Reduced Signal Fading and Link Correlation Based Routing Protocol in Vanets

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Abstract- *In urban Vehicular Ad hoc Networks (VANETs), selection of optimal relaying node in an intra-street and determination of the next street at the intersection are the main challenging issues due to its high mobility and uneven distribution of vehicles. In this, the probability of link availability can be estimated by a link model which considers the stable and unstable vehicle states. In an existing concept, the periodic route discovery message broadcasting increases the delay in path establishment. A novel concept called the link correlation which represents the influence of different link combinations in network topology. The link correlation concept is applied to transmit a packet with less network resource consumption and higher good put. Based on link correlation, an opportunistic routing metric is designed as the selection guidance of a relaying node in intra-streets and it is called as Expected Transmission Cost over a multi-hop Path (ETCoP). This opportunistic routing metric can also provide assistance for the next street selection at an intersection. Ultimately, a street-centric opportunistic routing protocol is proposed based on ETCoP (SRPE) for VANETs. Forwarding candidate selection technique based on velocity vector is contributed to improve the performance*

Keywords- Link correlation, opportunistic routing, street centric, vehicular ad-hoc network

I. INTRODUCTION

VANETs in complex urban environments are one of special-type networks, which consist of vehicles equipped with communication devices. The urban VANETs have the following characteristics: (1) Frequent changes in network topology due to high mobility, (2) The topology of networks can be regarded as a subset of city map and the movement of vehicles are restricted along the streets and by the traffic conditions. (3) They can easily obtain the information about their geographical positions, moving direction and velocities, etc., using Global Position System (GPS) and a street-level digital map that are already equipped in vehicles. (4) The distribution of vehicles along the streets is uneven and it depends on the conditions of streets, such as one-/two way streets, speed limit and traffic conditions. Designing an efficient routing protocol is one of key issues in VANETs. However, due to high mobility, uneven distribution of vehicles and restricted movement in urban environments, it is very difficult to maintain the global topology of VANETs for every vehicle. Conventional node-centric routing protocols was proven to be worse than the street-centric routing protocols in which the streets are selected one by one instead of finding the entire routing path in advance with a divide-and-conquer approach. How to select an optimal relaying node in an intra-street and how to determine a street selection at the intersection are two challenging issues in designing an efficient routing protocol in complex urban environments[6].When selecting a relaying vehicle in an intra-street or the next street at an intersection, the selected metric (or information) and strategy may affect the performance of a routing protocol. All the global routing metrics operate based on link quality information. However, the link quality information used in these metrics cannot fully characterize the links in urban VANETs, where network dynamics and it is more applicable to VANETs in a dynamic urban environment. When a vehicle determines a relaying vehicle along the intra-street, it can make a decision on the fly according to the varying real-time network conditions. The vehicle selects the forwarding candidate based on the velocity vector along with ETX for achieving more reliable performance.

II. VEHICULAR AD-HOC NETWORKS

VANET are wireless networks which facilitate information exchange between mobile vehicles with no permanent network infrastructure required. VANETs become a cornerstone of the envisioned Intelligent Transportation Systems (ITS). There is an increasing interest in developing efficient vehicular ad-hoc routing protocols to expand the internet to vehicles on the road, thereby allowing point-to-point communication between vehicles as well as access to services available on the Internet in the proposed system is a novel vehicular communication system for detecting traffic jam through information gathered using inter-vehicles communication. This information is processed by the vehicles on-the-fly, allowing them to determine the congestion spots in urban areas, and thereby computing alternative and less congested itineraries. Traffic safety is the main concern for many countries. Many accidents are caused by insufficient traffic information and by slow driver reaction to local visual and acoustic inputs. VANETs (Vehicular Ad hoc Networks) overcome these problems by enhancing both the accuracy of traffic information and the delivery of alarms, thus helping prevent collisions as shown in Fig.1.In a VANET, cars communicate with each other over a wireless channel. They can send packets directly to neighbors within radio range[2]. Alternatively, intermediary cars route and forward packets to intended destinations. Communication is peer-to-peer, without centralized coordination. In VANETs[4], cars can exchange routine information such as current speeds, locations, directions, as well as emergency alarms like notifications of emergency braking, etc. With VANETs, cars can collect more accurate traffic information electronically than drivers can visually. Direct activation of commands (brakes, accelerator, steering wheel, etc.) by an alarm will ensure a car's prompt reaction without depending on the driver's alertness.

III. RELATED WORKS

Selection of an optimal relaying node is one fundamental issue in designing a multi-hop routing protocol, when packets are transmitted along a path. The greedy forwarding strategy has been widely used to solve it in VANETs. The greedy perimeter stateless routing (GPSR) [16] is a geographical routing protocol and it first puts forward with the greedy forwarding scheme, in which a sender selects a neighbor with the highest geographical progress as a relaying node. In order to better adapt to varying urban environments, Lee et al. [8] pointed out the disadvantages of the existing local maximum problem [16] in the greedy forwarding schemes and proposed an enhanced routing named the GpsrJ+.Rao et al. [9] proposed GPSR-L, in which they considered the link lifetime and geographical progress when selecting a relaying node to deal with a high-mobility scenario. Although it is easy to deploy the greedy forwarding strategy, the link between two vehicles may be unstable and the routing decision lacks the global information, which may result in a local maximum problem. Based on further prediction of the mobility of vehicles, Eiza and Ni [1] proposed an evolving topology-based reliable routing (EGRAODV)for supporting quality-of-service (QoS).They built a link model based on the movement condition in urban environments and abstracted the topology using a directed graph to search the optimal routing path. However, it requires a route discovery (RD) process and maintains the end-to-end topology, which induces an addition delay. Wuet al. [17] only utilized beacon packets to establish a backbone of the topology called the BBR and the packets are only forwarded through the backbone vehiclesA fuzzy logic algorithm was used to combine the information of direction, speed, density and antenna height of vehicles to select the backbone vehicles. The BBR does not need to maintain the entire topology information, thus, without any additional control overhead. In order to improve the reliability of packet transmissions and achieve high throughput, Biswas and Morris [15] proposed an opportunistic routing strategy, which utilizes the inherent characteristic of broadcast called the ExOR.Since the ExOR does not need to maintain a fixed route,relaying nodes are selected on the fly by the sender or receiver according to the mechanism of MAC layer. The guidance metric, the expected transmission count [11] for packet forwarding is implemented on the ExOR protocol to achieve high throughput. Cai et al. [18] proposed a link state aware geographic opportunistic routing protocol(LSGO), which uses the enhanced ETX metric to adapt to urban VANETs. Yoo and Kim [19] proposed a robust and fast forwarding (ROFF) protocol, which optimizes the waiting delay based on the distribution of vehicle during the opportunistic relaying process. Ding et al. [20] proposed a geography and road traffic flow (ORRIS), which considers the geography positions,motion vectors and traffic flows with an opportunistic routing strategy to achieve higher delivery ratio and shorter transmission delay. Wu and Ma [21] proposed an opportunistic routing protocol, which takes the interface into account and builds a rate distortion model for video streaming with maximum delivery ratio and minimum end-to-end delay.Several routing protocols were proposed to solve the optimal street selection at an intersection, when a packet is held at the intersection. The static attributes of streets [22]were first utilized for selecting intersections. Yang et al. [23]proposed an adaptive connectivity aware routing protocol

(ACAR) and pointed out that a wider street indicates a higher vehicle density, which is utilized for selecting intersections. Recently, the dynamic characteristics of streets were also considered as decision factors for selecting streets.Jerbi et al. [3] proposed an improved greedy traffic aware routing protocol (GyTAR) in an urban environment, which considers both the static length of streets and the dynamic vehicle density of streets. Xiang et al. [5] proposed a geographic stateless vehicular routing protocol (GeoSVR), which has two core algorithms. One of them aims to select a global routing path, which is the shortest connected path with the highest vehicle density from the source to destination. Jeong et al. [24] proposed a trajectory based statistical forwarding (TSF) scheme to improve the end-to-end delay. It utilizes the trajectory of a destination vehicle and transmits a packet to a rendezvous area where the destination vehicle is expected to pass by. Zhao and Cao [2] designed a delay model for each street based on the vehicle density and proposed a vehicle assisted data delivery (VADD) protocols. They assumed that each vehicle can obtain the. vehicle density in each street through the assistance of a third-party service. Higher vehicle density in a street causes lower delay. An adjacent street with the shortest delay towards the destination is selected at an intersection. To deal with the routing loop at the intersection, they also proposed the L-VADD, D-VADD, and H-VADD schemes. Nzouonta et al. [6] proposed a road-based (the same as street-based) vehicular traffic (RBVT) routing protocol and implemented a reactive protocol RBVT-R and a proactive protocol RBVT-P. In the RBVT-R, a source broadcasts a route discovery message to establish a global routing path. In the RBVT-P, each node uses the periodic connectivity packets (CPs) to maintain the information of the entire topology in a distributed manner.

THE OPTIMAL RELAYING NODE SELECTION IN INTRA-STREETS

Packet delivery ratio is an important metric affected by packet losses for unicast routing protocols in VANETs. The main cause of packet losses is due to high mobility of vehicles in urban environments. 1) A sender determines a neighbor as a relaying node based on the information of its neighbors exchanged through beacon packets. However, the information which the sender maintains may be outdated.For instance, vehicle VB is within a communication range of VA at time t1. When vehicle VA has a packet to send, it assigns vehicle VB as a relaying node at time t2. However, vehicle VB is out of the communication range(OCR), which results in a packet loss, as shown in Fig. 1.2) Taking into account the maximum number of retransmission attempts (seven for RTS and four for data frames), a packet may be dropped by a sender at 802.11 MAC layer after a maximum number of transmission retries (MTR), due to signal fading at PHY layer, channel contention and hidden terminal at MAC layer, etc. 3)Data traffic may be aggregated at some vehicles through improper routing, which incur longer queue length (i.e.,longer one-hop delay), even worse may induce buffer overflow (BF), leading to packet drops at network layer.

The expiry time of the routing table reflects the refresh interval for routing entry updates. Each vehicle periodically checks its neighbor list and removes the neighbors from which it does not receive any beacon packets. Taking a closer look at how the dynamic attributes of VANETs affect the packet losses in a high mobility scenario,the velocity of vehicles is fixed at 40 km/h in two way streets, and 50 vehicles and two pairs of constant bit rate (CBR) connections are distributed and selected in a street with 2 kilometers long (note that the detail of simulation parameters can be found in Table 1 of Section 5). Fig. 2 shows the results about the proportions of different causes of packet losses with expiry times of 2 and 5 s, and the routing protocol GPSR [16] is implemented with an Ns-2 simulator. Therefore, it is important to design a routing protocol based on an appropriate link model to improve the packet delivery ratio. In Section 3.1, we establish a link model to estimate the link quality between a sender and a receiver vehicle in urban environments. And the proposed model considers the signal fading and vehicle movement characteristics. In Section 3.2, based on link (quality) correlation, we propose a routing metric to select good links near the destination to constitute the optimal routing path.

Link Model

Due to high mobility of vehicles traveling in urban environments, it is complex to estimate or predict the link condition between two vehicles. We propose a link model utilizing the static and dynamic properties to predict the link quality between two vehicles. The static properties include the distance between the two vehicles and the moving direction of the two vehicles at the current time, and they are used as the basic link condition. On the other hand, the dynamic properties include the mean velocity of vehicles and the relative velocity, and they are used to predict the link condition accurately

SYSTEM OVERVIEW

In this section discuss about the ETCOP architecture and designing principle of the system.

The architecture of ETCOP where the vehicles are communicate between each other by using VANETs. The red color indicate communicate between vehicle to vehicle and orange indicate crashes occur .A sender determines a neighbor as a relaying node based on the information of its neighbors exchanged through beacon packets.

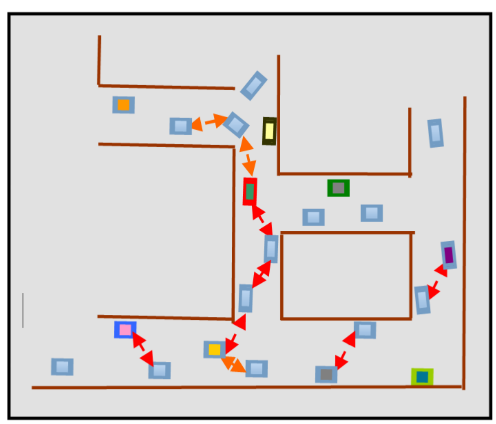

Figure 1. ETCOP ARCHITECTURE

IV. MODULES

1. LINK CORRELATION

Link correlation represents the influence of different link combinations in network topology to transmit a packet with less network resource consumption and higher goodput. The ETX of a path is the sum of the ETX of all the links along the path. The expected transmission time (ETT) of a packet over a link accounts for the loss rate and bandwidth of the link, and it also considers the interference of the links which use the same wireless channel. Each vehicle maintains the successful transmission rate which is calculated and updated upon receiving a beacon packet from its neighbor. The ETX of an individual link is the reciprocal of the successful transmission rate. The total expected number of transmissions for one packet in each path is different. The link correlation is introduced in the opportunistic routing scheme with simplified calculation of chain-links. In this, if two adjacent paths having different link sequences, same amount of packets are passed through the Paths and have the same ETX, a different amount of network resources are consumed. When a packet is not successfully received by the end node, the expected number of transmissions of an k-hop path p is estimated under the failed receptions of the end node as F(k)p. The detailed calculation of a chain-link for successful transmission is shown below.

$$F(k)_p = 1 - P_k + 2 P_k (1 - P_{k-1}) + \ldots + k P_k P_{k-1} \ldots P_2 (1 - p_1)_k,$$

$$= 1 - P_k + \sum_{n=2} n (1 - P_{k-n+1}) \prod_{i=k-n+2} P_{i},$$

Where, Pi denotes the link quality of the ith link of path p from the destination to the source. To reflect the real transmission cost of a packet transmitted from the source to the destination, define the expected transmission cost ETCoP (k)p , which represents the total transmission cost on each link along the path p , when a packet is successfully received at the destination vehicle.

$$ETCoP(k)_p = \frac{F(k)_p + k \prod_{i=1}^{k} P_i}{\prod_{i=1}^{K} P_i}$$

Where $\frac{\prod P^k i}{i=1}$ i=1P_i is the aggregate of the link qualities of all the links from itself to the destination. Therefore, the end-to-end packet delivery ratio and the whole transmission cost along the path is considered to design a routing metric based on the link correlation.

A STREET-CENTRIC OPPORTUNISTIC ROUTING PROTOCOL BASED ON ETCOP (SRPE)

Link Correlation

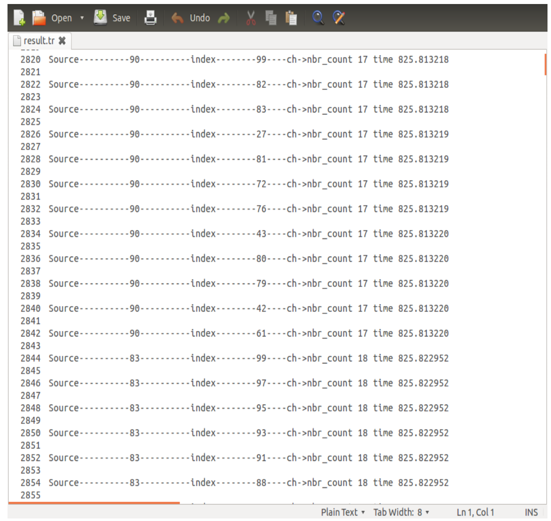

Figure 2.

Each node maintains the neighbour count and attaches the neighbour count in hello message.

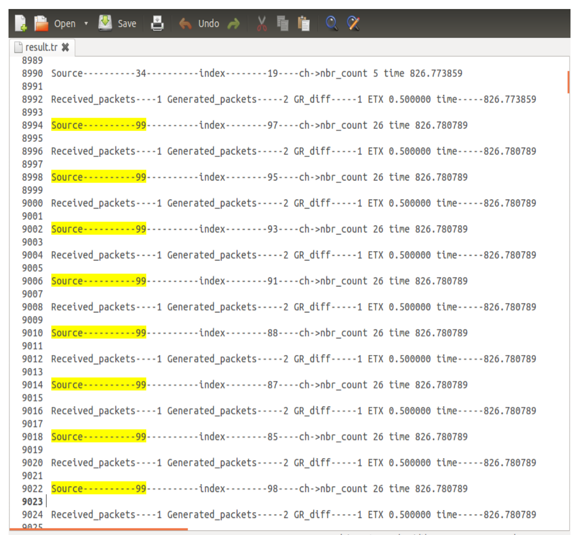

Figure 3.

When the hello message is received by neighbour nodes, they calculate the Expected Transmission Count (ETX) based on generated packet counts and received packet counts.

GR_difference = Generated packets - Received Packets

ETX = Generated packets - Received Packets / Generated Packets

2. Candidate Set

The cardinality of a candidate set is an important factor in the opportunistic routing scheme that affects the routing performance. When a packet needs to be forwarded to a relaying vehicle, it needs to be broadcast to its candidate set. Only one vehicle in the candidate set of the sender can be selected as the relaying vehicle. A large cardinality of the candidate set can improve the one-hop delivery ratio, however, the candidate set may contain some candidates with small geographic progress. The vehicles in the candidate set should satisfy the two rules. (i) The vehicles in the candidate set should have greater geographic process than the sender, which ensures the direction of propagation. (ii) The vehicles in the candidate set should have smaller ETCoP values than the sender, which ensures the selection of relaying vehicles to be appropriate. When a source vehicle wants to send a packet to destination vehicle, it calculates the ETCoP and assigns the priorities of neighbor vehicles. In the opportunistic relaying scheme, a sender broadcasts a packet and then a vehicle with the highest priority is selected from the vehicles, which has successfully received the packet in the candidate set in a distributed manner.

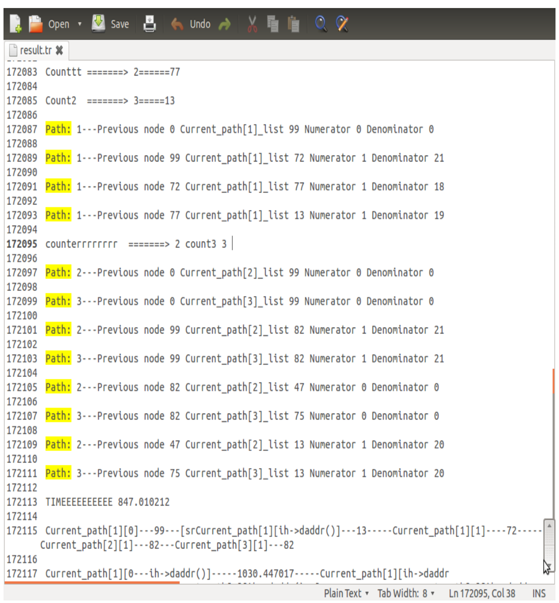

Figure 4.

ETX values of two available paths are maintained.

At data transmission each router calculates the Fc (Chain link) and ETCoP (Expected Transmission Cost of multi-hop Path) for both paths.

3. Routing Based on Inter-Street Paths

Obtaining the instantaneous information of all the vehicles along the routing path are very difficult due to the complicated urban scenarios and high mobility of vehicles. The divide-and-conquer strategy exploits to address these issues. Because of uneven distribution of vehicles in topology, a vehicle may encounter a network partition and the topology covers the part of the street. Hence, the topology of the street is divided into some connected topologies, logically, and the anomaly does not affect our routing decision. A street-centric opportunistic routing protocol based on ETCoP proposed to make a routing decision at the intersections one by one without maintaining of global topology information. A Street-centric routing protocol dynamically chooses the streets to comprise the routing path. The expected transmission cost is estimated from intersections of the street to the destination vehicle in the digital map. The street which has the low ETCoP value selected as a next routing street.

$$ETCoP\ (S_{ab}\ ,\ V_d) = ETCoP_{\ ab} + ETCoP_{\ (b,\ Vd)}$$

Where, ETCoP (Sab,Vd) represents the expected transmission cost towards destination Vd through street Sab, and ETCoP ab is the expected transmission cost from intersections a to b. The ETCoP (b, Vd) is the estimated remaining cost from intersection b to Vd, which can be calculated as follows:

$$ETCoP_{\ (b\ ,\ V d\ )} = \frac{D_{\ (b\ ,\ Vd)}}{d_{ab}}$$

D (b , Vd) represents the shortest distance from b to Vd in the digital map, and dab is the distance of the street Sab

4. Routing Based on Inter-Street Paths

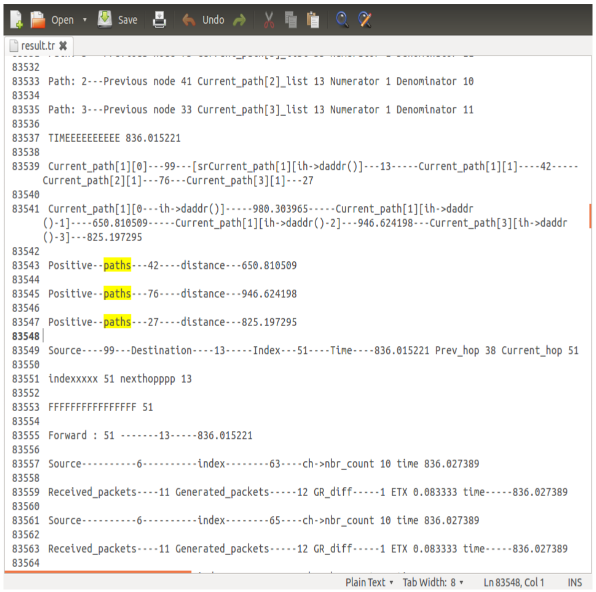

Figure 5.

A Street-centric routing protocol dynamically chooses the streets to comprise the routing path.

5. Velocity Vector based Forwarding Candidate Selection

The selection of forwarding candidates along with ETX is based on the velocity vector for opportunistic routing. The functionality of opportunistic forwarding is affected when the overhearing functionality is failed due to the mobility of forwarding candidates. Hence the appropriate forwarding candidates have to selected with respect to velocity vector along with ETX for reliable communication.

Enhanced a Street-Centric Opportunistic Routing Protocol Based On ETCoP (E_SRPE)

Velocity Vector based Forwarding Candidate Selection

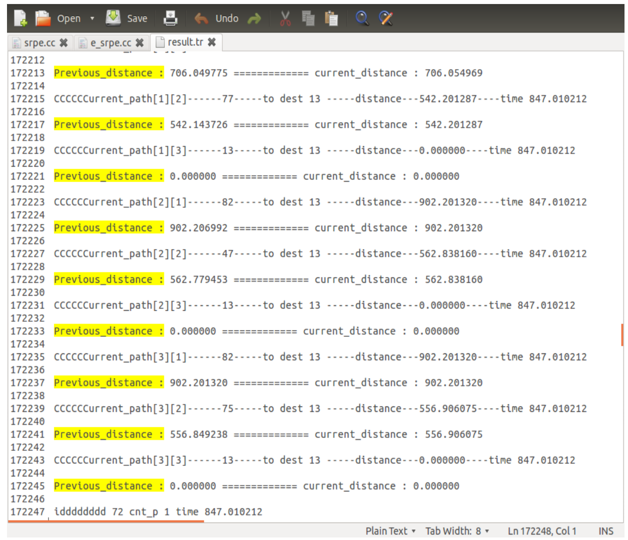

Figure 6.

Each vehicle maintains the previous and current distance between vehicle and destination

IV. RESULTS AND DISCUSSIONS

The performance of ETCoP (Expected Transmission Cost Over a multi-hop Path) is analyzed using network simulaor2. The experimental model is with 100 nodes distributed randomly the architecture of network with number of nodes, the source node is 99 and destination node is 53 the packets are transmitted through the sources to destination square surface of 600×600 .

PERFORMANCEAND EVALUATION

Simulation Model

SIMULATOR	NS-2 (VERSION 2.35)
CHANNEL TYPE	Channel/Wireless Channel
ROUTING PROTOCOLS	(SRPE) Street-Centric Opportunistic Routing Protocol Based On ETCOP
SIMULATION DURATION	100 seconds
NUMBER OF NODES	100
TRANSMISSION RANGE	250m
MOVEMENT GENERATOR	SUMO AND MOVE
MAC LAYER PROTOCOL	IEEE 802.11
SPEED	100m/s
PACKET RATE	10 Packets/s
TRAFFIC TYPE	Cbr
DATA PAYLOAD	512 bytes/packet

Figure 7.Simulation Model

(i) The end-to-end delay is reduced:

End-to-end delay refers to the time taken for a packet to be transmitted across a network from source to destination. Delay depends on number of hops and congestion on the network. The delay can be reduced due to the selection of appropriate forwarding node based on the ETX.

(ii) Reliability is improved:

Reliability defines the successful packet delivery without need of retransmission. The transmitted packets reach the exact destination even dynamic topology changing conditions.

(iii) Packet delivery ratio is increased:

The packet delivery ratio defines the ratio of packets that are successfully delivered to a destination compared to the number of packets that have been sent out by the sender

Comparative Graph

Control Overhead

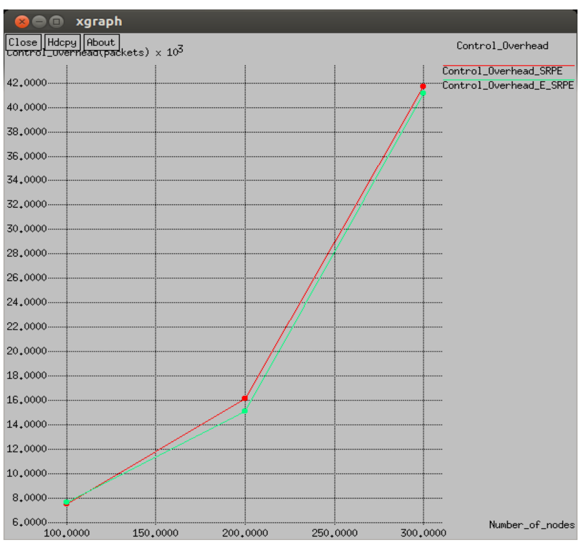

Figure 8. Control Overhead

X axis - Number of nodes
Y axis - Control overhead
When number of nodes are increased Control overhead is increased and E_SRPE achieves reduced control overhead when compared to SRPE method.

Packet Delivery Ratio

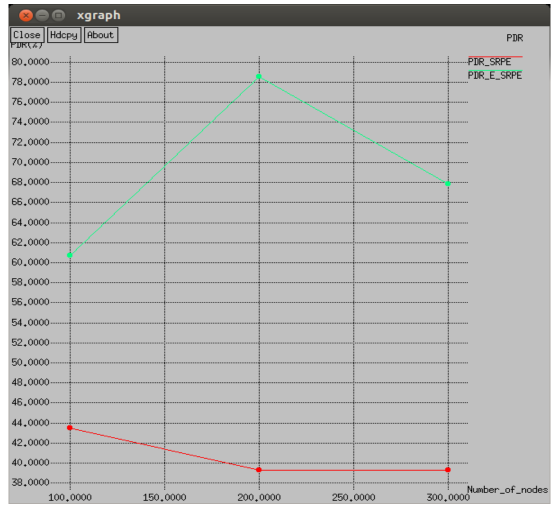

Figure 9. Packet Delivery Ratio

X axis - Number of nodes
Y axis - Packet Delivery Ratio (%)
When number of nodes are increased PDR is increased and E_SRPE achieves increased PDR when compared to SRPE method.

Dealy

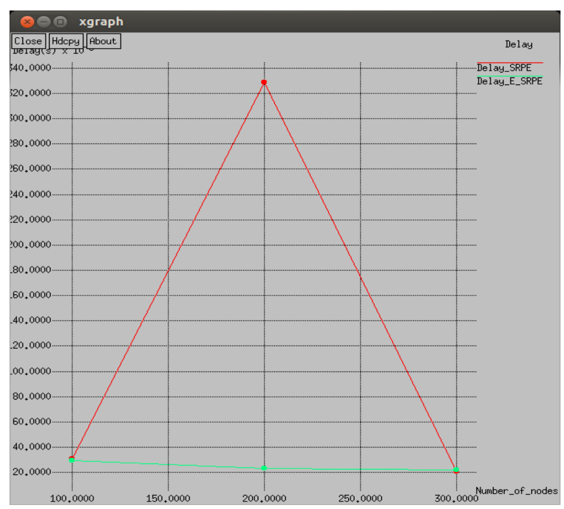

Figure 10. Dealy

X axis - Number of nodes
Y axis - Delay(s)
When number of nodes are increased delay is reduced and E_SRPE achieves reduced delay when compared to SRPE method.

V. CONCLUSION

This paper proposes the expected transmission cost of multi-hop path (ETCoP) routing metric to achieve the maximum forwarding reliability and minimal transmission cost in intra-streets based on the link correlation and velocity vector. A new link model has been designed to adapt the complex urban environments which considers the signal fading and vehicle movement characteristics. Finally, proposes the street-centric opportunistic routing protocol based on ETCoP in which packets are dynamically forwarded at the intersections based on the adjacent street information. In street-centric opportunistic routing, velocity vector also considered to achieve reliable communication, shorter end-to-end delay and high packet delivery ratio compared with other conventional protocols.

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