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An Improved Heterogeneous Motion Prediction Algorithm for Vehicle-to-Vehicle Message Ferrying in VANETs

S. Srithar[1] · **N. M. Saravanakumar**[2]

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Abstract
In infrastructure-less ad-hoc networks, the nodes can converse directly with other nodes without centralized servers. The vehicular networks are derived from the features of mobile ad-hoc networks (MANETs) whereas the message transmissions between the nodes are direct with each other or through some fixed terminals. But, a unique trademark is that the vehicle-to-vehicle ad-hoc links are poor because of extreme mobility which leads to frequent route breakage that causes emergency message delivery failure. The routing protocols availed in MANETS does not suit due to quick topology changes. The hop selection is based on the best cumulative communication duration that will be failing in some cases. Also, the worst/average case scenario is that the minimum connectivity to the source vehicle is not described in existing approaches. The core idea about the proposed research is to deliver data through an optimum path and to eliminate rupture link during the packet transmission. The system uses the Heterogeneous Motion Guess (HMG) algorithm for vehicular networks to set up a vested path. The HMG will select the relay vehicle's current position is near to the target vehicle plus the vehicle will opt the relay forwarder that has good radio coverage. The link lifetime of the selected hop should be greater than the minimum connectivity duration with the source vehicle. The selected vehicle will append the link expiry time and minimum connectivity duration in Route Demand Dispatch message in a unicast manner. This approach significantly minimizes the hop count numbers and improves the stability of the path. It radically predicts the link life, so the node can decide an alternative vested route. The simulation result shows how well the reactive demand-based HMG affords optimum results in terms of packet transmission success rate, average minimum hop counts, and communication delay.

Keywords Heterogeneous motion guess (HMG) algorithm · Link_age (LA) · Fine factor (FF) · Fine_threshold (FT) heterogeneous transmission · Vanets · Manets

✉ S. Srithar
sss.srithar@gmail.com

N. M. Saravanakumar
saravanakumaar2008@gmail.com

[1] Assistant Professor, Department of CSE, KPR Institute of Engineering and Technology, Coimbatore, Tamilnadu, India

[2] Professor & Head, Department of CSE, Vivekanandha College of Engineering for Women, Tiruchengode, Tamilnadu, India

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1 Introduction

As per the world health organization's report, 50 million injuries and 1.25 million peoples lose their lives all year due to vehicle crash [1]. Our objective behind the research work is to provide a safety warning assistance message to the drivers for an emergency. The Smart Transportation System came into the picture for various applications such as collision warning, rollover warning, route change warning, work zone warning, etc. [2]. Nowadays, in transport systems, vehicle-to-vehicle safety messages dissemination to the right destination is a tricky issue. The communication grid changes quickly due to the diverse speed, position, and range of each vehicle. Vehicular networks can transmit the messages in a hop-by-hop fashion. The link between the pair of the vehicle is unstable because the nodes are always mobile [3]. In Vehicular and Mobile Ad-hoc Networks the communication is in the form of single-hop or multi-hop. In MANET the node movement is quite less and the topology gets changes slowly. But a unique characteristic of the vehicular network is the nodes with high mobility and fast topology changes [4]. So the MANETs proactive/ reactive routing protocol does not fit for packet transmission.

The vehicle-to-vehicle smart transport system offers short-range communication for fast and reliable communication over the VANET environment [5]. The nodes in the vehicular environment are always cooperative which broadcasts the hello packets periodically to know its neighbors. The hello packet carries information about nodes velocity, the location, and the communication range. The MANET is fully infrastructure-less, where the nodes are cooperative. The Vehicular network similar to that of MANET but the difference is the communication is infrastructure/ infrastructure-less [6]. Vehicles can directly speak with other vehicles that are within the communication range, which falls under infrastructure-less network communication. The vehicles use the IEEE standard called 802.11P for fast and reliable data transmission [5]. The fixed terminals called roadside infrastructure unit monitors the behaviors of each vehicle. But the construction of Roadside infrastructure for vehicular communication is too expensive. In such cases, vehicle-to-vehicle communication is commonly preferred for fast and reliable message transmission. Direct communication with the destination is not possible in all cases due to vehicle capacity variance. In such situations, the packets can be transmitted through the cooperative relay peers. But a key consideration in inter-vehicle message transmission is frequent path breakage.

The proposed work addresses this problem by making good cooperation among the nodes, and to avoid frequent rupture link failures. The term message is in the form of ambulance arrival intimation, vehicle crash, traffic assistance, work zone overtaking assistance, etc. In our paper assume that the vehicle crash notification can be reached out to the ambulance for faster recovery where it works in all possible extends.

In Fig. 1, Source vehicle V_1 wants to transfer a packet to the destination V_5. There are three available routes such as V_1–V_3–V_5, V_1–V_2–V_3-V_4–V_5, V_1–V_2–V_3–V_5 The lifetime of the link V_1–V_3 is poor due to high speed. So the source vehicle will select the next available route for packet transmission.

In Fig. 2, Source vehicle A wants to send an emergency safety assistance messages to the destination D. For ease of discussion, we skip the opposite moving vehicles, and consider only the vehicle movement belongs to the same direction. The vehicle B and C is in communication range of the source vehicle A at time t1. The offered literature selects the relay vehicle whose location of the vehicle is near to the destination [7] as a forwarder node, i.e., the vehicle B is much near to destination vehicle. But at time t2 vehicle B not belongs to the communication range of source vehicle A. Therefore the option of relay

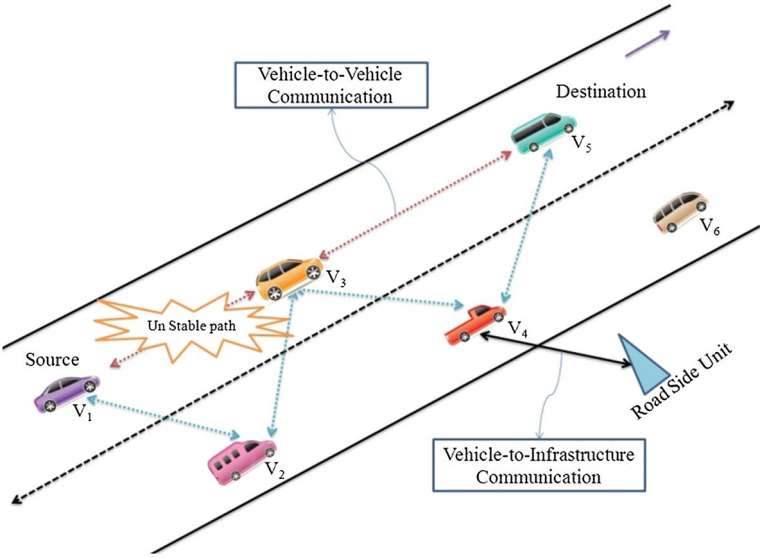


Fig. 1 VANET architecture communication scenario

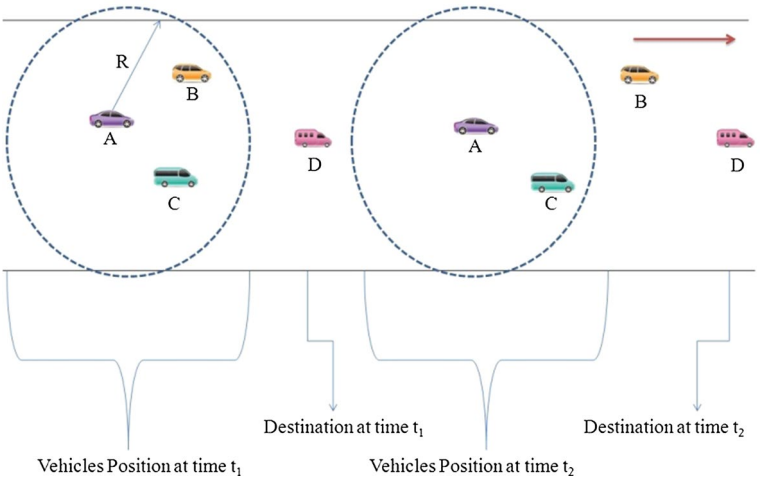


Fig. 2 Sample movement prediction at time t1 and t2

vehicle B will give poor performance in packet delivery. So the existing literature offered a perimeter prediction combined with greedy forwarding [3] which selects the relay by considering link lifetime. Therefore the best alternate route is node C; it will be elected as the right next-hop for packet forwarding.

The literature focuses on the homogeneous transmission range. But, various types of vehicles may be located on roads their communication range is always not equal [8]. And the best-hop decision is made by a vehicle by a group of neighbor vehicles. The Good Fit forwarder is selected by the vehicles that have the highest cumulative communication

range [9]. But the minimum connectivity to the source could not be defined; it causes wrong next-hop selection. Also, the blind route request dispatch in existing approaches will increase the communication overhead.

The proposed approach considers Fine Factor (FF) which ensures that the minimum connection duration with the hop-to-hop is ensured. Also, our approach will consider the stability in an asymmetric way. Here we introduced Unicast Route Demand Dispatch (URDD) which eliminates unwanted flooding of the route request. By all these, the warning messages can be transferred in a better way to the destination.

The remaining sources listed as follows. Section II shows the analysis of the previous works. Section III investigates the proposed methodologies for best-hop selection in the VANET environment. Section IV shows the analysis results and discussion of the proposed work. Finally, section V discussed the conclusion and future enhancement of ongoing research.

2 Related Work

In Karimi et al. [3] investigated the stable routing by introducing PGRP which predicts the position of a neighbor in the near future for best next-hop forwarding. The high speed of nodes leads to frequent route breakage that affects the vehicle-to-vehicle transmission and the path becomes unstable [8]. The PGRP is combined with greedy forwarding with perimeter prediction where the greedy forwarding will opt the best-hop which is near to destination vehicle. The perimeter forwarding chooses the farthest node that has a good stability factor. The angle for neighbors and the position of neighbors is used to find the weight of the predicted link. The best next-hop selection is made by the hop that has the highest weight. Whenever the node does not find any relay peers the system uses right-hand rule for optimum relay selection. The assumption of the perimeter prediction hop-to-hop communication range is homogeneous. But, dissimilar types of vehicles are in the road environment, where the range of communication is heterogeneous. The weight of the neighbor purely depends on the exact location of the destination and the vehicle's speed. But in wireless/ad-hoc networks the location of the destination is unknown. Also, the lifetime of the link not only depends on the current vehicle radio range but also depends on the neighbor vehicle coverage range. In such a situation the poor choice could be made which leads to an unstable link and packet loss.

In Yang et al. [9] formulated the method MM-GPSR where the destination vehicle's minimum angle and maximum duration will be calculated for best hop selection. The choice of a next-hop will be the cumulative communication duration should be maximum. If the number of forwarding neighbors is very less then unstable hop selection possibility is high. Also, the location of the destination and speed must be known well in advance to make a successful prediction. But the scenario is the destination current location and speed may not be predictable. If the greedy fails, then the minimum angle vehicles are chosen for further to incorporate a stable node selection process. The heterogeneous velocity of the vehicle is common in the ad-hoc network, but MM-GPSR assignment limits to homogeneous.

In Lin et al. [4] investigated dynamic moving zone construction which forms the cluster whose node speed is similar to the captain by ensuring good connectivity throughout the communication. The vehicles have extreme mobility is simply rejected in the cluster group.

The captain vehicle will manage all other vehicles belong to the cluster and select the best forwarder for message dissemination.

In Nguyen et al. [10] deals with a challenging issue when the relay peer is not present for packet transmission. The vehicle follows the SCF methodology at a time of no relay options. Whenever no relay peers present the vehicle puts all the packets in the buffer and pauses the retransmission. Once relay found, immediately the packets can be transferred.

In Sivakumar et al. [11] proposed and investigated SRP which uses Reliability Index (RI) for finding a stable route between the pairs. The reliability index is calculated by assuming different numeric constant values for the vehicles moving in the same and the opposite direction. The SRP will send the blind Route Demand Dispatch (RDD) message to its one-hop neighbors to know its destination. If no direct route exists then the vehicle will forward the RDD to its neighbors.

In Wang et al. [8] projected SMPR in which the forwarder selection chooses the relay vehicle of its type which has a better radio range that compresses the number of intermediate hops and improves packet delivery success rates in certain cases. The processing power and memory capacity of the vehicle may not homogeneous. The high capacity of vehicles equipped with a longer radio range antenna and queue size. If the relay peer has faster movement than the source vehicle, then route breakage may happen, which gives a poor performance in packet transmission.

In Atallah et al. [5] addressed the various spectrum access technologies for vehicular communication. The frequency allocation for V2V and V2I is 5.850 to 5.925GHZ band. The inter-vehicle communication uses 802.11P standard for reliable packet transmission.

In Fogue et al. [12] investigated CNPV which proactively collects the one-hop neighbor's information by their periodic hello packets. Before selecting the next hops, the vehicle will verify the position of neighbors. This approach will minimize the vehicle count for a packet relay.

In Fonseca et al. [13] reviews the routing algorithms such as topology-based routing and position-based routing. The topology-based routing protocols are reactive or proactive. The position-based routing algorithms are GPSR, MOPR, GPCR, and GSR, etc.

In Xiaoxia et al. [14] examined the traditional reactive routing protocol available in a self-configuring mobile environment such as AODV is reconstructed by considering multipath routing. When the node traverses the packets through multiple routes then the packet delivery success ratio improves and communication delay reduced. The structure of a vehicular network grid environment always dynamically changes due to vehicle speed movement. A single path packet delivery may not provide good results in vehicle-to-vehicle, because quick topology changes. This approach will provide better backup paths of safety message distribution because multiple disjoint paths are available.

In Namboodiri et al. [15] proposed prediction-based routing where the neighbor vehicles network connectivity, speed, movement, and direction of the vehicles are recognized to predict the life of the path. The assumptions made for vehicle transmission capacity are homogeneous. Due to the diverse speed, the path may break in quicker time. In Menouar et al. [16] proposed a position-based routing such as Movement Prediction Routing (MOPR) which calculates the stability based on the diverse speed, position, and direction of movement. The source will not maintain the complete path for transmitting the packets. The source will select the best successor hop and forward the packets.

In Lochert et al. [17] investigates GPCR where the node will send packets to the special node called the coordinator. If the coordinator belongs to one-hop, then directly the packets are transferred. Else the packets are transferred through the relay vehicle. Only good next-hops are known which do not know the complete path.In Lochert et al. [18] analyzed

the position based Geographic Source Routing (GSR) opt the shortest path to reach the destination by the length of pair hops using the Dijkstra algorithm. The packet transmission may happen through the number of hops in vehicular networks. So the straightest route considered by fewer intermediate hops and the complete path to the destination is known from the source before sending the packets.

In Karp and Kung et al. [7] proposes GPSR in that the node will choose a one-hop neighbor forwarder close to the destination. The destination node's current location is appended in the route request dispatch message and broadcast to the neighbors. This approach will decrease the number of intermediate peers, but the stability of the path completely ignored (Table 1).

3 The Proposed Method

A challenging job in vehicular communication is to transfer the safety assistance messages without any packet loss. But due to its nature of fast node movement path breakage may happen. The proposed approach assumes that the vehicle having a different communication range. Therefore the communication between the vehicles A->B will not be equivalent to B->A. The proposed approach uses a unicast Route Demand Dispatch (RDD) message forwarding strategy which minimizes the blind route request. It automatically minimizes the overall control overhead.

A considerable aspect of forwarder selection is the communication range of vehicles is heterogeneous. So the relay peer should have good transmission power for subsequent best next-hop selections. The proposed approach uses the Heterogeneous Motion Guess (HMG) algorithm which considers five factors of a Good Fit route selection. They are,

- Average case next-hop selection avoided.
- The forwarder should be very close to the destination.
- The relay peer should have a good transmission power.
- A lifetime of the forwarder should be good enough for packet transmission.
- Minimum connectivity with source assured.

The objective of the Heterogeneous Motion Guess (HMG) Algorithm is to maintain the Good Link_Age(LA) during the emergency message forwarding and also the levels of hops should be minimum for optimum packet transmission.

3.1 Collaborative/Cooperative information sharing by hello packet transmission

In the VANET environment, all the vehicles are cooperative in nature and the smart vehicles equipped with GPS to get navigation information. Each vehicle periodically shares the control packets to all single-hop neighbors to advertise its presence [19]. The control packet contains information like speed, location, and the heterogeneous transmission range of vehicles. The direction of the vehicle is identified by comparing the two consecutive hello messages entries for the neighbors. Simply the opposite moving vehicles rejected for the cooperative forwarder list where the stability of opposite moving vehicles with the source is too low.

In Fig. 3, the source vehicle S will get hello messages from the vehicles V1, V2, V3, V4 and V5 from different regions R1, R2, R3, and R4. As we know that the hello

Table 1 Worst/Average case prediction analysis

	Major issue addressed	Base methodology used	Key consideration	Worst/average case scenario
PGRP	Network stability	Greedy + perimeter prediction	Farthest node selection, Angle of neighbor position	Range of node is homogeneous
MM-GPSR	Network stability	Greedy + perimeter prediction	Cumulative communication duration, Min angle of the node	No FT between the Hops
MOZO	Routing	Moving zone	Cluster formation	Frequent cluster dissolve
SRP	Path stability	Reliability index	Numeric constant for same and opposite moving nodes	Blind RDD
SMPR	Relay selection	Minimum hops prediction	Heterogeneous vehicle types	Relay selection stability ignored
MOPR	Route stability	Movement prediction	Speed, direction and range of vehicles	Asymmetric path stability
GSR	Best path selection	Dijkstra algorithm	Minimum hops	Path stability
GPSR	Network Stability	Greedy approach	Minimize number of hops	Asymmetric path stability

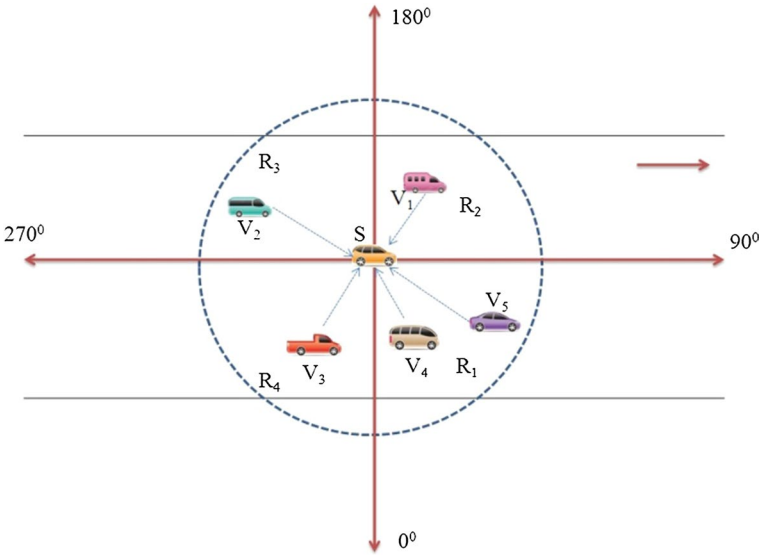


Fig. 3 Collaborative information sharing by hello packet

packets contain information such as current location (V_{Loc}), Speed (V_K), and Radio Range (V_R) of each vehicle. If the destination belongs to the same radius then directly the message delivered. Else the HMG plays a role for next-hop forwarder selection.

The source node will consider the vehicles V1, V4 and V5 belong to the regions R1& R2 for forwarding search and V2 and V3 belong to the region R3 and R4 for backward search Good Fit next-hop selection process.

$$\mathrm{GF}\left[\mathrm{Vehicles}\left(V_1|V_2|\ldots|V_n\right)\right]\in R_{1-4}\mathrm{GF} \tag{1}$$

3.2 Next-Hop FF Analysis

The vehicles will come to know the current location, velocity, and the range of all the one-hop neighbors by receiving the periodic control packets. The current vehicle will find the distance between the vehicles by considering the axis between the current location ($V_{curr\text{-}Loc}$) and the one-hop neighbor node location ($V_{next\text{-}Loc}$).

$$\mathrm{Dist}(V_{curr-Loc}, V_{next-Loc}) = \sqrt{\left(x_2 - x_1\right)^2} + \sqrt{\left(y_2 - y_1\right)^2} \tag{2}$$

where the axis (x_1, y_1) indicates the current location (x_2,y_2) represents the neighbor node location.

The FF for the Best-Hop selection can be obtained by considering the neighbor's maximum radio range and the node which is very near to the destination. The FF is in the range $0 < FF < 1$ where the limit 0 indicates the Fitness is very low and FF with limit 1 indicates Fitness in high. The FF for the Best-Hop is obtained by the Eq. (3).

$$FF(V_{curr}, V_{next}) = |\{Dist(V_{curr}, V_{next}) + [V_{next-R} - (V_{curr-R} - Dist(V_{curr}, V_{next}))]\}/\{Dist(V_{curr}, V_{next}) + V_{curr-R}\}| \quad (3)$$

In Fig. 4, Assume that the vehicle's communication range and velocity are heterogeneous. The FF for the routes S->V1, S->V2, and S—>V3 are calculated by the Eq. (3). The FF for the Hop S->V2 contains the maximum value 0.97, as the initial considerations in the Best-Hop selection process.

3.3 Next Hop LA Prediction

In the vehicular environment, the motion of vehicles is different direction and velocity. If the destination vehicle (V_D) located ahead of the source vehicle, then we skip the opposite moving direction vehicles. The LA says that the cumulative communication duration is good enough to assure a stable link. There are three cases to represent the LA is.

Case 1 Assume that the vehicle S needs to find the LA with vehicle V_1. The location of vehicle V_1 is in the region R_2 (Fig. 4). The direction of both vehicles is the same and the speed of vehicle S is slower than the vehicle V_1. Therefore the LA can be found by the following formula.

$$LA(V_{curr}, V_{next}) = \left\{(Min(V_{curr-R}, V_{next-R}) - \left|Dist(V_{curr}, V_{next})\right|/(|V_{curr-k} - V_{next-k}|)\right\} \quad (4)$$

Case 2 Assume that the vehicle S needs to find the LA with vehicle V_3, where the direction of both vehicles is the same (Fig. 4). But the speed of vehicle S is higher than Vehicle V_3. At a certain point, both vehicles meet and vehicle S leaves from the communication point of vehicle V_3. Therefore the LA can be found by the following formula.

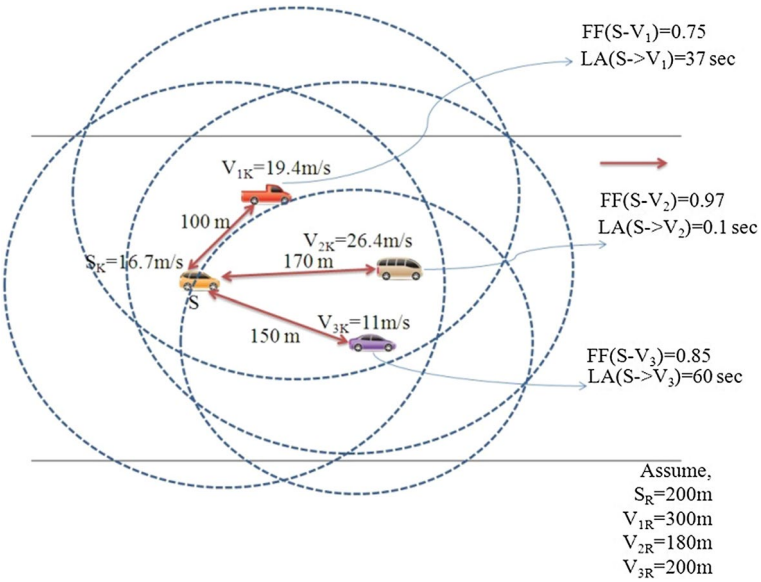


Fig. 4 FF and LA prediction for the different hops-An example

$$\mathrm{LA}(V_{curr}, V_{next}) = \{(\mathrm{Dist}(V_{curr}, V_{next}) + \mathrm{Min}(V_{curr}, V_{next}) - |W(V_{curr}, V_{next}))|/(|V_{curr} - V_{next}|)\} \quad (5)$$

where $W(V_{curr},V_{next})$ indicated the width of the road between the Vehicles current node and neighbor node.

Case 3 The vehicle moving in the opposite direction is simply rejected based on the 2 consecutive control messages.

The LA of the pairs of a vehicle is heterogeneous due to diverse speed and topology changes. Let us consider the vehicle S has the neighbors V_1, V_2, and V_3 (Fig. 4). The LA of the pair S->V_2 too low and which is less than the FT. So that the next maximum FF will be chosen and LA calculation is done. The HMG relay selection is combining FF and LA to get GF forwarder.

3.4 Heterogeneous Motion Guess (HMG) Algorithm: A Good Fit Forwarder selection

An Example Scenario

Assume that the vehicles V_1–V_9 moving with different speeds and radio coverage. The vehicle speed, radio range, current neighbors and Distance between the current Vehicles and its Neighbors at the time 't1′ is given below (based on the control packet information) (Table 2).

3.4.1 HMG Route Demand Dispatch

The source node will send the RDD must be in the following form.

<Source_ID, Destination_ID, Next_Hop, Unicast_ID, FT, LA, No. of Hops, Source_Seq_Number, Time-to-Live>

The Source_ID is to identify the requester vehicle, whereas Destination_ID is to identify the destination vehicle. The field Unicast_Id indicates that the uniqueness of the RDD. The Sequence number checks the newness of the RDD. The RDD message expired when

Table 2 The Heterogeneous speed, range, distance and neighbor assumption

Vehicles	Speed (m/s)	Radio range(m)	Current neighbors	Distance b/w the current vehicles and its neighbors (m)
V_1	23	350	V_2, V_3	75.2, 150
V_2	27	200	V_1, V_3, V_5	75.2, 75.1, 155
→V_3	25	270	V_1, V_2, V_4, V_5	150, 75.1, 150, 170
V_4	20	180	V_3, V_5	150, 80.2
V_5	27	250	V_2, V_3, V_4, V_6, V7, V_8	155, 170, 80.2, 80.2, 120, 170
V_6	30	100	V_5, V_7, V_8	80, 40.1, 90.1
V_7	20	160	V_5, V_6, V_8	120, 40.1, 50
V_8	23	200	V_5, V_6, V_7	170, 90.1, 50.1
*V_9	26	160	V_7, V_8	150, 100

the destination not reached with a certain hop count limit which is indicated by Time-to-Live. The FT is the one which is appended by the source to confirm the minimum connectivity duration (in Seconds) with source vehicle. The LA can acquire by the Eqs. (4), (5) depending on the vehicle movement and speed. If the vehicle LA is greater than the FT of the source vehicle, then that is elected as the next forwarder. Suppose if the LA of the subsequent hops less than the current nodes LA then the minimum LA could be appended to the RDD message. This process is continued until the destination found.

Figure 5 shows, the random vehicle (here we assume as V_3) want to send an emergency message to the destination V_9. The minimum connectivity preferred by the source is 20 sec which is FT. The vehicle V_3 continuously received the control packets from its neighbors. The neighbors V_1, V_2, V_4, and V_5 are located at the distances150, 75.1, 150 and 170 m. The vehicle V_3 will check the destination_id with the current neighbor list. If it is present in that list, then the destination found can initiate the data transmission. Otherwise, the FF of the R_1, R_2 (Backward Region) and R_3, R_4 (Forward Region) is calculated and the best of both regions were elected and the LA of the vehicle will be found. The LA of the V_3′s neighbor is 0.76, 0.29, 0.63 and 0.76. The Best FF of the forward and backward region is 0.76 and its corresponding LA is 60 and 40 which is greater than the FT. The vehicle V_3 send an RDD message to the vehicle V_1 and V_5.

Based on the incoming RDD the vehicle will check the presence of the destination vehicle V_9. The vehicle V_1 did not find any destination or any neighbors in R_1, R_2 to forward the data, so the RDD is expired. Similarly, the node V_5 checks the presence of the vehicle V_9 and still the destination not found. Then the vehicle V_5 will find the FF of the vehicle which belongs to the forward region. The backward region hello packet entries are not considered for the FF calculation because to eliminate the zig-zag route. This way we can remove the additional burden in the best next-hop selection process. The vehicle V_5′s neighbor's V_6, V_7, and V_8 whose FF are 0.06, 0.54 and 0.78. The vehicle V_8 having the maximum FF and its corresponding LA is 91.75 s it is also greater than the FT. The minimum connectivity to the source vehicle is 40 s previously, so the LA 40 s is appended in RDD. The vehicle will update and append the next_hop, LA and number of Hops to vehicle V_9. This process repeated until the destination is found.

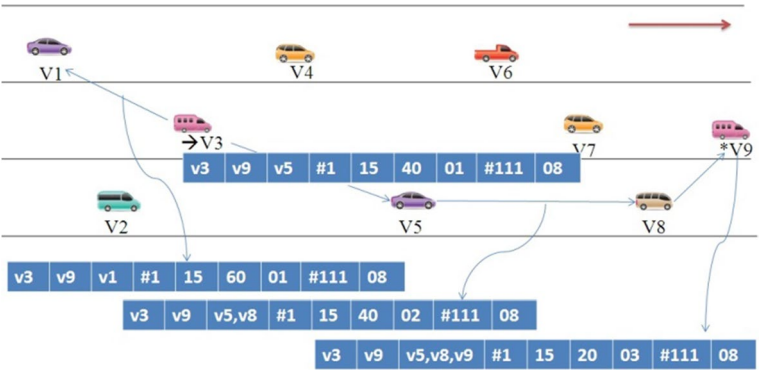


Fig. 5 Route demand dispatch (RDD) from V_3 to V_9

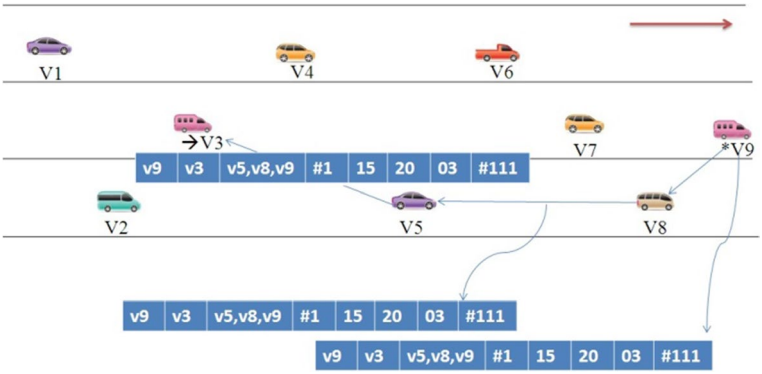


Fig. 6 Route Response Dispatch (RRD) from V9 to V3

3.4.2 HMG Route Response Dispatch

Once the RDD reaches the target vehicle, then the destination will set up the reverse path. The Route Response Dispatch (RRD) is in the form,

<Destination_ID, Source_ID, Next_Hop, Unicast_ID, LA, No. of Hops, Source_Seq_Number>

Table 3 List of abbreviations and its meaning

Abbreviation	Meaning
HMG	Heterogeneous Motion Guess
FF	Fine Factor
LA	Link_Age
FT	Fine_Threshold
ITS	Intelligent Transport System
GF	Good Fit
DSRC	Dedicated Short Range Communication
V2V	Vehicle-to-Vehicle
V2I	Vehicle-to-Infrastructure
WAVE	Wireless Access in Vehicular Environment
GPS	Global Positioning System
TTL	Time-to-Live
OHNs	One-Hop Neighbors
RDD	Route Demand Dispatch
RRD	Route Response Dispatch
CFO	Checking for outbound
MANETs	Mobile Ad-hoc Networks
VANETs	Vehicular Ad-hoc Networks

Table 4 List of notations and its meaning

Notation	Meaning
V_S	Source vehicle
V_D	Destination vehicle
V_{Curr}	Current vehicle
$V_{Curr\text{-}Loc}$	Current vehicle location
V_{next}	Neighbor vehicle
$V_{next\text{-}Loc}$	Neighbor vehicle location
$V_{Curr\text{-}R}$	Current vehicle range
$V_{next\text{-}R}$	Neighbor vehicle range
V_{Loc}	Current Vehicle Location
N_{Loc}	Neighbor Node Location
V_K	Velocity of vehicles
$Dist(V_{curr},V_{next})$	Distance between current and neighbor vehicle
$R_T(V)$	Routing Table of vehicle V
R_1,R_2,R_3,R_4	Region / Quadrant

The source node can know the path expiration time in advance because the LA could be appended to the RRD message. The proposed approach maintains the maximum life of the link throughout the communication which trim down the number of relay peers, improves message transmission success rate and communication delay.

Figure 6 shows once the RDD reaches the vehicle V_9 reverse path can be set in the same way. The RRD contains the sender id (V_9), receiver id (V_3), Next_hops (V_5, V_8, V_9), unicast_id (#1), LA (20), No. of Hops(3) and Source sequence no.(#111). Once the source reaches the RRD then the data transmission starts.

This approach will ensure the minimum connectivity with the source since the stability in data transmission ensured. It also will eliminate the blind route request dispatch since the burden in an overall network could be minimized.

HMG Workflow

See Fig. 7.

HMG RDD Ferrying Procedure (Refer Table 3 and 4 for Abbreviation and Notations meaning).

1. Start
2. Basic Assumption:
   Source Vehicle←V_S
   One_Hop_Neighbors←V_{next}
   Destination_Vehicle←V_D
   Route_Table←$R_T(V)$
3. V_S← Receive Hello packets ∀ V_{next}
   $V_S \supset \{V_{Loc}, V_K, V_R$ of $V_{next}\}$
4. Reject: Opposite moving vehicle by comparing 2 successive hello packets
5. If($V_{next}[V_{Loc} \in R_{1\text{-}4}]$)
   Then
   Update $R_T(V)$;
6. If($R_T(V) \supset V_D$)
   Destination Found;
   Then
   Setup_Reverse_Path;
   Else
   Calculate V_{next} FF;[As per **Eqn.(3)]**
7. Choose MAX_FF(V_{curr},V_{next});
8. If((LA(V_{curr},V_{next})> FT)&& (FF(V_{curr},V_{next})==MAX))
   Next_Hop←V_{next};
   Append: (F_T, LA)→ RDD;
   Unicast RDD; **Goto(2)**
   Else if (LA <FT && Next_Hop!= NULL)
   Next_MAX_FF(V_{curr},V_{next}); **Goto (6)**
   Else
   Next_Hop==NULL
   Slow Start.
9. End

HMG RRD Ferrying Procedure

1. Start
2. Send_Route_Response→(V_D,V_{next})
   RRD←{ D_ID, S_ID, Next_Hop, U_ID, LA, No. of Hops, Source_Seq_Number}
3. If(V_{next} ! ⊃V_S)
   FRWD_RRD;
   Else
   V_S Found;
4. End

4 Simulation and Results

The proposed HMG algorithm is examined with Network Simulator 2.35. The simulation result shows the performance of HMG with existing reliable routing approaches MM-GPSR [9] and PGRP [3]. The simulation is taking place in the 5 km highway lane. The MAC protocol used here is IEEE 802.11P whereas the propagation model is TwoRay-Ground. The range of communication is assigned heterogeneous in which the vehicle communication range is assigned as 100 m to 350 m. The Vehicle's acceleration is randomly distributed as 50 km/hrs to 100 km/hrs. A source will try to send a maximum of 1052 packets from the source to the destination. The minimum connectivity FT with the source is assigned as 10,15,20,25 and 30 s. The Constant Bit Rate (CBR) traffic type is used for the packet transmission. The packet interval rate is assumed as 0.05 s. The entire process is simulated with 150 s (Table 5).

The simulation taken from the 100 average simulation runs. Each run has a different sender and the receiver. Our approach uses reactive routing, so two-way communication is ensured. Each node periodically shares control packets to aware of the neighbors.

(1) Packet Transmission Success Rate (PTSR)

The amount of successfully received packets in total simulation time in percentage is referred to as Packet Transmission Success Rate (PTSR). The method MM-GPSR [9] opts the relay that has the maximum cumulative communication duration which works fine for a homogeneous range of vehicle coverage. If the greedy fails, then the neighbor with a minimum angle will be chosen as a next-hop. The assumption made in the existing approach is not true in all cases. The different types of vehicles may

Table 5 Simulation Parameters

Parameters	Value
Simulator	NS2.35
Simulation area	5000 m × 5000 m
MAC protocol	IEEE 802.11P
Propagation model	Propagation/TwoRayGround
Hello packet interval	0.5 s
Minimum vehicle speed	50 km/hrs
Maximum vehicle speed	100 km/hrs
Max transmission range	350 m
Min transmission range	100 m
Number of lanes	3,5
Packet size	1052 bytes
Number of vehicles	50, 100, 150, 200, 250, 300, 350, 400, 450, 500
Fine_Threshold(FT)	10, 15, 20, 25, 30 s
Traffic type	CBR
Packet interval	0.05 sec
Routing protocols	HMG, MM-GPSR, PGRP
Average number of Simulations	100
Highway simulation time	150 s

participate in communication whereas the communication between V1–V2 ≠ V2–V1. If the neighbors belong to the average-case scenario, then the wrong choice leads to a packet loss during the packet transmission. For PGRP [3] the CFO with the source depends on the current vehicle range and the distance. If the hop count increases dramatically packet success rate is decreased. Both PGRP and MM-GPSR doesn't guarantee the minimum connectivity with the source vehicle. Figure 7 shows when the number of vehicles minimum the choice of selection is very limited since the packet loss occurs. For example, when the number of the vehicle is 50, frequent disconnections happen in MM-GPSR. During the simulation, vehicles are distributed randomly containing a heterogeneous range, speed and all. Say for example, if the current vehicle has 3 neighbors whose cumulative communication duration 1.2, 3.3 and 2.7 s, the node having the maximum connectivity 3.3 s will be selected as the forwarder. But, all these choices could not ensure the stability in communication so the average PTSR is around 5%. PGRP focuses on stable communication by considering the homogeneous communication range. If the forwarder belongs to an average case, then the number of hops increased becomes the packet delivery rate of 7% in PGRP.

Our approach ensures minimum stability with the source, so the packet delivery rate arrives at 11.2%. If the number of vehicles is maximum the PTSR percentage improves because the choice of selection is much higher in which the stability of the communication and the fitness factor for the vehicle is improved. When the number of vehicles over 150 then the HMG gradually improves the performance since the disconnection

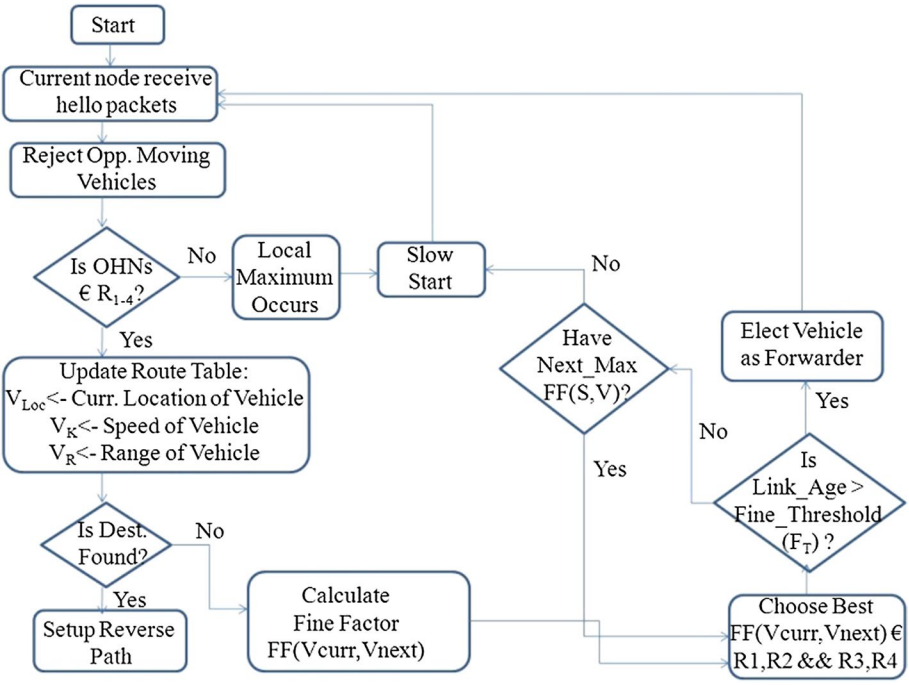


Fig. 7 Heterogeneous Motion Guess (HMG) Algorithm working Principle

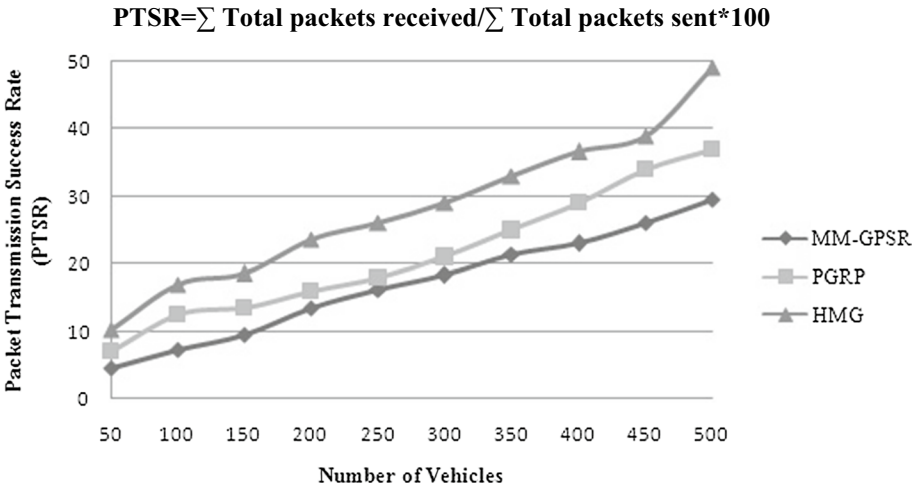


Fig. 8 Packet Transmission Success Rate (PTSR) in a Higway Scenario

minimized than the existing methods. Figure 8, shows that HMG Packet Transmission Success Rate (PTSR) outperformed MM-GPSR by 11.28% and PGRP by 6.89%.

(2) Average Communication Delay (ACD)

The packet arrival delay may happen to the receiver side due to jam or heavy load in the network connection. The time taken between the sending and arrival time of the packet is referred to as communication delay. In MM-GPSR if the greedy fails, then the perimeter forwarding choice is made by the minimum angle of the vehicle. The cause of perimeter forwarding will result in zig-zag routing. When the number of nodes is 50, then the average delay is more than 3.5 s. When the number of nodes falls in 150 then the communication delay is near 2 s. Due to hello packet transmission and environment factors the delay is gradually increasing if the nodes above 150 the communication delay sets as over 3 s. In PGRP if the number of nodes over 300 then the delay in communication is linear. Because the choice of selection in the 1st and 2nd quadrant for neighbor hop selection is too good. The method HMG always considers the FF of the node so that the average number hop count is near 1.3 and the results go linearly.

The proposed approach HMG results little upper in 50–150 nodes, but it falls after 150 nodes. Because, HMG ensures minimum hop count with the source vehicle during the packet transmission. The average communication delay after 150 nodes falls into 1.25 s. Figure 9, shows that HMG communications delay outperformed MM-GPSR by 62.09% and PGRP by 35.63%.

(3) Average Minimum Hops (AMH)

It refers to the average minimum number of hops required to traverse to reach the destination. The existing approaches [17, 3] use the right-hand rule if greedy fails.

In MM-GPSR the average number of hop counts nearly 3.68 in due to zig-zag routing up to 350 nodes. Again a sudden increase over 350 vehicles because the average case scenario comes in picture. The PGRP will give an average hop count of nearly 2.51 which is lesser than MM-GPSR because the range of current vehicle considered for

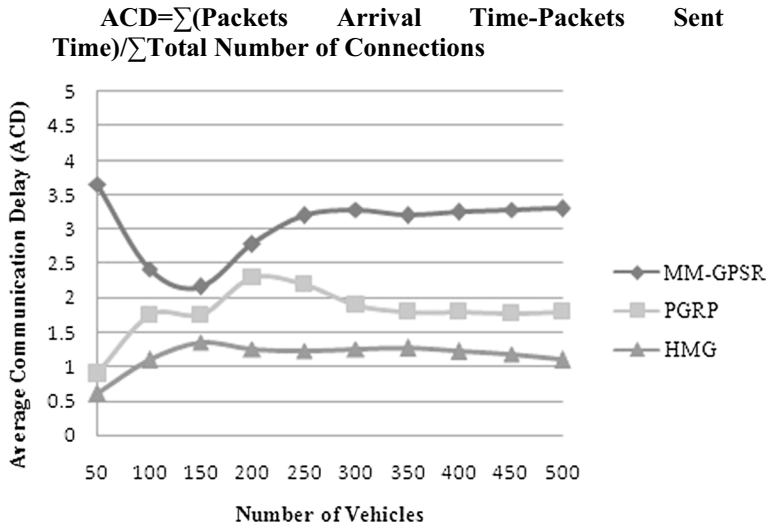


Fig. 9 Average communication delay in a highway scenario

checking the outbound. The proposed approach hop count gradually decreases because the FF opts the best radio range and the LA ensures the maximum link connectivity.

The proposed approach will consider the linear route to forward the packets. If no such forwarder present, then the system falls into the slow start mode. The choice of selection is made by considering 3 factors such as maximum range of neighbor, maximum LA and minimum connectivity. The approach HMG ensures the above three factors. So the number of hops also greatly reduced. The average number of hops is nearly 2.044 in HMG. Figure 10, shows that HMG Average Minimum Hops outperformed MM-GPSR by 44.4% and PGRP by 18.7%.

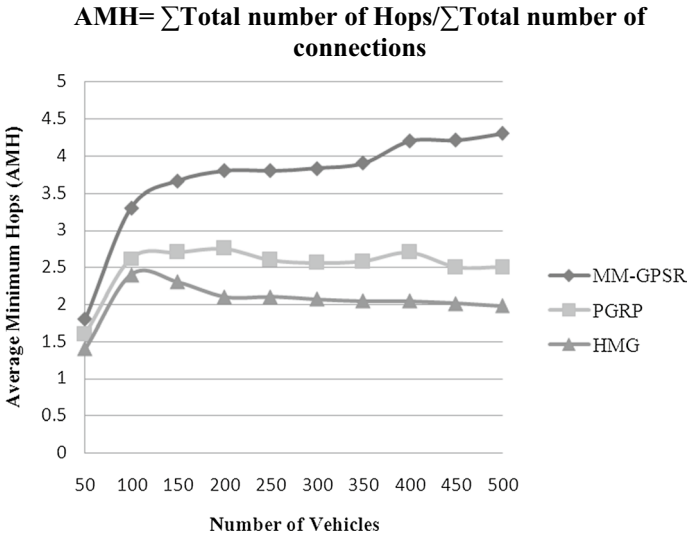


Fig. 10 Average Minimum Hops in a Highway Scenario

5 Conclusion and Future Enhancement

The motive behind the research work is to give some assistance to the drivers for safety and comfort journey. The unexpected path breakage during the vehicle's emergency message dissemination will give poor performance in the VANET environment. Due to fast and dynamic topology changes vested path prediction for emergency message dissemination is a challenging one. The traditional routing protocol available in MANET does not suit for the vehicular ad-hoc environment. The proposed Heterogeneous Motion Guess (HMG) Algorithm ensures the minimum connectivity duration with source vehicle and better path stability during the data transmission. The source vehicle can select a more optimal path for transmission. The source can take up the new route before the expiry of the path. Our approach enhances the connectivity during packet transmission which results in better Packet Transmission Success Rate, Average Communication Delay, and Average Minimum Hops.

In future work, we planned to enhance the emergency warning message distribution for no junction areas in city scenarios.

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S. Srithar received the B.E. degree in Computer Science and Engineering and M.Tech degree in Information Technology from PSN College of Engineering and Technology, Tirunelveli, Tamilnadu, India in 2011, 2013. He currently pursuing Ph.D. degree in Information and Communication Engineering from Anna University, Chennai. He has 6.5 years of experience in teaching. He currently serves as an Assistant Professor in Department of Computer Science and Engineering at KPR Institute of Engineering and Technology, Coimbatore, Tamilnadu, India. His research interests include Mobile computing, Wireless networks, Mobile Ad-hoc Networks, Vehicular Ad-hoc Networks etc.



Dr. N. M. Saravana Kumar received his Ph.D. Degree in Information and Communication Engineering and M.E. in Computer Science and Engineering at Anna University, Chennai. Currently working as a Professor and Head in the Department of CSE at Vivekanandha College of Engineering for women(Autonomous), Tiruchengode, India. He is recognized as a Research Supervisor for Ph.D. Programme (By Research) in Computer Science and Engineering for Anna University, Chennai. He has more than 19 Years of Teaching experience. He has attended more than 40 International Conferences and published around 40 papers in various reputed International Journals including Springer, Inderscience and Elsevier. At present 9 research scholars doing their research under his guidance. He has conducted more than 20 workshops on various fields of Big Data Analytics, Network Security, Cyber Security and Hadoop – Harton. He acts as a reviewer of various journals like Journal of Networks and Computer Application, International Journal of Computational Science and Engineering, Journal of Medical Imaging and Health Informatics and International Journal of Advanced Information and Communication Technology. He has been contributed as a Technical committee member and session chair in and outside India. His interests include Network Security, Wireless Network, Mobile Communication and Distributed Systems. He is life member of ISTE, IAENG and CSI.