

# Review of Leach Routing protocol and its extension versions of wireless sensor network

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**Abstract—** Routing protocols are responsible for the efficiency of the wireless sensor network. In this paper we have reviewed the LEACH Routing protocol as well as its extended versions also like S-LEACH, M-LEACH, Multi-Hop LEACH etc. technology is changing day by day these days and these efforts are done in wireless sensor networks to manufacture a low power consuming and a multiple tasking sensors for the wireless sensor networks. In WSN's the network is made up of having the combination of multiple small tiny sensors nodes. That can be deployed in those areas where human approach is not possible. With the many advantages wireless sensor networks have its biggest limitation i.e. power consumption of wireless sensor network. So to make energy efficient power consumption many routing protocols have been introduced in wireless sensor networks researchers are doing work on routing protocols to find out more and more energy efficient routing protocol which can increase the lifespan of the network.

**Index Terms—** WSN, LEACH, NETWORK LIFESPAN, S-LEACH, M-LEACH, MULTI-HOP.

## I. INTRODUCTION

The increase in today's technology leads the wireless sensor networks to manufacture low power consumable low cost multiple-tasking sensor nodes the common architecture of wireless sensor networks contains of power source, trance-receiver, microcontroller (CPU), analog and digital converter, external memory and a sensing unit (sensor) [1]. Figure show below shows the architecture of wireless sensor node.

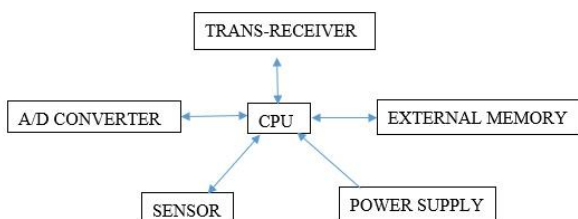


Figure 1

The wireless sensor network is a set of millions of billions of sensor nodes and these wireless sensor networks are basically battery operated equipment's and these batteries are non-rechargeable [2]. In wireless sensor networks sensors are used to monitor physical environment. The conditions which are sensed by the sensor nodes are such as like sound, temperature, pressure etc. sensor nodes share the information through links [3]. The paths through which data is sent is known as routing path of the networks and in

wireless sensor networks routing protocols takes care of routes and all routes are decided by these routing protocols and these protocols has to make sure that a reliable communication path has been made in between transmitter and receiver. The working capability of a particular sensor is low but the combined power of the entire network is capable enough to perform the user defined tasks. Nodes are battery operated and can be deployed into environment randomly or by deterministically. Energy consumption is the major issue in WSN's [4]. The network having sensor are designed in such a way that they can work up to their last as the source is limited the work of routing protocols increases automatically cause the routing of sensor network consumes lots of power so a routing protocol is required on which we can count and this routing should contain two properties which are 1. It should be reliable. 2. It should be energy efficient. Many protocols have been introduced to achieve the above said goals [5]. For increasing the lifespan of sensor network a data should be sent in such a way that it consumes less energy and this is maintained among all the nodes [6]. This review paper discusses the LEACH routing protocols and also its extended versions to analyze the performance of LEACH and its extended versions.

## II. ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORKS.

In wireless sensor networks routing is different from the traditional wired fixed networks in which wires are used for communication purpose. In wireless sensor networks links are unreliable sensor nodes in sensor networks may fail due to any reason and in between this routing protocols of the wireless sensor networks has to meet strict energy saving requirements [7]. So many routing protocols have been deployed for sensor node networks and these routing protocols can be split into six major categories of routing protocols as shown below in table 1 which is redrawn from [2].

Sr. No.	Types	Representative Protocol
1	Hierarchical Protocols	LEACH, PEGASIS, TEEN, APTEEN
2	Data-centric Protocols	SPIN, Directed Diffusion, Rumor Routing, Gradient-Based Routing, Energy-aware Routing,
3	Location-based Protocols	MECN, SMECN, GAF, GEAR, TBF,

4	Multipath-based Protocols	Sensor-Disjoint Multipath, Braided Multipath, N-to-1 Multipath Discovery
5	Heterogeneity-based Protocols	IDSQ, CADR, CHR
6	QoS-based protocols	SAR, SPEED

### III. HIERARCHICAL PROTOCOLS

Hierarchical protocols are basically a cluster based routing in wireless sensor networks [8]. These routing protocols have special advantages which are related to the energy efficiency and scalability of communication which is the most important in case of routing protocols. In this type of routing protocols node having higher energy can be utilized to process and used to transmit the data to the base stations and on the other hand sensors having low energy can be used to sense the environment conditions up to their lasts this justifies that creating cluster heads in cluster and assigning them a special task can contribute to overall wireless sensor networks system a lifespan, scalability and energy efficiency using Hierarchical protocols routing can be used in efficient way to achieve lower energy consumption with in the network or the cluster and by executing data aggregation and data fusion number of messages that is to be transmitted to the base station can be reduced [9]. Hierarchical protocols are two layers routing protocols in which one layer is responsible to the selection of the cluster heads and the other layer is used to select the routing.

### IV. LEACH

LEACH is the first Hierarchical routing protocol in wireless sensor networks and stands for low energy adaptive clustering Hierarchy it is a self-organizing adaptive clustering routing protocol. In this energy load is distributed among the sensor nodes equally. Sensor networks are randomly selected and randomization process is done in this routing protocol. LEACH protocol works on following assumption [9].

- Node located close to each other have harmonized information.
- Sensor nodes can transmit data with sufficient power so that it can reach base station.
- Every sensor node has adequate computational energy so that it can support various MAC protocols.

According to LEACH routing protocol. The base station of a networks has a fixed location and it is located very far from the network and its location may vary in some cases. While the sensor nodes are energy constrained and homogenous in a cluster one sensor node is called cluster head it works as local hub or station for other sensors and its works is to collect all information from the sensor nodes with in its cluster. Selections of these cluster heads rotates randomly and sensors having higher energy level are elected as the cluster head of the current round. And by selecting the cluster head randomly the energy consumption is distributed among all sensor nodes equally. It also compresses the data when information is sent from sensor nodes of a cluster to cluster heads and from cluster heads to the base station and this

process is known as the data fusion process in the fields of wireless sensor networks, purpose of all this is to reduce the energy consumption and increase the life span of the network. LEACH performs its all task in two phases which are:

- Set-up phase
- Steady state phase

Setup phase: In setup phase whole network is split up into clusters and cluster head selection process is done for each cluster of the network. Cluster heads are being selected from the sensor node at a time with a certain probability [8]. Each and every sensor node generates the random number from 0-1 and if this number is below threshold node  $T(n)$  then this particular node becomes the cluster head for the next round. The equation by which cluster heads are selected is given below and it is rewritten from [10]

$$T(n) = \frac{p}{1-p} \left[ r \bmod \left( \frac{1}{p} \right) \right] \quad n \in G = 0 \text{ otherwise} \dots 1$$

Where  $r$  is the current round  $p$  is the percentage of the sensor nodes that are cluster heads.  $G$  is the set of those sensor nodes who have not served as a cluster heads in the last  $1/p$  rounds. Cluster heads allocates time slots to nodes within its sensor nodes within its cluster clustering of leach is shown below in figure 2

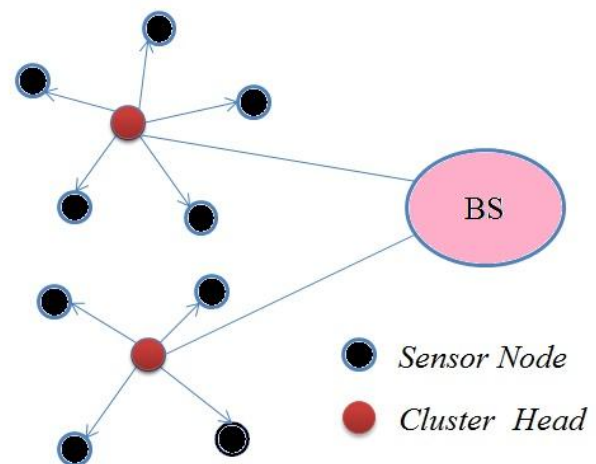


Figure 2

In the next phase or phase II which is steady state phase sensor node send their gathered data or information to the cluster heads when their time slots arrive using time division multiple access technique. When the cluster head receive data from its cluster then it sends data to base station after doing data fusion base station is located far away from the cluster head so cluster head needs high energy to transmit its data to the base station so it consumes more energy than other nodes. This affects only cluster heads. This is why the selection of cluster heads remains depending upon the remaining energy of the node. Various routing protocols have been extracted from the LEACH routing protocols and every protocol is introduced with an enhancement in basic routing. Some of them are

- Multi-hop leach
- S-LEACH (solar aware LEACH)

- M- LEACH

#### A. MULTI-HOP LEACH:

When in wireless sensor networks a network area is raised beyond a particular level a distance between the cluster-head and base station increases exceptionally this frame-work or scheme is not suitable for LEACH protocol [11]. Base station and cluster-heads are connected through single-hop and this is why power wastage in cluster-head cannot be affordable. To overcome this issue multi-hop LEACH is introduced by rajshree et.al. in [12] multi-hop LEACH is extension of LEACH routing protocol and it is used to increase the network energy efficiency in the wireless sensor networks [13]. This routing protocol is also entirely cluster based routing protocol. Similarly as in LEACH routing protocol. In this sensor nodes in sensor field elects them as cluster-heads and all the other node of the field collaborates themselves with the particular cluster head to achieve the cluster formation in the set-up phase. In other phase which is steady state phase cluster-head collects all data from the all sensor nodes with in its field and then transmit it through the trans-receiver to the hub or base-station after performing fusion and data aggregation on the information which is received from the sensor nodes. There are two types of communications in MULTI-HOP LEACH 1) Intra-cluster and 2) Inter-cluster.

#### B. S-LEACH:

S-LEACH stands for Solar aware LEACH. Energy consumption is serious issue in some applications of wireless sensor networks mostly when the node was deployed in some of those areas where human interference is almost negligible or those areas where sensor nodes are non-accessible [14]. Authors introduced in S-LEACH routing protocol in [14] they increased the life span of the wireless sensor network with the use of solar energy. In S-LEACH few of the sensor nodes in the network are packed up with the solar energy and these nodes straight-forwardly acts as a cluster-heads in the field of the sensor networks and these particular sensor nodes which are geared-up with solar power depends directly upon their solar status. S-LEACH is further explained into two types which are 1) SOLAR AWARE DISTRIBUTED LEACH and 2) SOLAR AWARE CENTRALIZED LEACH.

- Solar Aware distributed LEACH: in this only those sensor nodes are elected as the cluster heads which are geared up with the solar power or are solar driven. Probability of sensor node which are solar driven is higher than the battery operated sensor nodes in sensor field

$$T(n) = Sf(n) \times \frac{p}{1 - \left(\frac{CHEADS}{NUMNODES}\right)} \dots\dots 2$$

Equation two is rewritten from [15] where Sf(n) is equal to 4, p denotes the percentage of previously elected cluster heads Cheads implies the number of cluster head nodes

since the start of the cycle and numnodes are total number of nodes in a cluster [16][14].

- Solar aware centralized LEACH: in solar aware centralized LEACH cluster heads are elected by the base station for this base station uses the improved central control algorithms. Base station normally selects the solar powered nodes through increasing their unused energy. Authors have increased the cluster-head selection algorithm by using LEACH-C [17] [18]. Sensor node which are geared up with the solar sends their energy status to the base station with solar status the sensor nodes which have higher energy status are elected as the cluster heads by base station on the above said parameters energy efficiency and performance of the sensor node field is increased only when the number of solar powered sensor nodes is more. Lifespan of the networks totally depends upon the duration of the sun. if any sensor node is serving as the cluster head is battery operated and a sensor node in a cluster sends the information with the flag, then its solar-power is raised up and that sensor node becomes the cluster head for the next round and it takes place of the first serving cluster head and this also increases the life span of the wireless sensor network.

#### C. M-LEACH:

M-LEACH is a combination of similar networks with respect to energy which is not a sensible approach in a single round unevenly nodes are attached to the many cluster heads in this case the cluster heads which are connected to or associated with the large number of sensor node in a sensor field drains more energy than those which are associated with the less number of nodes hence they dies quickly as compared to others however there is a another issue with the LEACH routing protocol i.e. the mobility support. To minimize these issues in LEACH M-LEACH is proposed in [19] authors introduced that M-LEACH authorizes the mobility of the sensor nodes as well as cluster heads during the setup phase as well as in steady state phase. Similar to LEACH M-LEACH also consider the remaining power of the cluster heads for the election of the cluster head for the next round. Global positioning system is also used for the location information of the sensor nodes and base station. Base station in M-LEACH has fixed location a suitable cluster head is elected in M-LEACH for the selection of the cluster head M-LEACH uses the attenuation model [20] a sensor having lowest attenuation power is elected as a cluster head for the next round. The elected cluster head transmits its status to the all other sensors within its range with the help of trans-receiver then the sensor node in sensor field selects its cluster head having maximum remaining energy while in steady state phase in some cases sensor nodes of the sensor fields moves far away from the cluster head or cluster heads moves away from the sensor nodes communication range then the nearest cluster head becomes the best choice to the sensor nodes but because of this the cluster formations gets disturbed so to deal with this issue M-LEACH provides a mechanism to resolve this issue to switch on to new cluster heads i.e. handover mechanism. When a sensor node decides

to hand over the transmit a message DIS-JOIN to their present existing cluster-head and also transmits a message request message JOIN-REQ to the new cluster head which they want to switch to after the handover process cluster heads reschedules their transmission pattern.

## V. CONCLUSION

In this review paper we have discussed LEACH routing protocol and its extended routing protocols like MULTI-HOP, S-LEACH, M-LEACH routing protocols for the wireless sensor networks. The major motive of this review paper is to study the LEACH protocol and its extinctions and to analyze how these protocols are capable enough to increase the lifespan and energy efficiency of the wireless sensor network. It has found that every extensions of LEACH discussed in this paper increase the efficiency and lifespan of the network in their respective manner during our study. Some Common Mistakes

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