

Review of Energy Efficient Swarm Intelligence Based Cluster Head Selection (EESI-CHS) Algorithms in MANET

S.Kalaipriya, Coimbatore, Tamil Nadu, India, kalaipriya0109@gmail.com

ABSTRACT: A Mobile Ad hoc Network (MANET) is a wireless system where mobile nodes are associated with every other during infrastructure-fewer connections. Cluster Head (CH) is a node in the group which is active as a leader node. It preserves the data having listing of nodes, path of each and every node associated towards its related cluster. In MANET, usual CH selection algorithms depend on energy, however it is still an argument in MANET and particularly when nodes are travelling. Several parameters are being able to be measured for choosing the most excellent node as a CH. A number of these parameters consist of the position of the node via other nodes, mobility, energy, network lifetime, and delay of the node. These parameters will not straightforwardly resolve with existing usual CH selection algorithms. Aim of this review is to clearly discuss their parameters for CH election based on intelligence methods. In this paper we review various Energy Efficient Swarm Intelligence Based Cluster Head Selection (EESI-CHS) methods and clustering methods in MANET. This review work is used to converse a wide number of algorithms introduced formerly for CH election in MANET is noticeably discussed. This review paper will focus on the issues of mobility and energy efficiency to which CH selection methods are inspired by SI methods. The chosen CHs pay attention to mobility and remaining energy for choosing nodes in the direction of serving as CHs for a longer duration of time. The proposed AI based algorithm and existing methods are widely experimented via NS-2 network simulator. Simulation results are measured via metrics like Network Lifetime(NL), energy consumption, Average End-To-End Delay(E2D) and Packet Delivery Ratio (PDR).

INDEX TERMS: Clustering, Cluster Head (CH), Energy Efficient Clustering(EEC), Efficient Swarm Intelligence Based Cluster Head Selection (EESI-CHS), Mobile Ad hoc Network (MANET), Network simulator, Swarm Intelligence (SI).

I. INTRODUCTION

Mobile Ad hoc Network (MANET) is a self-reliant structure in which more than one hosts are related with every different the use of multihop wi-fi hyperlinks [1]. MANET is the set of Mobile Nodes (MNs) successful to share information with their neighbors. The MNs may also generate their very own data, or they can also be obtained from different neighbors. MANET might also be used for managing distinctive applications for example, rescue, flood monitoring, border monitoring, catastrophe management, and conflict subject communication. The clustering methods operate properly when the MANET dimension will become large in contrast to flat MANET in spite of routing method. Developing a clustering algorithm in a position to route data by means of small effort is a require of the day in MANET (See Figure 1). Clustering is a vital idea, and its significance can be referred to in two ways. Firstly, network management is able to be carried out correctly by the clustering algorithm. Secondly, the issues like controlling the topology, development of digital network, intrusion

detection, and routing be able to be solved by means of the assist of clustering [2],[3]. All the subjects noted until now are dedicated primarily based on simple MANET clustering (Figure 2).

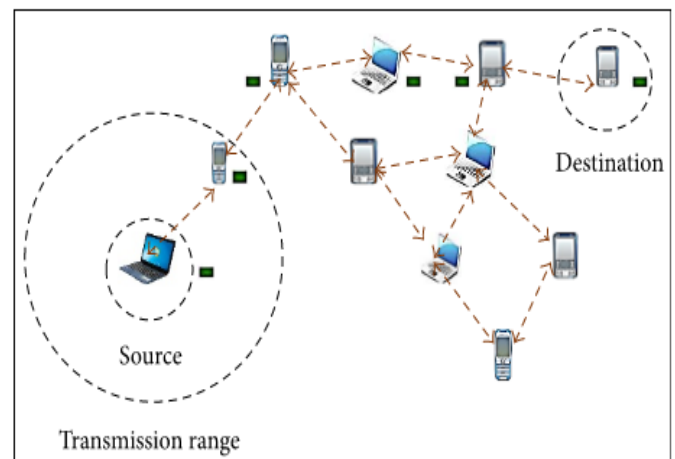


FIGURE 1. A MOBILE AD HOC NETWORK (MANET)

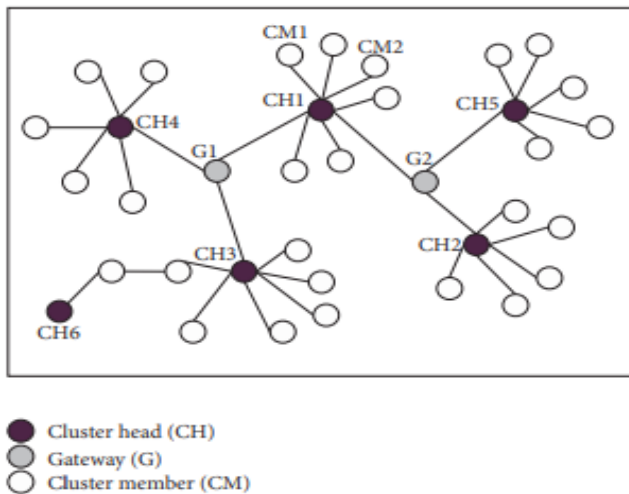


FIGURE 2. AN ILLUSTRATION OF CLUSTERS IN MANET

Clustering approach reduces the quantity of radio transmissions and will increase sensor network lifetime [4]. Clustering is the approach, which separates the geographical location into small sectors [5], [6]. It helps sensor nodes to distribute workload amongst all the server nodes evenly and one of the nodes be assigned as the head of the cluster, which named as ‘Cluster Head’ (CH). The resolution of CH is a predominant function for higher statistics transmission. In practical, CH reformed whilst wonderful iterations to supply the pleasant performance.

The special cluster consists of a CH with greater cluster members. The duty of the CH is that it needs to coordinate all the nodes current in the cluster [7], [8].

However, the ideal CH decision [9], [10] alongside with most reliable capabilities is vital to stability the network’s energy-efficiency ratio. Thus the resolution of most efficient CHs is an NP-hard trouble [11].

With the development of plenty nature inspired methods for one-of-a-kind optimization problems, researchers are inspired to improve options for CH choice in MANET by way of talent methods. There are quite number purposes of bio-inspired computing and the want of all these algorithms is for CH choice problem. Each viable answer in an optimization algorithm is derived in two ways, that is, deterministic and stochastic. All deterministic algorithms are typically included by way of a positive mathematical system and the search proceeds in solely one direction; that is, these are unidirectional searches guided with the aid of positive rules. Artificial Intelligence (AI) fashions which include Artificial Bee Colony (ABC), Particle swarm Optimization (PSO), Genetic Algorithm (GA), and evolutionary algorithms are used for clustering method to over the NP-hard optimization issue.

Optimal CH decision framework with the aid of AI strategies outcomes in minimization of energy, delay, distance and so on. Among the countless algorithms, most of

them have been adopted to accomplish the most useful CH determination in WSN. Moreover, this work is the complete evaluate of each and every factor concerning the cluster-based algorithms and schemes for MANET. The goals of this work are to severely evaluation and analyze the prominent state of the artwork of cluster-based MANET algorithms. First, a variety of cluster-based schemes are allotted into aim particular categories. Second, comparative learn about of quite a number methods thru AI is presented, which assists in creating the environment efficient cluster-based protocols. Finally, open lookup problems are mentioned which can be the future line of directions.

II. REVIEW OF CLUSTERING METHODS IN MANET

The recent research on the cluster-based algorithm in MANET is presented in this section. The clustering procedures are divided into the following classes such as energy efficient clustering methods and Optimization and Swarm Intelligence-Based Clustering.

I.1 Energy-efficient clustering methods

Saxena et al [12] introduced an energy aware algorithm based totally on clustering for longer existence of MANET. In this method MANET is divided into little and self manageable corporations for enhancing the community lifetime. The proposed algorithm would be an energy aware clustering algorithm that makes use of each scalability and strength metric for cluster layout. In this approach, the notion of Lowest ID Clustering (LIC) algorithm is used. Maxheap is used for resolution of cluster head. The Clusters are designed the use of max-heap on the foundation of strength level; the node which has the best electricity in the cluster will act as a CH. With the use of Multi Point Relay (MPR), the congestion in the MANET can be decreased and this can store the power of closing CH.

Choukri et al [13] described a routing schema for a conversation network constituted via MANET nodes. This gadget optimizes power consumption. It divides the MANET into clusters. Thereafter it detects the pleasant way in phrases of power to be taken through a move of data. This consists to calculate the power required for every on hand route and pick out the most desirable gateways. Each cluster is recognized via a cluster-head which is elected in accordance to its role and its residual strength with the aid of the use of a clustering algorithm. The important goal of this work is to optimize the quantity of stay nodes by using assigning to every network undertaking the excellent nodes.

Kaur and Kumari [14] introduced a proficient and modified load balancing algorithm. This paper suggests the effects of the proposed energy based load balancing algorithm. Global reclustering is initiated when the network turns into extensively unbalanced i.e. if the variance of degree of the CHs in the MANET is increased than a pre-determined threshold. Degree of all cluster heads would be required at a single node to consider the common of degree of all cluster heads in the MANET and as a result the variance amongst themselves, which is no longer viable in adhoc network due to the fact of its disbursed nature. For this, a system is derived in which variance can be up to date at every hop i.e. variance of N nodes can be expressed in phrases of variance of (N-1) nodes and common of (N-1) nodes. The consequences of simulation point out that in contrast with the load balanced routing algorithm Dynamic Energy Efficient Clustering Algorithm (DEECA), the proposed algorithm accelerated the Network lifetime, packet Delivery ratio (PDR) at unique traffic.

Barma and Kar [15] proposed an 'Energy Efficient Weighted Clustering Algorithm (EEWCA)'. The algorithm avoids re-clustering by using making 2nd minimal weighted node as cluster head, which is saved in weight listing desk maintained by way of every cluster head. WCA, CH is chosen based totally on weight of every node. Weight is calculated based totally on some metrics like node degree, distances with all neighbour nodes, node velocity and time spent as a CH. Proposed algorithm targets to resolve this hassle and for this reason minimize the energy consumption by way of averting flooding of messages all through cluster maintenance. The key notion of this algorithm is that it avoids re-election of cluster head and reduces specific flooding of messages amongst member nodes. This improves the overall performance and consumes much less power.

Rajesh et al [16] introduced a Cluster based algorithm with reduced energy usage and evaluates upgrades over the current systems. This work contributes closer to the enhancement of the power effectively of the algorithm for an incredibly dense MANET structure except disproving the advantages of the greater congestion manipulate and decrease period of the routing algorithms. The work establishes the extended effects in contrast to the current algorithms. In the direction of the study, the work gives the classifications of the MANET routing algorithms with their superb dismissal prerequisites for any given network.

Oh and Lee [17] proposed a superior energy-conserving ideal path schedule method. The proposed algorithm units the routing path the usage of the relative angle which is measured based on distance between the supply node and the base station. Simulation outcomes in contrast the proposed algorithm to current algorithms, which shows that the proposed work,

performs better than the existing methods. The protocol used with the aid of the proposed algorithm presents a greater Packet Delivery Ratio(PDR) and decrease power consumption than the lowest ID clustering algorithm and the mobility-based metric for clustering in the MANET algorithm.

Muthurajkumar et al [18] introduced a new secured routing protocol known as Cluster primarily based Energy Efficient Secure Routing Algorithm (CEESRA) which is energy environment and makes use of cluster based totally routing in which they trust scores on nodes are used to observe the intruders successfully. It decreases the Denial of Service assaults greater successfully via the use of AI for high-quality selection making in routing. From the experiments carried out with this trust based secured routing algorithm, it has been located with the purpose of this proposed routing algorithm now not solely enhances the protection however additionally reduces the strength consumption and routing delay. The proposed algorithm is simulated in NS3 and observed to supply higher effects in CH decision in phrases of variety of clusters shaped and lifetime of the CH.

Drishya and Vijayakumar [19] introduced a Modified Energy-Efficient Stable Clustering (MEESC) algorithm in which node mobility is specified extra significance in weight determination for the decision of CH. One of the methods is weight-based clustering which entails the weight determination of nodes the use of quite a number metrics of nodes such as residual electricity in the battery, transmission range, degree of the node and mobility. Moreover, have confidence issue is additionally viewed in weight determination which assist to go with exceptional node as CH. It considers the mobility and has faith of the node exceptionally and selects the CH which will continue to be energetic for extra time in the network. Amutha et al [20] proposed a Cluster Manager Based Cluster Head Selection (CMBCH) scheme to solve the energy usage issues and influence CH workload. CMBCH includes of two parts, such as Cluster Manager (CM) and Cluster Head (CH). The CM takes the accountability of controlling and monitoring of nodes actions. The CH leads and performing packet switch amongst the nodes in the MANET. At this stage, when cutting-edge CH power level is drained, CM elects the related node with excessive power level and the new, as properly as historical CH things to do are concurrently saved via CM. To show the proposed scheme efficiency, a simulation test was once performed for 20 to a hundred nodes below the AODV routing protocol. The results outcomes are in contrast to others; CMBCH conserves minimal power and bandwidth and additionally achieves dependable throughput via secure routing.

Dixit et al [21] introduced a Light Weight Efficient Cluster based totally routing Model (LWEC) in which

the lifestyles of CH is extended via lowering the useless load on CH in MANET. A regular nodes is the element of a cluster which neither the CH now not the gateway node. A new kind of node is delivered referred to as refugee node in addition towards the CH, gateway and regular node. Refugee nodes comes into survival whilst cluster maintenance. When a CH die or depart from its cluster, its member nodes strive to affiliate themselves to close by clusters. When the orphan node does no longer in a position to hear any close by CH however capable to hear a member of a cluster, it can connect itself to network mutely as refugee node thru this member node. The notion of refugee node is primarily based in the notion with the purpose of the re-affiliation is much less comfortable as examine to re-clustering. LWECM algorithm makes sure the honest load distribution amongst the CH through determining the burden element which is the feature of node's degree and last power.

I.2 Optimization and Swarm Intelligence-Based Clustering methods

This section presents a swarm intelligence-based clustering and optimization methods for CH selection in MANET.

Ali et al[22] proposed a multi-objective key by way of the usage of Multi-Objective Particle Swarm Optimization (MOPSO) algorithm towards optimize the variety of clusters in an MANET as nicely as electricity dissipation in nodes in order to supply an energy-efficient solution and minimize the community traffic. In the proposed work, inter-cluster and intra-cluster site visitors is handling by using the CHs. It includes the metrics like degree of nodes, transmission power, and battery consumption of the cellular nodes. The important gain of this technique is that it gives a set of options at a time. These options are finished via most excellent Pareto front. Simulations outcomes exhibit with the purpose of the proposed strategy is a high-quality strategy for clustering in MANET surroundings and performs higher than the different two approaches.

Khatoon [23] centered on the issues of mobility and power effectively to improve a clustering algorithm stimulated by using multiagent stochastic parallel search method of PSO. The election of CHs takes care of mobility and last power as nicely as the diploma of connectivity for choosing nodes to serve as CHs for longer length of time. The cluster formation is introduced by means of taking the use of multiagent stochastic parallel search with PSO. The proposed work is experimented appreciably in the NS-2 simulator and in contrast with the different current algorithms. Simulation results shows that the proposed algorithm performs better with respect to network lifetime, common variety of clusters formed, common variety of reclustering required, electricity consumption, and Packet Delivery Ratio(PDR).

Pathak [24] proposed Proficient Bee Colony-Clustering

Protocol (PBC-CP) which is based totally on synthetic BC algorithm. PBC-CP approach, has taken essential elements for determination of heads such as node's energy, degree of node, and distance from base station towards node. For transmitting the information from CH to base station, it chooses the energy-efficient direction which similarly minimizes the power consumption of sensor network. Simulation experiments exhibit the effectiveness of proposed approach.

Ahmad et al [25] proposed a new method for clustering formation. Later, an algorithm on the origin of honey bee algorithm, Genetic Algorithm and Tabu Search (GTBC) for internet of things is considered noticeably. In this algorithm, the person (bee) represents a viable clustering shape and its health is evaluated on the foundation of its steadiness and load balancing. The proposed work is performed by combining of honey bee and genetic algorithms to assist the populace to cope by means of the topology dynamics and create top first-class options to be intently associated to every other. The simulation effects performed for validation exhibit with the purpose of the proposed work types stability and steady clusters. The proposed GTBC algorithm performs better with respect to network lifetime and clustering overhead etc.

Elhabyan et al [26] proposed a single multi-objective trouble method attempting these two troubles simultaneously with the purpose of discovering the choicest network configuration. It takes into consideration the variety of CHs, the range of clustered nodes, the hyperlink high-quality between the Cluster Members (CMs) and CHs and the hyperlink pleasant of the built routing tree. To choose the optimal multi-objective optimization method, two Multi-Objective Evolutionary Algorithms (MOEAs) are introduced, and their overall performance is in contrast the usage of two accepted great indicators: the hypervolume indicator and the Epsilon indicator. The proposed protocol is developed and examined in realistic environment and. Simulation effects exhibit with the purpose of the proposed protocol works better in terms of average consumed energy per node, number of clustered nodes, the throughput at the Base Station (BS) and execution time.

Ahmad et al [27] introduced a honey bee algorithm for dividing the MANET nodes addicted to extraordinary clusters. The bees work to accumulate in corporations towards operates their activities. This clustering forms clusters in a capable way by means of smaller amount assets such as energy and bandwidth use. A node is chosen as CH depending on node degree, neighbor's behaviour, mobility direction, mobility speed, and remaining energy. Appropriate to the environment friendly nature of bees and most parameter's consideration, the proposed approach stimulated from the foraging conduct of

honey bee's offers environment friendly and steady cluster formation. The manage message overhead is additionally avoided. The work is validated accurately, and simulation has been carried out for exceptional scenarios. The simulation results show with the purpose of the proposed algorithm is used for clustering performs better when compared to existing schemes.

Gupta et al [28] proposed an Artificial Fish Swarm Optimization (AFSO) to choose the CH in MANET process. The selection of CH takes care of mobility and remaining energy as properly as the diploma of connectivity for deciding on nodes towards serve as cluster for longer length of time. From the simulation results, it is located with the purpose of the proposed technique gives the most NL time as 80 to 140 hours and minimal energy usage as 9 to a 130 J, in contrast with current protocol and optimization technique.

Rahul and Kaarthick [29] introduced a Node Quality-based Clustering Algorithm (NQCA) the usage of Fuzzy-Genetic for Cluster Head and Gateway Selection (FGCHGS). In this algorithm, NQCA is carried out based totally on the Improved Weighted Clustering Algorithm (IWCA). The NQCA algorithm divides the complete MANET into quantity of clusters and the Cluster Head (CH) for each cluster is elected on the groundwork of the node priority, transmission vary and node local fidelity. Merged weight values are optimized by using the use of Genetic Algorithm (GA) to select the most optimum weight cost that selects each top-quality CH and gateway. On the other hand, the convergence time of GA and the error suitable towards consideration tuning at some stage in optimization are high. Hence, a NQCA the usage of Fuzzy-Fruit Fly optimization is introduced for CH and Gateway Selection (FFFCHGS). Fruit Fly (FF) algorithm is proposed as a substitute of GA to choose the most ultimate CH and gateway. At last, an overall performance effectiveness of the FFFCHGS algorithm is measured via the simulation effects in phrases of energy, Packet Loss Rate (PLR), etc.

Sampath Kumar and Veni [30] introduced an Enhanced Energy Steady Clustering (EESC) scheme to gather the constant clustering communication. The sender accumulates each and every one data and transmits to receiver via path, which need supplying regular clustering communication. Examination of convergence node is reduced the loss of conversation particulars. Consequently, the convergence node based path algorithm is created in MANET set-up. The convergences of every node, which are successful to accomplice with likely neighbour nodes, are scheduled, in which these nodes have higher quantity of convergence factor and it will selected for packet transmission. It decreases packet loss rate, and development network lifetime. Subsequently, the greatest direction is chosen by means of Hybrid Chicken

Swarm Optimization (HCSO). The fitness function is utilized to attain the most desirable direction from source node to destination node to decrease the energy usage in multipath routing. The overall performance is compared to the likely EDC protocol with the current Trust-Based Task Assignment (TBTA), Improved Trust relying Cluster Communication (ITCC), and Energy Efficiency Optimization (EEO) techniques illustrates the expected EDC protocol which gives better results.

Maganti and Patnaik [31] introduced a new Metaheuristic Quantum Glowworm Swarm Optimization Clustering with Secure Routing Protocol (QGSOC-SRP) for MANET. QGSOC-SRP method follows two major steps, specifically most fulfilling CH choice and route selection. Firstly, the QGSO algorithm derives a characteristic the usage of 4 variables such as energy, distance, node degree, and trust factor trust factor for most efficient election of tightly closed CHs. Secondly, the SRP the use of Oppositional Gravitational Search Algorithm (OGSA) is utilized for the finest choice of routes to BS. The standard GSA is stimulated by means of the regulation of gravity and interplay amongst masses. To enhance the effectiveness of the GSA, OGSA is derived primarily based on the oppositional based totally mastering notion for populace initialization and era jumping. For validating the nice consequences of the introduced QGSOC-SRP technique, a set of experiments had been carried out and the effects are decided interms of distinct measures.

Devika et al [32] proposed a Particle Swarm Optimization (PSO) and Wolf Search optimization techniques to enhance the performance of Low Energy Adaptive Clustering Hierarchy (LEACH) algorithm. PSO is castoff for cluster formation and Wolf search for detection of two relay nodes: intra and inter relay node. Proposed LEACH PSO Wolf search based Optimization (LEACH-PWO) is simulated via Spyder-py3 device. The proposed algorithm is compared with LEACH, power-efficient gathering in sensor records systems, Ant Cuckoo optimized the use of energy-efficient information aggregation, and GA information Aggregation LEACH protocols point out extended lifetime of MANET and extended throughput.

III. RESULTS AND DISCUSSION

In this part describe the simulation outcomes of the SI based totally CH decision methods. First carried out the already present associated clustering algorithms, that is adaptive CH resolution by MOPSO, PBC-CP, and PWO in MANET. It is respective CHs and hence forming an extra compact cluster with best load stability on CHs. NS2 simulator [36] for execution of our simulation work. To check proposed algorithm, the range of nodes varies from 20 to a hundred Nodes are deployed in the

simulation place of 750m × 750 m. The transmission vary of nodes varies from 10m to 180m and nodes are initialized with a preliminary electricity of 80000 Nanojoule (NJ). The simulation parameters are summarized in Table 1. The simulation consequences exhibit the effectivity of the MOPSO, PBC-CP, PWO in phrases of Packet Delivery Ratio (PDR), Average End-To-End Delay(E2D), Network Lifetime(NL), and power consumed.

TABLE 1: SIMULATION PARAMETERS

Parameter	Value
Number of nodes	20-100
Simulation area	750m × 750 m
Simulation time	500 seconds
Simulation iteration	100
Initial Energy	80000 NJ
Packet Size	512 bytes
Packet rate	35 packets/seconds
Transmission range of nodes	10 m- 180 m
Routing Protocol	AODV
Traffic type	Constant Bit Rate(CBR)
Movement model	Random way point
Maximum Speed	20 m/seconds
Radio Propagation model	Two-ray Ground

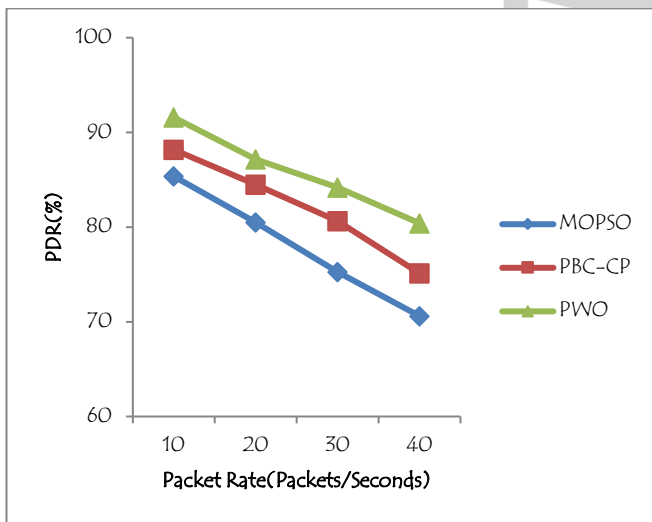


FIGURE 3. PDR VERSUS PACKET RATE

Figure 3 affords the PDR for MOPSO, PBC-CP, and PWO with a make bigger in packet rate. This is an essential overall performance metric which suggests the profitable range of packets acquired with the aid of a destination node. From the parent it can be observed that for the PWO the PDR is comparatively greater than PBC-CP and MOPSO. This is due to the fact in proposed work have taken steadiness deviation which is primarily based on the mobility of nodes, their route of motion, distances with neighbors, and the degree of connectivity as properly as strength depletion for CH selection. These parameters truly multiplied the lifetime of CHs.

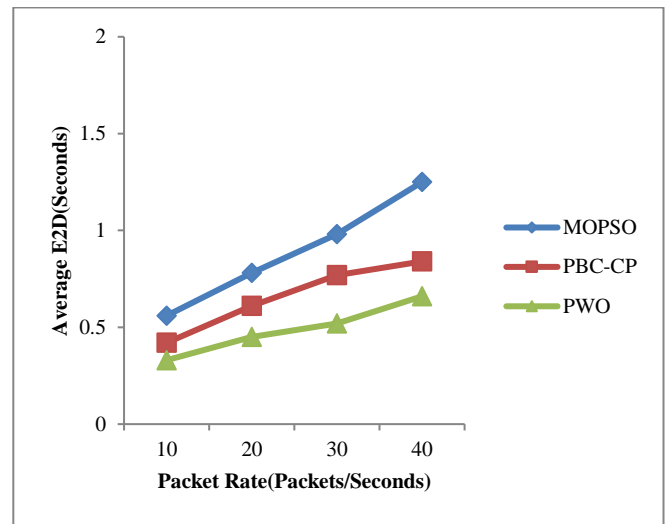


FIGURE 4. AVERAGE END-TO-END DELAY(E2D) VERSUS PACKET RATE

Figure 4 depicts the E2D with various packet rates. It can be found from the figure with the purpose of the proposed PWO algorithm has a decrease extend compared to MOPSO, and PBC-CP. This is due to the reality that in work centered on optimization of the electricity of CHs which relies upon on the ratio of their residual energy. Thus, depending on the electricity of CHs, a node receives affiliated with the one in its transmission vary having most strength. This eventually balanced hundreds on CHs and decreased the charge of packet dropped and subsequently reduces the average E2D in packet transmission.

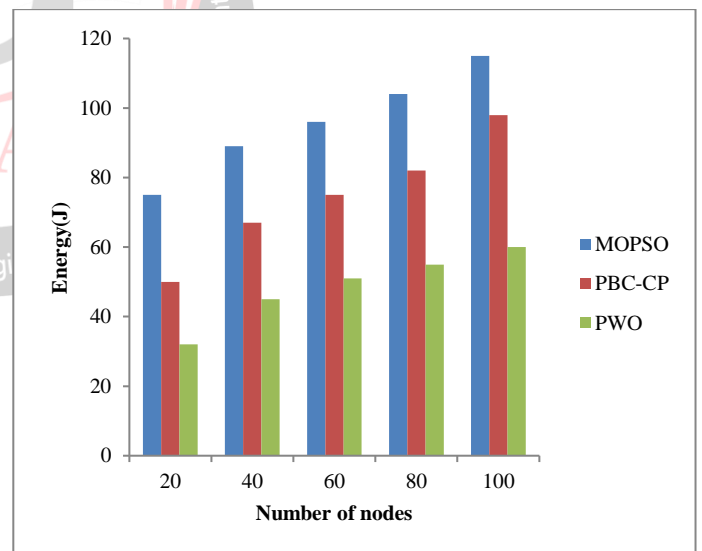


FIGURE 5. REMAINING BATTERY ENERGY PER NODE

Figure 5 suggests the effectiveness of PWO algorithm coupled with LEACH routing protocol in contrast with coupling the equal with MOPSO, and PBC-CP. As proven in this graph, three nodes died due to the exhaust in power when the proposed clustering algorithm is coupled with MOPSO, and PBC-CP has elevated node died when the identical coupled with LEACH.

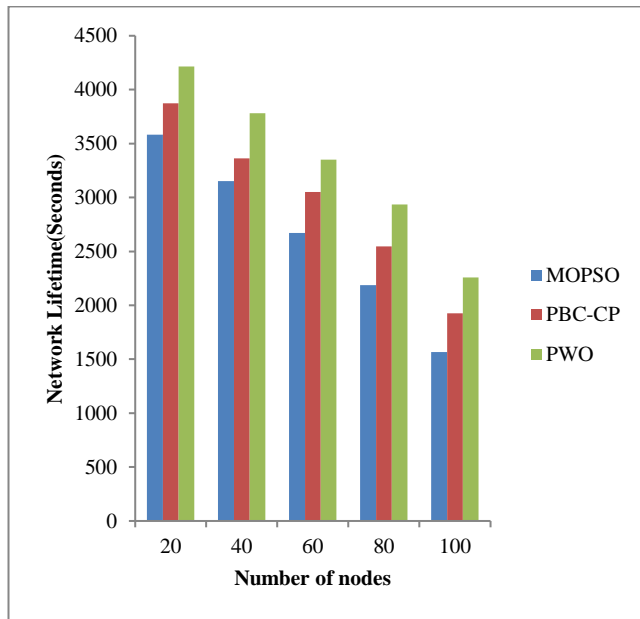


FIGURE 6. NETWORK LIFETIME VS. NUMBER OF NODES

Figure 6 indicates the effectiveness of the proposed algorithm in phrases of the network lifetime. This is an essential overall performance parameter described in a number methods by means of unique researchers like the time until the demise of the first CH or the closing CH or the demise of some share of CHs in the network. NL is proven as the time until the loss of life of the first CH in the network. The result proven in the diagram depicts the effectiveness of the proposed PWO work as the maximization of the lifetime of CHs maximizes the average network lifetime in contrast with the different existing algorithms.

IV. CONCLUSION AND FUTURE WORK

In this paper, a review of energy efficient clustering methods for MANET based on swarm intelligence approaches are clearly discussed. In SI based methods, each cluster includes an exacting node named Cluster Head (CH) is selected according to the grouping of metrics and SI behaviour. In SI methods, energy usage is considered the most important metric at the same time as choosing the CH. It helps to enlarge the network lifetime and energy efficient usage. CH which coordinates their cluster members used for longer duration of time depending on the metrics like energy, distance, delay, Network Lifetime (NL), stability. Each and every one the methods have used some metrics for CH selection which is clearly discussed in the review section. The review paper also presented a detailed survey of traditional clustering algorithms and SI based clustering methods for solving energy efficiency issues in MANET. It makes a clear difference between the universal clustering methods and SI based clustering in MANET. The simulation results of SI based clustering methods in MANET are also clearly discussed in this review paper. In the future further

enhance the algorithm for optimizing inter cluster multihop routing in MANET using SI methods. The simulation results of SI based clustering methods gives improved results than the other methods which are clearly shown in the results section. It concludes that the SI methods give increased NL, lesser delay, lesser energy usage, lesser distance and higher stability. The major findings of the work are to introduce a new SI based clustering methods for MANET, in order to reduce the energy efficient issue in CH selection. How the SI algorithms will increases the energy efficient issue rather than normal algorithms will be evaluated by applying different SI methods. In the future further enhance the algorithm for optimizing inter-cluster multihop routing in MANET using SI methods.

REFERENCES

- [1] Raza N., M. U. Aftab, M. Q. Akbar, O. Ashraf, and M. Irfan, "Mobile ad-hoc networks applications and its challenges," *Communications and Network*, vol. 8, no. 3, pp. 131–136, 2016.
- [2] Bokhari D. M., H. S. A. Hamatta, and S. T. Siddiqui, "A review of clustering algorithms as applied in MANETs," *International Journal of Advanced Research in Computer Science and Software Engineering Research*, vol. 2, pp. 364–369, 2012.
- [3] Azni, A.H., Ahmad, R., Seman, K., Alwi, N.H.M. and Noh, Z.A.M., 2016. Correlated topology control algorithm for survival network in MANETS. In *Advanced Computer and Communication Engineering Technology* (pp. 93-102). Springer, Cham.
- [4] Zhu E., R. Ma An effective partitional clustering algorithm based on new clustering validity index *Appl. Soft Comput.*, 71 (2018), pp. 608-621.
- [5] Baradaran A.A., K. Navi CAST-WSN: the presentation of new clustering algorithm based on steiner tree and C-means algorithm improvement in wireless sensor networks *Wireless Pers. Commun.*, 97 (1) (2017), pp. 1323-1344.
- [6] Ge X., Q. Han, X. Zhang Achieving cluster formation of multi-agent systems under aperiodic sampling and communication delays *IEEE Trans. Ind. Electron.*, 65 (4) (2018), pp. 3417-3426.
- [7] Zhang D., X. Wang, X. Song, T. Zhang, Y. Zhu A new clustering routing method based on PECE for WSN *EURASIP J. Wireless Commun. Network.*, 162 (2015), pp. 1-13.
- [8] Gavhale M., P.D. Saraf Survey on algorithms for efficient cluster formation and cluster head selection in MANET *Procedia Comput. Sci.*, 78 (2016), pp. 477-482.
- [9] Kalaikumar K., E. Baburaj FABC-MACRD: fuzzy and artificial bee colony based implementation of MAC, clustering, routing and data delivery by cross-layer approach in WSN *Wireless Pers. Commun.*, 103 (2) (2018), pp. 1633-1655.
- [10] Sahoo R.R. , A.R. Sardar, M. Singh, S. Ray, S.K. Sarkar A bio inspired and trust based approach for clustering in WSN *Nat. Comput.*, 15 (3) (2016), pp. 423-434.

- [11] Rajpoot P., P. Dwivedi Optimized and load balanced clustering for wireless sensor networks to increase the lifetime of WSN using MADM approaches *Wireless Netw.* (2018), pp. 1-37.
- [12] Saxena, M., Phate, N., Mathai, K.J. and Rizvi, M.A., 2014, Clustering based energy efficient algorithm using max-heap tree for MANET. In 2014 Fourth International Conference on Communication Systems and Network Technologies (pp. 123-127).
- [13] Choukri, A., Habbani, A. and El Koutbi, M., 2014, An energy efficient clustering algorithm for MANETs. In 2014 International Conference on Multimedia Computing and Systems (ICMCS) (pp. 819-824).
- [14] Kaur, S. and Kumari, V., 2015. Efficient clustering with proposed load balancing technique for MANET. *International Journal of Computer Applications*, 111(13), pp.21-26.
- [15] Barma, M.K.D. and Kar, P., 2017, Energy Efficient Weight Based Clustering in MANET. In Proceedings of the International Conference on Graphics and Signal Processing (pp. 101-105).
- [16] Rajesh, M.V., Gireendranath, T.V.S. and Murthy, J.V.R., 2017. A novel energy efficient cluster based routing protocol for highly dense MANET architecture. *International Journal of Computational Intelligence Research*, 13(5), pp.719-744.
- [17] Oh, Y.J. and Lee, K.W., 2017. Energy-efficient and reliable routing protocol for dynamic-property-based clustering mobile ad hoc networks. *International Journal of Distributed Sensor Networks*, 13(1), p.1550147716683604.
- [18] Muthurajkumar, S., Ganapathy, S., Vijayalakshmi, M. and Kannan, A., 2017. An intelligent secured and energy efficient routing algorithm for MANETs. *Wireless Personal Communications*, 96(2), pp.1753-1769.
- [19] Drishya, S.R. and Vijayakumar, V., 2019. Modified energy-efficient stable clustering algorithm for mobile ad hoc networks (MANET). In *Recent Developments in Machine Learning and Data Analytics* (pp. 455-465). Springer, Singapore.
- [20] Amutha, S., Kannan, B. and Kanagaraj, M., 2020. Energy-efficient cluster manager-based cluster head selection technique for communication networks. *International Journal of Communication Systems*, p.e4741.
- [21] Dixit, P., Pillai, A. and Rishi, R., 2020. A light weight efficient cluster based routing model for mobile ad hoc networks (LWECM). *International Journal of Information Technology*, 12(4), pp.1085-1091.
- [22] Ali, H., Shahzad, W. and Khan, F.A., 2012. Energy-efficient clustering in mobile ad-hoc networks using multi-objective particle swarm optimization. *Applied Soft Computing*, 12(7), pp.1913-1928.
- [23] Khatoon, N., 2017. Mobility aware energy efficient clustering for MANET: a bio-inspired approach with particle swarm optimization. *Wireless Communications and Mobile Computing*, vol.2017, no.1903190, pp.1-12.
- [24] Pathak A., "A proficient bee colony-clustering protocol to prolong lifetime of wireless sensor networks," *Journal of Computer Networks and Communications*, vol. 2020, Article ID 1236187, 9 pages, 2020.
- [25] Ahmad M., A. Hameed, F. Ullah et al., "A bio-inspired clustering in mobile adhoc networks for internet of things based on honey bee and genetic algorithm," *Journal of Ambient Intelligence and Humanized Computing*, vol. 2018, pp. 1–15, 2018.
- [26] Elhabyan R., W. Shi, M. St-Hilaire A Pareto optimization-based approach to clustering and routing in Wireless Sensor Networks *J. Network Comp. Appl.*, 114 (2018), pp. 57-69.
- [27] Ahmad, M., Ikram, A.A., Lela, R., Wahid, I. and Ulla, R., 2017. Honey bee algorithm-based efficient cluster formation and optimization scheme in mobile ad hoc networks. *International Journal of Distributed Sensor Networks*, 13(6), p.1550147717716815.
- [28] Gupta, D., Khanna, A., SK, L., Shankar, K., Furtado, V. and Rodrigues, J.J., 2019. Efficient artificial fish swarm based clustering approach on mobility aware energy-efficient for MANET. *Transactions on Emerging Telecommunications Technologies*, 30(9), p.e3524.
- [29] Rahul, P. and Kaarthick, B., 2021. Quality Based Clustering of Node using Fuzzy-Fruit Fly Optimization for Cluster Head and Gateway Selection in Healthcare Application, pp.1-25.
- [30] Sampath Kumar D. and Veni S., "Enhanced Energy Steady Clustering Using Convergence Node Based Path Optimization with Hybrid Chicken Swarm Algorithm in MANET", *International Journal of Pure and Applied Mathematics*, Vol. 118 No. 20 2018, 767-788.
- [31] Maganti, S. and Patnaik, M.R., 2021. Metaheuristic Quantum Glowworm Swarm Optimization based Clustering with Secure Routing Protocol for Mobile Adhoc Networks, pp.1-26.
- [32] Devika, G., Ramesh, D. and Karegowda, A.G., 2021. Energy optimized hybrid PSO and wolf search based LEACH. *International Journal of Information Technology*, pp.1-12.