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Energy Aware Ant Colony Optimization based Dynamic Random Routing Strategy for MANET

S. Beski Prabaharan[1], Dr. R. Ponnusamy[2]

Research Scholar, Department of Computer Science, Bharathiar University, Coimbatore, India [1]

Principal, Rajiv Gandhi Engineering College, Nemili, Sriperumpudur, Chennai, India [2]

Abstract: Incorporating energy awareness in identifying the routes in MANET is one of the mandatory mechanisms to be incorporated in any routing protocol. This helps reduce selfishness in node and hence prolongs the network's lifetime. This paper presents a metaheuristic based routing scheme for MANET that identifies next hop nodes not only based on their distance, but also on the residue charge left in them. This approach uses a modified Ant Colony Optimization technique with threshold limits for exploration and exploitation levels. These limits are set such that the exploration is given more importance, in-order to maintain the randomness and avoid repetitive usage of the same node. Experiments reveal that this approach exhibits low computational complexity and provides sufficient randomness for the node selection mechanism.

Keywords: MANET; Routing; ACO; CDF; Energy efficiency; Altruism; Selfishness.

I. INTRODUCTION

Mobile ad hoc Networks (MANET) is a collection of mobile nodes integrated to form a network. MANET is an infrastructure free architecture and communications are performed over a shared wireless medium [1, 2]. MANET have limited processing speed, storage, battery and communication capabilities. The mechanism used for routing plays a major role in maintaining the consistency of the system. Routing mechanisms in MANET can be divided into proactive [3, 4] and reactive [5, 6] types. The proactive routing schemes maintain routing tables, while reactive routing schemes identify hops only when the demand arises. In terms of routing, major focus has been on the energy depletion rates due to the high energy constraints depicted by the nodes in MANET.

Selfishness and altruism are major characteristics exhibited by nodes in a MANET depending of their battery levels. Altruism is defined as the state of a node in which a node is willing to forward packets not intended for itself. Since the communication capabilities of MANET are limited, this state of operation becomes mandatory in order to perform communications within the network. If the battery capacity of a node is too low when compared to the average battery levels of the network, the node tends to become selfish. A selfish node does not forward any packets except for its own transmissions. Though this scheme maintains network stability, it acts as a huge downside to the co-operative environment to be maintained in the network. The major requirements of node selection schemes is to maintain average charge levels of all the nodes in the network such that all the nodes remain altruistic for maximum possible time.

II. RELATED WORKS

Routing schemes and techniques have been in existence since the days of data sharing. Hence this is a mature technology and has several contributions to its credit. This section describes several recent and major contributions associated in this domain. Several single and multipath routing protocols were proposed as variations of existing protocols [10, 11]. A multipath routing protocol based on AODV was presented by Obaidat et al. in [10] and a variant of AOMDV was presented by Khimsara et al. in [11]. Candidate property based node selections are also on the raise due to the need for increased reliability and trust. A Stable Backbone based Multipath Routing Protocol (SBMRP) was presented by Mallapur et al. in [12]. Swarm based techniques are on the raise in the domain of routing due to their basic nature of providing optimal solutions at acceptable time intervals. A Particle Swarm Optimization (PSO) based routing scheme was proposed by Jamali et al. in [7]. This method considers energy awareness as the major requirement and employs Binary PSO to the TORA [8] protocol to enhance the route selection scheme. It formulates the routing scheme as an optimization problem and claims to provide enhanced network lifetime. Estimating the link reliability is one of the major difficulties in selecting a routing path. The reliability based link estimation technique was proposed by Prabha et al. in [9]. This method works on the basis of probable disconnections in the route. Scheme to identify a new route in case of a break in the regular path is imposed in the algorithm using swam intelligence.

A similar link availability based method called LEAT was proposed by Yu et al. in [13]. The links are identified on the basis of distances between the two nodes heuristically. A DYMO routing based protocol in Hybrid MANET was presented by Matsuda et al. in [14]. This method focuses specifically on transmission of sensitive data over the network by identifying the best and the most secure gateway for transmission. Trust and energy plays a vital role in the process of routing. A co-operative protocol for MANET operating of distributed trust and energy

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management was presented by Venkanna et al. in [20]. This approach identifies malicious behavior in nodes using their trust and energy values obtained from the neighbor nodes. This helps the routing algorithm identify a co-operative path rather than the shortest path, hence ensuring packet delivery. A similar technique was proposed by Thorat et al. in [21]. This paper presents an opportunistic routing protocol by considering the presence of selfish nodes in the network. A new metric called 'path goodness' was introduced to identify the best path in the network.

III.ENERGY AWARE ANT COLONY OPTIMIZATION (EA-ACO) BASED DYNAMIC RANDOM ROUTING STRATEGY FOR MANET

Selfishness and altruism remains to be the major problems in MANET due to its ad-hoc nature and battery constraints. Dynamic On-Demand Routing mechanisms tend to solve this problem effectively by computing the requirements prior to transmissions. This approach presents an on demand dynamic routing mechanism using Ant Colony Optimization incorporating energy awareness as a part of its fitness calculation (Figure 1).

Modified Ant Colony Optimization technique, incorporating the energy levels of the nodes as a parameter in calculating the fitness is used in the process of route identification. The on-demand routing process using ACO [16, 17] is initiated on transmission initiation.

The initial population size is estimated according to the number of nodes initialized in the network [15]. The ants are then distributed in the nodes using the Uniform Distribution Function. A Tabu list [18] is maintained for each ant, recording its movement in the network. Size of the Tabu list is fixed to the size of the search space. The initial node that the ant currently resides is added to the Tabu list. Fitness values of all the unused nodes in the network are identifies and the ant movement is triggered towards the node with the best fitness. Fitness value of a node n_1 is identified by calculating the probability of movement of an ant to n_1.

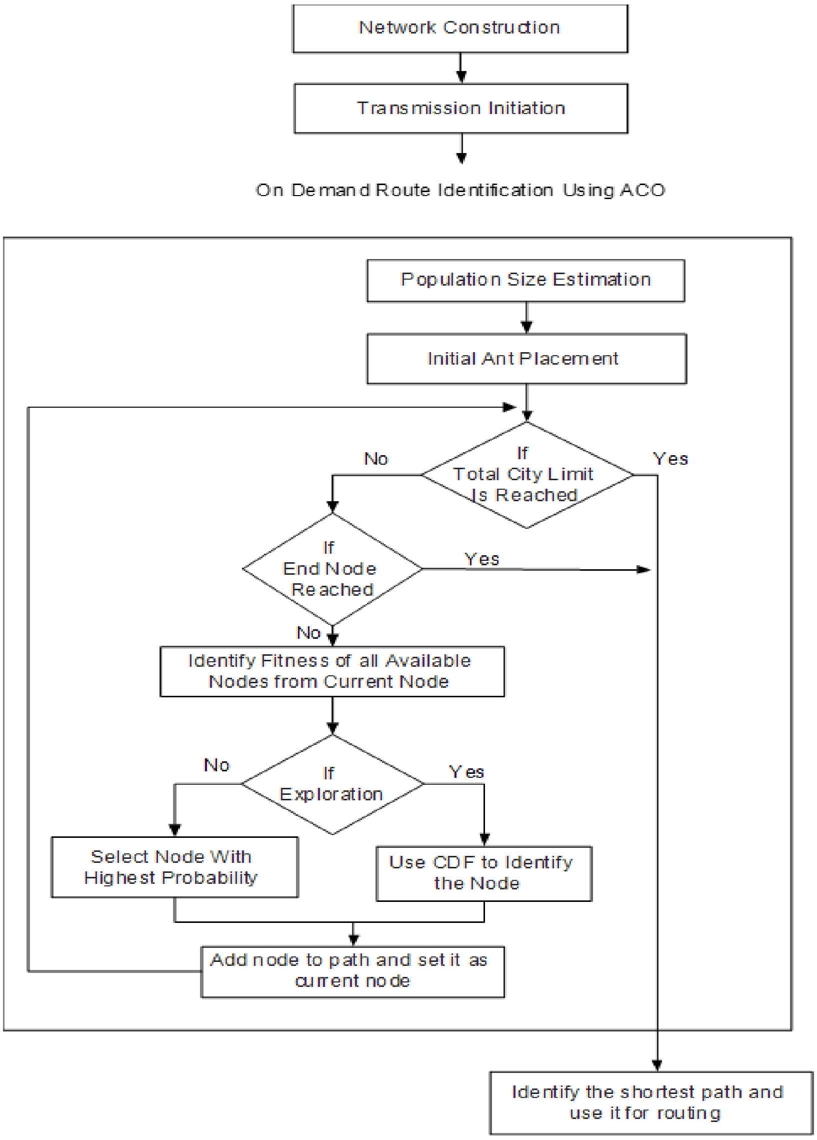

Fig. 1. Energy Aware Ant Colony Optimization (EA-ACO) based Dynamic Random Routing Strategy for MANET

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Consider m to be the number of ants and *n* to be the number of nodes in the network, then the probability that an ant m_i will select a node is given by

$$p_{ij}(t)=\frac{\left[\tau_{ij}(t)\right]^{\alpha}.\left[\eta_{ij}\right]^{\beta}.\left[\varepsilon_j\right]}{\sum_{j=1}^{n}\left[\tau_{ij}(t)\right]^{\alpha}.\left[\eta_{ij}\right]^{\beta}.\left[\varepsilon_j\right]}$$

where τ_{ij} is the pheromone intensity in the edge *ij* ε_j is the charge contained in the node and η_{ij} is the visibility range of the edge *ij*. α and β are the weights provided to the pheromone trial and the visibility respectively.

This approach uses the three opt variant of ACO. Hence the exploration and exploitation levels can be varied in the algorithm itself. This approach sets a threshold of 30% exploitation and 70% exploration levels. Hence our algorithm prefers exploration to exploitation. This enables the incorporation of randomness into the node selection mechanism. If the approach is enabled for exploitation, the algorithm selects the best bath that it has traversed so far and if the exploration setting is enabled, the algorithm tries to find a path using the Cumulative Distribution Function (CDF) [19].

After the identification of the complete path, the path from each ant is checked and the path with least total distance is identified as the best path and is used as the final route. The energy levels of each of the nodes contained in the final path are reduced. On next transmission, the new energy levels are used to identify the fitness values. Hence the more a node is utilized, its fitness value gradually reduces lowering the probability of selection of the node. This scheme leads to a utilization scenario, where all the nodes are utilized in a uniform manner and hence reducing the probability of a node turning selfish. This approach also leads to low node breakdown, hence prolonged network lifetime.

IV. RESULTS AND DISCUSSION

Experiments were conducted to observe the efficiency of the presented approach in terms of identifying the routes. The algorithm was implemented using C#.NET and path construction was carried out using 30, 50 and 100 nodes. Distance covered, time taken, randomness levels and path reuse levels were considered as the metrics for measuring the performance of the algorithm.

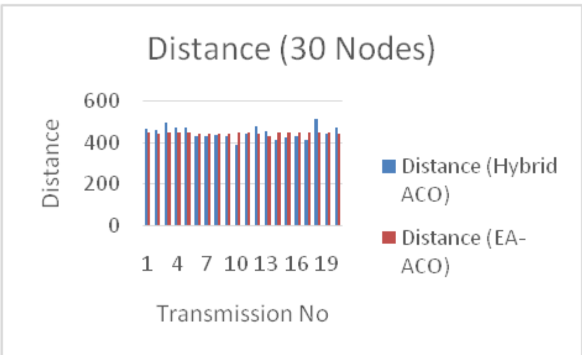

Fig. 2. Distance (30 Nodes)

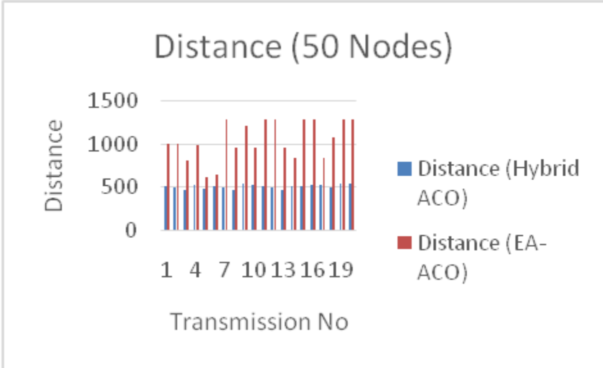

Fig. 3. Distance (50 Nodes)

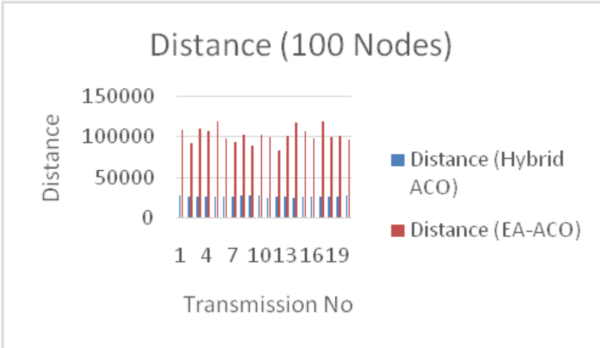

Fig.4. Distance (100 Nodes)

Figures 2, 3, 4 show the graph corresponding to the distance covered in completing one complete cycle covering all the nodes in the network. It could be observed from Figure 2 (representing 30 Nodes) that both the hybrid ACO and the EA-ACO takes almost the same distance in traversing through the entire network. As the number of nodes increase, Figures 2-4, it could be observed that Hybrid ACO performs better than the energy efficient ACO. This could be attributed to the fact that distance and several other parameters form the basis for selecting the rout in Hybrid ACO, while EA-ACO considers only the energy efficiency of a node while making its traversal.

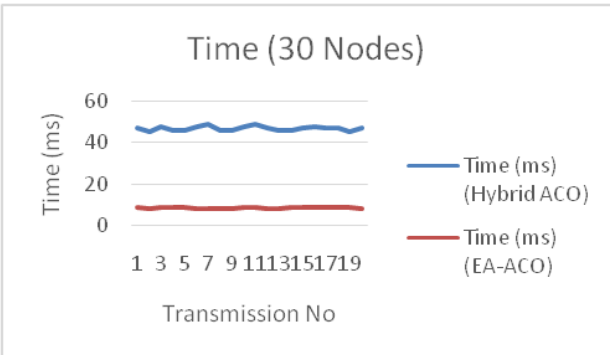

Fig. 5. Time (30 Nodes)

The advantage of EA-ACO comes from the fact that the time taken by EA-ACO is far too low when compared to the time taken by the Hybrid ACO (Figures 5-7) . This is due to the large number of complex operations involved in Hybrid ACO.

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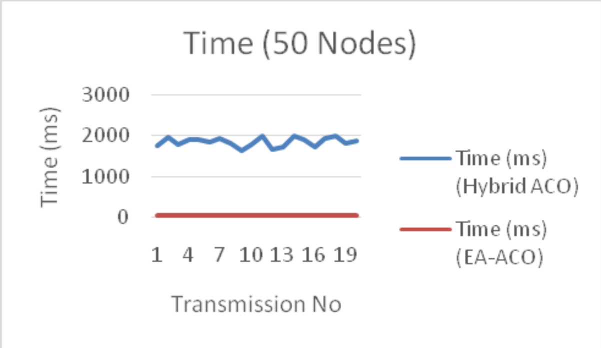

Fig. 6. Time (50 Nodes)

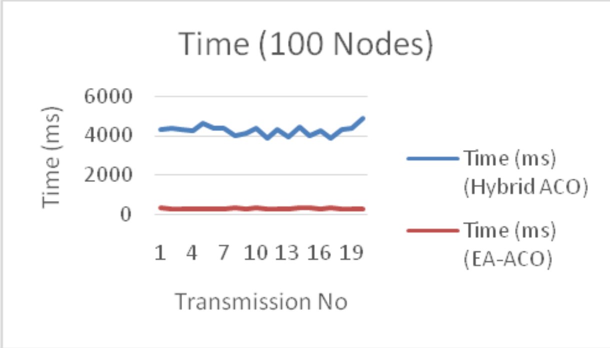

Fig. 7. Time (100 Nodes)

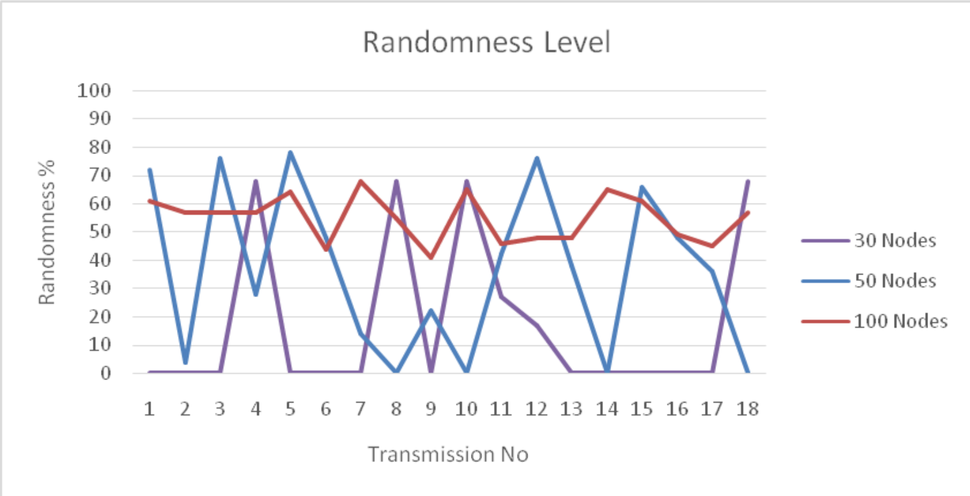

Fig. 8. Randomness Level

Figure 8 show the randomness levels of obtained in traversing the complete network. The graphs show the randomness levels obtained in using 30 nodes, 50 nodes and 100 nodes. It was observed that the network containing 30 nodes exhibited low randomness levels, while better randomness levels are exhibited by 50 and 100 nodes. Randomness is identified by analyzing edge reuse in the past 2 transmissions. The low randomness levels are achieved in 30 nodes due to the lesser number of available edges. As the number of nodes increase, so does the edges, hence better randomness is achieved.

Even with a moderate sixed network of 100 nodes, it could be observed that an average randomness of 57% was achieved by this approach.

Figure 9 shows the path reuse (edge reuse) levels when a path from a fixed edge to a fixed edge is requested by the user. It was observed that on an average path reuse levels are maintained very low, as most of the reuse points plot to 0, meaning that no nodes of the previous *n* transactions were reused. One transaction shows elevated levels of 65% of path reuse, which can be attributed to the randomness incorporated in the algorithm.

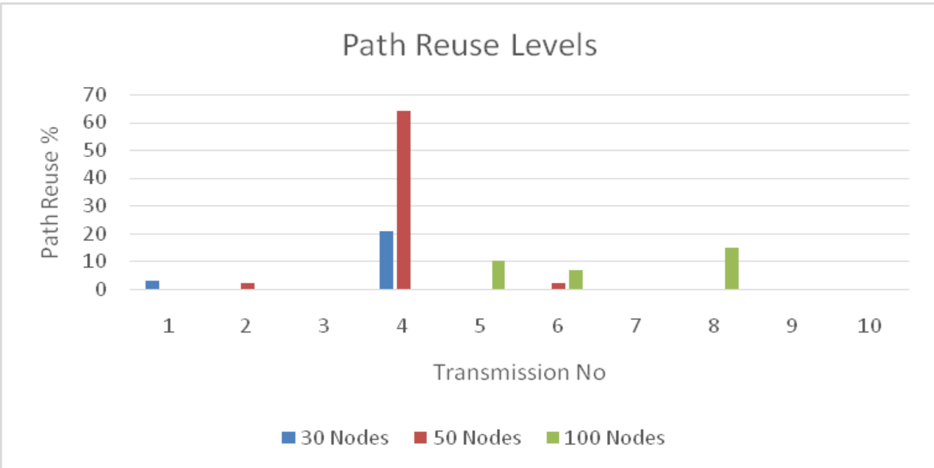

Fig. 9. Path Reuse Levels

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Figure 10 shows the node usage levels when traversing from a fixed node to a fixed node. It could be observed that due to the moderate number of nodes available, the transactions on 30 and 50 nodes show elevated levels. As the nodes are increased to 100, very low reuse levels are observed (maximum of 25% and average of 13.5%).

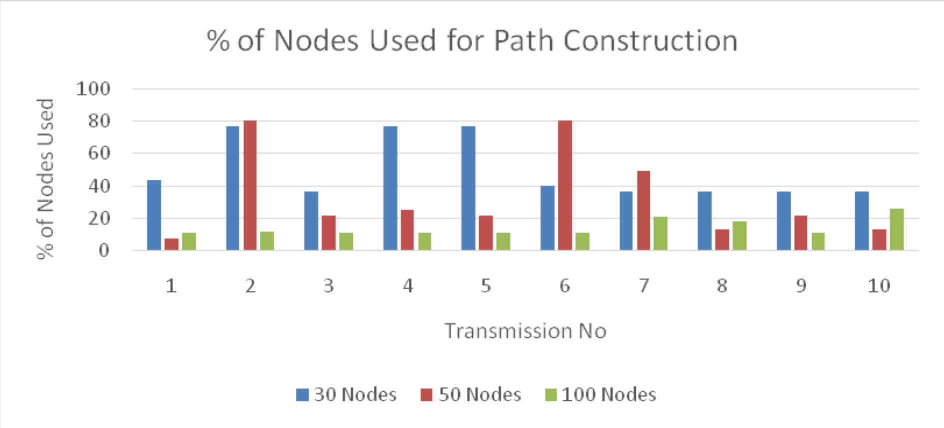

Fig. 10. % of Nodes Used For Path Construction

V. CONCLUSION

Energy conservation is one of the major concerns in the current MANET systems. This approach presents an effective MANET routing scheme based on modified ACO. The fitness function of ACO is modified to incorporate the energy efficiency associated with the destination node. This approach is designed with exploration as its major concern. Hence preference is always biased towards nodes that have high charge and nodes that have not yet been visited. This scheme of operation utilizes the global network space, hence avoiding frequent usage of any particular set of nodes. This leads to global charge dissipation, hence lower probability of any node turning selfish in the early stages of network operation. Future research directions will be aimed on reducing the time further by parallelizing the proposed algorithm. Other directions of research includes identifying node breakdowns and incorporating schemes to counter such breakdowns dynamically such that retransmissions are avoided.

REFERENCES

[1] S. Basagni, M. Cont, S.Giordano, I.Stojmenovic, "Mobile ad hoc networking", JISR, 2004, pp. 201-207.
[2] Y. Jiazi, A. Asmaa, D. Sylvain, P. Benoît, "Multipath optimized link state routing for mobile ad hoc networks", Ad Hoc Networks 9, 2011, pp. 28-47.
[3] C.C. Chiang, H.K. Wu, W. Liu, M. Gerla, "routing in clustered multi-hop mobile wireless with fading channel", Proceedings of IEEE SICON, 1997, pp. 197–211.
[4] S. Murthy, J.J. Garcia-Luna-Aceves, "An efficient routing protocol for wireless networks", ACM Mobile Networks and Application Journal, 1996, pp. 183–197.
[5] Y. Ko, N.H. Vaidya, "Location-aided routing (LAR) in mobile ad hoc networks", In: Proceedings of ACM MOBICOM1998dddd, 1998, pp. 66–75.
[6] S.Y. Wang, , J.Y Liu, C.C. Huang, M.Y. Kao, Y.H. Li, "Signal strength-based routing protocol for mobile ad hoc networks", In: Proceedings of 19th International Conference on Advanced Information Networking and Applications, 2005, pp. 17–20.
[7] S. Jamali, L. Rezaei, and S. J. Gudakahriz, "An energy-efficient routing protocol for MANETs: a particle swarm optimization approach." Journal of applied research and technology, 11(6), pp.803-812, 2013.
[8] V.D. Park and M.S. Corson, "A Highly Adaptive Distributed Routing Algorithm for Mobile Wireless Networks", INFOCOM, 1997, pp. 52-59.
[9] R. Prabha, and N. Ramaraj, An improved multipath MANET routing using link estimation and swarm intelligence. EURASIP Journal on Wireless Communications and Networking, 2015(1), pp.1-9.
[10] S. V. Mallapur, S. R. Patil, "Stable backbone based multipath routing protocol for mobile ad-hoc networks." Paper presented at the 2013 International Conference on Circuits, Power and Computing Technologies (ICCPCT), IEEE, Nagercoil, 20–21 March 2013 pp. 1105–1110.
[11] M. Yu, W. Liu, T. Xing, "Link availability modeling for routing algorithms to reduce the link break time in MANETs." Paper presented at the 2011 IEEE International Conference on Networking, Sensing and Control (ICNSC), IEEE, Delft, 11–13 April 2011, pp. 115–120.
[12] M. Yu, and J. Bao, "A ranging-based link availability routing algorithm for MANETs." In Wireless Communications and Networking Conference (WCNC), (pp. 1-6), IEEE, 2010.
[13] T. Yelemou, "New approach to improve the robustness of AOMDV protocol." In Systems, Signals & Devices (SSD), 10th International Multi-Conference on (pp. 1-6), IEEE, 2013.
[14] T. Matsuda, H. Nakayama, X. S. Shen, Y. Nemoto, and N. Kato, "Gateway Selection Protocol in Hybrid MANET Using DYMO Routing." Mobile Networks and Applications, 15(2), pp.205-215, 2010.
[15] A. Prakasam, and N. Savarimuthu, "Metaheuristic Algorithms and Polynomial Turing Reductions: A Case Study Based on Ant Colony Optimization." Procedia Computer Science, 46, pp.388-395, 2015.
[16] M. Dorigo, V. Maniezzo, and A. Colorni, "The ant system: An autocatalytic optimizing process." (No. 91-016, pp. 163-183). Technical report, 1991.
[17] M. Dorigo, and L. M. Gambardella, "Ant colony system: a cooperative learning approach to the traveling salesman problem." Evolutionary Computation, IEEE Transactions on, 1(1), pp.53-66, 1997.
[18] F. Glover, "Future paths for integer programming and links to artificial intelligence." Computers & operations research, 13(5), pp.533-549, 1986.
[19] J. H. Xue, and D. M. Titterington, "The p-folded cumulative distribution function and the mean absolute deviation from the p-quantile." Statistics & Probability Letters, 81(8), pp.1179-1182, 2011.
[20] U. Venkanna, J. K. Agarwal, and R. L. Velusamy, " A Cooperative Routing for MANET Based on Distributed Trust and Energy Management." Wireless Personal Communications, 81(3), pp.961-979, 2015.
[21] S. A. Thorat, and P. J. Kulkarni, "Opportunistic routing in presence of selfish nodes for MANET." Wireless Personal Communications, 82(2), pp.689-708, 2015.