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A New Method for Reducing Energy Consumption in Wireless Sensor Networks using Fuzzy Clustering and Fault Tolerance

Vahab ashrafian
Department of Computer Science and Research Branch
Islamic Azad University
Ardabil, Iran

Ali Harounabadi
Member of Science Board of Computer Group in Azad
Islamic university of Tehran Center, Iran

Mehdi Sadeghzadeh
Member of Science Board of Computer group in Azad
Islamic university of Mahshahr, Iran

Abstract: Nowadays, wireless sensor networks, clustering protocol based on the neighboring nodes into separate clusters and fault tolerance for each cluster exists for sensors to send information to the base station, to gain the best performance in terms of increased longevity and maintain tolerance than with other routing methods. However, most clustering protocols proposed so far, only geographical proximity (neighboring) cluster formation is considered as a parameter. In this study, a new clustering protocol and fault tolerance based on the fuzzy algorithms are able to clustering nodes in sensor networks based on fuzzy logic and fault tolerance. This protocol uses clustering sensor nodes and fault tolerance exist in the network to reduce energy consumption, so that faulty sensors from neighboring nodes are used to cover the errors, work based on the most criteria overlay neighbor sensors with defective sensors, distance neighbor sensors from fault sensor and distance neighbor sensors from central station is done. Superior performance of the protocol can be seen in terms of increasing the network lifetime and maintain the best network tolerance in comparison with previous protocols such as LEACH in the simulation results.

Keywords: Wireless sensor networks; fault tolerance; fuzzy algorithms; clustering; faulty sensor.

1. INTRODUCTION

Nowadays, remote control and monitoring systems are one of the challenging issues in the field of electronics and computer science. This investigation whenever looking for a solution to take into accounts the specific conditions and expectations for the answer. In terms of quality and the same thing, whatever the cost /effectiveness ratio is lower, the same way as its popularity is higher. Aware of their surroundings or changes the state of each set of equipment that can be used as sensors are known. Each sensor can take into account the changing environment in terms of certain parameters such as temperature, humidity, pressure ... Senses and offer. Based on information from a set of sensors embedded in the environment, can controls environment and its changes.

Recent advances in electronics and wireless sensors make it possible multiple-purpose sensors provided with low energy consumption and cost. These sensors are able to communicate with each other over short distances. A node is a very small sensor with sensing equipment, data processing and wireless communication. In fact, a sensor network is a collection of numerous sensor nodes are distributed in the environment and each autonomously and in collaboration with other nodes to follow a particular purpose. Nodes are close together, and each node can communicate with another node and other nodes located in their data available to the environment, finally the status of desired environment to be reported to central point.

Techniques and methods used in sensor networks are highly dependent on the nature of the application, network topology structure, and environmental conditions, limits and efficiency and cost parameters. So today, throughout the reputable universities and computer research centers, electronics and telecommunications, wireless sensor networks are considered as a very attractive and popular research field. Many suggestions and research on various topics sensor network has been presented and volume of research in this field is increasing. The main goal of all these efforts and provide solutions, having a system with a simple control methods, which is easy and low cost to meet the desired needs (bandwidth, energy, and environmental interventions . . .) that could stood up against constraints and provide general conditions in accordance with the wishes and aspirations (transfer bulk data content, continuity, long life, low cost, etc.).

In order to neither do tasks in a wireless sensor network must consider the time and consumption energy to loss duly works nor drastic decline in lifetime of the network. In other words, the constraints facing these networks, and how much and manner of consume energy is of particular importance because complete loss of battery in the sensors means they are destroy and due to the environment and use networks changing of thousands of sensor node batteries is virtually impossible.

The reduction of energy consumption in wireless sensor networks has a direct relationship with increased longevity. Ideal mood in the sensor networks is that the energy of all nodes to finish concurrent and it is a mood in which highest lifetime is possible for the network. Thus, to increase in network lifetime trying to distribute the load on the network is a uniform distribution to mineralize the time between death of the first node and the last node.

To achieve this goal, several communication protocols have been proposed so far, in which the protocols are based on clustering, significantly lowers energy consumption.

The Protocols of the entire network is partitioned into several cluster-ware and each cluster has a node is selected as cluster heads. In this case, instead of each node sends its data directly to the base station, send it to the cluster heads, finally, the cluster heads then collecting and combining data from all of the nodes in the cluster, and data are sent to the central station.

In this protocol, choose a sensor as a replace faulty cluster and appropriate clustering significantly increase the network lifetime, scalability and efficiency.

2. Previous Work

Ahmadinia and his colleagues are provided a clustering method of nodes in sensor networks based on ICLA. In the clustering method, various parameters such as balancing the cluster size, clusters energy and ... taken into consideration and compared with other clustering methods, create clusters with more balanced and increases network lifetime [1].

Akbarzadeh and his colleagues declared that was originally selected cluster heads by fuzzy logic and considering the energy parameters of the sensor, numbers of neighbor sensor and spacing parameters for proper distribution of cluster heads done in the network then optimize point to move the base station using a genetic algorithm are determined to energy efficiency consumption of cluster heads [2].

Attention to the problem of clustering based routing in wireless sensor networks aimed to reduce energy consumption and maintain network coverage has been paid. For this purpose, neural network self-organizing map (SOM) is used to provide energy-based clustering protocols. The new protocol based on the energy of the self-organizing clustering protocol (EBCS) is called clustering according to three criteria: level of energy and spatial coordinates of each node are performed and its superiority in terms of longevity and maintains network covering (simulation) are proved. (Supervisor: Dr. Reza Askari Moghadam), (Supervisor: Dr. A. Taraghi Haghighat) [3].

Roshan Zadeh et al are provided an optimize algorithm for energy consumption and send the matched packets. In the proposed algorithm is called (PT-Multipath) routing decisions make is based on the residual energy of nodules. Also, select nodes for racing with information node one to one and double jumping node were sender. Simulation results show that the proposed algorithm efficiently distributed terrific load of network between nodes overall lifetime wireless sensor networks has increased. Furthermore, the proposed algorithm reduced the number of packets sent to the destination during the release [4].

Toloe Honari using genetic algorithm is implemented as a central base station, where the cluster heads are determined so that the network will have minimum energy consumption. In fact, during the course of operations data, selection criteria for the new generation of "minimum energy difference grid" have taken place. Balance and uniformity of the energy consumption of nodes and long life of network is outcome of use genetic algorithms in this study [5].

Dechene and his colleagues have been concerned on how clustering, necessity, benefits, and various combinations of these patterns in wireless sensor networks and effect of clustering in wireless sensor networks, both energy efficiency and optimal use of resources are examined. In addition to the mentioned issues quality of service in wireless sensor networks, a high level of importance. Cases include delay rates, packet loss and network fault tolerance can be achieved by clustering topics. Protocols introduced in this paper meet the above mechanism by mentioned clustering. It should be noted that the optimal number of clusters is a factor that reduces network soldiers, increase efficiency and improve the routing and load distribution in the network. After clustering, in this article some cases need to re-clustering [6].

Handy and his colleagues presented a method for selecting cluster heads in a tree structure with the lowest cost. The protocol based on adaptive clustering or selecting definite cluster heads cause of death postponement of the first node, intermediate node and the last node in the network. That is a smart way to choose cluster heads that select the cluster heads without the knowledge of their location in the network. Some of the ideas in this thesis will be based on the same reference [7].

Mao and his colleagues are considered data collect as a common but critical operation in various applications in wireless sensor networks, using the innovative techniques to improvement the electronic energy consumption and as a result are necessary to long life of the network. Clustering is a useful method for topology control in wireless sensor networks which can increase network scalability and lifetime. In this paper a clustering approach called EECS offered select better cluster heads on accordance with energy consumption loads in the network. Decision-making methods selection cluster heads taking into account the residual energy through local radio communication is effective load balancing among cluster heads. Simulation results show that EECS significantly increasing the network lifetime over 35 % effective [8].

Ray has been applied his original idea on LEACH protocol with the aim of improving the energy consumption and increase the lifetime of the network. In this paper, based on the residual energy of cluster heads nodes, the distance to sink and the nodes in their cluster heads will be periodically decision on future processes. So that cluster heads node with low residual energy, the distance from the sink is high and exist in the network as cluster heads will have any chance to cluster head. Simulation results indicate that the death of the first node, the intermediate node and the last node in the proposed protocol, respectively, 41%, 36% and 25% occur later than LEACH protocol [9].

3. Proposed Protocol

In the proposed protocol, it is assumed that the base station is located in a square in LEACH protocol for data transmission nodes to the base station will consume more energy. This could be one of the causes of the failure are not considered faults in the network, which is not covered the sensor nodes running out their energy and incorrect clustering nodes. This protocol uses fuzzy logical error coverage reduce network lifetime, we will work to increase the network lifetime. At each step of the algorithm based on fuzzy system sensors, each sensor prioritized and the highest priority will be selected to move.

The fuzzy fault tolerant algorithm three criteria for selecting neighbors considered: The criterion measures the amount of overlay neighbor's node with broken sensor, distance neighbor from broken sensor and distance neighbor from the base station. For each neighbor, the values are given as input and the fuzzy system considered priority for each neighbors in comparison to other neighbors for each group, the overall relationship of fuzzy system to choose neighbors would be equation (1).

$$f(x) = \frac{\sum_{l=1}^{m}(y^l \prod_{i=1}^{n} \mu^l(x_i))}{\sum_{l=1}^{m}(\prod_{i=1}^{n} \mu^l(x_i))} \quad (1)$$

The relation (1), m is the number of fuzzy rules and n is the number of inputs of the fuzzy system, the system will be 3 times. f (x) x is neighbor priority Xth defines each groups. Iy is the answer bet Lth and $\mu(x_i)$ is equal to amount of input fuzzy sets. $\mu(x_i)$l given amount of input overlay and distance of each sensor and fuzzy triangular used for each of them.

In the algorithm priority of each neighbor in a group according to its distance from the failed sensor and the overlapping range of the observations will be determined using a fuzzy system. Linguistic variables are used to describe the distance between neighbor and failed sensors, in the short, medium and long are expressed.

The amount of observations overlapping area of each sensor neighbor with his neighbors than the sum of all overlapping neighboring failed sensors sensor is calculated. To obtain this ratio, the total observations overlapping area of all neighboring failed sensor with its neighbors is calculated.

The overlapping ratio each neighbor is equal to the ratio of the observations overlapping area with its neighbors and total observations overlapping area of all the neighboring sensors. So much overlapping neighbors of each sensor are a relative value. Those values said, are normalized value and expressed in the range 0-100, the proportion is amount overlapping neighbor to other neighbors. To express the observations overlapping area of the sensor with their neighbors the linguistic variables very low, low, moderate, high and very high are used. To determine the priority of linguistic variables very bad neighbors, bad, acceptable, good, and very well used. Fuzzy rule system is designed to select neighbors summarized in Table 1.

Table 1. Fuzzy rules for selecting neighbors

Cases	Distance neighboring nodes of faulty sensor	Distance of central station from sensor	Overlapping	Probability of selection
1	High	High	Low	Very low
2	High	High	Middle	Low
3	High	High	High	Relatively low
4	High	Middle	Low	Low
5	High	Middle	Middle	Relatively low
6	High	Middle	High	Middle
7	High	Low	Low	Relatively low
8	High	Low	Middle	Middle
9	High	Low	High	Relatively high
10	Middle	High	Low	Low
11	Middle	High	Middle	Relatively low
12	Middle	High	High	Middle
13	Middle	Middle	Low	Relatively low
14	Middle	Middle	Middle	Middle
15	Middle	Middle	High	Relatively high
16	Middle	Low	Low	Middle
17	Middle	Low	Middle	Relatively high
18	Middle	Low	High	High
19	Low	High	Low	Relatively low
20	Low	High	Middle	Middle
21	Low	High	High	Relatively high
22	Low	Middle	Low	Middle
23	Low	Middle	Middle	Relatively high
24	Low	Middle	High	High
25	Low	Low	Low	Relatively high
26	Low	Low	Middle	High
27	Low	Low	High	Very high

4. Simulation Results

The simulation of the proposed protocol used ns-2 version 2.29 software package to better display the results of the second and third series of simulations have been done. In the first series of nodes in the network 25 nodes, in the second series 50 nodes and in the third series 100 nodes have been compared. To determine the performance the proposed algorithm with the well-known LEACH algorithm has been evaluated. As the graphs will show the proposed algorithm could performs better than other proactive and reactive algorithms.

4.1 Distance of Neighbor to Central Station

It is some nodes based on the location of nodes compare to the central station, using fuzzy variables center is characterized. Central chart is displayed in the fuzzy set. To find the central node, selects the base station of each sensor nodes and average distance nodes from the base station calculates.

4.2 Distance of Neighbor to failed sensor

It is some nodes based on location of node are compare to faulty nodes by fuzzy variables interval are specified. Distance chart is displayed in the fuzzy set. To find the

distance select any sensor and the average distance from the failed sensor calculates.

4.3 The amount of overlap

It is some nodes based on location of node than failed sensor is classified, by fuzzy variable the amount of overlapping neighboring sensors than failed sensor in the fuzzy set is shown.

Linguistic variables used to represent overlapping, divided to three level respectively low , medium and high, and three level to represent the central node and the distance to the base station , there are near , intermediate and far away, respectively.

Probability to selects to neighboring sensors are divided motion direction into seven categories: very low, low, relatively low, medium, relatively high, high and very high. Fuzzy base low includes the following rules: If the faulty sensor distance from the nearest neighbor, distance between neighboring sensors near the central station overlapping the neighboring sensors with failed sensor is too high so the probability selection motion direction is very high.

So we'll use 3^3 =27 rules for fuzzy rule base. In order to provide fuzzy sets near, far and medium we use the average of the triangular membership functions and to represent fuzzy sets low, medium, and large, trapezoidal membership functions are used.
Development of Membership functions and related linguistic states is shown in fig.1 and all nodes are compared based on the probability that the sensor is selected motion direction with most likely.

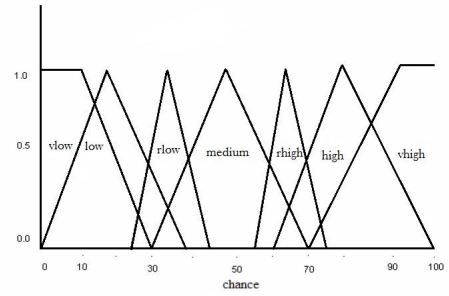

Figure 1. fuzzy sets and probability fuzzy variables

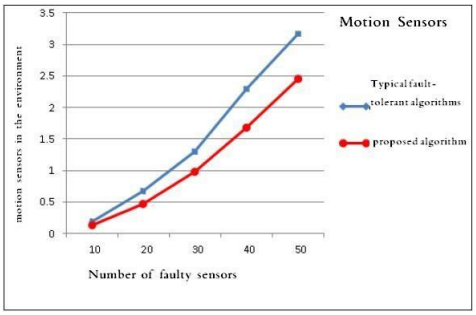

Figure 2. comparing the amount of sensor motion in the network environment

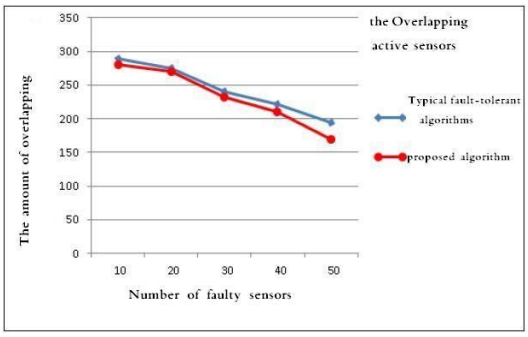

Figure 3. overlapping sensor ratio in the networks

Figures 1 and 2 shown the results of 100 times the performance of the proposed algorithm on network with 100 sensor nodes in a 50 x 50 environment. The results obtained in the above figures is the result of the proposed algorithm both in terms of overlapping amount of sensors in the environment to cover the lost areas and amount of observation overlapping area of sensors. As is clear from the figure, failed sensors how many are reduced down, lost space due to downtime to easily compensate as well as improving network coverage. Simulation results show that the proposed fuzzy algorithm provided better coverage than the conventional fuzzy algorithm and the network's energy consumption is reduced.

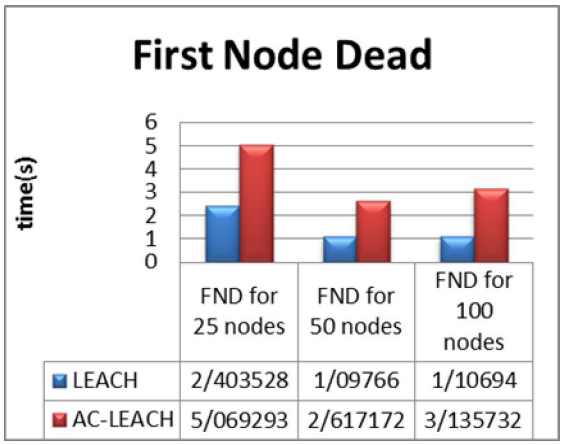

Figure 4. first node dead

As figure 4 is shown; the proposed protocol has better efficiency than LEACH protocol in the parameter of first node death.
As can be seen in 25 nodes that is 5.069293 increasing the number of nodes randomly reduces or increases the duration of the first node death. In total, 100 nodes have shown an increase than in the 50 nodes. But the number has dropped to 50 nodes compared to 25 nodes. The results show a decrease in energy consumption in the network.

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