Addition of Neighbors in the Number of Vanets Node Factors: DSR-PNT Performance Study

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Received: September 29, 2022; Accepted: December 12, 2022; Published: December 31, 2022

Abstract

Vehicular Ad Hoc Networks (VANETs) are part of Mobile Ad Hoc Networks (MANETs). Vehicles that become a node in VANETs move quickly, and speed is variable to change the topology quickly. One of the most prevalent challenges in VANETs is vehicle connection and picking the most appropriate vehicle to act as an intermediate between the sender of the packet and the destination to decide the node. The most suitable technique for communicating nodes requires research in creating the most desirable nodes as forwarders. Vehicle speed, acceleration, the direction of movement, and vehicle quality are examples of these factors. Futures Total Weight Route (TWR) may determine the ideal route from source to destination if these three characteristics at each neighbor node are known. This study discusses the impact of adding a parameter—the neighbor node on the routing metric in determining the value of TWR. The contribution of this research is to improve the performance of data packet transmission by adding a neighbor node on a DSR-PNT in the selection of routing nodes (node forwarder, next hop) to increase the PDR (packet delivery ratio). TWR provides the reference parameter (Speed, Acceleration, Link Quality) most prioritized continuously according to the changing scenario and node condition.

Keywords: Connectivity Model, Pattern Connectivity, Relay Node, Vehicular Networks, VANET, VANET Scenario.

1 Introduction

VANETs network was formed based on mobile computing where vehicles become a node. Today, VANETs developed to communicate between vehicles on highways and urban areas (Toh, Delwar and Allen, 2002). VANET is a technology that enables mobility everywhere for mobile users (Zafar *et al.*, 2021). VANET is the core structure of intelligent vehicles (Alharthi, Ni and Jiang, 2021). VANET offers several user apps for passengers and drivers and security and internet access apps. The efficient data transmission between vehicles, reliable routing protocols are considered a significant challenge

Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications (JoWUA), volume: 13, number: 4 (December), pp. 196-210. DOI: *10.58346/JOWUA.2022.I4.013*

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(Kandali, Bennis and Bennis, 2021). VANET appears to fix traffic accidents, traffic jams, and infotainment (Hossain *et al.*, 2021).

VANETs (Vehicular Ad Hoc Networks) is a network that is dynamic and highly susceptible to delay time of the data transmission from the sender to the receiver because the node of VANETs is constantly changing (multi-hop communication on vehicle and roadside units). Therefore, it needs a method to improve data transmission efficiency on VANETs. VANETs (Vehicular Ad Hoc Networks) is a network-based mobile ad hoc network that runs the principle of MANETs (Mobile Ad Hoc Network). In general, VANETs require RSU (Roadside unit), which acts as a bridge/connection between nodes (vehicle) in VANETs. In the real world, of course, there is a condition where there is absolutely no way the vehicle, the road is very congested and the deserted street. Here are circumstances that may affect data transmission efficiency VANETs (Raw, 2012). Traditional routing protocols do not support VANETs.

A mobile ad-hoc network (MANET) collects lymph nodes that can interact on sensitive radio communications and dynamic green goods with radio connections and without association infrastructure (Albu-Salih and Al - Abbas, 2021). The consistency of such highly dynamic network routing must be considered in VANETs as communication links are destroyed in VANETs more often than Mobile ad-hoc Networks (MANETs) (Kazi, Khan and Haider, 2021). MANETs generally consist of wireless portable devices that can connect and eject networks for free. Due to deficiencies in an organization, MANET is regulated at a lower cost than necessary by deploying a cable network (Nithya *et al.*, 2022). MANET is a wireless network consisting of autonomous, self-organized, limited energy capacity, and mobile nodes (El-Sayed, Younes and Alghamdi, 2021; Shan *et al.*, 2021).

Because of its capacity to set up flexible networks, MANET is predicted to be one of the technologies that suit the demands of future Internet connectivity (Nguyen *et al.*, 2021). MANET plays a crucial role in recent improvements in technologies and services that dynamically build network connections that bring variation in network topology (Rathish *et al.*, 2021).

Increase the efficiency of data transmission on mobile networks such as VANETs. In recent years, opportunistic networks based on MANET's Ad-Hoc Mobile network have provided better solutions to complex social network data transmission problems (Fang *et al.*, 2021; Mizeraczyk *et al.*, 2021). There are several points to consider: the volume of traffic, the mode of data transmission employed, and the designation as a case study.

In this case, the authors take the urban areas (urban) as the location for the case study. The urban area is an area that has a high traffic density, and the driver in urban areas urgently need information on the highway. This condition requires optimizing the data distribution when information is transmitted from the sending node to the receiving node.

The study aims to increase DSR performance as assessed by a routing metric (Packet Delivery Ratio, Routing Overhead, delay). It is finding the value of the total weight of the route (TWR) with additional parameters, that neighbor node as a reference to determine the reliable next-hop node to looking for a weight factor to each parameter. TWR can be known parameters prioritized according to the node's state. Such nodes are classed as low-priority access to media, and their data transmission is scheduled using time-sharing of multiple access methods (Vergaray-Mendez, Meneses-Claudio and Delgado, no date; Bouazzi *et al.*, 2021).

2 Literature Review

2.1 Predicting Node Trend Concept

Predicting Node Trend (PNT) is a node movement prediction method resulting in the delivery package. Forwarder nodes can choose the most optimal node to forward the packet to get to the destination (Shen *et al.*, 2015). Improvement on the PNT is as follows.

1. Routing Metric Improvement and calculate the total weight of the route (TWR).
2. Predict the future of the TWR node and calculate the threshold stability to determine whether the relay node is stable.

2.2 Total Weight Route (TWR) Calculation

Four main factors are used as a parameter in the routing metrics. Based on four factors, TWR is calculated to find that the next-hop node is the most optimal. Details of the four factors are as follows:

1. The speed and acceleration of the vehicle
   The larger the TWR, the significantly the difference in speed and acceleration between the two vehicles. The reason is to anticipate link breakage caused by the difference in speed of the vehicle. The vehicles are moving at the speed and acceleration of the same relative in radio communication distance in a shorter period.
2. The direction of movement of vehicles
   Logically, the vehicles are moving in the same direction in the radio communication range for a longer time. Therefore, the vector direction also becomes crucial in the calculation of TWR. The direction is an essential parameter in determining the preferred route—values obtained from the different directions of the angular difference calculation driving directions.
   The quality of the links between vehicles
3. Parameter another area to consider is the link quality between the source node and the next-hop. In VANETs, other vehicles, buildings, and other objects can affect the quality of the links between vehicles.

Based on information from the movement of vehicles, we can get the Sij stability index of the link (i, j) (Shi, Yao and Bai, 2004).

$$Sij = 1 - \frac{\min(\sqrt{(i_x - j_x)^2 (i_y - j_y)^2}; r)}{r}$$

Information:

r = maximum communication distance between two adjacent nodes.

ix, iy = coordinates of node i.

jx, jy = coordinates of node j.

The value of the link quality Q.

TWR from the source node to the next-hop node is calculated using the following equation:

$$TWR = fs \times |Sn\text{-}Sd| + Fa \times |An\text{-}Ad| + Fd \times |\Theta n\text{-}\Theta d| + Fq \times Q$$

Information:

Sn, An, and Θn = speed, acceleration, and direction of the next-hop node.

Sd, Ad, and Θd = speed, acceleration, and direction of the destination node.

fs = weighting multiplier speed.

fa = the weight multiplier acceleration. fd = weighting multiplier distance.

fq = weight of the link quality multiplier.

Q = the quality of the link between the source node to the next-hop node.

2.3 Total Weight Route Future Prediction

Future TWR is calculated based on the following factors:

1. Prediction velocity and acceleration of the vehicle
   The study assumed that the acceleration of a node is constant during the period TWR future calculations—node speed change according to the formula acceleration.
2. Prediction of the direction of movement of vehicles
   In the actual world, when there is a bend in the road, the car accelerates negatively, and the turn signal lights illuminate. Vehicles that meet these conditions are calculated in the vector direction with the help of GPS.
3. Prediction quality of the links between vehicles
   Based on the vehicle's speed, acceleration, and direction, this method gets a node's coordinates in the future. The quality of the links between nodes can be calculated-based on the coordinates of the second node.

After getting the data, the future TWR of the nodes can be calculated. This value is used as a parameter to determine whether a node is eligible for a relay node. Furthermore, the feasibility assessment of a node to be used as a relay node is described in Table 1.

Table 1: Assess the Feasibility of a Ready Node

Current TWR	*Status*	*Future TWR*	*Conclusion*
Optimal Optimal	Unstable Stable	Better	Select node Select node
Suboptimal	Unstable	Better	Select node
Suboptimal	Stable Other conditions		Select node Ignore node

TWR today: the smaller the value is, the better TWR. Node with TWR smallest value is "Optimal," while another node with the value of good TWR is called "Suboptimal."

Status: A value W is determined as a threshold value. If the absolute value of the difference in the current and future TWR (Δ TWR) is less than W, then the node is regarded as a stable node. If Δ TWR is more than W, the node is considered unstable.

Simulations were carried out using Network Simulator (Erdmann *et al.*, 2012). The parameter simulation conducted in this study can be seen in Table 2.

Table 2: Simulation Parameters VANET

Number of nodes	100,120,140,160
Channel type	Wireless
Routing protocol	DSR
Mac type	802.11p
Source of traffic	Constant bit rate (CBR)

Package size	512 bytes
Network simulator	NS-2
Simulation environment	Urban (urban)
Propagation models	Two Ray Ground
Model mobility generator	SUMO [6]
Speed	15 m/s, 20 m/s

3 Simulation and Results

The trial results in this study were divided into two parts, namely the grid scenarios and the actual scenario. The trial results of this study can be seen in the sub-chapters below.

3.1 Grid Simulation

The test scenario grid in this study was performed 10 times with random node mobility scenarios on a map grid at size 1000 m x1000 m. The number of nodes in this study was 100, 120, 140, and 160. Node 160 is the maximum number of nodes used in this scenario.

Table 3: Packet Delivery Ratio of AODV, DSR & DSR- PNT with 15ms Speed at Grid Scenario

Number of Nodes	*AODV*	*DSR*	*DSR- PNT*	*(DSR vs DSR-PNT)*
100	0.6872	0.7231	0.9364	0.2133
120	0.7214	0.7918	0.9783	0.1865
140	0.7367	0.7274	0.9779	0.2505
160	0.7423	0.7569	0.9711	0.2142

Table 4: Packet Delivery Ratio of AODV, DSR & DSR- PNT with 20ms Speed at Grid Scenario

Number of Nodes	*AODV*	*DSR*	*DSR- PNT*	*(DSR vs DSR-PNT)*
100	0.6946	0.7567	0.9482	0.1915
120	0.7376	0.7830	0.9629	0.1799
140	0.7255	0.7423	0.9679	0.2256
160	0.7469	0.7246	0.9773	0.2527

Based on the data in Table 3. and Table 4. above, a graph representing the packet delivery ratio calculate results can be seen in Figures 1. and 2.

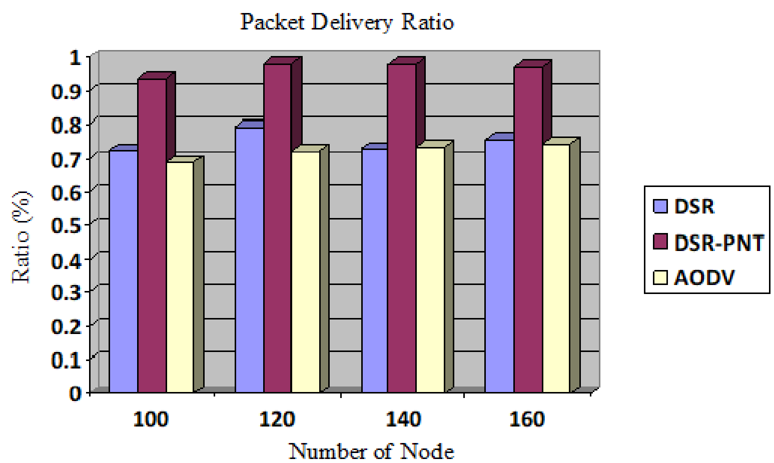

Figure 1: Packet Delivery Ratio of AODV, DSR &DSR-PNT with 15ms Speed at Grid Scenario

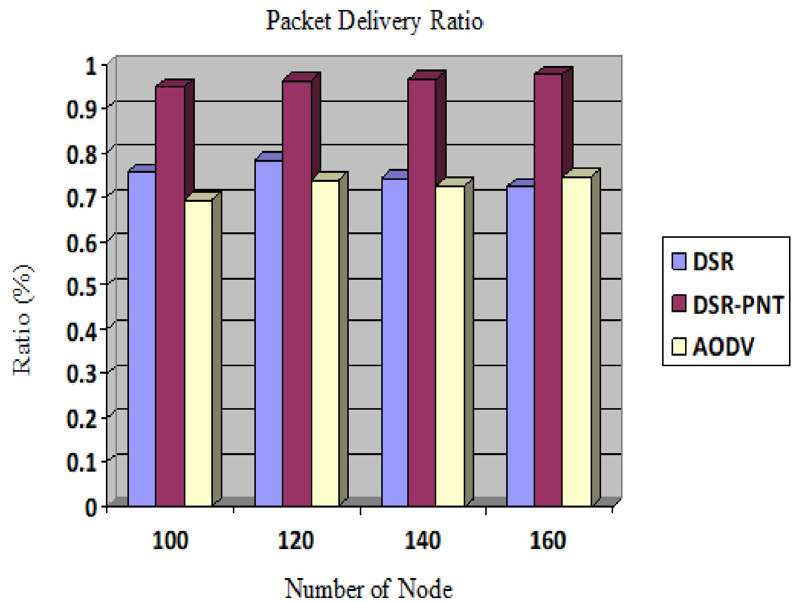

Figure 2: Packet Delivery Ratio of AODV, DSR & DSR-PNT with 20ms Speed at Grid Scenario

In Figure 1, there is an increased packet delivery ratio in DSR PNT modification of 0.2133 at node 100, 0.1865 on node 120, 0.2505 at node 140, 0.2142 at node 160. It is concluded that on area 1000x1000 original DSR protocol has had a packet delivery ratio that is already high, in the range of 70%. In the AODV protocol, the packet delivery ratio in this research scenario falls in the range of 70%. In comparison, the DSR-PNT packet delivery ratio increased to a range of 90%. TWR future calculations cause this to determine the most optimal relay node to minimize the route error and perform packet drop when the relay nodes are not included in the list received from the RREQ.

It contributed an assist to network congestion in the VANETs network. Packet deliveryratio remains stable at node 160 means a high number of node density most likely to increase the number of nodes that qualify as relaying nodes to create many alternative routes to the destination so that broken links can be minimized.

Table 5: Average end to end Delay at Grid Scenario with 15ms Speed

Number of Nodes	*AODV*	*DSR*	*DSR- PNT*	*(DSR vs DSR-PNT)*
100	232.32ms	163.01ms	444.70ms	281.69ms
120	253.45ms	214.34ms	404.94ms	190.60ms
140	287.76ms	171.67ms	414.14ms	242.47ms
160	296.17ms	201.69ms	413.11ms	211.42ms

Table 6: Average end-to-end Delay at Grid Scenario with 20ms Speed

Number of Nodes	*AODV*	*DSR*	*DSR- PNT*	*(DSR vs DSR-PNT)*
100	224.67ms	158.32ms	432.64ms	274.32ms
120	263.59ms	184.47ms	424.43ms	239.96ms
140	271.42ms	173.73ms	410.29ms	236.56ms
160	293.66ms	196.18ms	443.12ms	246.94ms

Based on the data in Table 5 and Table 6 above, a graph representing the calculation results of average end-to-end delay can be seen in Figures 3 and 4.

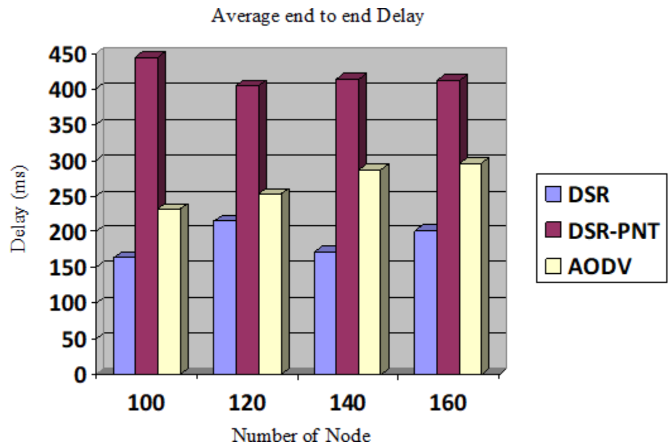

Figure 3: Average AODV, DSR, and DSR-PNT end-to-end Latency with 15ms Speed at Grid Scenario

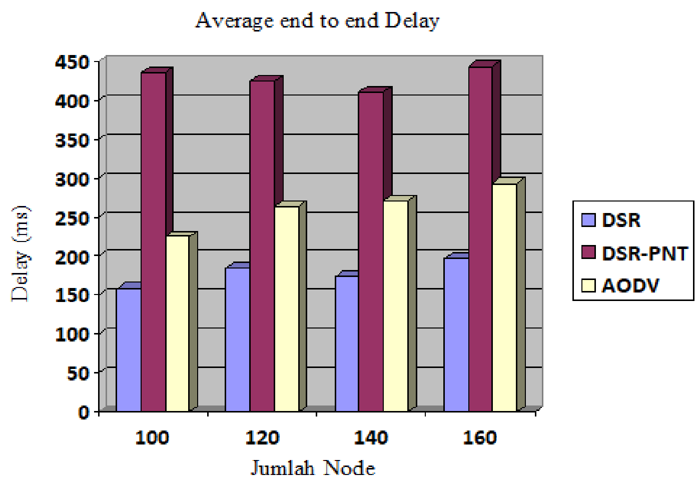

Figure 4: Average AODV, DSR, and DSR-PNT end-to-end Latency with 20ms Speed at Grid Scenario

Figures 3 and 4 show that increased delay occurred in the DSR-PNT since node 100, whilethe DSR protocol has a lower delay on all the many nodes in this study. The smaller the number of nodes used as a scenario, the less the average end-to-end delay. However, the low delay and fewer nodes do not guarantee that the packet delivery ratio increases. Due to fewer nodes being provided as a neighbor node, so fewer nodes qualify as a relay nodes. The addition of speed variations in the speed of 15ms and 20ms on average end-to-end delay parameters does not significantly change the DSR-PNT protocol. However, it provides a pretty small change in DSR and AODV protocol. DSR-PNT is not too affectedby the factor of speed variations due to the selection of relaying nodes through computation TWR that caused the delay in the DSR-PNT. While the protocols DSR and AODV are a selection relaying node by node most eager to transmit a reply to the sender node with a short relative latency.

In Figures 5 and 6 it can be seen that the routing overhead of DSR-PNT is slightly superior to the DSR protocol. Selection of the appropriate node in the node relaying orEligible contained in the relay node list set makes the DSR-PNT slightly superior. AODV routing protocol has the highest overhead because it has several packets, packet reception, and high packet error. It is directly proportional to the increase in the number of nodes in the network. The higher the number of nodes in the network, the routing overhead of AODV is likely to increase. The second method uses the current broadcast route discovery method because of the increased number of nodes, the send rate, receive error rate, and rate increase. DSR - PNT is not too affected to speed variation factor for the selection of relaying nodes through TWR calculations, while the DSR and AODV protocol to vote relaying node by node fastest node sends the reply to the sender. The addition of speed variations in the speed of 15ms and 20ms on overhead routing parameters does not provide a significant change to the DSR-PNT protocol. However, it provides a minor change in DSR and AODV protocol.

Table 7: Overhead Routing Grid Scenario Speed 15ms

Number of Nodes	*AODV*	*DSR*	*DSR- PNT*	*(DSR vs DSR-PNT)*
100	4983	3243	2987	256
120	5107	3458	3142	316
140	5324	3776	3544	222
160	5529	3990	3793	197

Table 8: Overhead Routing Grid Scenario Speed 20ms

Number of Nodes	*AODV*	*DSR*	*DSR- PNT*	*(DSR vs DSR-PNT)*
100	4713	3359	2933	426
120	4989	3498	3129	369
140	5247	3627	3487	140
160	5355	3842	3676	166

Based on the data obtained in Table 7 and Table 8, a graph can be made representing the result of the routing calculation overhead that can be seen in Figure 5 and Figure 6.

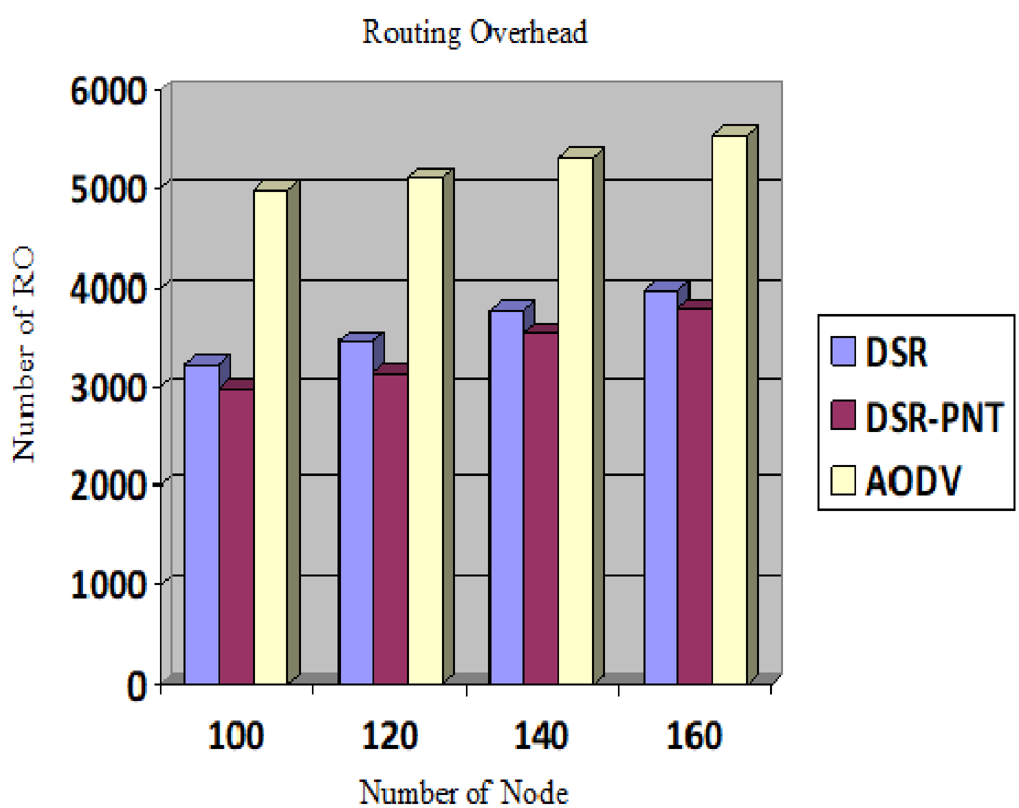

Figure 5: Routing Overhead AODV, DSR & DSR-PNT with 15ms Speed at Grid Scenario

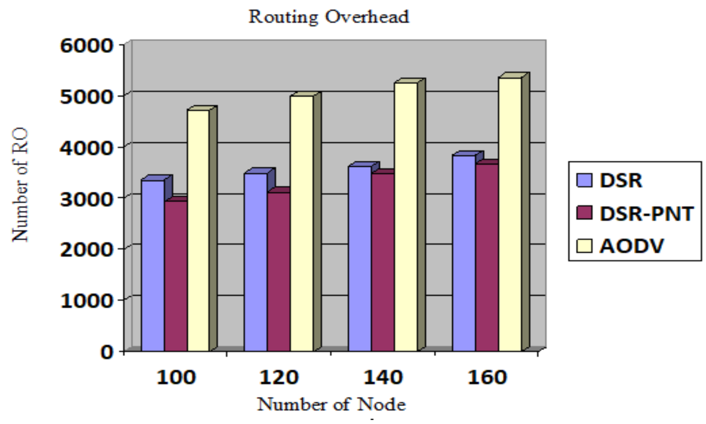

Figure 6: Routing Overhead Delay AODV, DSR & DSR-PNT with 20ms Speed at Grid Scenario

In Figure 6.6, the routing overhead of DSR-PNT is slightly superior to the DSR protocol. The second method uses the current broadcast route discovery method because of the increased number of nodes, the send rate, receive error rate, and rate increase. Selection ofthe appropriate node in the node relaying or Eligible contained in the relay node list set makes the DSR-PNT slightly superior. AODV routing protocol has the highest overhead because it has several packets, packet reception, and high packet error. It is directly proportional to the increase in the number of nodes in the network. The higher the numberof nodes in the network, the routing overhead of AODV is likely to increase.

DSR - PNT is not too affected to speed variation factor for the selection of relaying nodes through TWR calculations, while the DSR and AODV protocol to vote relaying nodeby node fastest node sends the reply to the sender. The addition of speed variations in the speed of 15ms and 20ms on overhead routing parameters does not provide a significant change to the DSR-PNT protocol. However, it provides a minor change in DSR and AODVprotocol.

3.2 Real Simulation

This real trial scenario in this study was performed 10 times with random node mobility scenarios on a map grid measuring 800 x 600 m. The number of nodes in this study was 100, 120, 140, and 160. Node 160 is the maximum number of nodes used in this scenario.

Table 9: Packet Delivery Ratio of AODV, DSR & DSR - PNT with 15ms Speed at Real Scenario

Number of Nodes	*AODV*	*DSR*	*DSR- PNT*	*(DSR vs DSR-PNT)*
100	0.6862	0.7160	0.9318	0.2158
120	0.7241	0.7077	0.9270	0.2193
140	0.7593	0.7701	0.9517	0.1816
160	0.7732	0.7414	0.9509	0.2095

Table 10: Packet Delivery Ratio of AODV, DSR & DSR- PNT with 20ms Speed at Real Scenario

Number of Nodes	*AODV*	*DSR*	*DSR- PNT*	*(DSR vs DSR-PNT)*
100	0.6913	0.7032	0.9331	0.2299
120	0.7421	0.7174	0.9243	0.2069
140	0.7619	0.7680	0.9532	0.1852
160	0.7743	0.7328	0.9443	0.2115

Based on the data in Table 9 and Table 10 above, a graph representing the packet delivery ratio calculate results can be seen in Figures 7 and 8.

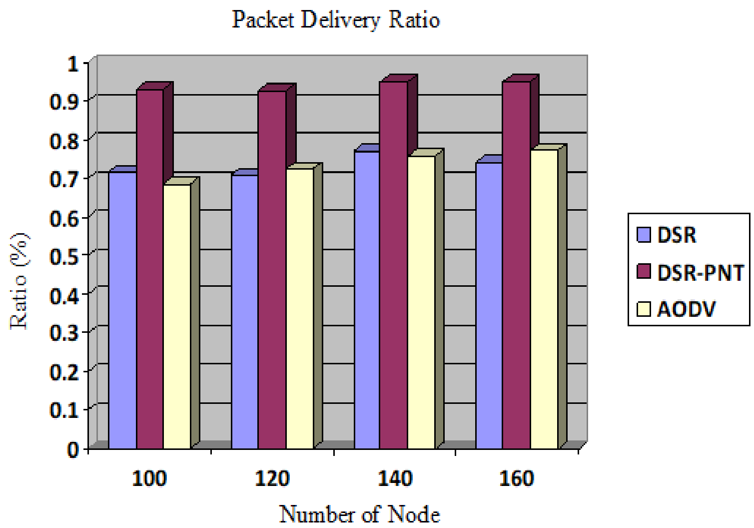

Figure 7: Packet Delivery Ratio DSR, DSR-PNT & AODV Real Scenario at 15ms

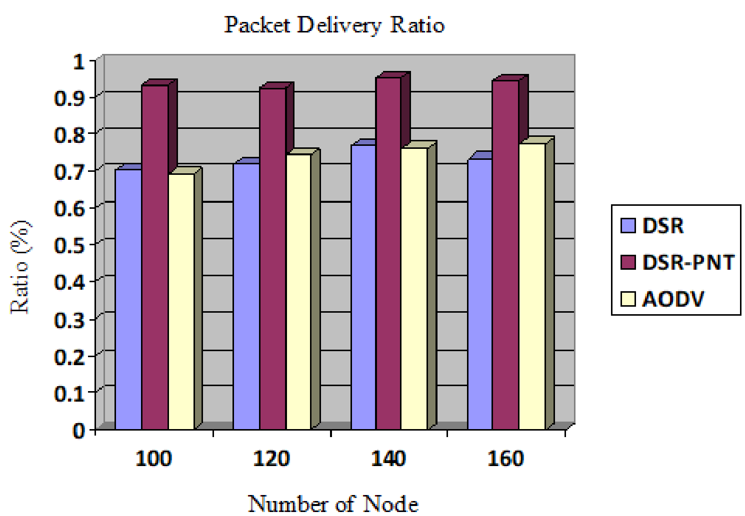

Figure 8: Packet Delivery Ratio DSR, DSR-PNT & AODV Real Scenario at 20ms

In Figure 8, there is an increasing PNT DSR modification packet delivery ratio of 0.2299 at node 100, 0.2069 on node 120, node 140 0.1852, and 0.2115 at node 160. It is concluded that in the area of 800x600 original DSR protocol already has a packet high delivery ratio is in the range of 70%. In the AODV protocol, the packet delivery ratio in this research scenario falls in the range of 70%. DSR-PNT packet delivery ratio increased to a range of 90%, TWR future calculations cause this to determine the most optimal relay node to minimize the route error and perform packet drop when the relay nodes are not included inthe list received the RREQ.

The speed to 20ms variation does not provide a significant change in packet delivery ratio. It contributed an assist to network congestion in the VANETs network. Caused by TWR calculations, which make the selection of nodes included in the eligible node, the node drops the packet if a node has a higher speed but is not included in the eligible node. Packet delivery ratio stable at node 160 means a high node density increases the number ofnodes that qualify as relaying nodes to create many alternative routes to the destination to minimize broken links.

Table 11: Average AODV, DSR, and DSR-PNT end-to-end Latency with 20ms Speed at Real Scenario

Number of Nodes	*AODV*	*DSR*	*DSR- PNT*	*(DSR vs DSR-PNT)*
100	246.31ms	210.28ms	404.29ms	194.01ms
120	274.76ms	253.11ms	430.99ms	177.88ms
140	293.14ms	256.51ms	456.33ms	199.82ms
160	310.81ms	236.64ms	432.15ms	195.51ms

Based on the data in Table 11 to Table 12, graphs representing the calculation results of average end-to-end delay can be seen in Figure 6.9 and Figure 6.10.

Table 12: Average AODV, DSR, and DSR-PNT end-to-end Latency with 20ms Speed at Real Scenario

Number of Nodes	*AODV*	*DSR*	*DSR- PNT*	*(DSR vs DSR-PNT)*
100	253.63ms	214.49ms	410.42ms	195.93ms
120	277.92ms	242.31ms	442.12ms	199.81ms
140	298.26ms	246.18ms	467.23ms	221.05ms
160	332.17ms	258.33ms	455.21ms	196.88ms

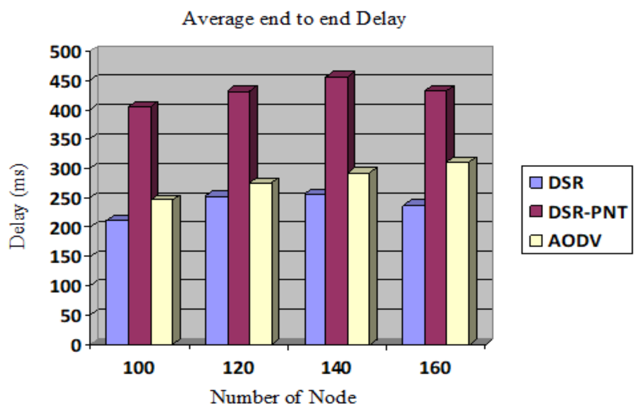

Figure 9: Average AODV, DSR, and DSR-PNT end-to-end Latency with 15ms Speed at Real Scenario

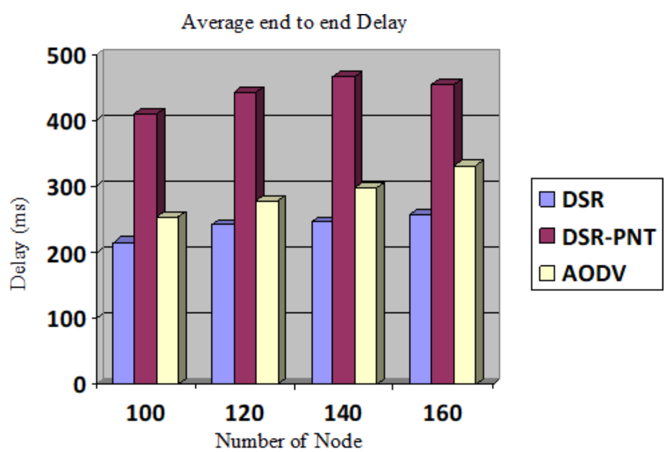

Figure 10: Average AODV, DSR, and DSR-PNT end-to-end Latency with 20ms Speed at Real Scenario

Figures 9 and 10 show that increased delay occurred in the DSR-PNT since node 100, while the DSR protocol has a lower delay on all the many nodes in this study. Due to fewer nodes being provided as a neighbor node, so fewer nodes qualify as a relay nodes. The smaller the number of nodes used as a scenario, the less the average end-to-end delay. However, the low delay and fewer nodes do not guarantee that the packet delivery ratio increases.

The addition of speed variations in the speed of 15ms and 20ms on average end-to-end delay parameters does not significantly change the DSR-PNT protocol. However, it provides a minor change in DSR and AODV protocol. DSR-PNT is not too affected by the factor of speed variations due to the selection of relaying nodes through computation TWR that caused the delay in the DSR-PNT. The protocol DSR and AODV is a selection relaying node by node most eager to reply to the sender node with a low relative delay.

Table 13: Routing Overhead of AODV, DSR & DSR- PNT with 15ms Speed at Real Scenario

Number of Nodes	*AODV*	*DSR*	*DSR- PNT*	*(DSR vs DSR-PNT)*
100	4632	3350	3010	340
120	4801	3593	3442	151
140	5120	3824	3718	106
160	5391	4123	4009	114

Table 14: Routing Overhead of AODV, DSR & DSR- PNT with 20ms Speed at Real Scenario

Number of Nodes	*AODV*	*DSR*	*DSR- PNT*	*(DSR vs DSR-PNT)*
100	4582	3247	2983	264
120	4718	3418	3279	139
140	5271	3793	3621	172
160	5405	4011	3903	108

Based on the data obtained in Table 13 and Table 14, a graph can be made representing the result of the routing calculation overhead that can be seen in Figure 11 and Figure 12.

DSR- PNT is not too affected to speed variation factor for the selection of relaying nodes through TWR calculations, while the DSR and AODV protocol to vote relaying node by node fastest node sends the reply to the sender. The addition of speed variations in the speed of 15ms and 20ms on overhead routing parameters does not provide a significant change to the DSR-PNT protocol. However, it provides a minor change in DSR and AODV protocol.

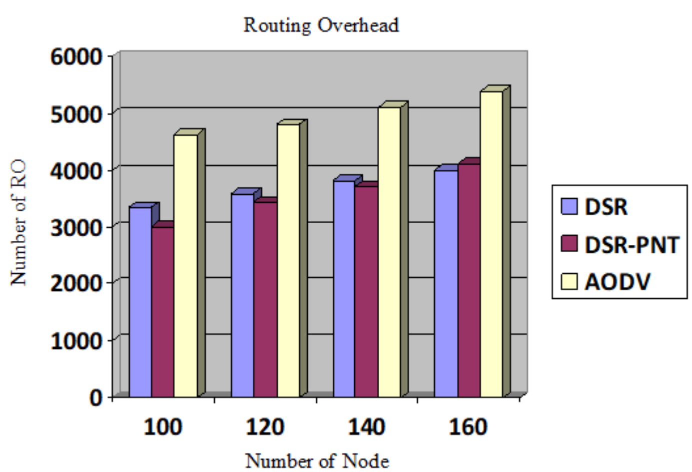

Figure 11: Routing Overhead of AODV, DSR & DSR- PNT with 15ms Speed at Real Scenario

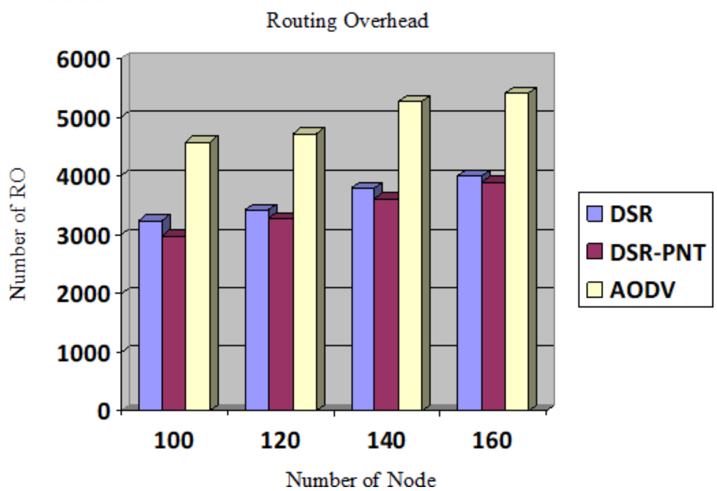

Figure 12: Routing Overhead of AODV, DSR & DSR- PNT with 20ms Speed at Real Scenario

Figure 11 and Figure 12 shows that the routing overhead of DSR-PNT is slightly superior to the DSR protocol. Selection of the appropriate node in the node relaying or Eligible contained in the relay node list set makes the DSR-PNT slightly superior. AODV routing protocol has the highest overhead because it has several packets, packet reception, and high packet error. It is directly proportional to the increase in the number of nodes in the network. The higher the number of nodes in the network, the routing overhead of AODV is likely to increase. The second method uses the current broadcast route discovery method because of the increased number of nodes, the send rate, receive error rate, and rate increase.

4 Conclusion

This study gives conclusions that can be drawn and suggestions on development that can be done about this research in the future.

The study's conclusion is based on trials that have been done as follows: Packet Delivery Ratio of DSR-PNT increased by 18% to 25% in the grid and the real scenario compared with the DSR. The increasing number of vehicles on the network improves the packet delivery ratio in the DSR-PNT.

The average end-to-end delay on the DSR-PNT is suitable on the grid, and real scenarios are likely to be high on any number of nodes in the scenario of this study. In comparison, in the original DSR, the average end-to-end delay is lower but increases as the number of vehicles in the network increases.

Routing overhead of both the grid and real scenarios in DSR-PNT tend to be lower than the original DSR. Because of the increased number of nodes, then send rate, receive error rate, and its rate increase, the second method uses the current broadcast route discovery method. Selection of the appropriate node in the node relaying or Eligible contained in the relay node list set makes the DSR-PNT slightly superior.

We are using selecting the optimal relaying node during packet transmission. The node density or the number of neighbors improves the packet delivery ratio in the DSR-PNT. At a higher number of nodes, the packet delivery ratio still has a high rate to compensate for the increased average end-to-end delay.

Research Limitations

The recommendations might be based on the findings of trials conducted to investigate the weight factor and potential TWR. The study is associated with the various types of scenarios that vary, so it takes a weight factor that is adaptive to handle different scenarios.

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