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VANET Analysis for Real Time Traffic of Nepal Using SUMO and NS3 under different protocol

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Abstract

Vehicular ad hoc network (VANET) is a promising Intelligent Transportation System (ITS) technology, which enables vehicles to communicate with each other and roadside station, where nodes involve themselves as servers and/or clients to exchange and share information. VANET have some unique characteristics like high dynamic topology, frequent disconnections and restricted topology, so it needs special class of routing protocol. This paper studies performance of different routing protocol like DSR, DSDV and AODV with 802.11p MAC protocol on VANET. For simulation of VANET the real time traffic scenario mobility file has been generated using SUMO and the network simulation has been performed using NS-3. Packet delivery ratio and Average end-to-end delay are used as parameter of the performance evaluation of different protocols. AODV protocol performs better in terms of Packet delivery ratio, however the DSR is better in terms of Average end-to-end delay.

Keywords

VANET – SUMO – NS-3 – ITS

1. Introduction

Vehicular ad hoc network (VANET) is a promising Intelligent Transportation System (ITS) technology, which enables vehicles to communicate with each other and roadside station. Both vehicle-to-vehicle (V2V) and vehicle-to-road-side-unit (V2R) communications are supported in VANETs to efficiently collect/report traffic updates from/to vehicles as well as road side units (RSUs). It can support critical vehicular safety applications such as emergency warning, collision avoidance, road condition broadcast, and lane-changing assistance [1]. The collected real-time traffic information can be utilized for freeway-traffic-flow managements, individualized vehicle path planning, andvehicle localization. However, most of the related works assume that the incorporated VANETs have sufficiently small delivery delay for real-time information collection. Actually, as VANETs rely on short-range multi-hop communications, the end-to-end transmission delay can be non-neglectable in some scenarios. Therefore, evaluations should be conducted to study how the end-to-end transmission performance of vehicular communications impacts on the performance of path planning in different scenarios and how to design the transmission mechanisms to reduce the delay when delay is not neglectable. The VANET architecture is shown in Figure 1.

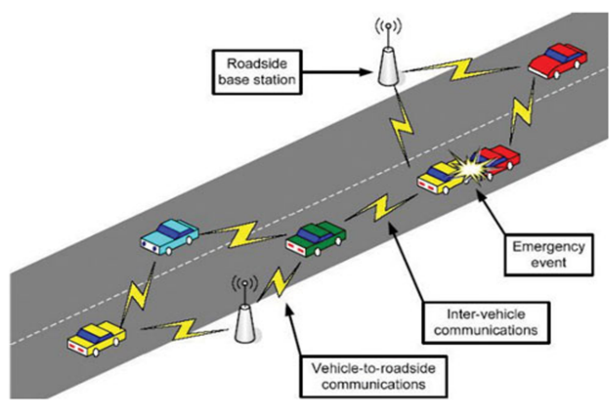

Figure 1: VANET Structure [2]

Recently, VANETs experience rapid development due to these application, as well as emerging self-driving car technologies. An IEEE dedicated short range communication (DSRC) standard [3], also known as IEEE 802.11p, has been initialized to specify Media Access

Control (MAC) protocols and Physical Layer (PHY) for VANETs.

Continuous mobility is a key feature of VANETs, which can result in rapid topology changes, unstable communications, and high overhead for exchanging new topology information. A central challenge in the design of ad hoc networks is the development of dynamic routing protocols that can efficiently find routes between two communicating nodes. The goal is to carry out a systematic performance study of DSDV, DSR, AODV routing protocol for ad hoc networks.

2. Related Work

Several researchers have done the qualitative and quantitative analysis of Ad Hoc Routing Protocols by means of different performance metrics. They have used different simulators for this purpose.

Mr. Rafi U Zamam [4] studied & compared the performance of DSDV, AODV and DSR routingprotocols for ad hocnetworks using NS-2 simulations.

Vahid Garousi [5] studied an analysis of network traffic in ad-hoc networks based on the DSDV protocol with an emphasis on mobility and communication patterns of the nodes. In this paper, he observed that simulations measured the ability of DSDV routing protocol to react to multi-hop ad-hoc network topology changes in terms of scene size, mobile nodes movement, number of connections among nodes, and also the amount of data each mobile node transmits.

C.E. Perkins & P. Bhagwat [6] studied & proposed an efficient DSDV (Eff-DSDV) protocol for ad hoc networks. Eff-DSDV overcomes the problem of stale routes, and thereby improves the performance of regular DSDV. The proposed protocol has been implemented in the NCTUns Simulator and performance comparison has been made with regular DSDV and DSR protocols. The performance metrics considered are packet-delivery ratio, end-end delay, dropped packets, routing overhead, route length. It has been found after analysis that the performance of Eff-DSDV is superior to regular DSDV and sometimes better than DSR in certain cases.

Chao,C-M., Sheu,J-P.,and Hu [7] studied the performance comparison based on packet delivery fraction and normalized routing load. In the future, extensive complex simulations could be carried out in gain a more in-depth performance analysis of the ad hoc routing protocols. This would include delay of data packet delivery and performance comparison on location-based ad hoc routing protocols.

3. Related Theory

3.1 Wave

WAVE is an overall system architecture for vehicular communications. The standards for specifying WAVE include a set of extensions to the IEEE 802.11 standard, found in IEEE Std 802.11p-2010, and the IEEE 1609 standard set, consisting of four documents: resource manager: IEEE 1609.1, security services: IEEE 1609.2, network and transport layer services: IEEE 1609.3, and multi-channel coordination: IEEE 1609.4. Additionally, SAE standard J2735 describes a Dedicated Short Range Communications (DSRC) application message set that allows applications to transmit information using WAVE.

The WAVE protocols are designed for the 5.850-5.925 GHz band in the United States (US), known as Intelligent Transportation Systems Radio Service (ITS-RS). This 75 MHz band is divided into one central Control Channel (CCH) and six Service Channels (SCHs). An overview of the WAVE protocol families is illustrated in Figure 2. The IEEE 802.11p standard [8] defines the physical (PHY) and Medium Access Control (MAC) layers based on earlier standards for Wireless LANs. The IEEE 802.11p uses the Enhanced Distributed Channel Access (EDCA) MAC sub-layer protocol designed based on that of the IEEE 802.11e with some modifications, while the physical layer is OFDM (Orthogonal Frequency Division Modulation) as used in IEEE 802.11a.

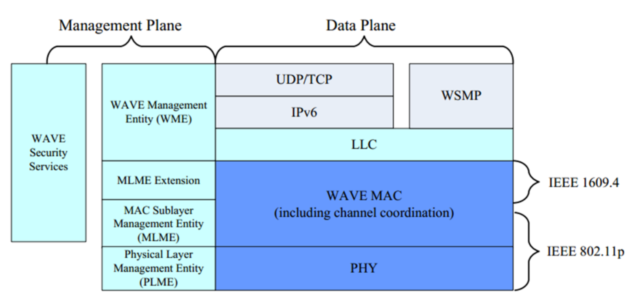

Figure 2: The WAVE Protocol Unit

In the U.S., the IEEE1609 WAVE (Wireless Access in Vehicular Environments) protocol stack builds on IEEE 802.11p WLAN operating on seven reserved channels in the 5.9 GHz frequency band. The WAVE protocol stack is designed to provide multi-channel operation (even for vehicles equipped with only a single radio), security, and lightweight application layer protocols. Within the IEEE Communication Society, there is a Technical Subcommittee on Vehicular Networks & Telematics Applications (VNTA). The charter of this committee is to actively promote technical activities in the field of vehicular networks, V2V, V2R and V2I communications, standards, communications-enabled road and vehicle safety, real-time traffic monitoring, intersection management technologies, future telematics applications, and ITS-based services.

3.2 Channel Condition on Physical Layer

The path loss of a wireless link can be given by

$$P_L(s_i) = K_1 {s_i}^{k_2} \quad (1)$$

Where s_i is the distance between the transmitter and receiver, $K_1 = \frac{4\pi^2}{(G_t)(G_r)_0^2}$, K_2 is the path loss exponent, λ_0 is the carrier wavelength, $\lambda_0 = \frac{C}{f_0}$ (c is the speed of light and f_0 is the carrier frequency), G_t and G_r are the antenna gains of the transmitter and receiver, respectively.

The small-scale fading is denoted by h, where $E[|h|^2] = 1$. $E[\cdot]$ denotes the mean operator. Let γ denote the instantaneous received signal-to-noise ratio (SNR). Given an additive white Gaussian noise (AWGN) with power $N_0 = \frac{|h|^2 p_t}{N_0 p_t}$. Therefore, at the CH the average received SNR from the i-th member vehicle can be given by

$$\bar{\gamma}(s_i) = \frac{p_t}{K_1 N_0 {s_i}^{k_2}} \quad (2)$$

Where $i \varepsilon 1, 2, 3. \ldots, n$ and $i \neq i_c$. We assume that vehicle within the cluster have the same transmitting power,p_t, and the same data rate of r_d Mbps.

3.3 DSDV, DSR and AODV

The Destination Sequenced Distance Vector Protocol (DSDV) is a proactive, distance vector protocol which uses the Bellmann -Ford algorithm. DSDV is a hop-by hop distance vector routing protocol, wherein each node maintains a routing table listing the “next hop” and “number of hops” for each reachable destination. Each entry in the routing table contains a sequence number, the sequence numbers are generally even if a link is present else, an odd number is used.This protocol requires each mobile station to advertise, to each of its current neighbors, its own routing table (for instance, by broadcasting its entries). The entries in this list may change fairly dynamically over time, so the advertisement must be made often enough to ensure that every mobile computer can almost always locate every other mobile computer of the collection.

The Dynamic Source Routing (DSR) protocol is an on demand routing protocol based on source routing. DSR Protocol is composed by two “on-demand” mechanisms, which are requested only when two nodes want to communicate with each other. Route Discovery and Route Maintenance are built to behave accordingto changes inthe routes in use, adjusting them-selves when needed. Along with those mechanisms, DSR allows multiple routes to any destination, thus can lead easily to load balancing or increase robustness .In the source routing technique, a sender determines the exact sequence of nodes through which to propagate a packet. The list of intermediate nodes for routing is explicitly contained in the packet’s header. In DSR, every mobile node in the network needs to maintain a route cache where it caches source routes that it has learned. When a host wants to send a packet to some other host, it first checks its route cache for a source route to the destination. In the case a route is found, the sender uses this route to propagate the packet. Otherwise the source node initiates the route discovery process.

The AODV (Ad-Hoc On-Demand Distance Vector) routing protocol is a reactive routing protocol that uses some characteristics of proactive routing protocols. Routes are established on-demand, as they are needed. However, once established a route is maintained as long as it is needed. The AODV uses a combination of a DSR and DSDV mechanism. It uses the route discovery and route maintenance from a DSR and hop-by-hop routing, periodic advertisements, sequence numbers from DSDV. The AODV easily overcomes the counting to infinity and Bellman Ford problems, and it also provides quick convergence whenever the ad hoc network topology is altered.

4. Methodology

In this paper, the VANET analysis for real time traffic goes through two steps

i) Real Time Traffic Mobility Generation using traffic simulator

ii) Network Simulation using network simulator

4.1 Traffic Simulator

Traffic simulation is Mathematical modelling of transportation systems which is used for the application of computer software in order to help and provide a better way to effectively plan, design and operate transformation systems.

4.1.1 Simulation of Urban Mobility

Simulation of Urban Mobility (SUMO) is an open source traffic simulation package including net import and demand modelling components. SUMO helps to investigate several research topics e.g. route choice and traffic light algorithm or simulating vehicular communication. Therefore the framework is used in different projects to simulate automatic driving or traffic management strategies.

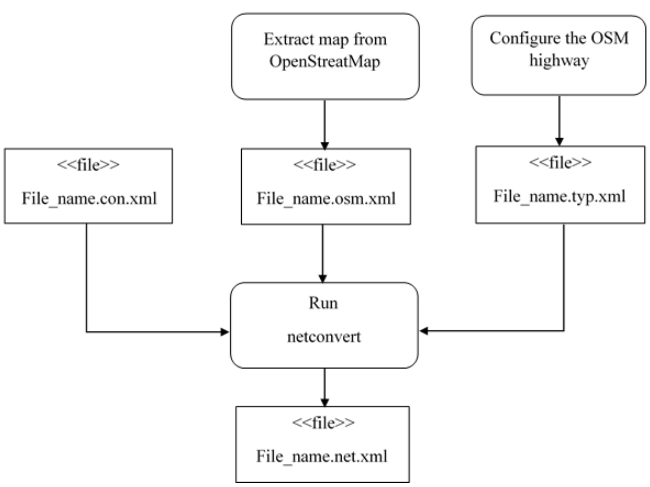

Figure 3: Steps of converting a Real World Map into SUMO network file

The map of Maitighar, Kathmandu area which is to be simulated is exported from OpenStreetMap (OSM). The map is saved as .osm file. The .osm file is then converted into sumo network file i.e .net.xml file using the steps mentioned in Figure 3. The .net.xml file and route file which consists of the vehicle type and route from source node to destination node is then converted into sumo trace.xml file using the configuration file of sumo.

After getting the sumo trace.xml, this file is converted into ns2 mobility file using the traceExporter.py of SUMO, which is then used for mobility model of nodes for network simulation of VANET. Here the map of Maitighar region of Nepal as shown in Figure 4 is selected for the generation of mobility traffic for the analysis of VANET.

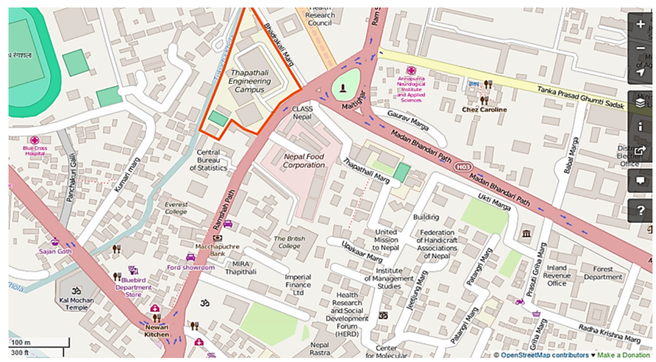

Figure 4: Map of Thapathali

4.2 Network Simulator

A network simulator consists of a wide range of networking technologies and protocols and help users to build complex networks from basic building blocks like clusters of nodes and links.

4.2.1 NS3

NS-3 is a discrete-event network simulator and a free software which succeeds popular network simulator NS-2, licensed under the GNU GPLv2 license and is publicly available for research, development and use [9]. The goal of the NS-3 project is to develop a preferred, open simulation environment for networking research. NS-3 is available for Linux, Mac OS and MS Windows using cygwin.

A simple NS-3 script can be written in either C++ or Python language. NS-3 is built on both-C++ and Python bindings. Here C++ scripts is used in simulation. Here different routing module with propagation module and wave as well as 802.11p modules have used for the performance analysis of VANET.

5. Simulation

In this thesis the real time traffic simulation created for Thapathai area is shown in Figure 5.

Figure 5: Thapathali Traffic Simulation

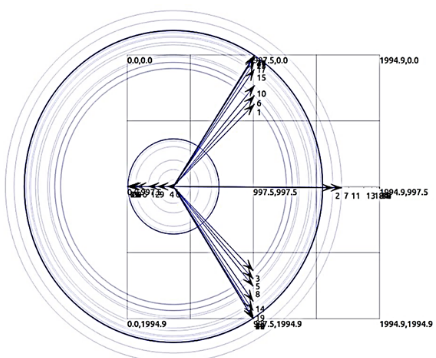

Figure 6: Animation of Packet Delivery of VANET

The VANET network is simulated under various routing protocol using the above generated mobility file. Figure 6 shows the animation of simulation of VANET.

Table 1: Simulation Parameters for VANET

MAC/Phy Layer Parameter	Value
Propagation Model	Two Ray
MAC Protocol	802.11p
Basic Safety Packet Size	200B
Rate	6Mbps
Application Routing Packet Size	64B
Application Packet Rate	2.048Kbps
Transmit Power (dBm)	20
Carrier Frequency f_0	5.9GHz
Antenna Height above z	1.5m
Antenna gains of transmitter and receiver	1dB

The VANET is tested on the basis of parameter in Table 1.

6. Result and Discussion

Different routing protocol are compared on the basis of packet delivery ratio and end to end delay by simulating in real traffic environment in Nepal.

$$\text{Packet Delivery Ratio} = \frac{\text{Total Packet Received}}{\text{Total Packet Sent}}$$

The simulation result obtained for packet delivery ratio for AODV, DSDV and DSR protocol for varying number of nodes is shown in Figure 7. The figure shows the relative performance of the aforementioned protocol on packet delivery ratio. From the figure it is observed that AODV protocol have better performance over DSR & DSDV on the basis of packet delivery ratio. For the same rate of packet transmission and number of nodes, AODV protocol delivered more data packets to the destination than DSR & DSDV. It is because AODV uses a combination of a DSR and DSDV mechanism.

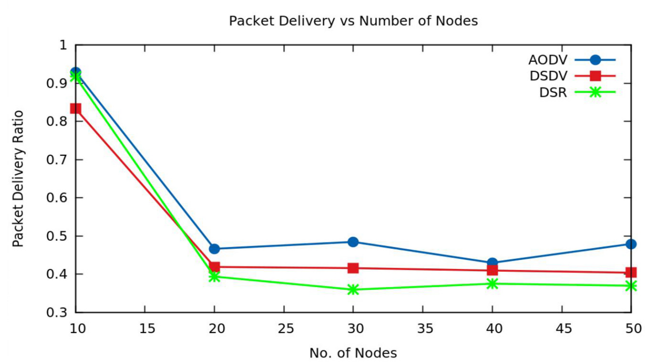

Figure 7: Packet Delivery Ratio vs Number of Nodes

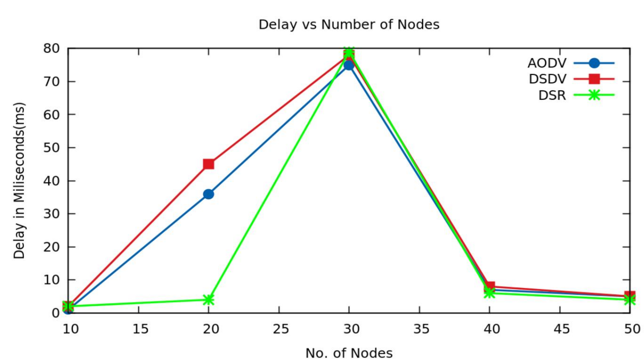

Figure 8: Average end-to-end delay vs No of nodes

Figure 8 shows the simulation result of average end-to-end delay of packet transmission vs nodes. It is observed from figure that DSR protocol have better performance over AODV & DSDV protocol in dynamic topology on the basis of average end-to-end delay.

7. Conclusion and Future Works

Here on comparing the performance of various protocol in real traffic of Maitighar on the basis of packet delivery ratio and average end-to-end delay, it has been observed that it is very difficult to say which of them has over-all better performance. Since AODV has better performance among them in terms of packet delivery ratio, however DSR has better performance in terms of average end-to-end delay. So a selection of routing protocol is made on the basis of required parameter. But it can be concluded that the reactive routing protocol AODV and DSR have better performance than the others.

The packet delivery ratio and end-to-end delay in highly dynamic network VANET is also affected by physical layer condition and MAC layer condition. So in the future the study can be carried out on the combined effect of physical layer, MAC layer and routing protocol for the better performance of VANET.

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