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Survey of Fuzzy logic clustering protocols

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ABSTRACT
Several clustering algorithms for wireless sensor networks (WSNs)have been developed in recent years. Fuzzy logic is useful in making decisions without requiring complete information about the environment. Moreover, complete and accurate information about the environmentis generally necessary in traditional control algorithms. Fuzzy logic may also be usedin decision-making based on several environmental parameters by putting these parameters under predetermined rules. In this study, we present a energy-efficient approaches for WSNs as fuzzy logic clustering protocols.

I. INTRODUCTION

Fuzzy logic is a computational paradigm based on how humans think. It examines the world in imprecise terms in a manner that is nearly identical to the way that the human brain receives information (e.g.temperature is hot, speed is slow) and then responds with precise actions. The hu- man brain can reason with uncertainties, vagueness, and judgments. By contrast, computers can only handle precise valuations. Fuzzy logic aims to combine the two techniques; it can simultaneously manage numerical data and linguistic knowledge. Fuzzy logic differs from classical logic given that statements are no longer black or white, true or false, ON or OFF and 0 or 1. In fuzzy logic, a membership function (MF) is a curve that defines the manner in which each point in the input space is mapped onto a membership value (or membership degree) between 0 and

MFs allow the graphical quantification of linguistic terms and representation of a fuzzy set. An MF for a fuzzy set A on the universe of discourse X is defined as $\mu A : X \longrightarrow [0, 1]$.

Here, each element of X is mapped onto a value between 0 and 1. Such value is called membership value or membership degree. It quantifies the degree of membership of an element in X to fuzzy set A. The x-axis represents the universe of discourse. The y-axis represents the membership degrees in the [0, 1] interval. Multiple MFs can be used to fuzzify a numerical value. Simple MFs are selected because using complex functions does not add precision to the output. Examples of all MFs for LP, MP, S, MN and LN are provided in Figure 2.4. Triangular MF shapes are the most common among MF shapes, such as trapezoidal, singleton and Gaussian. Here, the input to a five-level fuzzifier varies as shown in figure 2.4.

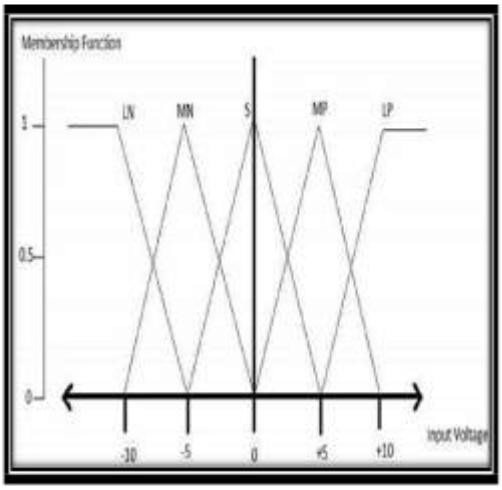

Figure 2.4: Example of all membership functions [3]

The fuzzy logic model[12] has four controls: a fuzzifier, fuzzy rules, fuzzy inference engine and a defuzzifier (Figure 2.5) [3]. The Mamdani method is the most com- monly used fuzzy inference technique [4]; its simplicity in applying a set of fuzzy rules is provided by experienced human operators. A fuzzy set does not have a crisp, clearly defined boundary set. Moreover, its fuzzy boundary is described by MFs; hence, the membership degree of elements ranges from 0 to 1.

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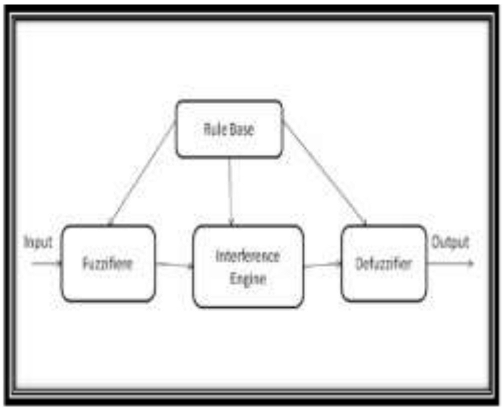

Figure 2.5: Fuzzy logic Model

The fuzzy logic model is performed using four steps (Figure 2.5).

Fuzzification crisp values are the input variables (intermediate value between 0 and 1) that will be converted to fuzzified values based on the degree of membership grade that belongs to a particular rank. The first step is to receive the crisp inputs. The degree to which these inputs belong to each of the appropriate fuzzy set is determined by x1 and y1.

The fuzzified inputs are received and applied to the antecedents of the fuzzy rules in rule evaluation. Then, they are applied to the consequent MF Figure 2.6 presents an example of the fuzzy logic process.

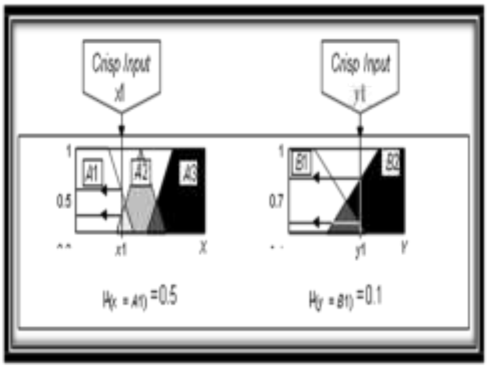

Figure 2.6: Fuzzification process [4]

Example: The second step is to obtain the fuzzified inputs m means (membership), i.e. m(x=A1) = 0.5, m(x=A2) = 0.2, m(y=B1) = 0.1 and m(y=B2) = 0.7, and then apply them to the antecedents of the fuzzy rules. If a given fuzzy rule has multiple antecedents, then the fuzzy operator (AND or OR) is used to obtain a single number that represents the antecedent evaluation result. Subsequently, this number (i.e. the truth value) is applied to the consequent MF. An example of rule evaluation is as follows. The inputs are A and B, with three-member functions (Low/Medium/High). The output is C, with five-member functions (Very Poor/Poor/Fair/Good/Very Good).

Rule 1: If A and B are Low, then C is Very Poor. Rule 2: If A is Low and B is Medium, then C is Poor. Rule 3: If A is Medium and B is Low, then C is Poor. Rule 4: If A is Low and B is High, then C is Fair.

Rule 5: If A is High and B is Low, then C is Fair. Rule 6: If A and B are Medium, then C is Fair.

Rule 7: If A is Medium and B is High, then C is Good. Rule 8: If A is High and B is Medium, then C is Good. Rule 9: If A and B are High, then C is Very Good.

The third step involves the aggregation conditions of the rule outputs; that is, the unification of the outputs of all the rules. The MFs of all rule consequents that were previously clipped or scaled are selected and combined into a single fuzzy set. The input of the aggregation process is the list of clipped or scaled consequent MFs, whereas the output is one fuzzy set for each output variable. The OR fuzzy operation is conducted to evaluate the disjunction of the rule antecedents. Fuzzy expert systems typically use the classical fuzzy operation union:

mAE(x) = max[mA(x), mB(x)] (2.8)

Similarly, the AND fuzzy operation intersection is applied to evaluate the conjunc- tion of the rule antecedents:

mAC(x) = min[mA(x), mB(x)] (2.9)

The result of the antecedent evaluation can be applied to the MF of the consequent (Figure 2.7).

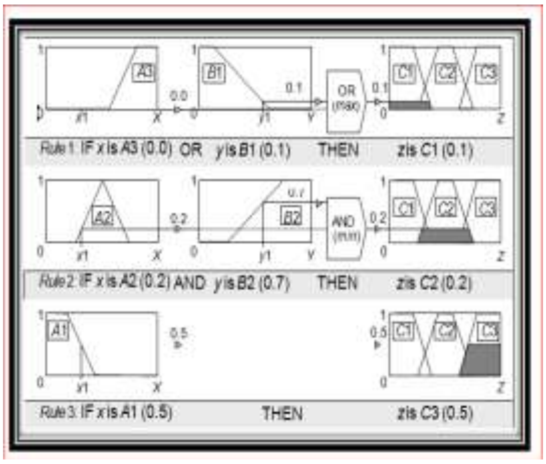

Figure 2.7: Example of (rule evaluation)

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The most common method for correlating the rule consequent with the truth value of the rule antecedent is clipping, in which the consequent MF is cut at the level of the antecedent truth. The clipped fuzzy set loses information given that the top of the MF is sliced. Nevertheless, clipping is frequently preferred because it involves less complex and faster mathematical operations; moreover, it generates an aggregated output surface that is easier to defuzzify. Although clipping is a commonly used method, scaling provides a better approach for preserving the original shape of a fuzzy set. The original MF of the rule consequent is adjusted by multiplying all its membership degrees by the truth value of the rule antecedent. This method, which generally loses minimal information, can be extremely useful in fuzzy expert systems (Figure 2.8).

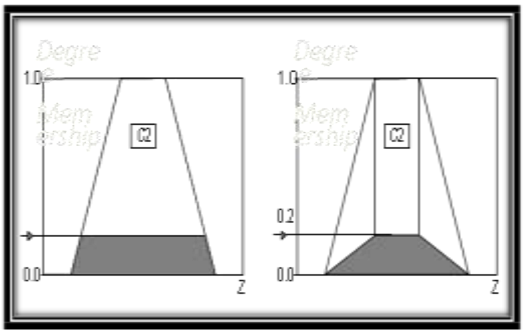

Figure 2.8: Clipped and scaled membership functions [4]

The input of the aggregation process is the list of clipped or scaled consequent MFs, whereas the output is one fuzzy set for each output variable (Figure 2.9).

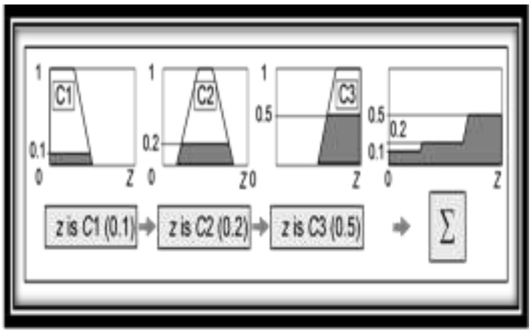

Figure 2.9: Aggregation of the rule outputs

The last step in the fuzzy inference process is defuzzification, which is the opposite operation of fuzzification. Fuzziness helps evaluate the rules; however, the final output of a fuzzy system should be a crisp number. The input for defuzzification is the aggregate output fuzzy set, whereas the output is a single number. In the first procedure, the crisp values of the input variables are fuzzified into membership degrees with respect to fuzzy sets.

Accordingly, the last procedure extracts a precise quantity from the range of fuzzy sets to the output variable, as shown in figur2.9. In addition, the centroid method (also called centre of area or centre of gravity) are used in fuzzy logic process.

- **Gupta protocol**

Gupta et al. [1] proposed centralised approaches that adopt three fuzzy controls, namely, concentration, residual energy, and centrality, when selecting an optimal cluster head (CH). Concentration refers to the number of nodes present in the neighbouring area, whereas centrality indicates nodes near the centre cluster. For every round, each node forwards its data to the base station in which CHs are centrally selected.

- **CHEF: Kim et al. [2]**

Proposed the CH election mechanism that uses fuzzy logic (CHEF), in which two fuzzy controls are used: residual energy and local distance. Local distance refers to the total distance between the tentative CH and the nodes within the predetermined constant competition radius. In this approach, the base station is not required to collect data from all the sensor nodes.

- **Moving base station scheme:**

A fuzzy logic-based moving base station scheme [3] was proposed for extending lifetime in WSNs. This protocol considers two controls when selecting an optimal CH, namely, energy and centrality. Each node probabilistically decides whether to become a CH; thus, two CHs that are in the proximity of each other may be selected. In reality, considering only one factor, such as energy, is unsuitable for appropriately electing a CH because a relationship exists between centrality and energy. Moreover, the centrality of nodes related to the cluster determines the amount of energy dissipated when other nodes transmit to it. The more central a node is to a cluster, the more energy efficient it's for the other nodes to send through the selected node. this protocol has shorter lifetime for the network.

- **FCA:**

Sensor node generates a random number between 0 and 1 for each round. If the random number for any node is smaller than the predetermined threshold T, which determines the percentage of the desired tentative CHs, then that

node will become a tentative CH. The Fuzzy clustering algorithm (FCA) [4] will use the residual energy parameter with the distance of the node to the base station as metrics competition the radius. This radius will decrease the service area of a CH when its residual energy is reduces. If the competition radius remains constant as residual energy decreases, then the sensor node will rapidly run out of battery. Radius computation is conducted using fuzzy IF-THEN mapping rules [12] to handle uncertainties, also this protocol still has shorter lifetime for the network.
Fuzzy C-means clustering protocol for WSNs:

- **Fuzzy C-means (FCM [5])**

is a centralised clustering technique in which the nodes with the highest residual energy can be used to gather data and send information. The FCM protocol analyses a cluster-based protocol which uses the FCM method. Simulation results show that FCM prolongs the lifetime of k-means clustering,

LEACH, and MTE. This protocol uses the FCM algorithm to create cluster structurestures that can minimise the distance between the nodes; thus, an improved cluster
formation is achieved, also this protocol still has shorter lifetime for the network.

- **FL-LEACH:**

The novelty of FL-LEACH [6]
lies in its designed fuzzy logic system, which determines the number of CHs without any information about the network [52]. This protocol uses two criteria: the number of nodes in the network and node density. FL- LEACH has a longer lifetime than LEACH and genetic-based protocols (e.g. LEACH-GA) [53], Nevertheless, this protocol still has shorter lifetime for the network.

- **Super CH:**

This protocol involves a super CH (SCH [7]) that is selected from amongst CHs that can only send data to the mobile base station by choosing appropriate fuzzy descriptors, such as base station mobility, residual energy, and centrality of clus- ters. Fuzzy inference (Mamdani) is used to determine the chances selecting CH for each round. (1) CHs are selected based on a threshold value. (2) k Optimal CHs are selected in each round. Then, the SCH is chosen from amongst CHs based on fuzzy IF-THEN rules. All CHs send the aggregated data to the SCH, and the base station collects the information from the SCH. The simulation results indicate that this protocol has a considerably better lifetime than the LEACH protocol, also this protocol still has shorter life time the network.

- **FM-SCHM:**

The Fuzzy method based super cluster head election Mechanism (FM-SCHM) [8] protocol considers three fuzzy parameters in electing a super cluster head (SCH): remaining battery power, mobility, and distance to the base station. However, this protocol suffers from a major drawback, i.e. the lifetime of the network will remain constant regardless of mobility variation, Furthermore, this protocol still has shorter lifetime for the network.

- **F-MCHEL:**

The fuzzy-based master CH election LEACH (F-MCHEL [9]) protocol is an ad- vanced level of CHEF. Instead of transmitting from several CHs, this approach selects only one CH. as a master CH having the maximum energy. Simi- lar to CHEF, F-MCHEL uses two input parameters for its fuzzy inference system (FIS), namely, distance and energy for each selection of CH after one master CH has been chosen. Only the master CH is responsible for aggregating data from numerous CHs and then sending them to the base station. The simulation comparisons (Table 2.3) show that F-MCHEL improves the first node dies (FND) of the LEACH and the moving base station approach , Nevertheless this protocol still has shorter lifetime for the network.

Table 2.3: Lifetime of previous Fuzzy logic protocol

Algorithm	FND
LEACH	1132
CHEF	1457
Moving BS Approach	1682
F-MCHEL	1952
FLG	2100

- **FEAR:**

The fuzzy energy-aware tree-based routing (FEAR [10]) protocol extends a net- work's lifetime and improves existing tree-based routing protocols by using the limited sensor nodes energy of nodes. The cross-layer concept is adopted to design a proto- col that gathers information from different layers to save energy. All nodes maintain a neighbour and parent child list. This protocol exhibits tree construction, message transmission, new node engagement, and tree reconstruction. FEAR analysis is based on sent and received control messages, and the consumed power based on these messages minimises energy consumption. Nevertheless, this protocol still has shorter life time for the network.

- FLG Protocol

FLG[11] protocol uses 2 diminssionteqniques with 3 creteriasof fuzzy logicas; residual energy , distance to basestation,distance to cluster head. It uses the fuzzy ranking system then selected the optimal cluster head between nodes this protocol shows more energy efficiency than other previous protocols

2.6 Discussions

The objective of studying and comparing previous fuzzy logic routing protocols is to implement a new fuzzy logic protocol that can solve some of the problems such as radius distance between nodes and improving its network lifetime in terms of FND and LND. This research includes many considers and assumptions, as detailed in the subsequent sections.

II. CONCLUSION

In the FLG protocol, fuzzy logic makes important decisions in selecting CHs. CHs are selected at the base station with nine grids because this number of grids will minimise the distance between nodes, which helps reduce energy consumption amongst nodes when transmitting data. In every round, the base station will transfer information to the clustering nodes and to the member nodes within the nine grids. The base station determines three fuzzy sets during CH election: distance between nodes, distance between nodes and the base station and residual energy in each node.

The base station selects CHs according to the IF–THEN fuzzy rules (Table 4.1). After the base station selects the CH, it broadcasts the results of the CH election to the entire network. All clustering decisions are made at the base station. The base station will elect more precise CHs by using the three criteria in all the stages because base stations are more powerful than normal nodes. Moreover, a base station possesses all the knowledge of the entire network.

REFERENCE

[1]. Gupta, D. Riordan and S. Sampalli, "Cluster-head Election using Fuzzy Logic for Wireless Sensor Networks", Communication Networks and Services Rearch Conference, pp.255-260, May 2005
[2]. Jong-Myoung Kim, Seon-Ho Park, Young-Ju Han and TaiMyoung Chung, CHEF: Cluster Head Election mechanism using Fuzzy logic in Wireless Sensor Networks, ISBN 978- 89-55 19-136-3, Feb. 17-20,2008 ICACT 2008.
[3]. Alkesh, Abhijeet & Singh, Ashutosh & Purohit, Neetesh. (2011). A Moving Base Station Strategy Using Fuzzy Logic for Lifetime Enhancement in Wireless Sensor Network. 198 - 202. 10.1109/CSNT.2011.49.
[4]. Godbole, Vaibhav. FCA - An Approach On LEACH Protocol Of Wireless Sensor Networks Using Fuzzy Logic,2013.
[5]. Hoang, Duc Chinh & Kumar, Rajesh & Panda, Sanjib. Fuzzy C-Means clustering protocol for Wireless Sensor Networks. (2010). 3477 - 3482. 10.1109/ISIE.2010.5637779.
[6]. Nayak, P., & Devulapalli, A. A fuzzy logic-based clustering algorithm for WSN to extend the network lifetime. IEEE Sensors Journal, 16(1),2015, 137–144.
[7]. Madhumitha K, Dr.Arulanand N.," Type 2 Fuzzy Logic Clustering Algorithm for Multi-hop Wireless Sensor Network for Balancing Effective Energy", Journal of Information Systems & eBusiness Network(Elsevier) ,ISSN: 1556-5068, India ,2017,195-203
[8]. P. Nayak, D. Anurag, and V. V. N. A. Bhargavi, "Fuzzy based method super cluster head election for wireless sensor network with mobile base station (FM-SCHM)," in Proc. 2nd Int. Conf. Adv. Comput. Methodol., Hyderabad, India, 2013, pp. 422–427
[9]. T. Sharma and B. Kumar, "F-MCHEL: Fuzzy based master cluster head election leach protocol in wireless sensor network," Int. J. Comput. Sci. Telecommun., vol. 3, no. 10, pp. 8–13, Oct. 2012
[10]. Ehsan Ahvar1 , Alireza Pourmoslemi2 , Mohammad Jalil Piran3," FEAR: A FUZZY-BASED ENERGY-AWARE ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORKS", International Journal of Grid Computing & Applications (IJGCA) Vol.2, No.2, June 2011,pp.33-45
[11]. Emad Mohammed ibbini& Lun, Kweh& Othman, Mohamed & Zurina, Mohd Hanapi & Baradaran, Amir. (2018). An Efficient

Protocol using Fuzzy Logic and Grids with Two-Dimensional Techniques for Saving Energy in WSN. International Journal of Advanced Computer Science and Applications. 9. 262.
[12]. P. Nayak and A. Devulapalli, “A fuzzy logic-based clustering algorithm for wsn to extend the network lifetime,” IEEE sensors journal, vol. 16, no. 1, pp. 137–144, 2016.