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A Survey on Cluster Head Selection Techniques

Abstract

Wireless Sensor Networks are becoming very popular now days as of low cost and easy to deploy and maintain. The network consists of collection of sensor nodes which are capable of computing, sensing and communicating. Sensor nodes are equipped with limited energy and are deployed in inaccessible areas so it is hard to replace the batteries. Therefore to increase the lifetime of the network proper clustering and cluster head selection methods should be adopted. In this paper we investigate fuzzy, genetic and neural network based cluster head selection methods with their working techniques. Motivation behind genetic algorithm is Darwin's theory of evolution. Darwin suggested that an individual who is fittest will survive in the competition of the existence. Genetic algorithm selects a node as a cluster head depending upon its fitness i.e. node which has higher fitness will be a candidate for cluster head selection. Fuzzy logic can be used to work on partial data. Fuzzy logic variable can have a partial truth value. In neural network, three layers are used. Nodes in the input layer will match the input pattern and node in the output layer is a cluster head.

Keywords: *Wireless Sensor Networks(WSN), cluster head selection, Neural network, Fuzzy logic ,Genetic algorithm*

1. INTRODUCTION

Sensor nodes have limited computational capability and energy. Energy consumption can be minimized if network is properly configured [1]. Energy can be saved if only one node is sending sensed data to the Base Station(BS) as they may be equidistance from the member nodes and mostly immobile. These nodes are called Cluster Heads (CH). All the member sensor nodes sense the data and send this data to cluster heads. As there is possibility that sensed data can be redundant so cluster heads need to do the additional task of performing aggregation of the data and send this aggregated data to base station. Cluster head selection within the cluster is based upon certain parameters like- residual energy of the node, its distance from the cluster centroid, mobility of the sensor node and concentration of nodes.

There are three cases where the node is eligible to become the Cluster Head [2]. (1)If the node has higher residual energy, more are the chances of a node to become a cluster head. (2) If the distance of a node from cluster centroid is lesser, then there are more chances that a node will become a cluster head. (3) If the network topology is changing more often, reselection of the cluster head is required. As we are investigating three technologies for cluster head selection methods, so the first method stated as the basic principle of the genetic algorithm is "selection of the best". The second method is Fuzzy or Soft Method which says that in fuzzy logic, the truth value of a fuzzy logic variable can range between 0 and 1 i.e. fuzzy logic variable can have partial truth values i.e. values ranging between true and false. Fuzzy logic has the capability to act on incomplete or partial data by considering multiple fuzzy descriptors and various combinations of them and then check the results [3]. The third method is the neural network that has three layers: input layer, output layer and competition layer. Sensor nodes in the input layer fulfill the criteria of input patterns. Neeraj Kumar et. al [9] states that nodes in competition layer compete with each other for selection and the one who has least energy associated with delivery ratio becomes a cluster head. Output layer consists of the sensor node which is selected as cluster head.

2. SURVEY

2.1 Genetic Algorithm Based Cluster Head Selection

In genetic algorithm every sensor node is represented as bits of chromosomes. For determining the fitness value of the chromosomes, we can consider different parameters like residual energy of the node, node centrality, concentration and degree of mobility of the node. Fitness value of chromosome is function of all the fitness parameters [4]. Initially random population of chromosomes is considered and after the reproduction stage, the node which copies itself in the next generation is selected as cluster head. G. Ahmed et. al [2] states genetic algorithm based cluster head selection method. He considered four parameters for cluster head selection: distance of the node from centroid of the cluster, vulnerability index, degree of mobility and residual energy of the node. Possible values for distance of the node from cluster centroid are NEAR and FAR. Possible values for vulnerability index, degree of mobility and residual energy are LOW and HIGH. Initial population is selected randomly. There is fitness value associated with every node. This fitness value is function of all the parameters that we consider. For example in this case above discussed four parameters are fitness parameters. Each sensor node is represented as 4 bit binary number called as a gene. For example sensor node can be represented as: X1X2X3X4. Here

X1: distance of the node from cluster centroid

X2: vulnerability index

X3: degree of mobility

X4: residual energy

Fitness function was given as *f(x)=f(x1,x2,x3,x4)*. [2] takes fitness function as f(x)=x^2. The node which is copied in the next generation becomes cluster head. The node which has higher residual energy, low vulnerability index, low mobility and the one which is closer from cluster centroid will have a high fitness value and there are more chances of the node becoming a cluster head.

2.2 Fuzzy Logic Based Cluster Head Selection

Fuzzy logic control system consists of a fuzzifier, a fuzzy inference engine, a defuzzifier and fuzzy rules. Fuzzy logic system works in following stages.

- Fuzzification of input:- Fuzzification of these parameters is the first step and it means checking extent to which input parameters belong to particular fuzzy set.
- Rule evaluation: - Fuzzy rules are of IF-THEN form. We check fuzzified inputs for the condition and then apply membership function.
- Defuzzification: - Input is aggregated fuzzy set and output is a single crisp number. We use different combinations of parameters as fuzzy rule base .Depending upon the rules cluster head is selected. For example, a node with high energy and close from the cluster centroid will be selected as cluster head.

Ashutosh Kumar Singh et. al [6] consider two parameters, residual energy and centrality of the node as input to fuzzy logic control system. As explained earlier fuzzification of the input parameter is the first step. [6] He considered three values for residual energy as LOW, MEDIUM and HIGH and three values for node centrality as FAR, CLOSE and ADEQUATE. Different combinations of these values are considered and probability of whether node will become cluster head or not is given. If node has high residual energy and its centrality value is close then it is selected as cluster head.

Indranil gupta et. al [7] also use fuzzy logic for selecting cluster heads in WSN. Three parameters were considered as residual energy of the node, node centrality and concentration of the nodes. The famous Mamdani method for fuzzy inference was used. First step is fuzzification of three parameters as energy, centrality and concentration. Rule evaluation for the fuzzified inputs is done. All the outputs of rule evaluation were considered together and applied for defuzzification stage. Output of this stage was a single crisp number. Here also three values are considered for as energy, centrality of the node and node concentration. For energy values are as LOW, MEDIUM and HIGH. For concentration three values are as LOW, MEDIUM and HIGH and for centrality of the node three values are as FAR,CLOSE and ADEQUATE. If a node is distant from the center and its energy is low then there are low chances of a node becoming a cluster head.

Jin-Shyan Lee [8] also explains the use of fuzzy inference system for cluster head selection. Two parameters were considered are as residual energy and expected residual energy. Output was the chance of whether a node will become a cluster head or not. He has considered six possible values for residual energy as LOW, RATHER LOW, VERY LOW, HIGH, RATHER HIGH and VERY HIGH. Three possible values for expected residual energy are LOW, HIGH, and MEDIUM. There is only one fuzzy output variable *chance* which indicates chances of a node becoming cluster head. It has seven values as LOW, VERY LOW, RATHER LOW, MEDIUM, HIGH, VERY HIGH, and RATHER HIGH. By using various fuzzy rules, output variable CHANCE can be found. For example if the residual energy of the node and expected residual energy is high then there are greater chances of a node to become a cluster head.

2.3 Neural Network Based Cluster Head Selection

Basic structure of neural network consists of three layers: input layer, output layer and competition layer. Nodes in the input layer should agree to the input patterns of sensor nodes. Nodes compete with each other for becoming cluster head in competition layer and the one who has least energy associated with delivery ratio becomes cluster head [9]. Neeraj kumar et. al [9] proposes a three layered neural network. Network consists of input, competition and output layer. Sensor nodes in input layer should fulfill the input pattern criteria of sensor nodes which are competing for becoming cluster head. Nodes in the input layer are completely connected with output nodes in competition layer. Output layer consists of only

one node that has least energy associated with delivery ratio. This node is selected as cluster head.

Cordina M and Debono C.J. et. al [10] proposes a routing protocol in which cluster head selection is done by using Self Organizing map(SOM) neural network. Parameters used for cluster head selection are SOM inputs. Minimum separation filter need to be applied on SOM output so that minimum separation distance is achieved between selected cluster heads.

3. COMPARATIVE STUDY

Sr No.	Technique used	Advantages	Disadvantages
1	Fuzzy Logic	1. Classical techniques can consider only true or false values. Fuzzy logic can consider partial truth values of parameters. 2. Fuzzy systems can reach real time decisions with incomplete information [7]. 3. Increase in lifetime of the network is achieved. 4. Linguistic variables can be used in fuzzy logic based cluster head selection.	1. This method is reasoning based and not exact. 2. All the parameters are given same importance.
2	Genetic Algorithm	1. Fitness function defines probability of whether a node will become a cluster head or not. 2. As a fitness function is function of various fitness parameters, one can evaluate the possibility of cluster head selection for various parameters. 3. Here only a node which copies itself in next generation becomes cluster head. 4. Simple and easy representation of network using chromosomes. 5. Crossover operator can help in finding a better individual.	1. Mutation can sometimes result in worse individuals. 2. Initial population is generated randomly. This can result in inefficiency.
3	Neural network	1. As neural networks have simple nature, they are easy to implement. 2. As they have 'learning' capability, neural networks can be used to efficiently solve cluster head selection problems.	1. Neural networks have black box nature. 2. They have heavy computing burden. [11]

Table 1: Comparative study of CH selection techniques

4. CONCLUSION

In this paper we conclude that limited energy of the sensor node is a great challenge in designing wireless sensor network. If proper cluster head selection methods are adopted then

substantial increase in network lifetime can be achieved. This paper investigates some cluster head selection techniques. By changing the parameter set, further improvement in the network lifetime can be achieved. Our further work intends to compare above investigated techniques and find optimized cluster head selection techniques.

In this paper we conclude that limited energy of the sensor node is a great challenge in designing wireless sensor network. If proper cluster head selection methods are adopted then substantial increase in network lifetime can be achieved. This paper investigates some cluster head selection techniques. By changing the parameter set, further improvement in the network lifetime can be achieved. Our further work intends to compare above investigated techniques and find optimized cluster head selection techniques.

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