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Route Optimization using Ant-PSO Technique in MANET for Reliable Communication (LACPSO)

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Abstract- An ad hoc network consists of autonomous, self-organised nodes. Mobile nodes use the wireless medium for transferring information to other nodes. Strong link establishment is the major issue in MANET. The nodes are moving at random mobility speeds. The link bandwidth is limited, so a limited amount of data can be transferred. Thus, two nodes can communicate directly if and only within each other's transmission radius. Ad hoc network routing must not only be fast and efficient, but it must also be adaptable to changes in network topology, or performance will suffer significantly. A message is sent from a source to a destination node in a given network in a routing task. Two nodes normally communicate via other nodes in a multi-hop fashion. In this research, we proposed a Link Reliable using Ant Colony and Swarm Optimization techniques (LACPSO) to route packets through shorter and more feasible routes. Each Ant, moving towards a destination, collects information about the address of each visited node along the followed path using pheromones. During backward travel, the Ant modifies the local network traffic model and routing table based on the following path's goodness. The performance of LACPSO provides the possibility of light-load traffic routes that were not possible in the previous ACO, PSO, and hybrid approaches. LACPSO provides efficient load balancing based on high and low pheromone values. Simulations show that the proposed scheme is better than other routing protocols because it constantly looks for better paths in the network while requiring less work.

Keywords: ACO, LACPSO, Routing, Congestion, Pheromone

I. INTRODUCTION

A Mobile Ad-hoc network, also called MANET [1], consists of a set of nodes that communicate with each other using a wireless medium over single or multiple hops and do not need any existing infrastructure such as access points or base stations. Therefore, mobile ad-hoc networks are suitable for temporary communication. The biggest challenge in this kind of network is to find a path between the communication endpoints. The routing scheme in a MANET [1] can be classified into two major categories-Proactive and Reactive. The proactive or table-driven routing protocols (DSDV) maintain routes between all node pairs all the time. It uses periodic broadcast advertisements to keep the routing table up-to-date. This approach suffers from problems like increased overhead, reduced scalability and lack of flexibility to respond to dynamic changes. The reactive or on-demand (DSR, AODV) approach is event-driven, and the routing information is exchanged only when the demand arises.

The source initiates the route discovery hybrid approaches that combine the features of both approaches. The ant colony optimisation rule (ACO) [2, 3] could be a probabilistic technique for finding computational issues, which may be reduced to finding smart methods through graphs. This algorithm could be a member of the Ant colony algorithms family. In swarm intelligence strategies, the first rule was reaching for the best path during a graph; it supported the behaviour of ants seeking a path between their colony and food supply. The first plan has since varied to solve a wider category of Numerical issues. As a result, many issues have emerged, drawing on numerous aspects of the behaviour of ants. Figure 1 represents the ant routing behaviour based on maximum pheromones. One Ant search a route, two Ants follow possible routes, and three ants follow routes based on pheromones. Ant Colony Optimization (ACO) is a subset of Swarm Intelligence. The basic idea of Ant colony optimisation is taken from the food-searching behaviour of real Ants [4,5]. When ants are on the way to search for food, they start from their nest and walk toward the food. When an ant reaches an intersection, it has to decide which branch to take next.

While walking, ants deposit a pheromone, which ants can smell, marking the route taken. The concentration of pheromone on a certain path indicates its usage. With time, the concentration of pheromones decreases due to diffusion effects. This property is important because it integrates dynamics into the path-searching process [6]. The article consists of VII sections. Section I describe the introduction to MANET and Swarm optimisation, and section II elaborates on existing work of reliable link identification. Section III describes the proposed LACPSO technique, section IV discusses the proposed LACPSO algorithm, section V describes the simulation parameters, the section in section VI describes the analysis result, and section VII describes the conclusion and future approach to MANET.

II. RELATED WORK

This section describes various existing systems of Ant and swarm optimisation for increasing reliability and efficient data transmission under mobile ad hoc networks. Here those works are briefly elaborated to improve the QoS of MANET.

Rangaraj et al. in [7] proposed ACO that improves the links' packet transmission rate, achieving a fair solution for path selection. The source node initialises forward Ant randomly to visit all the available nodes in the path. The ants drop some amount of pheromone over the visited links during traversal. On reaching the destination, the ants update the pheromone of all the nodes visited during traversal. Here throughput of a node is considered a pheromone. M.M. Goswami et al. [8] proposed Reinforcement Learning (RL) based solutions for routing in dynamically changing node location scenarios. It is shown that RL-based solutions provide a better outcome in comparison to static algorithms. Static algorithms fail to adapt to changing situations, while RL-based solutions can adapt to these changes and minimise the average packet delivery time. The RL-based algorithm works according to the rewards and penalties it gets from the performed steps.

A rewarded step is kept in memory for future actions. However, exploration is done for new cases, and the learning algorithm is updated accordingly. The least busy paths are normally chosen as the first step of the proceeding. Gradually from learning outcomes, the least busy paths may be avoided for optimal performances. Wenjia Liu P et al. in paper [9] proposed a multipath routing protocol called Heterogeneous Ad hoc On-demand Multipath Routing Based on Node Stability (HAOMDV-NS) which discovers paths based on node stability. We define the node stability by the number of one-hop neighbours, the neighbour similarity between adjacent time and the average received signal strength indicator. The coefficient of variation method is used to weigh these three factors. The received signal strength indicator measures the path quality. In this paper, every node in the network has three different radio interfaces, so there are three node stability values. Nodes broadcast the node stability by Hello packets to neighbour nodes periodically. When the source node initiates a new route discovery process, it selects the interface with the largest average neighbour node stability value to broadcast RREQ with the path quality to the network. The protocol updates the path quality hop by hop and always selects the most stable interface as the transmission interface in the discovery process. The source node obtains multiple stable paths and chooses the primary path with the largest path quality value compared with AOMDV, the performance of HAOMDVNS is better on packet delivery, average end-to-end delay and route overhead. Periyasamy et al. in [10] proposed a major contribution of this work is to introduce the shortest link reliable and modified version of AOMDV routing protocol for wireless ad hoc networks, called Link Reliable Multipath Routing (LRMR) protocol. Wireless ad hoc networks, due to their ad hoc nature and mobile environment, make frequent use of broadcast primitives such as bandwidth, energy, delay, load, etc., to adapt to network changes. Reliable data transmission in MANET has been an issue due to the frequent failures of wireless links between nodes. Therefore, it is essential to develop a link reliable reactive routing protocol that selects reliable links during data transmission. The AOMDV uses the traditional routing metric hop count for finding multiple routes and selects a route with few hops counts among them for data transmission. During data transmission, if any link between the nodes of that route fails, then data loss occurs in AOMDV. To rectify this problem, they propose an improved AOMDV routing protocol which uses hop count and CETX for multiple links' reliable paths selection.M. Ahmed et al. [11] propose two ways to enhance the Ad-Hoc On-Demand Distance-Vector (AODV) protocol. The main goal of the protocol design was to reduce the routing overhead, buffer overflow, and end-to-end delay and increase the performance. A projected multipath routing protocol relies on AODV and ant Colony optimisation (ACO). This protocol is referred to Multi-Route AODV Ant routing (MRAA). Also, we propose a load-balancing technique that uses all discovered ways simultaneously for transmittal knowledge. During this technique, information packets are balanced over discovered ways, and the energy consumption is distributed across many nodes through the network.ACO has been formalised into a Meta heuristic for combinatorial optimisation problems by Dorigo et al. [12, 13]. ACO takes inspiration from the foraging behaviour of ant species which deposit pheromones on the ground to mark some favourable paths that other colony members should follow. ACO exploits a similar mechanism for solving optimisation problems. An individual ant is a simple insect with limited memory and can perform simple actions. Though a single ant has no global knowledge about the task it is performing, and its actions are based on local decisions and are usually unpredictable, an ant colony expresses a complex collective behaviour providing intelligent solutions to problems such as carrying large items, forming bridges and finding shortest routes from nest to a food source. This intelligent behaviour naturally emerges as a consequence of self-organisation and indirect communication among ants which can be termed emergent behaviour or swarm intelligence. P.Deepalakshmi et al. [14] have proposed an Ant-based QoS routing protocol for MANET to support multimedia communications. Multiple paths have been found from the given source to the destination with varying path preference probability. The multimedia data is sent over the path with higher path preference probability which can provide lesser delay, higher bandwidth and shorter path in terms of the number of hops.BR Sujatha et al. [15] have proposed a PBANT algorithm which optimises the route discovery process by considering the position of the nodes. The position details of the nodes (position of the source node, its neighbours and the position of the destination) can be obtained by positioning instruments such as GPS receivers. PBANT is ARA, where position details of the nodes are known a priori. In this study, the performance of PBANT has been evaluated in terms of delivery rate, delay and control traffic for different values of the algorithm parameters. Shahab Kamali et al. [16] have proposed POSANT, a new ant colony-based routing algorithm that uses information about the position of nodes to increase the efficiency of ant routing. In contrast to other position-based routing algorithms, POSANT does not fail when the network contains nodes with different transmission ranges. Unlike the previously defined position-based routing algorithms, which are single paths, POSANT is a multipath routing algorithm. While in some cases, regular position-based routing algorithms find a route much longer than the shortest path, POSANT converges to routes that are close in length to the shortest path. Srinivas Sethi et al. [19] have introduced a novel meta-heuristic on-demand routing protocol Ant-E, using the Blocking Expanding Ring Search (Blocking-ERS) to control the overhead and local retransmission to improve the reliability in terms of packet delivery ratio (PDR). This method enhances the efficiency of the MANET routing protocol. Ant-E is inspired by the Ant-colony optimisation (ACO) used to solve complex optimisation problems and utilises a collection of mobile agents as "Ants" to perform optimal routing activities.

III. PROPOSED RESEARCH

Route discovery and maintenance processes in mobile ad hoc environments are tedious. The node mobility uncertainty of network topology is the low capacity of network devices, which increases the hurdle to developing a mobile ad-hoc-like network. Past research on the mobile ad hoc network field mainly focuses on providing feasible routing and developing routing protocols like AODV, DSR, OLSR etc., out of the existing routing protocols. AODV is more feasible for that type of network. But it provided only the shortest path with demand-based routing and needed more improvement to increase the routing reliability. In this dissertation, we aim to develop a methodology that enhances the routing reliability using the Ant and swarm optimisation combined technique to fulfil our defined goals' requirements. The proposed LACPSO routing algorithm provides a reliable route with quality of service to the MANET.

Ad hoc on-demand distance vector routing (AODV) is used in this work for new route search, with Ant colony optimisation method support. Where the Ant algorithm calculates the probability of each link used to select a link for data communication, and if the selected link is greater than the probability of all other connected links to the same node, we establish the path. After selecting a route, the particle swarm optimisation (PSO) method is used in the second module to improve network reliability. The PSO method is useful during the break route re-establishment process; in this method, if a route is broken during communication, the PSO module searches for a new route based on minimum delay and minimum hop count, as well as formulating an algorithm to find the gbest and determining the node velocity. After the routing module, actual data is sent from the source to the destination. We also modify the queuing mechanism and acknowledgement-based data rate changing in our proposed work. Set the queue size dynamically in the queue method, which increases and decreases based on data arrival in the concerned node. Another technique is acknowledgement-based data delivery, which is useful for controlling flow when data sending rates are high, and data is dropped between routes, as acknowledgement does not arrive at the source node. In this case, the source should wait three times the round-trip time before researching the route. In another case, when dynamic time acknowledgement arrives at the source node, the source computes the acknowledgement delay difference. It sets a new data rate inversely proportional to the delay, increasing data reliability. With the help of LACPSO's proposed work, we improve the network reliability in terms of route selection and quality of service in terms of performance.

IV. PROPOSED LACPSO ALGORITHM

This section describes the LACPSO algorithm, which helps to implement the proposed work in network simulator 2. The algorithm is split into three parts input, output and procedure. The input section discusses the variable used in the algorithm, the output used to analyse the result and the procedure used for working on our proposed technique. Initially, the routing protocol was used as AODV and the optimisation technique as Ant, which selects reliable and shortest paths. While the communication path is established, start the data transmission and continue swarm optimisation to monitor the intermediate node reliability, which helps provide reliable service to the network.

Algorithm: Route Optimisation using Ant-PSO Technique in MANET for Reliable Communication (LACPSO).

Input:

K_l: l number of mobile nodes
t_i: transmit node $\in K_l$
r_i: receiver node $\in K_l$
i_n: n^{th} intermediate node $\in K_l$
q_n: queue for temporary data store $\forall K_l$
ψ: Network Radio Range 550m^2 $\forall K^l_{k=1} = K_{k-1}$
P_{prot}: AODV
O_{pt}: PSO, ACO
f_t: fitness function to find the best path
$pbest_i$: past best path (initial = 0.0)
U_v: random position
W_p: search space 550m^2
C_l: current location
R_{prd}: successful full receiver data from predecessor
fd_i: forward to next neighbour by i^{th} node
f_{surc_i}: failure to receive by successor node
Pl_r []: population array
V_i: Velocity of the i^{th} node
$path_i$: the path between t_i to r_i
l_i: updated location

Output: Throughput, percentage of data receives, delay, overhead

Procedure:

Step1: K_l initialise Pl_r [], U_v under W_p
t_i execute route_req(t_i, r_i, P_{prot})
Step2: for j= 1 to l
Apply ACO to find the reliability of i_n
If i_n in ψ && i_n**!** =r_j **then**
i_n forward(t_i, r_i, P_{prot}) to next-neighbor
Else if $i_n$in ψ&& i_n==r_j **then**
r_j store($path_i$, f_{t_i}, $i_i \in path_i$)
r_j generate the reverse path to t_i
t_i receives ack from r_j
Send-data (t_i, r_i, $path_i$)
Else
r_j not reachable or not in range
End if
End for
Step3: send-data (t_i, r_j, data)
Step4: t_i checks $i^n_{j=1}$ those nodes in $path_i$
If (i_n in route)
Execute PSO (i_n)
Calculate $f_{t\_k} = 1 - \frac{\sum_{i=1}^{n}(fd_j - f_{surc\_i})}{R_{prd}}$
If f_{t_k}>$pbest_i$ **then**
$Pbest_i = f_{t\_k}$
$l_{new\_k} \leftarrow l_{old\_k} + V_{kd}$
Else
$Pbest_i$
$l_i \leftarrow l_{old\_k}$
Discard route packet
Call P_{prot}
End if
End if
Step5: **for** i 1 to n
If receives data at i^{th} node&&i_n! = r_i **then**
$q_i \leftarrow q_i + 1$
i_n check, route table to send next-successor
Else if data forward from i^{th} node&& i_n! = r_i**then**
$q_i \leftarrow q_i - 1$
i_n forward (t_i, r_i, data) to next-successor
Else if it receives data at i^{th} node&&i_n == r_i, **then**
$q_i \leftarrow q_i + 1$
Retrieve data from q_i
Send ack to t_i from reverse $path_i$
Else
r_i not in ψ or $path_i$ break
Connection terminates
End if

V. SIMULATION ENVIRONMENT

Table 1 represents the following simulation parameters to make the scenario of routing protocols. The detailed simulation model is based on network simulator-2 (ver-2.31), which is used in the evaluation. The NS-2 instructions can be used to set up the service source and the receiver, as well as to define the topology structure of the network and the way the nodes move.

Table 1: Simulation Parameter for Deployment of MANET

Parameters	Configuration Value
Simulation Tool	NS-2.31
Routing Protocol	ACO, PSO, Hybrid, LACPSO
Simulation Area	1000m*1000m
Node Maximum Velocity [m/s]	20
Network Type	MANET
Number of Nodes	100
Physical Medium	Wireless, 802.11
Simulation Time (Sec)	550Sec
MAC Layer	802.11
Antenna Model	Omni Antenna
Traffic Type	CBR, FTP
Propagation radio model	Two ray ground
Energy (Initial)/J	Random

VI. SIMULATION RESULT

A.Data Receiving Analysis

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The good packets received indicate that the approach works properly in the network.

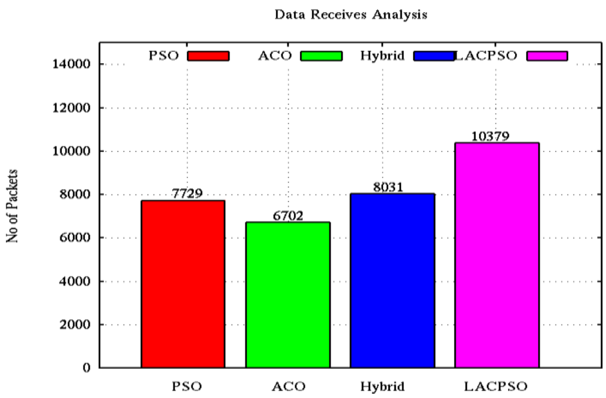

Figure 1 Data Receiving Analysis

The protocol performance is completely dependent on the network conditions. It means the network load is greater than the possibility of success. Data received is not guaranteed without an ACK of received packets sent to the sender through the receiver. This graph demonstrates the performance of packet receiving with PSO, ACO, Hybrid, and LACPSO. The performance of LACACO packet receiving is much better than the rest of the protocols. The hybrid approach received 2000 more packets, higher in ACO and PSO cases. The proposed approach has maintained link stability, and because of that, the packets are received frequently.

Table 2: Data Receive Analysis

Data Receives Analysis				
Protocol	**PSO**	**ACO**	**Hybrid**	**LACPSO**
#Packets	7729	6702	8031	10379

B. End-to-End Delay Analysis

In end-to-end delay analysis, we compare the performance of PCO, ACO, hybrid, and LACPSO. Suppose senders send data greater than the available bandwidth. In that case, the chances of data dropping will be greater, and acknowledgement of sending packets will be delayed due to load on the intermediate path node. In a link breakage situation, fair share cannot be higher than achieved through proper data reception, as it will affect other flows. The LACPSO approach can reduce delays in the network.

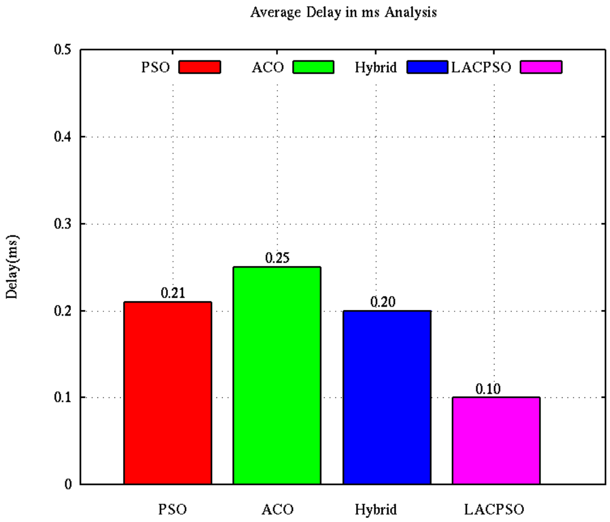

Figure 2 Delay Analysis [ms]

But for partial distribution fairly or if the fair share is certainly higher than the achieved throughput, choose the lightly loaded route for successful receiving. The Hybrid Approach shows a 0.20ms delay, but LACPSO gives a 0.10ms delay. It means the proposed approach is better.

Table 3: Average Delay

Average Delay Analysis [ms]				
Protocol	**PSO**	**ACO**	**Hybrid**	**LACPSO**
Delay	0.21	0.25	0.20	0.10

C. Overhead Performance Analysis

The number of routing or connection-established packets delivered in a network is used to calculate the routing load. A routing packet requires finding the destination and then beginning data delivery. Suppose the link in the network is broken due to the mobile nature of the network. In that case, it is necessary to establish a connection in the network and then successfully deliver data. It means that delivering more routing packets degrades network performance while increasing the routing load in the network. In this graph, the performance of routing protocols is measured based on routing load, and we identify that the proposed LACPSO is less than other PSOs, ACO and Hybrid. Here in the case of the hybrid approach, routing packets are delivered in the network, but in the proposed scheme, the overhead is only 2.20. The proposed scheme provides strong and more possibilities for the path by minimising the routing overhead.

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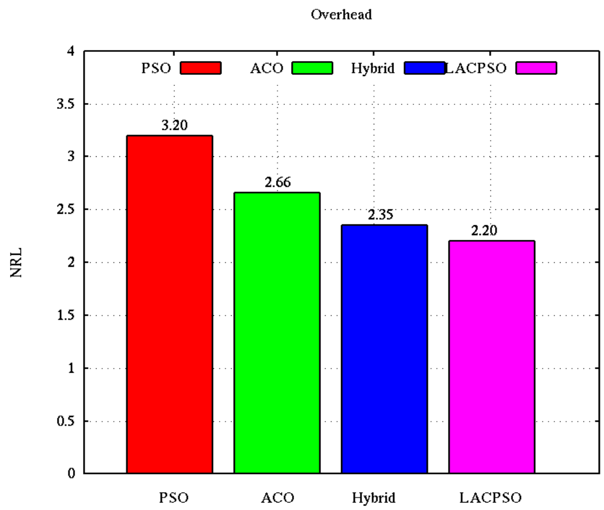

Figure 3: Overhead Analysis

Table 4: Overhead Analysis

Overhead Analysis				
Protocol	**PSO**	**ACO**	**Hybrid**	**LACPSO**
Overhead	3.20	2.66	2.35	2.20

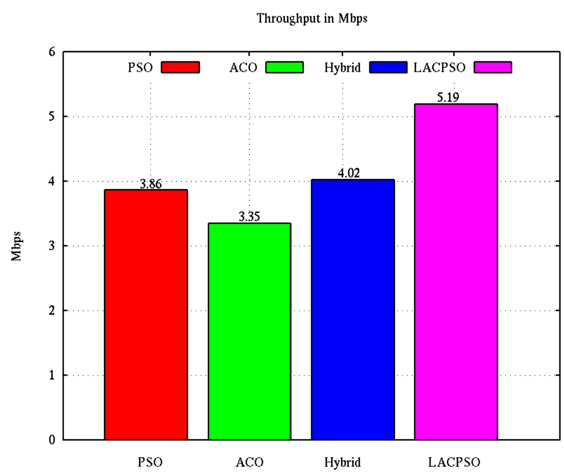

Figure 4: Throughput Analysis

D. Throughput Performance Analysis

This graph represents the throughput analysis in the cases of PSO, ACO, Hybrid and LACPSO. The throughput in the case of the proposed scheme is much less than the all-previous scheme. In the case of the proposed scheme, a larger amount of data packets is delivered to the network. The reason for throughput minimisation is only to handle packet delivery based on strong link establishment and proper nodes buffer space utilisation. The throughput increases in LACPSO because of higher data packets received in the network. But if we measure the other performances, the proposed LACPSO is at least 1.10Mbps if compared with hybrid better in the network.

Table 5: Throughput Analysis [Mbps]

Throughput Analysis [Mbps]				
Protocol	**PSO**	**ACO**	**Hybrid**	**LACPSO**
Throughput	3.86	3.35	4.02	5.19

E. Packet Delivery Ratio Analysis

The Packet Delivery Ratio (PDR) is the percentage ratio of the number of packets successfully received at a destination. The PSO, ACO and Hybrid routing approaches cannot handle the network load efficiently. The proposed LACPSO technique can improve the routing capability of the normal ACO routing protocol by proving the number of alternatives in the network for delivering data between sender and receiver through intermediate nodes. In this graph, the performance of normal PSO, ACO, hybrid, and LACPSO is compared, and it is finally observed that the proposed approach is showing remarkable growth in performance. Here we visualise that the PDR of the hybrid approach is about 85%, but in the case of the proposed approach, it is 95%. Regarding PDF, the proposed scheme shows about 5% more improvement.

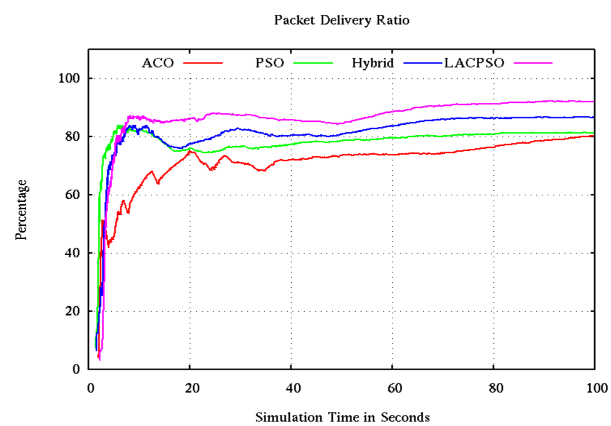

Figure 5: Packet Delivery Ratio Analysis

VII. CONCLUSION AND FUTURE WORK

MANETs are highly dynamic and distributed in nature. Previous research has shown that nature-inspired routing protocols can solve at least one or several areas' problems, such as battery life, scalability, maintainability, survivability, adaptability, and so on. Generally, it isn't easy to design scalable routing protocols under extreme traffic conditions. However, incorporating link breakage awareness complicates the problem by incurring overheads in an already heavily loaded network. This paper proposes the Link Reliable using Ant Colony and Swarm Optimization techniques (LACPSO) to reduce link breakage and packet drooping. In the LACPSO technique, ants leave pheromone trails at nodes or edges, which increases the likelihood of other ants following these trails. The PSO method is useful during the break route re-establishment process but cannot resolve the link breakage problem. If a route is broken during communication, the LACPSO searches for a new route based on minimum delay and minimum hop count, formulating an algorithm to find the best and determining the node velocity. The proposed scheme selects routing paths based on traffic density to balance the network traffic load. The trade-off between the amount of overhead expended in finding congestion-free paths and data delivery is very delicate at high-traffic loads. The packet receiving is more about 2000packers as compared to the hybrid approach. The same difference is observed in performance, delay and overhead. The PDR performance of LACPSO is 5% better than the hybrid approach. However, while improving network routing capability, we have seen that the proposed scheme can achieve better performance in higher traffic load conditions than PSC, ACO, and hybrid approaches.

One of the areas of potential future research would be to develop coordination and communication among the various network layers to achieve QoS in MANETs. In the future, we will also access the coordinate-based method to improve the QoS parameter.

Reference

[1] C.-K. Toh. Ad hoc mobile wireless networks: protocols and systems. Prentice Hall, 2002. ISBN: 0-13-007817-4.

[2] Z.Liu, M. Z. Kwiatkowska and C. Constantinou, "A biologically inspired QoS routing algorithm for ad hoc networks", International Conference on Advanced Information Networking and Applications, AINA 2005 1: 426-431, 2005

[3] Sthitaprajna Jena, Jyoti Prakash Lakra, "Application Of Ant Colony Optimisation technique For Manets", pp-1, 2009.

[4] M. Subha, Dr R. Anitha, "An Emerging Ant Colony Optimization Routing Algorithm (Acora) For MANETs, Journal of Computer Applications", Vol-II, No.3, July-Sep 2009.

[5] S. Prasad1, Y.P.Singh, and C.S.Rai, "Swarm Based Intelligent Routing for MANETs", International Journal of Recent Trends in Engineering, Volume 1, No. 1, May 2009.

[6] Mehran Abolhasan, Tadeusz Wysocki and Eryk Dutkiewicz, "A Review of Routing Protocols for Mobile Ad hoc Network", Ad hoc Network Journal "Elsevier" Volume 2, Issue 1, pp. 1-22, 2004.

[7] Rangaraj and Anitha, "Efficient QoS Routing in MANET by a Novel Hybrid Technique, Springer, LNDECT 26, pp. 233–243, 2019.

[8] M.M.Goswami, "AODV Based Adaptive Distributed Hybrid Multipath Routing for Mobile AdHoc Network", IEEE International Conference on Inventive Communication and Computational Technologies, (ICICCT 2017), pp. 410-414, 2017.

[9] Wenjia Liu, Yuebin Bai, Weitao Wang, Yuhao Gu, Jihong Ma, Linbin Xu and Lijun Zhang, "A Node Stability-Based Multipath Routing Protocol in Heterogeneous Ad Hoc Networks", IEEE 18th International Conference on High-Performance Computing and Communications; IEEE 14th International Conference on Smart City; IEEE 2nd International Conference on Data Science and Systems, pp.70-77, 2016.

[10] P. Periyasamy, Dr E. Karthikeyan, "Link Reliable Multipath Routing protocol for mobile ad hoc networks", IEEE International Conference on Circuit, Power and Computing Technologies [ICCPCT], 2015.

[11] Ahmed M. Abd Elmoniem, Hosny M. Ibrahim, Marghny H. Mohamed, and Abdel-Rahman Hedar, "Ant Colony and Load Balancing Optimizations for AODV Routing Protocol", Ash din Publishing International Journal of Sensor Networks and Data Communications Vol. 1 (2012).

[12] Dorigo, G Di Caro, The ant colony meta-heuristic, in New Ideas in Optimization, ed. by Corne D, Dorigo M, Golver F, pp. 11–32, McGraw-Hill, 1999.

[13] M Dorigo, G Di Caro, LM Gambardella, "Ant algorithms for discrete optimisation, "Artif Life 5(2), 137–172, 1999.

[14] P.Deepalakshmi1 and Dr S.Radhakrishnan, Ant Colony Based QoS Routing Algorithm For Mobile Ad Hoc Networks, International Journal of Recent Trends in Engineering, Vol. 1, No. 1, May 2009, 459-462.

[15] B.R.Sujatha and Dr M.V. Sathyanarayana, PBANTOptimized ANT Colony Routing Algorithm For Manets, Global Journal of Computer Science and Technology Vol. 10 Issue 2 (Ver 1.0), April 2010, 29- 34.

[16] Shahab Kamali, Jaroslav Opatrny, A Position Based Ant Colony Routing Algorithm for Mobile Ad-hoc Networks, Journal Of Networks, Vol. 3, No. 4, April 2008.

[17] S. Basagni *et al.*, "A Distance Routing Effect Algorithm for Mobility (Dream)," Proceeding of 4th Annual ACM/IEEE Int. Conf. Mobile Computing and Networking, MOBICOM '98, pp. 76–84, Dallas, TX, USA, 1998.

[18] S. Basagni, I. Chlamtac, and V. Syrotiuk, "Geographic Messaging in Wireless Ad Hoc Networks," Proceeding of 49th IEEE International. Vehicular Technology Conference, Houston, TX, USA, vol. 3, pp. 1957–61, 1999.

[19] Srinivas Sethi and Siba K.Udgata, The Efficient Ant Routing Protocol for MANET, International Journal on Computer Science and Engineering, Vol. 02, No. 07, 2010, 2414-2420.