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Energy efficient clustering method to find the optimized location for the super cluster node using PSO algorithm

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Abstract: Sensor networks are highly distributed networks of small, lightweight wireless nodes, deployed in large numbers to monitor the environment or system by the measurement of physical parameters such as temperature, pressure, or relative humidity. So, the monitored information sent to the base station or sink. If the sensor nodes sent the information to sink individually, the nodes are loss the high energy and the network will be have less life time. So, the LEACH protocol was proposed to form a cluster head (CH) and all the sensor nodes communicate with sink through CH only. Still the problem was arising in the network for forming the cluster in heterogeneous networks. So, we have proposed the super cluster head approach to overcome the above mentioned issues. The SCH node is selected by using the particle swarm optimization algorithm. The SCH node is iteratively changed in every round based on the various parameters. In the proposed system, new SCH is selected based on distance from the base station and energy level of the node. The proposed approach which is used for increasing the lifetime of the network, reduced the end to end delay, reduced the control overhead and increases the bandwidth. The simulation results shows the comparison of leach protocols and leach ere and leach with PSO for the improvement of lifetime, energy and reduced the delay.

Keywords: cluster head, super cluster head, energy

I. INTRODUCTION

A Sensor network is composed of a large number of sensor nodes that are deployed in a wide area with very low powered sensor nodes. The wireless sensor networks can be utilized in a various information and telecommunications applications. The sensor nodes are very small devices with wireless communication capability, which can collect information about sound, light, motion, temperature etc and processed different sensed information and transfers it to the other nodes. The following figure-1 illustrated the Wireless Sensor Network scenario.

Usually, WSNs are closely organized in dangerous places where battery recharge or replacement is closely unbearable and human monitoring system is extremely risky. The outmoded routing protocols have numerous limitations when functional to WSNs, which are mostly owing to the energy-constrained nature of such networks [1]. Minimum Energy Communication Network [2] is a location-based protocol for attaining minimum energy for haphazardly organized ad hoc networks, which efforts to set up and preserve a minimum energy system with mobile sensors. It is self-reconfiguring protocol that preserves network connectivity in spite of sensor mobility. It calculates an optimal spanning tree rooted at the sink, named minimum power topology, which comprises only the minimum power paths from ach sensor to the sink.

During the operation of a wireless sensor network energy dissipation by the system is of major concern. The energy of each sensor node is constrained by the battery-life. In conventional routing algorithms such as direct transmission or MTE (minimum transmission energy) lead to non-uniform dissipation of energy across the sensor nodes leading to uneven die-out time of nodes and lower system lifetime. In contrast, LEACH (Low Energy Adaptive Clustering Hierarchy) provides a balancing of energy usage by random rotation of cluster-heads, consequently enhancing energy-dissipation and system lifetime. The compression of data can be used to reduce the amount of transmission data.

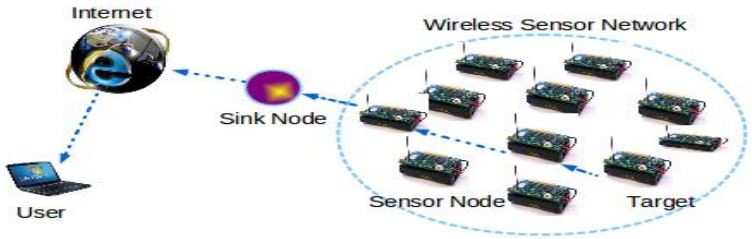


Figure 1: Wireless Sensor Network

In super-cluster head based protocol each of the elected cluster-head select a super-cluster head among themselves and transmit their compressed data to it, which further compresses the data and transmits to the base station.

II. RELATED WORKS

Sun et. al., [3] suggested a numeral group formation protocols have been anticipated newly. This research is familiarized secure distributed cluster formation protocol to establish sensor networks into equally disjoint groups. This procedure has the subsequent possessions: (1) normal nodes are alienated into equally disjoint groups;(2) all the normal nodes in individual clique approve on the similar clique memberships; (3) although peripheral attackers can be prohibited from contributing in the cluster formation procedure, privileged attackers that do not trail the protocol semantics can be recognized and detached from the system; (4) the communication directly above is modest; (5) the etiquette is completely distributed.

Heinzelman et. al., presented [4] LEACH protocol for better energy consumption. This etiquette forms clusters grounded on the acknowledged signals and by means of distributed procedures. Nodes make decisions deprived of concentric control self-sufficiently. With the intention of balance the energy ingesting to each node, in each round, all clusters have the occasion to convert the cluster head. In this etiquette cluster head nodes are cast-off as route finders (to the base station). All data processing, certain data buildup and amalgamation in every cluster are achieved close by.

Lee et. al., presented [5] LEACH which is most efficient for CH selection in a probabilistic means and attempts to poise the load at apiece sensor node in a rotation base. Nonetheless numerous studies extant the competence of LEACH protocol, it has definite drawbacks that necessity to be deliberated. As LEACH trusts on probabilistic value, it influence occur that in every round more than one cluster heads are designated or no cluster head is designated. Added, the cluster head may be designated at the border of the network which aims to the indecorous energy distribution. LEACH also does not reflect the distribution of sensor nodes and residual energy of apiece node after conclusion of separately round.

Particle swarm optimization (PSO) is a modest, actual and well-organized optimization algorithm. PSO is cast-off to search the search place. It is tranquil to tool and it can be functional for both scientific research and engineering practice. In PSO, a global fitness function is cast-off by all the elements in the swarm. In this, No overlapping and mutation scheming rapidity is very dissolute. It estimates the suitability of every particle. It inhabits the superior optimization capability and it whole effortlessly. Particles in outdated PSO characterize the candidate solutions to a lone optimization problem.

III. PROPOSED METHODOLGY

LEACH (Low-Energy Adaptive Clustering Hierarchy) is a cluster-based routing protocol for WSNs. It adapts the clustering concept to distribute the energy among the sensor nodes in the network. It improves the energy-efficiency of WSN beyond the normal clustering architecture. It uses a TDMA/CDMA MAC to reduce inter-cluster and intra-cluster collisions.

As a result, we can extend the life time of our network, and this is the very important issue that is considered in the WSN field. The following figure-02 illustrated the LEACH protocol with cluster nodes and cluster heads.

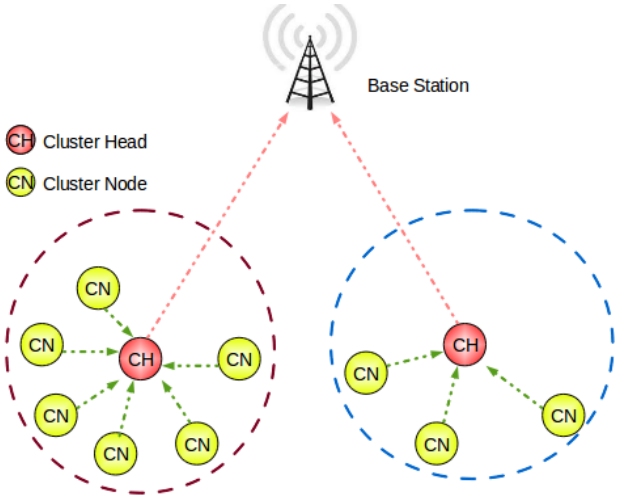


Figure 2: Cluster Architecture

3.1 Energy Model

Energy consumption model [10] to compute energy ingesting in communication, disregarding energy consumption of nodes in the process of computing, storage, etc. In the procedure of conveying l bits message over distance d, the energy ingesting of the transmitter is:

$$E_{Tx}(l,d) = E_{Tx\_elec}(k) + E_{Tx\_amp}(l,d) = \begin{cases} lE_{elec} + l\varepsilon_{fs}d^2, & d < d_o \\ lE_{elec} + l\varepsilon_{mp}d^4, & d \geq d_o \end{cases} \quad (1)$$

Receiver's energy consumption is

$$E_{Rx}(l) = E_{Rx\_elec}(l) = E_{elec} \quad (2)$$

Operation of LEACH
The operation of LEACH is divided into two phases:

Setup Phase (Where cluster-heads are chosen)

- Cluster-head Advertisement
- Cluster Set-Up
- Transmission schedule creation

Steady-state Phase (The cluster-head is maintained when data is transmitted between nodes)

- Data transmission to cluster heads
- Signal processing (Data fusion)
- Data transmission to the base station

The following figure-03 shows the above two functions of LEACH protocol

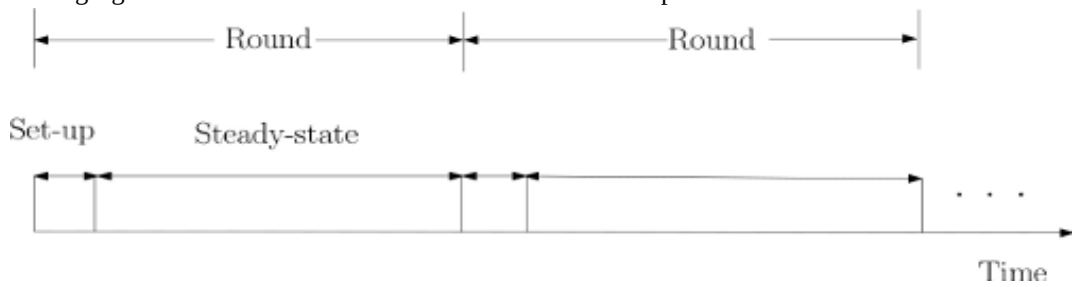


Figure 3: Illustration of LEACH function with Setup and Steady State Phase

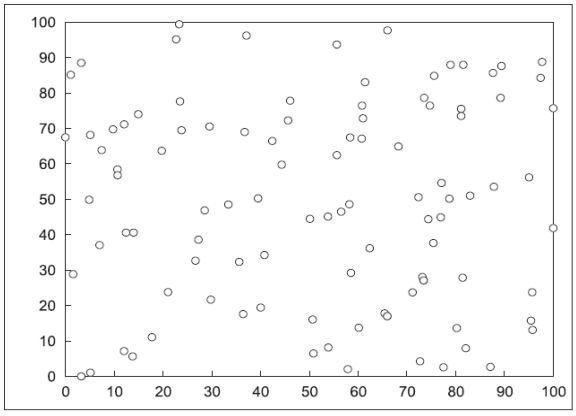


Figure 4: Distributed Node

Algorithm for Setup Phase

Execute the following for each node

- Cluster-head Advertisement

1. Let x be the random no between 0 and 1, n is the given node, P is the cluster-head probability, r is the current round, G is the set of nodes that were not cluster-heads the previous rounds.

2. if x < T(n), then that node becomes a cluster-head. The threshold T(n) is determined ([viii]) as:

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

3. Nodes that are cluster-heads in round 0 can't be again next 1/P rounds; after 1/P - 1, the threshold value will be T(n)=1
4. In 1/P rounds, all nodes are eligible again to become cluster-heads
5. After the election of cluster head, each nodes will broadcasts an advertisement message to the rest of the nodes by using a CSMA MAC protocol.

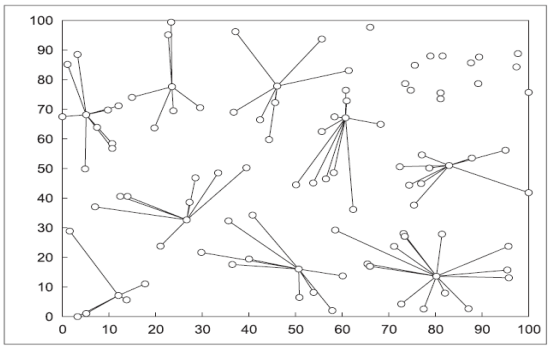


Figure 5: Cluster Formation

The algorithm is designed so that each node becomes a cluster-head at least once.
After the completion of this phase, each non-cluster-head node decides the cluster by using the received signal strength of the advertisement.

Cluster Set-Up

1. Each node informs the cluster-head node about its choice
2. Each node uses CSMA- MAC protocol to transmit the information
3. Cluster heads must keep receivers ON

Transmission schedule creation

1. Creates a TDMA schedule as per the number of nodes in the cluster.
2. Each node send their data during their allocated transmission time to the cluster head

Algorithm for Steady State Phase

1. Begin sensing and transmitting data to the cluster-heads.
2. Then, the cluster-head node, receive all the data, aggregates it before sending it to the base-station.
3. After a certain time, which is determined a priori, the network goes back into the setup phase.

3.2 Super Cluster Head (SCH) Selection

PSO is an evolutionary algorithm which is used to optimize the parameters such as network life time, energy level, throughput, delay, minimum distance and packet delivery ratio. PSO as the furthermost prevalent

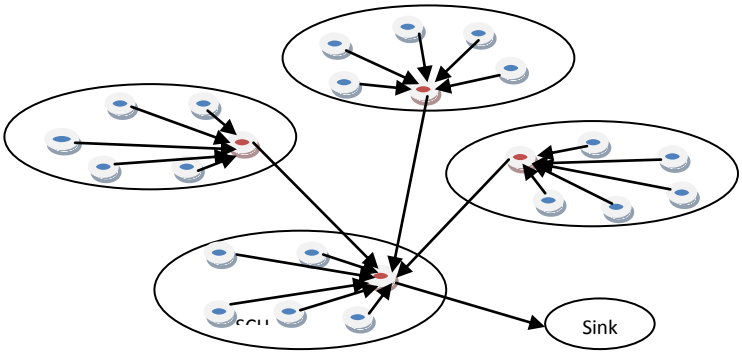


Figure 6: Super Cluster Head Architecture

optimization procedures which is grounded on Swarm Intelligence cast-off for fuzzy rule bases. PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles. The swarm is usually demonstrated by particles (nodes) in multidimensional space that have a position and a velocity. These particles fly through hyperspace (i.e. Rn) and have two indispensable cognitive competences: their distance of their own finest position and energy of the global or their neighborhood's best. In a minimization optimization difficulty, problems are expressed so that "best" merely incomes the location with the minimum objective value. Members of a swarm communicate decent locations to each other and regulate their own location

In current years, certain methods have been offered to produce fuzzy rules and membership functions. A well-organized PSO grounded method to build a fuzzy rules base from specified WSN. This technique consider that the fuzzy logics can be also expressed as a space difficulty, where for each point of fuzzy sets corresponds to a fuzzy logic i.e. signify membership functions, rule base and henceforth the consistent system behavior [21]. The SCH is grounded on trails.

$$E_{Tx} = E_{elec} * k + \varepsilon_{amp} * k * d^2 \quad (3)$$

$$E_{Rx} = E_{Rx-elec} * k \quad (4)$$

Here '*k*' message length and '*d*' Æ transmission distance. Thus energy indulgence diverges linearly with message length and as a square for transmission distance. The SCH will be a node from selected cluster heads which will be at an optimum distance, system lifetime, least delay, high packet delivery ratio, greater bandwidth and energy deliberation from the base station. Thus by super-clustering[22] we may be cumulative the length of the ultimate conveyed message but by means of only one node for communicating to the base station a ration of energy is protected, since distance factor is abridged. The limitations are designed grounded on the weight basis and D signifies the distance, E represents the energy, P symbolizes the packets and NL means the network lifetime.

$$T_c = W_1 * D + W_2 * E + W_3 * P + W_4 * NL \quad (5)$$

Prepare every node weight = 0 is
Head = false *p*
Particles (nodes) = 0
Velocity = empty // To supply al., neighbor nodes Rendering to instantaneous topology,
Find neighbor // nodes in Range
If distance < Range
Edge exists
Else
No edge exists
Increment weight // connectivity measure
Compute objective function using (5) which performs minimum delay node, maximum packet transmission ratio, minimum energy and high network lifetime nodes
Find high transmission nodes with shortest distance using (3)
Set a, b, g, d values // control parameters
Iterate *i* to *n* times
Select *i*th node as Super Cluster Head
First-rate neighbor with supreme possibility as subsequent cluster head till all nodes are protected
Evaluate fitness value
The fuzzy rules are produces effective membership functions
The fuzzy parameters act as particle (node)
The fuzzy parameters are optimized using

$$v_{ij} \leftarrow c_o v_i + c_1 r_1 \left(globalbest_j - x_{ij}\right) + c_2 r_2 \left(localbest_{ij} - x_{ij}\right) + c_3 r_3 (neighborhoddbest_j - x_{ij}) \quad (7)$$

$$x_{ij} \leftarrow x_{ij} + v_{ij} \quad (8)$$

The procedure is recurrent till aim is attained or optimization technique touched the global best
Update best node as SCH
Discover ultimate set of SCH with supreme possibility (with Weight and Updated nodes)
Get the optimal fuzzy set nodes as SCH

The algorithm describes that the optimal SCH is performed by using PSO based fuzzy approach and also the fuzzy rules are optimized using PSO optimally. It is used to reduce the number of iterations efficiently and improves the network lifetime significantly. A complete novel membership function effectively attuned from

normal fuzzy membership function. It could be prepared with exemplification of fuzzy membership function value as particles (nodes). In the every repetition in optimization way, the node characterize will be vagaries to grasp the optimal value[23]. The membership function will shrivels, transfer or enlarge over the vicissitudes of every value. The Fuzzy PSO has attuned fuzzy membership function and enhanced the recital outcome in term precisely to target and quicker in rapidity of convergence.

IV. EXPERIMENTAL RESULTS

In this experiment, the setup considered 40 nodes randomly deployed over the area between (x=0, y=0) and (x=100, y=100) with BS location (x=50, y=50). We assume four no. of clusters. Each round duration is 20s. The bandwidth of the channel is 1 Mbps. Each data message is 500 bytes long; packet header length is 25 bytes. We have used a simple energy model. The communication parameters and the required parameters of interest are given in Table 1.

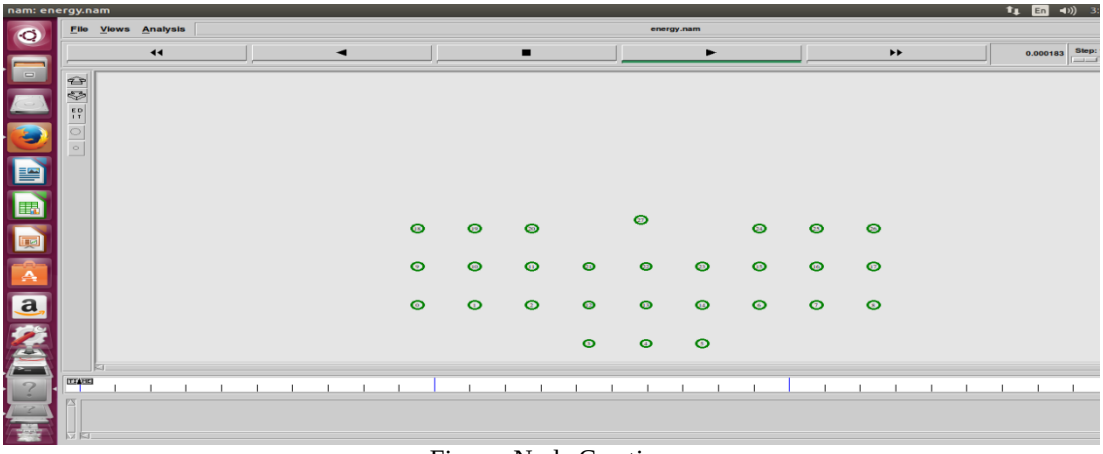


Figure: Node Creation

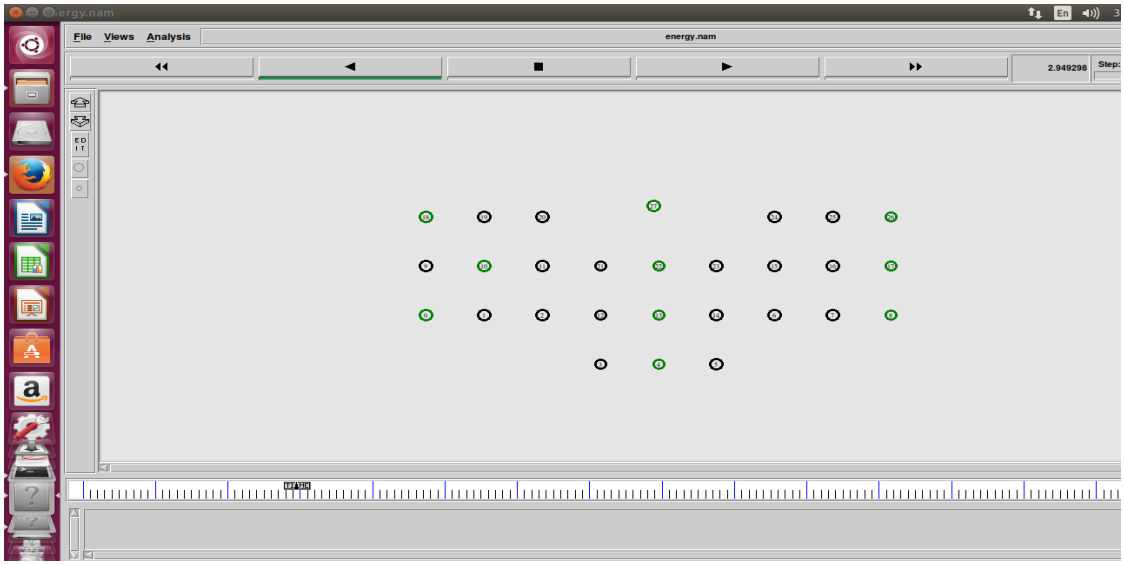


Figure: Cluster Head Selection

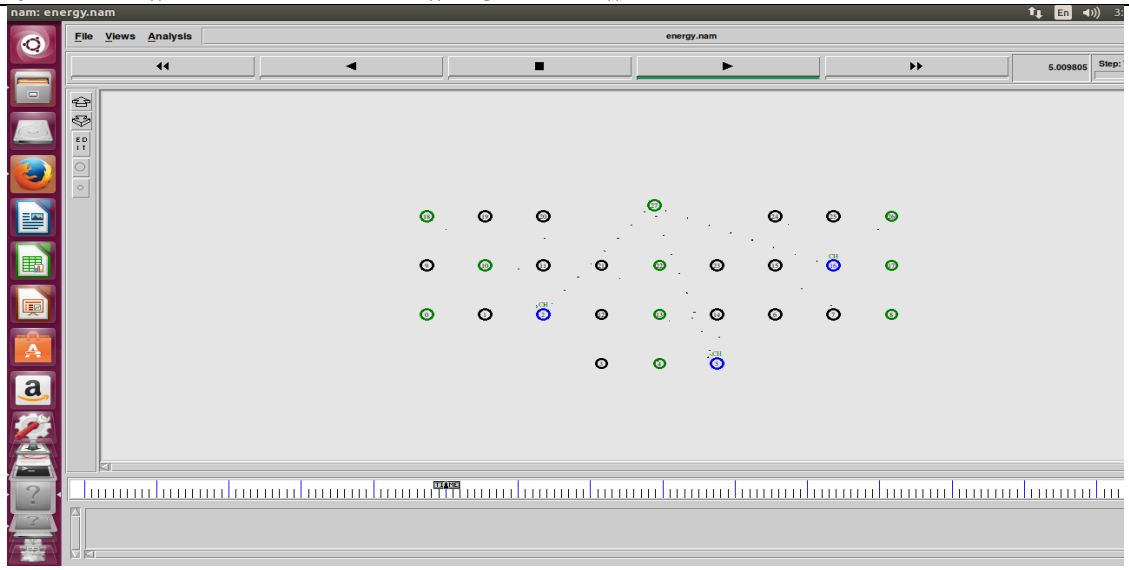


Figure: Super Cluster Head Selection

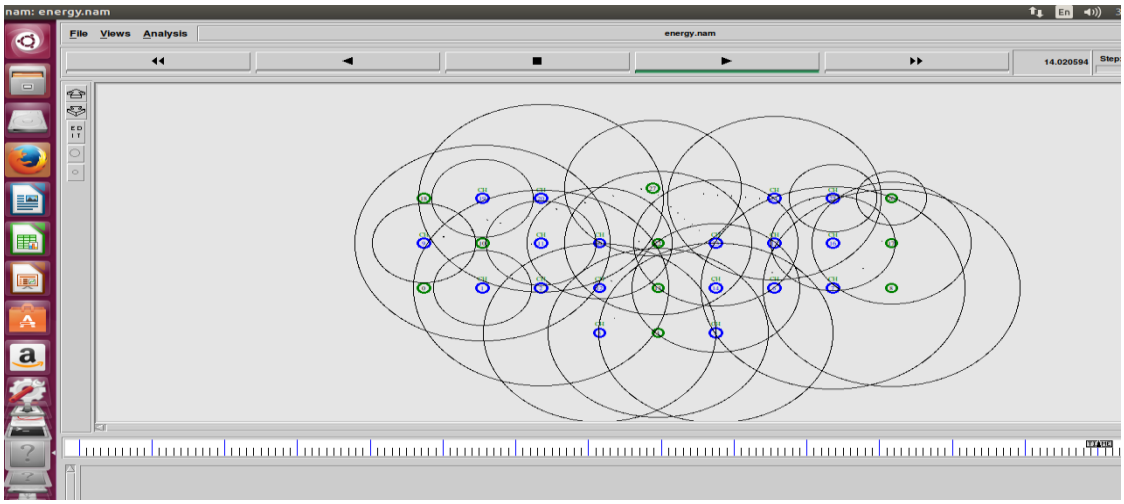


Figure:Data Transfer to the Base Station

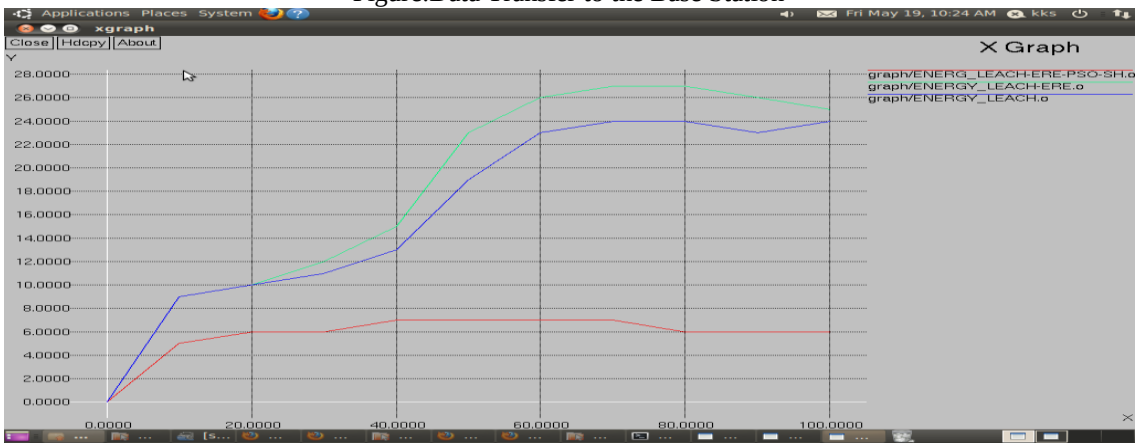


Figure: Energy

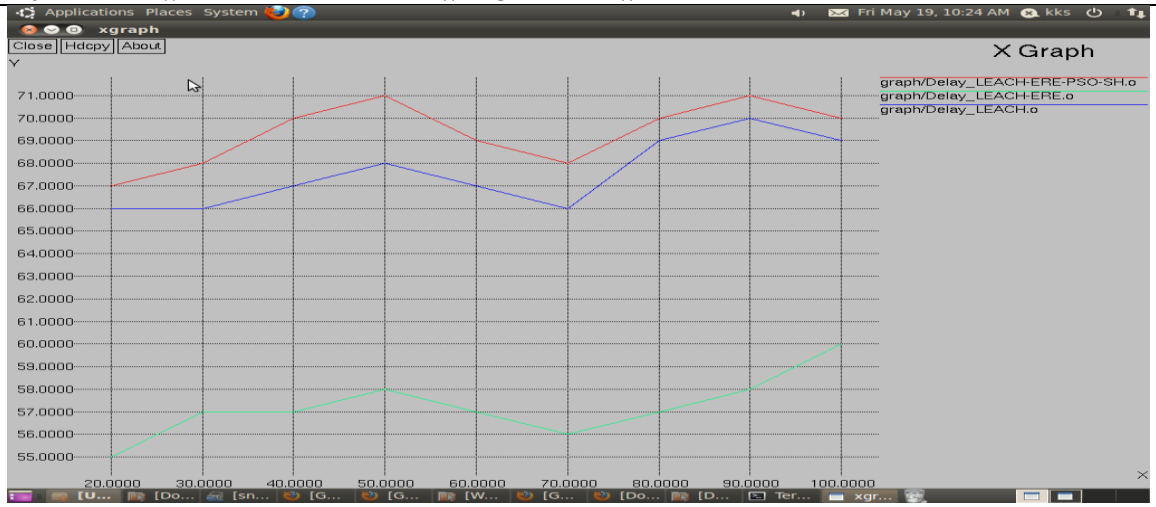
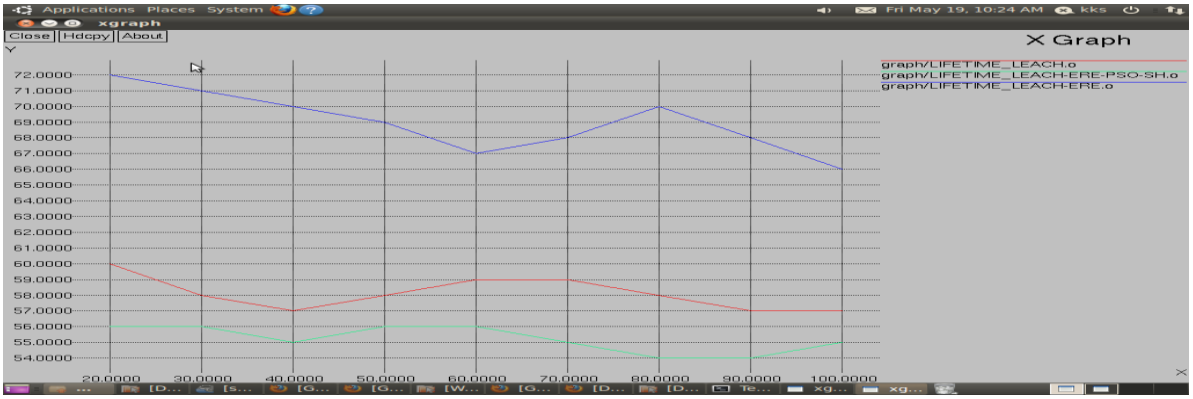


Figure: Delay



V. CONCLUSION AND FUTURE WORK

In this paper, we have show good performance of SCH node in the WSN. The existing system has the cluster formation and selects the cluster head node. Here, the PSO algorithm is applied to elect a best Super Cluster Head from among the cluster head. By electing the SCH node, the network life time, energy is improved in the all cluster node. In the future work, the two stay PSO techniques to be used to find the best position of the node to improve the energy of the network.

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