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Analyzing Transmission of Data Packets in Heterogeneous Wireless Sensor Networks using Z-Sep in Different Energy Levels and Area Ranges

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Abstract: ***We have learnt a lot about Wireless Sensor Networks (WSNs) especially about heterogeneous WSNs , these have two different types of nodes namely normal nodes and advanced nodes which transmit data in completely different ways to the base stations. The transmission of data in heterogeneous WSNs is done using Z-SEP. Z-SEP stands for Zonal Stable Election Protocol. It is an improved version when compared to SEP and LEACH. SEP stands for Stable Election Protocol which has clustering hierarchy to transmit data from nodes (or) clusters to the destination. LEACH stands for Low Energy Adaptive Clustering Hierarchy in which there is not possibility of selecting a cluster head as in the other two. In Z-SEP the network found is separated into zones and the transmission happens through clustering technique. In the work we are analyzing the transmission of the data packets in different energy level and area ranges. We compared the performance of Z-SEP with the other two protocols (LEACH & SEP). For doing the performance analysis and simulation we have used the MATLAB simulator.***

Keywords: WSN, LEACH, SEP, Z-SEP, Clustering ,Heterogeneous WSN , MATLAB

I. INTRODUCTION

A WSN consists of randomly placed dedicated sensors which are used for sensing, storing, monitoring and communicating data from the transmitter to the sink [1]-[3]. Once sensor nodes are developed in a network, they tend self-organize in the area. WSNs have many applications like weather monitoring, recording physical conditions and so on. These kind of sensing networks contain components which can sense, process, transmit and receive the data [4]-[5]. In transmission of data, a certain set of rules must be followed that is protocols must be followed. Protocols design mechanisms to spot and make connections with suitable devices to transmit data and provide formatting rules to specify how the data packets have to be sent and received [6]. Hence protocols must be selected for successful and efficient transmission of data packets from the sink to the destination node. WSNs are usually of three types [7]-[8]

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1. ***Clock Driven:*** Data is sensed constantly at uniform intervals and the sensor nodes transmit the data periodically.
2. ***Event Driven:*** Data sensing is stimulated by a particular event.
3. ***Query Driven:*** Communication of data is done as a retaliation to a query.

II. LEACH PROTOCOL

LEACH protocol stands for Low Energy Adaptive Clustering Hierarchy Protocol is used when the network requirement includes low power consumption. In this protocol, the nodes use clustering technique which extends the existence span of the network. LEACH transmits data packets to the destination base stations through the cluster heads. There are two phases of operation in LEACH, namely, setup phase and steady state phase. In setup phase, clusters are formed in the network, cluster head is selected and scheduling of the transmission is done. In second phase that is the steady state phase, the data from all the nodes is collected by the cluster head, compressed and then sent to the base station. **Fig1** Shows the architecture of the LEACH Protocol. It follows a single hop method for transmission of data packets from the sink to the destination. This protocol is sensitive to heterogeneous sensor networks.

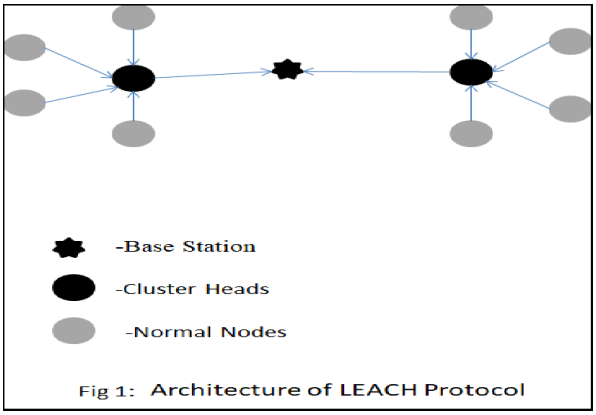


Fig:1 Architecture of LEACH Protocol

III. SEP

SEP stands for Stable Election Protocol. It has two types of nodes in a random fashion in a network. The two nodes positioned in the network are normal nodes and advanced nodes. Here the nodes are distinguished on the basis of energy in the node and the distance between the node and the destination.

The energy required by the nodes closer to the destination is less than the energy required by the nodes farther. The nodes which are at a greater distance have scarcity of energy while the nodes near the base station have ample of energy left in them. Due to the lack of energy in the farther nodes, these nodes die faster than the other nodes. In order to conserve these nodes, they are given α times more energy for transmission. These nodes with α times more energy are called as advanced nodes. This protocol also ensures no wastage of energy in the network. Advanced nodes consume more energy if they have to send data directly to the destined base station. Fig:2 shows the Architecture of the SEP protocol.

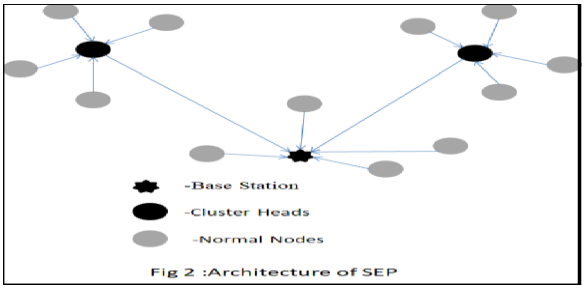


Fig:2 Architecture of SEP

IV. Z-SEP

Z-SEP is Zonal Stable Election Protocol has its nodes divided into three zones in a network. It is an add-on to SEP and it follows direct transmission and transmission of data packets through cluster heads. Zones are divided based on the Y coordinate of the field and the energy level. These Zones can be classified as Zone 0, Head Zone 1 and Head Zone 2. Based on the distance of the nodes from the destination, we assume a fraction of nodes are given more energy as in SEP and assume the fraction to be n where m is the fraction of all the nodes in the network. The n nodes with energy α time more than the normal energy supplied are called advanced nodes while the rest are normal nodes. The nodes which comes under the range of 20 to 80 co-ordinate comes under the Zone 0 i.e (for zone 0 <Y<=20). Half of the advanced nodes comes under the range of 0<Y<=20 comes under the Head Zone 1. Head Zone 2 suited for the area range of 80 to 100, i.e (80<Y<=100 for Head Zone 1) . Fig:3 Shows the Architecture of Z-SEP.

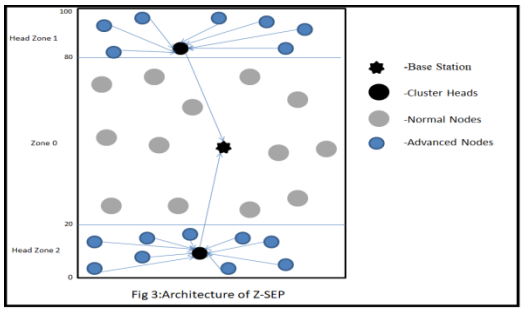
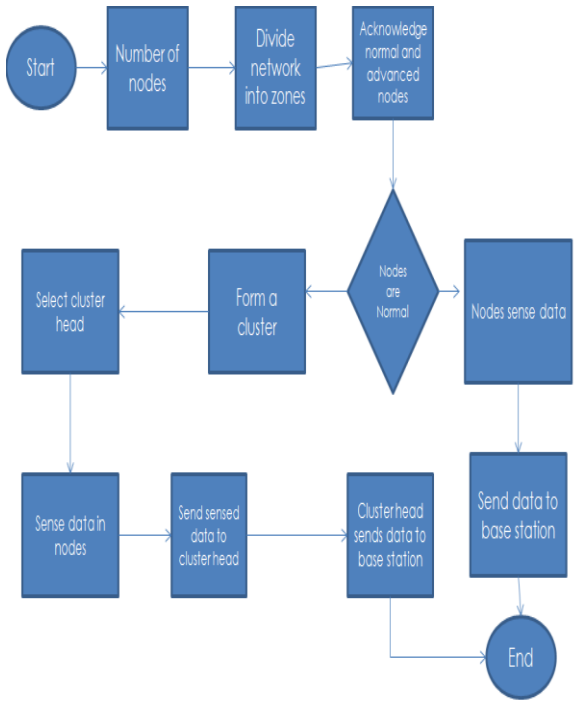


Fig:3 Architecture of Z-SEP

V. FLOWCHART OF Z-SEP OPERATION



VI. OPERATION OF Z-SEP

The transmission of data packets from the sink to destination node can happen in two ways. They are:

1. ***Direct Transmission:*** The nodes which are present in Zone 0 are the normal nodes and they transmit the data directly to the base station as they are nearest to the base station.
2. ***Transmission through Cluster Heads:*** The nodes in the zone select a cluster head and transmit data through the cluster head to the base station.

Considering the most favourable number of clusters to be K_{opt} and the number of advanced nodes to be n, the probability of becoming a cluster head can be given as

$$Popt=\frac{Kopt}{n}$$

Becoming a cluster head, in a round depends mainly depends on the node itself. It depends on the random number issued between 0 and 1 for the node. If the random number is more than the threshold then it is not a cluster head but if the random number is less than or equal to the threshold, then the node can become as cluster head. The threshold can be given as

$$T(n)=\frac{Popt}{1-Popt\left(r\times mod\frac{1}{popt}\right)}\ if\ nEG\ \ 0\ otherwise$$

Where, G is the group of the nodes which are not able to become as cluster head in the last $1/P_o$ rounds.

The chances of an advanced node to become a cluster head can be given as

$$P_{adv}=\frac{Popt}{1+(\propto.m)}\times(1+\propto)$$

Similarly, the threshold of an advanced node can be given as

$$T(adv) = \frac{Padv}{1 - Padv\left(r \times mod \frac{1}{Padv}\right)} \; if \; adv \in G' \;\; otherwise \; 0$$

Where G' is the set of advanced nodes which were not able to become cluster heads for the past $1/P_{adv}$ rounds. Once the process of for the cluster head over , the cluster head sends a message to the remaining nodes. The remaining nodes accept the message and calculated in which cluster they belong to for that round. This phase is known as the cluster formation phase. The nodes then become a member of that cluster and send a message retaliating the cluster head. By the help of TDMA, the data from the nodes to the cluster head can be transmitted. After receiving the data from the nodes, the cluster head compresses it and transmits it into the base station. We can also say that Z-SEP is a hybrid protocol of SEP. The technique used here is also called as clustering technique.

I. SIMULATION PARAMETERS

Parameters	Value
Initial energy E0	0.5J
Initial energy of advance nodes	E0(1+a)
Energy for data aggregation EDA	5 nJ/bit/signal
Transmitting and receiving energy Elec	5nJ/bit
Amplifying energy for short distance	10Pj/bit/m²
Amplifying energy for long distance	0.013 pJ/bit/m²
Probability	0.1

VII. RESULTS AND DISCUSSION

PART-1 Based on Different Area Ranges

Energy (E=0.5) and Numbers of rounds (7000) are kept constant

(A) AREA RANGE-100X100m

ALIVE NODES

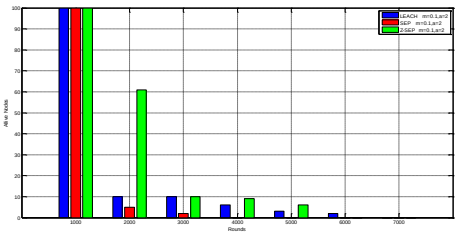


Fig 4: simulation results of the Alive Nodes under 100*100 area.

By analysing the **Fig 4** simulation graph, we came to know that as the number of rounds increasing the alive nodes will be decreases although the area remains constant i.e.,100mx100m but at the initial stage that is for 1000 rounds the alive nodes are constanti.e.,100nodes for all the three protocols.

DEAD NODES

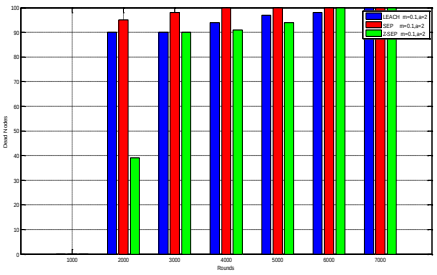


Fig 5: Simulation Results for the Dead nodes in 100*100 area range.

By analysing Fig **5**, we observe that as the number of rounds increases the dead nodes will increases. In case of 100mx100m we have observed that for leach protocol the nodes become dead from 3000 rounds, by 6000 rounds 90-100 nodes will be dead. Where as in case of SEP protocol they are precise to 90 nodes only. In case of Z-SEP the nodes will become dead from 6000 rounds.

PACKETS TO THE BASE-STATION

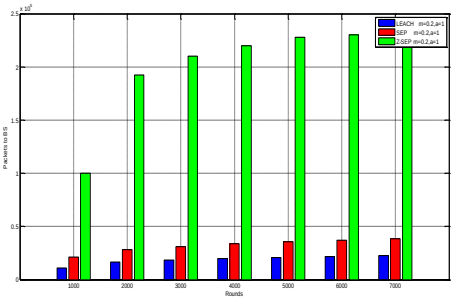


Fig 6 : Simulation result for the Packets send to the base station

From the **Fig6** we came to know that for lower range of energy there will be less transfer of packets to the base station, in case of LEACH & SEP there will be constant increase in transfer of packets to the base station where as in case of Z-SEP at 7000 rounds there will be a greater number of packets that will be transferred to the base station.

(B) AREA RANGE-200X200

ALIVE NODES

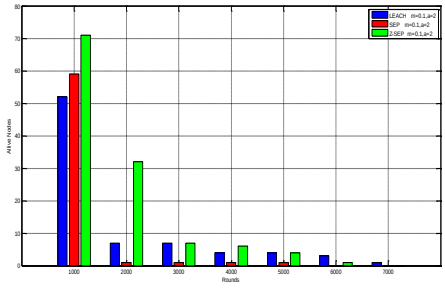


Fig 7: Simulation results of the Alive nodes in 200*200 area range.

By observing the **Fig7** we can say that compare to 100mx100m the alive nodes values changed in 200mx200m i.e., in case of 100mx100m the alive nodes are constant at 1000 rounds and 2000 rounds but in case of 200x200m the values of alive nodes start varying from 1000rounds itself means the Z-SEP starts transferring the data from 1000rounds itself.

DEAD NODES

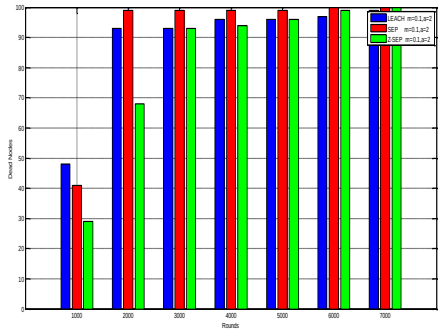


Fig 8: Simulation Results for the DEAD Nodes in the area of 200*200

Fig 8 signify that on Comparison of 100mx100m and 200mx200m plots we came to know that as the area increases the nodes become dead from 1000 rounds only in case of LEACH and SEP where as in case of Z-SEP the nodes will become dead from 2000 nodes.

PACKETS TO THE BASE STATION

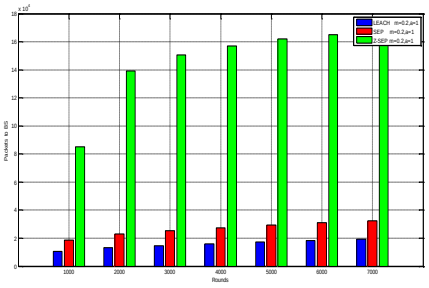


Fig 9: Simulation results for the packets to the base station under 200*200 area

Fig 9 gives the proof that as compared to the 100mx100m, there is more number of packets that is transferred to the base station for lesser number of rounds i.e., for 1000 rounds. In case of all the 3 protocols i.e., LEACH, SEP& Z-SEP the number of packets that transfer to the base station are going to increases for every 1000rounds.

(C) Under 300X300 RANGE

ALIVE NODES

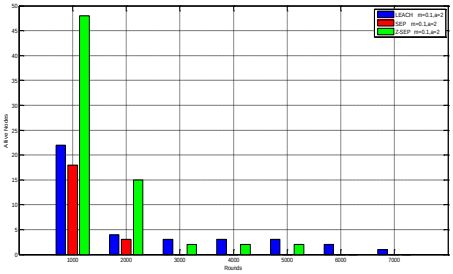


Fig10: Simulation result of Alive nodes under 300*300 range

From the **Fig:10** we can observe that in case of 300mx300m area the alive nodes start decreasing from 1000rounds itself for all the three protocols i.e., LEACH, SEP and Z-SEP.

DEAD NODES:

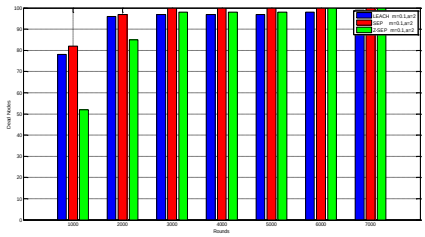


Fig 11: Dead nodes simulation result

By observing the **Fig11** we can easily understood that the , count for the dead nodes increases with increase of area from lower number of rounds itself.

PACKETS TO THE BASE STATION:

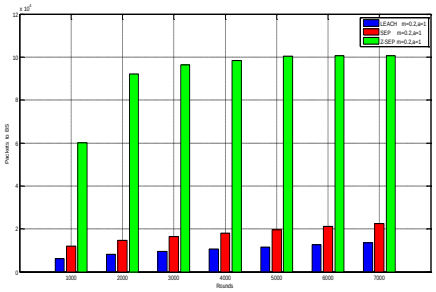


Fig 12: Simulation results for the packets to Base station

Fig 12 shows the simulation results of the packets sent to the base station by the different protocols.

PART-2 Based on Different Energy levels

AREA IS KEPT CONSTANT AT 100X100m RANGE

(A) For Energy E=0.9J

ALIVE NODES

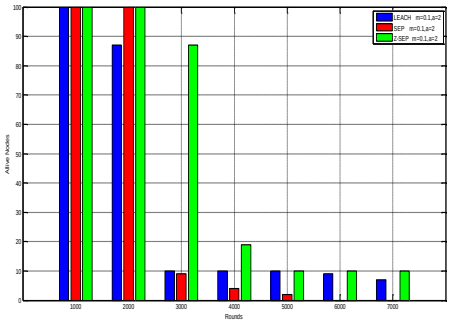


Fig 13: Simulation results for the Alive nodes at E=0.9J and area is constant at 100*100m

By analysing the **fig 13** we observed that When the area is constant the alive nodes are also constant for lesser number of rounds i.e., for 1000 rounds and 2000 rounds. From 3000 rounds they start decreasing in case of LEACH and SEP whereas for Z-SEP for 3000 rounds also it is constant that means the performance of Z-SEP is far better and more accurate than the LEACH and SEP.

DEAD NODES

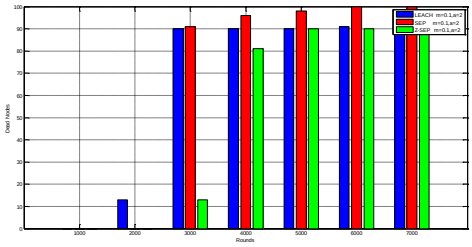


Fig 14: Simulation Results for the Dead nodes at energy level 0.9J and keeping the area constant

By observing the **Fig 14**, we understand that as the number of rounds increases the dead nodes increases in case of all the three protocols but we can specify Z-SEP as for 2000 rounds also the dead nodes are zero means the packets are still transferring to the base station where as in case of LEACH and SEP the dead nodes are more even at 3000 rounds also.

PACKETS TO THE BASE STATION

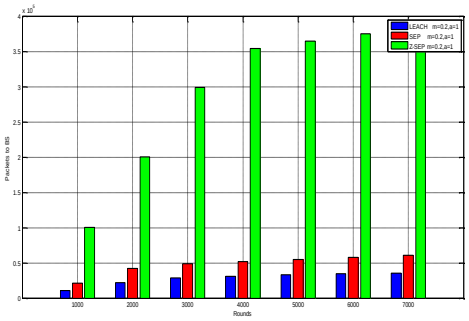


Fig 15 : Simulation result for the packets to base station

From the **fig 15** we can observe that the count of packets to the base station increases with respective to the number of rounds i.e. if count of rounds are increasing the number of packets to the base station also increasing in all three protocols, but coming to the Z-SEP protocol number of packets to base stations are very high compared with the other protocols.

(B) For energy level E0=0.5J

ALIVE NODES

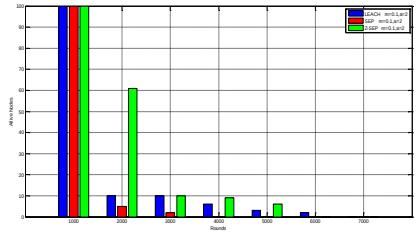


Fig 16 : simulation results for the alive nodes at E=0.5J.

By analysing the **Fig 16** we can tell that as the energy decreases the stability of alive nodes decreases means as the energy increases the alive nodes will become dead early. We observe that from graphs of E0=0.9 and E0=0.5, in case of 0.9 the alive nodes are constant for 1000 rounds and 2000 rounds for all the three protocols LEACH, SEP & Z-SEP but in case of 0.5 they are constant only at 1000 rounds.

DEAD NODES

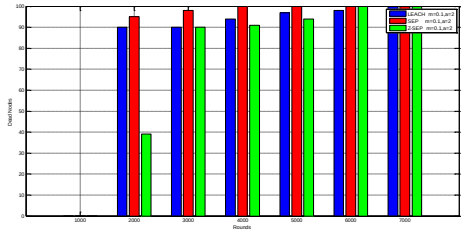


Fig 17: Simulation results for the Dead nodes at energy level 0.5J

By **Fig 17** ,we can say that Compared to E0=0.9 as the energy decreases the dead nodes will Increases in case of all protocols but here we can observe that by decreasing the energy SEP and Z-SEP show less number of dead nodes comparing with LEACH, in this energy value Z-SEP is better form the all three protocols. Why because it is only have less number of dead nodes from given particular value of energy.

PACKETS TO THE BASE-STATION

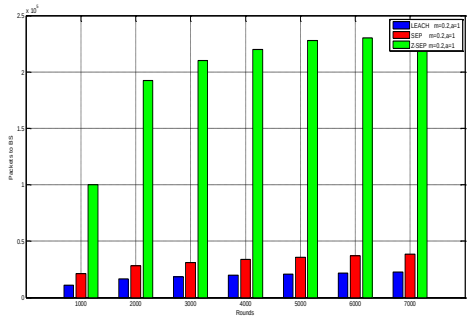


Fig 18 : Simulation results for the packets to the base station at E=0.5J

Fig 18 tells that if the count of packets to the base station is increasing constantly for more number of rounds then , the value of packets to base station is very high in the Z-SEP protocol compared with SEP and LEACH.

(C) For energy level E0=0.2J

ALIVE NODES

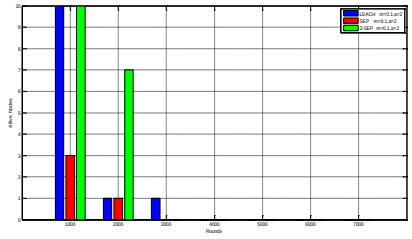


Fig 19: Simulation results for the energy level 0.2J keeping the area constant at 100*100m

By analysing the Fig **19**, we can say that Z-SEP works properly for low energy also i.e., 0.2 when compared to LEACH and SEP and we can also observe that the nodes will become dead early if the energy becomes low.

DEAD NODES

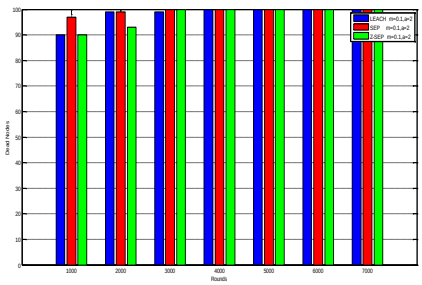


Fig 20: Dead nodes simulation results at energy level e=0.2J

From the **Fig 20,** we observe that by decreasing the energy value the number of dead nodes is constantly increasing irrespective of the number of rounds except at 1000 rounds and 2000 rounds. Dead nodes are increase constantly from 4000 rounds.

PACKETS TO THE BASE STATION

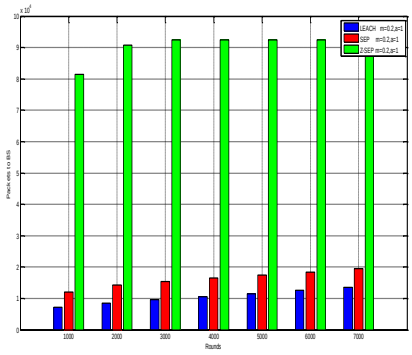


Fig 21: Simulation Results for the packets to base station

By observing the **Fig 21**, we can tell that energy value decreased to 0.2 but packets to base station are increased. In the case of Z-SEP the values of packets to base station are constantly increasing from lesser number of rounds i.e. 1000 rounds.

VIII. OBSERVATIONS BASED ON PART 1 AND PART 2

PART1- BASED ON AREA

Observation from graphs regarding ALIVE NODES

Based on area we came to know that, as the area increases the alive nodes starts decreasing from 1000 rounds in case of LEACH at 300mx300m and they are constant at 100mx100m and 200mx200m, in case of SEP it is similar to LEACH whereas Z-SEP starts decreasing from 1000rounds at 200mx200m area itself and at 300mx300m range they are is much more decreased.

Observation from graphs regarding DEAD NODES based on area:

By observing the simulation results, we understood that as the range of area increases the dead nodes will increase for the lesser number of rounds compared to low range of area.

Observations based on results regarding packets to base station

As the range of area increases the count of packets that transfer to the base station will increases in all of the three protocols i.e., LEACH, SEP & Z-SEP for every 1000 rounds.

PART-2 BASED ON ENERGY

Observations of results regrading ALIVE NODES

From this simulation results we can say that as the energy becomes low the performance of LEACH, SEP & Z-SEP also becomes less. But on comparison of three protocols we can say that Z-SEP is far better and accurate than LEACH and SEP because at lower energy also the total number of alive nodes are high in case of Z-SEP compared to LEACH and SEP.

Observation of simulation results regarding DEAD NODES:

From the plots we can say that as the energy decreases the performance of these three protocols decreases such that the dead nodes will become more for every 1000 rounds there by we can conclude that Z-SEP is having better performance compared to LEACH and SEP for different values of energy.

Observation of simulation results regarding packets to base station:

By observing the all the simulation results regarding to packets to base station, by varying the energy value doesn't affect the value of the packets to base station. In the three cases packets to base station values are constantly increases in all three protocols which are LEACH, SEP and Z-SEP. but we comparing all three protocols values of Z-SEP protocol is very high. Hence it is better than LEACH and SEP.

IX. CONCLUSION:

In this Work, we done the analysis of SEP, LEACH and Z-SEP protocols based on different parameters. By analysing the results, we conclude that the transfer of the data from nodes to the base station in Z-SEP very accurate and better then remaining two protocols which are LEACH and SEP. The performance of the Z-SEP is better in the case of different area ranges also where as other two protocols LEACH and SEP are fails. Specially, when we kept area constant and varying the energy level the performance of the Z-SEP is superior compare to its counterparts' protocols (SEP & LEACH). Also, the number of Alive Nodes are more in less energy level compare to other two protocols. Overall, we can easily observe that the performance of the Z-SEP is far better then the other two protocols (LEACH & SEP).

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