PERFORMANCE COMPARATION OF DTN ROUTING PROTOCOL MAXPROP AND SPRAY AND WAIT UNDER VARYING NODE SPEED AND VOLUME

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***Abstract*— Small number of vehicle and high mobility cause some problem in VANET. Since there is no complete end-to-end path cause conventional VANET routing protocol can't handle an intermittent connectivity and large delay properly. In this research, I implement the DTN routing protocol Maxprop and Spray and Wait to solves the problem in VANET. The performance of Maxprop and Spray and Wait is evaluated by observing the performance parameters of both routing protocol under varying node speed and node volume. Simulation result shows that the increment of node speed reduces the overhead of both routing protocol for about 10.8% for Spray and Wait, and 5.9% for Maxprop. It is also increases the delivery probability of both oruitng protocol about 9.37% for Spray and Wait . The increment of number of node gives the biggest impact and raises the overhead ratio of both routing protocol. The overhead ratio of Maxprop rise for about 74.7% and Spray and Wait for about 88%.**

Keywords—DTN, VANET, Spray and Wait, Maxprop

I. INTRODUCTION

Vehicular Ad Hoc Network (VANET) face high density of vehicles that affects to connectivity and Ad Hoc Network coverage to increase high delivery probability [1]. But in special case, when node density decrease drastically, vehicle move in high speed and a limited radio range cause the intermittent connectivity. When the environment quiets sparse, there doesn't exist a stable end-to-end path. Short time of message transmission and unpredictable future network topology raises the transmission delay significantly. The type of the environment we study in this paper fall in to a category of Delay Tolerant Network.

Since there is no stable connectivity and fixed path in DTN, traditional ad hoc routing scheme such DSR and AODV can't handle the intermittent connectivity properly. Reactive routing scheme will fail to discover the complete path from source to destination, proactive routing scheme will fail to converge because of a large number of network topology update message [2]. But, it is not mean that messages can't be delivered to the destination. It can be solved by applying DTN store-carry-forward paradigm. Store-carry-forward paradigm means message transmission in DTN is based on opportunity. If there is no opportunity to transfer the message, node will not dropped the message instead store it in to the internal storage.

DTN concept was initially design for deep space communication. It compensates the disconnection caused by interplanetary long distance. But now days, the applications of DTN is not limited to that aspect. In a several years, there are a lot of researchers have identified various environment that the DTN concept can be applied. For examples, underwater communication, satellite communications network, military environment, undeveloped areas, and also the environment that the stable infrastructure destroyed by natural disaster [1] [2] [3] [4]. There are a lot of articles concern about efficient routing protocol in mobile DTNs but have not been considered for VANET.

The contribution of this paper is considered for VANET. We use Maxprop and Spray and Wait as an effective routing scheme that deployed in VANET. We evaluate the performance that achieved by DTN routing scheme in given limited buffer size. We did the survey to obtain valid data related the characteristic of the environment we choose in order to get the real network simulation. The simulation parameters refer to IEEE 802.11p.The purpose of this research is to understand how the DTN routing scheme solve the problem in VANET caused by high node mobility and sparse node.

II. RELATED WORK

Vahdat and Becker [5] have studied the DTN areas and deployed a novel routing protocol for DTN called Epidemic. It spreads message to network wide like epidemic disease. The purpose of this scheme is to attain high delivery probability and decrease transmission delay. But disadvantage of this scheme is exhausting node's storage capacity because of the large amount of message copies and raises network overhead.

Spreading messages to random node mechanism in Epidemic is fixed by PRoPHET [6]. PRoPHET is novel routing protocol for DTN based on contact prediction. It stores an encounters and a movements history to predict the probability that messages will reach destination. Therefore, source node only sent the messages to nodes which have a high probability to reach destination.

But the large amount of message copies can't be fixed by PRoPHET, the large consumption of network resources caused by Epidemic can be diminished by controlling the message replication. Spyropoulos et al [2] introduced effective routing protocol called Spray and Wait. Only source nodes that have an authorization to replicate the message. So, the number of message copies is fixed throughout the simulation. In [2], the evaluation of Spray and Wait routing protocol have been done by observing di effect of traffic load to the network performance, percentage of total connected nodes under the varying the transmit range and the number of nodes (*M*). The simulation has a 100 nodes in a network and move according to a Random Way Point.

Maxprop [7] is another effective routing protocol for DTN based on schedule the messages transmitted to neighbor node or dropped. Maxprop divided the storage in to two parts, one part for messages that have a high priority to be transmitted and another part for messages that have a low priority to be transmitted or will be dropped first. Maxprop use an acknowledgement propagates to all nodes in network to remove the stale messages from network buffer. Burgess et al in [7] did the experiment based a real mobility and transfer of the bus. Using a 802.11b access point attached inside the bus to provide internet access to passengers inside the buss and passerby. The mobility and probability of contact occurs between two buses can be predicted since the bus has a regulated operation time and move through the regulated route. The performance of Maxprop routing protocol was evaluated by observing the influence of differ buffer size, and message size, differ buses radio range and differ number of package sent per hour to average latency and delivery probability.

In this paper, we did the experiment based on VANET consideration. We use the IEEE 802.11p access point attached inside On Board Unit (OBU). We focus to the vehicles that move along a highway road. The mobility of a vehicle is unpredictable. We can't predict the topology of the network or probability of contact occurs between two vehicles. The type of vehicle we use in this simulation is not limited to buses but include a private car, and mini buses that enter the Padalarang toll entrance. We evaluate the performance of Maxprop and Spray and Wait routing protocol by observing the influence of differ speed of nodes and differ number of nodes in the network to average latency, delivery probability and overhead ratio.

III. SYSTEM MODEL

In this paper we focus on the vehicles that move along a high way route. Buses, mini buses, and private car are the VANET's mobile nodes that DTN concept will be deployed on that. We did the survey to the research environment in order to get the valid data. The objective is to approach a rill condition of our simulation.

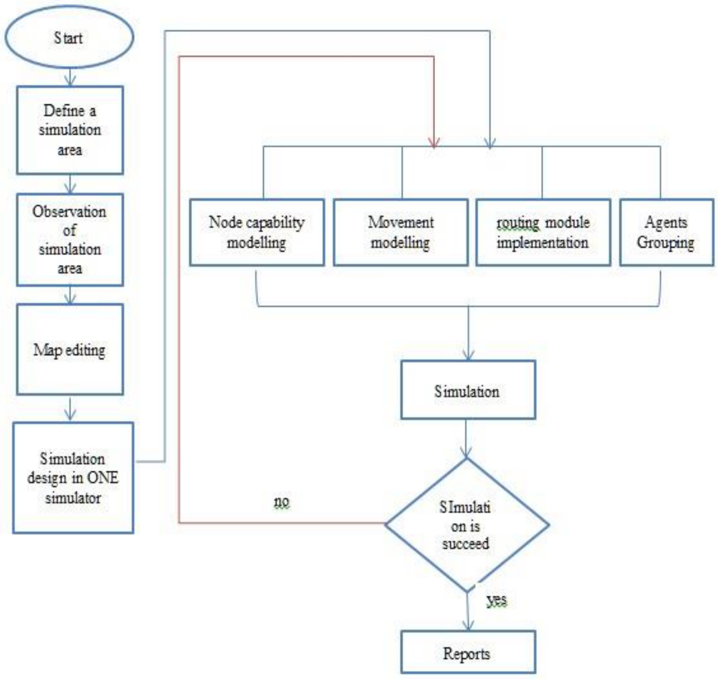

Figure 1. Sequence of simulation

Figure 1 shows the simulation sequences design. The simulation was started by define the characteristic of the environment we need for simulation. The direct survey has been taken to observing the situation and the condition of the simulation environment. A various data have been collected form the observation as an input for simulation design in ONE simulator.

A. Characteristic of Highway Roads

In this paper, vehicle move according to the given route on a geographical map with a different speed. A contact opportunity occurs when two nodes are in each other radio range. This simulation does not consider a minor factor such a traffic light, and traffic accidents as a factor that will obstruct the vehicle's movement. We choose Padalarang-Kopo, Bandung highway roads as our route.

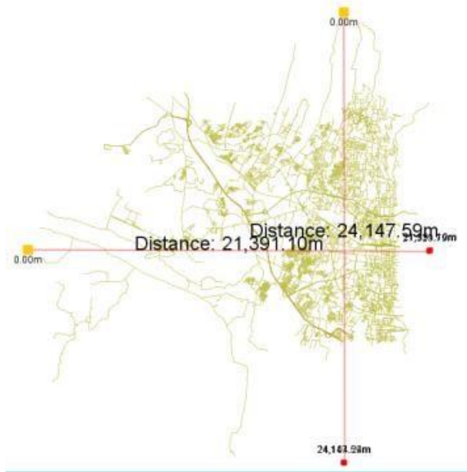

Figure 2. Geographical Map of Padalarang-Kopo Toll

Figure 2 shows the geographical map of Padalarang-Kopo toll road and the environment around toll road. The size of the map is 21.391x24.147 m^2. The information of a traffic volume obtained from calculating the number of vehicles enter the Padalarang toll entrance for a couple hours. The average speed of vehicles obtained by speed test along the roads using a smart phone application that integrated with GPS. This application gives some information such a variance of speed per second, minimum and maximum speed attained by vehicle, and total distance. The intensity of vehicles is determined as follows: Q indicates a number of vehicles enter the entrance in hour, V indicates the average of node's speed [8].

$$Q / V = I \tag{1}$$

The traffic volume *v* is determined by multiplying the total distance and intensity as follows [8]:

$$I \times d = v \tag{2}$$

Where, *I* indicates intensity of a vehicles, and *d* indicates total of distance in Km.

B. Design of a Node's Route

We imported the geographical map from OpenStreetMap. The file format of this map is *.osm. since we want that vehicles move along a predetermined route on a map, we use a map data defined as Well Known Text (WKT). WKT data is mostly converted from real world map such OSM or G-map or may be designed manually using Geographic Information System (GIS) programs such as OpenJUMP [9]. In this paper we do not create the routes manually. We remove several lines we don't need from our map and leaves the line we need to simulation.

Figure 3. Selected Route

Figure 3 shows the simulation route. This is the final route of simulation, the vehicles will move and follow this route on a geographical map in ONE simulator. The start point is from Padalarang toll entrance and the end point is Kopo toll exit.

C. Movements

In this simulation, we use a Map Based Movement model that integrated with one simulator. This movement model allows vehicles move along the road defined by map. This movement generated by internal movement module in ONE simulator.

ONE simulator released a three type of a Map Based Movement model [9]. 1) Random Map-based Movement (MBM). MBM is the simplest movement model of Map-based model. Nodes move with a different way but constantly follow the defined route on a map. This movement model provides a not very accurate data of a real human mobility. 2) Shortest Path Map-Based Movement (SPMBM), nodes choose one random point as destination and move through the shortest route toward that point. The destination may be chosen randomly or based on Point of Interest (POI). POI is chosen from a popular destination lists such a gas station, restaurant, and shopping center. 3) Routed Mab-based Movement (RMB), node moves along a fixed infrastructure like train and buses.

IV. SIMULATION AND EVALUATION

A. Methodology

The main approach of the simulation to evaluate performance of VANET is the use of mobility model. Mobility model controls the movements of a vehicle corresponding to our simulation objectives.

We use a map based movement model as the best movement model for our simulation since we need the vehicles move and follow predetermined route on a map. It simplifies the evaluation process of a network performance in certain areas. The problem is to modeling the factor that would obstruct the mobility of vehicles such a car crash in to our simulation. It is better if we can put the vehicle in a certain coordinate. In this paper, the coordinate where the vehicles placed is determined by a simulator. We also didn't put a road side along the road as a static relay node in our simulation.

B. Tools Chain

The objective is to design a simulation of VANET that as close as possible with the rill condition around a Padalarang-Kopo toll road to DTN simulator.

First, we imported our geographical map from OpenStreetMap. The format of map data taken from OpenStreetMap is *.osm file. Since we use map based movement model, and the type of movement model required a WKT file format, we converted the map data in to WKT file using osm2wkt converter that written with java language. The editing process performed using OpenJump.

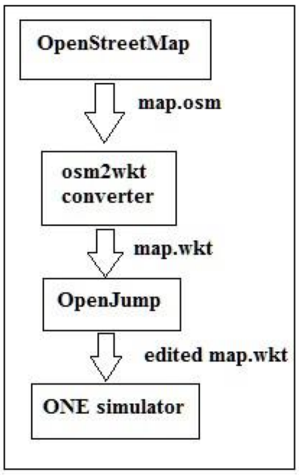

Figure 4. Simulation toolchain

Figure 4 describe the sequence of tools utilization. Hereafter editing the geographical map, we put the WKT map as the input map to ONE simulator. In ONE simulator we begin to set our simulation scenario. ONE (Opportunistic Network Environtment) is the DTN simulator based on Java. The main functions of ONE simulator is to modeling the movement of nodes, message handling, routing model, and contacts between two nodes [9]. Movement model is implemented by a movement modules and routing model is implemented by routing modules. But it is possible to create our own movement or imported from external movement generators. But in this paper we use an internal movement model that integrated with ONE. The results of the simulation will be saved in reports file. The reports are generated by report module.

C. *Simulation Setup*

The scenario has been simulated for 720 second. 720 is the duration taken to drive through the route from Padalarang toll entrance to Kopo toll exit. This data is taken from survey.

The simulation has a 179 of nodes along a 15.589Km of road. 50 of nodes act as a source node 50 other as a destination and 169 other as a relay node. They move together and follow the route and implement each routing protocol mechansims during the simulation. The radio range of each node is 250m based on IEEE 802.11p. The transmission speed that achieved by VANET is 3Mbps up to 21Mbps [10]. Since Indonesia have no any regulation about this, we set the transmission speed is 9Mbps or 1.125MBps. We have investigated a various speed rate of message transmission and the most effective for our simulation is 9Mbps. The speed of nodes is 83.77Km/h up to 120.98Km/h. the message size sent during a transmission opportunity is 1MB with 90MB size of storage capasity.

TABLE I. PARAMETERS OF SIMULATION

No	***Parameters***	
1.	Interface	Wifi 802.11p
2.	Transmit Range	250
3.	Transmit Speed	1.125MBps
4.	Number of Agents Group	3
5.	Message Size	1MB
6.	Buffer Size	90MB
7.	Number of Nodes	179
8.	Size of the Simulation Environment	21391x24147 m^2
9.	Total Distance	15.589Km
10.	Speed of Node	83.77-120.98Km/h

TABLE I shows the parameter that we use for the simulation. for visualize the simulation, ONE was integrated with Graphical User Interface (GUI).

D. *Performance Paramenters*

1) *Delivery Probability*

Delivery Probability is the ratio of total amount of messages arrive in destination and total amount of messages have been sent [11].

$$Delivery\ Probability = \frac{number\ of\ messages\ arrive\ in\ destination}{number\ of\ messages\ have\ been\ sent} \quad (3)$$

2) *Overhead Ratio*

Overhead ratio is a number of messages except the original messages have been sent during the simulation. the messages sent for supporting the transmission process [11].

$$Overhead\ Ratio = \frac{number\ of\ relayed\ messages - number\ of\ received\ messages}{number\ of\ received\ messages} \quad (4)$$

3) *Average Latemcy*

Average latency is the transmission average time needed from the message is produced until the message arrives in the destination [11].

$$Latency\ Averge = \sum_{i=1}^{n}\left(\frac{time\ when\ message\ received - time\ when\ message\ produced}{number\ of\ message\ received}\right) \quad (5)$$

E. *Simulation Result*

The various performance parameters use to evaluate the performance of Maxprop and Spray and Wait routing protocol. We have observed the effect of differ buffer size, message size, speed of node, and number of node to average latency, overhead ratio and delivery probability of both routing protocol. We set the interval of message production is constant. The interval of message production is 10 up to 20 second.

1) *Scenario 1 : Effect of Node Speed*

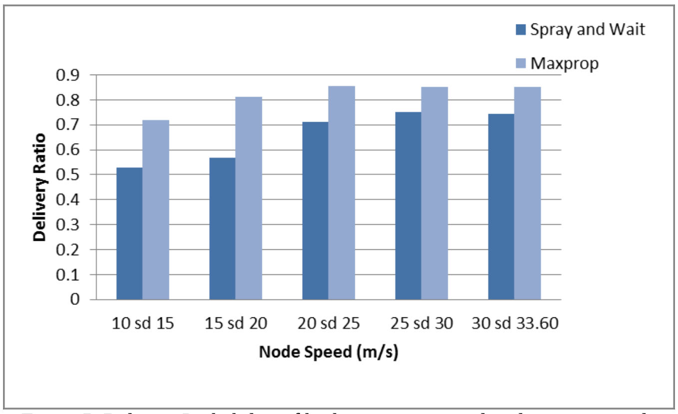

Figure 5. Delivery Probability of both routing protocol under varying node speed

Figure 5 shows the delivery probability of both routing protocol under varying speed of node. In a general, the delivery ratio of Maxprop increase caused the increment of node speed. The increment of node speed helps Maxprop to find the destination faster. But when nodes move with the high speed, the contact duration between two nodes is short. It caused node aborted the transmission of the message and move to find other node and other transmission opportunity. The delivery probability of Maxprop increase for about 5.9%.

Spray and Wait got a lot of advantages of the increment of node speed. Since Spray and Wait doesn't has a complex mechanism which Maxprop does, it helps Spray and Wait to reduce the duration of wait phase to do the direct delivery and send message to the destination. In addition to gain the delivery probability, it also reduces the average latency of Spray and Wait and will be explained by Figure 6. The delivery ratio of Spray and Wait is constantly raised and the increment of delivery probability of Spray and Wait is about 9.37%.

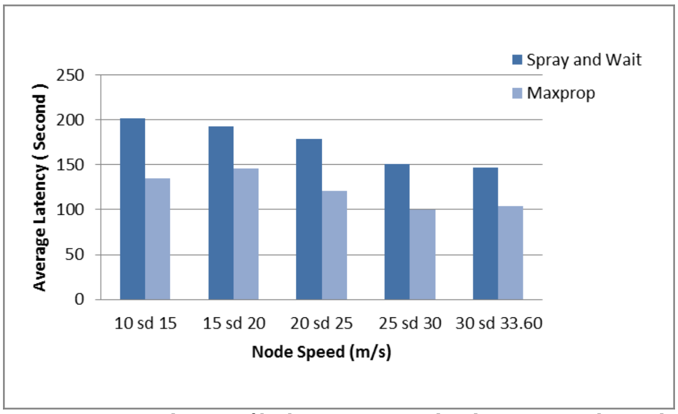

Figure 6. Average latency of both routing protocol under varying node speed

Figure 6 shows the average latency of both routing protocol under varying speed of node. The duration of end-to-end message transmission of Spray and Wait is longer than Maxprop. Spray and Wait has 53 second longer latency than Maxprop. It caused by a mechanism which owned by Spray and Wait. Spray and Wait limits the message replications by initiates the L effective number of message copies in a source node. Therefore, after all message copies have been relayed to neighbor nodes, L distinct nodes carry the message and wait until find the destination to perform direct transmission.

We can see that the average latency of both routing protocol reduced by the increment of node speed. As mentioned before, when node moves faster, they help to spread message faster and in the same simulation duration the contact occurred between two nodes is more frequent. Then, the average latency is reduced.

The average latency of Spray and Wait is reduced for about 7.6% and Maxprop is for about 5.3%. The increment of node speed gives the biggest impact to Spray and Wait. It is very helpful for node to reduce the wait phase duration.

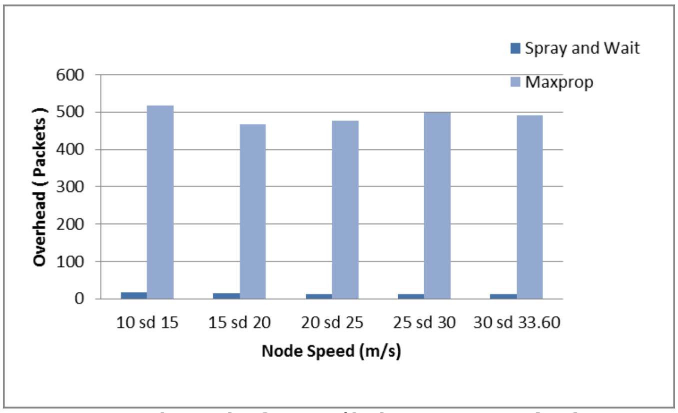

Figure 7. Fig. 7 The Overhead Ratio Of both Routing Protocol under varying node speed

Figure 7 shows the overhead ratio of both routing protocol under varying node speed. Maxprop relayed about 42 times more messages than Spray and Wait. Maxprop generates a lot of messages for several mechanisms in order to define which packet will be first transmitted or deleted. In addition, Maxprop also sent an acknowledgement to all nodes in the network in order to delete the stale message from node's buffer either because the message has been reach the destination or being dropped.

The number of message copies initiated by Spray and Wait is fixed from the beginning of simulation until the end of simulation. Therefore, Spray and Wait has a lower overhead than Maxprop. As a general, the overhead ratio of Spray and Wait is decrease for about 10.8%. The increment of node speed limits the duration contact between two nodes to communicate to each other. Since Spray and Wait only wait for direct delivery in a wait phase, node doesn't need to communicate a lot of information to each other in wait phase. Therefore, it reduces the overhead ratio of Spray and Wait.

The overhead ratio of Maxprop is decrease for about 1.21%. But Maxprop face a various circumstances as an effect of node speed. Maxprop communicate a lot of information in contact opportunity with neighbor node. As described in a previous paragraph, the uncompleted mechanism is the reason for nodes to try and find other contact opportunity. And it gains a lot of relayed messages and gains the overhead ratio of

Maxprop. And we can see that the overhead of Maxpropis increase in speed 25 up to 30 m/s.

2) Scenario 2 : Effect of Node Volume

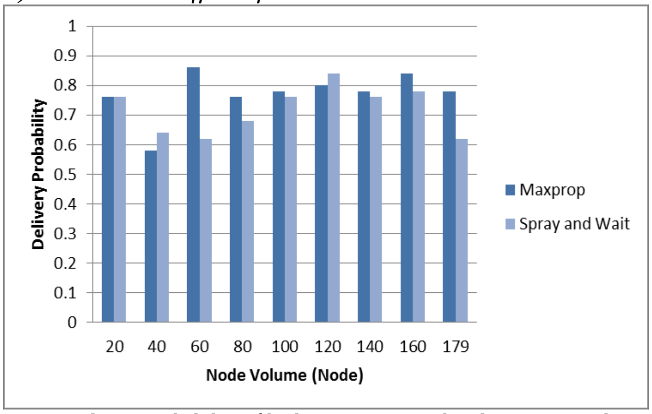

Figure 8. Delivery probability of both routing protocol under varying node volume

Figure 8 shows the delivery probability of both routing protocol under the varying node volume. For evaluate the effect of node volume to Spray and Wait performance, we have to define the number of L effective message copies that initiated by source node. In this research, we set the same number of L message copies for each node volume. It is cause the fluctuation of the performance achieved by Spray and Wait. Delivery ratio of Spray and Wait shows that a small number of vehicles get the sufficient number of message copies. Then, the delivery probability is increase. When the number of vehicles begins to require a larger number of message copies and the given number of message copies is not sufficient, the delivery probability is going down.

A various fluctuation is also faced by Maxprop. The uncomplete mechanism in Maxprop is the main reason for decreasing the delivery probability. The high speed of node helps Maxprop to meet another node and meet the destination faster. Which is mean the messages can also travel faster within the network. But it also brings the problem of short duration of contact between peers. Since the number of vehicle is going up, there are a lot of probability factor compared by node and required a longer duration. Several mechanism are aborted before its completely done. Then, decreases the delivery probability of Maxprop and increases the average latency as described by Figure 9 below.

Both routing protocol face the unstable performance. But, as general the performance of both routing protocol is increase. The delivery probability of Maxprop increase for about 2% and Spray and Wait increase for about 1.79%.

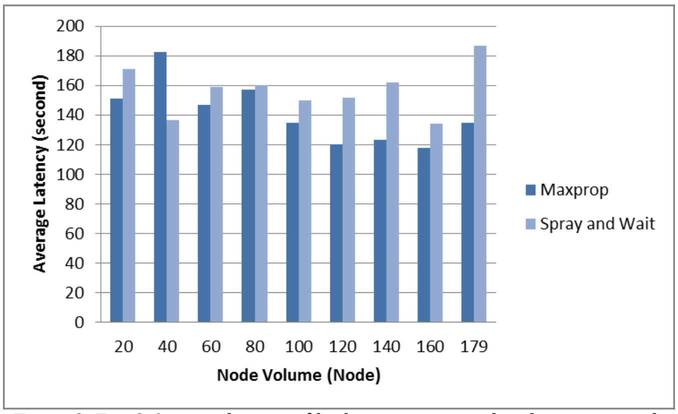

Figure 9. Fig. 9 Average latency of both routing protocol under varying node volume

Figure 9 shows the average latency of both routing protocol under varying node volume. The average latency of Spray and Wait is longger than Maxprop for about 13.36%. The average latency of Spray and Wait is relatively increase for about 2.56%. The performance of Spray and Wait affect by node volume. To define the number of message copies initiated by source node, we need to include the total number of node in the network in to the calculation [2]. When the network is more dense, nodes will looking for the destination one by one to each node. And its increase the average latency of Spray and Wait.

The average latency of Maxprop is relatively decrease for about 0.48%. when the network is more dense, nodes have a bigger opportunity to be in radio range of each other. It helps Maxprop to forward the messages to neighbor node faster, and decrease the average latency. In certain condition under node volume, the average latency of Maxprop is increase drasticaly. It has a corelation with the decrement of delivery probability and probability comparation described in previous paragraph. Nodes require a longer duration for comparing the cost probability of each node, since the number of node is larger. This comlplex mechanism was interrupted before completely done. Then, the average latency is increase and the delivery probability is decrease.

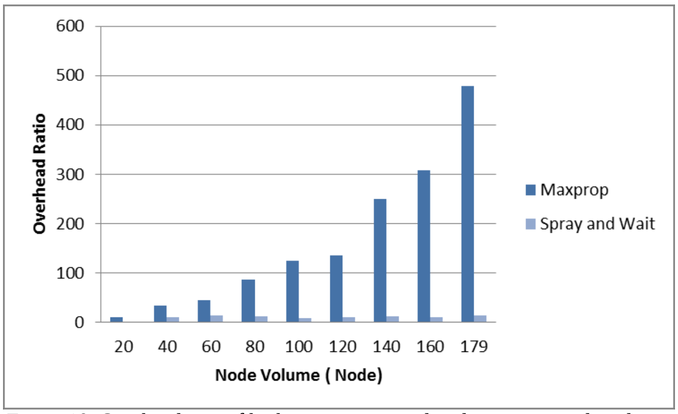

Figure 10. Overhead ratioof both routing protocol under varying node volume

Figure 10 shows the overhead ratio of both routing protocol. Maxprop relays 14 times more messages than Spray and Wait. The increament of node volume increases the overhead ratio of both routing protocol. The overhead ratio of Maxprop increase for about 74.70% and the overhead ratio of Spray and Wait increase for about 88.81% .

V. CONCLUTION

In this paper we presented the evaluation of performance of DTN routing protocol Maxprop and Spray and Wait. Both routing protocol are implemented in VANET. we focus to vehicle that move along a high road. The simulation was taken in Padalarang-kopo toll road.

The evaluation result shows that varying node speed give the biggest impact to average latency of Maxprop and the delivery ratio of Spray and Wait. The varying node volume give the biggest impact to overhead ratio of both routing protocol.

The effect of node volume to Spray and Wait performance will be accurately measured by calculating the L number of efficient message copies spread by source node. Measuring the Spray and Wait performance under varying node volume regardless the L message copies calculation caused the fluctuation of its performance.

Both routing protocol need to communicate more message when the network is quiet dense. Nodes have to pass a lot of node to forward the message copies or even just to make sure that node is destination or not.

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