Survey of MIRP for Vehicular Ad-Hoc Networks in Urban Environments

Kavya[1], Dr. Basavaraj Patil S[2], Panduranga Rao M.V[3]

[1]Dept of Computer Science and Engineering
BTL Institute of Technology
Bangalore, India
kavya1kolar@gmail.com

[2]Dept of Computer Science and Engineering
BTL Institute of Technology
Bangalore, India
csehodbtlit@gmail.com

[3]Dept of Computer Science and Engineering
BTL Institute of Technology
Bangalore, India
raomvp@yahoo.com

Abstract: ***Vehicular communication is attracting growing attention from both academia and industry, owing to the amount and importance of the related applications, ranging from road safety to traffic control and up to mobile entertainment. The vehicular ad-hoc network is an emerging new technology. Many VANET routing protocols use a carry-and-forward mechanism to deal with the challenge. However, this mechanism introduces large packet delay, which might be unacceptable for some applications. In this proposed system, we first analyze the unique feature of urban VANET that vehicles have different types, and move like clusters due to the influence of traffic lights. So the concept of using buses as the mobile infrastructure to improve the network connectivity is proposed. We also develop a novel routing protocol named as MIRP (Mobile Infrastructure Routing Protocol) which makes full use of buses, making them a key component in route selecting and packet forwarding.***

Keywords: MIRP, VanetMobiSim, MANET, VANET, AODV, DSR

1. Introduction

Vehicular Ad-hoc Networks (VANETs) represent a rapidly emerging, particularly challenging class of Mobile Ad Hoc Networks (MANETs), which supports data communications among nearby vehicles and between vehicles and nearby fixed infrastructure, and generally represented as roadside entities.

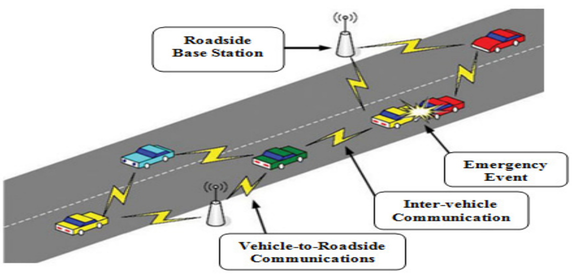

Figure 1.1 Vehicular Ad-hoc Networks

As shown in Figure 1.1, when multi-hop communication is implemented, VANET enables a vehicle to communicate with other vehicles which are out of sight or even out of radio transmission range.

Some VANET routing protocols use a carry-and-forward mechanism.. But, this mechanism introduces a large packet delay, which might not preferable for a lot of applications. As the frequent network disconnection is caused by the characteristics of VANET, we first analyse the features of urban VANET:

1. Vehicle movements are constrained in roads.
2. Traffic lights have great influence on the vehicle movement that vehicles are moving like clusters.
3. Vehicles have at least two different types which are ordinary cars as well as buses as analysed in RBM [10].

Then we propose to improve the connectivity of the network by taking advantage of buses which have fixed travel lines and can carry better equipment's with a larger transmission range. Based on this idea, we develop a VANET Routing Protocol based on mobile infrastructure, which we believe suitable for urban VANETs. This protocol estimates the density of each road segment based on the bus line information for road segment selection, and prefers buses to ordinary nodes as the forwarding node. Our contribution is folded as two:

- The concept of using buses as the mobile infrastructure to improve the network connectivity is proposed by the analysis of the unique features of urban VANET.
- VANET Routing Protocol based on mobile infrastructure is developed. Both the transmission quality of each road segment and different transmission abilities of various vehicles are considered in the algorithm.

The reminder of this paper is organized as follows: In Section II, the literature survey is presented. In Section III, we analyse the features of urban VANET, and propose the strategy of improving the network connectivity with the help of buses. The design of MIRP is described in section IV. Section V presents simulation settings and results. Finally, conclusions and future works are summarized in section VI.

2. Literature Survey

The routing protocols in VANET are categorized into six types. Topology based, Position based, Geocast based, Cluster based, Broadcast based and Infrastructure based.

Topology based routing protocols discover the route and maintain it in a table before the sender starts transmitting data. They are further divided into Proactive and Reactive protocols. These are of two types: Proactive protocols and Reactive protocols

Position based routing protocols these protocols use geographic positioning information to select the next forwarding hops so no global route between source and destination needs to be created and maintained. In Greedy Perimeter Stateless Routing (GPSR), **e**ach node periodically broadcasts a beacon message to all its neighbours containing its id and position.

Table 2.1: Comparison of Various Protocols

Parameters / Protocols	**Forwarding**	**Routing**	**Recovery**	**Control Packet**
FSR	Multi hop	Proactive	Multi hop	High
OLSR	Multi hop	Proactive	Multi hop	High
AODV	Multi hop	Reactive	Store and Forward	Low
DSR	Multi hop	Reactive	Store and Forward	Low
GPSR	Greedy Forwarding	Reactive	Store and Forward	Moderate
GyTAR	Greedy Forwarding	Reactive	Store and Forward	Moderate
SADV	Store and Forward	Reactive	Multi hop	Low
RAR	Store and Forward	Reactive	Multi hop	Low

Recently, some other routing protocols for VANETs have been proposed. The Geographical Source Routing [7] protocol combines position-based routing with topological knowledge. GyTAR [4] is another protocol, in which the real time road traffic variation is taken into account. Traditional wireless ad-hoc networks routing protocols, such as DSR [5] and AODV [9], are not suitable for VANET.

There are also several VANET routing protocols based on infrastructure or road side unit (RSU). SADV [2] utilizes some static nodes at road junctions. With the assistance of static nodes at junctions, a packet can be stored in the node for a while and wait until there are vehicles within communication range along the best delivery path. RAR [8] is a vehicular hybrid network routing protocol in which roads are divided into sectors by RSUs, and the route consists of vehicles and RSUs. The drawback of these protocols is the requirement and distribution of static node or RSU.

To deal with the rapidly changing network topology, a new routing technique based on location information has been developed. One famous strategy is GPSR [6]. GPSR selects the node that is the closest to the destination among the neighboring nodes. To evaluate routing protocols for VANETs by simulation, various traffic mobility models have been studied. VanetMobiSim [3] is a well-known and validated traffic generator, which is developed by Eurecom. We use this traffic generator in our simulation studies.

3. Features of Urban VANET Analysis

The unique features of urban vanets are: Firstly, vehicle movements are constrained by roads. Secondly, in urban VANETs, traffic lights have great influence on the vehicle movement. Another important feature of urban VANETs is that vehicles have at least two different types which are ordinary cars and buses. All these features should be considered in the routing protocol design.

As vehicle movements are constrained by roads, the simple greedy forwarding strategy without taking urban environment characteristics into account in MANET such as GPSR is not applicable for VANET. Figure 3.1 shows an example. Assume vehicle S wants to send a packet to D, and S has two neighbors: A and B. GPSR will choose B to forward the packet because B is closer to D. But in common sense, we should choose A as vehicle movements are constrained in roads. The routing in VANET should be a sequence of road segments in macros copy, and the decision to choose which road segment near the junction for forwarding is critical.

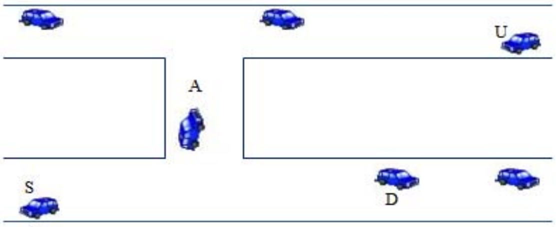

Figure 3.1: Example of selecting node closest to destination may not good.

In urban VANET, traffic lights have great influence on the vehicle movement. Red traffic light at junction stops vehicles from approaching which is an important factor to network disconnection. When the traffic light turns green, stopped vehicles will continue to move and those moving in the same direction will be close to each other like a cluster. Suppose the road segment length is L, the period of red traffic light is T, and the average velocity is V , then the expectation distance between two clusters is min(T*V;L).

As mentioned above, in urban VANETs, there are at least two types of vehicles which are ordinary cars and buses. The number of buses is much less than ordinary cars under normal conditions. For example, according to Helsinki Traffic Management Bureau [1], about 80 percent of all motor vehicles in Helsinki are ordinary cars, and buses only compose 20 percent. In addition, the buses are larger and more powerful, so they can carry better wireless equipment with a larger transmission range than ordinary car hoping to improve the connectivity of the network by increasing the transmission range between buses.

Figure 3.2: Uniformly distributed vehicles

Assume that vehicles are uniformly distributed on the road as figure 3.2. If the average distance between two vehicles is X, so the average distance between two buses will be X/20%, because buses only compose 20 percent of all motor vehicles. To improve the connectivity of the network, transmission range required between buses should be over five times those of other vehicles. Since signal reception is difficult if vehicles are not on the same road due to radio obstacles such as high-rise buildings, packet transmission is constrained in one road, or adjacent streets when packet is near a junction. So even if the buses have a five times transmission range, they still can hardly communicate with each other when the distance between them is close to that maximum transmission range because there are obstacles. The moving vehicles are affected by traffic lights. When the light turns green, those moving in same direction will be close to each other like clusters as shown in figure 3.3.

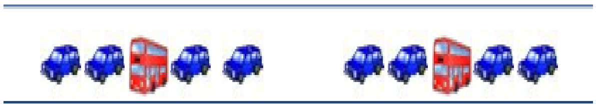

Figure 3.3: Vehicles move like clusters

Vehicles are close together to each other in one cluster and the distance between two clusters may be a little longer. Ordinary cars in different clusters may not be able to communicate, but buses can as they have larger transmission range. Additionally, buses are dispatched periodically, so the distribution of buses in the network is relatively dispersive. In this case, without having a five times transmission range, connectivity can be improved if the communication range between buses is wider than the distance between adjacent clusters, which is min(T*V;L). This means 2-3 times transmission ranges between buses may produce a much better connectivity.

The road segments in the real area showed in figure 3.4 have 0 to 12 bus lines and 7 lines on average. And the departure time interval of each bus line is about 15 minutes.

Figure 3.4: A real map from Helsinki

As there are two directions in each road, the average time between two adjacent buses is 15/7*2. Moreover, bus takes a large proportion of time on bus stop and traffic lights, and has a lower speed than ordinary car. Though the average distance between buses is hard to estimate, but it is not very long that buses can form a mobile backbone.

To improve the connectivity, assume two wireless interfaces on each bus, which works on different channels, while ordinary cars have only one interface. The transmission range between cars and between a car and a bus is R_1 on channel one, and that between buses is R_2 ($R_2 > R_1$) on a different channel. So buses constitute a mobile backbone to enhance the multi-hop communication. Now, a new routing protocol is proposed. This protocol makes full use of the buses, making them a key component in route selection and packet forwarding.

4. Design of MIRP

MIRP is a based on location reactive routing protocol. Here we assume that each vehicle knows its location through GPS, and has a digital street map including bus line information. We also provide the availability of a location service, so the source node can get the destination information. In addition, each bus has two wireless interfaces working on different channels, while ordinary car has only one interface.

The transmission range between cars and between a car and a bus is R1 on channel one, and the transmission range between buses is R2 (R2 > R1) on a different channel.
The MIRP protocol consists of two essential parts:

- Selecting an optimal route which consists of a sequence of road segments with the best estimated transmission quality.
- Efficiently forwarding packets hop-by-hop through each road segment in the selected route.

4.1 Routing

In the road segments are chosen one by one, considering the transmission quality of each road segment: when selecting the next forwarding road segment, a node (the sending vehicle or an intermediate vehicle near a junction) checks the route table and chooses the best neighbouring road segment with a min estimated hop count to the destination. To select an optimal route with the min estimated hop count, we have first to estimate the hop count of each road segment. Generally speaking, the more buses on the road the more vehicles on it, because the road with many buses is often a prosperous area. So we can estimate the hop count of each road segment by the expectation bus density and road length. For convenient, we define the following notations:

- R1: the transmission range of ordinary cars and buses on channel one.
- R2: the transmission range of buses on channel two.
- Xi: the total route length of bus i
- Lj : the length of road segment j
- Nj : the expected number of buses on road segment j
- Cj : the estimated hop count on for road segment j

Suppose the route length of bus i is Xi, and the route of bus i contains road segment j. So the probability that bus i is on road segment j is Lj/Xi .Although the bus movement is affected by many other factors such as bus stops and traffic lights, we can estimate the probability by Lj/Xi because the longer a road segment is the more bus stops and traffic lights there will be. Then the expected number of buses Nj on road segment j is:

$$N_j = \sum_i f_{i,j} * \frac{L_i}{X_i}$$

$$f_{i,j} = \begin{cases} 1, & \text{busline } i \text{ contains road } j \quad (1) \\ 0, & \text{busline } i \text{ not contains road } j \quad (2) \end{cases}$$

As every bus departs periodically, they will scattered distribute in the network, the average distance between buses on road segment j is Lj/Nj.

Suppose when the density of buses on the road segment is high enough to reach an average distance D (a constant number, which we choose D = R2/2 in our simulation) between buses, packet forwarding on road segment j can be completed by buses and without any help of ordinary cars.

The hop count Cj on this street can be estimated by:

$$C_j = \frac{L_j}{R_2}, (N_j > \frac{L_j}{D})$$

Otherwise, buses and ordinary cars are both needed for packet forwarding. As the network connectivity is strongly and positively related to road segment density, we can estimate the hop count on road segment j by the formula:

$$C_j = \frac{L_j}{D * N_j} * \frac{L_j}{R_2}, (N_j < \frac{L_j}{D})$$

Where Nj/Lj is the density of road segment j, 1/D is the road density if the average distance between buses is D, so Lj/D*Nj is the density proportionate to reach an average distance D between buses. This formula is not absolutely accurate, but it is simple and can be used as an estimation of the hop count. A large hop count number will appear when the road segment is not connected. Routing algorithm prefers not to choose them for the optimal route. Now that we know the expected hop count for each road segment, the total hop count for a certain route can be calculated. Afterwards, the Dijkstra algorithm can be used to select a shortest route with the minimal expected hop count. Two implementations can be used. One is that the best route consisting of a sequence of road segments is computed by the source and put into the packet header. The disadvantage of this method is the increase of packet size and network bandwidth cost. The other is calculating the route of each junction pairs at the network beginning. The next road segment and estimated hop count are both recorded in a route table. And the next road segment is chosen when packet is near a junction. This scheme requires less bandwidth. Our protocol uses the second implementation.

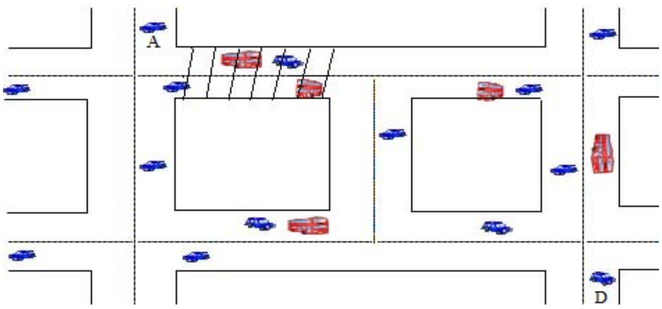

Figure 4.1: Route Selection

Figure 4.1 shows an example of how the next road segment is selected. Once vehicle A which is near a junction receives a packet, it checks the route table. Considering the distance and expected number of buses, the road segment with shadow will be chosen as the next road segment.

4.2 Forwarding

Once the next road segment is determined, the “bus first” strategy introduced below is used to forward packets on the road segment. Each vehicle periodically sends beacon packets which contain its location and vehicle type (bus or not). They also maintain a table of its neighbours’ information and select one neighbour for packet forwarding.

Traditional algorithms select the node which is closest to the destination or closest to the next junction to be the next hop. As the transmission range between buses is larger, prefer choosing a bus to be the next hop showed in figure 4.2. But this does not mean that buses always have higher priorities than ordinary cars, there still have some other factors to be traded off.

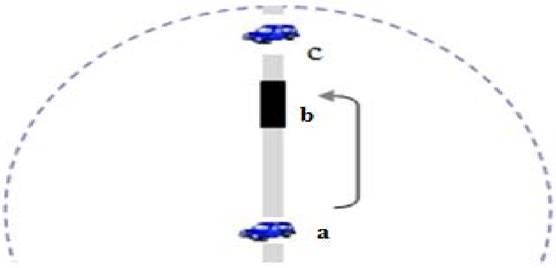

Figure 4.2: Buses have higher priorities

Traditional algorithms select the node which is closest to the destination or closest to the next junction to be the next hop. As the transmission range between buses is larger, prefer choosing a bus to be the next hop showed in figure 4.2. But this does not mean that buses always have higher priorities than ordinary cars, there still have some other factors to be traded off.
Firstly, as the route is consisted by a sequence of road segments, the decision near the junction is critical. We’d better send the packet to the node on the next road segment when it is near the junction. That means the nodes on the next road segment always have higher priorities than the nodes on the same road.

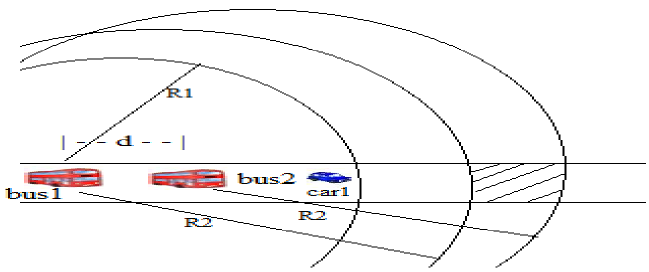

Figure 4.3: Buses don’t have higher priorities in some situation

Secondly, let’s consider the situation showed in figure 4.3. Assume that bus1 currently keeps the packet, and it has two neighbours (bus2 and car1) which are both closer to the next junction. The distance between bus1 and bus2 is d which is very small, and the distance between bus1 and car1 is much larger. As, bus1 knows that there is no other bus except bus2 on the next R2 meters of road segment, selecting bus2 as the next hop gains benefit only if there are any buses in the shadow area of figure 7. This probability is rather low, as the length of the shadow is about d which is very small. In this situation, choose car1 as the next hop is much better. Similar situation is not considered for ordinary cars, because cars only know that there is no other bus on the next R1 meters of road segment. So the forwarding neighbour is selected according to the strategy below which we called “bus first”:

- If the neighbour table contains any buses on the next road segment, choose the one which is closest to the junction after the next junction. Otherwise choose an ordinary car which is closest to the junction after next.
- If the neighbour table contains no vehicles on the next road segment, and packet is now on a bus: choose a bus which is closest to the next junction and the distance between them must be larger than d (a constant number much smaller than both R1 and R2), else choose a vehicle which is closest to the next junction.
- If the neighbour table contains no vehicles on the next road segment, and packet is now on a car: choose a bus which is closest to the next junction. If not available, we should choose a vehicle which is closest to the next junction.
- If there are no better suitable forwarding nodes, drop the packet.

5. Simulation Results

5.1 Simulation Model

In our experiments we use version 2.33 of the ns-2 simulator. The simulated area is based on a real map from Southern Beijing with a 1700m*1000m size.

Table 1: Simulation Parameters

Parameter	Value
R_1	150m
R_2	300m
Bandwidth for both channel	2Mb
Beacon interval	1.0
Vehicle Velocity	0-30m/s
Number of nodes	100-250
The bus percent	20%
TTL	32
Packet Size	512bytes
CBR data rate	128bytes/s

The vehicle movement trace is generated by VanetMobiSim, which is a well known and validated traffic generator .Other simulation parameters are listed in TABLE 1. We simulated the MIRP protocol and compared its delivery ratio and throughput with GPSR. Additionally, we evaluated two variants of MIRP called one-Channel and two-Channel respectively. In one-Channel algorithm, the buses have only one wireless interface with the transmission range R1 same as ordinary cars, but the route selection is the same as MIRP.

In two-Channel algorithm, buses have two wireless interfaces, and route selection the same to MIRP too. In both one-Channel and two-Channel, the strategy of next hop selection on a certain road segment is based on greedy forwarding rather than "bus first".

5.2 Simulation Result

As shown in figure 5.1, MIRP achieves the highest packet delivery ratio. GPSR incurs a highest data loss rate, because simple greedy forwarding strategy without taking urban environment characteristics into account is not suitable for VANET. After considering some urban environment characteristics, the performance of one-Channel algorithm is much better than GPSR. Two-Channel algorithm performs better than one-Channel for the following reason: as vehicles move like clusters, increasing the transmission range of a small percent of vehicles can notably improve the network connectivity. MIRP achieves the highest packet delivery ratio, because the difference of bus and ordinary car is taken into account and buses are given higher priority to become the next hop in some situation.

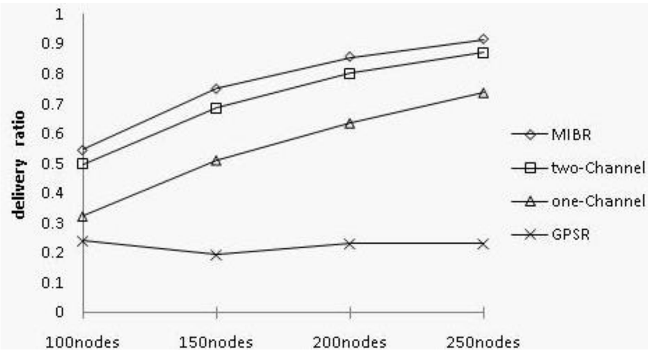

Figure 5.1: The data delivery ratio in different network density

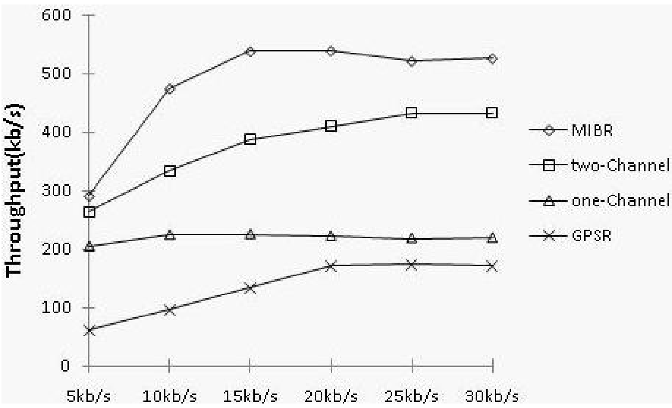

Figure 5.2: Throughput of networks with 200 nodes

To compare the throughput, we randomly select 50 communication pairs. Each source node generates CBR traffic for a period of 600 seconds with the sending rate from 5kb/s to 30kb/s. As shown in figure 5.2, the throughput of MIRP outperforms all the other protocols. The throughput of two- Channel algorithm is about twice that of one-Channel, because the buses have another channel for transmission. The performance of MIRP is much better, because channel 2 is less congested as buses only compose 20 percent of all vehicles, and MIRP prefer choosing a bus as the next hop. In addition, the packet control overhead of MIRP is small, because only beacon packets are used as control packet.

6. Conclusion

In this work, we have analyzed the unique features of urban VANETs and proposed the idea of improving network connectivity by increasing the transmission range of buses. Then we presented our new routing protocol MIRP which takes advantage of the buses as a mobile backbone. The proposed protocol is a geographical routing using the map topology and the bus line information to facilitate route selection. In addition, the "bus first" forwarding strategy is used because we assume that the transmission range between buses is larger. Additionally, the algorithmic complexity of MIRP is low, and the deployment is easy because no static nodes or RSU are needed in MIRP.

As the future work, we will incorporate more realistic factors into our routing protocol, such as the velocity, direction and even the history information of vehicle traffic.

References

[1] http://www.bjjtgl.gov.cn.

[2] Y. Ding, C.Wang, and L. Xiao. A static-node assisted adaptive routing protocol in vehicular networks. VANET'07: Proceedings of the fourth ACM international workshop on Vehicular ad hoc networks, pages 59–68, September 2007.

[3] J. Harri, F. Filali, C. Bonnet, and M. Fiore. Vanetmobisim: generating realistic mobility patterns for vanets. VANET '06: Proceedings of the 3rd international workshop on Vehicular ad hoc networks, pages 96–97, September 2006.

[4] M. Jerbi, S.-M. Senouci, R. Meraihi, and Y. Ghamri-Doudane. An improved vehicular ad hoc routing protocol for city environments. ICC'07. IEEE International Conference on Communications, pages 3972–3979, June 2007.

[5] D. B. Johnson and D. A. M. Y.-C. Hu. The dynamic source routing protocol for mobile ad hoc networks (dsr). Internet Draft: draftietf-manetdsr-10.txt, July 2004.

[6] B. Karp and H.T.Kung. Gpsr: Greedy perimeter stateless routing for wireless networks. MobiCom2000: Proceedings of the 6th annual international conference on Mobile computing and networking, pages 243–254, August 2000.

[7] C. Lochert, H. Hartenstein, J. Tian, H. F¨ußler, D. Hermann, and M. Mauve. A routing strategy for vehicular ad hoc networks in city environments. IEEE Intelligent Vehicles Symposium, pages 156–161, June 2003.

[8] Y. Peng, Z. Abichar, and J. M. Chang. Roadside-aided routing (rar) in vehicular networks. ICC'06 IEEE International Conference on Communications, 8:3602–3607, June 2006.

[9] C. E. Perkins and E. M. Royer. Ad hoc on-demand distance vector routing. Proceedings of the 2nd IEEE Workshop on Mobile Computing Systems and Applications, pages 90–100, February 1999.

[10] J. Wang and W. Yan. Rbm: A role based mobility model for vanet. 2009 International Conference on Communications and Mobile Computing, 2:437–443, Jan 2009.2009.

Kavya received her B.E. degree in Computer Science and Engineering from Reva Institute of Engineering and Technology, Bangalore. At present she is pursuing the Master of Technology in Computer Science and Engineering Department at BTL institute of Technology, Bangalore.

Dr. S Basavaraj Patil is the Founder & Principal Consultant; Predictive Research He received the PhD in, Computer Science & Engineering from Kuvempu Vishwavidyanilaya and M.Tech, Bio-Medical Instrumentation from S J College of Engineering, Mysore.
He worked as Assistant Vice President at CIBM Research, and HSBC Consultant at Manthan Systems and Technical Architect at Aris Global. He is presently working as head of the department at BTL institute of technology.

Panduranga Rao M.V is a Researcher at NITK, India. He received the M.Tech degree in computer Science from Visvesvaraya Technological University and B.E. degree in Electronics and Communication from Kuvempu University, Karnataka. He was Research Associate at JNNCE, during the period from August 1989 – April 2005. He received an award at Okinawa, Japan. . He is presently working as professor at BTL institute of technology.