An Improved Junction-Based Directional Routing Protocol (IJDRP) for VANETs

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Abstract: *Vehicular Ad-Hoc Networks (VANETs) is a novel technology that has recently emerged and due to its swift changing topology and high mobility nature, it has become problematic to design an efficient routing protocol in VANETs' amongst both moving and stationary units. Also, the existing routing algorithms are not very effective to satisfy all requirements of VANETs. This paper explores the need of a reliable routing and proposes an approach that makes use of an extended restricted greedy forwarding mechanism to select the next forwarding vehicle on basis of its average relative velocity and neighborhood density with its own neighboring vehicles. We also use static PCR junction node which forwards the packet to correct road segment vehicle based upon the relative information. The objective of this paper is to increase route reliability by increasing throughput with considerable end to end delay. Simulation results show that the proposed approach IJDRP outperforms existing GPCR and E-GyTAR.*

Keywords: *City environment, Position-based routing, Extended Restricted Greedy, Static PCR junction, VANETs.*

I. INTRODUCTION

MASSIVE investments in Intelligent Transportation System (ITS) during the past few years has led to the advancement in safety applications and management for traffic services for vehicular infrastructure including roads, junctions etc. Most accidents can be prevented by employing inclusive wireless communication mechanism between moving vehicles and stationary units for communicating emergency vital safety information.

Vehicular Ad-Hoc Network (VANET) is a technology that uses moving vehicles as nodes in a network to create a mobile network. Wireless VANETs operate on Dedicated Short-Range Communication (DSRC) frequency bands. DSRC comprises of multiple protocol standards situated at the center of vehicular networks for communicating safety messages [1]. The fast exchange of safety or security messages along with information regarding other vehicles movement that sometimes may not be noticeable to other vehicles in appropriate time, helps in increasing safety or security applications for most public. A Wireless Access in Vehicular Environments (WAVE) system provides interoperable, efficient, and reliable radio communications in support of applications offering safety and convenience in an Intelligent Transportation System (ITS). Wireless Access in Vehicular Environments (WAVE) is different from Wi-Fi or Cellular networks. The two major specifications characterized by IEEE802.11p and IEEE1609 represents a more modern set of standards for DSRC and WAVE networks

[1]. WAVE systems have very low latency requirements for communications. Although using the two terms are arbitrary as WAVE is the fundamental part of DSRC. The key challenge in VANET is to develop reliable, scalable, resilient, with low latency and high throughput applications that would remarkably save lives, minimize collisions and damages to properties. Currently, DSRC is the only wireless technology for road safety messaging that satisfies these requirements for VANETs. DSRC is presently considered as the most capable wireless standard to connect Vehicle-to-Infrastructure (such as roadside) (V2I) and Vehicle-to-Vehicle (V2V).

In V2V the communication is performed between the vehicles to exchange the information regarding the road condition, warning messages and current position tracking. The V2I communication is done between the vehicles and infrastructure units to communicate regarding the current traffic and weather conditions, and have access to a larger network. DSRC standard is based on the Wi-Fi architecture. There WAVE system comprises of basically two types of units: Onboard unit (OBU) and Roadside unit (RSU). These units are individually similar to Mobile Station (MS) and Base Station (BS) in the cellular networks. A typical MS communicates with other MS in the cellular environment through the BS. The vehicles' OBU directly interacts with other vehicles' OBUs within its radio communication range in the same way. The main advantage of using this type of direct V2V interaction decreases the message latency, because low latency is a vital necessity for various safety and security applications. In most applications the OBU is embedded in vehicle and connected via intervehicle network with other electronic vehicular peripheral systems.
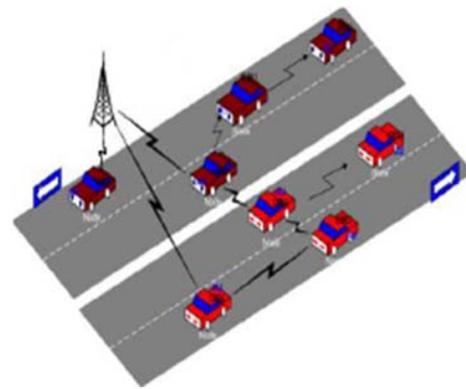

Fig. 1. A simple VANET Scenario showing V2V and V2I

VANET is a type of network formed between a group of vehicles, equipped with transmission capabilities and connected via wireless links. In position-based routing of VANETs; Each and every connected node of the sharing network identifies its own and neighboring nodes' geographic position through Global Positioning System (GPS) [2]. A simple VANET scenario is shown in the Fig. 1 with multiple vehicles in range of one another (V2V) and some vehicles in range of an infrastructure (V2I).

Despite VANET's many promising potentials, a major problem exists in the design of reliable communication routing models. There are many dynamic factors influencing against effective routing in VANETs, one pertinent research issue involves constructing an all-encompassing metric that can guarantee reliable routing in VANET. These requirements (including both reliable route communication metrics and effective routing algorithms) are non-trivial problems for VANET developers and contributing in this regard served to motivate the approach proposed in this paper.

Therefore, in this paper, we have presented an effective approach to improve V2V and V2I communications. The main purpose of this paper is to create an adaptive position-based routing protocol to satisfy multiple adaptations in the network, by using static PCR node at every junction which forwards the packet accurately to the destination. Our findings have provided the following contributions: 1) Employing an extended form of restricted greedy algorithm; 2) Introducing static PCR junction nodes to provide a reliable routing path during dynamic changing environment; 3) Proposing an improved junction-

based directional routing protocol (IJDRP) that utilizes the introduced methodologies for efficient data routing and manages a cooperative operation between V2V and V2I. Rest paper is organized into the following sections; Section II illustrates the Literature Survey of various position-based routing in VANETs. Section III presents the notation and mathematical framework of proposes methodology. Section IV proposes an Improved Junction-Based Directional Routing Protocol (IJDRP). Section V illustrates the analysis and evaluation of the simulated result when compared with other protocols. Lastly, Section VI presents the conclusion and future scope of this paper.

II. LITERATURE SURVEY

Greedy Perimeter Stateless Routing (GPSR) [3], is a routing protocol designed for VANETs which uses the mechanism of greedy forwarding of data packets by exploiting the positional information of vehicles. In case where the packet forwarding becomes impossible i.e. void region or local maximum, then the algorithm uses perimeter forwarding around that region. In order to forward packets, nodes are required to maintain one hop neighbor information through some location service as the forwarding decisions are dynamic. The GPSR recovery strategy consumes time and is inefficient especially due to VANETs extreme dynamic nature. GPSR is highly appropriate to open environment with regular positioning of nodes as direct interactions between nodes is not possible due to presence of obstacles. The use of planarize schemes: Relative Neighborhood Graph (RNG) and Gabriel Graph (GG) for removing selective edges (roads) from the graph that are not present in both RNG or GG would result in no-link crossing network, but could still partition the network by removing the only link connected. Another limitation states that current position of destination is never updated in packet header of intermediate nodes when mobility of nodes is very high.

Connectivity-Aware Routing (CAR) [4], is a routing protocol designed for both city and highway environment with the purpose to locate destinations' position and to find connected paths between the source-destination pair. It uses AODV for path discovery. If the path needs any adjustment they are auto-adjusted in real time without using any new discovery process. The "Guard" concept is used for path maintenance which enhances the data delivery rate and the average delay, with consideration of overhead created by path discovery phase in the first step. When compared with other routing protocols CAR provides a low scalable overhead and has no local maximum problem. In CAR sometimes unnecessary nodes are selected as an anchor which could increase delay. Also, when traffic environment changes dynamically it fails to auto-adjust with different sub-paths.

Greedy Perimeter Coordinator Routing (GPCR) [5], is an approach that does not requires any external/global information to design a simple planar graph of junctions and streets. GPCR uses restricted greedy forwarding mechanism and a repair strategy. In this approach, the packets are forwarded onto the junction and decision is made as which neighbor node is qualified as forwarder. GPCR does not uses any graph planarization algorithm as restricted greedy forwarding is itself difficult and challenging to sustain in any urban environment. The main challenge in GPCR is to identify junction nodes and avoid missing them while using restricted greedy forwarding. The foremost limitation of GPCR is that it takes assumption of an "always present" junction node but it is not accurate in real time scenarios. The junction detection method fails on both curve road and sparse road. In presence of low-density nodes or when no path to the destination exists, delay time increases, and local maximum problem goes unanswered.

Anchor based street and Traffic Aware Routing (A-STAR) [6], is explicitly proposed for Inter-Vehicular Communication Systems (IVCS) in an urban environment where the term "street awareness" play an important role. A-STAR employs "traffic awareness" which uses statistically estimated maps with pre-configured route information, and dynamically rated maps with re-configurable information by giving more preference to buses than ordinary vehicle. A-STAR uses different recovery strategy i.e. the street with void region is given the label as "out of service" for some time. This information is then broadcasted throughout the network to avoid the

use of "out of service" street by other packets. This improves packet delivery ratio with consideration of moderate end-to-end delay. A-STAR does not consider traffic density of vehicles. In city environment, streets with a greater number of bus lines have major traffic and using such streets for communication leads to bandwidth congestion and delay.

Improved Greedy Traffic Aware Routing protocol (GyTAR) [7], is best suited for city scenarios as it utilizes map topology and dynamic junction selection approach. This junction node then acts as a mere interface for a packet to pass to reach its destination, GyTAR employs the use of improved greedy forwarding strategy that directs the packets amongst two successive junctions. In the mechanism of improved greedy forwarding, the sender node computes new position based on direction and velocity of all its neighboring nodes, and then selects the closest one to the destination. The use of Digital maps identifies junctions' location and Dijkstra's algorithm is used to find the shortest path in the direction of the destination. GyTAR protocol can only be used with large vehicular density on the street to enhance connectivity or packet may not reach its destination. GyTAR provides better packet delivery ratio and less end to end delay with reasonable overhead in routing but control packet overhead is high due to junction selection. It suffers from void region forwarding problem because of not considering the direction of vehicles.

Intersection-based Enhanced GyTAR (E-GyTAR) [8], is a geographic routing protocol based on intersection and an extended version of GyTAR [7] designed for VANETs city environment. E-GyTAR is real time and/or non-real time configurable with bi-directional and multi-lane roads. It makes use of vehicles' velocity to determine the junction and forward the packets through that junction. E-GyTAR eliminates the constraint of GyTAR approach by selecting destination's junction with highest score. The scores are given to each junction on the bases on vehicles' density in destination's direction. The local maximum (i.e. void region) problem is eliminated by selecting streets that have high density of vehicles. E-GyTAR accomplishes increase in packet delivery ratio and decrease in end to end delay when compared with GyTAR.

It prefers the directional routes over the non-directional routes, so with increasing vehicular nodes the non-directional routes are ignored that might be the shortest route towards destination and in such case, packets may have to navigate longer routes to reach the destination which ultimately increases delay.

Contention-based forwarding (CBF) for MANETs [9], is a unicast position-based routing without any beacon messages. In CBF whenever the sender sends the packets, it has to broadcast that packet to all its neighbors within its range and these neighboring nodes will content amongst them as to which neighbor must forward the packet. CBF reduces the packet duplication through suppression scheme. This scheme can sometimes set incorrect paths causing routing overhead in a particular region of network. The elimination of beacon messages saves bandwidth. CBF works well in a highway scenario, as the destination is always in the same direction so local maximum problem never occurs, but it is not suited for any city environment as void region problem occurs repeatedly since the source and destination may not be present on the same path.

Delay-Aware Data Delivery [10], approach is designed for Vehicular Intermittently Connected Networks (VICNs) with aim to achieve minimal delay with a two-hop VICNs. This method uses retransmission of bundled copies, when necessary to the new arriving vehicles entering its communication range that can securely deliver data to the destination before other vehicles securing their earlier delivery. These arriving copies are then tossed out afterwards. All virtual copies have random expiry timers and dynamically updated according to the requirements. The essential goal is to analyze the behavior of a source stationary roadside unit using mathematical modelling. DADD improves performance for average bundle delivery, but is not suitable for completely unavailable network information as it increases delay.

Geographical Opportunistic Routing (GeOpps) [11], exploits opportunistic nature and essential aspects of VANETs concerning mobility and topographical information available in navigator systems of vehicles. It makes use of GPS to select only those vehicles that can carry the information. The vehicles with least arrival time become the next forwarder to that vehicular node.

Thus, the vehicles that are near to the destination become the next packets forwarder. GeOpps has good packet delivery ratio irrespective of nodes' density. As the navigational information is disclosed to the network, privacy and security are main concern in GeOpps.

GPSR with Advanced Greedy Forwarding (GPSR+AGF) [12], In GPSR [3] the out of date information of neighbor's location is commonly present in sender's neighbors' table and to eliminate this problem an approach called Advanced Greedy Forwarding (AGF) was proposed. As compared with traditional greedy forwarding the AGF technique is more fault-tolerant. The best results reveal that GPSR+AGF has ten times better packet delivery ratio as compared with standard version in VANETs. The packet header information of an intermediate node where the destination node is moving is updated, but GPSR+AGF fails to provide the best shortest connected path hence, it may deliver undesired solution.

GPSRJ+ [13], is an instinctive routing protocol which provides resolution to additionally improve the packet delivery ratio of GPCR [5], by anticipating which neighbor's junction node will forward packets on the road segment with minimal modification. GPSRJ+ does not uses any costly planarization algorithm like GPSR as it uses features from urban maps to form simple planar graph. GPSRJ+ improves the recovery strategy of geographic forwarding by using two hops neighbors' information for identifying suitable junction passes and calculating a better routing path. The number of hops used by the recovery mode are minimized by several percentages, yet it is not suitable for many delay sensitive applications. GPSRJ+ is not applicable on practical city maps as they follow complex trajectory, rather it requires simple trajectory.

Geographic Source Routing (GSR) [14], protocol uses combination of location-based routing and topological information to provide capable routing strategy for VANETs. GSR assumes that a map is always present. The shortest path is estimated using greedy forwarding in combination with Dijkstra's algorithm. GSR improves packet delivery rate, scalability and latency yet it performs poor in a low-density network with more chances of local maximum problem. Since GSR has more control messages,

it shows an increased routing overhead.

Position-Based Routing along with Distance Vector recovery (PBR-DV) [15], is a protocol that uses location-based service in combination with Ad-Hoc Distance Vector (AODV) recovery if the packet falls in local maximum i.e. greedy forwarding fails. PBR shows decent performance in highway scenarios, and along with AODV, it shows realistic performance in city scenarios. The packet delivery ratio and overhead parameters are uncertain since it has not been corelated with any other routing protocol. In case of distance vector routing excessive flooding is required which leads to congestion.

III. PROPOSED METHODOLOGY

The research challenges of VANETs to design an Intelligent algorithm for dynamic network connectivity problem have become a challenging issue because of the dynamic nature of increasing nodes and most importantly, research challenges in developing a reliable and efficient routing protocol that can support highly dynamic networks topology in VANETs. The proposed work (IJDRP) employs an extended form of Restricted Greedy forwarding mechanism [5] and use of static PCR junction nodes as shown in the Fig. 2 to reduce end-to-end delay based on the selection mechanism of the next forwarder and a recovery strategy. The GPSR [3] protocol uses two forwarding modes; First is the Greedy Forwarding mode and Second is the Perimeter Forwarding mode. In the First mode i.e. greedy forwarding mechanism, each forwarding node chooses the next forwarder vehicle on the basis of farthest distance in its communication range and closest to the destination vehicle. When there is no next forwarder available (i.e. local maximum), then forwarding mechanism changes to the Second mode i.e. perimeter forwarding mode to choose the subsequent forwarder, thereby effecting cost in terms of bandwidth and time. Vehicles moving with different speed variance may cause rapid change in topology, which ultimately results in inaccurate transmission [4]-[8] thereby making the routing protocol very inefficient for VANETs, where the bandwidth of radio communication is very limited. Hence, a

necessity for well-organized and resilient routing protocol is required for VANETs.
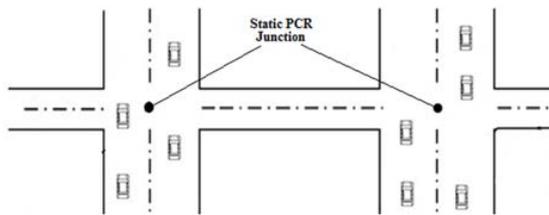

Fig. 2. A Static PCR Junction node present at the center of every intersection

This paper employs a more extended form of restricted greedy forwarding mechanism to selects the next hop forwarder within its radio range which may or may not be closer to the junction or destination. Simulation shows this extended greedy forwarding is more accurate than restricted greedy forwarding because it eliminates the issue of void region forwarding [5], [7]; since it is based on directional forwarding only. However, the current packet holder vehicle observes the attributes of its neighboring nodes (vehicles or PCR junctions) within its range such as velocity of every vehicle with their surrounding vehicles and then forward the packet either to junction closer to the destination or directly to destination. We propose a reliable junction-based routing protocol (IJDRP), with basic assumption i.e. the sender node is familiar with the destination's position via some certain location service. Furthermore, we also assume that all nodes in participating network are equipped with OBU and GPS.

The Mathematical Framework with assumptions and parameters for IJDRP comprises of two models:

1. Network Model

In this model we consider the scenario of a complex city environment with some static junction nodes and vehicles moving with different speed. The vehicles and PCR junctions that are within the range of one another are considered to be related/connected. The following entities model the V2V and V2I communications in VANET.

a) Sender: It is that vehicle which commences the data transmission, i.e. sent to a certain identified destination node.

b) Destination: It is that vehicle which receives the transmitted message from the source vehicle.

c) Suitable Next Forwarder: The best vehicle selected on the basis of predefined criteria from the neighborhood set of current packet holder within its radio range. The messages have the following characteristics:

- Source ID
- Destination ID
- Time to Live

d) Static PCR junction: This node is present at the center of every junction as shown in the Fig. 2 and upon receiving the packet it forwards that packet to the correct road segment vehicle.

This paper focuses on junction-based forwarding using position-based routing in each of V2V and V2I communications. All vehicles at regular period of time, estimate and transmit their updated positional information to all its neighboring vehicles with help of beacon messages. The traffic model used for demonstration is a complex city environment in which the traffic movement is unexpected due to multiple turns. Hence, to predict the velocity of the vehicle, we assume the change in geographic position over time. Using two or more beacon messages of positional information every vehicle can estimate acceleration, velocity, density and neighborhood of all vehicles within its range.

Assumptions: We have considered city as scenario with static PCR nodes and random distribution of vehicles. The city road segments are bidirectional with variable length and vehicle densities. The proposed framework assumes the following:

- GPS and Digital Maps are available in each vehicle.
- Transmission range is same of every vehicle and PCR junction node.
- A static PCR node is present at every available junction point for communication.

2. Logical Analysis

In this part we analyze and evaluate several performance specifications on the basis of the

Network Model. Various symbols/notations used for representing system parameters are shown in the Table I.

SYMBOL	REPRESENTATION/DESCRIPTION
NR_X	Neighborhood Region of a vehicular node X
R	Transmission Range of a vehicular node
λ	Threshold for Vehicular Density
VEL_X	Velocity of a vehicle X
AV_X	Average Relative Velocity of a vehicle X
j	Total number of static PCR junctions
PCR_j	A static PCR node j is present at the middle of every junction
SNF_X	Suitable Next Forwarder vehicle for current packet holder vehicle X
SNF_{PCR_j}	Suitable Next Forwarder vehicle for current packet holder junction j
RV_X	Recovery Vehicle X
Eucl_dis	Euclidean distance between two nodes

Definition1. The Neighborhood Density NR_A of a vehicle A is the count of all directly connected vehicles (such as vehicle(s) B) and a junction (such as PCR) within its radio range R. Hence, the neighborhood region of A can be defined as:

$$NR_A = \{ B_i \cup PCR_j \mid \forall B_i \ Eucl\_dis(A, B_i) \leq R, \\ \forall PCR_j \ Eucl\_dis \ (A, \ PCR_j \leq R)$$

$$(1)$$

where, B_i are the set of all neighborhood connected vehicles and PCR_j is the static junction node j in the communication range R of a vehicle A.

Definition2. The Average Relative Velocity AV_A with reference to NR_A is given by:

$$AV_A = \frac{\sum_{\forall B_i \in NR_A}(| VEL_A - VEL_{B_i}|)}{|B_i|} \qquad (2)$$

where, |Bi| is the total count of all neighborhood vehicle(s) and VEL_{Bi} is the velocity of each vehicle

B present in the range of the current vehicle A.

Definition3. A Suitable Next Forwarder (SNF) is the vehicular node to which the packet will be forwarded next to achieve desired reliability. For selection of Suitable Next Forwarder (SNF) two criteria are defined:

Definition3.1. SNF_{PCRj}: A static PCR junction node j will identify suitable next forwarder for vehicle A, if the given conditions are fulfilled:

- $C_i \ \epsilon \ NR_{PCRj}$
- $NR_C \geq \lambda$

If any vehicle C fulfills all above constraints, then the Suitable Next Forwarder SNF for some static PCR junction node j will be given by:

$$average = \frac{\sum_{\forall C_i \in NR_{PCR_j}}(| VEL_{C_i}|)}{|C_i|} \qquad (3)$$

$$SNF_{PCR_j} = \underset{C_i \ \epsilon \ NR_{PCR_j}}{argmin} \{ |average - VEL_{C_i}| \}$$

$$(4)$$

where, C_i is the neighborhood vehicle for PCR_j which satisfies the threshold and neighborhood constraint.

Definition3.2. SNF_A: A vehicle B will be identified to be suitable next forwarder for the current vehicle A, if the given conditions are fulfilled:

- $B_i \ \epsilon \ NR_A$
- $NR_B \geq \lambda$

If any vehicle B fulfills all above constraints, then the Suitable Next Forwarder SNF for some

vehicle A will be given by:

$$SNF_A = \underset{B_i \in NR_A}{argmin}\{\, |AV_A - VEL_{B_i}|\, \}$$

(5)

where, B_i is the neighborhood vehicle for A which satisfies the threshold and neighborhood constraint.

In reference to start the selection process of Suitable Next Forwarder (SNF) process, we consider only those vehicles that are moving in the direction of the destination and those neighborhood vehicles' must have a threshold value larger than or equal to λ.

Definition4. The SNF selection process may fail if the above criteria is not fulfilled; thereby, to avoid retransmission, the packet is then sent to the Recovery Vehicle (RV). The RV is the closest vehicle to the destination in its communication range. For selection of RV two criteria are defined:

Definition4.1. RV_E: The RV_E for a PCR_j will be the minimum Euclidean distance between the vehicle E and destination D and the maximum Euclidean distance between the current static PCR junction node j and vehicle E.

$$\underset{\forall E_i \in \{NR_{PCR_j}\}}{RV_E} \in \{min(Eucl\_dis\,(E_i, D))\,\&\&\,max\,(Eucl\_dis\,(PCR_j, E_i))\}$$

(6)

where, E_i is the neighborhood vehicle of the current PCR junction j, RV_E is the recovery vehicle selected on the basis of its distance with the destination D.

Definition4.2. RV_F: The RV_F for a vehicle A will be the minimum Euclidean distance between the vehicle F and destination D and the maximum Euclidean distance between the current vehicle A

and vehicle F.

$$\underset{\forall F_i \in \{NR_A\}}{RV_F} \in \{min(Eucl\_dis\,(F_i, D))\,\&\&\,max\,(Eucl\_dis\,(A, F_i))\}$$

(7)

where, F_i is the neighborhood vehicle of the current vehicle A, RV_F is the recovery vehicle selected on the basis of its distance with the destination D.

IV. PROPOSED ALGORITHM

ALGORITHM I: AN IMPROVED JUNCTION-BASED DIRECTIONAL ROUTING PROTOCOL (IJDRP)

Repeat
Vehicle A is the current packet holder (Current Forwarder)
If the vehicle A is in range of the destination D, then forward the packet directly to D
   Else if
      Static PCR_j Junction is in communication range of
      vehicle A then forward the packet to PCR_j
      Start SNF_{PCR_j} process
      If SNF_{PCR_j} condition not fulfilled then
         Select RV_E
      End if
   Else
        Start SNF_A process
      If SNF_A condition not fulfilled then
         Select RV_F
      End if
End if
Until packet reaches the destination D

In this section we propose an IJDRP based on infrastructure and inter vehicle communication. All vehicles and PCR junction nodes send the HELLO message to all its neighboring vehicles at some periodic time interval that carries position, direction, velocity and neighborhood density information with reference to their neighborhood density. Initially all vehicles send their velocity zero and afterwards, based on the received velocity information from the neighborhood, every vehicle computes average velocity and average relative velocity (AV). This AV is also useful for path maintenance. The vehicles periodically exchange this information in the HELLO packet sent to its neighbors.

Suppose a vehicle A is the current forwarding node, so it first gives preference to the PCR junction to select the Suitable Next Forwarder on

the basis of (3) and (4) and if no PCR junction is in its communication range then, the Suitable Next Forwarder for vehicle A is selected on the basis of (5). The algorithm gives preference to static PCR node to select the SNF because the average relative velocity (AV) computed by the static PCR node is more accurate when compared with the moving vehicles; hence, the PCR node can estimate the correct road segment vehicle to which the packet will be forwarded next. Whenever the packet travels across the junction the static PCR junction node selects the SNF for that current packet holder and, if not then, the current packet holder selects the SNF vehicle to route the packet between two consecutive junctions. This helps in achieving reliability in a dynamic changing environment. The SNF selection process does not fail under dynamic conditions and overcomes the problems stated by [5] and [7].

After a SNF has been selected based on (4) or (5), it then becomes the current forwarder node (vehicle A). If no vehicle satisfies the conditions for SNF selection, then a repair strategy is applied so that packet does not falls into local maxima. A recovery vehicle (RV) is especially used for this purpose. If the current forwarding node is a junction, then a vehicle E is selected as RV on the basis of (6), else; if the current forwarding node is a vehicle, then a vehicle F is selected as the RV on the basis of (7). After a RV has been selected it then, becomes the current forwarder node (vehicle A) and repeats until the packet reaches the destination. This allows the protocol to avoid frequent retransmissions, thereby, making it suitable for many complex city scenarios to provide a reliable route, and avoid the local maximum problem as mentioned in [8].

V. SIMULATION AND RESULT ANALYSIS

We did simulation of the proposed algorithm to analyze its performance. The effect of multiple parameters like vehicle velocity, route reliability and average hop count have been examined. The performance of the suggested method is compared with GPCR [5] and E-GyTAR [8] using NS-2 simulator version NS-v2.34 on Ubuntu 12.04.5 LTS. SUMO version 0.12.3 (Simulation of Urban MObility) is used for creating realistic

vehicular trace for city scenario consisting of two-lane roads with traffic lanes, junction nodes etc. Various parameters used in NS-v2.34 simulation are described in Table II.

TABLE II
PARAMETERS USED IN SIMULATION

Simulator	NS-2 (v2.34)
Simulation Time	400 secs
Simulation Area	2000 m x 2000 m
Maximum Velocity	10-60 km/hr
Transmission Range	250 m
Number of Vehicles	40-190
Static PCR nodes	10
Number of Lanes	2
Bandwidth	2 mbps
Traffic Type	CBR
Packet Size	512 bytes
λ	3

NS = Network Simulator, secs = seconds, m = meters, km = kilometers, hr = hour, mbps = megabytes per second, CBR = constant bit rate.

IJDRP selects the SNF node on the basis of average relative velocity and neighborhood density. The aim to use this approach is to certainly influence the route reliability and throughput without considerably having effect on end to end delay. Hence, we have performed simulation to observe the outcome of multiple selection parameters using proposed method and both GPCR [5] and E-GyTAR [8] to obtain the following results.

Fig. 3 represents the effect on Packet Delivery Ratio (PDR) with increasing velocity. The PDR of the proposed IJDRP shows significant improvement when compared with GPCR [5] and E-GyTAR [8] because of using extended restricted greedy forwarding mechanism and static PCR junction respectively as the route selected via the static PCR junction node is more reliable.
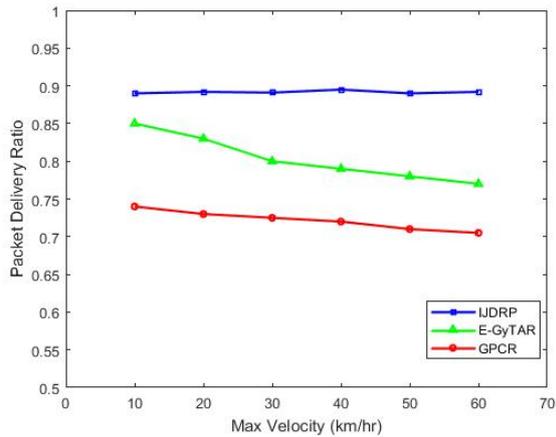
mechanism to select the SNF, but with one constraint that the vehicle or junction node is in the direction of the destination.

Fig. 3. PDR vs Velocity

Fig. 4 shows the effect on packet loss ratio (PLR) with increasing velocity. The PLR is more of GPCR [5] rather than E-GyTAR [8] when compared with IJDRP.
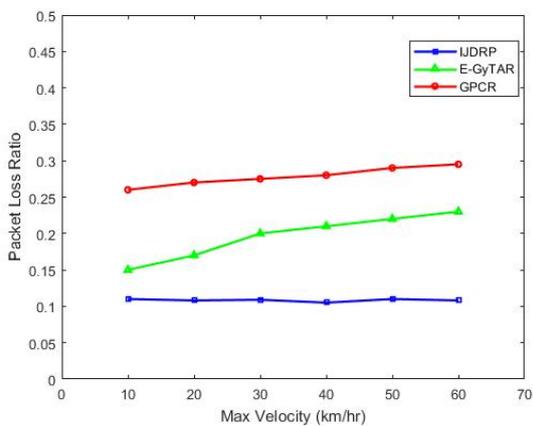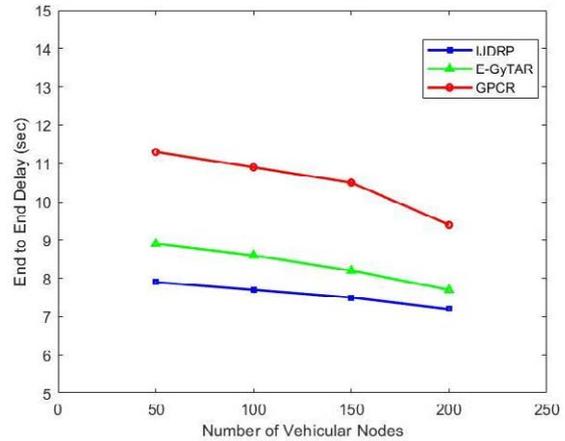

Fig. 5. Average End to End delay vs Number of Vehicular Nodes

Fig. 6 shows that routing overhead (packet) of GPCR [5] is very high as compared to E-GyTAR [8] because of the local maxima problem. IJDRP further minimizes this overhead by using RV as the retransmission does not occurs frequently. The RV also avoids local maximum problem, thereby, making IJDRP more efficient with dynamic number of vehicles.
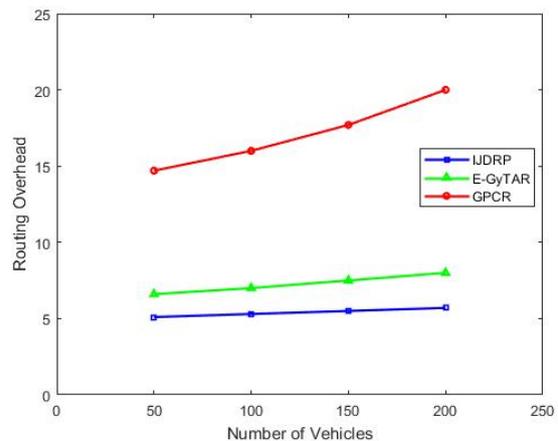

Fig. 4. PLR vs Velocity

We use 10 static PCR junction nodes along with minimum 40 and maximum 190 vehicles in this simulation. Fig. 5 shows that IJDRP provides less End to End delay with increasing number of vehicular nodes. The delay in GPCR [5] is higher due to its inability to select junction node efficiently, whereas in E-GyTAR [8] due to dynamic junction selection and directional routing only.

We use extended restricted greedy forwarding

Fig. 6. Routing Overhead vs Number of Vehicles

Fig. 7 shows that E-GyTAR [8] provides slightly better average hop count as compared to IJDRP. The average hop count is slightly more of IJDRP but reasonable because of reliable forwarding via junctional nodes, as the packet is always forwarded to the static PCR junction whenever the packet travels across the junction. This approach is very useful for path maintenance as well. The average hop count of GPCR [5] is more because, it assumes that, a junction node is always present at each junction.

using multi-lane scenario and considering 3D vehicular environment will be an interesting future work to explore.
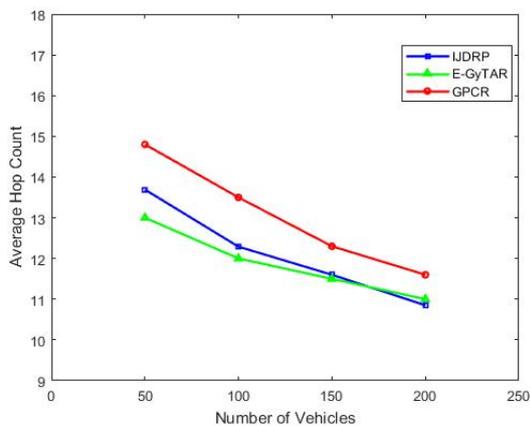

Fig. 7. Average Hop Count vs Number of Vehicles

VI. CONCLUSION

In this paper, we present an IJDRP that uses extended restricted greedy forwarding to select the SNF node based on the information of distance, velocity and neighborhood density. The static PCR junction node plays a significant role in packet forwarding, thus providing a reliable route to destination with reasonable delay. We also simulated our work IJDRP on NS-2.34 to analyze its performance with GPCR [5] and E-GyTAR [8] protocols. Simulation results show that the proposed approach IJDRP outperforms both GPCR [5] and E-GyTAR [8].

The proposed work IJDRP relies on static PCR junction node for its route reliability, thereby

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