# A New Multi-hop approach for sensing coverage in wireless sensor network

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**Abstract- Sensor networks provide a strong combination of distributed sensing, computing and communication. Wireless sensor networks (WSNs) are recently rapidly growing research area in wireless communications. WSNs are studied widely and usefully applied in many applications like military surveillance, environmental monitoring etc. This paper deals with the coverage problem of wireless sensor network. In WSNs, a large number of sensor nodes are scattered over a considered area; therefore, coverage problem occur in the network. In our method, we have used the clustering technique- K-means algorithm and the concept of gateway node to collect, receive and transferring data . In this paper, we propose a new multi-hop cluster based routing protocol and compare it with single-hop protocol LEACH.**

**Keywords-** wireless sensor network, sensing coverage, multi-hop communication, gateway node, K-means algorithm, LEACH.

## I. INTRODUCTION

*Wireless Sensor Networks* (WSN) [1] are used in wide range of applications such as medical, military surveillance, object tracking, security, information broadcasting, environmental monitoring, weather reporting, underwater and remote sensing etc. Wireless sensor nodes have existed for decades and first time used in 1978 DARPA- sponsored Distributed Sensor Nets Workshop Carnegie Mellon University(CMU), tracking for military applications[2]. Advances in wireless networking technology and portable information appliances have brought about two implementations of wireless networks defined by IEEE 802.11: infrastructure network and ad-hoc network. MANETS (Mobile Ad-hoc Networks) and sensor networks are two classes of the wireless Ad-hoc networks with resource constraints.

In wireless sensor networks, the resources of a sensor node is limited ,these tiny sensors have the ability of sensing , data processing, and communicating with each other. Wireless Sensor Networks which rely on collaborative work of large number of sensors are realized. Sensor nodes can be used within many deployment scenarios such as continuous sensing, event detection, event identification, location sensing, and local control of actuators for a wide range of applications such as military, environment, health , space exploration and disaster relief[2].

In wireless sensor network the sensor node having information is known as source node, their task is to send information to the base station(BS).But the question is that which is the most energy efficient way to send the information to the base station. In this paper we are trying to present an algorithm which will be more energy efficient. For that purpose we are using the K-means algorithm[3] to create the cluster and after formation of the cluster, with the help of gateway nodes the source node send the information to the base station(BS). In the cluster only the active sensor nodes involve in send information to the base station.

## II. RELATED WORKS

Routing is the process of data transmission. The researchers have developed a large number of protocols to intensify the life of wireless sensor network. To manage the energy efficiency of a wireless sensor network there are many clustering technique in routing protocols are hierarchically organize in a network

Wendi Rabiner Heinzelman et al [4] describe LEACH is the first protocol which was proposed for reduction of energy consumption. The main methodology of LEACH is to create a cluster first, then select a cluster-head as router to transfer data from the sensor nodes to the base-station via one-hop.

Lotfi Benmohamed et al [5] describe the concept of gateway nodes. They have described that on consideration of a wireless sensor network with deployment of large number sensors, a subset of sensors are covering the sensor field equipped with special communication capability to communicate with the sensor outside the sensing field. These sensors are called as gateway nodes.

Takumi MYOSHI et al [6] defined a maximum sensing coverage problem in wireless sensor network in his paper, where he proposed an algorithm to solve this problem. He was trying to define how minimum number of active sensor nodes can monitor maximum area.

Amlan Jyoti Baruah et al [7] defined a multi-hop algorithm which provides an energy efficiency. In this paper the authors are showing the combination of both gateway nodes and Maximum sensing coverge problem.

Sartaj Sahni et al [8] defined an algorithm for sensor network. In this paper the authors are discussing some recent advances in the development of algorithms for wireless sensor network. Authors focus on sensor deployment and coverage, routing and sensor fusion.

Multi-hop inter cluster is made up of one cluster-head (CH) and cluster members. The respective CH receives the sensed data from sensor nodes of a cluster, then aggregates the data and then sends the data to the Base Station via multi-hop[7] .

Multi-hop intra-cluster use single hop communication within a cluster for communication between the sensor nodes and the cluster heads, but it may not be the optimum choice.

## III. THE PROPOSED MULTI-HOP ALGORITHM

The main purpose of multi-hop algorithm is to transmission of data from cluster-head(CH) to the base station(BS). So in this algorithm we are using multilevel hierarchical data gathering network architecture. Here at the bottom most level first clusters are created using the concept of K-means algorithm, then cluster-heads are created in respective clusters. Thereafter sensor nodes senses data and send the data to cluster-head, finally cluster-heads send data to gateway nodes . In the next level all the gateway nodes communicate with a base station (BS).

### A. Some assumptions:

The required assumption for the multi-hop algorithm are as follows :

1. Base station is remaining stationary all the time when it is situated outside the network field.
2. All the sensor nodes spread over a two dimensional space and can't be recharge after deployment.
3. All the nodes are spread over the network in a stable mood.
4. All the sensor node can transmit information to gateway nodes very easily.
5. Gateway nodes know the location of the base station.
6. Cluster-heads send the data to the gateway nodes and gateway nodes transmit data to the base station.
7. It's a one to one connection between a cluster-head and a gateway node.
8. Cluster-heads collect data from the sensor nodes.
9. Each sensor node has same initial power.

### B. Proposed algorithm:

Proposed algorithm works in rounds. Performance of each rounds are given below:

- The base station increments the round number periodically from the previous one.
- Once the round number increase, cluster-head should be selected with the probability 0.1 on the basis of Leach protocol.
- Cluster-heads can be chosen on the basis of a random number 0 or 1. If the number is less than a threshold value T(l). The node becomes a cluster-head for the current round. The threshold value is set as following.

$$T(l) = \{D/1\text{-}D*(z \bmod 1/D)\} \text{ if } l \in U, \text{ if not its } 0.$$

Where D is the desired cluster-head probability, z is the number of the current round and U is the set of nodes that have not been cluster-heads in the last 1/D rounds.

- After formation of the cluster-head, it selects a gateway node lies closest to it.
- After selection of the cluster-head it's time to create the cluster.
- For creating the cluster the concept of K-means algorithm is used.
- When the cluster-heads are selected , with the help of K-means algorithm base station(BS) first chooses the initial K cluster-heads arbitrarily from the selected cluster-heads.
- Repeat.
- The squared error criterion is used to determine the clustering quality.
- (Re)assign each node to the cluster with the nearest CH, based on the mean value of the nodes in the cluster.
- Now update the cluster mean.
- Until no change.
- Finally clusters have been created because of the K-means algorithm.
- Then, on the basis of one-to-one communication the CHs aggregate data from the sensor nodes and then send the data to the gateway nodes.
- And finally BS receives the data from the gateway nodes.

## IV. COMPARISION AND PERFOMANCE EVALUATION

All the simulations are done with the help of MATLAB. Taking the assumption as 100 sensor nodes are deployed in a 200×200 network field and the base station is 100m away from the network field. Here the proposed Multi-hop protocol is compared with the single-hop protocol LEACH.

### A. Energy Model for Data comunication

For the experiments described here only the free space channel model is used. Thus, to transmit an *l*- bit message a distance *d*, the radio expends energy:

$$E_{Tx}(l,d) = (l\, E_{elec} + l\, E_{fs}\, d^2)$$

To receive this message, the radio expends energy:

$$E_{Rx}(l) = l\, E_{elec}$$

### B. Simulation

The simulation involves network lifetime & average residual energy is evaluated.

TABLE-I: SIMULATION PARAMETERS

| | |
|---|---|
| Initial Energy per node | 2 joule |
| Network Size | 200×200 |
| Number of nodes | 100 |
| Number of Gateway nodes | 10 |
| Data packet size | 500 bytes |
| CH probability | 0.1 |
| Data frame | 30 |
| Energy dissipation ($E_{fs}$) | 10×0.000000000001 Joule |
| Energy for Transmission ($E_{Tx}$) | 50×0.000000000001 Joule |
| Energy for Reception ($E_{Rx}$) | 50×0.000000000001 Joule |

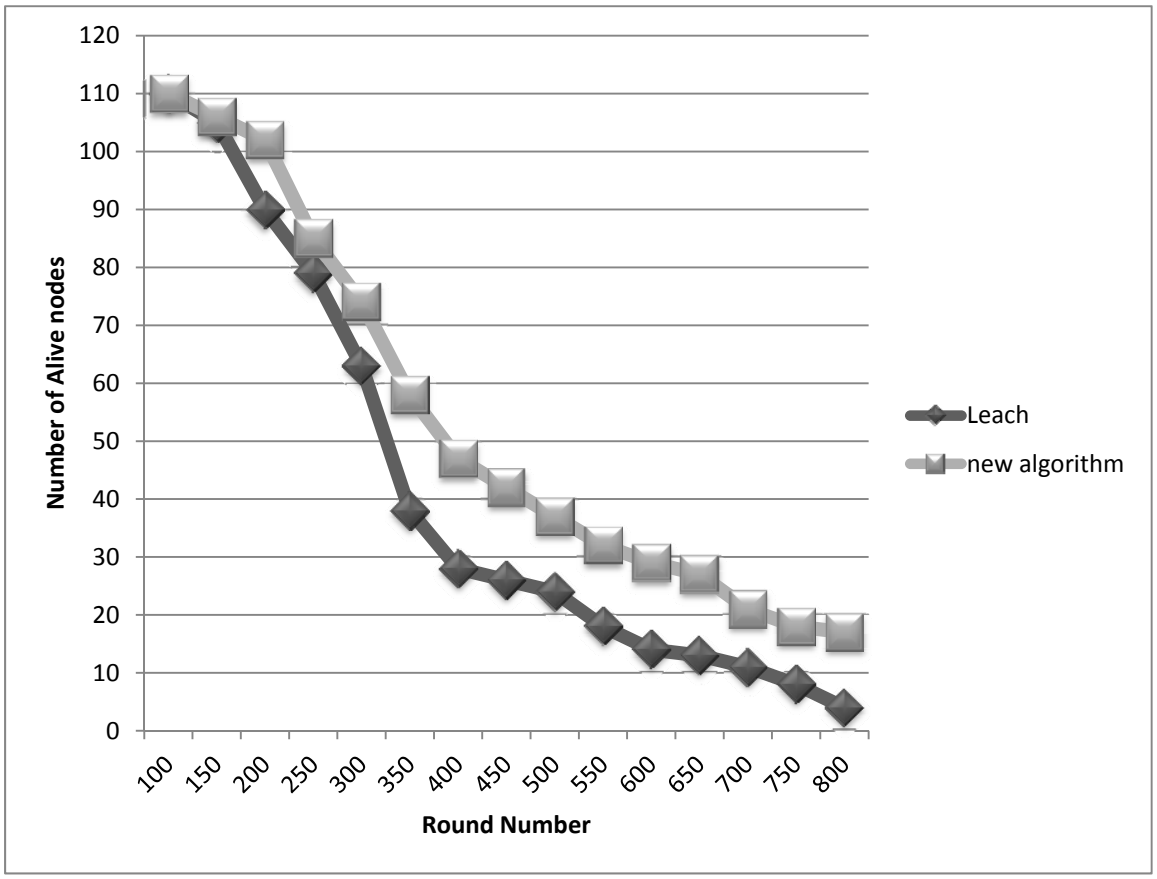


Fig 1 : Network Life Time( Number of Alive Nodes vs Round Number)

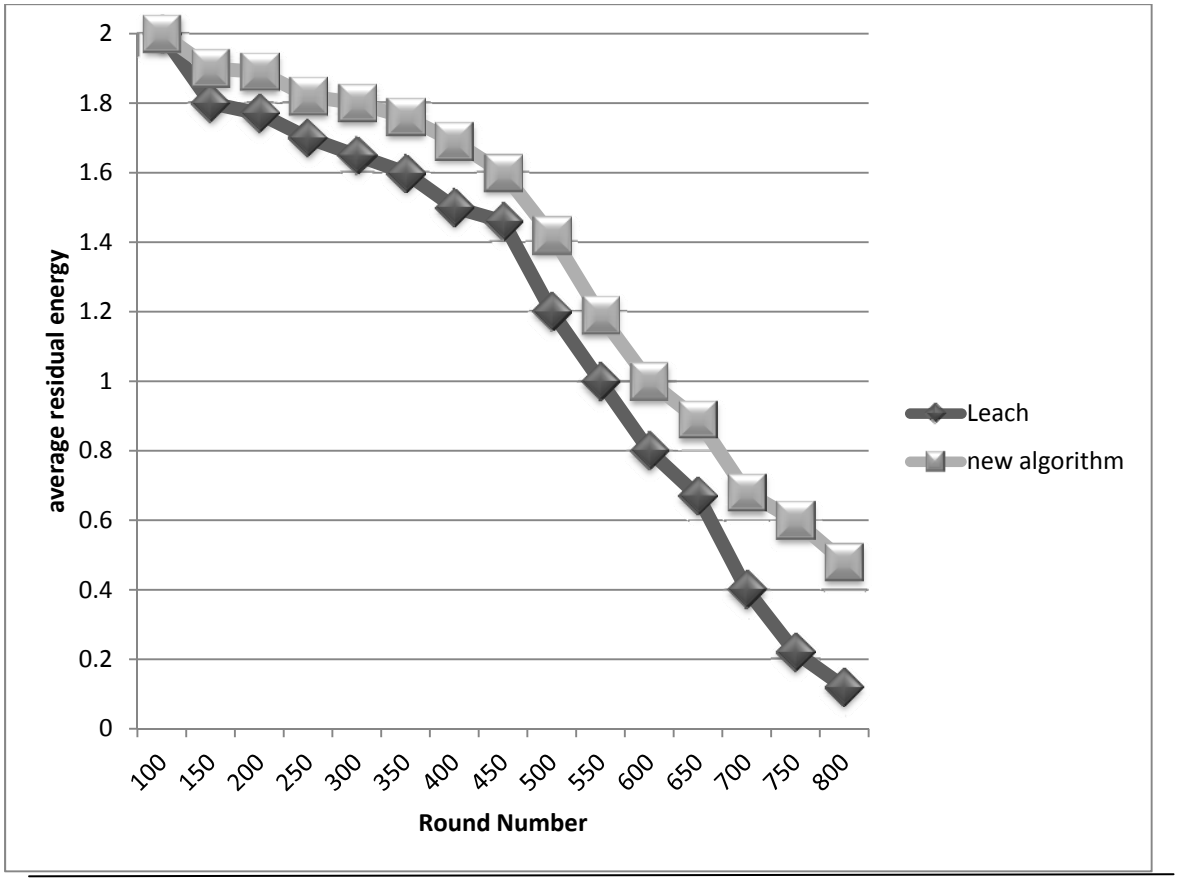


Fig 2 : Average residual energy vs Round number

From the above figures we come to know that average residual energy and Network Life time of the new algorithm is better than the LEACH algorithm.

**C. Theoretical Analysis and Comparisons :**

Here we are giving the comparisons between the proposed Multi-hop approaches and the LEACH Protocol. Comparisons are given below.

The simplest path-loss model, called free-space, assumes that there are no obstructions between transmitter and receiver. Free-space path loss is proportional to the square of the distance between the transmitter and receiver. Other models take into account effects of multipath fading and one of the most commonly used is long-distance path loss (PL) model.

$$PL \approx (1/t)^{\alpha} \quad (1)$$

This model employs path loss exponent α which can be measured under different propagation scenarios.

Using this model we can express receiving power $T_r$ at distance $t$ from the transmitter:

$$T_r = T_0 . (t_0/t)^{\alpha} \quad (2)$$

where $T_0$ represents known received power at distance $t_0$ from a transmitter and α is the path loss exponent.

A single-hop clustering routing protocol can reduce the communication overhead by selecting a CH to forward data to base station via one hop. LEACH is one of the single-hop clustering protocols. In case of LEACH protocol, firstly it creates the cluster by the sensors in an area. After formation of the clusters, all cluster members of a particular cluster sensed the data, then aggregate the data and send it to the particular cluster-head (CH). Cluster-heads finally transmit the data to the base-station (BS). We can show it through diagrammatically.

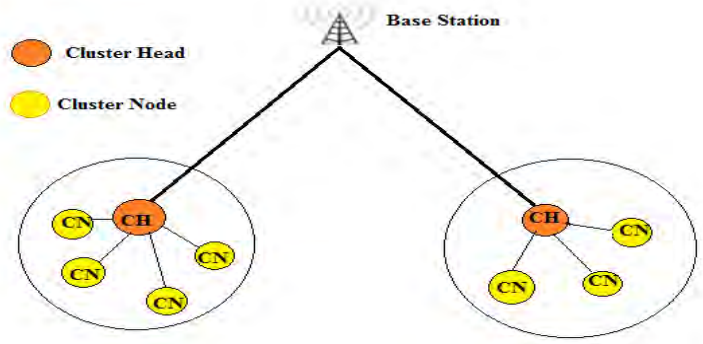


Fig 3 : Structure of LEACH protocol

From the Fig 3 we can see that the cluster-head (CH) send the sensed data to the base-station (BS) via single-hop. We can show it using the concept of distance Fig 4.

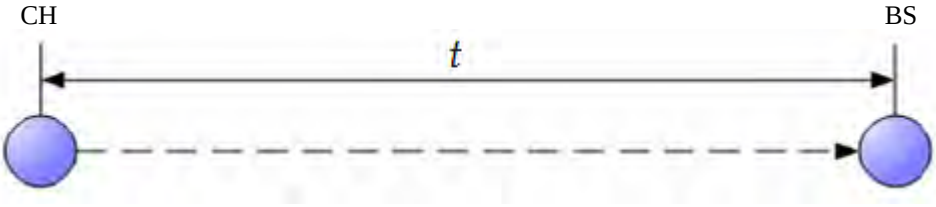


Fig 4 : Transmission distance for Singe-hop

Basic operation of proposed multi-hop clustering routing protocol is multi-hop transmission of data from CH to BS. In a cluster sensor nodes send the aggregated data to cluster head, and cluster head sends data to gateway nodes(GN). The gateway nodes, which forms the next level of hierarchy, are programmed to communicate with a Base station(BS). We can show it diagrammatically fig 5 and the distance concept by fig 6.

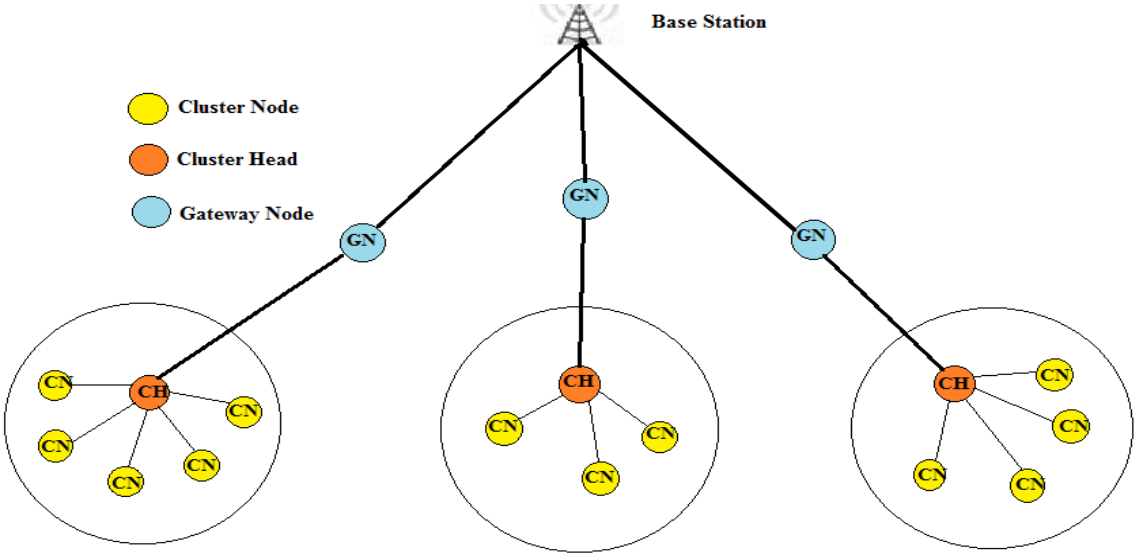


Fig 5 : Structure of proposed protocol

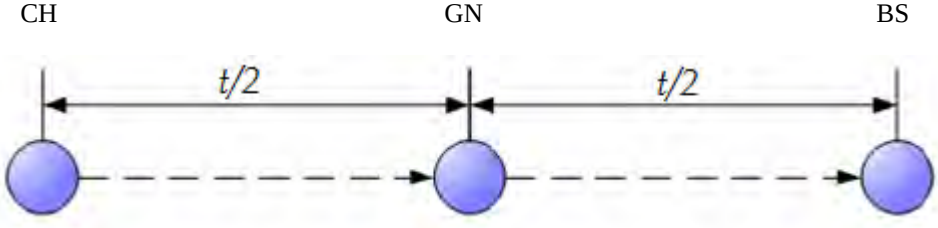


Fig 6 : Transmission distance for Multi-hop

If we assume that transmitter, in single-hop scenario, emits at such as power $T_1$ which is just enough to be received by destination node, we can address this power as receiver's sensitivity threshold $T_M$.

$$T_M = T_1 . ( t_0 / t)^{\alpha} \quad (3)$$

In case of double-hop and n-hop , necessary transmission powers are $T_2$ and $T_n$ will be :

$$T_M = T_2 . (t_0 / (t/2))^{\alpha} \quad (4)$$

$$T_M = T_n . (t_0 / (t/n))^{\alpha} \quad (5)$$

If we equalize equations (3) ÷ (4) we will get :

$$T_1 = T_2 .2^{\alpha} = \ldots = T_n .n^{\alpha} \quad (6)$$

Over all transmitter's power consumption used for single-hop (LEACH) ( $T_{1H}$ ), double-hop (Proposed algorithm)( $T_{2H}$ ), and *n*-hop ( $T_{nH}$ ) will be:

$$T_{1H} = T_1 \quad (7)$$

$$T_{2H} = T_2 + T_2 = 2.(T_1 / 2^{\alpha}) \quad (8)$$

$$T_{nH} = n. (T_1 / n^{\alpha}) \quad (9)$$

We can clearly see that for any value of the path loss exponent greater than one, multi-hop transmission will be more energy efficient than single-hop transmission. If we assume that receiver is not ideal and for its work requires power $T_R$, equations will get following form:

$$T_{1H} = T_1 + T_R \quad (10)$$

$$T_{2H} = 2. ((T_1 / 2^{\alpha}) + T_R) \quad (11)$$

$$T_{nH} = n. ((T_1 / n^{\alpha}) + T_R) \quad (12)$$

From this equations follows that proposed multi-hop communication will be more efficient than single-hop LEACH only if received power consumption is:

$$T_R < (n^{\alpha - 1} - 1) / ((n - 1) . n^{\alpha - 1}) . T_1 \quad (13)$$

## V. CONCLUSION AND FUTURE WORK

Energy consumption is a very important issue in case of wireless sensor network..In this paper, we have proposed a Multi-hop approach regarding multi-hop routing for wireless sensor network. The main purpose of the Multi-hop approach is to minimize the consumption of energy. In this paper we have made some comparison of the proposed algorithm with LEACH protocol and trying to show its advantages over the LEACH protocol..In future we can develop more energy efficient techniques following new concepts and ideas.

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