A Novel Routing Protocol strategy in CR-VANETs
Israa A. AbdUlmaged, Ahmed I. Saleh, Labib M. Iabe

Abstract—this paper aims at proposing new approach for routing in Cognitive radio for vehicular ad hoc networks (CR-VANETs). In this paper Flower Based Routing (FBR) scheme has been proposed. The FBR scheme consists of groups of networks on flower form and introduce hybrid mobility model for data forwarding. In addition, we categorize different types of routing protocols in CR-VANETs. Moreover, a comparison between them to our scheme is conducted to highlight the main issues, and pros & cons for each type. The motivations of this work are derived through an analysis for achieving efficient communication among the vehicles on the road. By this, we conclude the motivations for proposing new methodology for CR-VANETs. This methodology is considered as a suitable paradigm for achieving high degree of efficiency in such VANETs sophisticated network access to many online various applications. By comparing the proposed protocol with previous protocols, the enhanced performance in packet delivery ratio, control overhead, and end-to-end delay has been enhanced.

Keywords—VANETs, performance, Routing, Cluster, Cognitive radio

I. INTRODUCTION

The exhaustive increasing in the number of vehicles on the roads causes dramatic increment in traffic-related problems such as accidents. Therefore, one of the most suitable solutions of these problems is efficient traffic management by connecting vehicles wirelessly which led to avoid collisions and congestion. Traffic-related issues such that car accidents and congestions cost billions of dollars annually in many countries [1]. Therefore, the previous problems have a negative impact on the health and economy [2]. Consequently, we should build efficient traffic system to transmit reliable and quick messages between nodes or between nodes and infrastructure; the collected information will be used effectively to solve the mentioned problems and prevent accidents and collisions [3].

Recently, Vehicular Ad-hoc Networks (VANETs) have a perfect potential to enhance the traffic safety by providing the position data of each other by wireless vehicular communications. VANETs are a new class of Mobile Ad hoc Networks (MANET). This type of networks consists of a number of vehicles connected to each other. Vehicles in VANETs can transit with high mobility in all directions. Vehicles in VANETs communicate to each other directly through a wireless link if they fall in the same transmission range. Moreover, vehicles which not fall in the same transmission range will communicate through intermediate node in multi hop style [4].

VANETs integration into internet improves the flexibility of networking and coverage of these types of networks. Two of the most paramount issues for efficient routing protocols in VANETs are ensuring delivery and the handling dynamic connectivity capabilities. Therefore, VANETs Networks considered many challenges for implementing an efficient routing protocol due to their naturalistic characteristics.

In general, wireless ad hoc networks contain essentially three types of routing protocols i.e. Reactive, Proactive and Hybrid. The previous routing protocols are having different criteria for using and implementing.

In proactive routing protocols each node preserved a routing table which updated periodically through periodic exchanging of control messages among nodes. Therefore, each node has instant data about any changing in network topology. In this type of routing protocol the nodes preserved list
of routes to every node in the network, therefore, to start sending data, there is no initial delay. Many of Proactive routing protocols are proposed such as Destination Sequence Distance Vector (DSDV) and Optimized Linked State Routing (OLSR).

In reactive routing protocol routes are created when it needed; therefore, routing table updates is not mandatory. In this type of routing every destination node wait until discovering new root. Reactive routing protocols do not constantly update their routing tables with latest route topology. They create routes only when the source node needs that. Many of reactive protocols are proposed such as Dynamic Source Routing Protocol (DSR) and Ad hoc On-demand Distance Vector (AODV) [5].

Traditionally, VANET multicast algorithms may be used for data delivery the same transmission power. On the other hand, to group the vehicles, adjusts its transmission range and monitor the mobility of vehicles, Location based 2-hop multicast flooding (L2MF) algorithm uses the hierarchical clustering algorithm.

Because of L2MF flooding nature, at the time of less vehicle count, it achieves a better delivery ratio. But, if the vehicle density is high, overhead increases resulting in delivery ratio decrease. Data distribution throughout the network causes that L2MF performs better than AODV and DSDV [6].

This paper proposes a Flower Based Routing (FBR) Protocol for VANET. The propose protocol is established in two steps. Frist the FBR is implemented and explained to a- establish a path for packed transmission between nodes. Second comparison study is carried out between the proposed protocol and the previous protocols such as DSDV, AODV and L2MF, in the enhanced performance in packet delivery ratio, control overhead, and end-to-end delay. In this analysis the relationship between the packet deliveries ratio for any random source and destination, is shown control overhead, and end-to-end delay.

The rest of the paper is organized as the follows: in Section 2, presents related work. Section 3 proposed routing protocol is explained. Section 4 introduces results of the proposed protocol. Section 5, introduces the comparison and analysis. Finally, Section 6 will provide the conclusion and future research in this direction.

II. RELATED WORK

As mentioned before, varying network topology and frequent disconnections causes that conventional routing protocols are not suitable for VANETs. Many cognitive routing protocols are proposed for cognitive radio for VANETs (CR-VANETs). Routing in CR-VANETs should be considered important metrics such as channel switching delays, availability of spectrum, hop count, geographic location, etc. [7]

In ref [8] L2MF has been proposed to satisfy 2-hop routing, location based forwarding, multicasting and flooding. L2MF vehicles use continual learning to upgrade paths, and use these updates to search for new paths. Therefore, It is adaptive than AODV and DSDV.

One of the most important CR-VANETs protocols called Search [9]. This scheme is firstly proposed for cognitive radio Ad hoc networks in general and it’s pleasant for CR-VANETs as well. The main idea of this scheme is to choose a route and the channel that evade the regions of Primary User PU activities. In area where some vehicles may not have GPS information, search protocol may not be suitable.

The protocol proposed in [10] is another recent approach which based on RREQ packets. But, in this protocol we didn’t used the location information as all vehicles may not have GPS information. In this scheme there are two routing protocols: First protocol searches with each route evolving on a single channel through several routes; Second protocol discovers only one route, despite it exploits several channels.

A recent protocol CoRoute [11] is an anypath vehicular routing protocol for CR-VANETs that exploits geo-location and sensed channel information. CoRoute extends the anypath multi rate
scheme proposed in [12] to include cognitive radio and geo-location. With any path multirate routing, a node broadcasts to a set of nodes using a selected rate. Then, any one of them forwards the packet towards the destination in the same way while the other nodes in the set avoid broadcasting duplicate copies if they hear the first broadcast. This routing has an any path property that any node that received the packet can forward it and hence, the path can change depending on which node received the packet. If multiple nodes receive broadcast then, the one with highest priority forwards the packet.

CoRoute extends the any path multirate routing protocol such that the broadcasts are done on different channels depending on the sensed channel information and geolocation. The set of forwarders is chosen such that the nodes in the set are geographically closer to the destination. The channel with the least amount of congestion is chosen.

### III. PROPOSED ROUTING PROTOCOL

In this paper, an integrated system is proposed that is composed of flower clustering, hybrid mobility model and (FBR). In the proposed integrated system vehicles act as the backbone for the communication infrastructure of the network. Mobility and routing paradigm are explored to extend the range of the network. Mobility pattern also has an impact on the network performance, as it influences the connectivity. Relay nodes use store-and-forward mechanism to transfer information to nodes located at intersections between two flowers. This work investigates the influence of vehicle density and its mobility pattern on data delivery ratio and the delay observed in a VANET. Mobility’s of vehicles lead to various distributions of vehicles, which can be modeled in different ways. RPGM model is more probable at peak time; Random waypoint model is more probable at non-peak times. Sometimes combination of both these would be more appropriate. Hybrid mobility model provides multipath routing for VANETs.

The proposal the network is called flower clusters which used Flower Based Routing (FBR) protocol to route the packets between each other. It consist sofa group of network with flower shape, each flower has two parts the first one is the flower core which controlled by Flower Center, the second part is the number of flower leaves, each flower leave has Master Leaves (ML) that select leaves members. The node within the same flower has the same ID and each flower connected with another flowers by Neighbor Gateway (NG).

Vehicles are grouped based on the location of flower center. Road side units act as static flower center located at certain predefined places like junctions, traffic signals, hospitals, restaurants, congested places, shopping malls, city exit points and toll gates. Vehicles that are within the range of flower center become its members and information is shared between them in a full duplex manner. Flower Leaves are formed around the flower center located at the road signals, street corners and congested places. However, buses are chosen as master leaves based on speed, power and position, as shown in Fig. 1.
Figure 1: Flower Clustering

Flower leaves are consisting of three types of vehicle, master leaves, normal vehicle and gateway vehicle, as shown in figure 2.

Figure 2: Flower Leaves
After FC elect the ML. The ML will send messages contain the ID number to its members, if the vehicle receives more than one message with different ID number it means that the Vehicle is gateway. And then this gateway used to interconnect between two flowers.

If the vehicle receives more than one message with the same ID number from the same flower, the gateway will neglect the message the ML can send to other ML via flower center.

3.1 Flower Formation Algorithm (F²M)

In this section, we will explain the formation of flower in the proposed algorithm is explained. The construction of the flower is divided into two phases. The first phase is Flower Center Discovery (FCD) which responsible for discovering all nodes existing in the flower center. In addition, FCD needs to collect data for choosing the Leave Master (LMs). The second phase is Leave Master Election (LME), in this phase some parameters will calculated to choose the ML. the flow chart of figure (3) will show the F²M algorithm then the two phases is explained in details. In the following sections

3.1.1 Phase 1: Flower Center Discovery (FCD)

As mentioned before, the FCD is the process in which all nodes are discovered and data needed to choose LMs are collected as follow:

1. The Flower Center (FC) will broadcast message called Flower Formulation Massage (FFM) to all nodes in the range. The message format is shown in the figure (4).

2. When the previous message reach to certain node, the node will choose the level field such that:

   i- If there are old message received before and has the same time stamp, the node will compare the level field and chooses the less level field and store it as a node level. Then the level will increase by one and broadcast the message to all other nodes, and send it as unicast to the FC to detect the path.

   ii- If this message is the first one, in the current time stamp, the node will record the level which contained in the message as its level. Then increase the level by one and broadcast the message to all other nodes, and send it as unicast to the FC to detect the path.

   iii- If the node receives FFM message has less or equal time stamp less than the previous time stamp, the node will discard the message.

   iv- If the level equal n, the node will record its level as n. Then the node will send the message unicast to the follower center according to the path recorded on the FFM with additional information such as speed, power and position. The additional information will help the FC to elect the LM.

![Figure 4: FFM Message](image-url)
The example is shown in figure (5) shows how any certain node unicast the path to FC.

![Flow Chart of $F^2M$](image)

*Figure 3: Flow Chart of $F^2M$*

When the FFM message reach to the node, the node will separate the path included in FFM then add it’s ID.

![Unicast message to FC for FFM path](image)

*Figure 5: Unicast message to FC for FFM path*
3.1.2 Phase 2: Master Leave Election (MLE)

The flower center is divided into group of sectors. In each sector, the nodes which located in level n will be separated. If we suggested that \( M \) is the number of vehicle in round of flower center and we need \( n \) of MLs. If \( n \leq M \) then divide the flower center into group of sectors such that the number of sectors are equal to \( 360/n \). As in figure 6:

![Figure 6: Sector formulation](image)

The FC will elect the MLs according to the highest power and the lowest speed.

3.2 Flower Based Routing (FBR) Scheme

In the previous section the flower formulation is explained. In this section we will explain the proposed routing protocol, FBR. Is explained flow chart will display the proposed algorithm. As shown in the flow chart (figure 7), we suppose that the vehicle (A) need to send stream of data packets to the vehicle (B), thus it needs to determine the path of the vehicle (B). Initially, and at any sending process the Cognitive Radio (CR) network search for available channels around it. Therefore, it selects the free channel which satisfies the quality of service (QoS) requirements. At this moment, vehicle (A) sends request to Master Leaves (ML) to check whether the destinations in the same leave and reply path to vehicle (A). Therefore vehicle (A) send data to vehicle (B). If the vehicle (B) is not found in the same leaves, ML send request to Flower Center (FC) to ask about the path of vehicle (B) and then FC search in its global table about the path of vehicle (B), if it was found, FC will check the validation of this path, if the path valid, it send acknowledge (ACK) to ML. Therefore vehicle (A) send data to vehicle (B). If FC doesn't find the path in its table, it will send reply message "path is not found ". Then, ML sends request path of vehicle (B) to another neighbor Master Leaves (NML) using gateway node. If NML found the path in local leaves, it will send ACK to ML. Therefore, ML send reply path to vehicle (A) and then vehicle (A) will send data to vehicle (B). If NML doesn't find the path in local leaves, it will send reply "path doesn't found" to ML. Therefore; ML informs the FC that the path is not found. Accordingly, FC will send flooding request and wait for threshold time. If FC found vehicle (B), it will reply path to ML, then ML reply the path to vehicle (A), therefore, vehicle (A) send data to vehicle (B). If FC doesn't find vehicle (B), it will reply vehicle (B) is not found.
Figure 7: Flow Chart of FBR
3.3 FBR Routing Cases

FBR as a routing algorithm can be broadly divided into two cases, the first case is inter flower Routing and the second one is intra flower routing.

3.3.1 Case 1: Inter flower routing

Inter flower Routing is meaning that routing within the flower itself and it divided into two situations:

i. When the source node (A) needs to send packet to certain destination node (B) in the same leave. The source will ask master leave to check whether the destination node is within the local leaves or not. If the destination node is present within the leaves then the master leaves send the reply packet with its ID embedded in the packet to the source. Now, the source node forwards all the data packets required to be sent to the destination node after getting the path from the master leave. As in figure 8.

![Figure 8: two nodes in the same leave](image)

ii. When the source need to send packet to certain destination in different leave in the same flower. In this situation the master leaves send request to the flower center to check in its table about destination path. The flower center reply with packet contains its ID embedded in the packet. Now, the source node forwards all the data packets required to be sent to the destination node. As in the figure 9.

![Figure 9: two nodes in different leaves](image)
3.3.2 Intra flower routing

Intra flower Routing is meaning that routing out the flower and it divided into two situations:

iii. When the source need to send packet to certain destination in different flower. In this situation the master leaves doesn’t have information about destination, therefore it sends request to other master leaves by gateway node. As in figure 10.

![Figure 10: two nodes in different flower](image)

iv. When the source need to send packet to certain destination in neighbor leave in different flower. In this case the destination node doesn’t exist in the neighbor leave, therefore the flower center send flooding request to other flower leaves and wait for threshold time.

4.4 Route Maintenance

Route maintenance is the operation of following up the vehicles movements and modifications of paths continually in the period between two flowers construction. As shown in figure (11).

![Figure 11: route maintenance](image)

The movements of vehicles divided into two cases:

3.4.1 Case 1: if the vehicle moves inside the flower, the movement of the vehicle will be one of the following:

1. Core To Leave Same flower (CTLS)
2. Leaves To Leaves Same flower (LTLS)
3. Leaves To Leaves Different flower (LTLD)
4. Leaves To Core Same flower (LTCS)

Now, we will explain in details the cases mentioned before.

For any movements of vehicles, the position ID will be stored in the position ID field which changed its value after handshaking operation. The position ID consists of flower ID and Identity number as in figure(12).

**Position ID**

<table>
<thead>
<tr>
<th>Flower ID</th>
<th>Identity number</th>
</tr>
</thead>
</table>

*Figure 12: Position ID*

- The flower ID is the flower number, if this number changed, that is meaning that the vehicle moves from the current flower to the other one.
- The identity number is the core and leaves number. We have to know that the identity number is always zero for core. If this number changed, that is meaning that the vehicle moves from leaves to core or from core to leaves or from leaves to another one.

### 3.4.1.1 Core To Leave Same flower (CTLS)

In this case, the vehicle moves from core to leaves in the same flower and also it meaning that the identity number changed from 0 to the leaves number. Therefore, the Master Leave (ML) will make record for this vehicle and inform the Flower Center (FC) that this vehicle joined it. Consequently, the FC will remove this vehicle from its entries as in figure (13).

*Figure 13: Core To Leave Same flower (CTLS)*
3.4.1.2 Leaves To Leaves Same flower (LTLS)

In this case, the vehicle moves from leaves to leaves in the same flower. Therefore, the New Master Leave (ML) will make record for this vehicle and inform the Flower Center (FC) that this vehicle joined it. Therefore, the FC will inform the old master leave to remove this vehicle from its entries as in figure (14).

![Figure 14: Leaves To Leaves Same flower (LTLS)](image)

3.4.1.3 Leaves To Leaves Different flower (LTLD)

In this case, the vehicle moves from leaves to leaves in different flower. Therefore, the New Master Leave (ML) will make record for this vehicle and inform the Neighbor Gateway (NG) that this vehicle joined it. Therefore, the NG will inform the old master leave to remove this vehicle from its entries as in figure (15).

![Figure 15: Leaves To Core Same flower (LTCS)](image)
3.4.1.4 Leaves to Core Same flower (LTCS)

In this case, the vehicle moves from leaves to core in the same flower and also it meaning that the identity number changed from leaves to 0. Therefore, the vehicle broadcast message to ask about the FC and receive unicast message inform it about the path of FC. Therefore, the vehicle will put its path and unicast the message to FC. Thus, FC will make record for this vehicle and inform the ML about that as in figure (16).

![Figure 16: Leaves To Core Same flower (LTCS)](image1)

3.4.2 Case 2: if the vehicle moves outside the flower, the movement of the vehicle will be Core To Core Different flower (CTCD). When the vehicle moves with high speed, it will transfer from core of certain flower to another core in another flower. This case may be divided into four cases like the previous cases. Therefore, it is not needed to design algorithms or mechanisms for those cases as in figure (17).

![Figure 17: Core To Core Different flower (CTCD)](image2)
IV. IMPLEMENTATION OF THE FBR

The efficiency of FBR algorithm is evaluated in a number of simulation tests. Ns-2 simulator is used for the comparison of the performance of FBR, AODV, DSDV and L2MF. Ns-2 trace files are analyzed using trace graph [13]. Simulation considers, number of vehicles ranging from 50 to 500 placed randomly in an area of 2500m X 2500m. Each experiment is run for 2000 seconds. Data traffic is generated by 25 constant bit rate (CBR) sources. The sources send one 512-byte packet per second. Each CBR source starts sending at a random time between 0 and 180 seconds after the start of simulation, and keeps sending till the end. At the physical layer a two-ray signal propagation model is used.

The radio propagation range of the nodes is 250m. For different experiments in this setting, the mobility patterns of the nodes were varied. The tests with random waypoint mobility model were done to know impact of the variations in vehicle speed and the pause time. In Group Mobility Model, analysis is based on its location and speed. The simulation parameters for FBR are shown in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation time</td>
<td>2000s</td>
</tr>
<tr>
<td>Simulation area</td>
<td>2500m x 2500m</td>
</tr>
<tr>
<td>Communication range</td>
<td>250m</td>
</tr>
<tr>
<td>Vehicle speed</td>
<td>[10-120] km/h</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>11Mbps</td>
</tr>
<tr>
<td>Number of vehicles</td>
<td>50-500</td>
</tr>
<tr>
<td>MAC type</td>
<td>IEEE 802.11</td>
</tr>
<tr>
<td>Mobility model</td>
<td>RWP and RPGM</td>
</tr>
<tr>
<td>Routing protocol</td>
<td>FBR, AODV, DSDV and L2MF</td>
</tr>
<tr>
<td>Packet size</td>
<td>Packet size 512 bytes</td>
</tr>
</tbody>
</table>

4.1 Metrics Considered for Evaluation

FBR operates by periodical flooding of beacons in the network to create the multicast forwarding state. This mechanism serves two goals, first, to set up the multicast forwarding state when a source starts flooding and second, to recover from link failures during data transmission. Flooding interval is set as 2s. The following metrics have been used in evaluating the performance of the algorithm.

4.1.1 Data packet delivery ratio: Number of data packets delivered successfully at different speed of vehicles and at various vehicle density conditions.
4.1.2 Delay: This metric is defined as the average delay incurred in the transmission of all data packets that were successfully delivered.
4.1.3 Overhead: The ratio of beacons sent across the network during the data transmission.
V. RESULTS & ANALYSIS

We measure performance in different cases and conditions as follows:

5.1 Impact of Vehicle Density

Density is defined as the number of vehicles per unit length of the roadway. Data packet delivery ratio is considered as the metric for measuring the performance at various vehicle densities.

Figure 11 shows the impact of vehicle density on data packet delivery ratio. The FBR achieves a better delivery ratio at the time of less vehicle count because of its flooding nature. Flooding is an important communication primitive in mobile ad-hoc networks and also serves as a building block for more complex protocols such as routing protocols. Flooding is well controlled and not used repeatedly as done in L2MF which may cause traffic congestion. In high vehicle density, overhead increases resulting in delivery ratio decrease. Compared to L2MF, AODV and DSDV, FBR performs better because of data distribution throughout the network. AODV can perform a local repair to the source node using routing tables.

![Figure 11: Data packet delivery ratio at various vehicle densities](image)

Figure 11: Data packet delivery ratio at various vehicle densities

Figure 12 shows the delay of transmission during different vehicle density situations. At low-density conditions, FBR reduces delay. In high density conditions, node dispersion increases delay.

![Figure 12: Delays of transmission at various vehicle densities](image)

Figure 12: Delays of transmission at various vehicle densities
5.2 Analysis of FBR during Mobility

Data packet delivery ratio in random waypoint scenario at different vehicle speeds is shown in Figure 13. There is no additional overhead observed at low mobility. FBR, uses local repair mechanisms which avoid route failures by preemptively local repairing routes when a link break is about to occur, hence data packet delivery ratio decreases slightly when the mobility level is high. The flower clustering of FBR tends to locate the farthest node quickly, resulting in an improved delivery ratio than L2MF, AODV and DSDV.

![Figure 13 Data packet delivery ratio at various vehicle speeds under RWP scenario](image1)

Under random waypoint mobility, end-to-end delays at various vehicle speeds are shown in Figure 14. FBR is an adaptive one in which vehicles uses continuous learning to update paths, and use these to search for new paths; with the reference from nearby updated Cognitive Radio (CR) network that search for available channels around it and selects the free channel which satisfies the quality of service (QoS) requirements with minimal delay.

![Figure 14: End-to-End delays at various vehicle speeds under RWP Scenario](image2)

Under RPGM, data packet delivery ratio at various vehicle speeds is shown in Figure 15. In FBR, not all packets disseminated towards the destination node in a multicast manner. As said before, some packets are unicasted which reduces the overhead and improves the data packet delivery.
delivery ratio at low mobility conditions. Even at high mobility situations each node becomes the member of any one cluster and improves the data packet delivery ratio when compared with other routing techniques. Location based groups are formed between subsequent movements such that each node may be a member of any one of the groups. Sometimes gateway nodes may switch to neighbor cluster, leading in data packet delivery ratio decrease in L2MF, DSDV and AODV.

Figure 15 Data Packet delivery ratio at various vehicle speeds under RPGM scenario

Under RPGM, end-to-end delays at various vehicle speeds are shown in Figure 16. In FBR, multicasting and uncasting will reduce the queuing delay because the network traffic is distributed among different paths. Flooding can increase the delivery ratio even when some overhead is there. L2MF, AODV and DSDV will take more time for searching process when vehicle speed increases.

Figure 16 End-to-End delays at various vehicle speeds under RPGM Scenario

5.3 Analysis of Control Packet Overhead

The overheads and performance of the systems usually depend strongly on node mobility and the number of routing packets transmitted for every data packet sent. Routing overhead is the ratio of routing packets to the data packets and it can be calculated as the ratio between the number of the control packets and the number of the data packets. As the number of control packets is lower compared to L2MF, DSDV and AODV because of the unicast sending property, we expect a shrinking in routing overhead ratio.
Figure 17 shows the routing overheads at various vehicle speeds at random waypoint mobility conditions. At random waypoint, high mobility scenario, FBR does not allow rerouting operation. In DSDV, routing table updates take more time. In AODV, the dynamic nature does not yield quick results. In L2MF, control packet overhead increases when mobility increases due to repetitive flooding and data broadcasting.

![Figure 17 Routing overheads at various vehicle speeds under RWP Scenario](image)

Figure 17 Routing overheads at various vehicle speeds under RWP Scenario

Figure 18 shows the routing overhead at RPGM scenario. In FBR, the overhead at high mobility conditions, because of group mobility and their corresponding faraway transaction, increases whenever vehicle speed increases.

![Figure 18 Routing overheads at various vehicle speeds under RPGM Scenario](image)

Figure 18 Routing overheads at various vehicle speeds under RPGM Scenario

6.4 Analysis of the Number of Successful Delivery of Packets

Figure 19 shows the number of packets that are delivered successfully during data transmission.
In FBR, packets are distributed only towards the destination direction based on the neighbor table entries. FBR relies on routing table entries maintained in both flower center and master leaves, the number of packets reached destination successfully is more with minimal loss compared to L2MF, AODV and DSDV.

Flooding, multicasting and data broadcasting are used carefully in FBR unlike other algorithms. Unicasting sending aids in minimizing traffic jam especially in case of high vehicle density. Unicasting in addition to distributed centralization and well arranging of vehicles in flower clustering has shown to enhance data packet delivery ratio and decrease delay and overhead.

VI. CONCLUSIONS

In this thesis, a new method has been proposed as a routing algorithm in VANETs named FBR. FBR is considered to be a suitable paradigm for achieving high degree of efficiency in such VANETs sophisticated network access to many online various services and applications.

FBR was shown to improve upon the existing state-of-the-art methods for routing protocols in VANETs. We described the concept of FBR and its cluster construction idea and different packet routing cases.

By comparing the proposed protocol with previous protocols such that L2MF, AODV and DSDV, the enhanced performance in packet delivery ratio, control overhead, and end-to-end delay has been improved.

Many years of effort will be required to refine system designs and propose other methodologies, to satisfy the needed safety and reliability capabilities.

REFERENCES


