Fuzzy Link Cost Measure for Energy Efficient Routing in WSN

Raminder Singh Uppal[1],Karamjot Kaur[2]
[1]Department of ECE,BBSBEC, Fatehgarh Sahib
[2] Department of ECE, Fatehgarh Sahib
Email: [1]rsuppal@gmail.com, [2]karamjotkaur78@gmail.com

Abstract—Wireless Sensor network (WSN) is being widely used in various application but limited energy of remotely deployed sensor nodes remains area of concern. This concern had made energy efficient routing as a key parameter of WSN and various approaches had been used. In my earlier work of an Adaptive Energy Saving and Reliable Routing Protocol(AESRRP) combined link weights is determined based on the parameters node's residual energy and transmission parameters. Best Route selections were made based on link weight cost (crisp). In this paper fuzzy logic approach is used to calculate link cost between two adjacent nodes. Three parametersresidual energy of sensor nodes, distance of cluster head to sink and density of nodes in a cluster are considered.

Keywords: Wireless Sensor Networks, Cluster Head, Routing, Fuzzy Logic, Path cost.

1. INTRODUCTION

A wireless sensor network consists of numerous small devices called nodes. These are able to sense the environment, process and send data to collection point in a particular area. The nodes can communicate directly among themselves or to some base station deployed externally in the area. The nodes have limited battery, processing power and bandwidth [1]. From all the resources constraints, energy minimization is most important issue in WSN. One of the main design goals of WSN is to carry out energy efficient data communication while trying to prolong the lifetime of the network. In these networks, power usage is of primary concern. Extending system lifetime and robustness to unpredictable dynamics rather than optimizing channel throughput or minimizing the number of nodes is the biggest challenge in these networks [2] [3]. Basically, sensor nodes consist of units and these are of four types: sensing unit, processing unit, transceiver unit and power unit, which is shown in figure 1.

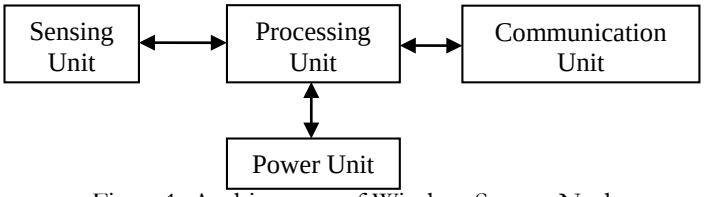

Figure1. Architecture of Wireless Sensor Node.

There are many different applications for such networks including military, protection, and home applications etc. The nodes communicate to each other and use radio frequency channels. The real-time multimedia data have strict QoS requirements such as bandwidth, delay, jitter and loss ratio. Meeting these QoS requirements requires more efficient sensor network routing protocols. The multipath transport provides higher available bandwidth for a session by splitting traffic and achieving better load balancing. The Heuristics-based solutions are used to find the set of paths that minimizes the cost or maximizes throughput are proposed in for ad hoc networks. First the typical mode of communication in a network is from multiple sources to a sink rather than communication between sources. Other than this is that since the data sensed by multiple nodes is based

on common purpose, some redundancy in the data is must in sensor networks. Third, in most of the situations the sensors are not mobile nodes. Finally, the single major issue in sensor networks is consumption of energy.Further, the paper is differentiated as follows: section II describes the related work. Section III presents the problem formulation, section IV gives detailed information of the performance metrics. Section V discusses the simulation results followed by a conclusion.

2. RELATED WORK

S. Taruna et al., (2012) [4]Energy consumption is the main key issue in design of routing for Wireless Sensor Networks. In this paper a new approach of cluster head selection by homogeneous sensor node in wireless sensor network is proposed. The proposed technique is choosing the cluster head lying near to the midpoint of the base station and the sensor node. All nodes can send data to Base station (BS).The BS has the information about the location of each node. It's assumed that the cluster heads and nodes have the knowledge of its location. The data compression is done by the Cluster Head. In the first round, each node has a probability (p) of becoming the cluster head. All nodes are of same specification and the nodes in the network have the same energy at starting point. The energy of transmission depends on the distance (source to destination) and data size. The nodes are uniformly distributed in network in a random manner. Mainly, routing protocol is designed to maintain energy efficiency and to extend the lifetime of network. To maintain the energy efficiency main protocols designed are LEACH protocol, HEED Protocol, PEGASIS, TEEN, APTEEN etc. But mostly LEACH –minimal path protocol is best protocol for energy minimization.

NojeongHeo et al., (2003) [5]Deployment of sensors is an energy consuming process. One must be very careful to design deployment algorithm for cluster based network which will be less energy consumed. After going through the algorithm, the ROI is covered by uniformly distributed nodes. The performance of the algorithm is determined by the percentage of region covered, computation and deployment time, the mean distance that is required for deployment, and the uniformity of the networks. The ROI needs to be covered by a given number of nodes with limited sensing and communication range. We start with a "random" distribution of nodes. Mostly the random deployment is preferred because it has less deployment cost and time. Random deployment may not provide a uniform distribution which is desirable for a longer system lifetime over the ROI.

Mohammad M. Shurman et al., (2013) [6]In this each sensor is working on battery. The consumption of this battery power is not only because of long-distance communication, it also depends on the active state period length. More Power consumption of each sensor means it is the reduction in the network lifetime. In other words, decreasing the distance between sensors and base station leads to improvement the network lifetime and increasing the network performance. Clustering is the best method to save energy consumption that helps in increasing the network lifetime. The use of genetic algorithm (GA) to cluster nodes in WSN in order to minimize the long-distance between the sensors and base station leads to reduction of energy consumption in the network. Each node in the network can be either a regular node/member in cluster or cluster head. Each member belongs to just one cluster head (i.e., the nearest one). The genetic algorithm (GA) with hierarchical clustering gives the best result which shows significant improvements instead of heuristics and normal genetic algorithms.

Mansoor-uz-Zafar Dawood et al. (2009) [7], Routing is divided into multipath-based routing, Query-based routing, Negotiation-based routing, QoS-based routing and coherent–based routing. To improvement in energy enhancement and WSN life cycle, create a new location aware (LA) WSN protocol to resolve the resource constrained for unattended wireless sensor environment. Many protocols are created like new routing and MAC layer protocol. These all protocolsare mainlyconcentrating on energy efficiency of sensor node. The transfer of data mainly depends upon quality of service andenhancing the WSN efficiency is of major concern. The majority of all the protocols mainly concentrate on energy efficiency of sensor nodes. Sensor applications have very important role especially in critical applications likedefence and health where the accuracy and guaranteed data transfer is an important issue.

I.PROBLEM FORMULATION

The constraints on network resources especially limited energy of sensors nodes and their deployment in harsh environment like battlefield pose challenge in designing routing algorithm in WSN. During network operations node energy got depleted and when it touches the threshold value, its sensing becomes faulty resulting in complex behaviour of network. This complex behaviour and harsh environment consume node energy in unbalanced manner in which some nodes which are frequently involved dies early as compared to other network nodes. Mathematical models would find difficult to optimize consumption of energy of individual nodes and balanced consumption of energy of whole network simultaneously.To address this problem of unbalanced energy consumption optimal routing involving traffic distribution over all the networks nodes in different rounds provides possible solutions. These optimal routes are based on link cost having residual and transmission energy [8]. The computation intelligence algorithms like GA, fuzzy logic, ACO, neural network provide solution to such un-predictive complex behaviour and their optimized results would extend the life time of WSN's.

II.PERFORMANCE METRICS

The productive utilization of energy within WSN can be bottleneck problem that will influence the network overall performance as well as its life time. The optimization of data routing significantly affect the energy consumption of nodes and increase the time in which nodes get drained out of energy. Intelligent and intellectual soft computing techniques like Fuzzy Logic (FL), Neural network (NN), Evolutionary Algorithm (EA) have been applied to find energy efficient routes.

1. Route Cost metric

In multi-hop WSN routing, each sensor node is responsible for both data sensing as well as routing. In order to find energy efficient route, location of the deployed nodes, node energy and location of the base station are the key parameters. With every round of routing the residue energy of sensor node is consumed in sensing and routing the data packets to base stations. To find energy efficient route the fuzzy route cost based approach is applied.

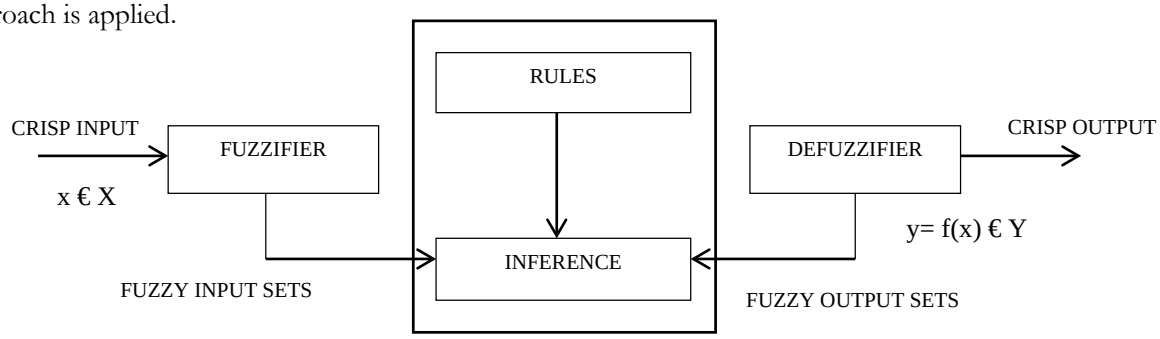

Figure 2: Fuzzy System

In this paper, we apply fuzzy logic system to optimize the routing process by some criterion. The main goal in designing the algorithm to use Fuzzy Logic Systems is to lengthen the lifetime of the sensor networks. The fuzzy System calculates Link cost between two sensor nodes which depends on residual energy, cluster weight and distance of CH to base station. After every round of routing, energy of nodes involved in sensing and routing is consumed and link cost again calculated.

2. Residual Energy (E)

Deployed sensor nodes are clustered by base station using K means Method. Nodes after sensing sends data packets to respective cluster heads, cluster head receive data and then forward it to base station in multi-hop communication mode. In a cluster m node energy is consumed in sensing data by nodes, cluster head consumes energy in receiving data from nodes, energy spent in transmitting data from CH to base station is

given by equation 1. The residual energy of every node is calculated after every round of routing and given by equation 2.

$$E_c = \sum_{J=1}^{M} E_{gp} + M^*_R + Epz \quad (1)$$

$$E_{RES}(r\text{-}1) = E_{RES}(r\text{-}1) - E_c(r\text{-}1) \quad (2)$$

Where r is the value of rounds in routing and E_{RES} is the residual energy.

3. Cluster Density(CD)

The cluster density is the sum of distance from cluster head to nodes, CD for cluster having m member nodes would be

$$CD = \sum_{i=1}^{m} d_{ip} \quad (3)$$

4. Distance (D)

The distance of cluster head at location (p) from base station at location (z) would be defined as:

$$D = d_{pz} \quad (4)$$

For a larger network, this distance should be minimized; otherwise the energy of most of the nodes will be wasted. However, for a smaller network that has a few closely located nodes; direct transfer to BS may be an acceptable option. If residual energy is good and distance between CH and base station is near and distance between CH and nodes is High (density) then route cost is low.Here residue energy , distance between CH and base station and density are input while route cost is output and near, good are linguistic variable of fuzzy system. This fuzzy system use mamdani implication and trigonal membership function. There are 27 rules in rule base of this fuzzy system.For a route between any two deployed nodes route cost is calculated by fuzzy system. The cost of all possible routes among (n) nodes is stored in NxN route metric. After every round of routing the fuzzy system calculate new values for the metric and this route metric cost changes.

3. SIMULATION RESULTS

We ran the simulation 3 times and at each time the node's starting energy (0,25J, 0,5J and 1J) was different. K – Mean clustering of m nodes and subsequently dynamic cluster head selection by population generation of GA enhances the network lifetime. The best fitness value of the route is calculated after 100 generation. Comparison of the proposed approach on the basis of number of rounds taken before first node dies is made with AESRRP.

Serial no	Parameters	Values
1	Number of Nodes (m)	100
2	Network Size (A)	50 x 50 Meters
3	Message Size (k)	2000
4	Base Location (z)	150,50
5	Cluster Head Rate	10
6	Radio Model	Full Radio
7	Cluster Head Transmission	Single Hop

Table 1: Shows parameters of Full radio

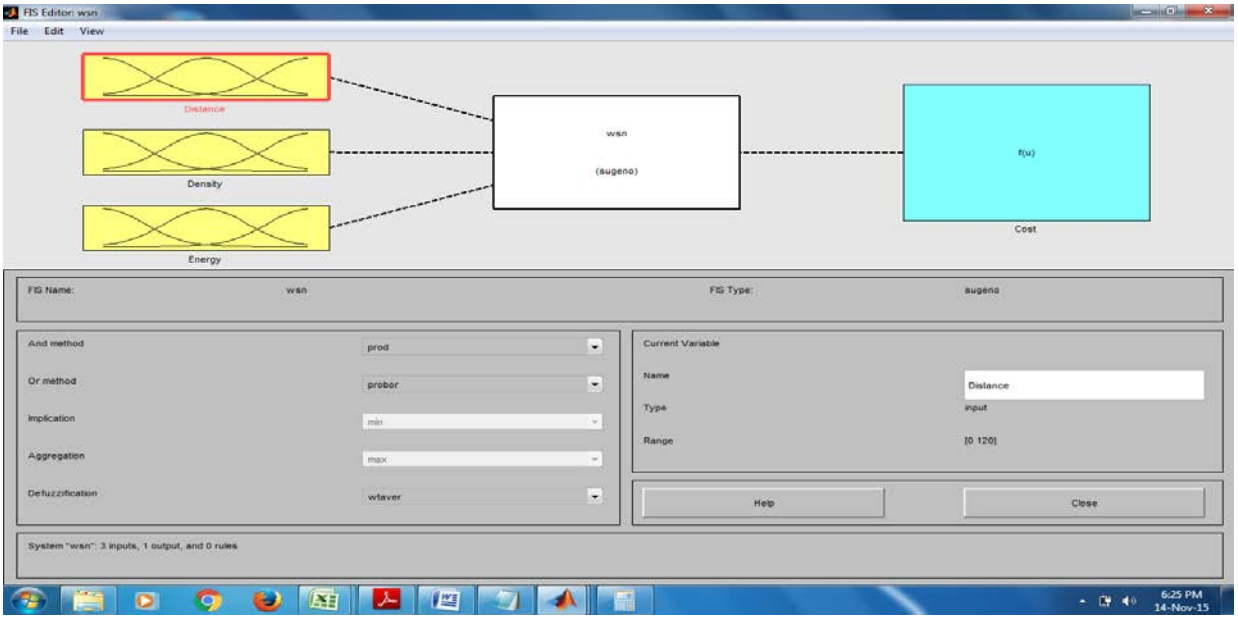

Figure 3.

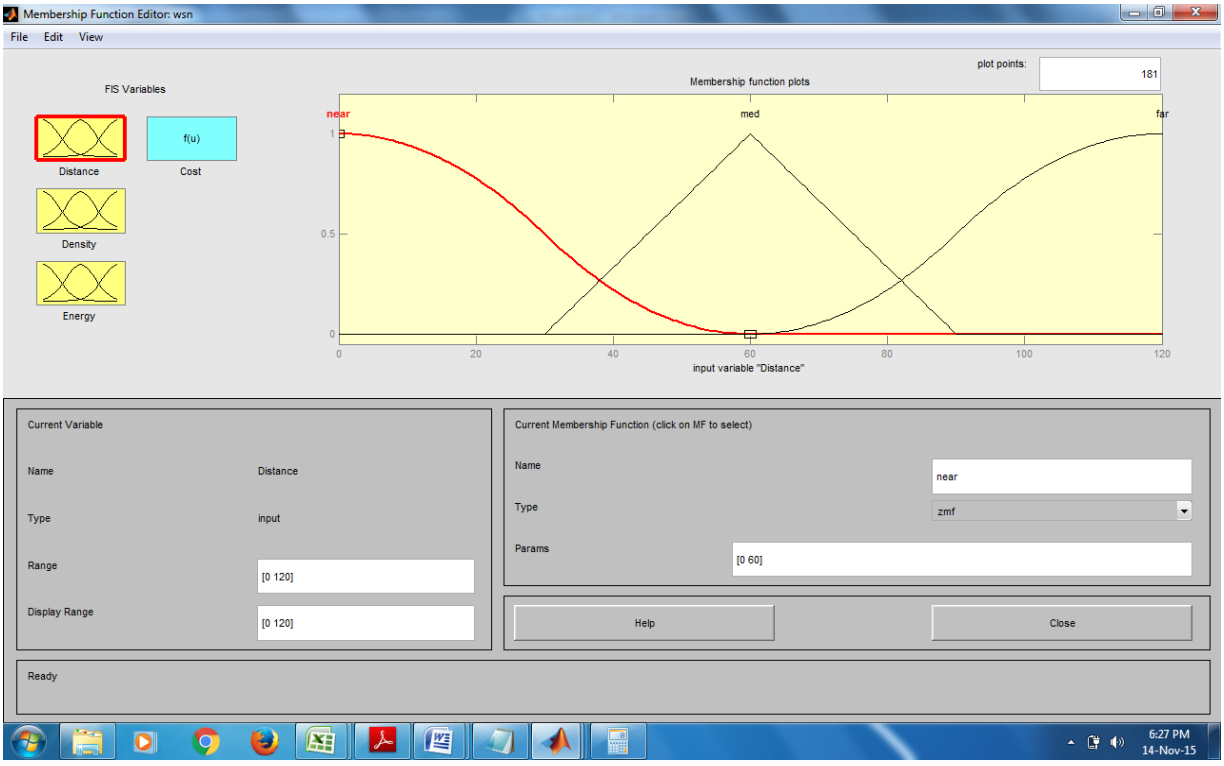

Figure 4: Membership Function

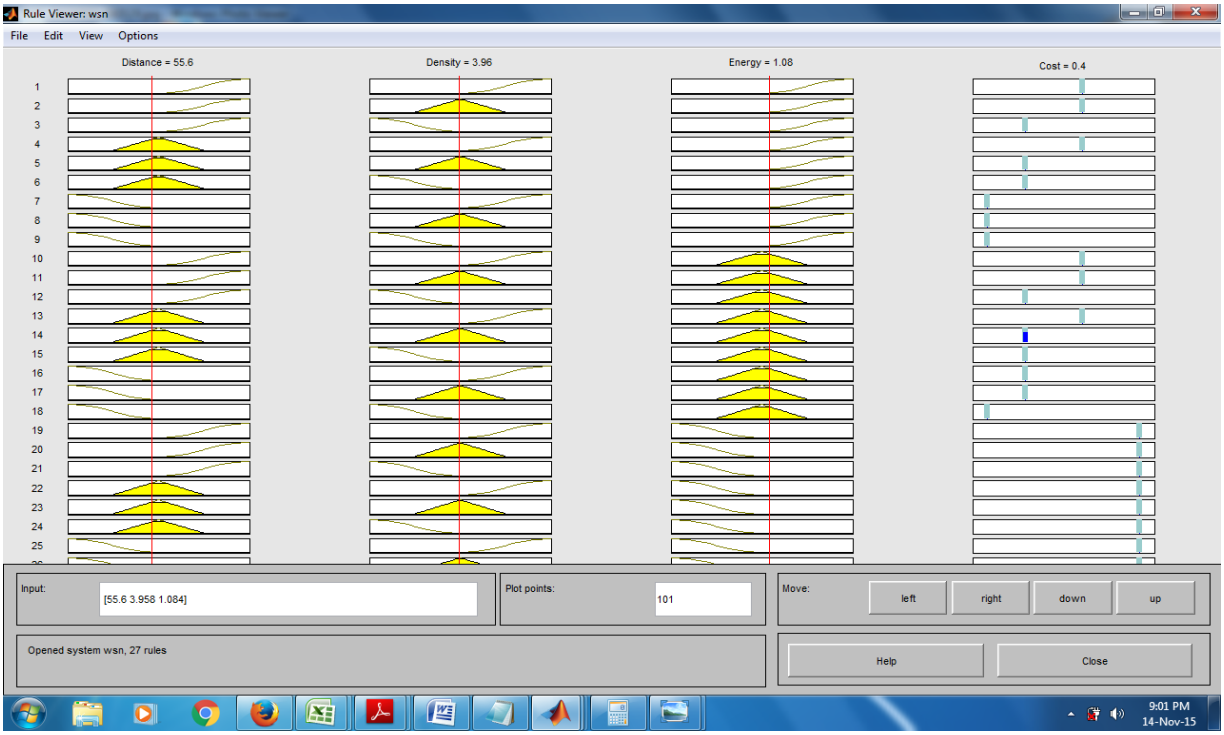

Figure 5: Rule Viewer

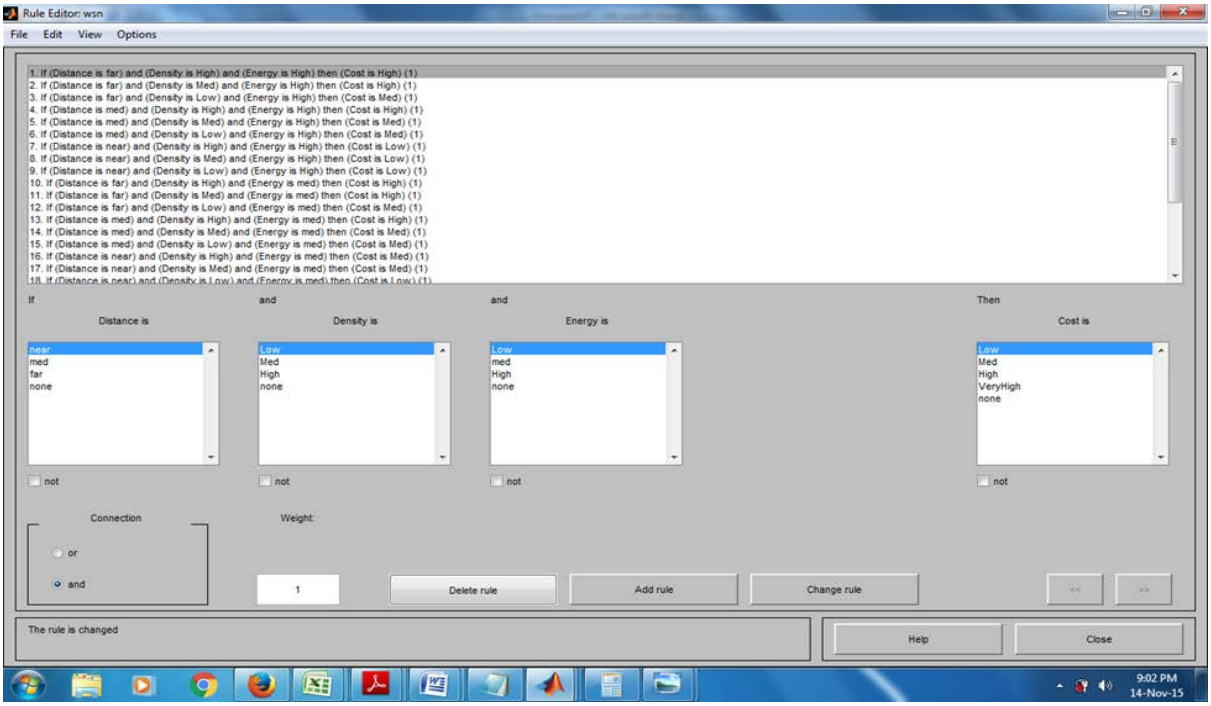

Figure 6: Rule Editor

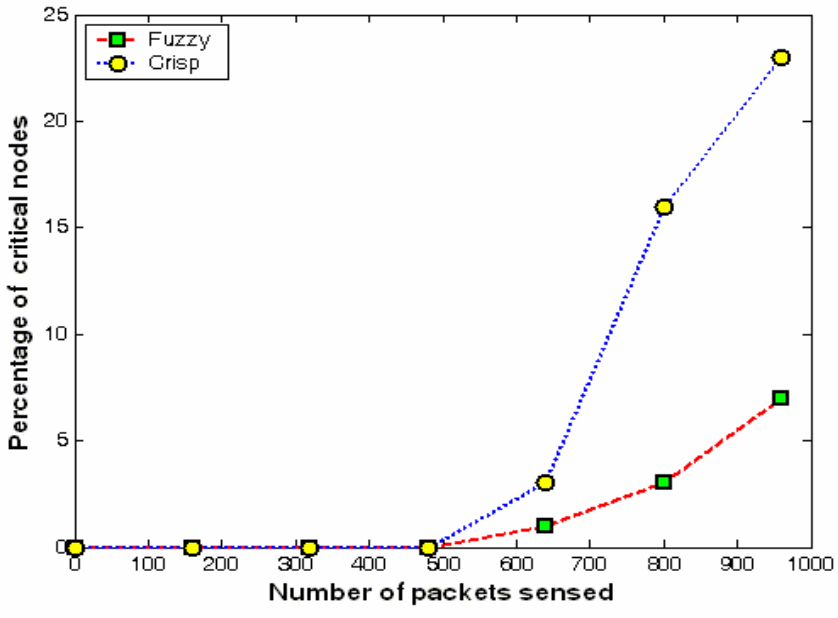

Figure 7: Network lifetime.

4. CONCLUSION

In this paper energy efficient routing for wireless sensor Network is proposed in which fuzzy logic is applied to calculate path cost between two adjacent nodes. This calculated fuzzy path cost is the fitness of soft computing algorithm. Genetic algorithm is used to route data packets from the nodes to the sink. The enhancement of the network lifetime is observed in different scenarios which were implemented in MATLAB. Results were compared with AESRRP algorithm which shows fuzzy approach shows better results. In future work Big Bang Big Crunch soft computing algorithm would be applied to enhance network lifetime.

REFERENCES

[1] Ali Chamam, and Samuel Pierre, "On the Planning of Wireless Sensor Networks: Energy-Efficient Clustering under the Joint Routing and Coverage Constraint" IEEE, Vol. 8, No. 8, August, 2009.

[2] Mohammad M. Shurman, Mamoun F. Al-Mistarihi, Amr N. Mohammad, Khalid A. Darabkh, and Ahmad A. Ababnah, "Hierarchical Clustering Using Genetic Algorithm in Wireless Sensor Networks" Mipro 2013, Opatija, Croatia 479, May 20-24, 2013.

[3] Mansoor-uz-Zafar Dawood, Noor Zaman, Abdul Raouf Khan and Mohammad Salih. "Designing of energy efficient routing protocol for Wireless Sensor Network (WSN) using Location Aware (LA) Algorithm" Journal of Information & Communication Technology , Vol. 3, No. 2, (Fall 2009).

[4] S. Taruna, Sheena Kohli and G.N.Purohit, " Distance based energy efficient selection of nodes to cluster head in homogeneous wireless sensor networks" International Journal of Wireless & Mobile Networks (IJWMN) Vol. 4, No. 4, August 2012.

[5] NojeongHeo and Pramod K. Varshney, "An Intelligent Deployment and Clustering Algorithm for a Distributed Mobile Sensor Network", IEEE, pp. 7803-7952, 2003.

[6] Mohammad M. Shurman, Mamoun F. Al-Mistarihi, Amr N. Mohammad, Khalid A. Darabkh, and Ahmad A. Ababnah, "Hierarchical Clustering Using Genetic Algorithm in Wireless Sensor Networks" Mipro 2013,Opatija, Croatia 479, May 20-24, 2013.

[7] Mansoor-uz-Zafar Dawood, Noor Zaman, Abdul Raouf Khan and Mohammad Salih. "Designing of energy efficient routing protocol for Wireless Sensor Network (WSN) using Location Aware (LA) Algorithm" Journal of Information & Communication Technology , Vol. 3, No. 2, (Fall 2009).

[8] R. Singh, H. Singh, and R. Kaler, "An adaptive energy saving and reliable routing protocol for limited power sensor networks," in Advances in Computer Engineering (ACE), IEEE, pp. 79–85, 2010.