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An Energy Efficient Adaptive Swarm Optimization for Cluster Selection for WSN

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ABSTRACT

Cluster based approach is widely used in Wireless sensor network (WSN) to reduce the consumption of energy, because in WSN deployed sensor node has limited power supply and the node which is nearest to the base station consumes more power and die very fast. Therefore energy efficient clustering mechanism and protocol is very important in WSN since it impact directly to network performance or life time of network. Many evolutionary techniques such as genetic algorithm and Particle swarm optimization has been proposed to find the optimal number of cluster but they all suffer in finding the best cluster head to overcome this in this work the author propose a new adaptive swarm optimization techniques in cluster formation based on efficient energy utilization. Result obtained from simulation is compared with existing algorithm in terms of network life time and energy efficiency and proved that our method is more suitable for energy efficient clustering in WSN.

Keywords: BS, Cluster, CH, Evolutionary technique, Sink.

1. INTRODUCTION

Wireless sensor network (WSN) is a growing technology in the field of networking. It is combination of autonomous node which is distributed among the network and that can monitor or sense the environmental or physical condition or it can also be used in health, military or home purposes. Wireless sensor node is a small devices this device receive information from its surrounding, some calculation is performed on that information and then after communicate with other sensor node or Cluster Head (CH). For short distance communication wireless sensor worked properly, it detected the real time data which is very useful at the time of disaster or critical situation like in military or health care application [1]. Through multihop fashion long distance communication can be achieved. Deployment of WSN done in an ad hoc manner for remote operation, radio frequency and IC design make this possible for sensing various kinds of activity and operation. Wireless sensor node size is small and inexpensive, it not requires lot of resources, but it requires uninterrupted power supply for continuous working. It needs better power supply management or low consumption of energy by the node, because it has limited power resources. WSN contain some issues like localization, deployment, energy aware clustering. Collected sensor data from a region or cluster for particular field like environmental data in that case every node of that particular field is live or work properly is very important. Sensor node's life depends on its battery which is small in size and limited to overcome this problem research is ongoing and many researches give the different type of clustering techniques for saving battery and increase the sensor node life.

Cluster based organization used hierarchical routing and protocol which is used in data gathering make it possible fusion of data and aggregation and it leads to significant energy saving [2]. Cluster formation process has two level one is cluster head called higher level and other is member node of cluster called lower level. Member nodes in cluster send their data to the corresponding cluster head node. Cluster head nodes collect the data and transmit that to the Base Station (BS), communication between CH nodes may be directly or it may happen through the intermediate CH node. Cluster head behave as a sink for cluster member and BS is behave as a sink for cluster head node. The node which are nearest to the sink losses their energy very quickly because they are responsible to forwarding data packets originating from sink. Here for energy conservation author purposed a new clustering algorithm called Adaptive Swarm Optimization (ASO). In this number of substance is deployed in the network which is continuously worked for finding the best position and if some new best position it find then replaced the old position by new one. Multiple clusters can be formed by the dividing network in a different- different cluster. Each cluster has their own cluster head in each cluster local data collection is performed. Here sensor node which has same energy level kept in one cluster, in that manner nodes are moving from one cluster to another based on their energy level. When node energy is degraded it can move in other cluster to improve node lifetime or energy. Sink received all the information from all CH node and perform global packet collection. Distance between cluster member and CH is less as compare to distance between CH and sink [3]. Here author goal to

make energy efficient clustering in WSN and make best possible number of cluster and minimize the energy consumption in multi-clustering. A very popular clustering technique is LEACH it also try to minimize the energy dissipation but LEACH has disadvantages that it hop by hop or single-hop communication in inter-cluster, communication is between CH and base station so it is not feasible for large network[4]. Benefits of using ASO are it is easy to implement on hardware or software, availability of CH for cluster member, Convergence is very quick.

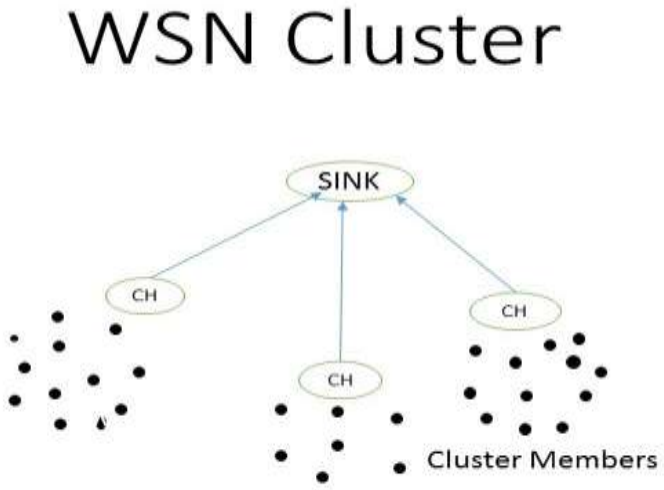

Figure. 1 WSN cluster design

Rest of the paper organization as follows in section 2 deals with previous related work in wireless sensor network in section 3 defined the network model for WSN and Energy utilization with cluster formation techniques Section 4 describe the simulation part and compare obtained result with existing one and at the end conclusion and future work is defined.

2. LITTERAURE SURVEY

Here [5] author proposed to make cluster where distribution of power is equal at every node and uniformity of power same as over a time. Frequent cluster reconfiguration avoided by the passing of data packet to the different node and then reached at the CH. Author try to optimize the constrained problem in linear array. But it is only successful when diameter of cluster is less or within 6 hops count. In [6] allocation problem of task in WSN is defined by the author distribution of task equally and properly to all the sensor node and reduction in overall power consumption for this soft real-time fault-tolerant task algorithm (FTAOA) is proposed by the author. It is based on making backup copies and using these copies like primary copy first and backup copy at the last. Task is provided to the node based on their performance, a task is allocated first to a node which performance is better in terms of energy consumption, failure ratio etc. Here [7] an aggregator selection is done for efficient energy consumption in WSN, but only single level of aggregation is done. Calculation of number of aggregator which minimize the consumption of energy in the network. Here [8] author focusses on the routing protocol in WSN. For efficient energy usages a node must accept only desired data rest part of data can be discarded. Routing protocol is in this concern for efficient network utilization factor such as usages of energy, Adaptability, Reliability, security, fault tolerance etc. may consider before choosing an appropriate routing protocol. In [9] a techniques is defined for finding the overload node and then distribute the load among the other node equally. A multipath structure is designed for reduced the convergence problems. A node only changes their parent when parent node not able to forward the data in that case node choose another node as a parent node. In [10] clustering techniques defined for WSN based on some advantage such as less overheads, scalability, easy maintenances etc. author analyses the existing clustering techniques TL-LEACH, LEACH, TEEN, EECS etc. and compare these protocol of clustering based on life time of network and energy consumption. In [11] challenged faced at the time of clustering in WSN is discussed and comparison of clustering algorithm is done based on their network size, residual energy, hop distance, CH distribution delay. Methodology used in formation of cluster. In [12] author a function for minimizing the distance between intra-cluster called fitness function, it minimize the distance between cluster node and CH. Through this function energy efficiency of network also increases. For the selection of CH all the sensor node send their residual energy level and location information to the sink. At that time network congestion is high because transmission in bulk and it also leads to unnecessary energy consumption.

3. PROPOSED ENERGY EFFICIENT CLUSTER SELECTION MODEL

A. Network Design

Sensor network designs have the following properties:
Sensor node has capability to sense the data and do this task periodically and send collected data to the sink.
A Cluster Head is defined for every cluster which received the data send by the cluster member and processes these received data.
Cluster Head can communicate directly to the base station or through the intermediate cluster head
A Base station may be established inside or outside of network sensor field.
Cluster Head behave as a sink for cluster member and base station behave as sink for CH
All sensor nodes has energy or power constraint
All nodes has capability to move one cluster to another as per their energy level
All nodes is capable to senses data and eligible for cluster head.
In network lets *K* be the number of sensor node, *P*, be the number of cluster, base station is called sink, let suppose *p* is the cluster head of *pth* cluster. In that case *p* perform local data collection based on its own analysis and it also received data from the local cluster member. After that each CH process the collected signal and send it to the Sink (BS) through noisy channel. At last sink perform data collection from all the CH and process it.

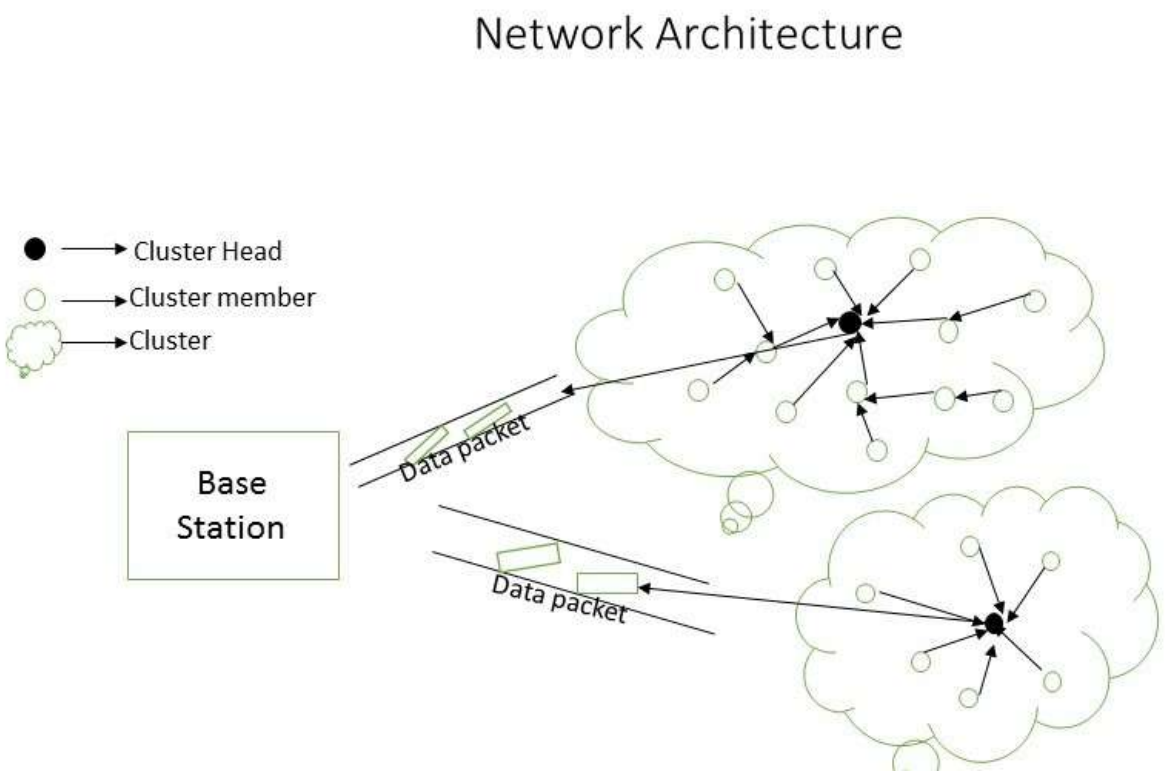

Figure 1 Communication between CH, Cluster Member and Base Station

B. Energy Utilization

In this phase energy utilization of a node in the sensor network is defined. Consumption of energy by a CH node in sensor network can be defined in these steps
Step 1: Sensing-Cluster Head sense the signal which is generated by the cluster member or self- sensing signal in that process it used the energy.
Step 2: Processing-Process the received data from cluster member and collect by CH itself
Step 3: Communication- At the last CH consume energy to transmit the data to the Sink.

In same fashion Cluster Member also used energy in sensing the signal , process the signal and transmit the signal to the CH. In the transmission of signal more energy is required because it used radio electronic as well as power amplifier. But at the time of receiving signal energy required in only radio electronics [13]. Let M number of sample point extracted from signal frame in each round. Let B is the number of bits, distance *r* between CH (*pth*) and Sink (s) can be defined by the $r_{s,p}$. Now energy utilized by the *Pth cluster head* in communication with sink can be given by

$$U^{p}_{ch,trans} = MBU_{eneu}\left(K_p - 1\right) + 8\mathrm{M}\left(U_{eneu} + \varepsilon_{amp} r^{4}_{s,p}\right) \quad (1)$$

Here energy utilize to run the radio wave is given by U_{eneu} energy require by the amplifier is given by $\varepsilon_{amp} r^{4}_{s,p}$, here base station is far away from cluster head hence energy dissipation follow the multipath model $r^4\ power\ loss$ and $K_p - 1$ is denote the energy received by the cluster head.
Now energy utilized by the *kth* cluster member in *Pth* cluster for transmission of frame can be computed based on distance between *kth* cluster member and *pth* cluster head which is denoted by $r_{mh,k,p}$ and energy dissipated by the amplifier is $\varepsilon_{rs} r^{2}_{mh,k,p}$, because distance between cluster member and cluster head is small so loss of power follow the free space model r^2

$$U^{p,k}_{cm,trans} = MB\left(U_{eneu} + \varepsilon_{rs} r^{2}_{mh,k,p}\right) \quad (2)$$

Energy utilized in computation or processing the signal senses by the node is tuff so not exactely but approximation calculation is done here, energy used by the *pth* cluster head in processing the signal can be given by

$$U^{p}_{ch,Proces} = \gamma_1 U_{pc} + \gamma_2 U_{pc} K^{2}_{p} \quad (3)$$

In the above equation γ_1 and γ_2 are scaling parameter [14], and energy utilized in processing is given by U_{pc}. Now we can compute energy utilized by the *kth* cluster member for processing the signal

$$U^{p,k}_{k,cm} = \gamma_3 U_{pc} \quad (4)$$

where γ_3 is scaling parameter. Now energy utilized by the sensing one sample point is represented by U_{se}.
Energy utilized by the CH and Cluster Member for sensing one signal frame can be given by

$$U^{p}_{ch,sen} = MU_{se} \quad (5)$$

$$U^{p}_{cm,sen} = MU_{se} \quad (6)$$

Now we can calculate the total energy utilization of *pth* cluster head

$$U^{p}_{ch,t} = U^{p}_{ch,sen} + U^{p}_{g,Proces} + U^{p}_{g,trans} \quad (7)$$

Total energy utilized by the *kth* cluster member of *pth* cluster is shown below

$$U^{p,k}_{cm,t} = U^{p}_{cm,sen} + U^{p,k}_{cm,trans} + U^{p,k}_{cm} \quad (8)$$

Now we can find the total energy utilization in whole network by adding the energy utilized by the cluster member and cluster head

$$U_{total} = \sum_{p=1}^{P} U^{p}_{ch,t} + \sum_{p=1}^{P} \sum_{k=1}^{K_p - 1} U^{p,k}_{cm,t} \quad (9)$$

Every round of data transmission is not successful, for this reason a rate of successful transmission called success transmission rate and denoted by ∂. We can measure probability of successful transmission ∂ in terms of total successful packet transmission by total number of round in transmission

$$actual\ utilized\ energy = \frac{U_{total}}{\partial} \tag{10}$$

Actual energy utilization vary with P, now we can defined ideal number of cluster as P_{ideal} to minimize the actual energy consumption

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C. Network Design

Let suppose area of sensor node deployment is $A \times A\ m$ and sink or BS is $ht\ m$ above the center of area. Where $ht > A$. Let suppose cluster member are uniformly distributed among network, position of cluster member and sink is not changed after deployment. Cluster head position is initialized randomly in the sensing area. Position of pth cluster head can be given by two dimensional X, Yaxis as X_p, Y_p. Each cluster head choose randomly T number of cluster member for joining their cluster, after that a beacon signal is generated by the CH for other node who want to join a cluster. Other node check their distance from CH and find which cluster head is nearest to them and then it join the nearest cluster. At a time one node can join only one cluster.
Our motive for creation of cluster to minimize the energy utilization relating to distance

$$U_r = MB \sum_{p=1}^{P} \sum_{k=1}^{K_p - 1} r_{mh,k,p}^2 + 8M\varepsilon_{amp} \sum_{p=1}^{P} r_{s,p}^4 \tag{11}$$

Position of cluster head is reform by employing the proposed ASO algorithm. In this process first we have start set of "substance". For position or location optimization problem each substance is a nominee solution for each individual node based on adaptive manner. Each substances provided some initial parameters, and each substance keep the record of information about previous position and position which is best in global. Through this record substance can move towards better solution space. When a better fitness is find it replace the individual best fitness and update the nominee solution. Let Sth substances is represented by position W position of substances at tth time instances where velocity of substances is V defined below

$$W(t) = \mathrm{W}(t-1) + \mathrm{V}(t) \tag{12}$$

Now velocity V at tth time instance can be defined as

$$V(t) = \mathrm{V}(t-1) + l1 \times q1 \times \left(W_{sbp} - W(t-1)\right) + l2q2 \times W_{gbp} - W(t-1) \tag{13}$$

If new global fitness is better than old one than old global fitness is replaced by new one or W_{sbp} is replaced by W_{gbp}. The substance which holds the knowledge about best global fitness also contains the optimized location of all CH.
List of variable used in equation (13)
$V: velocity\ of\ substance$
$w: Positionof\ substance$
$t: time\ instance$
$l_1, l_2 : learning\ factors$
$q_1, q_2 : random\ variable\ between\ 0\ and\ 1$
$W_{sbp} : substance\ best\ position$
$W_{gbp} : global\ best\ position$
Now based on above proposed method we analyzed the result in terms of network efficiency and network life time.

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4. SIMULTION RESULT AND ANALYSIS:

The system environment used is windows 8.1 enterprises 64-bit operating system with 4GB of RAM. We have used sensoria simulator which is based on C# programing and used dot net framework 4.0 visual studios 2010. We have conducted simulation study on following parameter for network lifetime and communication overhead and compared with existing system and find that our proposed system is more efficient. We have varied network node size like 450, 500, and 700 in our simulation, and simulation parameter is showing in table 1.

Table 1 Simulation Parameter

Network Parameter	**Value**
No. of Nodes	450,550,700
Network Size	30×30
Base station location	1m*1m
Size of Data Packet	2000 bits
Energy of sensor node initially	0.1 J
Energy dissipation	50 nj/bits
Data packet processing delay	0.1 ms
Amplification energy	100 pJ/bit/m2
Ideal energy consumption	50 nj/bit
Bandwidth	5000 bit/s
Rate of Transmission	100 bit/s
q_1	Random number between 0 and 1
q_2	Random number between 0 and 1

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Firstly in our analysis we focused on over all network lifetime when lifetime of sensor node reaches 30% in WSN in figure 3,4 and 5 below we perform network life time analysis for 450, 500, and 700 nodes respectively in WSN network. Proposed system in result denoted as *PS* and Existing System denoted as *ES*. The experimental result show that the when the node size is increased the network lifetime performance of existing algorithm decreases. The lifetime performance of proposed work is improved by12%, 43.76% and 54.34% over existing approach when sensor node equal to 450, 550 and 700 respectively. The overall lifetime performance analysis for varied sensor nodes is shown in figure. From this we can see that the proposed approach is robust and scalable interm node density for improving life time of sensor network.

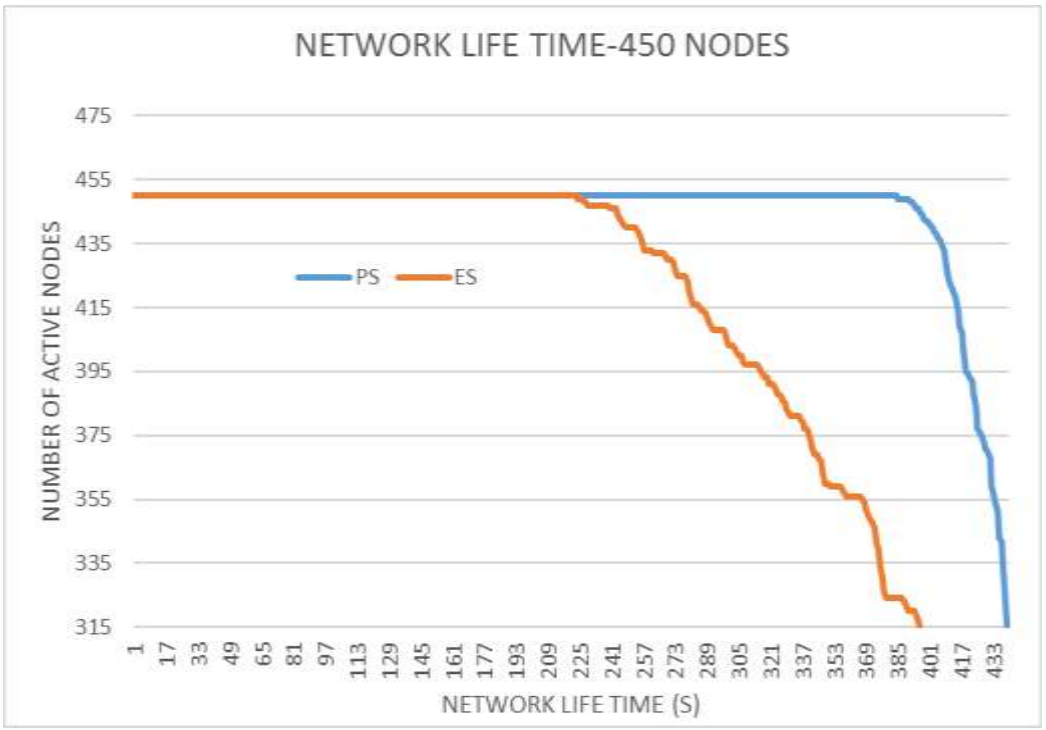

Figure 3. Network Life Time Analysis for 450 nodes

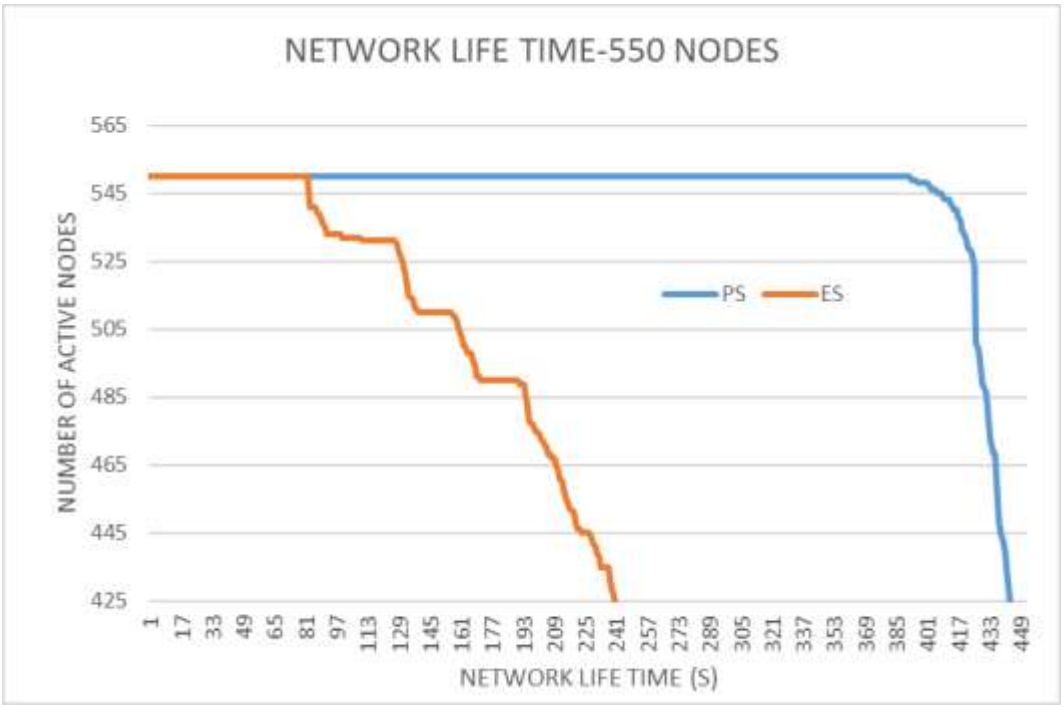

Figure 4. Network Life Time Analysis for 550 nodes

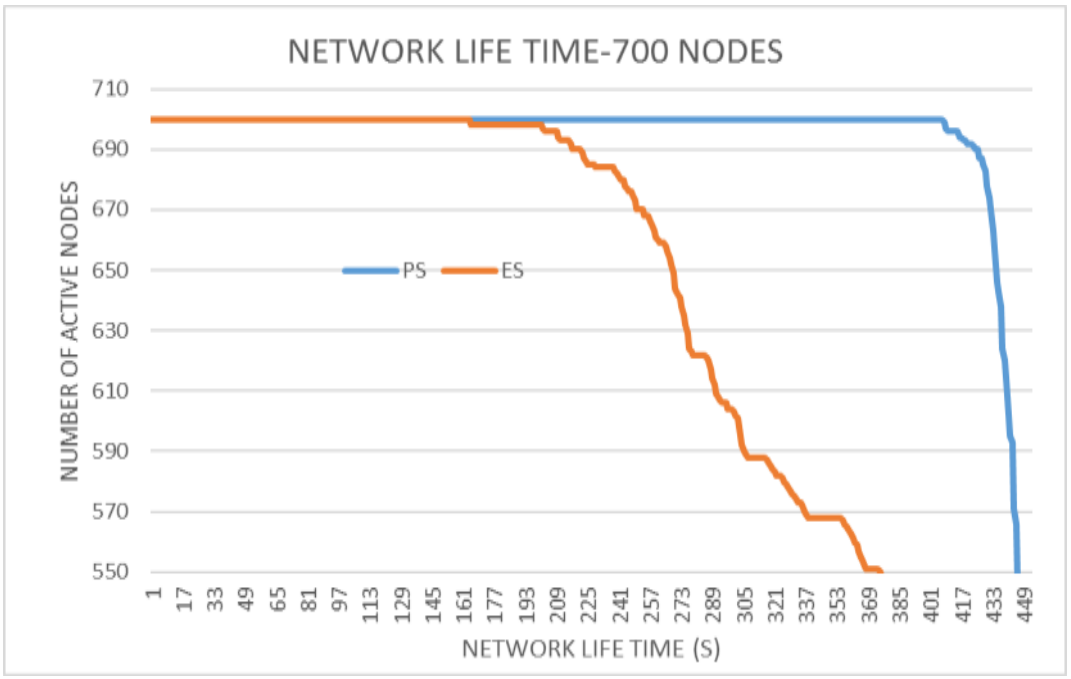

Figure 5. Network Life Time Analysis for 700 nodes

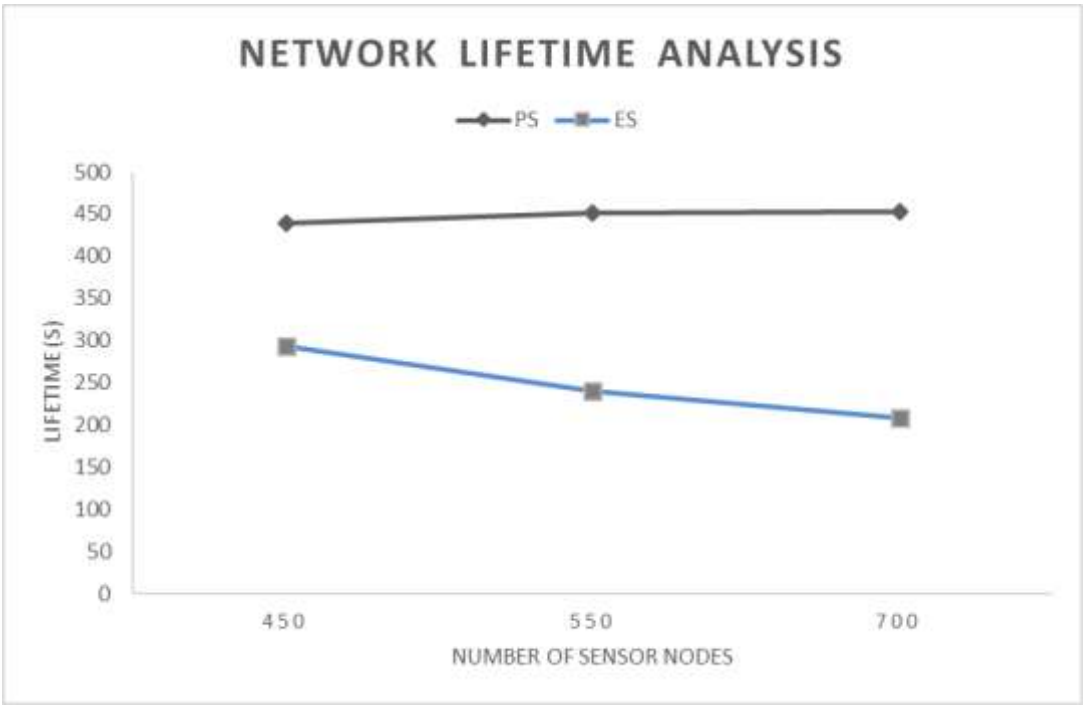

Figure 6. Network Life Time

In figure 7 we have evaluate the performance of node decay rate for 450, 500 and 700 nodes and compared proposed work with existing approach and it show that proposed work reduces the node decay rate by 78.26%, 81.62% and 83.32% over existing approach for 450, 550 and 700 nodes respectively.

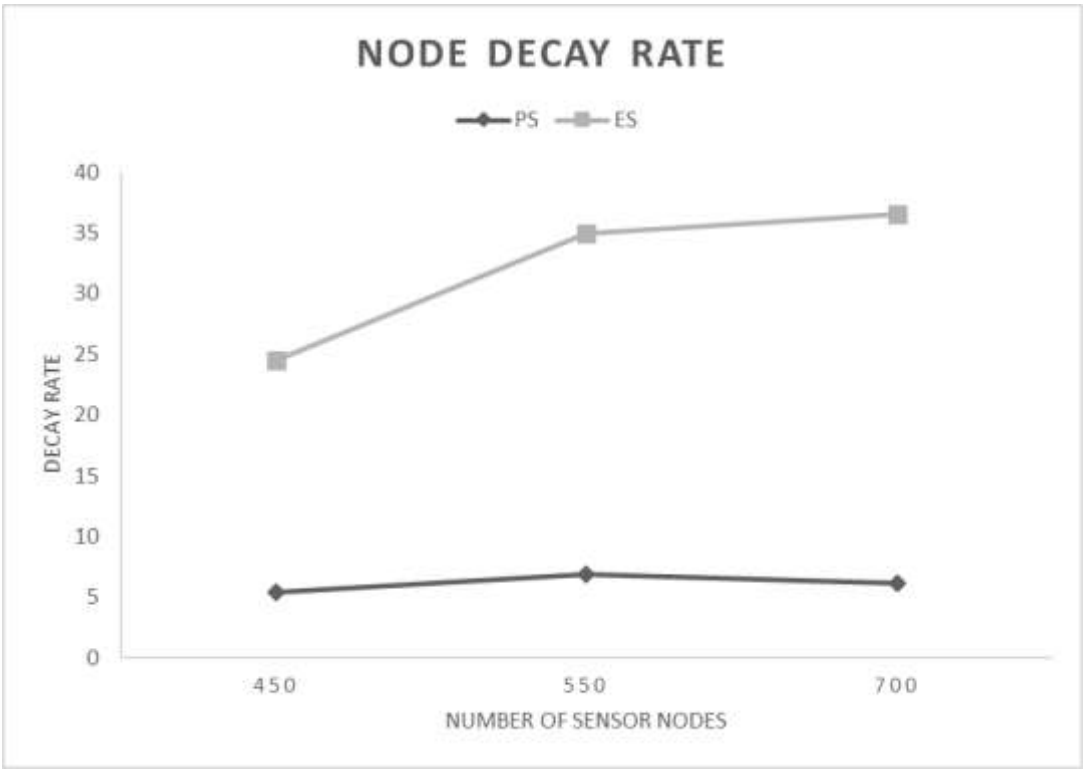

Figure 7. Node Decay Rate for PS and ES

5. CONCLUSION

Wireless sensor network in collecting the real time data like environmental data, military based data etc. so it is very useful at the of disaster like scenario, we can avoid that and may prepare for that before it happens. In WSN device or node which is used for sensing the signal or send it to the base station which is located somewhere else and collect all data from different-different node and process that based on over all data base station prepare some result. Sensor node has very small in size and deployed in a network and it is sensing signal all the time in this phenomena it consumed lots of energy and die very quickly which is the biggest problem in WSN.

In WSN energy utilization and how to save energy is major concern for increasing overall network life time. For saving the energy Cluster formation technique is developed in which cluster member not directly communicate with base station it communicate with cluster head, because in communication with BS require more energy. The existing evolutionary clustering protocol suffer in terms of overall network life time efficiency. So we worked on to enhance the network life time when size of network is also large and compare our result with existing result, and find that our proposed system is more efficient in terms of overall network life time and reduced the decay rate of sensor devices. In future we worked on finding the probability of packet failure among the cluster between cluster head and cluster member by considering larger network.

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