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Energy-saving in Wireless Sensor Networks based on Sink Movement Control using fuzzy logic

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Abstract: In this paper, a mobile base station is used to reduce the energy consumption. Clustering is done by the fuzzy method based on different priorities. In first clustering is done by energy and cluster centric priorities then the base station has moved with fuzzy logic approach on a predetermined paths for collecting data. In second, clustering is done by distance, energy and cluster centric priorities. Lastly, clustering is done based on distance and energy priorities. Simulation results show that network lifetime increases when the base station is moving and clustering is done by energy and cluster centric priorities.

Keywords: wireless sensor network lifetime, fuzzy method, mobile sink

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1. Introduction

A sensor network consists of large number of sensor nodes distributed in an environment widely and collect data from the environment. Necessarily, there is no pre-determined and specified place for the sensor nodes in environment. This feature makes it possible to take them into dangerous places or unreachable. Therefore, the sensors are randomly scattered in places that are inaccessible to humans. So it is almost impossible to replace or recharge the energy source.The energy management in networks is Attractive for researchers. Sensors in the transmission path consume more energy therefore lose its power and networks will soon be down if not replenished.
The remainder of the paper is organized as follows. In Section 2, we describe some related work in the area. In Section 3, we discuss the proposed method and the threat model. In Section 4, we present simulation parameters. Sections five summarize simulation results, and we conclude the paper in Section 6.

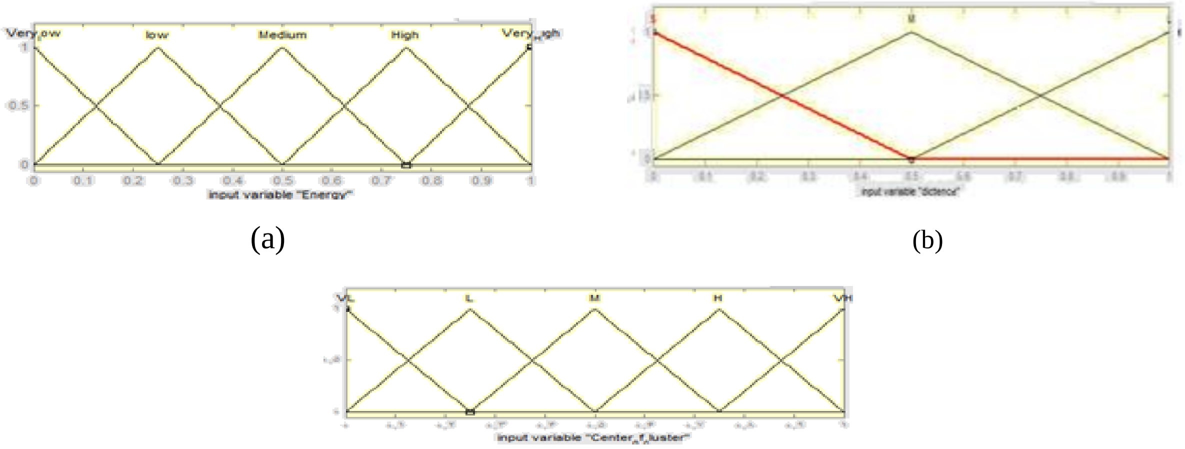
2. Related work

The work has been carried out for increasing network lifetime generally fall into two categories: The first category has a fixed base station and Network lifetime is calculated. The authors propose a novel two-phase clustering (TPC) scheme for energy-saving and delay-adaptive data gathering in wireless sensor networks. The proposed scheme partitions the network into clusters in phase I each with a cluster head, forming a direct link between cluster member and cluster head. In phase II, each cluster member searches for a neighbor closer than the cluster head within the cluster to set up an energy-saving data relay link. The sensors use either the direct link or the data relay link for their sensed data forwarding depending on the requirements specified by the users or applications [1]. In this work, the authors aim to find the best way to relocate sinks inside buildings by determining their optimal locations and the duration of their sojourn. Therefore, the authors propose an Integer Linear Program for multiple mobile sinks which directly maximizes the network lifetime instead of minimizing the energy consumption or maximizing the residual energy, which is what was done in previous solutions?. They evaluated the performance of our approach by simulation and compared it with others schemes. The results show that our solution extends significantly the network lifetime and balances notably the energy consumption among the nodes. In the second category, base station moves for gathering the data from the sensors in the network [2]. The base station may move randomly [2-4]. In [5] the base station moves on cross path. Simulation results of this work show that this scheme has more lifetime as compare to wireless sensor networks with stationary base station or it may fly over the network [6], or on the specified path moves [7]. In some of the work done, a collector moves for collecting data in a networked [7, 8]. In the case of the sink moving accidentally, a sensor may be in the direction of network that sink is not so gradually dies without sending data, and this will reduce the lifetime of the network. In the presented work in this paper, data sending will be by all sensors and clustering is dynamically. In [9], a mobile base station approach is used to reduce the energy consumption of cluster heads by enclosing the base station to them while a fuzzy logic is applied to manage the base station move.

A Critical Degree is assigned to each cluster heads by the fuzzy system based on the input parameters such as, energy, proximity to the base station and size of cluster. Then, it makes the base station move toward the cluster head with the most Critical Degree so that it can save much more of its energy. According to the simulation results, the proposed scheme has proved its efficiency in the network lifetime, residual energy of network and load distribution. The proposed scheme also proved to have considerable efficiency in different scenarios. In this paper, the Base station will move towards the cluster heads that have both lower energy and distance from the base station. And, thus the sensor will send its data to the base station before dying. And, lost data will be less.

3. The proposed method

In this method, clustering has been done with the fuzzy clustering method and based on the energy sensor and distance sensor from the sink. Cluster head has been defined by Fuzzy logic. The cluster heads are determined by three methods, results of the network lifetime are compared. At each step, the mobile base station will move towards the cluster head with higher priority. The base station controller has been with a fuzzy controller. In the first stage, cluster heads is determined with energy priorities, the distance to the sink and the centric cluster. The second, cluster heads with energy priorities and the centric cluster and in the third, cluster with energy priorities and distance to the sink is determined. Fuzzy rules to determine the clusters are given in Tables (1), (2) and (3). Membership functions of the fuzzy system parameters to determine the clusters are shown in Figures 1 (a),(b) and (c). Direction of move the base station is on a circular path, on the Square path, on the triangular path and on the hexagonal path these paths are considered the default. And the base station to move in this direction collects data from the cluster head. The base station is controlled by using fuzzy logic based on fuzzy priorities. Fuzzy controller Inputs are the residual energy of sensor and distance from the base station. Movement of the base station will be towards cluster head that has the highest priority. For example, a cluster that has a greater distance from the base station and less residual energy has the highest priority. Fuzzy rules to the motion control of base station are shown in Table 1.



(a) (b) (c)

Figure 1: (a) Membership function of energy (b) Membership function of distance(c) Membership function of the centric of cluster

Table 1: Fuzzy rules for moving the base station

distance / energy	Very near	Near	Medium	Far	Very Far
Very low	H	H	VH	VH	VH
Low	M	H	H	VH	VH
Medium	L	M	M	H	H
High	VL	L	M	M	M
Very High	VL	L	VL	L	L

Table 2: Fuzzy rules for determining cluster head with priorities, the energy and centric cluster

Number of neighbors / Energy	Very low	low	Medium	High	Very High
Very low	M	M	M	L	VL
Low	M	M	M	L	VL
Medium	H	H	M	L	M
High	VH	H	H	M	M
Very high	VH	VH	H	M	M

Table 3: Fuzzy rules for determining cluster heads with priorities the residual energy and distance from the base station

Distance / Energy	Very near	Near	Medium	Far	Very Far
Very low	M	M	M	L	VL
Low	M	M	M	L	VL
Medium	H	H	M	L	M
High	VH	H	H	M	M
Very High	VH	VH	H	M	M

Table 4: Fuzzy rules for determining cluster heads with priorities, energy, the centric cluster and distance from the base station.

If distance=low

Number of neighbors / Energy	Very low	low	Medium	High	Very High
Very low	M	M	M	L	VL
Low	M	M	M	L	VL
Medium	H	H	M	L	M
High	VH	H	H	M	M
Very high	VH	VH	H	M	M

If distance= Medium

Number of neighbors / Energy	Very low	low	Medium	High	Very High
Very low	M	M	M	L	VL
Low	M	M	M	L	VL
Medium	H	H	M	L	M
High	VH	H	H	M	M
Very high	VH	VH	H	M	M

If distance= far

Number of neighbors / Energy	Very low	low	Medium	High	Very High
Very low	M	M	M	L	VL
Low	M	M	M	L	VL
Medium	H	H	M	L	M
High	VH	H	H	M	M
Very high	VH	VH	H	M	M

4. Simulation parameters

Simulations are performed using Matlab software. Energy model used for the sensors is in accordance with the following formula. In this simulation, 200 sensors were randomly distributed in a square area of 200 to 200.

$$E_{TX} = E_{elect} * l + E_{fs} * l * d^2 \quad \rightarrow if\ d < d_0$$

$$= E_{elect} * l + E_{mp} * l * d^4 \quad \rightarrow if\ d \geq d_0$$

E_{TX} = Transfer Energy

E_{elect}= The activation energy for electronic circuits

d_0 = Energy threshold

l= bit length to send

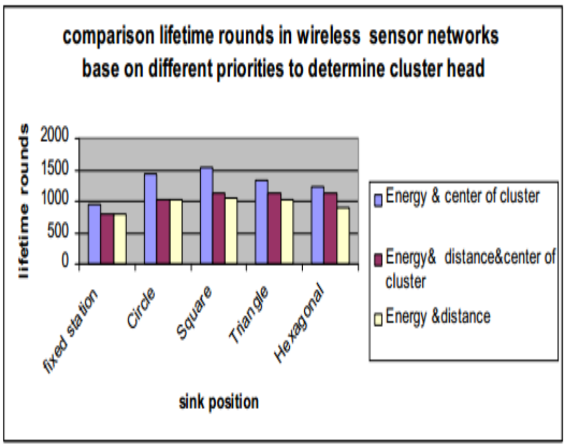
d=data sending distance

5. The simulation results

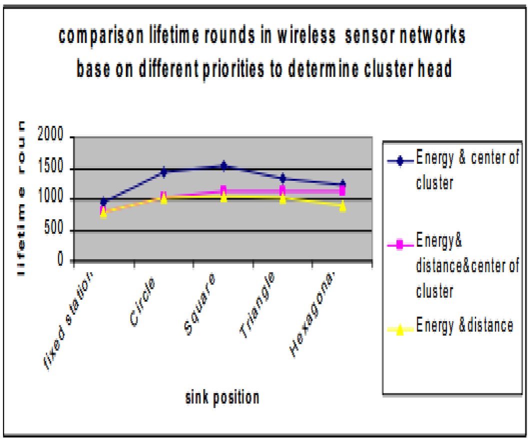
First, clustering has been by fuzzy method, and then clusters head are specified according to the fuzzy rules as listed in Tables (1) to (4). The results of the lifetime of the network for fixed and mobile stations are in Table 5. As can be seen in Table 5, when the cluster heads, is defined by three parameters: the cluster centric, the energy and when the main station is also considered constant, the lifetime of the network is 943 rounds, when the cluster heads is based on the distance, energy and the cluster centric, the lifetime of the network is 895 rounds and when the cluster heads is based on the distance and energy, the network lifetime is 807. If the base station is moving for different paths, Circular, square, triangular and hexagonal as well as a set of clusters head with different priorities, network lifetime is compared in Table 5, respectively is 1234,1324,1546, 1432 for the second is 1087, 1150, 1000, 1114. In the third stage, network lifetime is 907, 1021, 1056, and 1032. Figures 2, show network lifetime comparison between various states have been performed for fixed and mobile stations. As can be seen from Figure 2, when the base station is mobile, network lifetime increased compared to the fixed station. The network lifetime when cluster heads selected with energy priorities and clusters centric, is compared with other priorities for the selection of the cluster head, network lifetime is increased. Movement the base station on square path has had a greater increase in network lifetime. Figure 5, show location of fixed stations in the networks center. In Figure 3 (a), (b), (c), (d), and (e) is shown the base station movement on the path square, triangle, hexagonal and circular. According to the simulation results shown in Table 5. When the base station moves on the default paths the network lifetime increases compared to the fixed station. Also, when clustering is done by energy and cluster centric priorities and the base station is also being made to move, network lifetime is higher compared with other clustering.

Table 5: Network lifetime Simulation results for static station and mobile station with different priorities for the cluster heads

different priorities for the cluster heads	**Network lifetime**				
	Base station	**Shape of base station movement path**			
		Circular	**Square**	**Triangular**	**Hexagonal**
energy & cluster centric	943	1432	1546	1324	1234
distance , energy& cluster centric	895	1114	1000	1150	1087
distance and energy	807	1032	1056	1021	907

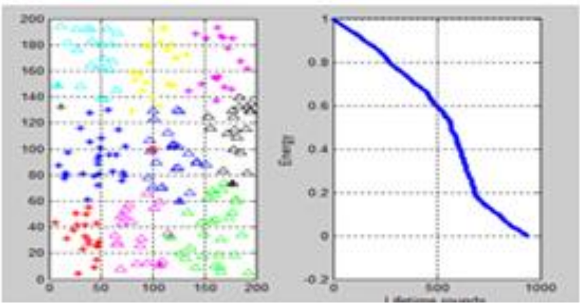


(a)

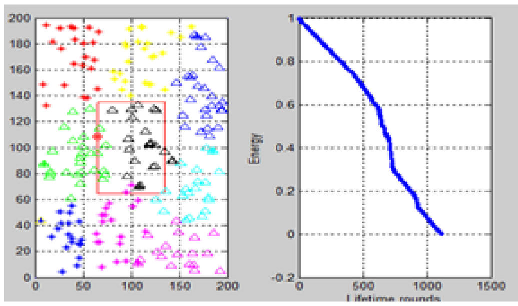


(b)

Figure 2: (a), (b) comparison lifetime in fixed station and movable with different clustering



(a)



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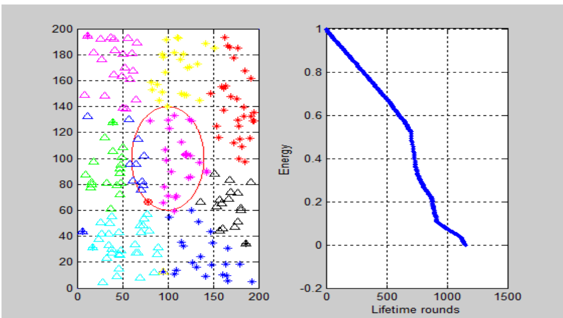
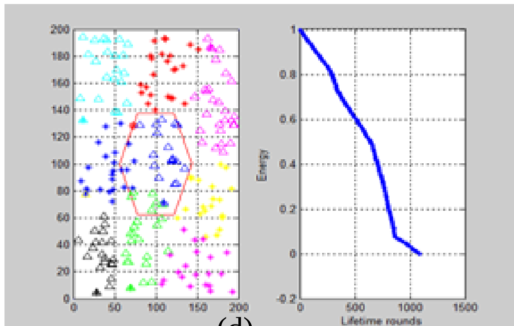


(c)



(d)

(e)

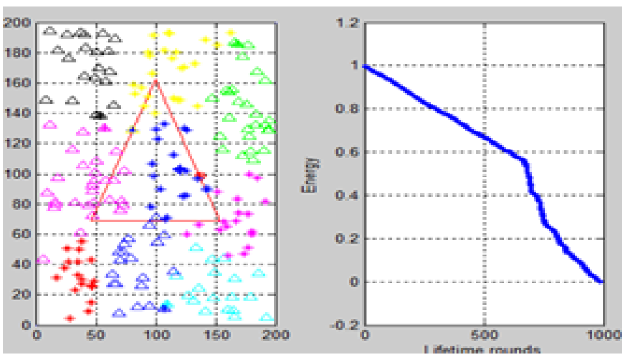


Figure 3: path simulation for moving sink and fixed sink **a:** static base station **b:** movement path is Square **c:** movement path is Circular **d:** movement path is Hexagonal **e:** movement path is Triangular.

6. Conclusion

In this paper, clustering has been by fuzzy method, and then clusters head are specified. In first method, clustering is done by energy and cluster centric priorities then the base station has moved with fuzzy logic approach on predetermined paths for collecting data. In second time, clustering is done by distance, energy and cluster centric priorities. Lastly, clustering is done by distance and energy. The base station motion control is done with fuzzy logic, network lifetime is compared in three types of clustering. When clustering is done by energy and cluster centric priorities and the base station is also being made to move, network lifetime is higher compared with other clustering. In future works can be route optimization techniques to optimize moving path of the base station.

7. References

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