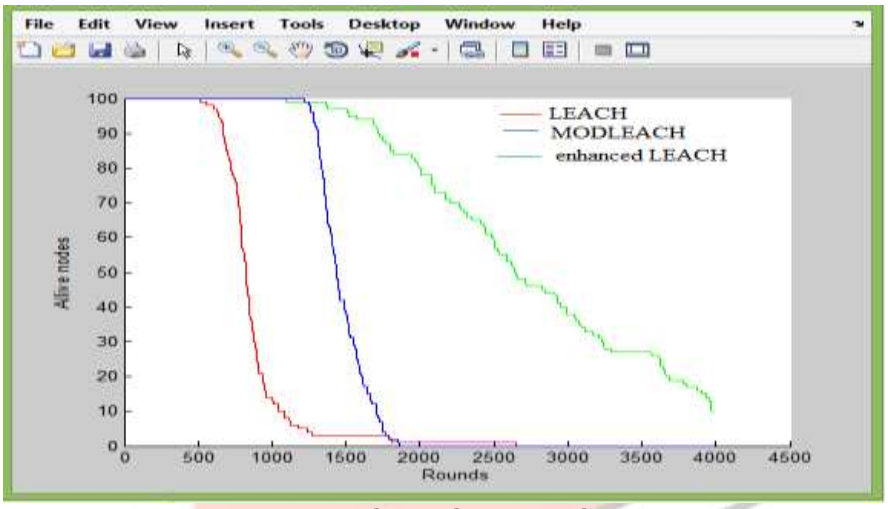

Fig.5: Alive nodes vs. rounds

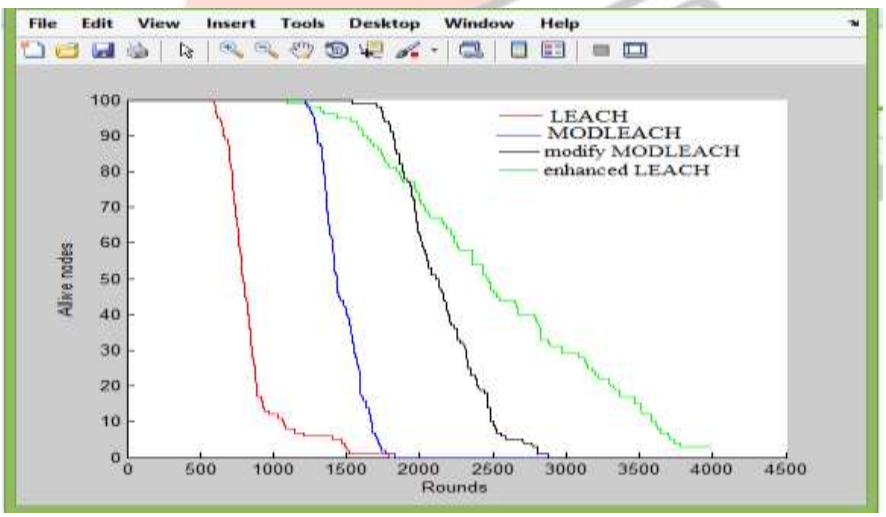

Fig.6: Alive nodes vs. rounds between four protocols

From Fig.4 it is clear that enhanced LEACH increases the lifetime of the network. Fig.5 clears the comparison of lifetime between LEACH, enhanced LEACH and MODLEACH. And Fig.6 tells the comparison between LEACH, enhanced LEACH, MODLEACH and enhanced MODLEACH also shows that enhanced LEACH is good in all.

In the below charts the terms we used are FND (First node dead), HND (Half node dead) and LND (Last node dead) show the dead nodes in the network. Alive nodes present in the network reflecting the stability of the network versus the maximum rounds. Network lifetime is the time from where the network starts its operation till the phase network has completed its operation. The operation is measured in terms of the rounds. So the network lifetime is measured in two ways alive nodes and dead nodes.

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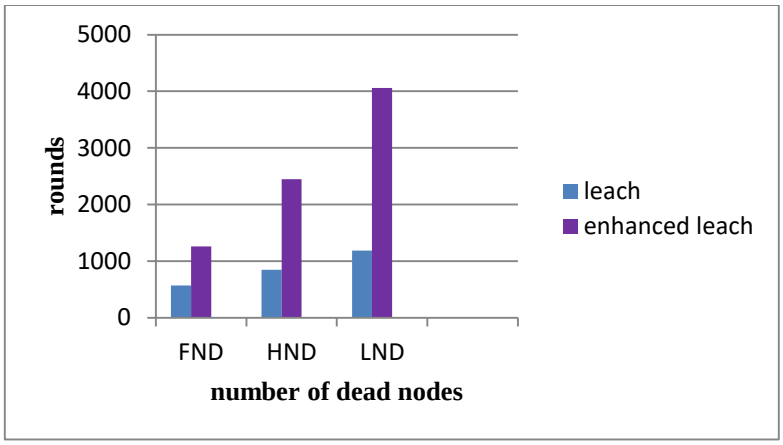

Fig.7: comparison of LEACH and enhanced LEACH result

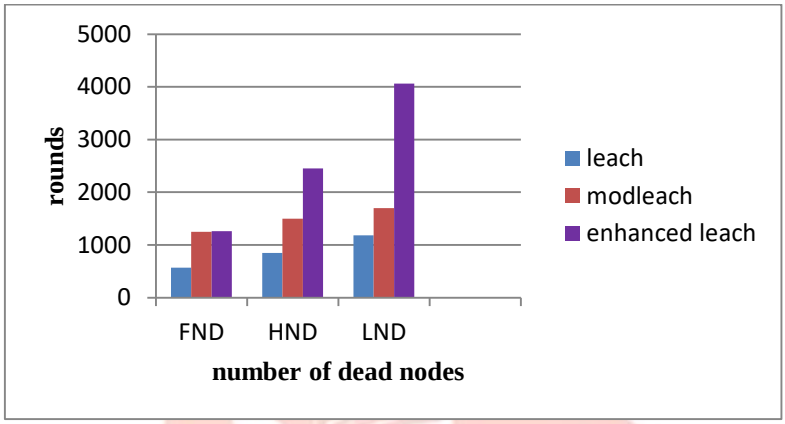

Fig.8: comparison of LEACH, MODLEACH and modify MODLEACH result

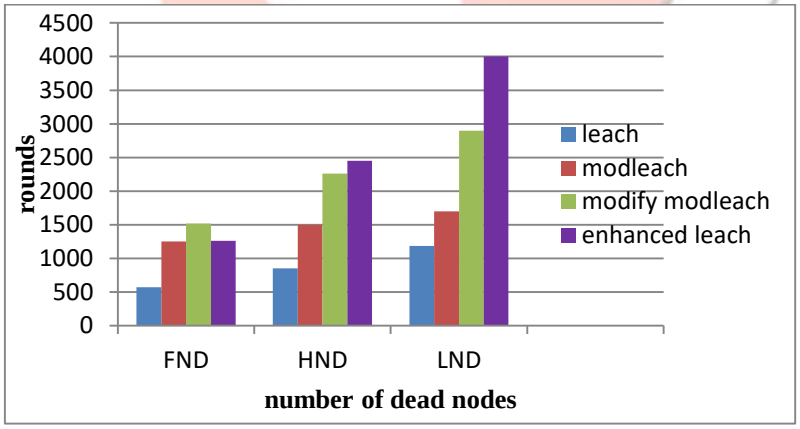

Fig.9: comparison between LEACH, MODLEACH, modify MODLEACH and enhanced LEACH

VI. ACKNOWLEDGEMENT: energy efficient Routing in sensor networks is an emerging area of research. Sensor nodes have limited energy. These nodes mostly consume energy during information transmission. So, routing protocols used in Wireless Sensor Network should be energy efficient to increase the lifetime of sensor nodes as well as the lifetime of the whole of the wireless sensor network. LEACH is a first well-known protocol introduced in WSN which save energy and increase lifetime of the sensor networks. MODLEACH is a variant of LEACH that is used for the efficient CH replacement to improve the lifetime of WSN. The protocols are enhanced on the basis of LEACH or MODLEACH and develop the enhanced LEACH or modify MODLEACH. The simulation result shows that the enhanced LEACH outperformed the protocols LEACH, MODLEACH and modify MODLEACH.

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