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Performance Evaluation of SEP, LEACH and ZSEP under the Influence of Network Area

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Abstract: In a Wireless Sensor Network, there are many number of nodes deployed randomly in the network. Though, these nodes are very tiny in size and thus are battery constrained and in most cases it is not feasible to replace it. Therefore energy consumption is a very important issue in wireless sensor network and hence, the network should be setup such that they can sustain for longer period and nodes can deploy energy efficiently. According to the requirement in the wireless sensor network, selection of right kind of protocol is also necessary as it can significantly affect the performance of the network. One of the requirements in setup of a wireless sensor network is its network area. This paper compares and analyses the performance of three protocols which are LEACH, SEP and ZSEP under the influence of varying network area. One of the attacks which affect the network is sinkhole attack. This paper mainly includes the optimization of data packets and data route for sinkhole attack using weight function over the network based on genetic algorithm and compare the results with and without optimization of sinkhole attack in the network.

Keywords: Wireless Sensor Network, LEACH, SEP, ZSEP, energy consumption.

1. INTRODUCTION

A wireless sensor network can be defined as wireless network that consists of locally distributed self governing nodes with sensors which senses and monitors physical and environmental conditions. Routing protocols are the set of rules which govern the network path for its transmission. Once sensor nodes are deployed in a network, they must be able to self organize themselves. They are also battery constrained, so once deployed in a network; it is not feasible to replace battery. Therefore, due to the energy constrained nature of such networks, it is very necessary to apply right kind of protocol in the network according to the requirements. Also there are other few parameters like throughput, energy consumption and network area in which the wireless sensor network has been deployed [1] [2].

A. LEACH Protocol

LEACH is Low Energy Adaptive Hierarchical protocol. It is the first hierarchal protocol introduced to reduce power consumption. It uses the clustering technique in which clusters are used to elongate the network lifetime. Cluster head is formed to transmit the data directly to base station. The operation of LEACH is divided into two phases; setup phase and steady state phase where steady state phase is longer than the setup phase. In setup phase, the network is organized into clusters, cluster head advertisement is done schedule for transmission is created. In steady state phase, data is aggregated, then compressed and transmitted to the base station. LEACH is very sensitive to heterogeneous environment [3], [4], [5].

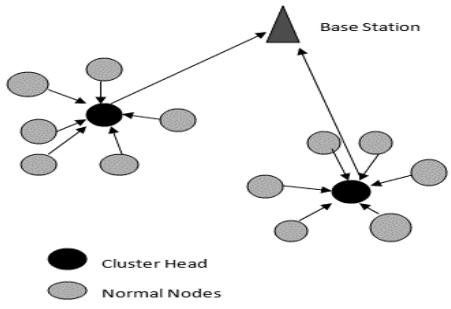

Fig. 1. *LEACH Protocol Network Architecture*

B. SEP Protocol

SEP is Stable Election Protocol in which two kinds of nodes are deployed in the network randomly; one is normal nodes and other is advanced nodes. What happens is that nodes which are near to the base station consume less energy in transmission than the nodes which are on the periphery of the network, thus the far away nodes die earlier and the energy remains in the normal nodes at the end of the network. This means far away nodes suffer from scarcity of energy and near nodes remain with more than required energy. Therefore to solve this problem, the far away nodes are provided α times more energy thus called advance nodes, than the nodes which are near to base station called normal nodes. This ensures that energy is not wasted at the end of the network. Also the advanced nodes send data directly to base station, then they will consume more energy, so clustering technique is used only for advanced nodes to save energy consumption. According to the remaining energy in each node, SEP uses election weighted probability of each node to become cluster head [6].

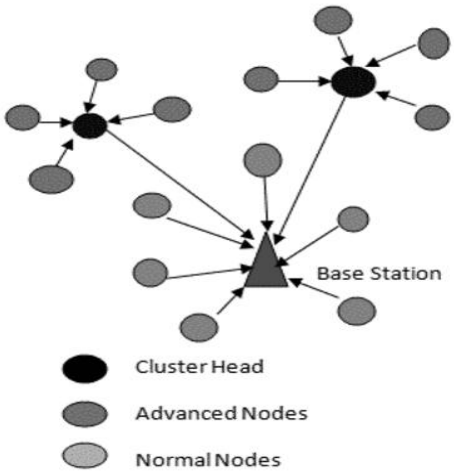

Fig. 2. *SEP Protocol Network Architecture*

C. ZSEP Protocol

ZSEP [7] is Zonal Stable Election Protocol in which there are three zones in network area where nodes are deployed. It is the extension of SEP and hybrid approach is followed that is direct transmission and transmission via cluster head. On the basis of energy level and Y coordinate of the field, there are three zones in network area; Zone 0, Head zone 1, Head zone 2. It is assumed that a fraction of total nodes n is fitted with more energy. The fraction of nodes is assumed m and α is the more energy than other nodes. Thus the nodes with α time more energy are advanced nodes and others are normal nodes. In zone 0, normal nodes are deployed in the area between 20<Y<=80 in random fashion. In Head zone 1, half of advanced nodes are deployed inconsequentially between 0<Y<=20. In Head zone 2, other half of advanced nodes are deployed between 80<Y<=100 randomly. In direct communication process, nodes in zone 0 sense data and gather the required information for transmission to base station. In transmission via cluster head, nodes in head zone 1 and head zone 2 selects cluster head in their respective zone and then cluster head sense data and gathers information from member nodes after the cluster head assigns its member cluster the TDMA schedule to send their data to cluster head. After gathering information and compressing it, the cluster heads send data to the base station.

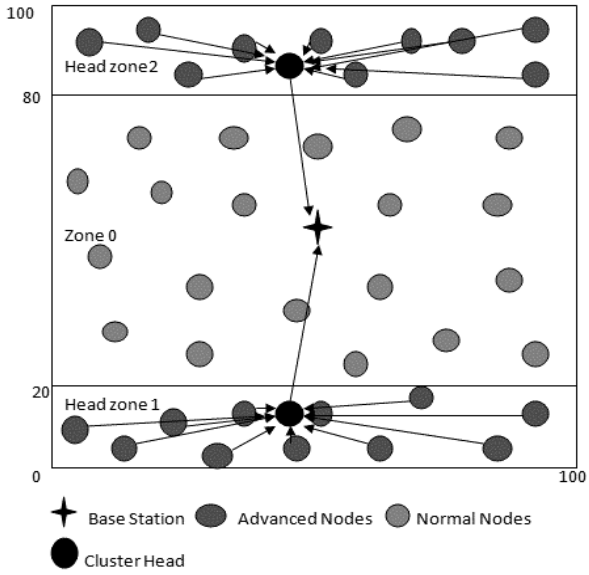

Fig. 3. *ZSEP Protocol Network Architecture*

2. RELATED WORK

In 2012, Edwin Prem Kumar Gilbert, Baskaran Kaliaperumal, and Elijah Blessing Rajsingh et al. [1] presented an overview on various problematic issues in wireless sensor network. The various applications of wireless sensor network have been studied in various areas like healthcare, military, environmental and industrial applications. In 2010, Shio Kumar Singh, M P Singh, and D K Singh et al. [2] gave a survey for protocols in wireless sensor network for the study of their strengths and comparison. By taking into account several classification criteria based on data aggregation capacity, physical and environmental conditions, Quality of Service and various other, they surveyed sample of protocols. In 2013, Chunyao FU, Zhifang JIANG, Wei WEI and Ang WEI et al. [3], they proposed that there is one parameter which is very important to be considered

and that is energy efficiency as while designing of protocol there is constraint of energy in nodes. A new protocol is proposed, LEACH-TLCH that reduces energy consumption and helps in increase of network lifetime. In 2014, Upasana Sharma, Sunil Tiwari et al. [4], for different base stations and terrain area, this paper analyses the performance of LEACH and SEP in terms of alive nodes and number of rounds. If the base station is closer than the base station far way the network node dies after more number of rounds. In 2014, Reenkamal Kaur Gill, Priya Chawla, Monika Sachdeva et al. [5] they analyses that in wireless sensor network until the battery dies, the node is useful. They analyses various advantages and disadvantages of LEACH protocol and attacks on it. In 2004, Georgios Smaragdakis, Ibrahim Matta and Azer Bestavros et al. [6] , they proposed SEP protocol which is heterogeneous routing protocol , to prolong the stability period in wireless sensor network which is very important for many applications where reliability is needed. In 2013, S. Faisal1, N. Javaid, A. Javaid, M. A. Khan, S. H. Bouk, Z. A. Khan et al.[7], they proposed a hybrid protocol called ZSEP, which compares the performance with SEP and LEACH and analyzed that the performance of ZSEP is much better than the both protocols. In 2014, Sanjeev Kumar Gupta, Poonam Sinha et al. [8], they provided the background in wireless sensor network. An architectural overview is provided in the beginning for sensor nodes, networking standards, communication protocol and various other parameters. They have also described the various advantages, disadvantages, challenges and issues and applications in wireless sensor network. In 2015, Dr. Deepti Gupta et al. [9], surveyed the area of application in which wireless sensor network is deployed such as military applications, tracking of target, surveillance of traffic, monitoring of environment and healthcare and this paper also surveyed about the area in which wireless sensor network can be deployed in future. In 2012, Aamir Shaikh and Siraj Pathan et al. [10] in the field of building automation provided the application in this field. This paper provides the survey on the application of wireless sensor network in various fields and also clears it to be new emerging technology. In 2014, Rajesh Chaudhary, Dr. Sonia Vatta et al. [11] gave a review on hierarchical routing protocol which is a subtype of network based protocol in wireless sensor network. It also studied the various issues in wireless sensor network and the most important issue to be considered is energy consumption and network lifetime. In 2013, Farooq Sultan, Salam A. Zummo, Munir A. Kulaib Al-Absi, Ahmar Shafi et al. [12] gave the concept of routing protocol based upon cluster head rotation which is further integrated into algorithm. The modified S-MAC protocol is integrated to reduce energy usage in nodes and the network utilizes this routing protocol. In 2011, Karsten Funk, Sharmila Ravula, Jochen Schaefer et al. [13], a method is provided to control a system in wireless sensor network from a user interface which is coupled to the internet. An internet based portal is interacted by user through user interface which establishes a secure connection between remote control module which is coupled to the wsn and the portal. In 2011, Jogesh Warrior, John C. Eidson et al. [14], proposed that the distributed sensor systems to which representative embodiments are directed, from there the measurement data I extracted using the mobile devices and calculate the probabilities of future access using the recorded information by the mobile devices to sensor devices. In 2014, Jianlin Guo, Philip Orlik, Kieran Parsons et al. [15], proposed that in each node a cluster head capability is determined to cluster the nodes in a network. On the basis of cluster head capability, each node selects one or more clusters to be cluster head and based on maximal cluster head capability, one node is chosen to be cluster head.

3. PRELIMINARIES

An attempt is made to study the significance of the application of the network area for the accurate functioning of the wireless sensor network in an environment. We get the parameters which are total number of nodes, number of rounds, width and length of network, optimal probability and other parameters. The simulation is carried out using MATLAB. Three routing protocols are used in heterogeneous environment to modify the network parameters that we use.We assume that n number of nodes is deployed in the network randomly. Initial energy is taken Eo with network area 150m X 150m, 200m X 200m and 250m X 250m. The goal is to study the effect of change in network area over the performance of protocols.

In LEACH, when cluster is formed, each node selects a random number between 0 and 1 and then this number is compared to a threshold value let us say T (η).If the number is less than this threshed value then that node becomes the cluster head for that round and if it is greater than the threshold vale, the node remains as a normal node for that round. The value for threshold is given as:

$$T(\eta) = \begin{cases} \dfrac{\phi}{1 - \phi * \left(r \bmod \dfrac{1}{\phi} \right)} & \phi \in \beta \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

Where, ϕ is the probability of each node to become cluster head, r is the number of the round; β is the collections of the nodes that have not yet been head nodes in the first 1/ϕ rounds.

SEP is based on weighted election probabilities where each node becomes cluster head according to the remaining energy in each node. In SEP, threshold value for normal nodes and threshold value for advanced nodes is given by following equation:

$$T(\eta_{nrm}) = \begin{cases} \dfrac{\phi_{nrm}}{1-\phi_{nrm} * \left(r \bmod \dfrac{1}{\phi_{nrm}} \right)} \phi_{nrm} & \in \beta' \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

Where, $\phi_{nrm} = \dfrac{\phi_{opt}}{1+\alpha m}$ is the weighted probability for normal nodes, r is the current round, β' is the set of normal nodes that have not become cluster heads the last $1/\phi_{nrm}$ rounds of the epoch. ϕ_{opt} is the optimal probability. m is the fraction of advanced nodes and α is the additional energy factor between advanced and normal nodes.

$$T(\eta_{adv}) = \begin{cases} \dfrac{\phi_{adv}}{1-\phi_{adv} * \left(r \bmod \dfrac{1}{\phi_{adv}} \right)} \phi_{adv} & \in \beta'' \\ 0, & \text{otherwise} \end{cases} \quad (3)$$

Where, $\phi_{adv} = \dfrac{\phi_{opt}(1+\alpha)}{1+\alpha m}$ is the weighted probability for advance nodes, r is the current round and β'' is the set of normal nodes that have not become cluster heads the last $1/\phi_{adv}$ rounds of the epoch.

Similarly in ZSEP, it follows hybrid approach in which each node decides to become cluster head in the current round by choosing a random number between 0 and 1.If the number is less than the threshold value then it becomes the cluster head otherwise remains as normal node for that round. The Threshold value for advanced nodes is given by following equation:

$$T(\eta_{adv}) = \begin{cases} \dfrac{\phi_{adv}}{1-\phi_{adv} * \left(r \bmod \dfrac{1}{\phi_{adv}} \right)} \eta & \in \beta \\ 0, & \text{otherwise} \end{cases} \quad (4)$$

Where, β is the set of nodes which have not been cluster heads in the last $1/\phi_{adv}$ rounds. Probability for advance nodes to become cluster head is given by the following equation:

$$\phi_{adv} = \frac{\phi_{opt}}{1+\alpha m} \times (1+\alpha) \quad (5)$$

4. SIMULATION SCENARIO

A simulation is performed using MATLAB and LEACH, SEP and ZSEP protocol is used to modify the network parameters. In the simulation, 100 nodes are deployed in heterogeneous environment with initial energy 0.5J.The network area of simulation is varied as 150 m^2, 200 m^2 and 250 m^2. The various parameters are evaluated like number of alive nodes, number of dead nodes and number of packets to base station, all with respect to number of rounds. The following parameters are taken for the simulation given in table below:

TABLE I. PARAMETER SETTING

Parameters	Values
Simulation Area	100mX100m, 200mX200m, 250m X 250m
Total Number of sensor nodes	100
Routing Protocol	LEACH,SEP,ZSEP
Total Number of Rounds	6000
Initial energy of advanced nodes	Eo(1+α)
Energy for data aggregation *EDA*	5 *nJ/bit/signal*
Transmitting and receiving energy *Eelec*	5 *nJ/bit*
Amplification energy for short distance *Efs*	10*pJ/bit/m2*
Amplification energy for long distance *Eamp*	0.013 *pJ/bit/m4*
Node Deployment	Random
Battery Model	Linear
Probability, ϕ_{opt}	0.1

5. RESULT AND DISCUSSION

Figure 4, Figure 5 and Figure 6 shows the result scenario for the effect of variation in network area on LEACH, SEP and ZSEP in terms of number of alive nodes. It can be seen that as the network area increases, the performance of each protocol degrades

significantly. Also comparing the performance of protocols with each other in such varying scenario, it can be seen that ZSEP performs much better than LEACH and SEP. The reason behind this is because of the network area divided in three zones. The normal nodes directly send data to base station and consume less energy. Only the advanced nodes form clusters and they have α time more energy than normal nodes. Therefore, inspite of increasing the network area, there is not much effect on the performance of ZSEP. In terms of number of alive nodes, LEACH performs better than SEP. This is due to the weighted election probability in SEP.

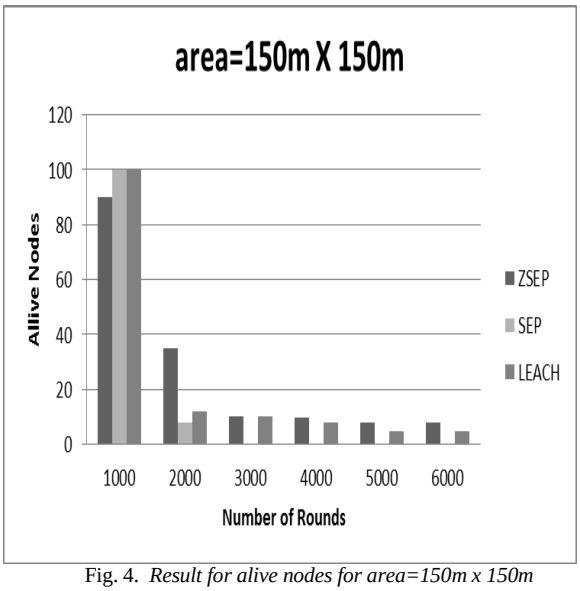

Fig. 4. *Result for alive nodes for area=150m x 150m*

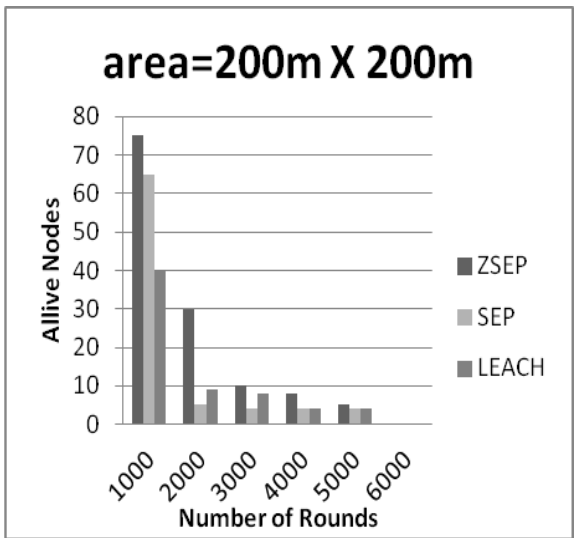

Fig. 5. *Result for alive nodes for area=200m x 200m*

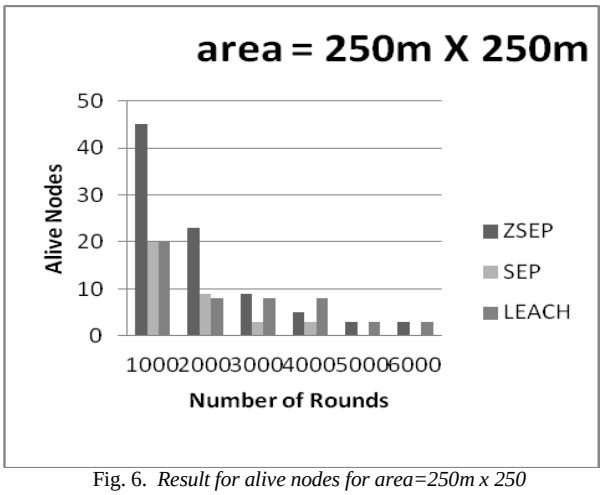

Fig. 6. *Result for alive nodes for area=250m x 250*

From figure 7, figure 8 and figure 9, the number of dead nodes per thousand rounds is shown for different network area in LEACH, SEP and ZSEP. The number of dead nodes increases as the network area increases. This results in degradation of performance of protocols. Again comparing the performance of each protocol, ZSEP still gives better performance than others. While in terms of number of dead nodes, LEACH shows more stability than SEP. In ZSEP, normal nodes in zone 0 directly communicate to base station and nodes in head zone 1 and head zone 2 communicate through cluster head to base station. As in clustering technique, cluster head consumes energy in the form of data aggregation and also by receiving data from nodes in the cluster. So this energy is conserved in normal nodes as they do not have to aggregate data and receive data from other nodes, so energy is not dissipated as that of cluster head, results in the increase of stability period. Network lifetime is also increased from SEP and LEACH because of the advance node. Advance nodes have α time more energy than normal nodes so advance nodes die later than normal nodes.

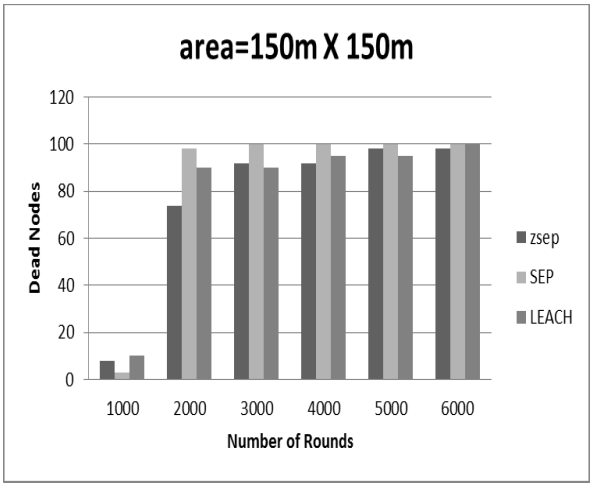

Fig. 7. *Result for dead nodes for area=150m x 150m*

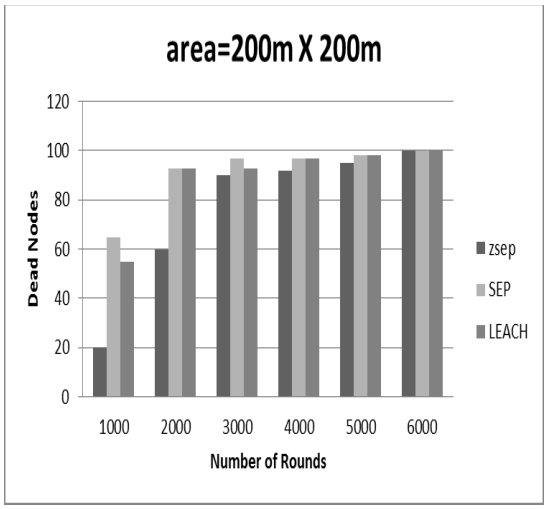

Fig. 8. *Result for dead nodes for area=200m x 200m*

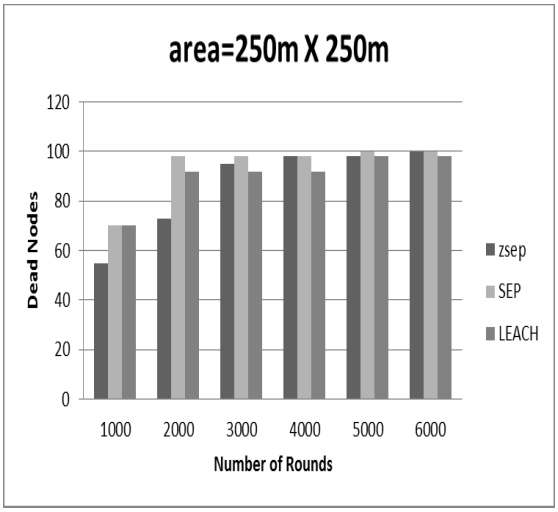

Fig. 9. *Result for dead nodes for area=250m x 250m*

From figure 10, figure 11 and figure 12, the number of packets sent to base station per thousand rounds also decreases in all the protocols. But the throughput of ZSEP is larger than LEACH and SEP because every normal node directly sends data to base station. As in SEP, LEACH does not have weighted election probability and also with respect to heterogeneity, it is very much sensitive. LEACH does not have weighted election probability as in SEP for even distribution of extra energy. In LEACH every node has equal chance to become cluster head so normal nodes die sooner than advance nodes. When compared with SEP, Z-SEP network life time is increased due to advance nodes which die slower than normal nodes. Here SEP performs better than LEACH due to weighted election probability.

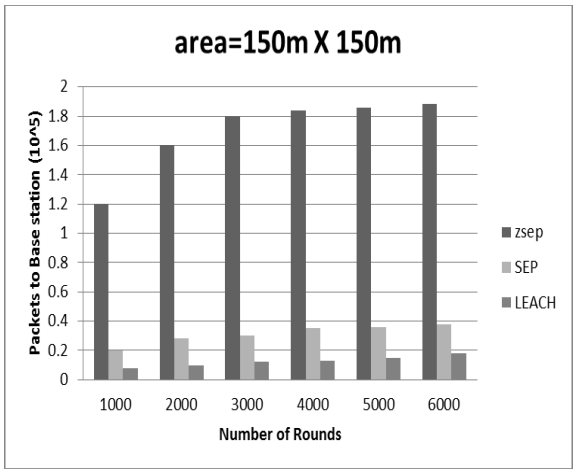

Fig. 10. *Result for throughput for area=150m x 150m*

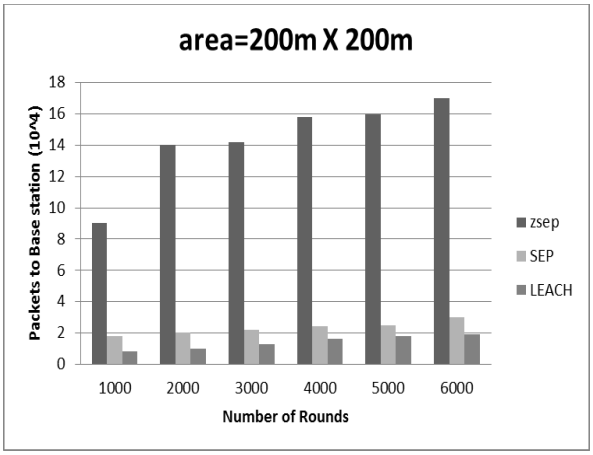

Fig. 11. *Result for throughput for area=200m x 200m*

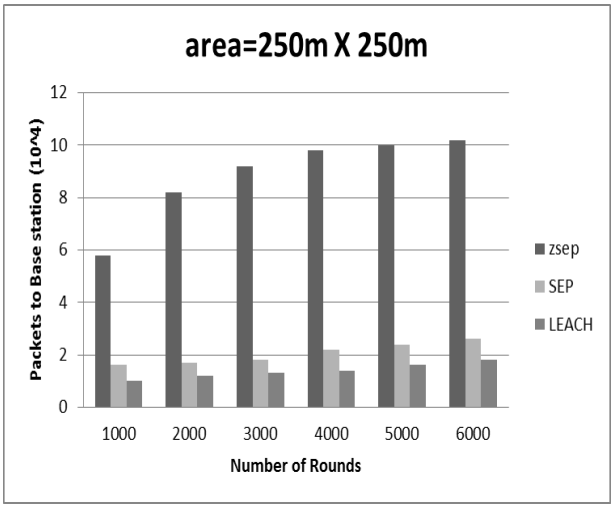

Fig. 12. *Result for throughput for area=250m x 250m*

6. CONCLUSION AND FUTURE WORK

This paper studies the effect of variation in network coverage on protocols and analyzes the performance of protocols and compares their performance with each other. The network coverage is a sensitive issue in wireless sensor network and there should be a tradeoff between the various parameters taken during the setup of the network. Also not every protocol gives same kind of performance in the same environment. They should be wisely selected to setup the network according to the requirement. The selection of protocols, the initial energy of the network, and the coverage area of the network, there should be an accurate tuning between them to perform the network at its best. It should be adaptive in case if there is a requirement to change in certain parameters in emergency case. It has a wide scope mainly in military and urban areas. The improvement can be done to cover the maximum area with better performance for wireless sensor network.

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