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Secure Path Planning Algorithm for Multi-Constrained QoS Routing in VANETs

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ABSTRACT: Vehicular ad hoc networks (VANETs) is an emerging technology which has received lot of attention due to its potential to improve vehicle and road safety, traffic control, efficiency as well as convenience for users. VANET is a sub category of mobile ad hoc network (MANET). A lot of research in VANET is done on routing, broadcasting, Quality of Security (QoS) and security. This paper proposes a novel path planning algorithm for efficient routing. The proposed system will traditionally distribute the work load over alternate paths in order to avoid congestion and reduce travel cost. It will also ensures reliable routing with less bandwidth requirement and high packet delivery ratio as it avoids packet loss. VANET may be affected by attacks on routing leading to altering messages and routes which will affect QoS parameters. The proposed algorithm will deal with providing security measures over the routing process. Therefore we obtain routing algorithm subject to multiple QoS constrains for secure VANET communication.

KEYWORDS: Multi-constrained, Path planning algorithm, Reliable routing, Vehicular ad hoc network.

I. INTRODUCTION

Vehicular Ad Hoc Networks (VANETs) are a form of wireless network made by vehicles acting as nodes in the network which communicate among themselves and with road side base stations or the road side units (RSU). A wide range of services have been developed for VANETs ranging from safety to information applications. Also, Intelligent Transportation System (ITS) provide fast and safe traffic system, so the interest in wireless communication studies and VANET commercializing VANET is growing. A primary requirement for such services is that they are offered with Quality of Service (QoS) guarantees in terms of service reliability and availability. Due to openness of VANET's, wireless channels are subject to both internal and external attacks, the application of security mechanism is mandatory to protect the offered QoS guarantees.

The proposed algorithm will help vehicles to bypass congestion and balance traffic evenly in the whole network. The algorithm set its main objective at providing alternate paths for vehicles to avoid congestion or accident and ensure secure and reliable routing satisfying multiple QoS constraints. Maintaining alternate paths to move to destination will also reduce the need for bandwidth as the traffic will be distributed. Previously some work has been done on VANETs which considered multi vehicle path planning which had some disadvantages such as it did not deal with average travel cost and drivers preference. The ACO rule tries to find optimal path to destination where other ants would follow the path of leading ant. In this case congestion avoidance was not taken into account. Whereas in our proposed method we will design a new system that will ensure global path planning algorithm which will fully utilize the network resources so that the average total cost of vehicles are considerably reduced and will avoid traffic congestion.

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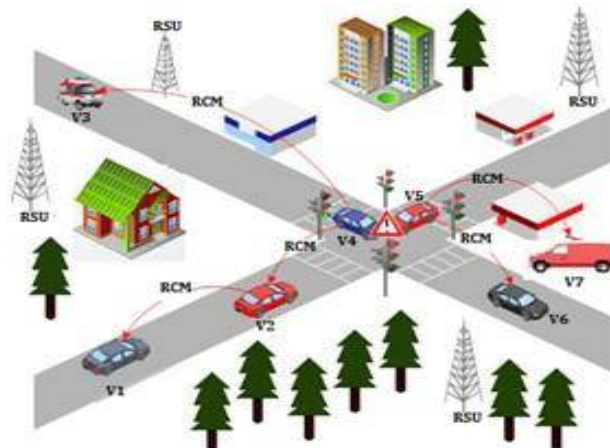


Fig. 1. Vehicular Ad Hoc Network

As VANETs are highly dynamic in nature it may subject to internal and external adversaries which raise important technical challenges in terms of reliability and secure routing. There is a possibility that messages between vehicle to vehicle (V2V) or vehicle to road side units communication about safe driving can be manipulated which may lead to accidents. There are different security mechanisms such as digital signatures, hash chains, plausibility checks, etc. could be applied together to protect the routing control messages (RCM). In order to prevent the network from such attacks the algorithm implies strong privacy preservation by making use of asymmetric key cryptography. This will lead to a secure communication over a reliable route.

In this paper we have implemented routing method [1], [4] to achieve a reliable and secure routing in vehicular ad hoc networks. In section II we have done literature survey of related work to solve the problem of routing and security in VANETs. In section III we state our problem definition of proposed system architecture and overview. In section IV we discuss existing system. In section V we describe our proposed system architecture. Section VI includes mathematical model whereas section VII covers algorithm of proposed system. Section VIII includes discussion of results obtained. Finally section IX concludes the work.

II. RELATED WORK

This section consist of survey of different papers related to routing algorithm and security in VANETs. As per our studies there is no previous research done on providing secure routing using path planning in VANETs. Both these aspects are implemented individually.

In paper [1] the author has proposed Secure Ant Colony Optimization based Multi-Constrained QoS aware routing algorithm (S-AMCQ) to compute feasible routes in VANETs subject to multiple QoS constraints determined by the data traffic type. This routing algorithm considers the class of applications having only a single destination, i.e., unicast routing. Further, the VANET-oriented evolving graph (VoEG) model is implemented to perform plausibility checks on the routing control messages exchanged among vehicles. Different types of routing algorithm have been proposed for VANET's. In paper [2] the author has proposed moving-zone based architecture in which vehicles collaborate with one another to form dynamic moving zones so as to facilitate information dissemination. It introduces moving object modeling and indexing techniques from the theory of large moving object databases into the design of VANET routing protocols. In [3] author surveys and discusses different meta heuristics applied to solve the routing problem within VANET. Furthermore, technical challenges and future trends are treated and presented. Routing algorithms such as Particle Swarm Optimization (PSO), Genetic Algorithm (GA) and Ant Colony Optimization are discussed in detail. It provides a comprehensive survey on the main uses of these methods with the challenges faced by VANET. In [4] this paper establish a hybrid intelligent transportation system (ITS), i.e., a hybrid-VANET-enhanced ITS, which utilizes

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both vehicular ad hoc networks (VANETs) and cellular systems of the public transportation system to enable real-time communications among vehicles, roadside units (RSUs), and a vehicle-traffic server in an efficient way. Then, author propose a real time path planning algorithm, which not only improves the overall spatial utilization of a road network but reduces average vehicle travel cost for avoiding vehicles from getting stuck in congestion as well. A stochastic Lyapunov optimization technique is exploited to address the globally optimal path-planning problem. Finally, the transmission delay of the hybrid-VANET-enhanced ITS is evaluated in VISSIM to show the timeliness of the proposed communication framework. In [5] the author has proposed a system employing the situational awareness (SA) concept and an ant colony system (ACS)-based algorithm to develop a situation-aware multi-constrained QoS (SAMQ) routing algorithm for VANETs. SAMQ aims to compute feasible routes between the communicating vehicles subject to multiple QoS constraints and pick the best computed route, if such a route exists. In [6] the author has proposed a shortest path algorithm using bidirectional search, whose complexity is deduced to be $O(N^2)$, where N represents the number of nodes and links in the network, respectively. Then it shows that bidirectional search can significantly accelerate the convergence of several existing QoS routing algorithms. Finally a novel cost-effective bidirectional multi-constrained routing algorithm, which can greatly alleviate the forwarding state scalability issue by supporting stateless QoS routing in IP networks via IP tunneling or constraints-based alternate routing in MPLS networks via label stacks. In [7] the author has proposed a novel bi-velocity discrete particle swarm optimization (BVDPSO) approach and extends its application to the nondeterministic polynomial (NP) complete multicast routing problem (MRP). First, a novel bi-velocity strategy is developed to represent the possibilities of each dimension being 1 and 0, where 1 stands for a node being selected to construct the multicast tree, whereas 0 stands for being otherwise. Second, BVDPSO updates the velocity and position according to the learning mechanism of the original PSO in the continuous domain. In [8] This paper proposes an AODV-based routing algorithm for VANETs. This routing algorithm uses a routing metric, which includes the length of each hop as well as the link remaining lifetime. In [9] the author has provided detailed categorization of various routing techniques and discussion on each categorization with respect to its advantages, disadvantages, various constraints and its applications. The above survey concludes with all of the routing algorithms studied for VANET's.

After routing of VANET it is important to secure the routing control messages in order to ensure secure VANET traffic flow. The following papers deal with providing secure communication in VANETs. In [10] the author proposes RBEM/CBEM handshake mechanism to enhance the broadcast protocol, which is dedicated to the emergency message broadcast in urban road environment. The reliability of emergency message dissemination can be improved by reducing the packet delivery failures caused by the collisions. In [11] author has proposed optimal resource allocation problem, at the base stations is to select optimal receiver vehicles to establish D2D links and assign proper channels for them, in order to minimize the total delay. The problem is equivalent to a maximum weighted independent set problem with dependent weights (MWIS-DW) which is NP-hard. To calculate the weights, an analytical approach is developed to model the expected end-to-end delay. Further a greedy based algorithm is proposed to solve this problem and develop a theoretical performance lower-bound for the algorithm. In [12] the author has proposed a new TDMA protocol called PTMAC based on a novel way of predicting encounter collisions and effectively reducing the number of collisions. This work [13] proposes a provenance-based trust framework, namely PROVEST (PROVENance-baSed Trust model) that aims to achieve accurate peer-to-peer trust assessment and maximize the delivery of correct messages received by destination nodes while minimizing message delay and communication cost under resource-constrained network environments. In [14] this paper, author proposes a new mechanism to maintain QoS for data dissemination among the different vehicles in VANETs. An intelligent forwarding mechanism is used by newly defined metric which assigns weights to the different routing paths from source to destination. Separate algorithms are designed for route construction, and maintenance in the proposed scheme. In [15] the author proposes an efficient decentralized public key infrastructure using the concept of Bayesian coalition game. Finally, in [16] the author has proposed a DOVE scheme inspired by processor scheduling treating roads as processors to optimize the workload assignment and improve the efficiency of on-road dissemination.

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III. PROBLEM DEFINITION

The problem definition of the proposed system is to design an efficient, congestion free and secure routing protocol for a vehicular area network that operates in an unattended manner and, sometimes, in hostile environment. As the traffic is increasing at very faster rates the routing protocol should provide alternate paths to manage the traffic as well as vehicular nodes are resource constrained (particularly limited energy and limited onboard storage capacity), the routing protocol should consume low power and should not burden the nodes with storage overhead. Also to allow secure delivery of data packets in multi-hop fashion by detecting and preventing attack on nodes.

IV. EXISTING SYSTEM

The existing system employs Ant Colony Optimization technique for computing feasible routes in VANETs subject to multiple QoS constraints. It is used for route discovery process based on the pheromone value. Once the pheromone is evaporated the route is discarded and new sub optimal route is discovered. It performs plausibility checks on the routing control messages exchanged among vehicles with the help of vehicle oriented evolving graph. The system implements Secure Ant-Based Multi-Constrained QoS Routing Algorithm(S-AMCQ) to achieve the goal of secure routing. Here all the ants follow the path of leading ant moving towards destination. If the size of the problem is large which means that if the density of vehicles is more the time taken for route discovery will increase. Therefore it will take long time for generation of optimal path for more number of vehicles. The network might stuck in congestion as all ants initially follow the same route. The algorithm is less energy efficient. These features need to be considered for ensuring efficient and reliable routing in VANETs.

V. PROPOSED SYSTEM

A. Design Considerations

- 1) Providing alternate paths
- 2) Avoid congestion
- 3) Minimize end to end delay
- 4) High packet delivery ratio
- 5) Reliability
- 6) Secure routing
- 7) Improved performance

B. Description of proposed system

The aim of this research is to investigate how routing techniques can be utilized to facilitate multi-constrained QoS in VANETs as well as to avoid security threats to the routing process and improve overall spatial utilization. For that purpose, we employ the Path Planning Algorithm technique to develop our Path Planning based multi-constrained QoS (PPMCQ) routing algorithm. The following discussion briefly describes the proposed algorithm.

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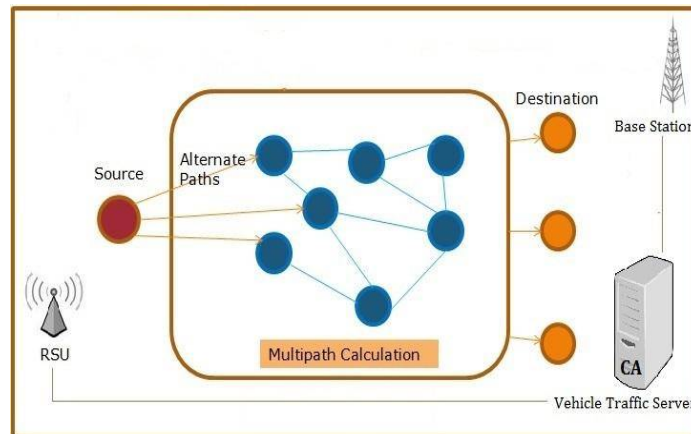


Fig. 2. Proposed System Architecture

C. Path Planning based Multi-Constrained QoS Routing Algorithm (PPMCQ)

In our proposed system PPMCQ routing aims at avoiding congestion in the network. We have considered urban road scenario. To achieve the objective we employ alternate paths for a destination which will reduce traffic overhead and required bandwidth. These factors will also benefit us with high packet delivery ratio, minimizing delay, reliable and secure routing. Thus, the performance of the system will increase and lead to an effective and efficient solution for the problem. It is an effective traffic management tool which improves utilization of road network and tries to reduce average vehicle travel cost for avoiding vehicles from getting stuck in congestion. While driving it is driver's choice to select route to move to his destination. Thus it becomes difficult to develop an algorithm for path planning. The path planning algorithm will provide alternate paths for same destination so that the traffic is distributed over the network and driver can choose one of the optimal path to move to its destination. With the help of ITS it is possible to have communication between vehicles and road side units. The overall spatial utilization of road in VANETs is improved by avoiding congestion. Once the congestion is avoided we can easily achieve QoS constraints such as maximize packet delivery ratio which will lead to reliable routing in VANETs.

D. Secure Routing Process

In VANETs the communication in network takes place between vehicle to vehicle (V2V) or vehicle to road side units (V2R). The communication needed for transferring routing control messages (RCM). Even though we design a good routing algorithm we also need to protect this routing information to ensure secure and reliable routing. Thus, messages need to be protected from attacks which may take place in VANETs. The attacks may lead to altering of message details which will change the routing details and may put the network in congestion. To avoid such kind of adversaries in network we need to provide security to the routing process. For implementing security in VANETs the following parameters need to be considered: Authentication of message, Availability of message, Non-repudiation of message, privacy of message and verification of data. To achieve this objective we will implement public key cryptography. In our scenario to secure the RCMs and converting it into unreadable format we will make use of Elliptic Curve Cryptography (ECC) algorithm. It will generate public and private key for vehicles from Certificate Authority (CA). The Vehicle Traffic Server acts as CA trusted by all nodes. This will ensure secure routing message transfers in VANETs.

VI. MATHEMATICAL MODEL

A. Set Theory

Let, S be a system, $S = N, CA, RSUs, AGR, PTH$ where,

- 1) Vehicle (nodes): $N = N_1, N_2, \dots, N_n$ N is set of all placed vehicles.
- 2) Base Station/Certified Authority: Vehicle traffic server is the CA trusted by all nodes.

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- 3) Roadside Units: RSUs are a roadside units aggregate data to be send to the BS.
- 4) Available Paths: PTH= P1, P2, ..., PN
PTH is a set of all available paths from source to destination.

B. Mathematical Model for Proposed System

- 1) For Energy Calculation:

$$E_{tx}(k; d) = E_{elec} * K + amp * k * d_n$$

$$E_{rx}(k) = E_{elec} * k$$

where,

d_n : Distance for neighboring node

amp: Energy required for the transmitter amplifier

E_{elec} : Energy consumed for driving the transmitter or receiver circuitry

k : bits per message

Above formula is used to calculate the energy required to transfer the data.

Nodes updated Energy = Available Energy - Energy Consumed

- 2) For Security:

Key generation

W : rc

where,

W : public key

r : random no. between 1 to $n-1$

c : point on curve

Encryption

$$C1 = kc$$

$$C2 = M + kW$$

where,

$C2$: cipher text

K : random no. between 1 to $n-1$

c : point on curve

M : original message

W : public key Decryption

$$M = C2 - dC1$$

- 3) For Routing:

$$PDR = PR/PS$$

where,

PDR : Packet Delivery Ratio

PS : Packet generated by source

PR : Packet received at destination

$$TDR = ET - ST$$

where,

ET : End time

ST : Start time

VII. ALGORITHM

Input: Request for route from source to destination

Output: Optimal Secure Route

- 1) Start

2) Register vehicles and RSU at base station/vehicle traffic server. Vehicle traffic server acts as a Certificate Authority(CA)

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- 3) Vehicle traffic server provide certificate to vehicles and RSU to authenticate them
- 4) RSU send message to vehicles within its range to identify their location and detect collision
- 5) Source vehicle request for optimal path to RSU with destination as its parameter
- 6) RSU will generate most optimal path
- 7) If collision in route, detecting RSU will send message to base station
- 8) Base station inform other RSU
- 9) RSU generate emergency message and provide alternate optimal route
- 10) Calculate the total energy for finding optimal route, authenticating nodes and sending message
- 11) Send optimal route to requesting vehicle
- 12) Generate key
- 13) Encrypt message
- 14) If message from authorised node, accept and decrypt message
- 15) If message from attacker discard the packet
- 16) Repeat steps 6 to 11 until all requests processed
- 17) Stop

VIII. RESULTS

This section covers the implementation part of the existing and proposed system model. The system is implemented in JAVA using Jung simulator to show the simulation.

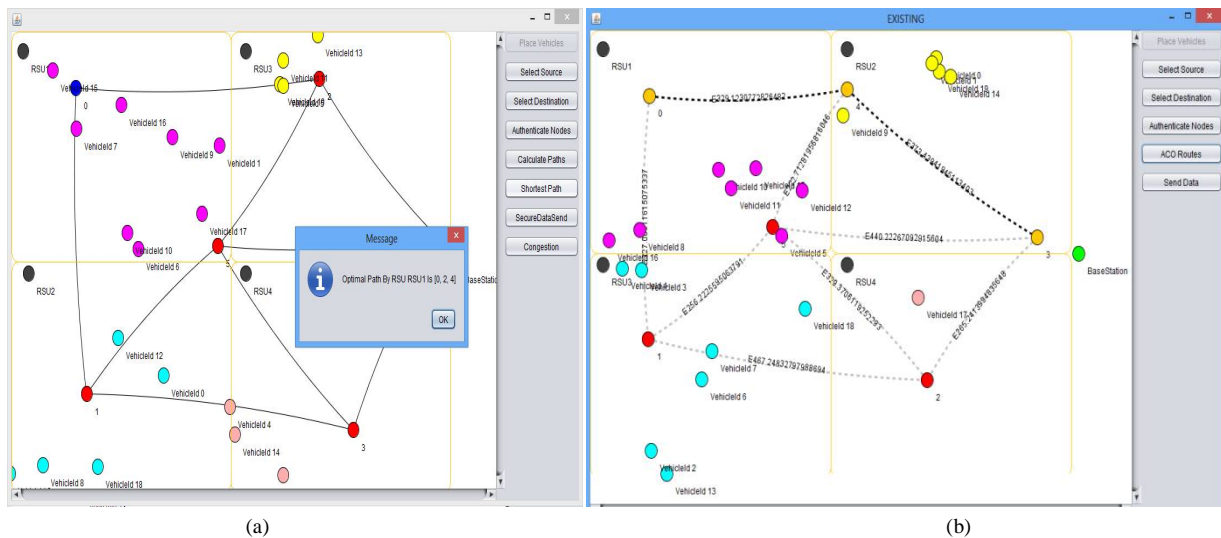


Fig. 3. Simulation of Ant Colony Optimization (a) Nodes deployment (b) Selection of shortest route

Fig. 3. (a) shows hops, RSU's and vehicles deployed on frame. The frame area is divided into four regions where each region is assigned a RSU responsible to provide optimal route to vehicles within is region. Figure (b) shows the shortest path that is the black coloured dotted lines selected as optimal route by ants and also depicts all possible pheromone paths by gray coloured dotted lines.

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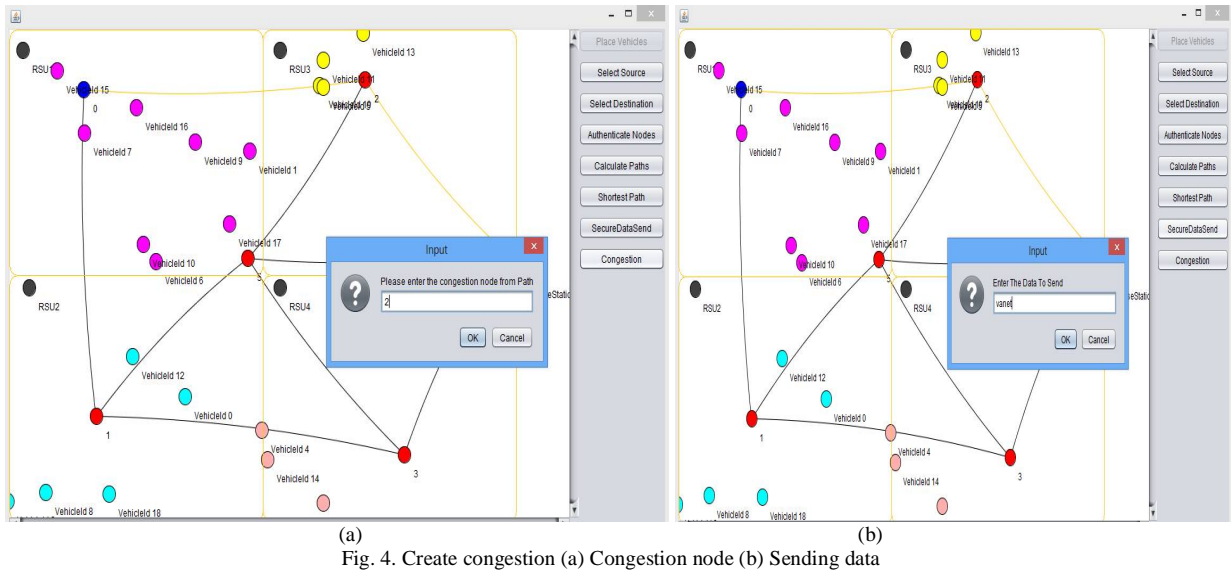


Fig. 4. Create congestion (a) Congestion node (b) Sending data

Initially network is deployed, source destination are selected and an optimal path is generated from source to destination. Fig. 4. (a) shows a congestion node in the optimal path whereas Fig. 4. (b) shows data to send.

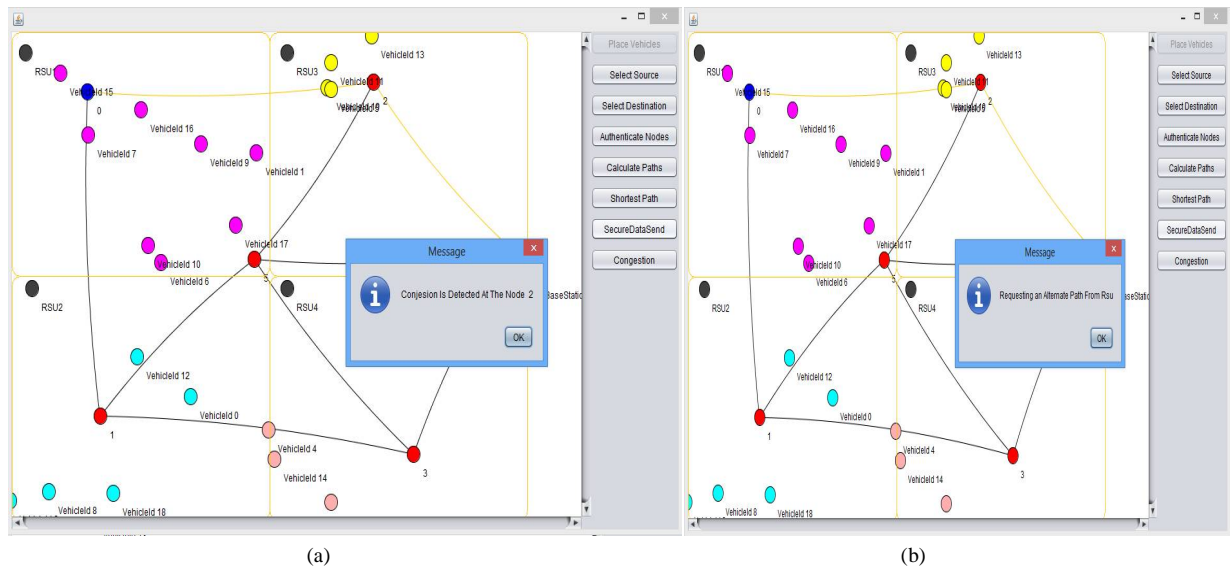


Fig. 5. Request for alternate path on congestion (a) Congestion detection (b) Alternate path request

Fig. 5. (a) shows trying to send data through the path but the data is blocked at the congestion node. Fig. 5. (b) shows an alternate path requested.

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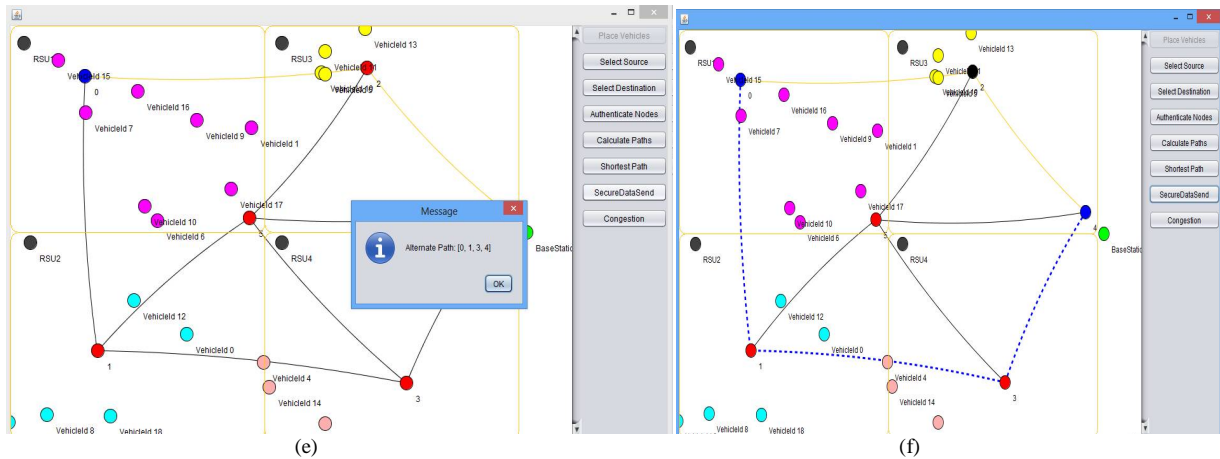


Fig. 6. Generation of alternate path (a) Alternate path generated (b) Sending data

Fig. 6. (a) shows alternate path generated [0,1,3,4] as [0,2,3] being the shortest route contains a congestion node 2. Finally Fig. 6. (b) shows data send though the alternate path.

The system performance is evaluated by analysing the parameters average packet delivery ratio, average time for route discovery, delay and energy.

Table 1. Experimental Setup

Parameter	Value
Simulator	Jung
Language	Java
Software	NetBeans 8.4, Java Framework (JDK 8)
Channel Type	Wireless
MAC Protocol	802.11p
Simulation Time	70 ms

Fig. 7. and Fig. 8. shows the comparison graphs of existing and proposed system.

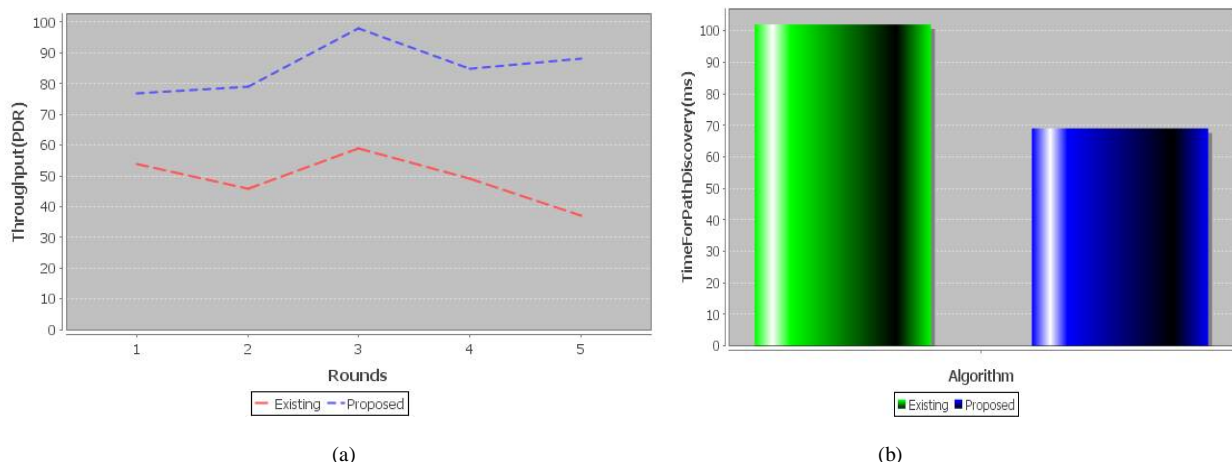


Fig. 7. Comparison graphs (a) Throughput (b) Average time for route discovery

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Fig. 7. (a) shows packet delivery ratio graph of existing and proposed system. We achieved packet delivery ratio of our proposed system 49% greater than the existing system. Fig. 7. (b) shows the comparison of average time for route discovery graph. We obtained time for route discovery process of our proposed system less as compared to existing system.

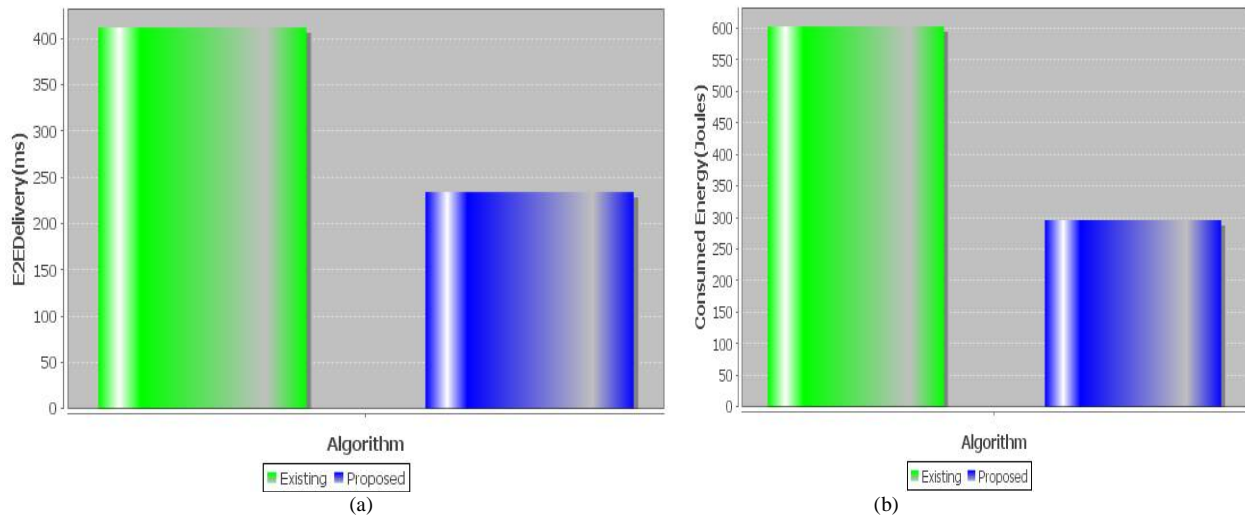


Fig. 8. Comparison graphs (a) E2E Delay (b) Energy

Fig. 8. (a) shows the comparison of delay of existing and proposed system. We achieved E2E delay of our proposed system greater than the existing system. Fig. 8. (b) shows the comparison of energy graph of existing and proposed system. We reduced energy of our system by 50% .

Table 2. Comparison table

S-AMCQ				PPMCQ			
Throughput	Time for path discovery (ms)	End to end delay	Energy	Throughput	Time for path discovery (ms)	End to end delay	Energy
49	100	400	600	86	70	240	300

The above comparison table shows the performance improvement of our proposed algorithm of path planning PPMCQ over the existing algorithm of ant colony S-AMCQ

IX. CONCLUSION

Traffic congestions and accidents have become a major problem in urban areas. This lead to loss of life and injuries. This system provides a solution for the problem by proposing an algorithm of proper route management. Path planning based multi-constrained QoS routing in VANETs is implemented in urban road scenario where it helps in providing alternate paths for destination avoiding congestion in VANETs. The proposed algorithm will ensure reliable routing by satisfying multiple QoS constrains such as minimize delay, increase delivery ratio and avoiding traffic jams. The routing process is secured by applying cryptographic operations on the routing control messages. Therefore our proposed algorithm will ensure secure and reliable routing in VANETs. In future, we will introduce priority based routing in VANETs.

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