Improvement of Least Congested Mobile Ad-Hoc Network Based on ANT Colony Optimization

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Abstract - DSR protocol is well known MANET protocol for their improved quality of service in high mobilty scenerio, It contains small overhead than other MANET [1] protocol such as AODV, DSDV [2], TORA etc. and the improvement in superior quality of service for DSR [3] in low mobility condition is achived by using Ant Colony Optimization Technique. It reduce the time and space requirements of DSR protocol through Swarm Technology. But the overhead increases due to ACO for finding shortest path that increases huge number of control packets [4] in the network. In this paper, the new approach of dynamic programming for the use of with and without ACO DSR is used in the different mobility condition. proposed for the reduction of control overhead in the network . The proposed work dynamically selects the techniques by taking decsion based on routes condtion accumulated during ants search. The noticed improvement is effective and considerable.

Keywords: ACO, DSR, MANET, AI, AntDSR .

I INTRODUCTION

In this paper, the problem of wireless ad-hoc network routing algorithm is discussed and analyzed for the enhancement of the technical aspects. Dynamically created and recreated routes generates many issues [5] like packets drop, delay, loop, cache memory overflow etc. The varying nature of network can be solve by adapting the condition and perform according to it. Artificial intelligence (AI) plays great role in such condition by relatively taking decision, swarm intelligence is sub part of AI. The aim of proposed work is to achieve two important goals, according to networking condition it is required to take advantages of AI to solve the challenging problem to provide path in Ad-Hoc wireless multi-hop networks. Another goal is to provide deep study and understanding for the swarm intelligence can be adapted to work well for realistic and verities of dynamic problem in the world. We inspect the issue of adaptive routing in MANET by applying the advantages of Swarm Intelligence (SI). Ant Colony Optimization (ACO) [6] is one of the technique in SI that provides us the opportunity to improve the DSR protocol at measurable level. Although ACO has great application in diverse field of engineering and society and remarkable achievement is also met during last few years. The properties of ACO, such as adaptive and robustness is too much useful in the problem of routing of the MANET and useful to overcome the challenges of MANET effectively. MANET and ACO resemble the similarity in the process hence it is one of the domain of research, test and improvement. The combination of ACO and other techniques of SI is literally works well and new techniques are developed for the problem at hand. One of the technique AntHocNet [7] routing algorithm is the combination of dynamic programming with ACO and conventional algorithms. The reactive and proactive functions act simultaneously work in hybrid algorithm provides a great algorithm. Recurrently performing many experiments and tests in wide range of different environments a performance metrics to reach the point where it out perform any of the conventional methods by attractive margin. Proposed work performed detailed analysis of internal working of the algorithm and provides vast write-up in a realistic urban environment. The ant colony optimization (ACO) meta-heuristic [8] is based on general problem representation and definition of ant's food foraging behavior. The ACO meta-heuristic has successfully been applied to a number of different combinatorial optimization problems such as Vehicle Routing Problem [9], traveling salesman [10], and routing in communication networks such as AntNet [11], Mobile Ants Based Routing (MABR) algorithm [12], ARA [13], and ARAMA [14],

II SWARM INTELLIGENCE: ACO

The problems related to NP hard class that can be solved and optimized by Ant colony optimization algorithms. It has been applied to many stochastic problems, multi-targets and parallel implementations, combinatorial optimization problems like quadratic assignment to protein folding or routing vehicles and a lot of derived methods have been adapted to dynamic problems in real variables. Travelling salesman problem is solved to nearest optimal value by ACO. It performed better than simulated annealing, genetic algorithm any other optimization approach when graph may change dynamically, the behavior of ant is to reach the destination with an optimized path and hence it continuous process of adapting changes in real time. Network routing and urban transportation systems are the two areas where ACO can successfully applied.

The travelling salesman problem is the first problem which was solved by an ACO algorithm in which the goal is to find the shortest round-trip to link a series of cities. The general algorithm is comparatively straightforward and based on a set of ants, each making one of the possible round-trips down the cities. At each phase, there is a rule according to ant chooses to move from one city to another, It must trip each city precisely once, A far-away city has less probability of being chosen (the visibility), The selection of edge is depends upon the amount of pheromone deposition and only those edge is selected which has largest pheromone deposition. The amount of pheromone deposition is depends upon number of ants travelled through that path which is shortest path among various available path in the network. This is because other path contains pheromone but pheromone deposition is evaporated due to larger path length and very few ants travelled through it.

III RELATED WORKS

ACO is based on bio-inspired Swarm intelligence nature of ants. The collective behavior of decentralized, self-organized system is essence of swarm intelligence which is further classified as Artificial Intelligence (AI) when it is developed by human. The famous ACO algorithm is developed by Gerardo Beni and Jing Wang in 1989, for the context of cellular robotic systems. Initially ACO is developed for solving computational problem related with probabilistic technique like finding good path through the graph. The behavior of ants was investigated and it is found that ants leave their pheromone on the path for future reference. With the help of pheromone, they help each other to follow same path for searching of food and completing their journey in less time. The performance of DSR is improved with small delay and increased throughput. Routing overhead is increased with 58% than DSR protocol, the analysis is one over different scenario, velocity and pause time in the network.

One of the methods of improvement is based on TTL. Time to live is a parameter used for packets to identify weather they reached to each node in the network during communication phase of Mobile Ad-Hoc network routing protocols. In the paper [15] by Tambuwal, A.B. , Noor, R.M. , Michael, O, there is comparative study of TTL_DSR and DSR. In TTL_DSR protocol there is reduction of route discoveries frequency and the propagation range of route discovery operations. But no assumption of route caching and overhearing. TTL is the value used in Route Request message for limiting the rebroadcast for a number of times. In the proposed paper randomized strategy is used which consist of random sequence of TTL value set. Node sends packet with TTL=1 at the initiation of ROUTE REQUEST. Node waits for base delay for any reply to arrive but if no reply is arrived in this time, it again broad cast the request and waits for a backoff period. Again if no reply come, node retry with 2*backoff period and this process repeated for maximum number of retries. For the limitation of aggressive route discovery, a cache mechanism is used in which learned or overheard routes are stored. With every ROUTE REQUEST a random TTL sequence is used. In addition to it a waiting period is also adjusted using TTL i.e.

$$waiting\_period(ttl) = ttl \times base\_delay$$

Base delay affect DSR_TTL much more than DSR because in DSR base delay is used only one time when TTL=1, whereas DSR_TTL uses it after each unsuccessful ROUTE REQUEST. Large value of base delay causing unnecessary delay for retransmitting ROUTE REQUEST and small value of base delay leads to waiting period expire before the ROUTE REQUEST reaches the furthest nodes. Only overhead is reduced in DSR_TTL than DSR for the large or small network with or without caching. Another technique which is based on randomized search strategy, choosing at least one new randomized sequence from the given non random TTL sequence. That minimized the effect of worst-case search cost.

The work [16] proposed by Jiaxu Chen, Yazhe Tang, Dian Fu, and Heng Chang, with low overhead DSR protocol also reduce its cost of route discovery using improved route cache strategy. DSR also work well in multipath routing and non symmetrical transmit pattern. Although DSR has some disadvantages such as additional path information in data packets, stale link accumulation and the RREQ packets flood. With all these demerits, the DSR protocol does not perform well for large scale network. A node cache the information of routes from the packets and it is used to send reply any kind of packets like RREQ, RREP etc. this information helps source nodes to get route more quickly than any other protocols. But it is more problematic when stale routes are flooded in the network. To overcome such problem there are three strategies proposed like cache structure, cache capacity and cache timeout. There two kinds of cache structure known as link cache and path cache. Link cache can store all the information during learning of node and requires less storage space therefore it is preferable than extensive graph search algorithm. The storage space is much larger in case of path cache for the network with N nodes. Cache is divided into two parts, primary cache and secondary cache. Time strategy for path cache is not required because of storage space limitation. For the link cache, time out mechanism works both as statically and dynamically. There are two life times of link cache T1 and T2 seconds. If the link is used during T1 time then T2 time unit is assigned to it. Active packets proposed for visiting all the nodes and gather link information and topology of the network. This packet updates the cache with latest information. This method helps in reduction of overhead and also miss rate. Active packet strategy uses new packet structure and its forwarding technology rather than only mild modification in route cache. The information collected by active packet is used to derive any one of the path from source to destination effectively. The proposed protocol Tiding Active Packets is based on active packet, it works with RERR flooding mechanism improves route cache. Tiding Active Protocol (TAP) is divided into three processes known as Topology Collection, Path Calculation and Topology Maintenance. Topology Collection phase requires active packet visit whole network two time, first when packet collect all the neighbor links and second time when all the nodes cache this information from the active packets. This is known as Path Calculation in TAP.

Another improvement in DSR protocol is in ACK reply as ABDULLAH GANI explained in [17], Routing protocol uses backup route for the data transmission in case of route is broken and if such backup route is also break than whole route is again discovered which causes unnecessary delay and overhead in the network. For solving such problem there is path from which ACK replied and also deploying TCP-BUS for reducing the unnecessary retransmission of lost data in the network.

IV OPTIMIZATION METHODS USED IN MANET

Artificial Intelligence (AI) is a demanding technique now a days in an engineering stream, many researchers are taking interest to implement the system which reduces the cost of fabrication, maintenance etc. The procedure of optimization is very simple and attractive because it iteratively compares the solution till an optimum or a satisfactory solution is achieved. The general procedures followed in optimization methods are need for optimization, selection of design variables, formulate constraints, formulate objective function, setup variable bounds, choose an optimization algorithm and finally obtains solution. There are various optimization algorithms like Evolution Programming, Genetic Algorithms, Simulated Annealing, Tabu search, and Neural Networks. In the publication ODSR [18] by Istikmal, that has studied and evaluated the performance of the algorithm in different scenarios like increasing speed of the nodes from 2 m/s to 18 m/s, pause time is varied between 10 to 100 m/s, and last one is varying number of connection with increasing speed. The performance is found to be better than existing DSR protocols and it is verified by measuring throughput, delay, and number of average hop count. But the network overhead is increases in the proposed technology.

DSR routing protocol based Mobile Ad-Hoc network faces many problems and one of the problem is packets loss, delay and network overhead due congested path selection. Dynamic Congested path detection technique is required decide the suitable path among many alternate paths. Ant Colony Optimization techniques is the bio-inspired optimization algorithm based on the behavioral pattern of ant movement for food searching and collection. ACO is used to select the path with least congestion by evaluating congestion matrix of different paths from source to destination.

V PROPOSED METHODOLOGY

Two working modes are defined for Ant based-DSR namely ACO mode and local mode.

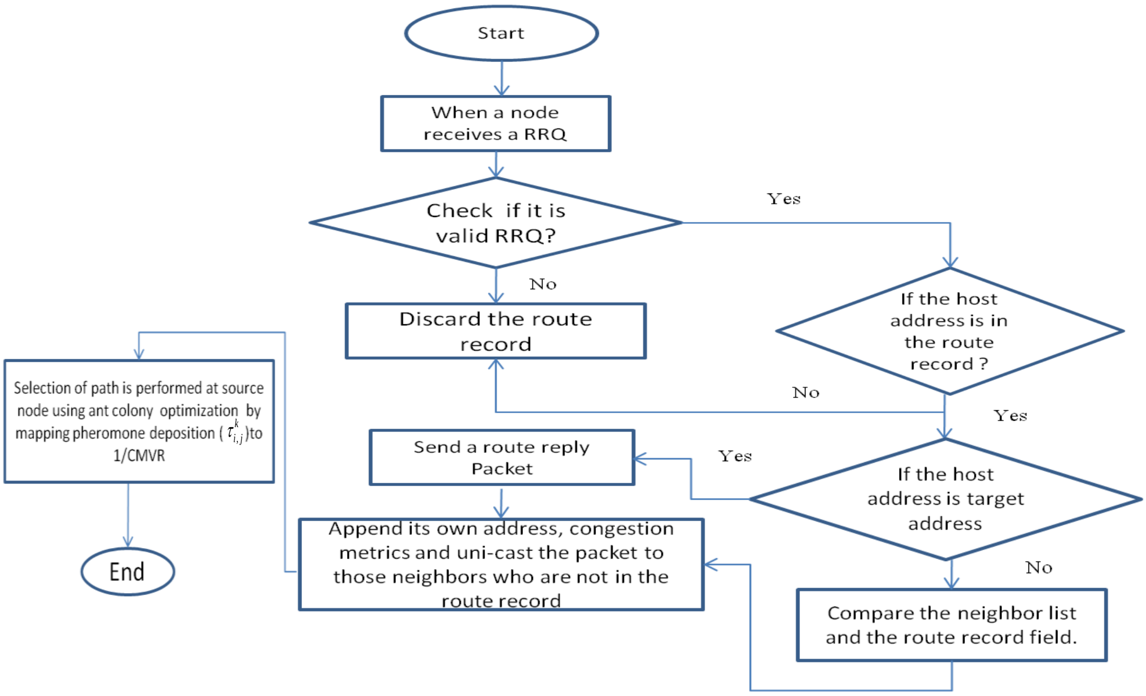

Fig 1: Flow chart representing the process of routing path selection

In ACO mode the dominant role is played by ACO-based proactive component in providing global information and preferences for path selection. On contrary, the information gathered by each node from its neighboring node makes the decision. The mode of operation is selected by each node independently. Each node selects its mode of operation independently. The goal of local mode is to stop or minimize the overhead of ACO based proactive component when it cannot perform as expected in highly dynamic network environments. The process of packets transmission from source to destination in AntDSR is same as DSR communication phases like first is route discovery, second is packets transmission and report error if it is there. Route discovery is done in respect of searching shortest route to destination node with the broadcasted route discovery packets in the network.

The process of route selection through ant colony optimization method is explained through flow chart as shown in figure 1

The congestion metrics is used to perform the task of optimization. Congestion metrics is based on three parameters namely channel load, the rate of dropped packets from the queue and the buffer occupancy. The calculation of congestion metric is performed by the following equation.

$$NNCM = (1-(1-LNCM)^2)$$

Where NNCM is nonlinear node congestion metrics, this congestion is occurred due to unpredictable rate of flow of data in the network i.e. busty nature of information origination. LNCM is a linear node congestion metrics, it based on the uniform rate of flow of data in the network. Each node calculates its congestion metric value of route (CMVR) value from the collected NNCM values of each path from source to destination and attached with DSR route request packet. The CMVR is a congestion metric value of route is used as optimization parameters for the ACO algorithm. The CMVR is calculated as in equation

$$CMVR = 1 * NNCM_1 * NNCM_2 * NNCM_3 * ......NNCM_i$$

VI APPLIED ACO METHOD

ACO perform optimization task with the information collected at the source node. According to ACO, their parameters are mapped with CMVR value like concentration of pheromone deposition by the ant i.e. τ_{ij} . The table is shown below contains the initial value of the parameters used in the ACO.

Table 1: Ant Colony Optimization Algorithmic Parameters Values

ACO Parameters	Initial Values
t (time)	0
NC (number of Cycle)	10
τ_{ij} (Concentration of Pheromone deposition)	C (randomly selected constant value)
$\Delta\tau_{ij}$ (Small variation of pheromone deposition concentration)	0

ACO runs with these initial parametric values and perform 10 iterations to fetch the best optimized values of the path with least congestion. For the calculation of optimized value, ACO uses the following equation

$$p_{ij}^k(t) = \begin{cases} \frac{[\tau_{ij}(t)]^\alpha [\eta_{ij}]^\beta}{\sum_{k \in allowed_k} [\tau_{ik}(t)]^\alpha [\eta_{ik}]^\beta} & if\ j \in allowed_k \\ 0 & otherwise \end{cases}$$

This equation helps in the calculation of best probable $p_{ij}^k\ (t)$ direction form node i to node j for the ant to move among various allowed k nodes options otherwise does not select. The value of parameters α *and* β, $\alpha > 0$ and $\beta > 0$, determines the relative importance of pheromone value and heuristic information. The heuristic information is optional, but often needed for achieving a high algorithm performance. Now for every iteration the concentration of pheromone deposition increases or varies according to ant traversal with the following equation.

$$\tau_{ij}(t+n) = \rho\tau_{ij}(t) + \Delta\tau_{ij}$$

$$\Delta\tau_{i,j}^k = \begin{cases} \frac{Q}{L_k} & if\ (i,j) \in tour\ describe\ by\ tabu_k \\ 0 & otherwise \end{cases}$$

The iteration is continues until the number of cycle is not equal to maximum 10 iteration. Where Q is constant and used for defining to be of high quality solutions with low cost. The quality of the solution of ant k would be the length L_k of the tour found by the ant. attractiveness, ρ, trail persistence.

VII SIMULATION AND RESULT ANALYSIS

The work is done on the network simulator NS2.34 [19]. The NS2 is developed in C++ and TCL programming language.

Mobile Ad-hoc Network Model

Wireless nodes are randomly located in the fixed area size field with random mobility. Some physical parameters are predefined for the simulation as shown in table 2

TABLE 2: PARAMETERS DEFINED FOR THE MANET

Simulation Parameters	Values
Time of Simulation	60second
Dimension	3000meter X 1000meter
Mobility Model	RWP (Random Waypoint)
Traffic Model	CBR(Constant Bit Rate)
Node Antenna Range	30meter
Maximum Speed Limit of a node	18 meter/second
MAC protocol	IEEE 802.11
Data Packet Size	64 byte
Minimum Pheromone level	0.0001
Timer value for receiving ACK message from the destination (TACK)	100 mili second
Required energy to transmit/receive a bit (Et = Er)	0.05 mili joules/bit
Initial Energy for each node	100 Joules

VIII RESULT ANALYSIS

The algorithm performance is measured by various parameters like average end to end delay (ms), packet delivery ration (PDF),Network Routing Overheads and energy consumed by the nodes. The PDF is calculated for six scenarios to validate the improvement of ANTDSR over DSR protocol. The results are analyzed and represented in the figure 2.

According to graph, it is observed that the PDF of ANTDSR is better than DSR protocols in all the six scenarios. About 2-4% improvement of ANTDSR over DSR protocol because presence of optimization technique in ANTDSR helps in identifying least congested path from source to destination. This least congested path is only identifying through selecting the path by ants with majority of pheromone deposition.

Delay is defined as the time is used by packets to travel from source to destination. The average is done to identify the delay of the network by summing the delay faced by each packet and divide the sum by number of packets. It is observed from the figure 3 that average delay in ANTDSR is lesser than DSR protocol. About 0.75 to 1.5 times improvement is noticed and this improvement is due lesser time taken by packets in the network to reach from source to destination in ANTDSR and it happens because path selected by ACO is optimized path with least congestion. There is too much time is saved by avoiding waiting in the queues of intermediated nodes, waiting in congested path etc.

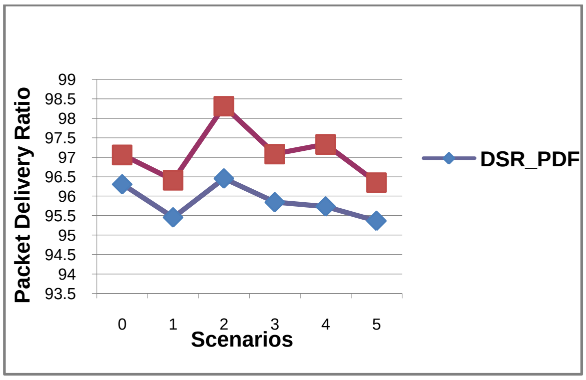

Fig 2: Packet Delivery Fraction comparison between DSR and ANTDSR

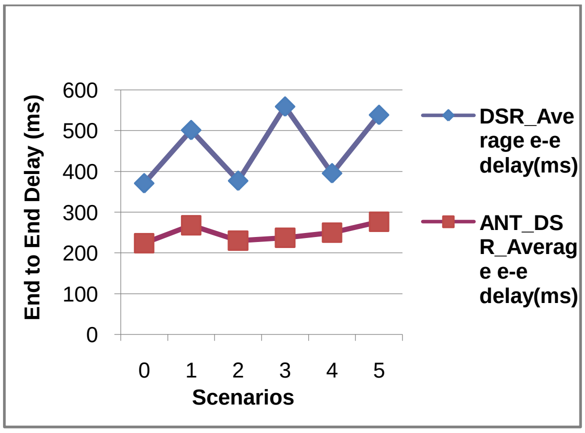

Fig 3: Delay Comparison between DSR and ANTDSR

The traffic of data packets over wireless network which is the combination of data packets [6] and control packets is termed as Network Load.

According to the proposed work, the experiment is done over six different scenarios and results are collected. The above result is evaluated and analyzed through graph as shown in the figure 4.

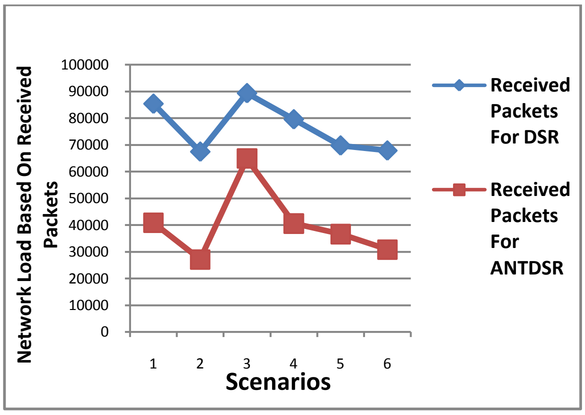

Fig 4: Network Load comparison for DSR and AntDSR

According to the graph as show in figure 4, it is observed that network load of DSR algorithm is high because of packets due to retransmission of packets. The retransmission of packets in DSR is too high because the selection of route is only depends on the shortest route search algorithm, shortest route might be highly dynamic or congested. But in case of AntDSR algorithm, the network load is low because there is pre decision of the selection of best route and it based on ACO algorithm. ACO helps in selection best route by evaluating each route on the basis of congestion matrix send by each node in the network. It is observed that about 1-1.25 time improvement in AntDSR than DSR.

Network Routing Load is defined as the traffic increases due to control packets which are transmitted to discover the path, maintain the path and terminate the connection.

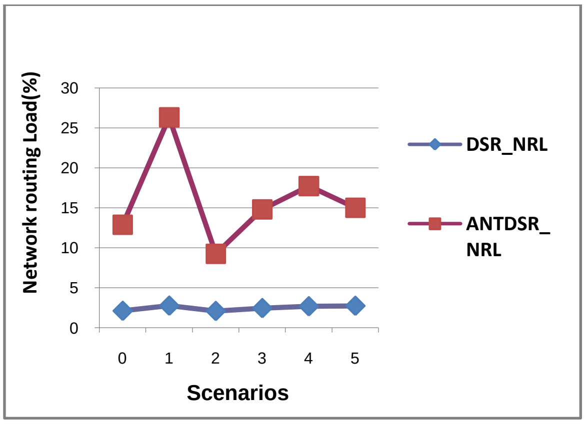

Fig 5: Routing Load Comparison of Network Routing Load

It is observed that routing load increases in the ANTDSR algorithm as per received packets because increasing algorithmic requirements of extra control packets for searching an optimized path. To travel in the network to fetch the information regarding route condition, ACO use agent travelling in network and evaluate each node's packet dropping rate, queue length, link status etc. These overhead will increase the routing in ANTDSR as shown in the figure 5 According to graph as shown above demonstrate that about 15-40 % routing load increases in the ANTDSR than DSR algorithm.

Energy consumption by the network is associated with the per bit energy required for processing and transmission. Rate of energy consumption decides the survivability of the network.

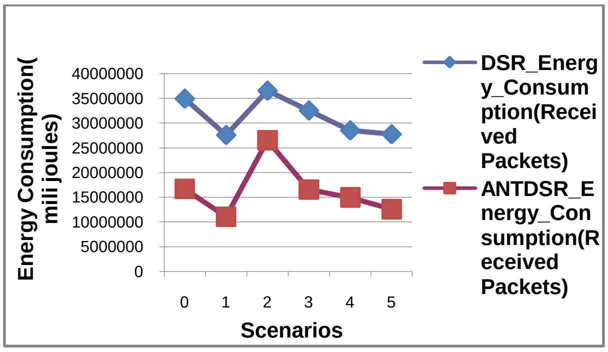

Fig 6: Energy consumption comparison in the Network

According to Figure 6, about 1 to 1.5 times better performance is given by ANTDSR algorithm as compared to DSR as validated by simulation of six different scenarios.

IX CONCLUSION

The route discovered in DSR algorithm might contain congestion and there is no mechanism that how to get know that path is congested before transmission of packets. To get earlier information of the best route, ACO perform optimization during selection of route based on least congestion metrics as decision variable. Selection of route is based on the ant behavior of route search for food hence it is known as bio-inspired optimization technique. According to the simulation results which came out after rigorous process of experiment done over NS2, it is depicting that there is improvement in DSR with ACO than DSR Algorithm. This improvement is about 1 to 4% with taking all metric under consideration like PDF, delay, energy consumption. But network routing load increases because ACO process requires information that involves extra routing packets in the initial phase of the communication. This improvement is due to the decision taken by source node to choose only that path which contains least congestion before data packets transmission.

X FUTURE WORK

In the proposed work congestion metrics is taken as decision parameter which might be not sufficient for good path selection, some more parameters should be taken as decision parameters. There are some more powerful optimization techniques are available like Neural network and PSO. They converge to the maximum or minimum within short interval of time than ACO and they reduce the time in the initial stage of the path section process.

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