# Efficient Routing in Vehicular Ad hoc Networks Using Firefly Optimization

*Thesis submitted in partial fulfillment of the requirements for the award of degree of*

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**Sahil Chhabra**

**(601403023)**


Under the supervision of


**Dr. Rajesh Kumar**

Professor, CSED

COMPUTER SCIENCE AND ENGINEERING DEPARTMENT

THAPAR UNIVERSITY

PATIALA – 147004


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# CERTIFICATE

I hereby certify that the work which is being presented in the thesis entitled, **"Efficient Routing in Vehicular Ad hoc Networks Using Firefly Optimization"**, in partial fulfillment of the requirements for the award of degree of Master of Technology in Computer Science and Applications submitted in Computer Science and Engineering Department of Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of Dr. Rajesh Kumar and refers other researchers' work which are duly listed in the reference section.

The matter presented in the thesis has not been submitted for award of any other degree of this or any other university.

Sahil Chhabra

601403023

This is to certify that the above statement made by the candidate is correct and true to the best of my knowledge.

Dr. Rajesh Kumar

Professor, CSED

Countersigned by:

Dr. Maninder Singh
Head
CSED
Thapar University, Patiala

Dr. S.S. Bhatia
Dean of
Academic Affairs
Thapar University, Patiala

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Sahil chhabra

(601403023)

# ABSTRACT

VANETs are used to provide the network environment for intelligent transportation system in which the node speed is high and topology changes frequently. So that route acquisition and nodes communications in the network are the tedious task. We can't apply the routing protocols of MANETs directly on VANETs. In this thesis work we describe an approach that is based on firefly algorithm (an implementation of swarm intelligence) to improve the routing performance in the terms of transmission time.

The firefly algorithm captures the nature of fireflies i.e. how they do the task individually and how they coordinate with each other to create a system. The proposed algorithm is compared with the state-of-the art routing algorithm and it improves VANETs routing performance in terms of transmission time. The proposed algorithm applies the idea of firefly algorithm on the vehicular ad-hoc network that enhances the performance of routing by efficient packets transfer from source node to destination node.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Overview of Ad- hoc Network

The recent advancements in wireless technology have resulted in low cost but more efficient applications. The networks are broadly classified as wired and wireless. Wired networks have a fixed infrastructure as compared to wireless counterparts which are constantly changing and posse's dynamic topology. The wireless networks are no physical link between the wireless devices. In such network, each node behaves like a router and multiple routing paths are available from a single source to destination. Long distance transmission is limbered by limited bandwidth.

The wireless network is divided into two parts, infrastructure based and infrastructure less. The infrastructure based networks are also called Cellular networks and have fixed gateway. All the nodes that exist within this network communicate via nearest base station. For data transmission base stations are required and they vary in shapes according to the network conditions. Another type of network is infrastructure less networks also called as Mobile Ad-hoc Networks (MANETs). MANET nodes are free to move in any direction. Not always there is a direct path between source and destination. In such situations, intermediate nodes are required. The source node relies an intermediate node to find a suitable route to the destination.

The Ad hoc network is having following properties.

- A network without any base stations.
- Collection of two or more devices equipped with communications system.
- It supports both Homogeneous (all nodes have identical capabilities and responsibilities) and Heterogeneous (differences in capabilities) devices.

## 1.2 Overview of Vehicular Ad-hoc Networks (VANETs)

The growth of the increased number of vehicles communicates with other vehicles form a special class of wireless networks called as VANETs [1]. VANETs are used to provide the communication between the vehicles. The communication between vehicles can be direct or indirect (means communication with the help of intermediate vehicle).

VANETs are mainly used to provide the safety applications to the users. With the help of VANETs, the vehicles can easily communicate with each other. Wireless Access in Vehicular Environment (WAVE) and Dedicated Short Range Communication (DSRC) standard are defined by IEEE 1609.1 to 4 and IEEE 802.11 [44]. Using WAVE and DSRC, the communication between vehicles become easier.

VANETs have the following features.

- Limited bandwidth.
- Multi-hop communication.
- No fixed infrastructure.
- Dynamic topology.
- The radio channel variations.

The VANETs have the following two goals.

- Information sharing.
- Co-operative driving.

## 1.3 Architecture of Vehicular Networking.

The architecture of vehicular networking has divided into following parts.

- Vehicle-to-Vehicle (V2V) communication.
- Vehicle-to-Infrastructure (V2I) communication.

VANETs do not have a fixed architecture. A VANET is different from MANET in the sense that vehicles do not move randomly and they follow the fixed path such as highways or roads. There are three different scenarios for communications of VANETs. First, all the vehicles communicates with each other through Road Side Unit (RSU). Second, vehicles directly communicate with each other, no need of RSU. Third, some vehicles are communicating directly and other with the help of RSU.

Figure 1.1 shows the architecture of Vehicular networks. These vehicles get the information from RSU. Vehicle communicates with each other in an Ad-hoc network via V2V communications or can communicate via RSU, called as V2I.

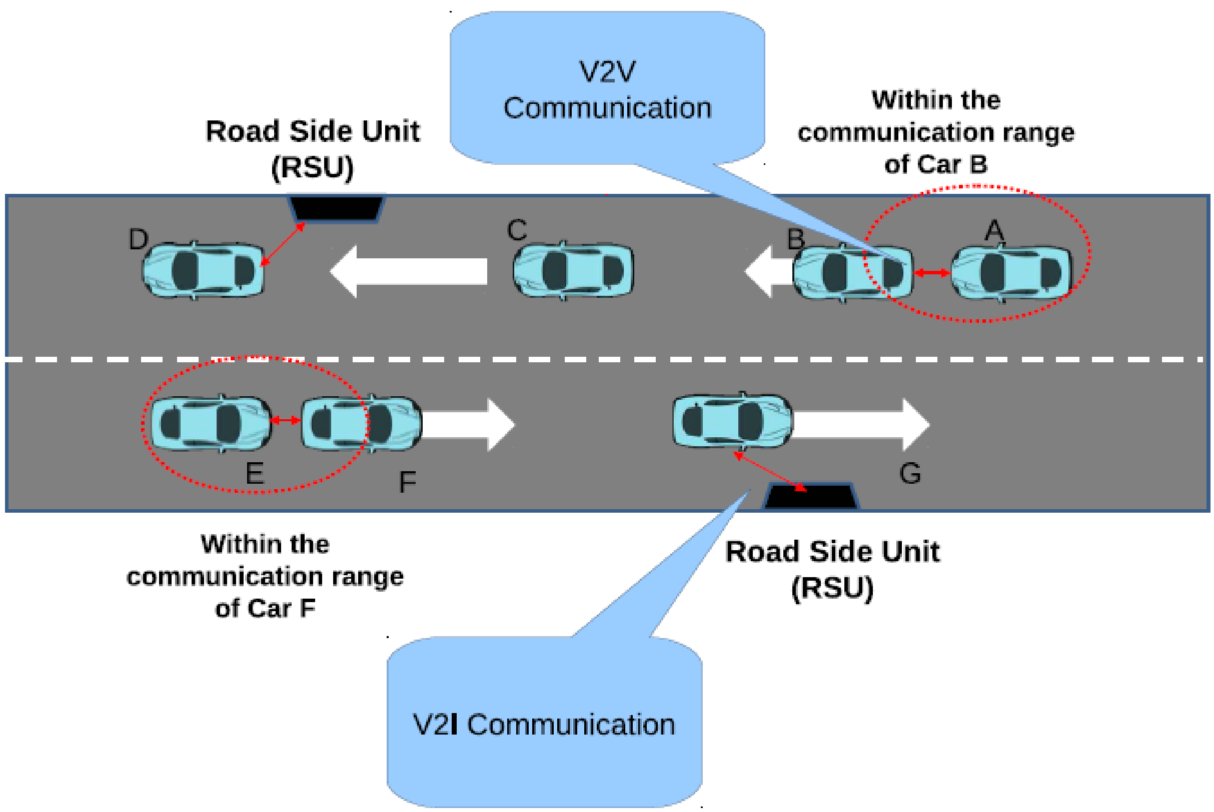



Figure 1.1 Vehicular Ad hoc Network Architecture [19]

## 1.4 Components of VANETs

There are two basic components that must be considered in VANETs communications which describes the internal structure of VANETs and procedures among vehicles.

- On-Board Unit (OBU): A device which uses the information like density and speed of the vehicle to processes the data that vehicle use for communication.
- Road Side Unit (RSU): It transmits the information to the entire network and stores the information. These are often considered to be as intermediate node.

## 1.5 Characteristics of VANETs

The characteristics that make VANETs different from other network are as follows.

- Unlimited transmission power: No power issue in VANET due to continuous moving vehicles which results in charged batteries.
- Higher Computational capability: Vehicles are moving very fast so it's hard to predict the current position of vehicles. This can be done by current technology such as Global Positioning System (GPS).
- Potentially large scale: There are a huge number of vehicles on the road. So network size is very high comparing to other mobile ad hoc networks.
- High mobility: Due to the high vehicle movement and dynamic topology, mobility model is high.
- Network topology and Connectivity: Vehicles have dynamic topology which means vehicles move on the road with different velocity.

## 1.6 Routing Protocol

In the past, the term routing meant forward the network traffic via different networks. Routing protocol describes the set of rules to transmit the data from source to destinations. Each protocol has different set of rules to transmit the data packet. So first we have to understand the concept of routing architecture. The routing architecture is divided into two parts Flat or Hierarchical. The routing architecture should be conceptually flat. An example of Flat routing algorithm is DSDV and WRP. Each node has entries of the other nodes in a self-organized manner. So when the network size is too large than flat architecture is not work well due to overhead load. So come to the hierarchical scheme to reduce the overhead. Clustering is the most useful technique for hierarchical routing. In which one of the node behaves like a cluster head. The other node that is not cluster head behaves like an ordinary node. When the ordinary node wants to send the packet first it sends to cluster head and then goes to the destination node.

### 1.6.1 Types of Routing Protocol

In the network the resources are limited so designing a reliable routing strategy is a difficult problem. We can design a routing strategy so that we can use the limited number of resources efficiently. The environment conditions changes from time to time such as traffic load, density and bandwidth.

If we consider the wired network basically, two types of routing algorithm were used. First, one is link state and the second one is distance vector routing algorithm. In the link state routing, each node will take the information of the other nodes by using the flooding strategy. In which each node will receive the update information and according to this link will be updated. According to this strategy, the next hop will be select as next hop for selecting the destination node. In the distance vector routing algorithm whenever a packet comes to router the neighbour router will give the vector table. So that a new vector table is calculate for forwarding the packets. It is an interactive algorithm because the output of the vector table is given as input for the other router to their calculation. It is a distributed algorithm because the vector table is calculating for every node whenever the packet comes. But these routing strategy can’t use in a large network. So reduce this problem various routing protocols have designed. Figure 1.2 describes the routing protocol types.

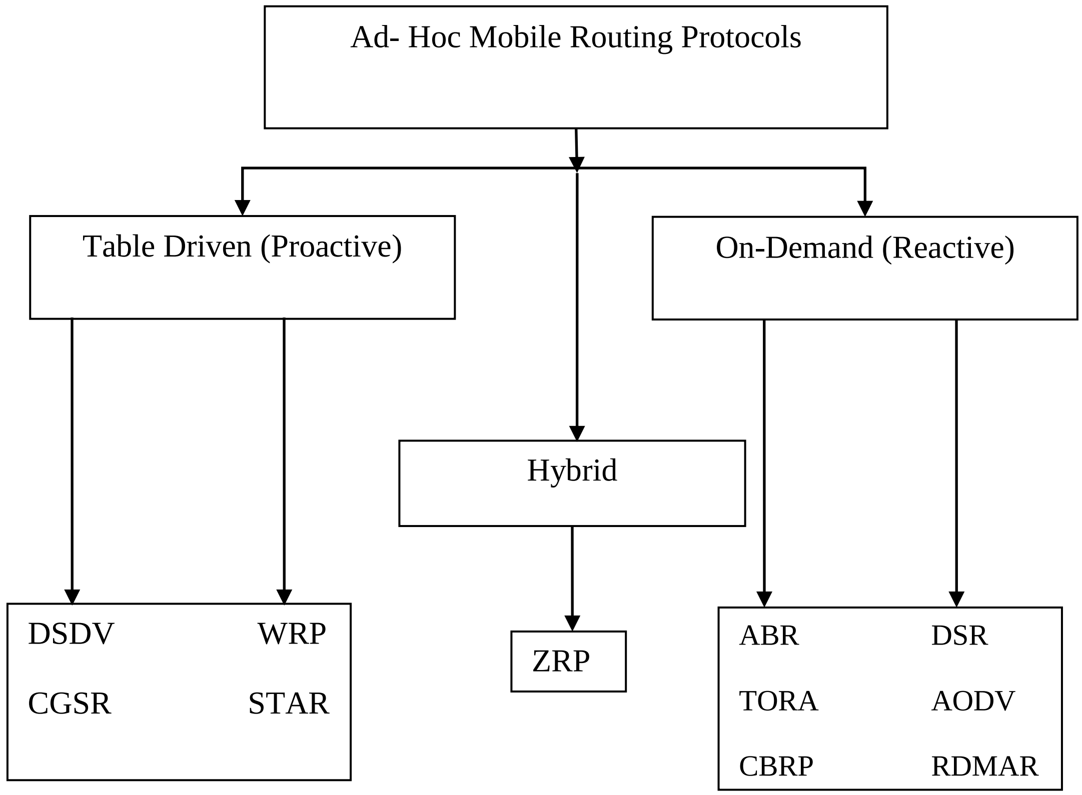



Figure 1.2 Routing protocol types

The routing protocol is dividing into three parts.

- Proactive
- Reactive
- Hybrid

Proactive:

These protocols are called table-driven [10]. In which node maintains the routes to the other reachable nodes. So that source node has a path whenever required. When any topology changes, then their respective routes will be updated and notify to all the other nodes for the respective change. The proactive routing protocols are following types.

- Wireless Routing Protocol (WRP).
- Destination – Sequenced Distance Vector (DSDV) routing protocol
- Optimized Link State Routing (OLSR) Protocol

- Fisheye State Routing (FSR) protocol.
- Topology Broadcast Reverse Forwarding (TBRF) routing protocol

WRP is unicast routing protocol. This protocol works for both positive edge weight as well as negative edge weight. Using WRP each node maintains the Message Retransmission List. We have to store the information about successor and predecessor to avoid the problem of count to infinity. Each mobile node maintains the entry of the neighbour node. If there is a link between the nodes than error free message will be display. The update message is transmitted between the nodes to exchange the routing table. When any information is required than the message is transmitted to the closest neighbouring node. We describe the model of WRP protocol with the help of undirected graph G (V, E). In which each node behaves like a router to store the respective information. In WRP, a node checks the information of the predecessor reported by the all its neighbour. The unique features of the WRP are: recovery is fast and eliminating the more temporary looping situations. The infinite looping and count to infinity problem is solved with the help of this protocol.

DSDV is a proactive unicast routing protocol. Thus its property keeps similar to WRP protocol. It maintains the routing table to improve the routing performance. It stores the information of the next hop towards the destinations. The sequence number is used to avoid the problem of the route loops. DSDV can use two types of route updates: event driven and table driven. Each node periodically transmits the route information and updates to intermediate neighbour. DSDV send the routing table in two ways either "full-dump" or "incremental update". In "full dumb" full routing table is updated but in the "incremental update" only that entries that have been changed be the part of the update. Packets are transmitting between them and they use the routing tables that are stored in the network. The topology changes dynamically so that to maintain the routing tables, each station periodically transmits the updated message when any changes occur. Each node will maintain the following information of the routes.

- Destinations place.
- Number of hops

- Sequence number of the packet

FSR is a hierarchical routing protocol by using “fisheye” technique to reduce the required information. Figure 1.3 shows the architecture of FSR routing. The eye of the fish captures the high details of a pixel near the focal point. FSR is similar to LSR because it maintains the routing information regarding the node but the difference is that the LSR uses the flooding technique whenever any changes occur in the respective topology. FSR can’t use the flooding technique to maintain the routing table. It maintains the information received from the neighbouring node. It periodically exchanges with the respective neighbouring nodes. When this exchange process happens the larger sequence number replace with the smaller sequence number. FSR avoids the problem of control message overhead by using the topology map and event-driven periodic message. To reduce the size fisheye technique is used. In the following figure, three scope of hop is shown hop1, hop2, and hop3. According to scope the respective color will be displayed. The reduction in the routing update has calculated by using the respective entries in the routing table.

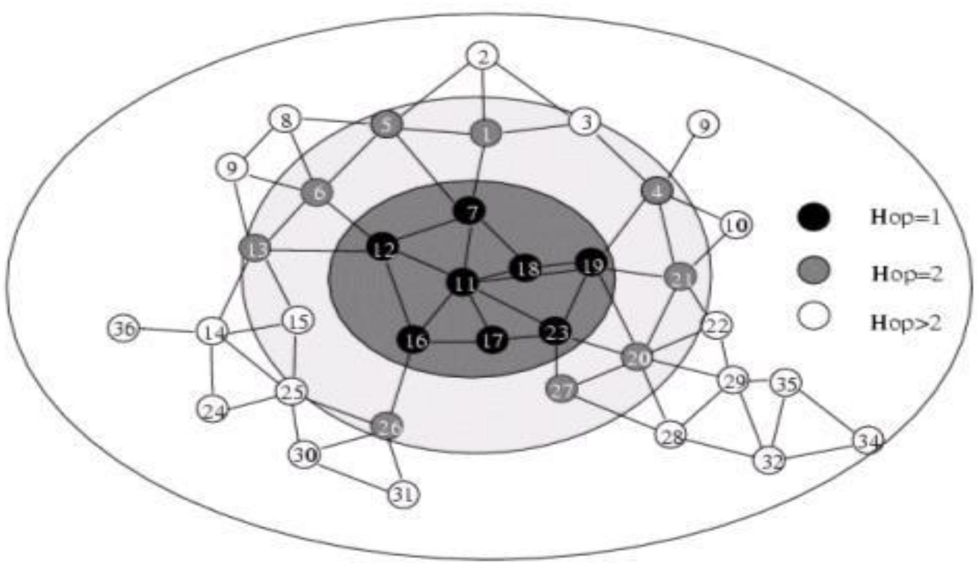



Figure 1.3 FSR Routing [12]

Reactive Routing Protocol:

These are called "on-demand" routing protocol. The respective paths are selected only when there is the any requirement. When any route determination occurs than route discovery invokes. The route discovery process is out of the process when no any route is finding from the source to destinations or no route is there between sources to the respective destinations. If we compare the reactive routing protocol with proactive routing protocol than reactive routing protocol is less overhead because routing table updated when required. If any change in the route than route maintains require at this time. Various reactive routing protocols are as follows:

- Ad –hoc On-Demand Distance Vector (AODV) routing protocol.
- Dynamic Source Routing (DSR) protocol.
- Temporally Ordered Routing Algorithm (TORA).
- Cluster-Based Routing Protocol (CBRP).
- Location-Aided Routing (LAR) protocol.
- Ant Colony-Based Routing Algorithm (ARA)

AODV routing protocol is reactive routing protocol. In which each mobile node behaves like a router and when there is any requirement of finding the route than the corresponding route will be search. This algorithm is well suitable for the dynamic network since links changes very frequently. It provides the loop-free routes when required. There is symmetric link between neighbouring nodes. Whenever there is any requirement of finding the route between the nodes, than it considers that link. They do not maintain any information regarding the routing table exchange. When there is any requirement of check the local connectivity between the nodes then each mobile node stores the information of the other node by using the various techniques. It broadcast the hello message to all the other nodes. The algorithm has the following goals.

- To send the discovery packets when required.
- To distinguish the local connectivity between the neighbours.
- When any mobile node needs the information of other nodes it provides the updated information by using the local connectivity.

The RREQ is sent by the sender and it has the following fields.

- Destination addresses.
- Source address.
- Broadcast address.
- Sequence number.
- Expiration time.

The other useful information is stored in the route table that is called “soft state” along with entry information. A mobile node has a route table for each destination of the interest. Each routing table has the following entries.

- Destination
- Next hop
- Hop count.
- Sequence number.
- Active neighbours.
- Expiration time.

DSR protocol is a simple routing protocol and it is very efficient especially for wired networks. This protocol forwards the data packet to each other using multiple “hops”. If any new node is leaving the network or join the network than all the updated information is maintained by the DSR protocol. The resulting network topology may change at any point of time. Each data packets have the complete information about the header data, ordered list of the nodes and updated information of the route. This information is used by the other nodes whenever required.

- Route discovery is considered when the source node wants to send the data packets to the destination node.
- Route maintenance is used when any change in the links. Then the information is updated with the help of Route maintenance.

TORA has distributed routing protocol basically used in the multi-hop wireless network. It is the family of “Link- reversal” algorithm. The protocol is highly efficient and scalable and it's very useful for the large network. This protocol uses the physical and logical clock of the network when ever topology change occurs. This algorithm has the following properties.

- Executed in a distributed manner.
- The calculated routes are loop-free.
- Display more than one route between the same paths.
- Minimize the communication overhead when possible.
- Establish the routes quickly.

Routing optimality is less important as it considers other factors. It is necessary to maintain the routes between every single entity to every desired node at any point of time. TORA is basically designed to minimize the reaction time, whenever any change in the topology. TORA is distributing routing protocol because of this property there is no need to maintain the information about the adjacent nodes. It provides the guarantees about the loop-free path and provides the multiple routes from a single path. TORA is "source initiated" means it provides the set of routes from the required path when desired.

In CBRP protocol each cluster maintains the topology information to reduce the overhead load. The up-to-date information is maintained with the help of cluster membership functions.

LAR protocol uses the location information to find the smallest route. We can understand working of this protocol with the help of an example. Suppose we have a network in which the one chosen node S wants to find the route to the node D. So the source node transmits the route request to all its neighbour nodes. When any node receives any route request then it compares the desired location with the given information. If a match occurs then there is no need of route discovery. Otherwise, node broadcast the information to other neighbouring nodes. It is possible that the destination node will not receive any request from the source side. At this time, the node will again find the route by the route discovery process. When the source node is request for the route discovery process than it sets a timeout message. If during the timeout process any route is not finding by the source node than again route discovery process is triggered. This process is repeating until cannot get the required path. For the route discovery process, the different sequence number is used at each point of time.

ARA Routing Algorithm is an on-demand routing algorithm. This protocol is based on an ARA based meta-heuristic algorithm. These approaches try to find the solution based on mathematical and engineering problems. This algorithm is totally based on the food searching behavior of real ants. So when there is a requirement to find the route than they consider the path used by ants. The ants are using the pheromone, to mark the route so that they consider it next. The value of pheromone decides the uses of the route and its indication. When an ant reaches the intersection point they have to decide which route to adopt. The same behavior of ants used to find the shortest distance in a network. This property of ants is very useful because used in a dynamic network or highly changeable topology. Nodes position changes time to time so finding the path in the dynamic network is a challengeable task. So the ant colony based routing algorithm used the behavior of ants to find the route from one location to another. The ARA routing algorithm behaves well in dynamic topology. It also supports for finding the multiple paths from one location to another. We have to choose that path which one is shortest.

Hybrid routing protocol: These protocols used to increase the scalability and route discovery overheads. It considers the close proximity to work together. The most common hybrid protocol is Zone based routing protocol which means the network is separate into the number of Zones. The packet has transmitted according to the selection of zones. The hybrid routing protocols are following types.

- Zone Routing Protocol (ZRP)
- Zone-Based Hierarchical Link State (ZHLS).
- Scalable Location Updates Routing Protocol (SLURP).
- Distributed Spanning Tree Based Routing Protocol (DST).
- Distributed Dynamic Routing (DDR) Protocol.

Zone routing protocol used the advantages of both of the routing approaches (proactive and reactive). It maintained the topology information at each zone centered on each node. ZRP uses the route discovery procedure to take the benefit of the local routing information of the zones. We get the complete information of the node easily which node inside the zone. Fig. 1.6 shows the architecture of Zone routing protocol.

To detect the link failures, ZRP uses the Neighbor Discovery protocol (NDP). NDP transmit the Hello message to all nodes in the regular time interval. The Intrazone Routing Protocol (IARP) provides the functionality to NDP protocol, which notifies Interzone Routing Protocol (IERP) when the neighbour table is updated. IERP forwards queries with BRP.

### 1.6.2 VANET Routing Protocol

The routing protocol of MANETs cannot efficiently apply on VANETs because we are not getting the better results in the terms of throughput [35]. VANETs routing protocols are classified into four parts Unicast, multicast, Geocast, and broadcast. The Unicast protocol is used to transmit the data between two devices. The multicast routing protocol is used to delivering multicast packets from a single device to all the other multicast members. The Geocast routing protocol is used to send the Geocast packets in a specific geographic region. The broadcast routing protocol sends the required packet to all other vehicles so that data packet reached other vehicles easily. The packet has dropped if it can't be transmitted by any of the protocols. The existing routing protocol of MANETs can't directly apply on VANETs because of the topology difference between MANETs and VANETs. The routing protocol of VANETs is as follows.

A. UNICAST routing protocol.
    a. Min-delay
        - Greedy Perimeter Coordination Routing (GPCR) Protocol.
        - Vehicle Assisted Data Delivery (VADD) routing protocol.
        - Connectivity Aware Routing (CAR) protocol.
        - Diagonal Intersection-based Routing (DIR) protocol.
        - Receive on Most Stable Group Path (ROMSGP) routing protocol.
    b. Delay-Bounded

B. MULTICAST and GEOCAST routing protocol.
    - Distributed Robust Geocast Multicast (DRGM) routing protocol.

- Multicast Protocol in Inter- Vehicle Geocast (MIVG) routing protocol.
- Spatiotemporal Multicast/Geocast routing protocol.

C. BROADCAST routing protocol.

- On the Broadcast Storm problem in networks.
- DV-CAST.

The goal of min-delay routing protocol is to transmit the data from source to destinations as early as possible. If we transmit the data from one location to another location, than there are two paths available, first one in which the distance between sources to the destination is less but the time required to cover this distance is higher than the other path. This is because of density and velocity of the vehicle that depends on the traffic conditions. The second path is higher in distance but less time required to covering the same distance. So in min-delay, we have to consider the low transmission time. GPCR is the position based routing protocol [36]. It is well suited for highly changeable or dynamic environments. When the packet has transmitted from one vehicle to another vehicle, it considers the vehicle junction as a decision point by using the repair strategy. It traverses the junction by using the greedy forwarding procedure. VADD used the idea of carry and forward message to select the required path. It uses the data delivery from moving vehicle to the static destination. To reduce the transmission delay it transmits the data packets through the wireless channels. This protocol assumes that the entire vehicle has located on a road with high digital maps and it chooses the road with high speed first.

CAR protocol considers the anchor points at intermediate junctions. When the packet is transmitting from one location to other location, than first the searching packet is transmitting to find the destination. The searching packet stores the information regarding the ID of destination and hop count. When the searching packet is reaches the destination place than it chooses the path that is minimum in the terms of delay. After that, it replies back to the source node. The next protocol is DIR based on diagonal intersections between source and destinations. This protocol is different from CAR in the terms of choosing the anchors points. It constructs a sequence of diagonal intersections (junction) between the source and destinations vehicles. There is more than one path exist between one source to destination. DIR protocol considers the property of auto-adjustability means choose the path with low data packet delay. So DIR protocol is better than CAR protocol because of automatically adjust the routing path from source to destinations. The next protocol is ROMSGP used to improve the routing reliability. The word routing means to find the reliable route from one position to another position. In VANETs, the vehicle is moving very fast so there are chances of loss of connectivity between them. The connectivity is breaking when the vehicle is out of transmission range. ROMSGP consider the velocity vector of each vehicle and according to this velocity vector, all vehicles splits into groups. The routing is dividing into two parts, first one is stable routing in which two vehicles are within the same group, otherwise the routing is said to be unstable routing. The last protocol of min-delay routing protocol is GVGrid routing protocol. This protocol basically improves the delay-time and routing reliability. The vehicles are taking the information from the other vehicles through the map. So it divides into several grids. It considers the minimum number of the grid using the RREQ and RREP packets. Both of the packets are passing through the different grid. Grid has chosen based on the distance between the vehicle and direction of the vehicles. The intermediate grid has chosen as next if the direction is same as the previous grid. The routing table has maintained based on a number of the grid.

Delay-Bounded routing protocol considers the two routing algorithms, first one is D-greedy and second one is D-Min Cost routing algorithm. D-greedy considers the local traffic information to make the routing decisions. It calculates the shortest path from one AP point to another AP with the help of map information. D-MinCost algorithms consider the global traffic information in the area to find the delay and cost of each and every path.

In Multicast/Geocast routing protocol the packet is transmitting in the specific geographic area. Various Multicast/Geocast routing protocol comes under this category. Distributed Robust Routing protocol is to deliver the data packets in a specific static geographic region. A vehicle will receive the data packet only when it is required. If the vehicle is present in this region than only it receives the data packets otherwise the packets drops or discarded by the respective vehicle. Under this category the IVG is defined. It considers the vehicle direction and position of the vehicle, according to the related information the risk area has defined. If any danger occurs in this area than the IVG protocol informs the other vehicle located in this area. This protocol considers the deferring time, maximum vehicle speed and it fragments the network traffic into several parts. According to this information, the re-broadcast period has calculated. The last protocol is spatiotemporally routing protocol which considers the time factor. It stores the time factor into the account. It delivers the routing information to the entire vehicles located in this region. The applications supported by this protocol such as online games, emergency event, and video advertisement.

The Broadcast routing protocol transmits the data packets to all vehicles. In the roads, there are a huge number of vehicles and they broadcast the data packets to other vehicles simultaneously. This problem is called broadcast storm problem. To reduce this problem DV-CAST considers the three traffic scenarios. First, one is dense traffic scenarios, second one is sparse traffic scenario, and the last one is regular traffic scenarios. In DV-CAST each vehicle stores the information of the other vehicle all the time to select the broadcasting decisions .If any vehicle receives the broadcast request from the other vehicle than firstly it checks whether the vehicle exists behind or not. If yes then simply broadcast otherwise forward the broadcast message in the opposite direction. Emergency-vehicle approach is used to send the information to that vehicle which is front of the current vehicle otherwise, traffic accident approach is used.

## 1.7 Challenges in VANETs

VANETs support the on-road applications. It requires efficient resource management strategies. So that vehicle can easily communicate with each other. This includes the bandwidth reservation, packet scheduling, QoS control and fairness assurance. It has the following research challenges.

- Information dissemination.
- Heterogeneity of applications.
- Frequent Link Disconnections.
- Dynamic Traffic conditions

## Conclusion

It is very necessary to understand the basic conceptual fundaments an attribute before initiate the new operation so that the resultant output will be very clear. We have first tried to understand the basic fundamental terminology of VANETs. In this chapter we describe the basic characteristics of VANET, routing protocol, Components and at last describe the challenges of VANET.

# CHAPTER 2

# LITERATURE SURVEY

Initially, Mehta [21] proposed Ant Colony-based Probabilistic Emergent Routing Algorithm (PERA). This algorithm is based on a calculation of pheromone value of each and every node. When the ants are searching the food, they follow the path towards food. The ants are using pheromone to mark the route so that they consider it afterwards. The value of pheromone decides the selection of the route and its indication. When ants reach an intersection point, they have to choose, which direction to go for next route search. The same behavior of ants is used to find the shortest distance within the network. Based on multiple routes the best route will be considered. The result is compared with AODV protocol and results in reduction of end to end delay.

Xiang [31] proposed an ACO based routing algorithm which is called as Adaptive Improvement. This algorithm works, when the session starts and the Ants used are called reactive Ants. The Ants maintain the path, when there is requirement of finding route from source to destination. The protocol comes under reactive routing protocol which means finding the route when there is any change in link or route.

TALEB *et al.* [24] proposed a stable routing that reduces the overall traffic. It takes the vehicle's movement information (speed, position and vehicle's direction). Vehicles are divided into groups and they depend on speed of the other vehicles. The proposed routing strategy reduces the overhead, delay and increases throughput.

Thomas *et al.* [6] proposed the dissemination algorithm that uses multi-hub routing approach. It reduces local traffic by taking information from short range. For implementing this used the Network Simulator Version 2 (NS2).

TALEB *et al.* [5] proposed VHRP routing protocol. This approach is already implemented in the existing routing protocol DSDV. The simulation result is better in terms of reducing packet delay and increase throughput.

Cabrera *et al.* [4] describes the problem of all the existing VANET routing protocols. Basically, the existing routing protocol of MANETs cannot be directly applied on the VANETs. The protocol which is feasible for MANETs may also be feasible for VANETs but their performance depends on traffic conditions and density. From the analysis, there was a few numbers of protocols that can be applied on both VANETs and MANETs to give us the better results.  The result is the comparison of all the VANET routing protocols.

Zhang *et al*. [26] proposed BBR protocol. It captures the Geographically-based Traffic Information (GTI) mobility model. The result shows that BBR performs well and does not rely on a location based service. The result is implemented using the Network Simulator Version 2 (NS2).

Nzouonta [8] proposed a routing protocol that is RBVT. It uses the geographical forwarding to transfer data between the intersections of nodes. It compares the result with respective protocols of the Ad-hoc network and VANETs. We can optimize the following message using the process of election. It will increase the average delivery rate by 40%. This protocol takes traffic information to create a required path. The result compared with the RBVT-P. It performs well in the terms of average delay.

Skordylis [25] investigated the problem of minimizing utilization of bandwidth in the traffic monitoring system. The efficiency of vehicle traffic system depends on the data's freshness. If the data is high fresh than we can easily select the fastest route from source to destination. The author designed a framework by using data delivery and monitoring traffic. The results are better in terms of reducing bandwidth utilization and improve system performance.

Archana *et al.* [30] using carry and forward message from the source vehicle to nearby Road Side Unit (RSU) and used the advanced encryption for adding the digital signature to each and every node. To improve the routing of packets, first improve the infrastructure of RSU, with this step the route packets are efficiently transmitted. It considers the secure mechanism.

Raw *et al.* [13] improves throughput and performance of the VANETs and provides the stable and reliable route. They consider path duration and link duration because vehicles are moving at a very high speed. So path duration is also considered to predict behavior of the nodes. To improve performance, path duration is a key factor which is to be considered (performance is changed by changing of connectivity graph). It provides reliable and efficient route between the nodes. They include parameters as density and counting hops.

Singh *et al.* [23] proposed the innovative Ant colony based routing technique by considering random destinations. Ants behave like the agents. When ants are moving from one location to another than pheromone table and data structure has to store the ant's updated value. The simulation is performed after considering the different parameters of the nodes. The result is better than AODV protocol. The author considered three phases, first one is route setup phase, second one is route discovery phase and third one is route maintenance phase.

Singla *et al.* [29] provides data security so that data reaches destination easily. It removes the traffic congestion on the road (if number of vehicles is higher in a region than it causes congestion). They used the Pretty Good Privacy (PGP) and AOMDV protocol to provide the dynamic path between VANETs. The vehicles location rapidly changes from time to time. So selecting the best path from one vehicle to another vehicle also changes from time to time.

Correia [27] proposed an ACO based optimization routing algorithm, it takes information such as speed, vehicle's position etc. Then we might create network for a short span of time. The main goal of this algorithm is to improve overhead and reducing transmission time.

Tian *et al.* [2] proposed PSO-based hybrid routing protocol. This is basically used to improve overhead load. The results obtained shows better performance compared with on-demand distance vector and bio-inspired bee swarm protocol. To perform the simulation we used Network Simulator Version 2 (NS2).

Khanderao *et al.* [7] proposed a hybrid ACO based techniques, it gives better results in terms of routing. It compares the result with other Meta-heuristic techniques Differential Evolution (DE). In VANETs vehicles communicate with each other on road and highways throughout the internet. So the main issue in VANETs is routing of data (how to transfer data from one position to another position). ACO is suitable for routing and used for MANETs and VANETs both. VANETs provide communications between two vehicles using DSRC. The compared result is best in the terms of route discovery and route maintenance phase.

Pandher [28] proposed an ant colony optimization techniques used by WIMAX. This is basically used to resolve security issues like authentications, collision detection and congestion avoidance by using communication system approach. The ACO algorithm is an efficient approach for VANETs. Whenever a road accident occurs, the information is flooded in city roads using WIMAX. The WIMAX takes less amount of time to transfer the required information. It also provides route identification in case of an accident when vehicles communicate with each other. It provides a safe path between vehicles over the networks.

Ranjan *et al.* [33] studies both MANETs and VANETs Routing protocol and compare results with each other. The routing protocol of MANETs is not feasible to VANETs but if we are trying to apply routing protocol on VANETs, than it does not provide better throughput. In this paper, they describe protocol which is better in terms of routing and gives efficient result for both MANETs and VANETs. It concludes that routing protocol considered based on architecture and performance analysis. The protocol which is feasible for MANETs also feasible for VANETs but their performance depends on traffic conditions and traffic density. Finally, if we consider the best routing protocol among all of those mentioned, than reactive routing is the best one as it works when there is any requirement or any change in link. From the analysis part, there are a few protocols that can be applied on both VANETs and MANETs and give us better results. AODV is best one and it will give efficient result when it’s applied on both protocol MANETs and VANETs.

Orang [34] proposed a routing algorithm that is based on Ant Colony Optimization (ACO). The ACO is totally based on the behavior of ant's means how ants find food, this property is used to search route from source to destination. It is a probabilistic technique to find route between nodes through the graph. They have considered two parameters, first is delay time and second is reliability. To implement proposed algorithm NS2 was used. It provides accuracy of path-finding with the changing environment.

Table 2.1 Comparison of related paper of MANETs and VANETs

| **S.No** | **Approach/ Protocol** | **Author name (year)** | **Ideology** | **Parameters** |
|---|---|---|---|---|
| 1 | Reactive | Baras and Metha (2003) | PERA | Reduced end-to-end delay |
| 2. | Hybrid | Yuan and Xiang (2004) | ARAAI | Lower average delay, Higher delivery ratio |
| 3. | Geocast | Victor Cabrera, Francisco(2004) | Routing protocols | Comparison of all VANET protocols |
| 4. | Geocast | M.Zhang and R. S.Wolff (2005) | BBR | Perform better in<br>Typical highway conditions. |
| 5. | Multi-hob | Thomas D.C little (2005) | Dissemination algorithms | Reducing the number of link breakage,<br>Throughput. |
| 6. | Geocast | Tarik Taleb, Mitsuru Ochi (2006) | VHRP | Reduce the traffic, increase the<br>Throughput. |

| | | | | |
|---|---|---|---|---|
| 7. | Broadcast | Tarik Taleb,Kazuo Hoshimoto (2007) | Stable routing | Vehicle speed, direction of the vehicle |
| 8. | Geocast | Jasiane Nzouonta (2009) | Receiver based next hop election | Average delivery rate. |
| 9. | Multi-hob | Antonios Skordylis (2010) | Data acquisition, Data forwarding | Bandwidth utilization, data delivery |
| 10. | Broadcast | S.L.O.P Correia (2011) | Ant colony | Speed of the vehicle |
| 11. | Geocast | R.S.Raw, Vikas Toor (2012) | Path duration | Throughput, the velocity of nodes |
| 12. | Broadcast | G.J.Archanna, R. Vnittaraj (2014) | Carry and forward | Security |
| 13. | Multi-hob | Gurpeet Singh, Neeraj Kumar (2014) | ACO based routing algorithms (ANTALG) | End-to-end delay, Throughput, Window size. |
| 14. | Geocast | Azmina D.Khanderao (2015). | Ant colony | Route discovery, Route maintenance. |
| 15. | Geocast | Tian, D., Shafiee (2009) | PSO | End-to-end delay. |

# CHAPTER 3

# PROBLEM STATEMENT AND OBJECTIVES

## 3.1 Problem Statement

VANETs in which vehicles are high speed, dynamic infrastructure less network. The main task of VANETs is to transmit data packets from one location to another and that too easily and safely. The performance of VANETs depends on efficient data transmission between vehicles. The vehicles are moving very fast thus packet loss during transmission, our target here is lossless data transmission among vehicles.

There are many routing protocols to improve the efficiency of VANETs such as topology based, geocast, multicast and broadcast routing protocol. Some of these protocols are position based as they consider vehicle speed and density and other vehicle parameters. But still there is a need of improvement in the routing protocol.

Some of the routing protocol of MANETs can be efficiently applied on VANETs but they do not prove feasible in terms of throughput and quality of services. The research work in my thesis is focused on the formulation of firefly based routing algorithm [17], because of the changes in topology we have to consider the reactive routing protocol (type of topology based VANET routing protocol). With the help of this protocol, we can achive the packet transmission from one vehicle to another with less overhead and lower transmission time. This approach can calculate the best routing path during packet transmission in VANETs.

## 3.2 Objectives

This thesis presents a novel, dynamic routing algorithm for VANETs inspired by the behavior of the fireflies. Various variations of firefly algorithm have been studied before implementing the proposed work. After formulating the related problem, following objectives were identified.

1. To study and review various data dissemination approaches for VANETs.

2. To design and develop an efficient routing algorithm for VANETs using Firefly Optimization.
3. To implement and test the proposed approach using standard simulation tools.

# CHAPTER 4

# PROPOSED WORK AND METHODOLOGY

## 4.1 Proposed Work

In firefly algorithm, each vehicle (node) behaves like a firefly. At the time of communication, probability of selection is higher when the intensity value or frequency of the flashes is high. The intensity value depends upon the objective function value. Figure 4.1 shows the flowchart of algorithm.

When we want to find route from source node to destination node then this algorithm will start its work and calculate the shortest path from source node to destination node. Initially, a sorted list is created which is based on objective function value, here rows represent the source vehicle and column represents the number of the vehicles in that region. Controlled flooding algorithm is applied at source vehicle, according to this algorithm packet is transferred to other vehicles in that region. The vehicle which has higher objective function value (based on density and speed of the vehicle) will be chosen next. Then we check whether the intermediate node is destination-node or not. If not then apply the same procedure again for finding the destination node. If yes then apply the reverse path to reach the source vehicle. The value of the updated objective function will be based on density and vehicle speed. With help of Prediction, it is possible to determine the next position of the vehicles and make the smarter decisions of the route.

GPCR is position based routing protocol [2]. It takes geographical information obtained from the roads, at the time of routing decisions. By taking the routing decision, find the route to destination node. It uses the repair strategy to find the local minimum [14]. This strategy decides, on each junction, which street packet follows next so that the packet is reaches the destinations easily. It considers the Right-hand rule (It chooses the street this is next one chosen counter clockwise from the actual packet has arrived on) to find the routing decisions at intermediate junctions.

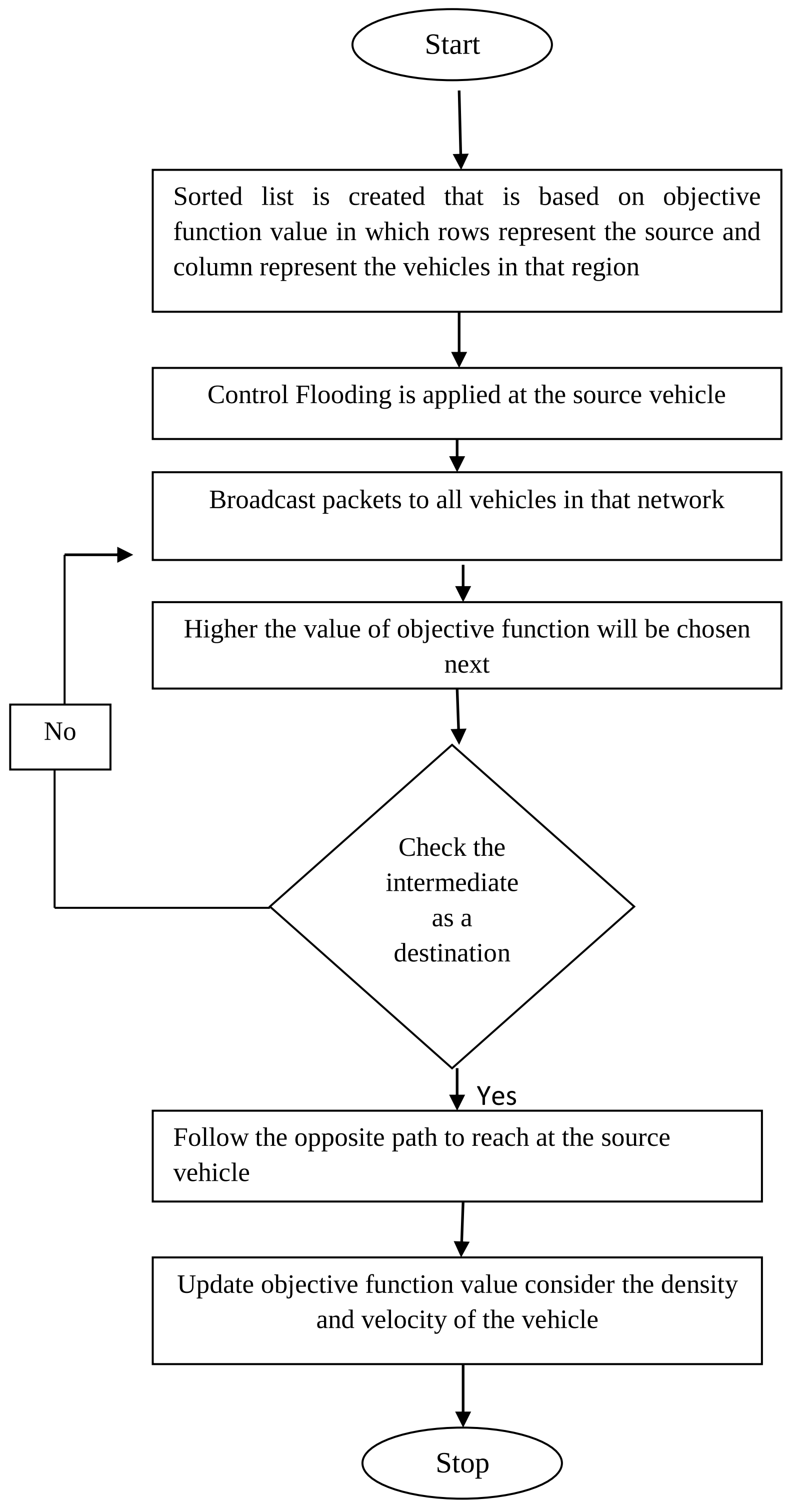



Figure 4.1 Flowchart of the Proposed algorithm.

## 4.2 Methodology

The firefly algorithm considers that all the firefly is unisex so one firefly attracts to another firefly [20]. Attractiveness depends on the brightness and distance between the firefly. Attractiveness is directly proportional to the brightness of the firefly and indirectly proportional to the distance between them. So one firefly moves forward to the next firefly depending on the attraction between them.

There is a specific entry of objective function in sorted list. So for better transmission we have to maximize the objective function value. We are calculating the objective function value at each vehicle node. Then

$$\beta = \beta_{0\ e^{-\alpha}} \qquad (1)$$

Where: - ß=Brightness, α=delay, $ß_0$=Initial value.

So the updated objective function will be (movement of the $i^{th}$ firefly to another firefly $k^{th}$ will be) [22].

$$ß_t=ß_0+|X_i-X_k|\ \alpha + \mu. \qquad (2)$$

Where

$$\mu = \mu_f(1- k/k_j). \qquad (3)$$

K=density, $\mu_f$=Free flow speed, $k_j$=jam density (traffic density associated with completely blocked traffic),

$|X_i-X_k|$=Cartesian distance between the $i^{th}$ and $k^{th}$ firefly.

This objective function takes the distance from the stationary point because all the vehicles are moving with different speeds and moving in different directions. We are taking the two-dimensional distance of the vehicle from the origin (stationary) point. The distance is basically the Cartesian distance between the two points. So our target is to maximize the objective function value for each vehicle. The vehicles are dynamically moved with respect to each other.

# CHAPTER 5

# SIMULATION AND RESULTS

This chapter presents the simulation, results and comparision for the proposed approach.

## 5.1 Introduction to NS-2

NS-2 stands for network simulator version two. It is basically used for simulation purpose. It has the following features:

- Ns-2 is the standard tool for designing the new protocols.
- It is Unix based.
- Use TCL as its scripting language.
- Object- oriented support.
- C++ and Otcl linkage.

The creation of new simulator object includes the following steps.

- Create a new simulator object.
- Open the trace file that you are actually creating.
- According to the related information create the network.
- Firstly, a link is created between the node.
- After that check each and every case by defining the traffic and transport connection.

### 5.1.1 Languages used

- C++: It is the system programming language required for the protocol simulations.
  - Supports algorithm implementation, byte manipulation and packet processing.
  - Turn around time is slower.
  - Runtime speed is important.
- Tcl : This is used in the case of simulation with varying confrigration.

- Quickly responses to a number of scenarios.
- Iteration time is more important.

### 5.1.2 Installation of Ns-2

First download the required package from the internet preferably UNIX system is chosen. The presence of GCC or g++ compiler is a must for working of the NS-2. The reason for this is it provides the interpret enppord to the coding performed in the GCC environment. To check the GCC compiler in the system use the following command:

# cd >gcc-v

Now if this command shows the configuration of GCC compiler it means that GCC is successfully installed on the system, otherwise reinstall it if required. To install the NS-2 use the simple Linux command and explore the .install file that is present in the NS-2 folder. After this exploration, the installation will start. NS2 can be further validate by using following command:

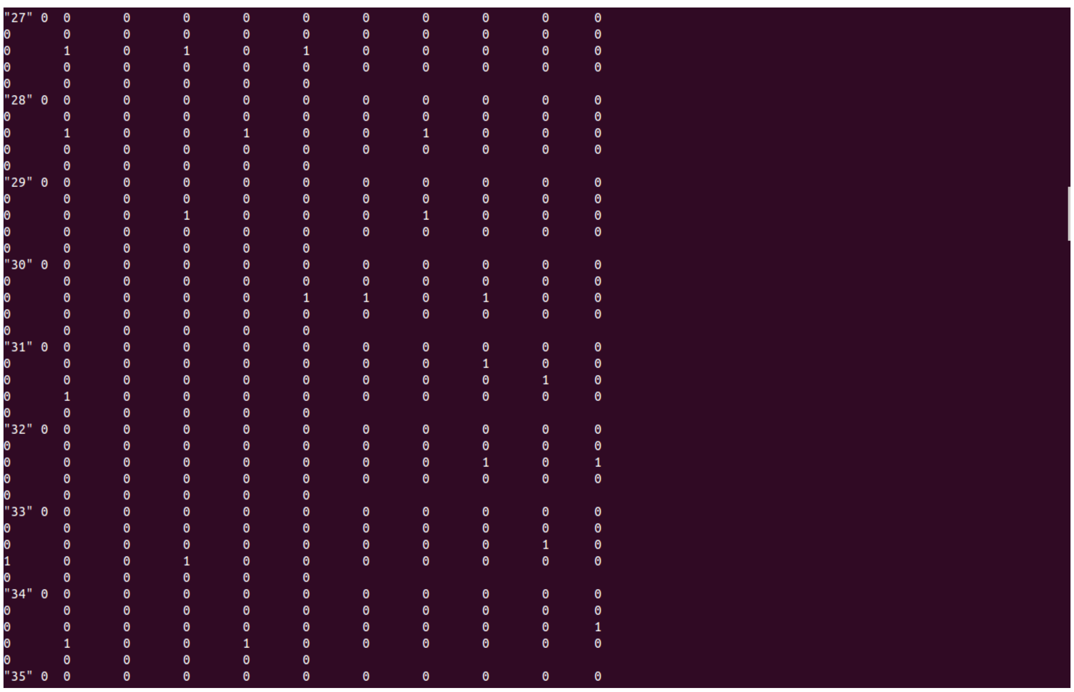
# cd>./validate.

## 5.2 Results

Here, the results of the proposed algorithm reduced the transmission time from source to destination and also improves the connectivity. There is more than one route possible to reach the destination place. So to reduce the transmission time we have to consider the vehicle speed and density as the parameter. The other considered parameters used for simulation are shown below in table 5.1.

Table 5.1 Simulation Parameters.

| Parameters | Value |
|---|---|
| Number of nodes | 5,10,15,20,25,30,35,40,45,50 |
| Number of fireflies. | 5,10,15,20,25,30,35,40,45,50 |
| Number of packets | 10 |
| Maximum speed | 30 Kmph |
| Minimum speed | 10 Kmph |
| Density | 30 vehicles/Km |
| Jam Density | 80 vehicles/Km |



```
"27" 0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0
0  1  0  1  0  1  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0
"28" 0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0
0  1  0  0  1  0  0  1  0  0  0
0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0
"29" 0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0
0  0  0  1  0  0  0  1  0  0  0
0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0
"30" 0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  1  1  0  1  0  0
0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0
"31" 0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  1  0  0
0  0  0  0  0  0  0  0  0  1  0
0  1  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0
"32" 0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  1  0  1
0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0
"33" 0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  1  0
1  0  0  1  0  0  0  0  0  0  0
0  0  0  0  0  0
"34" 0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  1
0  1  0  0  1  0  0  0  0  0  0
0  0  0  0  0  0
"35" 0  0  0  0  0  0  0  0  0  0  0
```

Figure 5.1 How the node connects in the network model

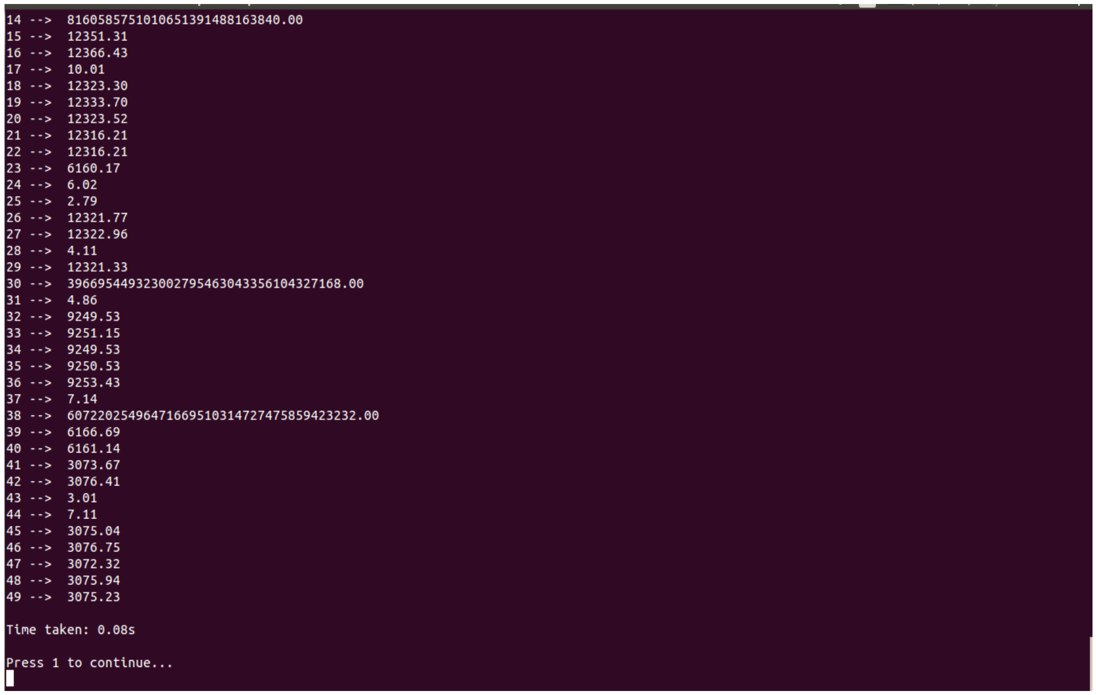
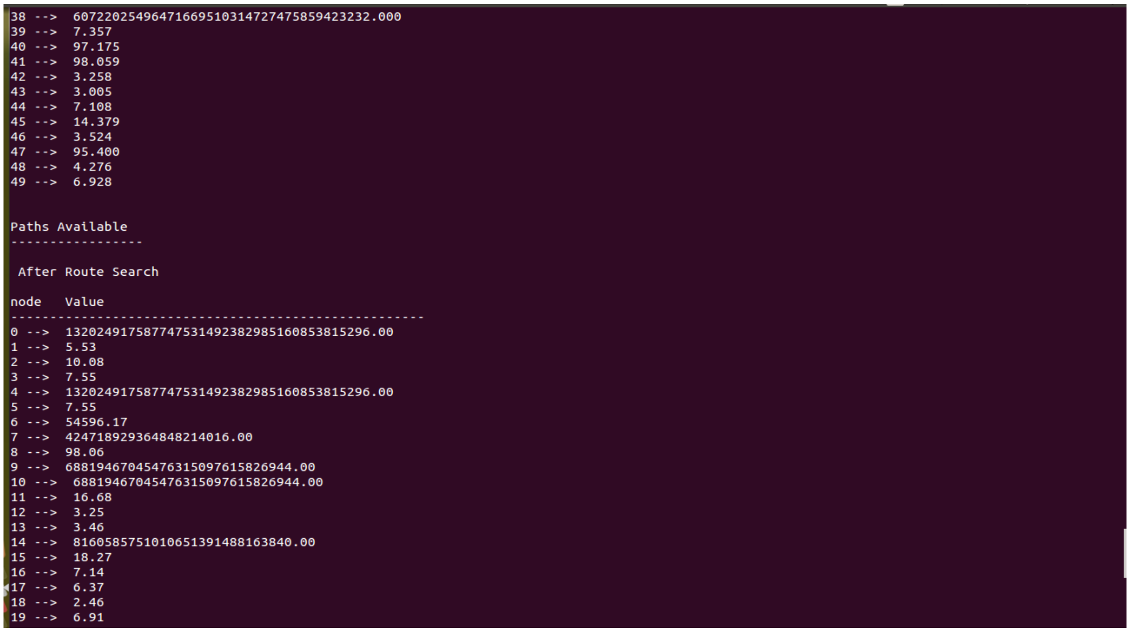



Figure 5.2 Objective function value at each node

Figure 5.1 shows that a value of '1' is used to show a connection and '0' presents the no connectivity. Figure 5.2 shows the initial value of each vehicle which is stored in the sorted list. Figure 5.3 shows the objective function value after the first iteration (after route search) but it cannot display the path (because in the first iteration the selected vehicle is not a destination node). Figure 5.4 shows the transmission time from source to destination. This time is calculated by the clock when the route begins. Figure 5.5 shows the considered path from source to destination. After that it displays the objective function value (node value) at each node.



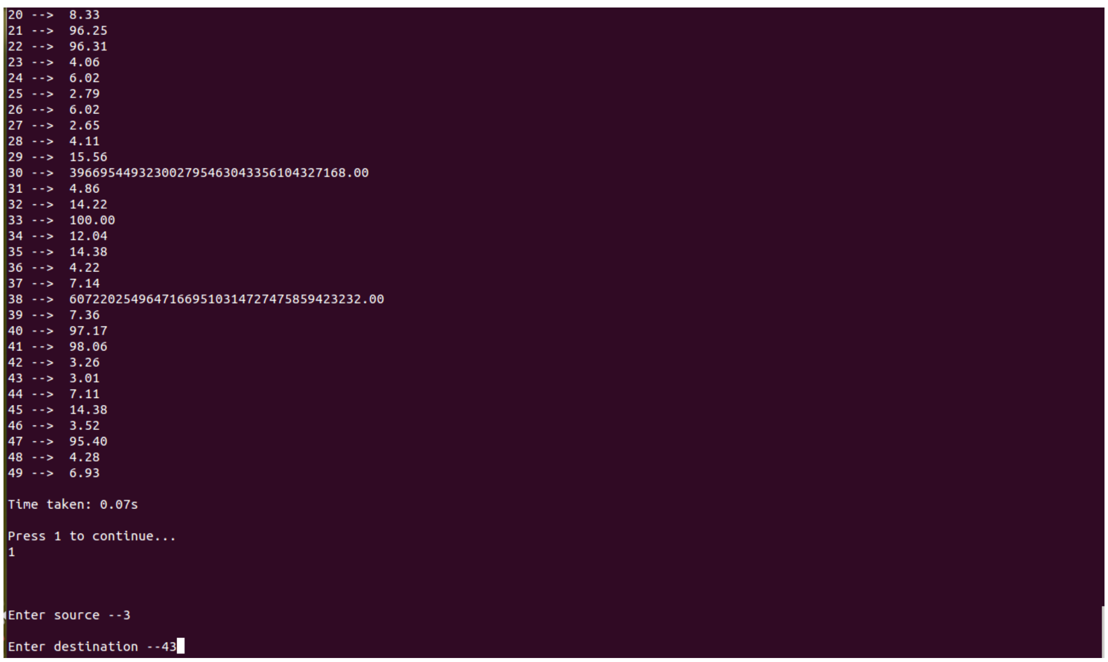
```
38 -->  60722025496471669510314727475859423232.000
39 -->  7.357
40 -->  97.175
41 -->  98.059
42 -->  3.258
43 -->  3.005
44 -->  7.108
45 -->  14.379
46 -->  3.524
47 -->  95.400
48 -->  4.276
49 -->  6.928


Paths Available
-----------------

 After Route Search

node   Value
-----------------------------------------------------
0 -->  132024917587747531492382985160853815296.00
1 -->  5.53
2 -->  10.08
3 -->  7.55
4 -->  132024917587747531492382985160853815296.00
5 -->  7.55
6 -->  54596.17
7 -->  424718929364848214016.00
8 -->  98.06
9 -->  68819467045476315097615826944.00
10 -->  68819467045476315097615826944.00
11 -->  16.68
12 -->  3.25
13 -->  3.46
14 -->  8160585751010651391488163840.00
15 -->  18.27
16 -->  7.14
17 -->  6.37
18 -->  2.46
19 -->  6.91
```

Figure 5.3 Display node value after the first iteration



```
20 -->  8.33
21 -->  96.25
22 -->  96.31
23 -->  4.06
24 -->  6.02
25 -->  2.79
26 -->  6.02
27 -->  2.65
28 -->  4.11
29 -->  15.56
30 -->  39669544932300279546304335610432 7168.00
31 -->  4.86
32 -->  14.22
33 -->  100.00
34 -->  12.04
35 -->  14.38
36 -->  4.22
37 -->  7.14
38 -->  60722025496471669510314727475859423232.00
39 -->  7.36
40 -->  97.17
41 -->  98.06
42 -->  3.26
43 -->  3.01
44 -->  7.11
45 -->  14.38
46 -->  3.52
47 -->  95.40
48 -->  4.28
49 -->  6.93

Time taken: 0.07s

Press 1 to continue...
1



Enter source --3

Enter destination --43
```

Figure 5.4 Display transmission time from source to destination


Figure 5.5 Display path size and node value after second integration

Table 5.2 show the transmission time calculated from different experiment. The time is based on selected source node and the destination node. Figure 5.6 show that the transmission time comparison with different destination nodes. A comparison is presented in figure 5.6 and table 5.2 which shown the trend using different source node. Table 5.3 show the transmission time calculated from different experiment. The time is based on the selected source node and the destination node. Figure 5.7 show the transmission time comparison with different source nodes. A comparison is presented in Figure 5.7 and Table 5.3 which shown the trend using different destination node.

Table 5.2 Transmission time calculated from different experiment.

| S.No | Destination node | Transmission time for source node 1 (sec) | Transmission time for source node 2(sec) | Transmission time for source node 3 (sec) |
|---|---|---|---|---|
| 1 | 5 | .07 | .07 | .06 |
| 2 | 10 | .06 | .08 | .07 |
| 3 | 15 | .06 | .06 | .08 |
| 4 | 20 | .09 | .08 | .08 |
| 5 | 25 | .07 | .07 | .07 |
| 6 | 30 | .06 | .06 | .08 |
| 7 | 35 | .08 | .07 | .09 |
| 8 | 40 | .09 | .08 | .07 |
| 9 | 45 | .09 | .07 | .07 |
| 10 | 50 | .08 | .08 | .09 |

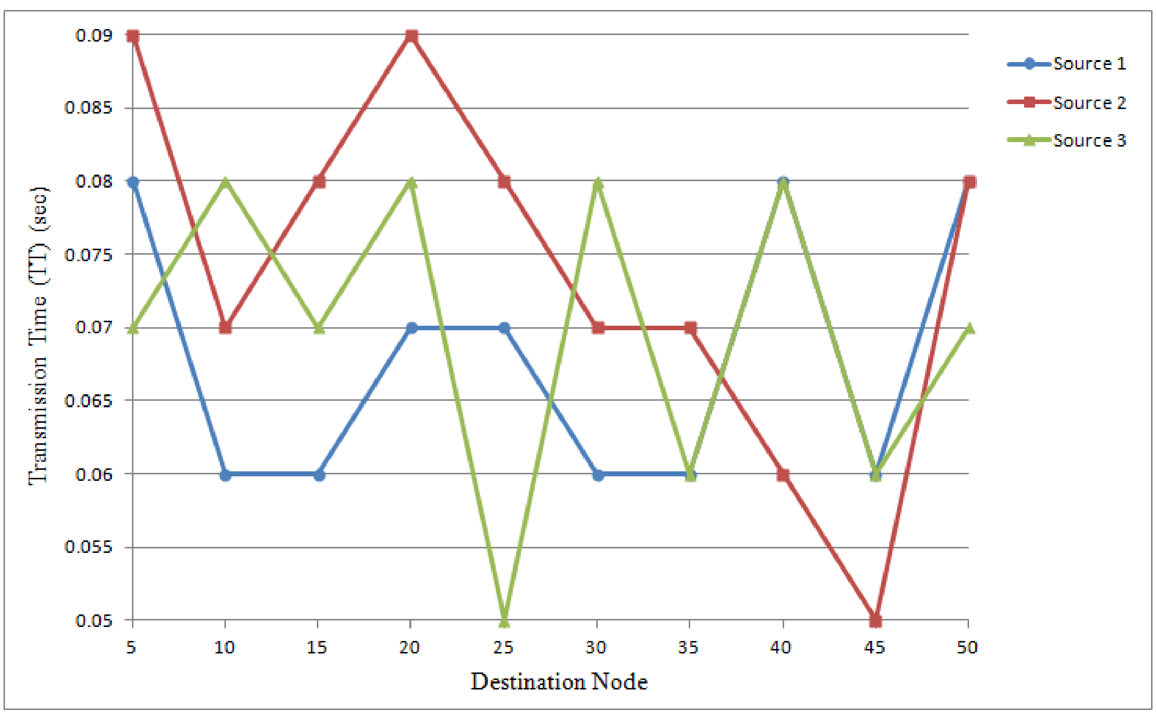



Figure 5.6 Transmission time on comparison with the different Destination node

Table 5.3 Transmission time calculated from different experiment

| S.No | Source node | Transmission time for Destination node 50 (sec) | Transmission time for Destination node 49 (sec) | Transmission time for Destination node 48 (sec) |
|---|---|---|---|---|
| 1 | 1 | .08 | .09 | .07 |
| 2 | 5 | .06 | .07 | .08 |
| 3 | 10 | .06 | .08 | .07 |
| 4 | 15 | .07 | .09 | .08 |
| 5 | 20 | .07 | .08 | .05 |
| 6 | 25 | .06 | .07 | .08 |
| 7 | 30 | .06 | .07 | .09 |
| 8 | 35 | .08 | .06 | .06 |
| 9 | 40 | .06 | .07 | .07 |
| 10 | 45 | .08 | .06 | .09 |

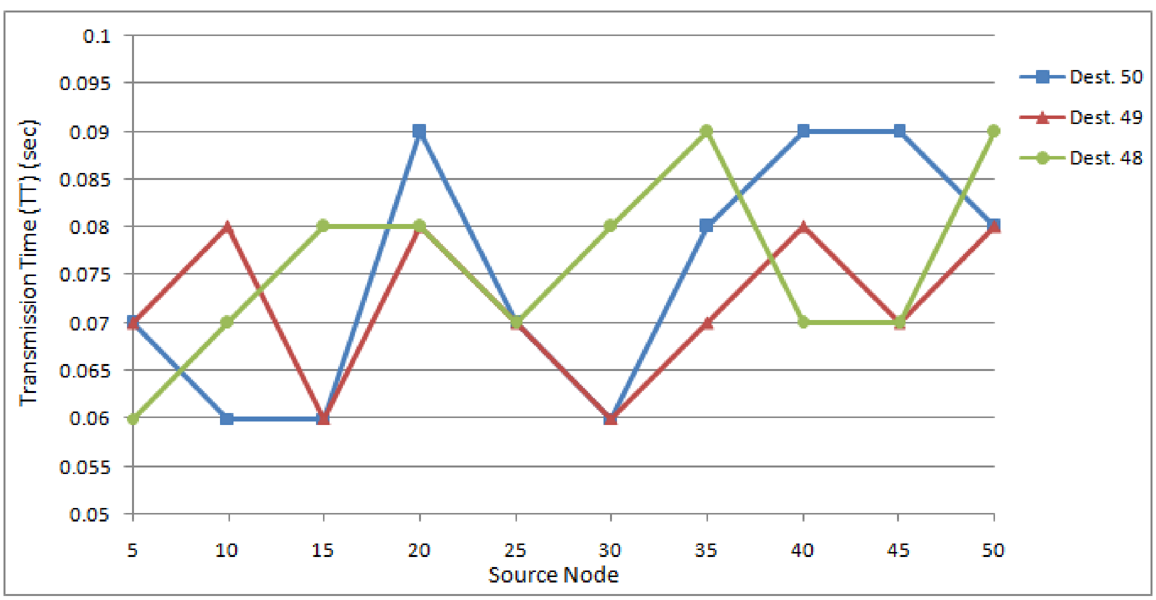



Figure 5.7 Transmission time on comparison with different source node

# CHAPTER 6

## CONCLUSION AND FUTURE SCOPE

VANETs are the collection of vehicular nodes operatory in ad hoc mode. The main issue with VANETs is the high mobility and consistent changes in the direction of vehicle. This made route acquisition and communication a tedious task. The existing routing protocols do not efficiently handle these issues. Then, an improved routing approach is suggested in this thesis work. The proposed routing is based on the properties of firefly algorithm. In order to maximize the objective function value the vehicle parameters (density and speed) are optimized.

The results suggest that the proposed approaches provide better route acquisition with less transmission time and better connectivity.

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