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Comparison and Review of LEACH, LEACH-C and PEGASIS Routing Protocols.

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Abstract **-Wireless sensor network is an interesting field of new technology for researchers and wireless sensor networks is growing and improving day by day. And in wireless sensor networks the major field of the research for the researchers is to that how to increase the life span of the sensor network and also to increase the energy-efficiency of the wireless sensor network. Various routing protocols have been proposed. Routing protocols provides the best and reliable communication path for the transmitter to the transmission of information is the main factor due to which energy is consumed by the sensor node. In this we have studied the PEGASIS routing protocol.**

Index Terms**—-lifespan, fusion, aggregation, routing protocols, WSN's**

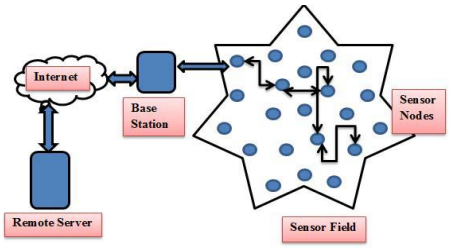
I. INTRODUCTION

Wireless sensor networks contain millions of billions of sensor nodes and these sensor nodes are well capable enough to sense the surrounding environment of their surrounding these sensors have to work in a collaborative manner with each other to achieve this assignment. one sensor node is not able to perform these assigned tasks by the user so this is why they have to work in collaboration with each other in wireless sensor network. According to [1] a wireless sensor network is a deployment of the so many small tiny self-powered and very in-expensive devices that are able to sense the environment conditions, compute the sensed information and to communicate with the other devices within its range with the help of trans-receiver. In WSN's it consists of many small tiny devices which are basically battery operated and due the battery as their major power source they have the limitation of that when the battery is exhausted they die or they were not able to work and the field where these sensor nodes are deployed are not-accessible for humans in some cases so it becomes very difficult for the human to replace the batteries of these sensors. So an energy efficiency is the major issue among the researchers and by increasing he energy efficiency life span of the network can be increased.

B.

II COMPONENTS OF WIRELESS SENSOR NETWORK

Major components of wireless sensor networks are shown in Fig.1 and discussed below



A. Sensor node: In sensor node it consists of a sensing unit i.e. analog to digital converter. Power supply unit communication unit (trans-receiver) sensor node is able to sense the specific quantity like pressure, temperature, sound etc. CPU mainly microcontroller is responsible for all computations and all controlling part is done by the CPU while the power supply unit is responsible for all power related requirements. Information which is sensed by the sensor node is transmitted by the communication unit with the help of the Trans-receiver to the base-station.

B. Remote server: Remote server depends upon the applications and they can be more than one and the remote server location depends upon the type of the assignment given by the user locations can be constructed and remote locations are used to record the information and analyzed the information.

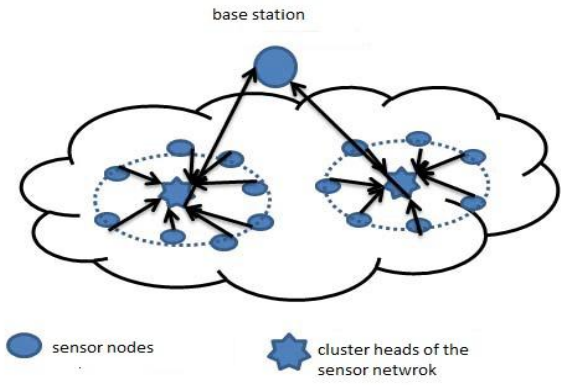
C. Base-Station: Multiple activities can be performed at base-station. Information which is collected by the sensor in a network is sent to the base station by the sensor node and base station collects that information. Base station can be far away from the network or it may can be near to the area of networks

user can communicate to the base station using internet for the information and base station has to reply accordingly to all remote location. The area where sensors are deployed or the investigation is known as sensing area this deployment of sensor node can be pre-determined or can be fixed it depends on the routing protocol and the distance between two sensors also depends upon the routing protocol.

D. Sensor Field: Area where sensor nodes were deployed is better known as sensor field or area. Deployment of sensor nodes may be random or pre-determined depending on the application of WSN. Distance between nodes is according to choice routing algorithm in application. Area size depends upon the number of nodes deployed in the environment.

III. CLUSTERING ROUTING PROTOCOLS

Routing protocols decide that how the sensor nodes will have the communication with each other in the wireless sensor network. The sensor nodes having Higher level of energy of network is spent for transmission of information signals. In Clustering techniques for Wireless Sensor Networks, sensor network is divided in between multiple groups known as clusters. One of the nodes of group is elected by the sensor node and is better known as cluster head. Role of cluster head can rotate among all other nodes of cluster depending on algorithm selected by the routing protocol. Signal packets are transmitted to the base station by the sensor node that is cluster head for present round. Cluster head may perform data aggregation or data fusion on received message or data before further sending to base station. In fig 2 network architecture for clustering technique is shown.



IV BENEFITS FROM CLUSTERING PROTOCOLS

In Clustering routing methods sensor nodes have to perform two types of tasks either to being as a cluster head or being non-cluster head being as a cluster head it performs all the sensing tasks. Election is divided in multiple rounds; at each round responsibilities may be changed to balance the energy consumption in the wireless sensor network. Clustering reduces the complexity of network by dividing into different sub-networks these sub-networks are clusters. Advantages of Clustering method are explained below:

- Manageable Network Size: In clustering, nodes are maintained in various groups. Cluster Head of cluster works with base station for transmitting information signals with the help of the trans-receiver. Base station receives information from the few nodes as compared to other routing protocol that are being used in wireless sensor network. This type of scheme is good for those applications where a great number of sensor are needed for the user defined assignment. Network can work efficiently using clustering protocols. Sensor Nodes do not contact with the base station directly.
- Load distribution should be balanced: Due to the splitting of sensor network into various cluster, the overall tasks is spitted which automatically helps to provide the energy dissipation among all the sensor nodes equally. In flat routing protocols, the nodes which are situated far away from the base station looses all energy as compared to node nearby base station and in result dies first this is just because of more energy consumption which is required by the sensor nodes to transmit the data to the base station. By the clustering all the sensor nodes have an assigned work to do within the specific time.
- Data Aggregation/ Fusion: nodes send the data signals to the cluster heads and cluster head, data is either aggregated to reduce volume of redundant information or fused to join information signals in single packet.
- Stable Network Lifetime: load distribution equally among many sensor nodes, networks can be able to increase the network lifetime for longer period. Sensor nodes consumes energy in each round of communication, by doing this the possibility of death of nodes in particular sensor field decreases. In these type of algorithms if network is becoming non-functional then it includes death of nodes from most of the part of the network after number of rounds of algorithm. By comparing with other algorithms Stability of network can be maintained for longer period.

- Collision Prevention: In wireless sensor network with flat model of communication, many nodes have to transmit signal to base station at same time that can result in intermixing of packets. On the other hand, clustering technique uses unique spreading factor method or any other method to prevent clashes.

V. LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY CENTRALIZED

LEACH-C: LEACH-C [2] is based on simple LEACH routing protocol and consists of cycles that are divided into two phases i.e. set-up and steady state phases. In LEACH routing protocols some of the cluster heads can be very near to base station or at far away from the base station. If the distance between cluster head and base station is more or very large then there will be more energy consumption. In LEACH-C an assumptions are made that are:

- Each sensor node within sensor field have knowledge of its energy level by calculating it.
- Sensor Nodes will send signal about its location to Base Station for localization propose.
- Each and every sensor node can send information to base station.

In LEACH distance does not matter when it elects cluster heads of the clusters which in results causes more energy dissipation. In LEACH-C, base station selects the cluster head of the sub-network on the basis of an energy level of sensor node and the communication distance between sensor node and base station which is going to be the cluster head of the present round. Cluster Heads gets changed with every change in the rounds in LEACH on the other hand in LEACH-C it is optimal value that is predetermined.

Set-up phase: In set-up phase, sensor nodes sends their status of energy level, location and node identity to base station. After an energy level comparison of sensor nodes with taking particular average value, base station elects the cluster head sensor nodes of the network on the bases of these parameters. If node had energy level more than the average energy value for the parameters, it can become cluster head of the network. Base station broadcast the identity of the elected cluster head to the sensor nodes of the existing network. After cluster head's selection, cluster head sends an advertisement message to all sensor nodes. Nodes that are not cluster head depending on the strength of the message signal received from the cluster head determines the cluster for the present round and for formation of clusters transmits signal to cluster head. Other functions of LEACH-C are same as LEACH.

Steady-state Period: In the steady state phase, TDMA scheduling is done for non-cluster nodes send information signals to cluster head. After data aggregation, messages are transmitted to base station. LEACH-C works better under fewer loads, but for higher load complexity of selecting cluster head by centralized method degrades its performance. Number of Clusters-heads: As LEACH-C is improved version of LEACH; optimal value of number of cluster heads is same as 5% of nodes in network.

VI. LEACH

Heinzelman et. al. [1] introduced a hierarchical clustering algorithm for wireless sensor network known as (LEACH) Low Energy Adaptive Clustering Hierarchy. It is a cluster based routing protocol which has distributed cluster creation LEACH protocol randomly selects a few sensor nodes as cluster heads and rotates this role constantly to distribute energy load along all node in the entire network, in LEACH the cluster head node compress data arriving from the sensor nodes that are in the particular cluster and send an aggregated packet of data to the base station to decrease the load of data that must be transmitted to the base station [7]. To reduce the intra-cluster and inter-cluster impact LEACH uses TDMA/CDMA MAC. Although all data which comes from the sensor node is transmitted to the cluster head and is operated continuously hence this routing protocol is utmost convenient when we need a regular supervision of wireless sensor networks. All data may not be needed by the user immediately hence continuous data transmission can be delayed which may save the limited resources of the sensor node. After a specific time limit a random rotation of the role of the cluster head is regulated so that the equal energy consumption in the wireless sensor network is achieved. W. Heinzelman, A. Chandrakasan and H. Balakrishnan found in their simulation that 5% among the nodes are needed to act as a cluster head. LEACH operates in two phases which are setup phase and steady state phase. In setup phase clusters are arranged and cluster heads are chosen. On the other hand in steady state phase the data transmission takes place from cluster head to the base station. The overall time period of steady state phase is longer than that of setup phase to reduce the overhead. During the setup phase a fixed fraction of nodes p, selects themselves to as a cluster heads. A sensor node chooses a random number r, between 0 and 1. If the selected random number is less than that of threshold value, T (n), the node becomes cluster head for the selected round [10]. The

threshold value computed based upon the equation that includes the required percentage to become a cluster-head, for the selected period. The bunch of nodes which are not selected as a cluster-heads in the last (1/P) rounds, denoted by G. The equation is given by:

$$T(n) = \frac{p}{1 - p\left(r \bmod \left(\frac{1}{p}\right)\right)} \quad if\ n \in G$$

Where G is the bunch of nodes who took part in the cluster-head election. Cluster-head which is selected from the election broadcast an advertisement message to the remaining nodes of the network that those broadcasters are the new cluster-heads. All sensor nodes decides the cluster to which they want to belong to after receiving this advertisement from the cluster-heads. All sensors in forms the suitable cluster-head that they will be the members of that of the cluster. The decision of selecting cluster-head by the sensor node is based on the strength of the advertisement signal. After receiving all the messages from the sensors nodes who wants to be in the cluster based on the amount of the nodes in cluster, the cluster-head node initiate creates a TDMA schedule and allocate each node a time-period that when they have to transmit. This scheme is broadcasted to all the sensor nodes in the cluster.

In steady state phase, the nodes can start broadcasting and sensing data to the cluster-head. After receiving the all data from sensor node data is aggregated and then it is transmitted to the base station by the cluster-head node. After a specific time period which is pre-determined the network switches back to the setup phase again and another round of selecting cluster-heads starts. Each cluster uses different CDMA codes to communicate and to reduce the interference from the all the sensor node in other nearby clusters [4] [8]. LEACH is able to increase the lifespan of the sensor network but still there are number of issues on the assumptions used in this protocol. In LEACH it assumes that all the sensor nodes are able transmit their data to the base stations with adequate power to reach the base station if needed and also that each sensor node has a power to compute and support various MAC protocols this simply states that this protocol is not suitable for the sensor nodes deployed in large area or region it also assumes that sensor nodes have always data to transmit and all sensor nodes are situated very close to each other and had related data [5]. It is not clear that how predetermined cluster-heads is distributed uniformly throughout the sensor network [9] [11]. So there is a great feasibility that these cluster-heads are concentrated only in one part of the sensor network [12]. Thus some of the sensor nodes do not have cluster head in their range. Besides the thought of the dynamic clustering causes extra overload because cluster head changes, advertisements etc. [13] [17] [18]. which may decrease the gain in power consumption. Last that all sensor nodes start with same value of energy for the election round assuming that the cluster-head consumes nearly same energy. An extension to LEACH, LEACH with negotiation was proposed in [1]. This makes sure that only data that provides new information is broadcasted to the cluster head before it was transmitted to the base station. Table1 shows the comparison between the SPIN, LEACH and Directed Diffusion Which is redrawn form the [3].

	SPIN	LEACH	Directed Diffusion
Optimal route	No	No	Yes
Network Lifespan	Good	Very good	Good
Resource Awareness	Yes	Yes	Yes
Use of Meta-Data	Yes	No	Yes

Table 1: Comparison between SPIN, LEACH and Directed Diffusion.

The table shown above shows the comparison between SPIN, LEACH & Directed Diffusion techniques according to different parameters. The table states that Directed Diffusion routing technique shows promising approach for energy-efficient routing in wireless sensor networks due to the use of processing in the network.

VII POWER EFFICIENT GATHERING IN SENSOR INFORMATION SYSTEMS (PEGASIS)

PEGASIS [4] form chain based network for communication instead of clusters unlike LEACH, LEACH-C. Each node transmits its sensed signal to its closed neighbor and this process continues till a node near to base station transmits the fused signal to base station. Assumptions made in the algorithm are:

- Base station is fixed and situated at far place from the nodes.
- Nodes are equipped with equal amount of energy.
- Nodes have knowledge of global positioning of sensors.

• In [5] In [5] author proposed an enhanced protocol over LEACH protocol known as Power-efficient Gathering in Sensor Information Systems

(PEGASIS), is a near optimal chain-based protocol. The main idea behind this protocol is that to extend the lifespan of the network, in this node needs to transfer data only to the closest nearby sensor nodes. Sensor nodes take turns to communicate with the base-station. When one cycle of all sensor node completes by doing communicating with base-station then new cycle starts and this kept on repeating again and again. Energy consumption among all nodes is spread uniformly to transmit data per cycle to reduce energy consumption required to transmit data and conserves energy. Thus PEGASIS has to two main aims. Firstly to increase the lifespan of the wireless sensor network by combining techniques and as a result lifespan of the wireless sensor network is increased and secondly to let on only simple coordination between nodes that are close enough to each other so that bandwidth utilized in between sensor nodes for communication is reduced. In PEGASIS opposite to LEACH, PEGASIS is the formations of clusters and utilize only one sensor node in a chain to communicate to base station rather than using many nodes [14]. To discover the closest nearby sensor node in PEGASIS, every node uses the strength of the signal to find the distance to all nearby nodes and then adjust the strength of the signal so that only one sensor node can be noted [6] [15]. The chain in the PEGASIS will consist of only those nodes which are adjacent to each other and then forms a route towards to the base station.

Data Transmission: Token indicates which node can transfer the data signal to next member of the chain. Receiver node fuses the received data signal with its own data signals [16]. When leader node receives the fused data signals it further transmit the data packet to base station after adding its own data signals.

VIII. COMPARISION OF LEACH, LEACH-C, PEGASIS ROUTING PROTOCOLS OF WIRELESS SENSOR NETWROKS

We have discussed Working of these routing protocols i.e. LEACH-C,LEACH and PEGASIS in this review paper. In table 2 comparison of these three routing protocols have been made on the basis of various parameters.

Sr. No.	Parameter	LEACH-C	LEACH	PEGASIS
1	Classification	Cluster based	Cluster based	Chain Based
2	Data Transmitter	Cluster based	Cluster based	Round Leader Node
3	Clustering Method	Centralized	Distributed	Hybrid
4	mobility	Fixed BS	Fixed BS	Fixed BS
5	Number of clusters	Multiple	Multiple	Single
6	Data aggregation	Yes	Yes	No
7	Query based	No	No	No
8	Choice of cluster	Based on energy level and distance from the base station	Based on the probabilistic approach	Based on the distance from the base station
9	Number of groups	Guaranteed	Not Guaranteed	Guaranteed
10	Scalability	Medium	Medium	Poor
11	Efficiency	Medium	Poor	High
12	Delay	Small	Very small	Very Large
13	Deployment of nodes	Random	Random	Random
14	Load balancing	Medium	Low	Medium
15	Complexity	Medium	Low	High
16	Service	No	No	No

IX. CONCLUSION

Many solutions have been resolve the energy efficiency issues which are involved in Wireless sensor networks. Routing protocol are responsible for the communication path between transmitter and receiver we have compared the three routing protocols that are introduced in the field of wireless sensor networks and during our studies we found that PEGASIS routing protocol maintains better lifespan as compared to LEACH routing protocol and LEACH-C routing protocol.

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