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Ranking Table for Cluster Head Selection of Wireless Sensor Network

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***Abstract*—Power consumption is always an important element for Wireless Sensor Network (WSN). The energy is the main constraint should be considered when designing the algorithm, protocol or the methods. Clustering is one of the effective methods to use in designing low energy usage in WSN. In the clustering, the appropriate cluster head selection can drastically reduce the energy consumption and prolong the lifetime of the network. This paper proposes the use of ranking table to select cluster head based on the Fuzzy Logic approach. The multi-tier clustering will be used to improve the energy consumption of WSN. Thus, this approach will increase the network lifetime and reduce the energy consumption of nodes while selecting the cluster head.**

Keywords-Wireless Sensor Network (WSN, Cluster Head (CH) and Fuzzy Logic

I. INTRODUCTION

Wireless sensor network is a type of network [1]. Fundamentally, it is a collection of small devices. This tiny device is called wireless sensor node or sensor node with a low cost, low power and multifunctional sensor nodes [2]. Basically, node is a computer with close sensors that can sense, communicate and process the data. According to Jun et al. [2], every node has the capabilities to sense, process and transmit data back to a base station. Sensor nodes used to monitor or record a physical environment situation such as motion, pressure and temperature. It communicate using radio transceivers [3]. Yang et al. [4], Xiao and Zhenhua [5] described wireless sensor network as a composed of a large number of sensors that are densely deployed for monitoring the events such as battlefield surveillance, intrusion detection, home security, smart space, target tracking and many other applications.

In WSN, the communication part is mainly energy consumed. Thus, energy consumption in a sensor node can be classified to either "useful" or "wasteful" sources Younis and Fahmy [6]. Useful energy consumption should be transmitting/ receiving data, processing query request and forwarding queries/ data to neighboring nodes. In contrast, wasteful energy consumption can be due to idle listening to the media, retransmitting due to packet collisions, overhearing and generating/ handling control packets. The sensor nodes have limitation in power which is easy to exhaust, computation capability and memory. Thus limitation of energy is very important design factor because of remaining energy of each sensor node is directly related to the lifetime of the WSN [7]. In most cases battery recharging is inconvenient or impossible. The energy cannot be replenished and the resource-constrained limitation make it essential at these sensor nodes to conserve energy to increase the lifetime of the sensor network [8]. Since it is infeasible to replace batteries once WSNs are deployed, an important design issues in WSN is to lessen the energy consumption with the use of energy conserving hardware, operating systems and communication protocols [9].

Fuzzy controllers are broadly used in many practical systems. Fuzzy controller module design creates a Knowledge Base that includes concept information which can be divided into a Data Base and Rules Base, Wen-Tsai et al. [10]. The Knowledge Base is a static data structure with predefined size and installed content. Before the application work is starting, the Knowledge Base structure should be defined first. The Data Base contains information about the fuzzy sets, which are linguistics terms used in fuzzy rules and to simplify the fuzzy calculation, the membership function can be form either triangular or trapezoidal. In WSN, sensor nodes consume energy while doing their activities such as receiving data, processing and also transmitting data. This sensor node actually equipped with batteries which are not rechargeable. Therefore, the energy efficiency is a major design goal in WSN [11] and Fuzzy Logic system is one of the method that can prove the energy consume in WSN.

In WSN, clustering is one of method for grouping the sensor nodes. Clustering can support network scalability, reduce the size of routing table which stored at each of the sensor nodes and can prolong the network lifetime. In each cluster should have at least one cluster head. The selection of the cluster head is an important part to be considered in order to minimize the overheads in energy limited sensor nodes. In order to extend the network lifetime and reduce the energy consumption of the sensor networks, the next cluster head selection at each cluster is the main issues where currently the next cluster head election only based on the remaining energy without considering the others attributes that can contribute to more effectives cluster head selection and energy can be preserved.

Therefore, the selection of the cluster head is important to make sure that the energy can be conserved and increase the lifetime of the sensor network. The clustering protocol such as LEACH, LEACH-C by Heinzelman et al. [12], PEGASIS by Lindsey et al. [13],

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CHEATS by Pires et al. [14], and HEED by Younis and Fahmy [6] are the earlier protocol introduced.

In this paper, the selections of the cluster head are based on the fuzzy logic approach where the next cluster head will be based on the ranking table. This protocol will be more effective rather than recalculate the metrics each round. The main contributions in this paper are described as follows. Fuzzy logic will be used for representation of cluster head selection. It will consider the residual energy of each node, the communication cost and the centrality. The multi-tier clustering topology will be used rather than heterogeneous. This paper is organized as follows. Section 2 describes the literature on cluster head selection using Fuzzy Logic. Section 3 describes the proposed Fuzzy Logic approach based on ranking table. This section also explains selected attributes for the proposed approach. In the last section, summarize the study and highlight direction for further research.

II. RELATED WORK

In this section, we review related works focus on clustering algorithms that determined the selection of the cluster head. Cluster Based Resource Allocation Architecture (CBRA) that contains resource monitoring and scheduling operations is introduced for mobile grid by Thenmozhi and Tamilarasi [15]. The mobile grid will be divided into cluster, and each cluster formed has one cluster head. In this architecture CH information and frequent updates will be controlled by Master Server (MS). The Monitoring Agent (MA) in the cluster will monitor the resource availability and periodically predict the mobility of the cluster nodes and update the values. This method is not good because the process of the next cluster head will calculate again the metrics that used more power. On the other hand, Xiao and Zhenhua [5] proposed the selection of the cluster head based on Fuzzy Petri Nets. Besides balances the energy load at each node, this algorithm also provides global reliability for the whole networks but the combination of the parameters must be accurate in order to reduce the energy consumption.

Additionally, Bagci and Yazici [11] introduced a Fuzzy unequal clustering algorithm (EAUCF) which the purpose is to prolong the lifetime of the WSN. This algorithm will adjust the cluster head radius to decrease the intra cluster work of the sensor nodes that are closer to the base station or have a lower battery level. Moreover, a power reduction algorithm for sensor networks using fuzzy logic and number of neighbor nodes for the cluster head selection is proposed Ando et al. [16]. Both methods is to adjust the radius and power but they are not solved the problem on how to select the next cluster head where in this method they still must recalculate the parameters to select the next nodes who will become the cluster head.

Again, Yan and Hui [17] developed a fuzzy expert system to intelligently select the cluster head in the network. In addition, Hoang et al. [18] used Fuzzy C-Means (FCM) to analyzed a cluster. This protocol shows that, it reduces the energy consumption and improved the network lifetime. Likewise, Fuzzy Logic method for energy efficient hierarchical clustering is proposed by S. Swapna Kumar [19]. This algorithm applies for cluster formation and cluster head selection in the distributed hierarchical environment. Furthermore, Dongmei et al. [20] proposed Overlapping Clustering which covers wide applications such as inter-cluster routing, topology discovery, node localization, and recovery from cluster head failure and so on. This approach describes the topology of control target tracking-oriented based on overlapping clustering in wireless sensor network. Similarly, Torghabeh et al. [21] proposed a Critical Degree that assigned to each cluster head 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. Most of the fuzzy approach plays with the fuzzy variables and parameters to select the cluster head of WSN but none of this method are concentrate on the selection of next cluster head which the next cluster head also contribute to energy consumption.

Besides, Fuzzy Position based on routing for clustering in the sensor network is proposed by Jing et al. [22]. This method applied for the WSN applications that have no GPS support. To avoid the long time and energy consumption while requesting and replying for node ID in traditional routing, the destination must locate with ambiguous position. Additionally, Barolli et al. [23] proposed power reduction using fuzzy logic and neighbor nodes. This author have evaluated performance using different parameter and the result shows that, when the number of neighbor nodes is increased, the probability of sensor nodes to be a cluster head is also increase and it remained the battery power. In addition, Rencheng et al. [24] proposed energy-adaptive cluster head election algorithm based on fuzzy inference system of Mamdani (CEFM). This author used residual energy level, the nodes position, the number of neighbors and the rate of retransmission to evaluate their algorithm. Most of these method used fuzzy because fuzzy can handle noisy data but it can be improved with the multi-tier clustering in order to maximize the lifetime of the sensor nodes.

III. PROPOSED APPROACH

The proposed is designed to establish a guideline to select the best nodes to become the cluster head in the clustering. This approach integrates with reliable attributes from prior research. Figure 1 shows the proposed approach and further discussion on the details is proceed below.

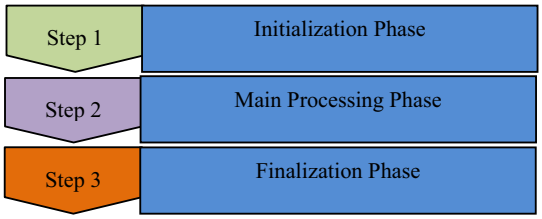

Figure 1. Flow Diagram for Cluster Head Selection

In initialization phase, the data from nodes need to be extract. Nodes within its networks exchange their information using cluster head node message. In the processing phase, the nodes that have higher residual energy will become cluster head and will broadcast it status within the networks. This information will be kept in the routing table. At this phase, the base station will have all the information of each node. The values of the three metrics used will be calculated and the higher value will be selected as cluster head. The base station will come out with the ranking table based on the values.

In the finalization phase or ranking phase, the ranking table will change based on the current node status. This ranking table will be update by the base station. The new ranking will be broadcast to each node that still not becomes a cluster head. The highest residual energy of the nodes will be selected to become the cluster head and the remaining nodes will know when its turn to become the cluster head. This process only happen when the nodes left 30 percent in the network. Nodes will exchange their routing table to other nodes so that, the remaining nodes will know the current status of each node left. In this phase, if a node completes the cycle of the clustering process and still not received any message from other nodes within its network, it will find itself uncovered and it must introduce itself as the last node.

IV. DISCUSSION: FUZZY LOGIC APPROACH

Table I shows the selection of the attributes is important to make sure the process to choose the cluster head is energy efficient. Prior researches show that the residual energy is considered when selecting the nodes to be a cluster head. This paper combines the attributes based on Fuzzy Logic to produce a better result and to prolong the energy of each node. Hence, a new protocol on selecting the cluster head based o fuzzy logic in the distributed multi tier energy efficient of WSN is proposed. The ranking table will be produced to effectively select the next cluster head node.

TABLE 1. COMPARISON OF THE PROPOSED ATTRIBUTES WITH PRIOR RESEARCH

Research/Attribute	Residual Energy	Communication Cost	Centrality	Multi-tier Clustering	Hierarchy Clustering
Ando et al [8]	X		X		
Neamatollahi et al. [7]			X		X
Xiao and Zhenhua [5]	X		X		X
Indranil et al. [9]	X		X		X
Younis and Fahmy [6]	X				
Taheri et al. [25]	X	X			X
Alkesh et al. [26]	X				X
Xinbing et al. [27]		X	X		
Min Seok et al. [28]	X				X
Saeedian et al. [29]	X		X		X
Pires et al.[14]	X		X		X
Proposed Method	X	X	X	X	

From the literature reviews, we find that, most of the clustering is based on heterogeneous where it is more energy efficient compared to the homogenous. The fuzzy logic approaches for the above method are quite similar, but the selection of the fuzzy attributes will play an important role for the cluster head selection. From the literature reviews, there are no methods can effectively select the next cluster head after the first cluster head dies. Most of the approach will be based on the residual energy and metric recalculation. However, the process of the recalculation uses energy too. So to conserve the energy for each node, the ranking table produces from the Fuzzy Logic metrics will be used for the next cluster head. From the Table 1 shows the proposed methods that will be combine all those three metrics which will support each other in produce efficient power consumption. These combinations can produce better result rather than only one or two metrics tested. The metrics that will be considered in this research are residual energy, which is the energy stage available in each node. The higher the energy the higher the chances for the nodes to become cluster head. The communication cost which is the value path from one node to other nodes and the centrality of the nodes that specify the value of the node based on the centrality of the cluster. Figure 1 shows the model of fuzzy logic control structure that will be used to blend all these three parameters.

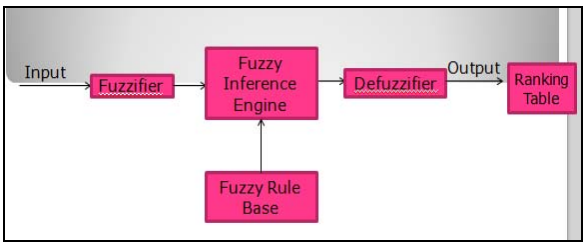

Figure 2. Fuzzy Logic Structure [16]

Fuzzy Logic control actually is capable in making real time decisions even with incomplete information. Besides that, Fuzzy Logic system is useful while blending different parameters. This combination can produce good results. Fuzzy Logic system also useful when there are no exactly mathematical model of the system can be used, with this approach it can computed less memory and power [26].

The model consists of fuzzifier, fuzzy inference engine, fuzzy rule base and defuzzifier. The input on the fuzzifier consists of residual energy, communication cost and node centrality. The rule evaluation is taking the fuzzified inputs and applying them to the antecedents of the fuzzy rules Indranil et al. [9]. Then it is applied to the consequent membership function. Aggregation of the rule outputs is the process of the unification of the outputs of all rules. Defuzzification is the input for the defuzzification process is the aggregate output fuzzy set chance and the output is a single crisp number. Then the ranking table will be produced to select the next cluster head. This study will focus on multi tier clustering. In the multi tier clustering, the multiple levels of the cluster head will be introduced. Only the highest level of the cluster head can transmit data to the base station.

V. CONCLUSION

This paper have reviewed and discussed several techniques of cluster head selection to reduce the energy consumption of WSN from previous studies. We enhance these efforts by proposed a new technique of cluster head selection that will improve energy-efficient and prolong the network lifetime. The efficient ranking table will be based on fuzzy logic approach and can be used as an indicator to select the next cluster head.

REFERENCES

[1] K. K. Kiran Maraiya, Nitin Gupta, "Study of Data fusion in Wireless Sensor Network," presented at the Proc. of the International Conference on Advanced Computing and Communication Technologies (ACCT 2011), 2011.

[2] Y. Jun, *et al.*, "A Novel Cluster-Based Data Fusion Algorithm for Wireless Sensor Networks," in *7th International Conference on Wireless Communications, Networking and Mobile Computing (WiCOM), 2011*, 2011, pp. 1-5.

[3] F. Hermans, *et al.*, "Quality estimation based data fusion in wireless sensor networks," in *IEEE 6th International Conference on Mobile Adhoc and Sensor Systems, 2009. MASS '09.* , 2009, pp. 1068-1070.

[4] J. Yang, *et al.*, "An energy-efficient data gathering algorithm based on clustering for wireless sensor networks," in *International Conference on Electronics, Communications and Control (ICECC), 2011*, 2011, pp. 1305-1308.

[5] F. Xiao and Y. Zhenhua, "A Reliable and Efficient Clustering Algorithm for Wireless Sensor Networks Using Fuzzy Petri Nets," in *2010 6th International Conference on Wireless Communications Networking and Mobile Computing (WiCOM),* , 2010, pp. 1-4.

[6] O. Younis and S. Fahmy, "HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks," *Mobile Computing, IEEE Transactions on,* vol. 3, pp. 366-379, 2004.

[7] P. Neamatollahi, *et al.*, "A novel fuzzy metric to evaluate clusters for prolonging lifetime in wireless sensor networks," in *2011 International Symposium on Artificial Intelligence and Signal Processing (AISP),*, 2011, pp. 118-123.

[8] H. Ando, *et al.*, "An Intelligent Fuzzy-Based Cluster Head Selection System for Wireless Sensor Networks and Its Performance Evaluation," in *13th International Conference on Network-Based Information Systems (NBiS), 2010* 2010, pp. 55-61.

[9] G. Indranil, *et al.*, "Cluster-head election using fuzzy logic for wireless sensor networks," in *Communication Networks and Services Research Conference, 2005. Proceedings of the 3rd Annual*, 2005, pp. 255-260.

[10] S. Wen-Tsai, *et al.*, "Multi-sensors data fusion for precise measurement based on ZigBee WSN via fuzzy control," in *International Symposium on Computer Communication Control and Automation (3CA), 2010*, 2010, pp. 156-159.

[11] H. Bagci and A. Yazici, "An energy aware fuzzy unequal clustering algorithm for wireless sensor networks," in *2010 IEEE International Conference on Fuzzy Systems (FUZZ),* , 2010, pp. 1-8.

[12] W. R. Heinzelman, *et al.*, "Energy-efficient communication protocol for wireless microsensor networks," in *System Sciences, 2000. Proceedings of the 33rd Annual Hawaii International Conference on*, 2000, p. 10 pp. vol.2.

[13] S. Lindsey, *et al.*, "Data gathering algorithms in sensor networks using energy metrics," *Parallel and Distributed Systems, IEEE Transactions on,* vol. 13, pp. 924-935, 2002.

[14] A. Pires, *et al.*, "CHEATS: A cluster-head election algorithm for WSN using a Takagi-Sugeno fuzzy system," in *2011 IEEE Latin-American Conference on Communications (LATINCOM),* , 2011, pp. 1-6.

[15] S. Thenmozhi and A. Tamilarasi, "A Cluster Based Resource Allocation Architecture for mobile grid environments," in *International Conference on Computing Communication and Networking Technologies (ICCCNT), 2010* 2010, pp. 1-5.

[16] H. Ando, *et al.*, "An Intelligent Fuzzy-Based Cluster Head Selection System for WSNs and Its Performance Evaluation for D3N Parameter," in *2010 International Conference on Broadband, Wireless Computing, Communication and Applications (BWCCA),* , 2010, pp. 648-653.

[17] S. Yan and J. Hui, "Energy-Efficient Cluster-Head Selection Based on a Fuzzy Expert System in Wireless Sensor Networks," in *2011 IEEE/ACM International Conference on Green Computing and Communications (GreenCom),* , 2011, pp. 110-113.

[18] D. C. Hoang, *et al.*, "Fuzzy C-Means clustering protocol for Wireless Sensor Networks," in *2010 IEEE International Symposium on Industrial Electronics (ISIE),* , 2010, pp. 3477-3482.

[19] M. N. K. S. Swapna Kumar, V.S Sheeba, "Fuzzy Logic based Energy Efficient Hierarchical Clustering in Wireless Sensor Networks," *International Journal of Research and Reviews in Wireless Sensor Networks (IJRRWSN),* vol. 1, 2011.

[20] Y. Dongmei, *et al.*, "Topology control algorithm based on overlapping clustering," in *2010 International Conference on Networking, Sensing and Control (ICNSC),* , 2010, pp. 737-741.

[21] N. A. Torghabeh, *et al.*, "Mobile base station management using fuzzy logic in wireless sensor networks," in *2010 2nd International Conference on Computer Engineering and Technology (ICCET),*, 2010, pp. V2-352-V2-356.

[22] W. Jing, *et al.*, "Fuzzy position based routing in clustered wireless sensor network for smart environment," in *2011 International Conference on Computer Science and Service System (CSSS),*, 2011, pp. 3945-3948.

[23] L. Barolli, *et al.*, "Evaluation of an Intelligent Fuzzy-Based Cluster Head Selection System for WSNs Using Different Parameters," in *2011 IEEE Workshops of International*

Conference on Advanced Information Networking and Applications (WAINA), , 2011, pp. 388-395.

[24] J. Rencheng*, et al.*, "Clustering Routing Protocol Based on Fuzzy Inference for WSNs," in *2011 7th International Conference on Wireless Communications, Networking and Mobile Computing (WiCOM),* , 2011, pp. 1-4.

[25] H. Taheri*, et al.*, "A local cluster head election algorithm in wireless sensor networks," in *CSI International Symposium on Computer Science and Software Engineering (CSSE), 2011* 2011, pp. 38-43.

[26] A. Alkesh*, et al.*, "A Moving Base Station Strategy Using Fuzzy Logic for Lifetime Enhancement in Wireless Sensor Network," in *2011 International Conference on Communication Systems and Network Technologies (CSNT),* , 2011, pp. 198-202.

[27] Y. Xinbing*, et al.*, "A new data fusion routing algorithm for wireless sensor networks," in *2011 IEEE International Conference on Computer Science and Automation Engineering (CSAE),* , 2011, pp. 676-680.

[28] C. Min Seok*, et al.*, "A New Polling Protocol with Efficient Cluster Creation for WSN," in *2010 IEEE/ACM Int'l Conference on Green Computing and Communications (GreenCom), & Int'l Conference on Cyber, Physical and Social Computing (CPSCom)*, 2010, pp. 357-362.

[29] E. Saeedian*, et al.*, "CFGA: Clustering Wireless Sensor Network Using Fuzzy Logic and Genetic Algorithm," in *2011 7th International Conference on Wireless Communications, Networking and Mobile Computing (WiCOM),* , 2011, pp. 1-4.