A Comparative Study of Multipath Routing Protocols in WSN

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Abstract— Wireless Sensor Network is the group of specialized transducers with a communication infrastructure that uses radio to monitor and record physical or environmental conditions. There are a number of routing protocols for wireless sensor network. In this paper, an effort has been made to compare the performance of various routing protocols. Three performance metrics are taken into consideration namely number of alive nodes, number of dead nodes and packets transmitted to the sink. Simulation is performed in MATLAB programming environment.

Key words: Wireless Sensor Network, SEP, Z-SEP, LEACH, Genetic Algorithm

I. INTRODUCTION

A Wireless sensor network comprises a large number of sensor nodes that are used for monitoring physical or environmental conditions such as pressure, temperature, etc. Hundreds to thousands such sensor nodes are deployed in a wireless sensor network. The components of a sensor node are shown below:

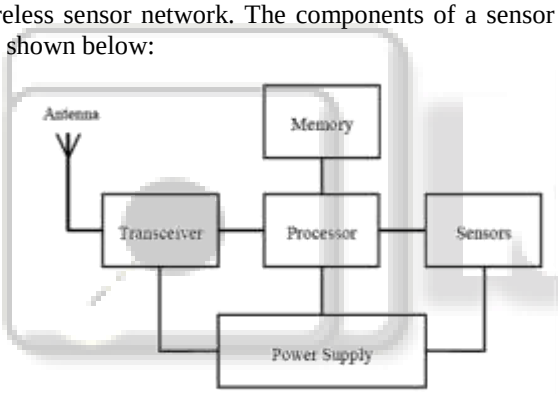

Fig.1 Components of a Sensor Node

The nodes in the network sense the data and transmit it to a processing center called 'Sink' or 'Base Station'. Based on the energy, the nodes are classified into two categories namely advanced and normal nodes. Nodes which have energy higher than the threshold energy are chosen as advanced nodes. The clustering method is used for improving the design of the protocols used in WSN.

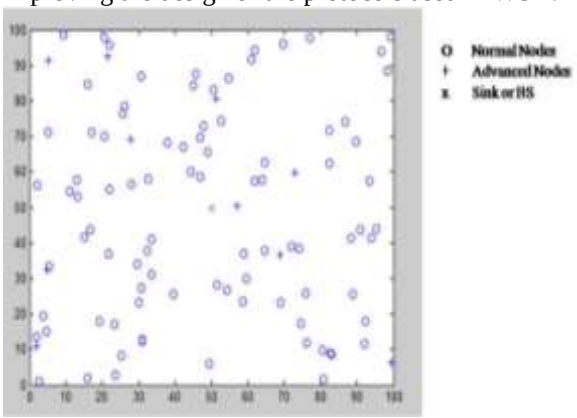

Fig. 2 Randomly distributed nodes

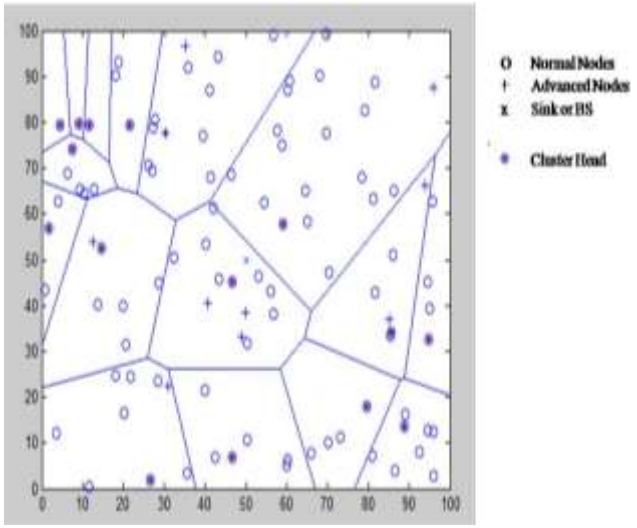

Fig. 3 Cluster Formation

II. RELATED WORK

A number of WSN routing protocols have been designed and comparisons have been done between these protocols based on various parameters. Mohammad Masdari and Maryam Tanabi[1] analyzed multipath routing protocols in wireless sensor networks. The paper investigated various multi-path routing protocols of the WSN in the literature and illustrated its benefits. Wang et al. [3] proposed an energy efficient and collision aware (EECA) node-disjoint multipath routing algorithm for wireless sensor networks. With the aid of node position information, the EECA algorithm attempted to find two collision-free routes using constrained and power adjusted flooding and then transmitted the data with minimum power needed through power control component of the protocol. Meena Ahlawat and Ankita mittal[6] presented Prolonging Lifetime of Wireless Sensor Network using Evolutionary algorithms. LEACH has been widely accepted WSN routing protocol for its energy efficiency. Evolutionary algorithm (EA) also used by researcher to resolve cluster based protocol in WSNs. Chunyao et al. [8] proposed an Energy Balanced Algorithm of LEACH protocol in WSN. Qian Liao and Hao Zhu[10] took node's residual energy and location information into account, optimized the selection method of the threshold for electing cluster-head, improved optimal cluster-head selection strategy that is normal nodes selected the optimal cluster-head based on the cost function. Norouzi et al. [11] designed a new Clustering Protocol for Wireless Sensor Networks using genetic algorithm approach and investigated the Genetic Algorithm (GA) as a dynamic technique to find optimum states. It was a simple framework that included a proposed mathematical formula, which increasing in coverage was benchmarked against life-time. Finally, the implementation of the proposed algorithm

indicated a better efficiency compared to other simulated works.

III. ENERGY MODEL

Consider a heterogeneous wireless sensor network i.e. all sensor nodes do not have the same energy. So, some of the nodes will have α times more energy than rest of the nodes. These can be referred as advanced nodes. Let m be the fraction of the total number of nodes n, which are equipped with α times more energy than the others[10].

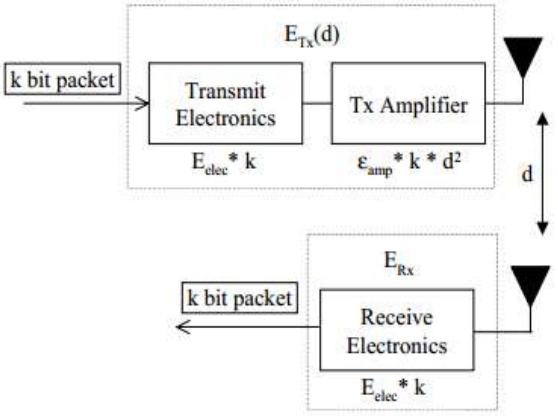

Fig.4 Radio Energy dissipation Model [6]

The energy consumption of k-bits message between two nodes with a distance of d can be evaluated as:

$$E_{Tx} = k.\ E_{elec} + k.\ E_{fs}.\ d^2, \text{ if } d \leq d_0$$

$$E_{Tx} = k.\ E_{elec} + k.\ E_{mp}.\ d^4, \text{ if } d > d_0$$

Where $E_{Tx}(k,d)$ is the energy consumption in transmitting k-bit data to a node with a distance of d, $E_{Rx}(k)$ is the energy consumption in receiving k-bit data. E_{elec} equals the per bit energy consumption for transmitter and receiver circuit .E_{mp} and E_{fs} are the amplifier parameters of transmission corresponding to the multi-path fading model and the free-space model respectively. d_0 is the threshold distance between multi-path fading model and the free-space model. By equating the two expressions at $d=d_0$, the following value is obtained:

$$d0 = \sqrt{\frac{Efs}{Emp}}$$

IV. ROUTING PROTOCOLS

A. SEP

A Stable Election Protocol (SEP) for clustered heterogeneous wireless sensor networks is designed for the two-level heterogeneous networks. The probability threshold, which each node s uses to determine whether itself to become a cluster-head in every one round, is as follow:

$$T(n) = \begin{cases} \dfrac{p}{1 - p\left(r \bmod \frac{1}{p}\right)} & if\ n \in G \\ 0 & otherwise \end{cases}$$

Where G is the set of nodes that are eligible to be cluster heads at round r. In each one round r, when node s find it is eligible to be a cluster head, it will decide a casual number between 0 and 1. If the number is less than threshold (s), the node si becomes a cluster head during the current round. Also, for two-level heterogeneous networks, p is defined as follow:

$$P_{nrm} = \frac{Popt}{1+\alpha.m} \quad \text{if s is normal node}$$

$$P_{adv} = \frac{Popt(1+\alpha)}{(1+\alpha.m)} \quad \text{if s is advanced node}$$

B. Z-SEP

Using this protocol, the network field is divided in three zones. The reason behind this type of deployment is that advance nodes have high energy than normal nodes. As corners are most distant places in the field, so if a node is at corner then it requires more energy to communicate with base station.

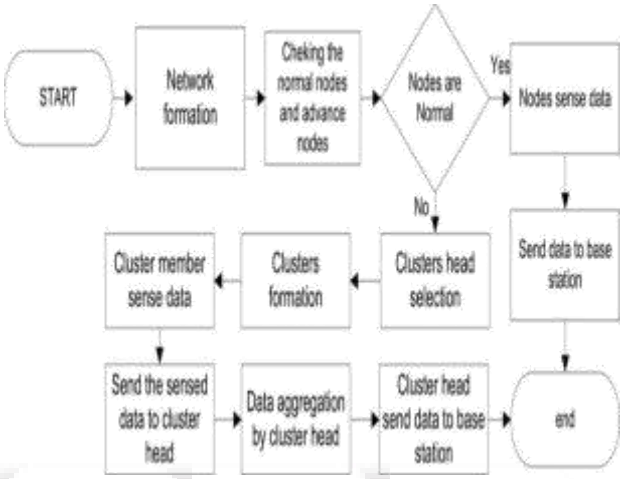

Fig. 5 Flowchart for Z-SEP

C. LEACH

The operation of LEACH is performed into two steps, the setup phase and the steady state phase. In setup phase the nodes are organized into cluster heads (CHs) are selected. These cluster heads change randomly over time in order to balance the energy of the network. This is done by choosing a random number between 0 and 1. The node is selected as a cluster head for the current round if the random number is less than the threshold value T (n), which is given by

$$T(n) = \begin{cases} \dfrac{p}{1 - p\left(r \bmod \frac{1}{p}\right)} & if\ n \in G \\ 0 & otherwise \end{cases}$$

Here G is the set of nodes that are involved in the CH election. In the steady state phase, the actual data is transferred to the BS. To minimize overhead the duration of the steady state phase should be longer than the duration of the setup phase. The CH node, after receiving all the data from its member nodes, performs aggregation before sending it to the BS. After a certain time period, the setup phase is restarted and new CHs is selected. Each cluster communicates using different CDMA codes to reduce interference from nodes belonging to other clusters [4].

D. Genetic Algorithm Approach

Proposed algorithm for applying GA to the routing protocols is as follows:

1) Create a heterogeneous wireless sensor network. For this initialize all the basic parameters such as number of nodes, initial energy, data aggregation energy, etc
2) Choose any routing protocol such as SEP, Z-SEP or LEACH and proceed to step 3.

3) Find the cluster head, normal nodes and advanced nodes of each cluster.
4) Evaluate the energy parameters.
5) With the help of the energy parameters obtained in step 4, find the number of alive nodes, the number of dead nodes and the number of packets transferred to Base Station.

Figure 6 illustrates an algorithm for applying GA to the routing protocols.

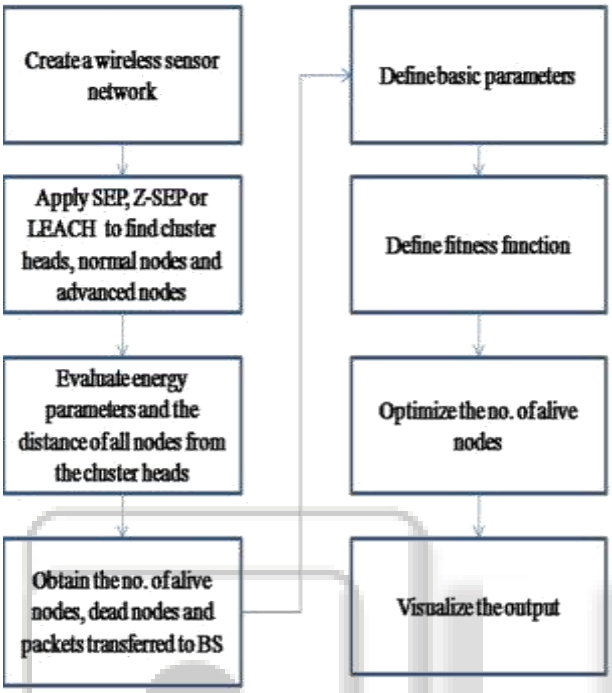

Fig. 6 Flowchart for applying GA to LEACH, SEP and Z-SEP

V. SIMULATION RESULTS

For simulation, MATLAB programming environment is used. The goal is to compare the performance of SEP, Z-SEP and LEACH. Performance Metrics used in the simulation are:

- Number of alive nodes per round
- Number of dead nodes per round
- Packets transferred from Cluster heads to Base station i.e. throughput

A population of 100 nodes in a sensor network field of dimension 100mX100m is considered. Only 10% of the nodes are advanced i.e. m=0.1 which are equipped with 200% more energy than other nodes i.e. α=2. The optimal probability of a node to become cluster head is 0.1. Other parameters are mentioned below:

Parameter	Value
P_{opt}	0.1
Sink location	(50,50)
Initial energy of normal node, E_0	0.5 Joules
K(message size)	4000
E_{fs} (free space model)	10 pJ/bit/m^2
E_{mp} (multipath fading model)	0.0013pJ/bit/m^4
Energy to run transceiver, E_{elec}	50nJ/bit
Data Aggregation Energy, E_{da}	5nJ/bit/message
Maximum Number of rounds	9000

Table 1: Simulation Environment Parameters

From figure 7, it is observed that the number of packets transmitted to base station is highest using Z-SEP.

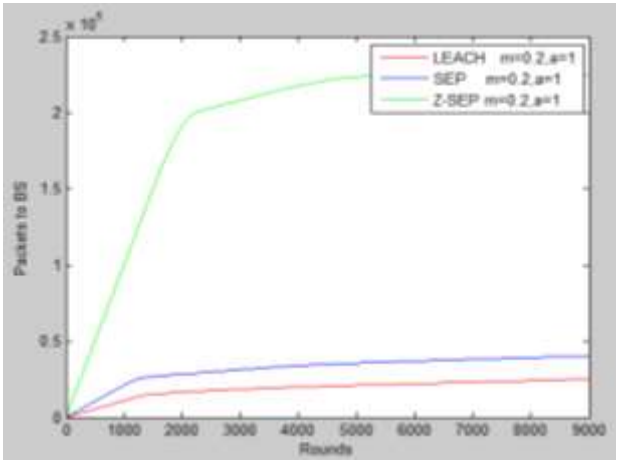

Fig. 7 Number of packets transferred to Base station per round

Round	SEP	Z-SEP	LEACH
1000	0.2 X 10^5	0.76 X 10^5	0.12 X 10^5
2000	0.29 X 10^5	1.7 X 10^5	0.18 X 10^5
5000	0.32 X 10^5	2.125 X 10^5	0.21 X 10^5
9000	0.4 X 10^5	2.25 X 10^5	0.25 X 10^5

Table 2: No. Of Packets Sent To Base Station

It is clear from figure 8 that the number of dead nodes is increasing with increase in number of rounds.

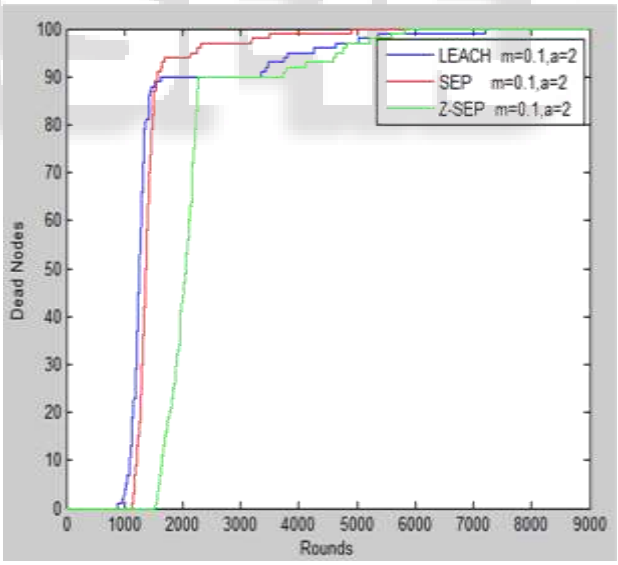

Fig. 8 Number of Dead nodes per round

Protocol	Round when first node dies
SEP	1100
Z-SEP	1550
LEACH	900

Table : 3 Dead Nodes Performance Evaluation

The performance metric on which genetic algorithm is applied is the number of alive nodes. From figure 9, it can be said that optimized SEP has highest number of alive nodes approximately up to 800th round. Afterwards, the optimized LEACH and the optimized SEP have approximately equal number of alive nodes.

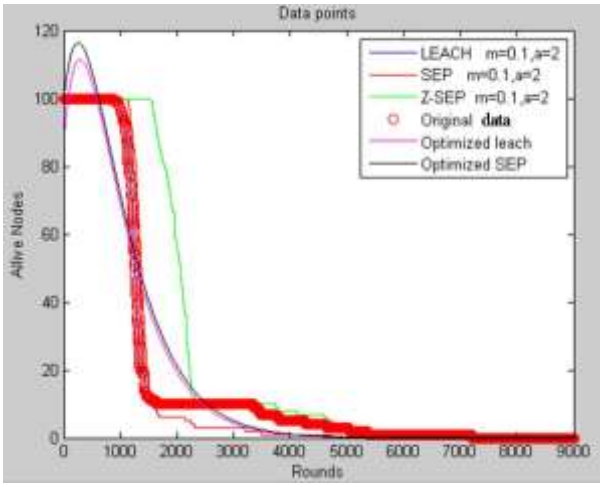

Fig 9 Number of alive nodes per round

Round	SEP	Z-SEP	LEACH	Optimized SEP	Optimized LEACH
125	100	100	100	114	105
250	100	100	100	118	110
1000	100	100	100	80	79
2000	6	70	10	22	20

Table 4 : Number Of Alive Nodes

VI. CONCLUSION & FUTURE WORK

This paper compares the existing routing protocols (e.g. SEP, Z-SEP, LEACH) used in Wireless sensor networks under various performance metrics through simulation. Simulations show that applying genetic algorithm to these protocols, gives better results. One of the most important issues that should be addressed in order to improve life span of the network is efficiency of energy. Formation of clusters greatly helps in achieving energy efficiency as it reduces communication distance. Genetic algorithm ensures that fittest node is selected as cluster head. The proposed genetic algorithm approach helps in increasing the number of alive nodes in the network, thereby minimizing energy consumption.

Protocols studied in this paper can be further optimized using the genetic algorithm and other techniques such as ACO, PSO, etc. taking constraints other than those used in this paper.

REFERENCES

[1] Mohammad Masdari and Maryam Tanabi, "Multipath Routing Protocols in Wireless Sensor Networks: A Survey and Analysis", International Journal of Future Generation Communication and Networking, Vol. 6, No. 6 (2013), pp 181-192.

[2] Marjan Radi, Behnam Dezfouli,Kamalrulnizam Abu Bakar and Malrey Lee, "Multipath Routing in Wireless Sensor Networks: Survey and Research challenges", Sensors 2012, 12, pp 650-685

[3] Zijian Wang, Eyuphan Bulut, and Boleslaw K. Szymanski, "Energy Efficient Collision Aware Multipath Routing for Wireless Sensor Networks", Proceedings of International Conference on Communnication, ICC09, Dresden Germany, June 14-18, 2009, pp 1-5

[4] Muhammed U. Mahdi, "Determining Number & Initial Seeds of K-Means Clustring Using GA"Journal of of Babylon University/Pure and Applied Sciences/ No.(3)/ Vol.(18), 2010

[5] Ms. Aparna K and Dr. Mydhili K Nair, "A Detailed Study and Analysis of different Partitional Data Clustering Techniques"International Journal of Innovative Research in Science, Engineering and Technology(An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 1, January 2014

[6] Meena Ahlawat and Ankita mittal, "Prolonging Lifetime of Wireless Sensor Network using Evolutionary algorithms", International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE), Vol. 4, Issue 4, April 2015, pp 212-215

[7] K.Deepthi, K.Rajani and Y.Suresh, "Random Routing Algorithm for Secured Data Collection Accessed in Wireless Sensor Networks", International Journal of Computer Science and Information Technologies (IJCSIT), Vol. 3(4), 2012, pp 4887-4891

[8] Chunyao FU, Zhifang JIANG1, Wei WEI and Ang WEI, "An Energy Balanced Algorithm of LEACH protocol in WSN", International Journal of Computer Science Issues (IJCSI), Vol. 10, Issue 1, No. 1, January 2013, pp 354-359

[9] Nishi Sharma and Vandna Verma, "Energy Efficient LEACH protocol for Wireless Sensor Network", International Journal of Information and Network Security (IJINS), Vol. 2, No. 4, August 2013, pp 333-338

[10] Qian Liao, Hao Zhu, "An Energy Balanced Clustering Algorithm Based on LEACH protocol", Proceedings of the 2nd International Conference On Systems Engineering and Modeling (ICSEM-13)

[11] Ali Norouzi, Faezeh Sadat Babamir, Abdul Halim Zaim, "A new Clustering Protocol for Wireless Sensor Networks using genetic algorithm approach", published online November 2011 (http://www.SciRP.org/journal/wsn)

[12] Gurbhej Singh and Rajneet Kaur, "Network Lifetime Enhancement Using Genetic Algorithm" International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE), Vol. 3, Issue 7, July 2013, pp 1375-1381

[13] Sajid Hussain, Abdul Wasey Matin, Obidul Islam, "Genetic Algorithm for Hierarchical Wireless Sensor Networks", Journal of Networks, Vol. 2, No. 5, September 2007, pp 87-97

[14] Ali Norouzi and A. Halim Zaim, "Genetic Algorithm Application in Optimisation of Wireless Sensor Networks", Hindawi Publishing Corporation The Scientific World Journal Volume 2014, Article ID 286575, 15 pages

[15] Navdeep Kaur and Deepiika Sharma, "Genetic Algorithm for Optimizing the Routing in Wireless Sensor Network" International Journal of Computer Applications, Volume 70, No. 28, May 2013, pp 32-36

[16] Mohammed Abo-Zahhad, Sabah M. Ahmed, Nabil Sabor and Shigenobu Sasaki, "A New Energy-Efficient Adaptive Clustering Protocol Based on Genetic Algorithm for Improving the Lifetime and the Stable

Period of Wireless Sensor Networks", International Journal of Energy, Information and Communications, Vol. 5, Issue 3 (2014), pp 47-72

[17] Vinay Kumar Singh and Vidushi Sharma, "Elitist Genetic Algorithm Based Energy Efficient Routing Scheme for Wireless Sensor Networks", International Journal of Advanced Smart Sensor Network Systems (IJASSN), Vol. 2, No. 2, April 2012, pp 15-21.

