

An Improved Moth-Flame Optimization Algorithm Based Clustering Algorithm for VANETs

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Abstract

Vehicular unplanned networks contain communication access points and aggregation data nodes and setting for traffic management a whole lot. Bunch area unit usually performed inside the transportunplanned networks for getting the specified target. Vary of transport unplanned links, consistency is that the most important disadvantage on it major analysis remains current. Throughout this text, a insect flame bunch rule is given for transport unplanned links, repetition the activity of insect flames in creating economical cluster. Moth flame's living routine is used to extract proposed framework. Augmented number of clusters is formed to make a communication in an effective manner. It is also called as intelligent algorithm due to the involvement of unsupervised clustering methods. In vehicular as hoc networks, clustering problems are optimized as well as resolved by using improved moth flame optimization framework which is an intelligent clustering method. Stability enhancement is the major objective of proposed work.

In comparison with well-known meta-heuristics, optimum outputs are produced by moth flame optimization, which is an intelligent clustering method as shown by results of experimentation. Based on clustering, robust routing mechanism is provided by this. In large highways, it is most commonly used to enhance, every vehicle's reliable delivery and productivity of quality communication

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1. Introduction

The simplest definition of links could also be a assortment of communication devices. utterly association totally different of various} devices to each different so as that the devices can merely transmit information to every different.

Links ar typically created inside utterly different domains for precise. In tiny things, link is formed on non-permanent basis. This network is termed adhoc links. These links are build less. In Adhoc links, there's multi sub-sections like transport surprising links, mobile surprising networks and surprising links. 1st focus

of the analysis is in transport surprising links. ideas of surprising is enforced beneath many things, presently manufacturing and obtaining used nearly all over. Number of using devices is increased by this method. For high productivity, researchers must this about new methods, which satisfies the need of increased demand and usage. In VANETs domain, various communication architectures and protocols have been developed [1]. For vehicles, which are running on road and units in road side are enabled with wireless communication by VANETs.

For road users, service providence is a major aim of this research. In research and implementation filed, VANETs are considered very often. For development of intelligent transportation systems (ITS), various projects are developed globally.

Vehicle-to-infrastructure (I2V or V2I), vehicle-to-vehicle (V2V), and hybrid version of both (V2X), are the further streams of VANETs. Traffic jam and various aspects are handled by this extensions [2]. During transportation, effective mechanism of communication is provided by this [3].

Analysis domain for quantifiability area unit necessary for link designers. At intervals last several studies, it is effective analysis result on inter-vehicle networks. New modifications and implementations ought to be developed. New analysis topic at intervals the VANETs is that the thanks to cluster or cluster the vehicles. In VANETs, vehicles communicate with each other. cars gather the info of traffic on the road, environmental factors, and different parameters [4].The gathered information is then transmitted to the anticipated vehicles. The transmission of information could also be a true troublesome issue as a result of the frequent modification in structure of the network. to contend with this issue, bunch is that the last word resolution. The aim is to with efficiency operate routing, care applications, quality management, military applications, safety alarms, data dissemination, and internet property.

The surroundings area unit formed by the factors of the matter and encourage the evolution to induce the best potential solutions. Evolutionary computation includes varied forms of Ea. variety of them area unit genetic programming (GP), genetic algorithms, process programming, evolution ways that, and learning classifier systems. Ea offers tight denumerable explanations to problems that cannot be resolved just by alternative ways. Varied improvement problems consist this cluster.

They will be really computationally thorough to go looking out a definite answer but generally a near-optimal clarification is adequate. In circumstances like these, process techniques area unit prosperous. Since the conveyance node bunch could be never-ending draw back, and additionally the EAs area unit really effective for this sort of problems, a system is projected for solving/optimizing the conveyance node bunch draw back in VANETs. Fig.1 shows the ultimate structure of VANETs. Our main contribution is to propose a routing protocol for the VANETs therefore hardness in communication could also be achieved. we have applied the nature-based technique to unravel the quality issue of VANETs. By victimization it, the load reconciliation is in addition achieved, and it reduces the procedure quality equally. what's additional, the simulation results area unit compared with the well-known existing algorithms to point the good analysis.

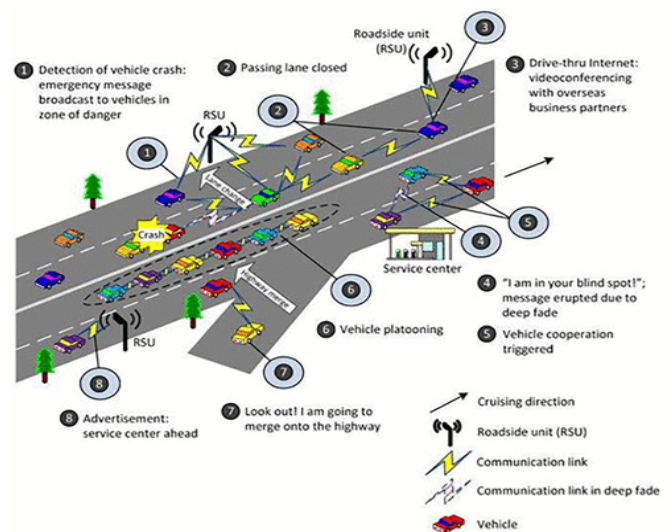


Fig.1. ITS service schematic

2. Existing Work

In vehicular ad hoc networks (VANETs), important role is played by ITS. For routing, it shows, various difficulties as well as opportunities [6]. In network, topology changes rapidly due to nodes mobile nature. This leads to lossy as well as short duration connections. Data transfer is made highly difficult

due to this [7]. Network's scalability issues are affected by this.

In VANETs, scalability and reliability can be enhanced by using clustering [8]. In addition to routing, entertainment applications and congestion recognition can also be helped by clustering. Various benefits are there in vehicles, information propagation cluster. Every vehicles are followed by each other with certain distance between them. With other vehicles or neighbouring nodes, large amount of clusters are formed by thie vehicles platoon, which keeps the connectivity of network [9].

For VANETs, huge amount of routing protocols are available [10]. Vodopivec et al [11] made a survey on various VANETs clustering methods. Cooper et al. [12] made comparison between various clustering methods of VANETs. Variation in environment is not considered by various methods, which is having high impact on VANET application performances. In VANETs, throughput as well as, performances is affected by changes in environment.

On demand protocol and ACO of different MANET, centred routing methods are implemented by [13]. Changes in environment are considered by this. ACO algorithm is employed commonly to compute route based on graphs. Entire space of population is searched by meta-heuristics algorithms and computation of ideal clustering is ensured.

A single objective algorithm provides one optimum solution. Ideal answer set is produced by multi-objective algorithms [14]. Weights of nodes are used for selecting CH. Various parameters are used for computing weights. Cost of communication and computation are decreased by Selection of CH procedure which is on demand and non-periodic. Difficult problems of optimization are addressed by various effective algorithms like, bee-inspired algorithms, ant colony optimization, particle swarm, swarm intelligence algorithms [15].

Using MFO, perform clustering. This is the major motivation of this work. Swarm intelligence forms

base of ACO and PSO. Wang et al. [16] used mobile link to implement a Wireless Sensor Networks clustering algorithm which is based on PSO. Performance of network is improved by using, PSO algorithm in connection with virtual clustering method. Clustering is done by ACO [17].

Mobile sink's optimum trajectory of mobility is computed using ACO. Shahzad et al. [18] presented a CLPSO clustering algorithm for MANETS. Knowledge about cluster node and CH are contained by every particle to compute, ideal cluster numbers.

Node mobility, ideal degree, power consumption of battery, transmission power of node are considered by this. in multi-objective optimization problems, multiple results can be obtained by using Evolutionary algorithms. In both VANETs and MANET, evolutionary algorithms can be applied. This leads us to develop Improved Moth-Flame Optimization Algorithm (IMFO) named as CAMONET.

3. Proposed Methodology

This work projects on enhanced vehicular clustering (ICAMONET) which is a nature inspired algorithm. Moths navigating procedure is used in this and it is termed as transverse orientation. Highway model is considered for vehicular clustering. Consider parameters like, vehicle speed, network node count, grid size, range of transmission, direction of vehicle.

Enhanced analysis is done using a results of simulation. Well –known meta-heuristics algorithms are used to make a performance comparison of CAMONET. In VANETs, clusters are created in an efficient manner by the optimum results produced by CAMONET. Cost of routing decreases and network performance is enhanced by this method.

1.1.MFO ALGORITHM

A minute bug corresponds to moths. Near to butterfly species, they are placed. In nature, there are around 1,60,000 moths types. Adult and larvae are the two major lifespan stages of it. In night, they can track the paths using a special mechanism. Moon

light is followed by flames of moth. With respect to moon, sing same angle, moths are flying. Long path and straight travelling uses this mechanism [8,9]. Figure 2 shows the spiral flying path and transverse orientation.

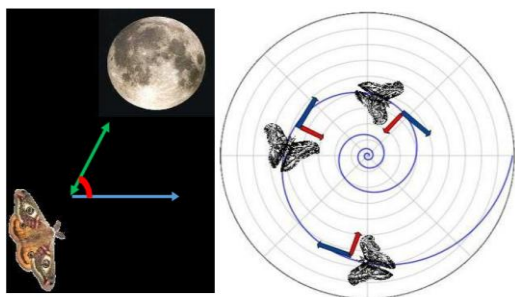


Fig.2. Transverse Orientation and Spiral Flying Path

A moth corresponds to a solution of candidate and problem variable corresponds to months position in this proposed MFO algorithm. With position alteration, moths are able to fly in hyper or 3 or 2 or 1 dimension. Involved steps are shown in Table 1 and MFO is a procedure based on population. In every iteration, a solution corresponds to flames and moth and in different way they are treated and updated.

Moths are real agents of search. In search space they fly to find a finest position. Flames are used to represent finest positions. In an alternative way, flags or pins corresponds to flames. In search space, they are released while searching. Neighbouring flags are explored by each moth and if best solution is obtained, they are revised. Proposed CAMONET algorithm is described in next section.

1.2. IMFO Algorithm for Clustering

Diverse assortment grouping an exceedingly VANET situation characterizes the connections extra consistent on the grounds that the wellspring of connections are appropriately utilized. Algorithmic rule use include of bunching inside the connections. This can be a result of the organic procedure proficiency of MFO that forces to pick the general assortment of results since it is efficient and worthy for particular and constant variable

issues. Tho' the execution of such calculations is similarly troublesome, these systems are computationally modest, explicitly once contended with an inside and out search to recognize the best goals. Accordingly, these qualities imply that MFO principally based methodology are independent for agglomeration in unintended systems, quite inside the situation of VANETs. The bit by bit working of the arranged approach is given as pursues. The pseudo code is utilized to call attention to the working of CAMONET. Abdominal muscle initio the system of self-ruling vehicles is shaped by helter skelter introducing their situation at interims the bound district referred to as network size. Next, the speed and heading of vehicles additionally are dispensed rash. The vehicle ID's are doled out for the ID along these lines inside the system topology of the system. Thereafter, geometrician separation is estimated between every one of the hubs to make a whole separation grid of entire system as appeared in line five. The inquiry zone is made by abuse the situation of moths. Development of search zone relies upon hardly any parameters, for example, measurements, edge and bound.

A while later, the wellness of moths is determined by misuse the situation of moths inside the pursuit region. The wellness esteems are contrasted with the past emphasis with make Associate in Nursing sorted out lattice in climbing request of wellness esteems. This wellness grid known the lower wellness worth of the lepidopteran. Along these lines, the lepidopteran position and wellness esteems are acclimated procure the best fire score. This encourages North American nation to refresh the value of lepidopteran position thus as appeared in line eleven to sixteen. Thusly, a directly diminishing issue 'an' is utilized to combine towards the appropriate response. The change of 'an' is $[-2, -1]$, least the value of 'an' implies that higher the likelihood to meet prior. At long last, the intermingling drives North American nation towards the measure of bunches expected to make the tough

correspondence inside the definite criteria upheld totally various parameters.

Moth fire enhancement algorithmic guideline plans the winding development of lepidopteran towards the fire (light). In MFO, the competitor arrangements are the moths, and in this way the administration factors are the situation of the moths inside the pursuit region. The arrangement of moths M is diagrammatical inside the accompanying lattice:

$$M = \begin{bmatrix} m_{1,1} & m_{1,2} & \dots & m_{1,d} \\ m_{2,1} & m_{2,2} & \dots & m_{2,d} \\ \vdots & \vdots & \ddots & \vdots \\ m_{n,1} & m_{n,2} & \dots & m_{n,d} \end{bmatrix}$$

Where n is that the scope of moths and d is the quantity of factors. The wellness esteems arranging might be given by the ensuing exhibit:

$$OM = \begin{bmatrix} OM_1 \\ OM_2 \\ \vdots \\ OM_n \end{bmatrix}$$

Where OM is that the wellness worth and n is the lepidopteran extend.

The wellness worth is that the come estimation of each lepidopteran, any place all moths are knowledgeable the wellness perform. The yield of the wellness perform is a twin of its wellness worth in OM cluster. An essential framework of MFO is diagrammatical by blazes. Flares grid might be

depict as pursues: $F = \begin{bmatrix} F_{1,1} & F_{1,2} & \dots & F_{1,d} \\ F_{2,1} & F_{2,2} & \dots & F_{2,d} \\ \vdots & \vdots & \ddots & \vdots \\ F_{n,1} & F_{n,2} & \dots & F_{n,d} \end{bmatrix}$

Here, the measure of moths is shown by n, while the measure of measurements (factors) is diagrammatical by d and along these lines the elements of exhibits F is identical. Dimension of moth's lattice is sufficient to the element of blazes framework. The wellness estimations of blazes might be arranged inside the accompanying exhibit:

$$OM = \begin{bmatrix} OF_1 \\ OF_2 \\ \vdots \\ OF_n \end{bmatrix}$$

It is cost referencing that every one of moths and blazes are arrangements. it's capability to recognize the differentiation between them once dissecting the gratitude to treat and refresh moths and fire positions all through running strategy. Moths are the search specialists chase for best position, though blazes are the banners or the best position of moths. The scientific condition speaks to the development of moths with reference to fire position, which might be created as pursues:

$$M_i = S(M_i, F_j)$$

where, M_i represents the lepidopteran at the request i, F_j speaks to the fire at the request j and S speaks to the winding way perform. In MFO algorithmic principle, the development of lepidopterans issue as list winding perform to refresh the situation of each moth with reference to fire; any winding development should fulfil the resulting conditions: Spiral development begins from moth, Spiral development finishing at fire position and Domain of winding development is confined via search region. MFO list winding perform might be given by the resulting condition:

$$S(M_i, F_j) = D_i \cdot e^{bt} \cdot \cos 2\pi t + F_j$$

Where D_i speaks to the hole of lepidopteran at the request i with reference to fire at the request j, b could be a consistent that doles out the type of winding algorithmic principle and t is an arbitrary range that lies in the middle of $[-1, 1]$. the hole D might be determined from the resulting condition:

$$D_i = |F_j - M_i|$$

Condition $S(M_i, F_j)$ demonstrates the winding way of the flying moths that update their position predictable with the fire position. Parameter t characterizes the closeness of lepidopteran to fire, any place at $(t = -1)$ the lepidopteran is at the closest

position with reference to fire, though at ($t = 1$) the lepidopteran is at the most remote situation with reference to fire inside the hyper conic segment of moths round the fire by and large bearings inside the pursuit region. The file winding way of moths around fire and along these lines the positions are demonstrated at totally various estimations of t , as appeared in Figure two. Trying to search out higher arrangements is expanded by considering the best arrangements in light of the fact that the blazes. Moths update their situation with reference to framework F steady with Equation F once the advancement strategy is proceeding; any place n is that the most recent best goals. Abuse is extra culminated by considering it as arbitrary $[r, 1]$, any place r is that the intermingling consistent that diminishes straightly inside the change $[-1: -2]$, all together that moths misuse their indistinguishable blazes precisely in rates corresponding to cycles run. the measure of flares is diminishing with the advancement of cycles running as appeared in Fig.2 and accentuated inside the accompanying condition:

$$Flameno = N - l * \left(\frac{N - 1}{T} \right)$$

where, l speaks to the present scope of iteration, $N-l$ speaks to the most extreme scope of blazes and T speaks to the greatest number of emphasess. The dynamic diminishing inside the scope of flares through the span of emphasess balances among investigation and abuse inside the inquiry zone.

Previously mentioned moths development conduct is across direction. Condition NGO speaks to the development of moths in hyper circle zone. IMFO procedure is portrayed by file winding development of moths round the flares inside the inquiry territory as showed in Equation $S(M_i, F_j)$. The winding development of lepidopterans is considered the essential} principal of IMFO that shows the degree of the refreshed moth areas round the blazes. Winding condition is described by the opportunity of moths to move around blazes and a bit much

inside the region between them; in this manner, the investigation and misuse of the inquiry zone are culminated. In [19] the creators wanted to change Equation of $S(M_i, F_j)$. This change uncovers new spirals for the normal methods for the moths round the fire. The multidimensional language of the arranged philosophy is outlined in Fig.3 and pseudo code is given in Table.1.

Table.1. ICAMONET-Pseudo Code

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1) In highway vehicles are arranged randomly.
2) Randomly vehicle direction is initialised.
3) Each vehicle speed/velocity is initialised.
4) Generation of mesh topology is done.
5) Vehicle distance is calculated and values is linked to the mesh .
6) Moths positions are initialized for creating search space
FOR i = 1: n
FOR j = 1: d
Moth_pos (i, j) = (ub(i) _ lb(i))/rand() + lb(i);
END
END
7) WHILE (Maximum Iteration == Iteration or solutions of
past 15 iteration are same,i-e stall iteration ==15)
8) {
9) FOR Mothi = 1 to size of swarm
10) { every moths positions fitness value is computed {
MothFitness = CostFunction (Moth_pos); }
Mothi.noOfclusters == empty and Mothi.Clusterfitnes ==
infinity noOfnodeSelected = 0 (means all the nodes
available for clustering ) a) WHILE (Nodes available for
clustering!= 0 or empty) b) Mothi.Clusterfitnes =
CostFunction(Mothi.noOfClusters) IF
Mothi.clusterfitnes<BestSol.clusterfitnes
BestSol = Mothi; END END WHILE END FOR
11) Fitness_sorted = sort(MothFitness); sorted_population=
F = sort (Moth_position (Fitness_sorted));
12) Obtained best flames position is updated
i) Best_flame_score=fitness_sorted(1);
ii) Best_flame_pos=sorted_population (1,:);

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13) Based on flame, moth positions are updated a) FOR i = 1: n
    FOR j = 1: d
    i) Distance of i-th Moth for j-th flame is computed
    ii) distance_to_flame=abs(sorted_population(i,j)-Moth_pos(i,j))
    iii) Update Moth_pos(i,j) moth position is updated END
    END
14) IF (Convergence curve(Iteration)==Convergence_curve(Iteration-1))
    a) stall iteration++; ELSE
    b) stall iteration = 0; END IF Iteration ++;
15) END WHILE TotalnoOfCluster = BestSol.noOfClusters;
    
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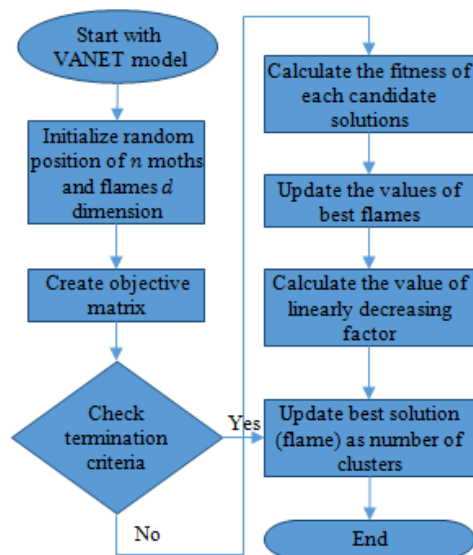


Fig.3.Flow chart of ICAMONET

4. Results and Discussion

Results are accomplished exploitation MATLAB version eight.5.0 on a core i5 a pair of 0.2 gigacycle .Whole range of links is varied from ten to sixty whereas the linkscommunication vary are additionally adjusted from a hundred to 600m. Nodes change on the coordinate during a dual direction. Nodes speed is systematically changed from eighty km per hour to a hundred and twenty km per hour. ICAMONET, few notable methods for bunch VANETs like

CLPSO and CAMONET also enforced. Projected ICAMONET is compared with the prevailing ways of CLPSO and CAMONET.

4.1 Number of Clusters vs. Transmission rang results

Figures four represents result, communication target the coordinate axis and range of nodes in coordinate line. The communication vary from hundred until 600 m, quantity of links is 30–60, whereas totally multi grid variation from one thousand to 4000 m is employed point out specified range of clustering consequently.ICAMONET represents the effective range of clustering delineated with green-colour circles. Quantity of needed clustering are reciprocally related to communication vary. Worth of communication vary is multiplied, specified range of clustering are attenuated. ICAMONET is representing the effective results as to CLPSOand CAMONET altogether provided eventualities. Scale of grid additionally modified to form results a lot of sturdy and excellent. Graph figure provides the results favourable to ICMFO. additionally, the quantity of nodes/vehicles are modified in order that the efficiency of projected technique will be monitored. Results are provided when the multi iterations for every situation so the common worth is chosen to draw the results.

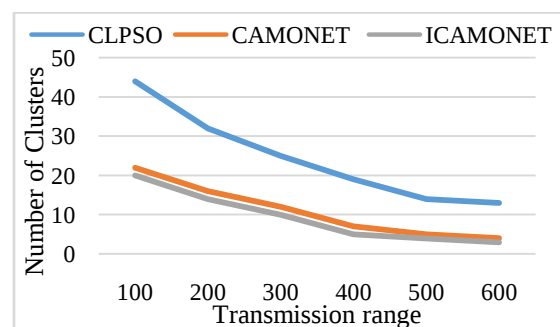


Fig.4 Cluster vs Communication

4.2 Load Balance Factor vs Transmission range results

Load balance issue is employed on the load in every CH as given in Fig.5. it is terribly tough for every clustering to assign equal range of CNS. Load Balance Factor is employed for the allocation of balanced load within the clustering. the first effect is effects to speedy motion of near by from the CHs.

$$LBF = \frac{1}{(n_c \times \sum_i (x_i - \mu)^2)}$$

Council is range of CHs, x_i is that the cluster cardinality i , and $\mu = (N - n_c) / n_c$ is that the mean range of near by of a CH.

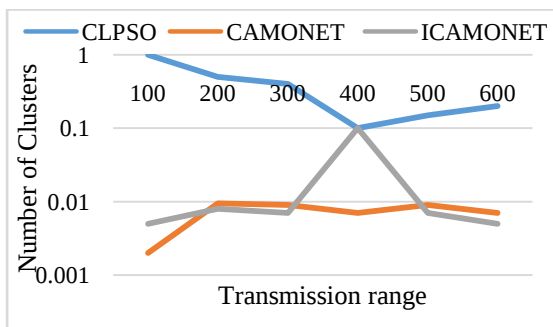


Fig.5. Load Balance Factor vs Transmission range results

5. Conclusion and future work

Elaboration of organic process, Improved MFO-under clump formula (ICAMONET) is enforced within the VANET is discussed in this article. It reduces the linking value for the transmission of complete network as expeditiously minimizing the desired variety of clustering. Low variety of clustering conjointly results in scale back the material requirement within the links. All this, ICAMONET taken into account because the well-united formula within the VANET. Comparing additionally finished the well-defined algorithms of VANET. Analysis is conjointly reflected the solution of ICMFO is higher. In ICAMONET, clump of conveyance nodes is proficiently accomplished and close to best result is created. The strategy of solution with different illustrious like

CLPSO and CAMONET are defined. Because of organic process ability of our formula, bigger search areas are decided, therefore the numbers of target operate are changed smartly. Results of simulation defines the results effects and suppleness of methods that makes it best around the theorems mentioned for using in VANETs clump situation. The linking value of packets is corrected by reducing the whole variety of clustering within the links. For longer term use, we are able to enhance the target operate consistent with completely different issues and necessities. The planned work may also be utilized for the multi-planned functions. For example, within the planned method, the most goal is that the consistency of links mistreatment the brilliant clump by concentrating the behaviour of variety of clustering.

References

1. Lyu, F, Zhu, H, Zhou, H. MoMAC: mobility-aware and collision-avoidance MAC for safety applications in VANETs. IEEE T Veh Technol 2018; 67: 10590–10602.
2. Balachandar, SR, Kannan, K. Newton's law of gravity-based search algorithms. Indian J Sci Tech 2013; 6: 4141–4150.
3. Haouari, N, Moussaoui, S, Senouci, S-M. Application reliability analysis of density—aware congestion control in VANETs. In: Proceedings of 2018 IEEE international conference on communications (ICC), Kansas City, MO, 20–24 May 2018, pp.1–6. New York: IEEE.
4. Cavalcanti, ER, De Souza, JAR, Spohn, MA. VANETs' research over the past decade: overview, credibility, and trends. ACM SIGCOMM Comp Com Rev 2018; 48: 31–39.
5. Daeinabi, A, Rahbar, AGP, Khademzadeh, A. VWCA: an efficient clustering algorithm in vehicular ad hoc networks. J Netw Comput Appl 2011; 34: 207–222.
6. C. Cooper, D. Franklin, M. Ros, F. Safaei, and M. Abolhasan, "A Comparative Survey of VANET Clustering Techniques," IEEE Communications Surveys & Tutorials, 2016.

7. Q. Luo, C. Li, Q. Ye, T. H. Luan, L. Zhu, and X. Han, "CFT: A cluster-based file transfer scheme for highway VANETs," *ArXiv*, vol. 1701, 2017
8. Y. Chen, M. Fang, S. Shi, W. Guo, and X. Zheng, "Distributed multi-hop clustering algorithm for VANETs based on neighborhood follow," *EURASIP Journal on Wireless Communications and Networking*, vol. 2015, pp. 1-12, 2015.
9. K. Padmanabhan, I. Jeyasubramanian, J. S. Pandian, and J. V. Rajendran, "Improving QoS in VANET Using Dynamic Clustering Technique," *International Journal of Networks and Communications*, vol. 6, pp. 72-79, 2016.
10. D. Patel, M. Faisal, P. Batavia, S. Makhija, and M. Mani, "Overview of routing protocols in vanet," *Int. J. Comput. Appl.*, vol. 136, pp. 4-7, 2016.
11. S. Vodopivec, J. Bešter, and A. Kos, "A survey on clustering algorithms for vehicular ad-hoc networks," in *Telecommunications and Signal Processing (TSP), 2012 35th International Conference on*, 2012, pp. 52-56.
12. C. Cooper, D. Franklin, M. Ros, F. Safaei, and M. Abolhasan, "A Comparative Survey of VANET Clustering Techniques," *IEEE Communications Surveys & Tutorials*, 2016.
13. A. Oranj, R. Alguliev, F. Yusifov, and S. Jamali, "Routing algorithm for vehicular ad hoc network based on dynamic ant colony optimization," *Int. J. Electron. Elect. Eng.*, vol. 4, pp. 79-83, 2016.
14. S. J. Nanda and G. Panda, "A survey on nature inspired metaheuristic algorithms for partitional clustering," *Swarm and Evolutionary computation*, vol. 16, pp. 1-18, 2014.
15. M. Mavrovouniotis, C. Li, and S. Yang, "A survey of swarm intelligence for dynamic optimization: algorithms and applications," *Swarm and Evolutionary Computation*, 2017.
16. J. Wang, Y. Cao, B. Li, H.-j. Kim, and S. Lee, "Particle swarm optimization based clustering algorithm with mobile sink for WSNs," *Future Generation Computer Systems*, vol. 76, pp. 452-457, 2017.
17. J. Wang, J. Cao, B. Li, S. Lee, and R. S. Sherratt, "Bio-inspired ant colony optimization based clustering algorithm with mobile sinks for applications in consumer home automation networks," *IEEE Transactions on Consumer Electronics*, vol. 61, pp. 438- 444, 2015.
18. W. Shahzad, F. A. Khan, and A. B. Siddiqui, "Clustering in mobile ad hoc networks using comprehensive learning particle swarm optimization (CLPSO)," in *Communication and Networking*, ed: Springer, 2009, pp. 342-349.
19. Soliman, G. M., M. M. Khorshid, and T. H. Abou-El-Enien. "Modified moth-flame optimization algorithms for terrorism prediction." *International Journal of Application or Innovation in Engineering and Management* 5 (2016): 47-58.