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Evaluation of Fuzzy Logic-based Clustering Techniques for WSNs

Abasaheb G. Patil[1], Dr. C. Ram Singla[2], Dr. Omprakash Rajankar[3]

[1] Ph.D. Student

[2] Sunrise University, Alwar,

[3] NBN,S.C.O.E., Pune

Abstract – Miniature devices that contain the sensing unit, data processing unit, and communicating components are termed sensors, and they are crucial to the development of low power, short distance communication. When compared to a conventional sensor, the sensor network is a vast improvement. Locational and thermal efficiency design problems Sensor node optimization is required due to the inability to easily replace or recharge the node's power supply. Saving power at each sensor node is essential for extending the life of the network as a whole. Together, sensor nodes form a "cluster," or a tightly knit group with a common goal. Clustering is used so that all of the available network power may be put to good use. This study highlights some of the clustering procedures researched by current researchers that rely on fuzzy logic. In order to create cluster heads, residual energy parameters are used. Accessibility from the base station to the closest node is calculated using the protocols of fuzzy logic based clustering.

Keywords - Fuzzy, Clustering, WSN and Review

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INTRODUCTION

Wireless sensor network [1] is a network organization comprising of spatially conveyed sensors nodes to check physical or ecological conditions. The sensor nodes can be conveyed either inside or near the detected phenomenon, they sense the area and send the detected information to the base station. The sensor nodes are dissipated in a sensor field.

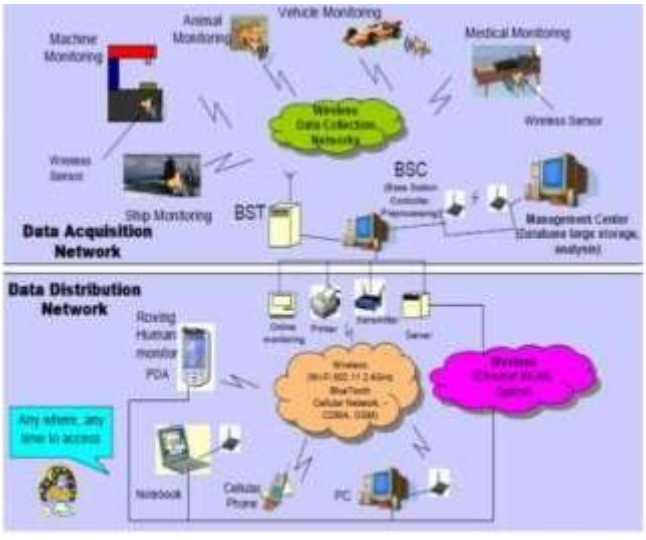

Figure 1: Scenario of WSN

Wireless sensor networks send an enormous number of sensor nodes subsequently grouping is the powerful method to deal with the nodes [2]. The sensor nodes are assembled in non over lapping sets known as clusters. Clustering methods give versatility of the organization, effective utilization of obliged assets to keep up topology security, asset sharing and better energy saving plans. Each bunch have their chief called cluster head (CH) and the target of the Group Head is to gather information from its individuals and forward it to next cluster head or the sink.

The ongoing application includes the broad use of WSN [3], which has a lot of potential for applications in different sorts of exploration. The fundamental benefit of the constant application is its ability of screening the climate rapidly, giving a prompt reaction to the customer, and effectively controlling the external climate. The external climate is straight forwardly connected with the PC structure through numerous sensors, information, yield devices, and actuators. WSN can engage the network restricted delay ensure, which is essential for a start to finish conveyance known as real-time WSN as shown below fig. 2.

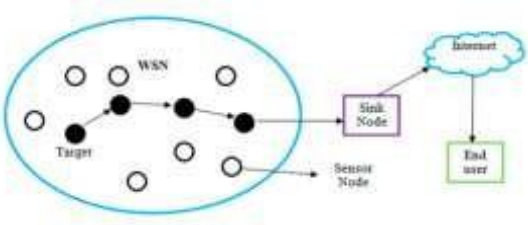

Figure 2: WSN Architecture

WSNs can be divided into five sorts relying upon the circumstance for which the network has been chosen [4]. Terrestrial WSN — This kind of WSN has numerous minor centers, which are arbitrarily sent in a specific locale in which the correspondence is impromptu. For the most part, a few dimensional, framework, or ideal position are used to coordinate these nodes. The fundamental downside of this kind of WSN application is the effect that helpless climate conditions, like snowing and raining, have on optical remote correspondence interfaces.

For sensor nodes energy savings, cluster dependent scheme concept is applied. Only few of nodes are having access to communicate with base station in such types of designs [5]. These nodes were known as cluster head (CH). In wireless sensor network saving of energy is central problem. Information interchange technical aspects was more consumer of energy. Thus We may bring down consumption of energy by gaining control on behaviour of communication, as energy consumption evaluated to process 3000 instruction set is equal for sending 1 bit information on a 100 meter distance [6]. It remains responsibility of CH for gathering data from other nodes of cluster and transmit aggregated information to Base Station which now has compressed data packet. Accurate CH choosing can significantly extends life span WSNs and decreases consumption of energy. To manage unpredictability in WSNs few of clustering algorithms uses fuzzy logic. I. Zedah presented fuzzy logic [7] that was much simpler to apply compared with that of probabilistic theory dependent algorithms.

Cluster head in clustering protocols act as a local coordinator for their clusters and responsible for various tasks like inter fuse correlated information by applying aggregation to attain information signals into smaller forms and send it to base station, data accumulated from its cluster members, and positioning intra-cluster transmission timeline, evolutionary algorithms, Fuzzy logic, reinforces learning, neural networks, artificial intelligence, swarm intelligence, have been proposed for Wireless sensor networks. Fuzzy logic is the most appropriate problem-resolving control system techniques, out of these methodologies, which gives simpler way to reach at a sure conclusion with imprecise, missing input information, non-numerical noisy. It performs such as human for intelligence reasoning in handling with unexpected conditions and incomplete information. Designing of protocol for wireless sensor network, fuzzy logic gives following benefits like, in terms utilised in WSN protocols behaviour and features of transmission media, drives this fuzzy representation realistic and easy. It can efficiently and easily manage many unpredictability of wireless sensor networks systems. LEACH is a major protocols for clustering algorithms. Probabilistic schemes is employed to select cluster head schematically. It takes decision depending on local information for cluster data to further processing. Numerous research activities have been done for exploring and overcoming constraints of WSNs thereby solving application and design related problems. This review thesis present many Fuzzy Logic dependent clustering algorithms. Fig. 3 represent different clustering in WSNs protocols/algorithms.

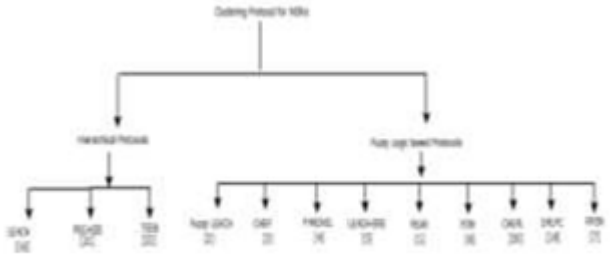

Figure 3: Clustering methods in WSNs algorithms/protocols.

FUZZY LOGIC

Extension of Boolean is Fuzzy logic. By applying —predefined set of rules known as protocols it maps input space into output space. It enables one to perform in questionable and indeterminate circumstances and handles not well-postured problems or issues with incomplete information. Fuzzy logic has been applied to find out proper sensor node as a CH in clustering methods [8]. Fuzzy logic needs subject expertise in choosing membership functions and enforcing set of rules to construct an inference from provided information. Fuzzy systems with same set of rules, however consist of various membership functions than can provide various outcome values. Therefore, knowledge at the beginning to select membership functions is important and necessary to design of system. It has ability of message overhead production and decreasing complexity.‖

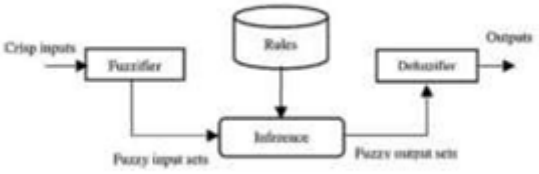

Figure 4: Fuzzy Logic System [8]

Depiction in fig. 4 primarily, input information is fuzzified into a many fuzzy sets and later as per already defined set of rules inference taken from fuzzy sets at input. Fuzzy sets is converted into a crisp value by defuzzifier. To find out proper sensor node as a CH, output crisp value is applied as chance in WSN. Type-1 and type-2 are two fuzzy logic systems that are employed for drawing an inference in different clustering methods. Membership functions are three-dimensional in type- 2 system, wherein membership functions are two dimensional type-1 fuzzy system. Membership functions of type-2 systems have capabilities to minimize uncertainties and are also fuzzy, that were not overcome by type-1 fuzzy system. They are deployed in WSNs for managing a various problems and challenges such as uncertainty in congestion estimation, Event detection, decision making, network security, Data mining and Routing.

REVIEW OF LITERATURE

This section provides a quick overview of the literature on the topic of clustering in WSNs. to arrange the sensors in a wireless sensor network, we present a distributed random clustering approach.[9] The programme creates a tree-like structure of cluster leaders, and it has been found that the deeper the hierarchy, the greater the energy savings.[10] Our algorithm's parameter values that reduce overall network energy consumption when all sensors send data through cluster heads to the processing centre are derived using stochastic geometry.

LEACH [11] described two clustering algorithms that are completely confined and budget-based: the Directed Budget-Based (DBB) algorithm and the Directed Budget-Based with Random Delays algorithm (DBB-RD). Mhemed et. al. [12] It is addressed how clustering status information that is easily accessible (for example, Rajeswari et al [13] through the HELLO exchanges) may lessen or eliminate token distribution contentions (both intra cluster and inter cluster), which significantly restrict the efficacy of prior budget-based systems.

Younis and Fahmy[14] with the aim of reducing power consumption in high-density sensor networks, an analytical method for calculating the optimum number of clusters was presented, Das et. al [15} taking into account the cross-layer structure of the underlying physical medium access control network. kim et al [16] Effects such as lognormal shadowing and a twoslope route loss model in the physical layer Li et al [17], as well as a number of MAC scheduling and multihop routing algorithms, Rajeswari et al [18]can be included into a crosslayer architecture.

Logambigai and kannan [19] A multi-antenna sensor node, also known as a MASN, was utilised as the cluster head (CH). It brings MIMO and SIMO communication modes into WSN Ganapathy et al [20]. MIMO stands for multiple-input-multiple-output, and SIMO stands for single-input-multiple-output. Selvi et al [21] When the transmission range is greater than a predetermined threshold, Anupam Das et al [22] it is possible for this network to make significant savings on energy use. Noman Mohammed et al [23] It explains the implementation of the heterogeneous network as well as the unique communication system.

Li et al [24] addressed the issue of clustering that occurs in WSNs, with upper boundaries placed on the maximum latency, the amount of energy used by intermediary nodes, and the size of the clusters XueWang et al [25]. These limitations are required to ensure that the system is reliable and to maximise its useful life span ZhengYan et al [26]. An method with polynomial time that computes minimal weighted dominant sets in a recursive manner, taking into account latency and energy consumption limitations along the way.

Rajeswari et al [27-29]Create a proposal for a distributed algorithm that might be used to create clusters in an ad hoc sensor network. Every sensor decides on its own, using a random waiting duration and some locally determined criteria, whether to form a new cluster or to join an existing one. Jong-Myoung Kim et. al. [30] The approach is asynchronous, does not need a centralised controller, and may be implemented with little to no prior knowledge of the sensors' locations.

T. Sharma and B. Kumar [31-34] presented a hierarchical clustering technique that uses attributes to group nodes. In order to limit the amount of broadcast traffic created by the sensors as they provide the requests, it suggests clustering them based on the attribute values they have in common. Heinzelman, WB, Chandrakasan, PA & Balakrishnan, H. [35]The approach creates a load-balancing system and a fail-safe mechanism for the cluster head by reassigning that role to different nodes in the cluster at regular intervals.

Younis, O & Fahmy, S. [36] A sensor node within a cluster that assesses its relative energy consumption in comparison to the energy consumption of other nodes within the same cluster. Sensor nodes will choose, M & Wu, J [37]on their own, a time period in which they will function as a cluster header in the subsequent round based on

the proportionate amount of energy that they will use in the current round.

Soro, S & Heinzelman, WB [38] a customizable top-down cluster formation method and a cluster tree creation algorithm, as well as a cluster tree self-optimization phase, a hierarchical cluster addressing system, and a routing scheme were both proposed. This type of self-organization makes it feasible to transmit messages to a sink as well as successfully deliver them inside the network.

Mhatre, V & Rosenberg, C. [39] developed a method of prediction and clustering that works together. The usage of a sleep/awake schedule for data aggregation is explored as a means of achieving energy efficiency in a clustering and integrating adaptively enabling/disabling prediction method. After giving some thought to the event-driven clustered wireless sensor network, Moslem provide a probabilistic method for measuring the network's lifetime when events occur at random over the network's playing field. Ye, M, Lil, C, Chen, G, & Wu, J.[40]The sensors' packet transmission rate is modelled based on the theory of coverage processes and Voronoi tessellation. Then, we calculate the likelihood that a specified lifespan will be attained by a set of sensors. The study of cluster lifespan then relies on this likelihood.

clustering strategy for heterogeneous wireless sensor networks that is stochastic as well as balanced, dispersed, and energy efficient has been devised.[41]The functionality of the protocol depends on the network being segmented into roving groups of nodes. A brand-new method that is both more equitable and flexible is used to compute the cluster head election probability.[42]

COMPARISON

This section involves our task, we executed comparison and reviewed different fuzzy clustering methods. Primarily, presented an analysis that depends on network lifespan enhancement with that of LEACH protocol for significant clustering methodologies and consequently comparative analysis of surveyed algorithms is provided in Table

1. GCHL-FL and CFGA had proved to have improved to about 90% whereas CHEATS had presented least enhancement around 10%. Behaviour of fuzzy clustering schemes depends on input parameter features of fuzzy logic system. For determining performance different methods applied using MATLAB. With respect to literature, it is considered that if first node die out, network is thought of as dead. The SCCH, LEACH-ERE and CHEF behaves in a better way compared to other methods in term of LND and FND. LEACH-ERE and CHEF concepts applied hybrid methodology of fuzzy logic and LEACH as in relation to SCCH, where hybrid methodology of fuzzy logic and DEC is implemented. Technical difficulties of applying type-2 system as compared to that of type-1 systems remains un touched in surveyed technologies moreover fuzzy inference system is executed by every sensor node in each round, so time needed to estimate and evaluate outcome value utilizing fuzzy logic is dissimilar for each technique. Therefore methods having large number of inputs needs more run time comparative to that with least amount of fuzzy inputs methodologies

Table 1: Fuzzy based clustering technique"s comparative analysis

CONCLUSION

Because of restricted access and resources, WSNs needs energy conservation techniques and self- organization topology management. Different methods have been provided to solve energy saving problems, however one of most best solutions and popular is hierarchical architecture with two layers and distribute different management jobs between sensor nodes to attain number of aims including topology management, adaptation to non-critical failure and energy efficiency. Fuzzy logic is applied for enhancing performance of clustering techniques but most significant issue is that it needs Initial expert knowledge for selecting appropriate membership functions and designing set of rules. Hence algorithm having various membership functions consisting of same set of rules can provide many outcomes. Basic and underlying variance amongst different concepts is in computing chance. value of sensor node in becoming CH by applying various parameters from input Choosing a reliable system, less complex and more efficient is a bigger challenge as networks of sensors are application oriented where with network objectives priorities changes such as if data fidelity is highest

priority then higher fuzzy order systems are more suitable for however applying higher order systems invites new challenges. Researcher extensively explored Fuzzy based clustering in various feilds, few aspects are not thoroughly investigated. With respect to this some research locations needing further study like as exploitation of spatial correlation at network layer for decreasing amount bits sent by taking help from fuzzy logic, application of neural network in WSN and optimum number of fuzzy input variables to anticipate behaviour of fuzzy dependent methodologies.‖

REFERENCES

[1]. W. Heinzelman, A. Chandrakasan, and H. Balakrishnan (2002), —An application — specific protocol architecture for wireless microsensor net — works,‖ IEEE Trans. Wireless Commun., Vol. 1, No. 4, pp. 660–670.

[2]. P. Nayak and A. Devulapalli (2016), —A fuzzy logic — based clustering algorithm for WSN to extend the network lifetime,‖ IEEE Sensors J., vol. 16, no. 1, pp. 137–144.

[3]. J. M. Kim, S. H. Park, Y.J. Han, and T. M. Chung (2008), —CHEF: Clus — ter Head Election mechanism using Fuzzy logic in Wireless Sensor Networks,‖ in Proc. 10th Int. Conf. Adv. Commun. Technol., vol. 1, pp. 654 — 659.

[4]. T. Sharma and B. Kumar (2012), —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.

[5]. W. Heinzleman, A. Chandrakasan, H. Balkrishnan (2000), —Energy efficient communication protocol for wireless sensor networks‖, International conference system science.

[6]. L. A. Zadeh (1965), —Fuzzy Sets‖, Information and Control, Vol. 8, pp. 338- 353.

[7]. Hemavathi Natarajan, Sudha Selvaraj (2014), —A Fuzzy Based Predictive Cluster Head Selection Scheme For Wireless Sensor Networks‖, International Conference on Sensing Technology, pp. 560-566.

[8]. Gupta, I., Riordan, D. and Sampalli, S. (n.d.). Cluster-Head Election Using Fuzzy Logic for Wireless Sensor Networks. 3rd Annual.Communication Networks and Services Research Conference (CNSR'05).

[9]. Al-Karaki, J. N., & Kamal, A. E. (2004). Routing techniques in wireless sensor networks: A survey.IEEE Wireless Communications, 11, pp. 6–28.

[10]. Akyildiz, I. F., &Vuran, M. C. (2010), Wireless sensor networks (pp. 131–141). Hoboken: Wiley.

[11]. Heinzelman, W. R., Chandrakasan, A., Balakrishnan, H. (2000), Energy-efficient communication protocol for wireless micro sensor networks. In Proceedings of the 33rd annual Hawaii international conference on system sciences, IEEE (pp. 1–10).

[12]. Mhemed, R., Aslam, N., Phillips, W., &Comeau, F. (2012), An energy efficient fuzzy logic cluster formation protocol in wireless sensor networks. Procedia Computer Science, 10, pp. 255– 262.

[13] Rajeswari, A.R., Kulothungan, K., Ganapathy, S., & Kannan, A. (2016) Malicious Nodes Detection in MANET Using Back-Off Clustering Approach. Circuits and Systems 7 (8), pp. 2070-2079.

[14] Younis, O., &Fahmy, S. (2004). HEED: A hybrid energy-efficient, distributed clustering approach for Ad Hoc sensor Networks. IEEE Transaction on Mobile Computing, 3, pp. 366–379.

[15] Das, A., & Islam, M. M. (2012). Secured trust: A dynamic trust computation model for secured communication in multiagent systems. IEEE Transactions on Dependable and Secure Computing, 9(2), pp. 261–274.

[16] J. Kim, S. Park, Y. Han, T. Chung (2008), CHEF: cluster head election mechanism using fuzzy logic in wireless sensor networks, in: Proceedings of the ICACT, pp. 654– 659.

[17] C. Li, M. Ye, G. Chen, J. Wu (2005), An energy-efficient unequal clustering mechanism for wireless sensor networks, in: IEEE International Conference on Mobile Ad Hoc and Sensor Systems Conference, p. 8.

[18] Rajeswari, A.R., Kulothungan, K., Ganapathy, S., & Kannan (2017), A. Trust Aware SVM Based Ids For Mitigating The Malicious Nodes In Manet. International Journal of Innovative Technology and Exploring Engineering.8(8). pp. 185-197.

[19] Logambigai, R., &Kannan, A. (2016), Fuzzy logic based unequal clustering for wireless sensor networks. Wireless Networks, 22, pp. 945–957.

[20] Ganapathy, Kulothungan, Yogesh, Kannan

(2012), —A Novel Weighted Fuzzy C-Means Clustering Based on Immune GeneticAlgorithm for Intrusion Detection‖, Proceeding Engineering, Elsevier, vol. 38, pp. 1750-1757.

[21] Selvi, M., &Nandhini, C., Thangaramya, K., Kulothungan, K., &Kannan, A. (2016). HBO based clustering and energy optimized routing algorithm for WSN. In Proceedings ofthe eighth international conference on advanced computing (ICoAC) (pp. 89– 92).

[22] Das, A., & Islam, M. M. (2012). Secured trust: A dynamic trust computation model for secured communication in multiagent systems. IEEE Transactions on Dependable and Secure Computing, 9(2), pp. 261–274.

[23] Mohammed, N., Otrok, H., Wang, L., Debbabi, M., & Bhattacharya, P. (2011). Mechanism designbased secure leader election model for intrusion detection in MANET. IEEE Transactions on Dependable and Secure Computing, 8(1), pp. 89–103.

[24] Li, F., & Wu, J. (2010). Uncertainty modelling and reduction in MANETs. IEEE Transactions on Mobile Computing, 9(7), pp. 1035–1049.

[25] Wang, X., Ding, L., & Wang, S. (2011). Trust evaluation sensing for wireless sensor networks. IEEE Transactions on Instrumentation and Measurement, 60(6), pp. 2088–2095.

[26] Yan, Z., & Prehofer, C. (2011). Autonomic trust management for a component-based software system. IEEE Transactions on Dependable and Secure Computing, 8(6), pp. 810–823.

[27] Rajeswari, A.R., Kulothungan, K., Ganapathy, S., & Kannan, A. (2017), Trust Aware Svm Based Ids For Mitigating The Malicious Nodes In Manet. International Journal of Innovative Technology and Exploring Engineering. 8(8), pp. 185-197.

[28] Rajeswari, A.R., Kulothungan, K., & Kannan,A. (2016), GNB-AODV: Guard Node Based – AODV to Mitigate Black Hole Attack in MANET International Journal of Scientific Research in Science, Engineering and Technology 2(6). pp. 671-677

[29] Rajeswari, A.R., Kulothungan, K., Ganapathy, S., & Kannan, A. (2017), Performance Analysis of Malicious Nodes Detection System in Manet Using Anfis Classifier International Journal for Research in Applied Science & Engineering Technology 5(1). pp. 14-21

[30] J. M. Kim, S. H. Park, Y. J. Han, and T. M. Chung (2008), —CHEF: Clus — ter Head Election mechanism using Fuzzy logic in Wireless Sensor Networks,‖ in Proc. 10th Int. Conf. Adv. Commun. Technol., vol. 1, pp.654–659.

[31] T. Sharma and B. Kumar (2012), –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.

[32] B. Baranidharan and B. Santhi (2016),—DUCF: Distributed load balancing unequal clustering in wireless sensor networks using fuzzy approach,‖ Appl. Soft Comput., Vol.40, pp. 495–506.

[33] P. Gupta and A. K. Sharma (2017),—Clustering – based Optimized HEED pro- tocols for WSNs using bacterial foraging optimization and fuzzy logic system,‖ Soft Comput., vol. 23, no. 2, pp. 507 – 526.

[34] A. Verma, M. Khosla, T. Rashid, and A. Kumar (2017), —Grid and fuzzy based stable energy — efficient clustering algorithm for heterogeneous wireless sensor networks,‖ in Proc. 14th IEEE India Council Int. Conf. (INDICON), pp. 1–6.

[35] Heinzelman, WB, Chandrakasan, PA & Balakrishnan, H. (2002), —An application — specific protocol architecture for wireless micro sensor networks,‖ IEEE Transactions on Wireless Communications, vol. 1, no. 4, pp. 660–670.

[36] Younis, O & Fahmy, S. (2004), —HEED: A hybrid, energy — efficient, distributed clustering approach for ad-hoc sensor networks,‖ IEEE Transactions on Mobile Computing, Vol. 3, No. 4, pp. 336–379.

[37] Chen, G, Li, C, Ye, M & Wu, J. (2009), —A n unequal cluster — based routing protocol in wireless sensor networks,‖ Springer Journal on Wireless Networks, vol. 15, no. 2, pp. 193–207.

[38] Soro, S & Heinzelman, WB (2005),—Prolonging the lifetime of wireless sensor networks via unequal clustering,‖ Proceedings of the 19th IEEE InternationalParallel and Distributed Processing Symposium IPDPS'05, vol. 13, pp. 236–244

[39] Mhatre, V & Rosenberg, C. (2004), —Design guidelines for wireless sensor networks: communication, clustering and aggregation,‖ Elsevier Journal of Ad Hoc

Networks, vol. 2, no. 1, pp. 45–63

[40] M, Lil, C, Chen, G, & Wu, J. (2005),—EECS: An energy efficient clustering scheme in wireless sensor networks,‖ IEEE International Conference on Performance, Computing and Communications, IPCCC, pp. 535–540

[41] Lei, L, Huang, A, Xu, N, Cheng, Y, & Zhang, H (2008), —An energy efficient ring — based hierarchical routing protocol for wireless sensor networks,‖ IEEE International Conference on Communications & Networking, ChinaCom 2008, pp. 737–742.

[42] Wei, D, Jin, Y, Vural, S, Moessner, K & Tafazolli, R (2011), —An energy efficient clustering solution for wireless sensor networks,‖ IEEE Transactions on Wireless Communications, Vol. 10, No. 11, pp. 3973 — 3983.

[43] Ben Alla, S., Ezzati, A., and Mohsen, A. (2012), Gateway and Cluster Head Election using Fuzzy Logic in heterogeneous wireless sensor networks. 2012 International Conference on Multimedia Computing and Systems.

[44] Mhemed, R., Aslam, N., Phillips, W. and Comeau, F. (2012), An Energy Efficient Fuzzy Logic Cluster Formation Protocol in Wireless Sensor Networks. Procedia Computer Science, 10, pp. 255-262.

[45] Lee, J. and Cheng, W. (2012). Fuzzy-Logic-Based Clustering Approach for WirelessSensor Networks Using Energy Predication. IEEE Sensors J., 12(9), pp. 2891-2897.

[46] Mao, S., Zhao, C., Zhou, Z. and Ye, Y. (2012). An Improved Fuzzy Unequal Clustering Algorithm for Wireless Sensor Network. Mobile Networks and Applications, 18(2), pp. 206-214.

[47] Mohan, C., Suman, and Kumar, A. (2013). Heterogeneous fuzzy based clustering protocol. 2013 IEEE Second International Conference on Image Information Processing (ICIIP-2013).

[48] Zhang, F., Zhang, Q. and Sun, Z. (2013). ICT2TSK: An improved clustering algorithm for WSN using a type-2 Takagi-Sugeno-Kang Fuzzy Logic System. 2013 IEEE Symposium on Wireless Technology & Applications (ISWTA).

[49] Afifi, W., and Hefny, H. (2014). Adaptive TAKAGI-SUGENO fuzzy model using weighted fuzzy expected value in wireless sensor network. 2014 14th International Conference on Hybrid Intelligent Systems.

[50] Zhang, Q., Sun, Z. and Zhang, F. (2014). A clustering routing protocol for wireless sensor networks based on type-2 fuzzy logic and ACO. 2014 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE).

[51] Nithyakalyani, S. and Kumar, S. (2013). Voronoi Fuzzy Clustering Approach for Data Processing in WSN. International Journal of Computational Intelligence Systems, 7(1), pp. 105-113.

[52]. Izadi, D., Abawajy, J. and Ghanavati, S. (2015). An Alternative Clustering Scheme in WSN. IEEE Sensors J., 15(7), pp. 4148- 4155.

Corresponding Author

Abasaheb G. Patil*

Ph.D. Student

E-Mail – agpatil112@gmail.com