ISSN 2229-5518

Analysis of Routing Protocols for Highway Model without Using Roadside Unit and Cluster

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ABSTRACT-VANET is an advanced version of Mobile Ad-hoc Network (MANET). Therefore, the protocols used in the MANET are applicable to the VANET also. The VANET communication has attracted the attention of the researchers who are engaged in preventing traffic accidents and traffic jams. The earlier VANET models discussed only the communication among vehicles through the RSU. Most of the researchers used standard 802.11 for VANET model considering the mobile nodes of the city environments. This paper discusses the latest VANET technology 802.11p and constructs a vehicular model in which the nodes are moving outside the city. Without using the RSUs, each vehicle in the network is treated as a router to communicate with the neighboring vehicles. With the use of the proposed Simple Highway Model and the latest VANET technology, 802.11p are used to study the performance of routing protocols. The standard VANET routing protocols are applied to the above mentioned VANET model and their characteristics are compared with the use of NS 2.34 version simulator and their results are presented.

KEYWORDS- MANET, VANET, SHWM, OBU , RSU, clusters, sans clusters

1. INTRODUCTION

The inter-vehicular communication field includes vehicle to vehicle communication and vehicle to Road Side Unit communication [1]. Each VANET node includes a Global Positioning System (GPS) device, which is used to find the position of each vehicle in the vehicular network [2]. In MANET, the mobile nodes are in a position to self-configure and communicate with each other without using any fixed infrastructural node or centralized node. In VANET, vehicles move only on a predefined road and they do not have the problem of resource, data storage and power. GPS Positioning is not a problem to VANET [3]. The Primary Architecture Components are On Board Unit [OBU] [4]. This information of the GPS is used by the VANET communication to identify the position of other vehicles and exchange information which decreases the road accidents in the highways. But the VANET communication suffers from high topology changes which require smaller latency and higher reliability [5]. These vehicles that move along the same road are able to communicate either directly to the destination or by using the intermediate node, such as router [6]. This Vehicular Ad-hoc Network Communication requires a new type of routing protocols for efficient data transmission. This paper compares the main routing protocols and analyzes how these protocols behave in the given highway scenario with varying traffic density and speed of the vehicles.

2. BACKGROUND RESEARCH WORK IN HIGHWAY MODEL

Much research has already been done on MANET. However, these cannot be directly applicable to VANET as there is a fundamental difference between the architecture of VANET and MANET [7]. Hence VANET requires a new model for studying the communication between vehicle and vehicle. Most of the existing models developed by the researchers deal the vehicular motion within a city area [8]. The real issue is to find a model for highway mobility outside the city [9]. For this purpose a simple highway mobility model has been developed. In the existing model, the communication at any point is done only through a Road Side Unit [10]. So when a vehicle moves in a high speed on the highways outside the city, it will not able to receive any communication from the road side unit.

Therefore, each vehicle is equipped with a Global Positioning System (GPS) device to identify the correct location of the destination node. Moreover, it is assumed that each vehicle has an on-board navigation system and the preloaded digital maps through which it can determine the position of its neighboring junction. It is also assumed that each vehicle has the knowledge about its velocity and direction of movement of the vehicle. The reliability of the routing protocols is analyzed only on the basis of the above mentioned assumptions. It is observed that in the existing research work, the IEEE standard used for data communication is 802.11. But due to the high speed vehicle movements, the standard 802.11p is included in this model [11].

3. SYSTEM MODEL

The range of 802.11 standards is nearly hundred meters, and the vehicles within this range behave as a router to propagate the information in a multi-hop communication [12]. To transfer the message from one vehicle to another vehicle, the network needs an efficient protocol. The main function of the routing protocol is to identify the position of each vehicle in a VANET [13]. The routing protocol can be classified according to the range of communication. By the use of routing algorithm, a route is established to link source and destination vehicles. For reliable vehicular communication, the performance of the routing protocol used to communicate the message is important. Different routing protocols are suited for different VANET characteristics and scenarios, but the main issue is how to select an efficient routing protocol from them [14]. For this purpose reactive and proactive protocols are taken into consideration and these protocols are applied to the proposed sans cluster based highway model scenario mentioned in this paper. The characteristics of these protocols are studied by the use of NS 2.34 version network simulator [15]. This paper also evaluates the performance analysis of the data communication between vehicle and vehicle without using the cluster concepts and compare this value with the cluster based vehicular model discussed by the author in another paper [16].

4. Proposed Simple Highway Model Without Cluster Concepts

A vehicle within a radio coverage range can communicate by using multi-hop communication without the support of the Fixed Road Side unit. Most of the previous works on routing protocols have been established for Mobile Ad-hoc Networks. Only a limited work has been done on vehicle to vehicle communication inside the city. But no major attempt has been so far made on vehicular communication outside the city area.

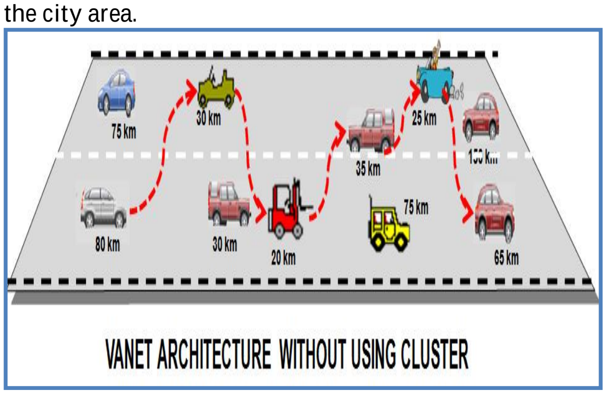

Figure 1: VANET architecture – Without Cluster concept

In addition to that, the IEEE 802.11 technology is used for data communication among the vehicles. For reliable high speed vehicle communication, a vehicular-based standard IEEE 802.11p technology is used in this paper [17]. The packets can be delivered from source vehicle to destination vehicle without using RSUs and each vehicle can act as a router. The performance parameters of routing protocols are analyzed for various nodes with different speeds of the nodes. This part of the research work can be analyzed by using IEEE standard 802.11 and 802.11p. The VANET architecture without using cluster concepts in highways is shown in Figure 1.

5. Simple Highway Model With Cluster Concepts

The clustering concept in simple highway network is briefly discussed in this paper because it is elaborately presented by the author in paper [18]. The proposed clustering algorithm splits the VANET area into a number of clusters. Each cluster has a cluster head. The cluster head may be any one of the vehicles in a cluster with good database storage and access capabilities. Each vehicle is equipped with an OBU. Each cluster head has all the service descriptions, which are regularly updated, if a new service enters into the network. All the Cluster heads are periodically synchronized to ensure that the cluster heads have latest service description. Nodes of the clusters are managed by service requests and service updates. In the cluster based VANET, the cluster area remains the same and predefined. But in MANET, clusters are created dynamically. The Service discovery architecture for cluster-based simple highway model is shown in Figure 2.

6. Data Communication In Cluster Based Vanet

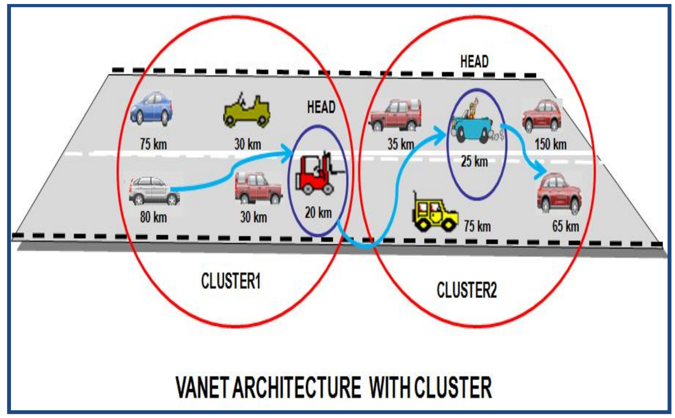

Figure 2: Service Discovery Architecture

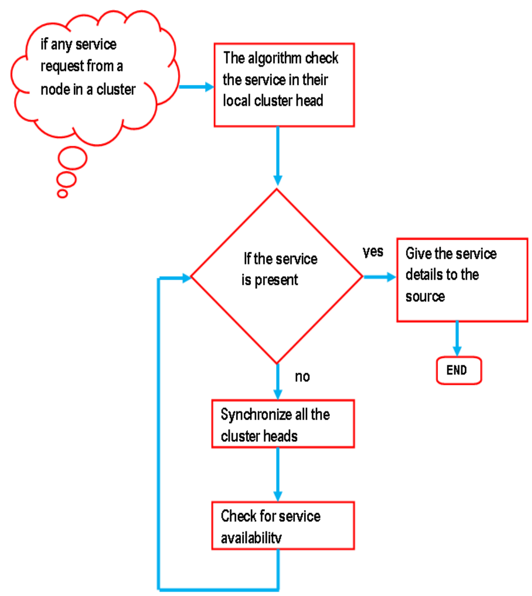

Table Service Discovery Procedure

If a vehicle wants to search a service, then it initially contacts its local cluster head. The local cluster head searches the local database for the specified service. If the specified service is present, then it will give the necessary details of the service provider and the data communication can be processed. If the service is not present, then the algorithm synchronizes all cluster heads in this model immediately. After synchronizing the procedure, it searches the cluster head again for the availability of the required service. This paper focuses the performance analysis of various protocols in sans cluster-based highway model and these results are compared with the results obtained from the cluster based highway model, which is discussed by the author in paper [16].

7. Routing Procedures In Sans Cluster - Based Highway Model

Instead of the random movement of nodes in MANETs, the nodes in VANET move in predefined road. The radio range of VANET is in between 250 and 350 meters. Within this range the vehicles can easily communicate with each other. The mobility of the vehicular node is dependent on parameters like speed, direction of the vehicles and the layout of roads. It is a fact that the speed of the moving vehicle on a highway is higher i.e. nearly 150 km/hr. Therefore, the topology in VANET changes more frequently. For this reason the IEEE standard 802.11 is not well suited for vehicular environment. So the amendment made on 802.11 establishes a new standard for VANET model. It is known as the wireless access in vehicular environment (WAVE). Another version of 802.11 is known as 802.11p [17]. The VANET model using cluster concept NS2 simulation screen scenario is shown in Figure 4. With the use of the above mentioned network parameter, an efficient routing protocol for sans cluster VANET model is studied in this paper.

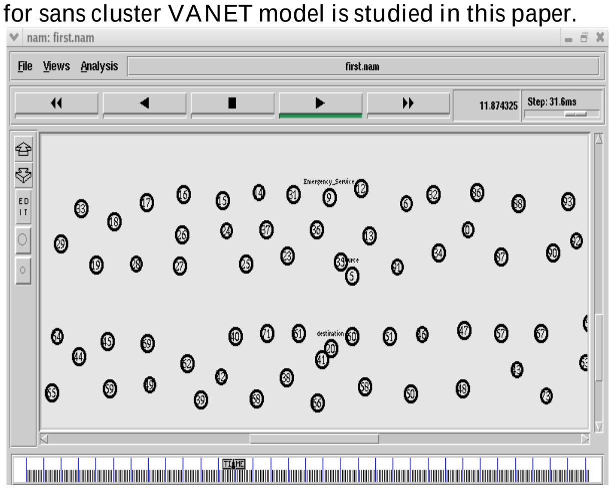

Figure 4 : SHWM without cluster -NS2.34 NAM file output

This paper discusses the routing protocols for VANET implemented in NS2.34 version. A comparison of the three protocols namely DSDV, AODV and DSR is made in this paper. Here the Destination Sequence Distance Vector (DSDV) protocol is a table driven protocol, while the other two, namely Dynamic Source Routing (DSR) and Ad-hoc On-demand Distance Vector (AODV) routings are on demand protocols. The VANET is a main component of MANET, so the operations of these two Ad-hoc networks are the same. Therefore, most of the MANET routing protocols are applicable to vehicular networks. DSDV is a modification of the Bellman-ford algorithm, which can solve routing problem in VANET environment. Each node maintains a routing table, which contains the shortest path information to other node in the vehicular network. The DSDV is well suitable for small scale ad-hoc network. The DSR and AODV are on-demand Reactive routing, in which network routes are only updated when a source vehicle wants to send a message to the destination vehicle. The DSDV is a proactive routing protocol while the other two are reactive routing protocols.

8. Simulation Environment

The simulation model is based on NS 2 simulation version 2.34. The simulation scenario is designed according to the normal state of car running on a road shown in Figure 3and 4. The position and the movement of the nodes are given in the screen scenario generator file shown in Table 4. This simulation results are displayed in the NAM file and the routing parameters obtained from the trace file. To evaluate the performance of the routing protocols, some parameters have been used in the TCL file for measuring the efficiency of vehicle-to-vehicle communication. The study of these parameters is analyzed by the NS 2 Trace file. Therefore the Agent Trace ON and Route Trace ON in the TCL file are activated. The speed of the vehicles is assumed to be constant between 5m/sec and 25 m/sec. An IEEE working group has invented a new PHY/MAC layer amendment of the 802.11 standard, which is designed for car- to-car and car-to-infrastructural communication only.

```
$node_(95) set Z_ 0.0000000
$node_(95) set Y_ 361.54
$node_(95) set X_ 1186.8
$node_(96) set Z_ 0.0000000
$node_(96) set Y_ 401.67
$node_(96) set X_ 1222.8

$ns_ at 2.5 "$node_(95) setdest 1250 179 10
$ns_ at 2.5 "$node_(96) setdest 1250 235.3 10
```

Table 4: Screen scenario generator

Network Area	1500 x 1500 m
Radio Range	200 m
Traffic Type	CBR
Visualization Tools	NAM, Tracing
Duration	200 Seconds
MAC Layer	IEEE 802.11p, 802.11
Protocol	DSDV,AODV,DSR
Mobility	Our proposed without using Cluster concepts in Simple High Way Mobility Model (SHWM)
No. of Nodes	25,50,75,100,125 &150
Speed	5m/s,10m/s,15m/s and 25 m/s

The critical parameter used in the NS2.34 version simulation is given in Table 5.

This paper uses the above mentioned parameter and estimates the performance of the Routing protocols DSDV, AODV and DSR for sans cluster based vehicular communication.

```
set opt(chan)  Channel/WirelessChannel  ;
set opt(prop)  Propagation/TwoRayGround;
set opt(netif) Phy/WirelessPhy  ;
set opt(mac)   Mac/802_11          ;
set opt(ifq) Queue/DropTail/PriQueue;
set opt(ll)       LL              ;
set opt(ant)   Antenna/OmniAntenna     ;
set opt(ifqlen) 50     ;
set opt(nn)     100          ;
set opt(adhoc Routing) DSDV  ;
set opt(sc) "cbr1" ;
set opt(x) 1500          ;
set opt(y) 1500          ;
set opt(seed) 0.0        ;
set opt(stop) 250        ;
```

Table 6: IEEE 802.11 Parameters in TCL file

It also compares Packet receiving time, Packet delay time, Average delay time and Throughput with standard 802.11 and 802.11p for sans cluster VANET model. These values are compared with the values obtained from the simple highway model using Cluster concept. For reliability, fifty samples are used to find the values and the average is given. The critical parameters used in TCL file are shown in Table 6 and Table 7. The performance of 802.11 and 802.11p standard was studied in our previous work.

```
set opt(chan) Channel/WirelessChannel ;
set opt(prop) Propagation/TwoRayGround ;
set opt(netif) Phy/WirelessPhyExt;
set opt(mac) Mac/802_11Ext;
set opt(ifq) Queue/DropTail/PriQueue;
set opt(ll)     LL  ;
set opt(ant)  Antenna/OmniAntenna
set opt(ifqlen) 50 ;
set opt(nn)    100  ;
set opt(adhocRouting) DSDV,AODV,DSR
set opt(sc)    "cbr1"   ;
set opt(x)     1500 ;
set opt(y)     1500 ;
set opt(seed)  0.0  ;
set opt(stop)  250  ;
```

Table 7: IEEE 802.11p Parameters in TCL file

9. EXPERIMENTAL ANALYSIS

The following analysis discusses the performance of various parameters without using cluster concepts in highway model.

9.1: Throughput for AODV, DSR and DSDV routing protocols without cluster concepts

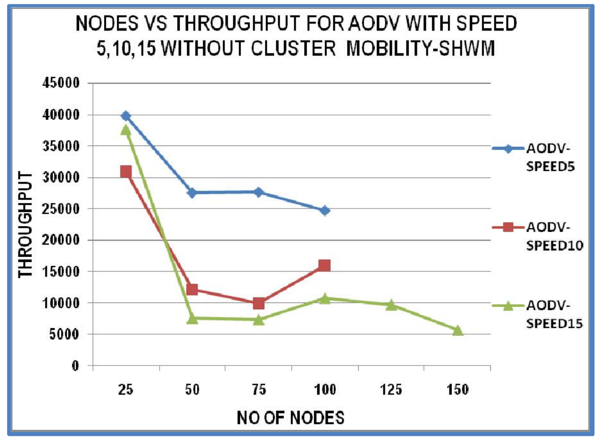

Figure 1: Throughput for AODV

The performance of various routing protocols without using the cluster concept but with varying vehicle speeds in SHWM model in terms of Throughput is shown in Figure 1, 2 and 3.

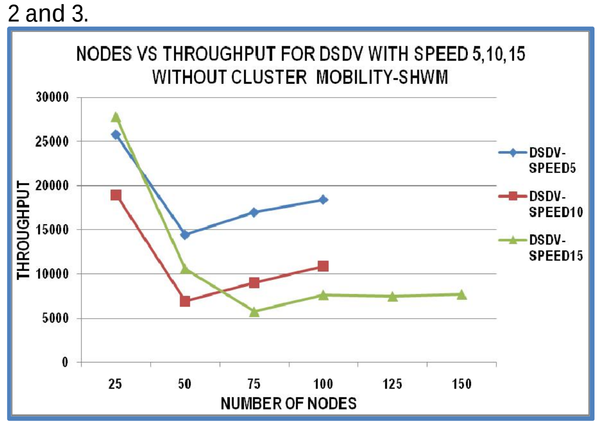

Figure 2: Throughput for DSDV

A new standard 802.11p technology which is well-suited for VANET communication is used in the scenario discussed. From the simulation result it is noticed that when the number of nodes increases, the throughput decreases in DSDV, AODV and DSR protocols. For 25 nodes, the throughput is higher than other sets of nodes. From this graph it is observed that DSDV, AODV and DSR with speed 5 yields higher value than the speed 10 and above.

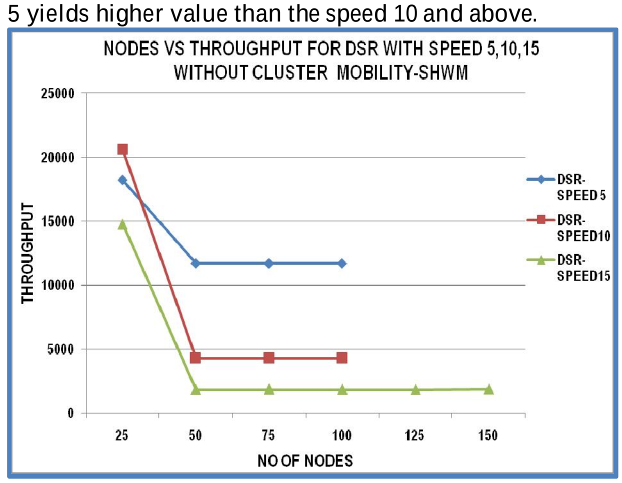

Figure 3: Throughput for DSR

ISSN 2229-5518

In Figure 4 and 5, it is observed that for speed 10 and 15 the routing protocol AODV gives better performance than the other two protocols with the same speed.

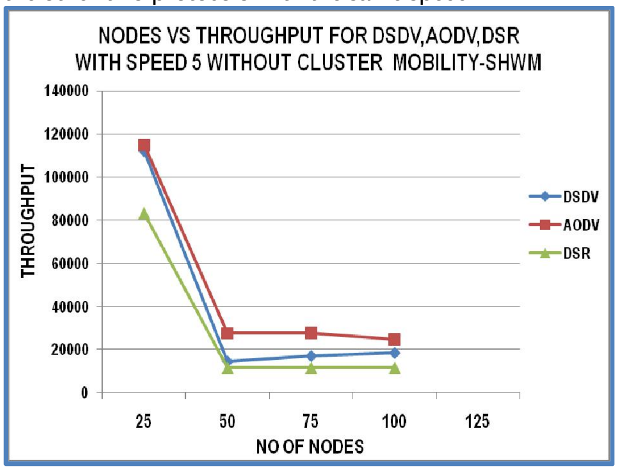

Figure 4:Throughput for DSDV,AODV & DSR –speed5

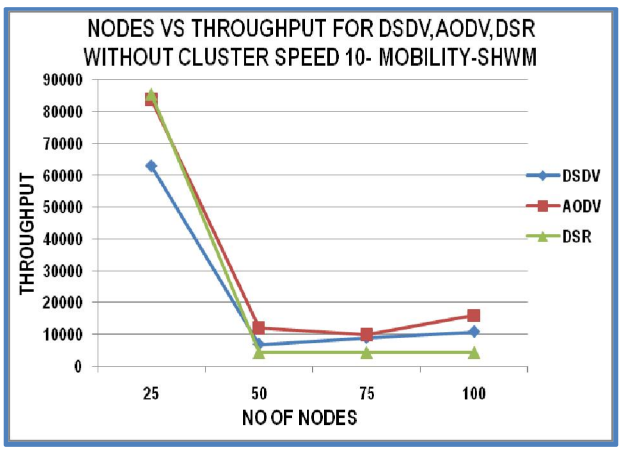

Figure 5:Throughput for DSDV,AODV & DSR –speed10

9.2: Packet forward ratio for AODV, DSR & DSDV

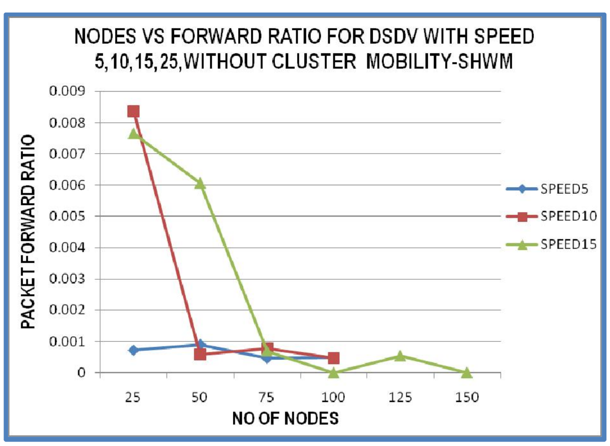

Figure 6:Packet Forward ratio for DSDV

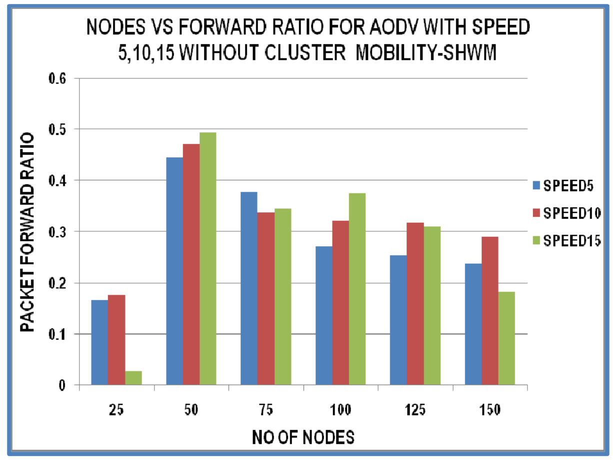

Figure 7:Packet Forward ratio for AODV

The packet forward ratio for DSDV and AODV with various speeds is given in the Figure 6 and 7. From this graph it is clear that high packet forwarded ratio results when the vehicle moves with a speed of 15 m/sec. The comparison of various protocols in a given scenario shows that AODV is better than DSDV protocol and very low value is recorded in DSR protocol, which is shown in Figure 8.

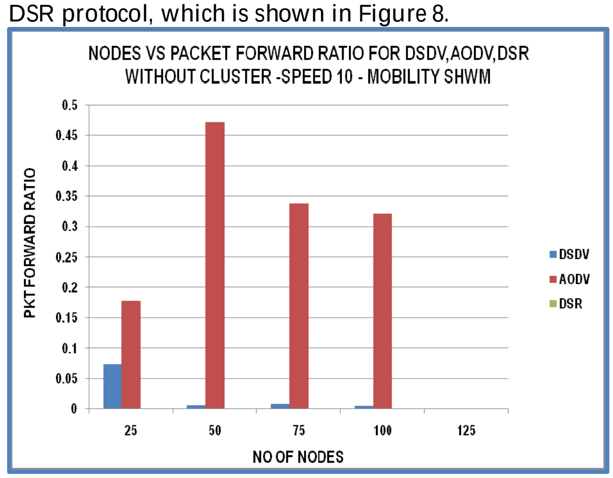

Figure 8:Packet Forward ratio for AODV,DSDV&DSR

9.3. Packet delivery ratio for DSDV & AODV

Figure 9, reveals when the speed of the vehicle is 15, the protocol that yields an optimal packet delivery ratio is AODV. Almost a constant value is obtained for 25 nodes and no major changes are found when the speed of the vehicle varies. From Figure 10 it is observed that for speed 5, the DSDV protocol gives maximum packet delivery ratio.

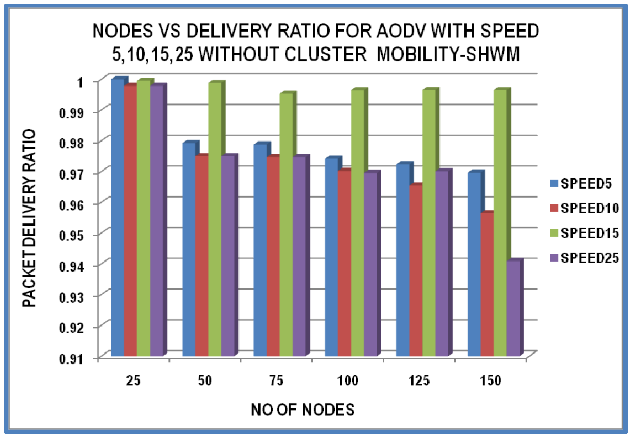

Figure 9:Packet Delivery ratio for AODV

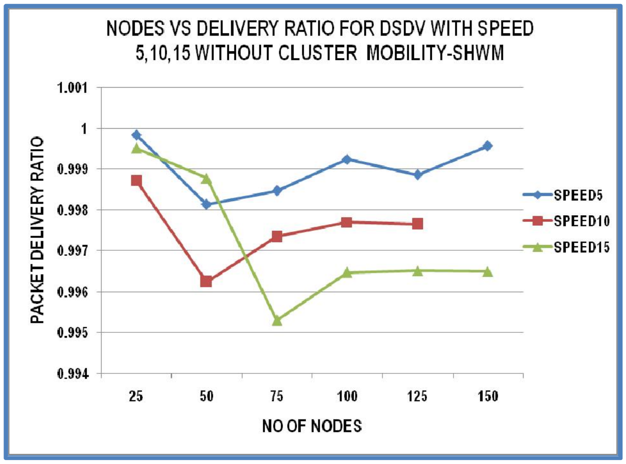

Figure 10:Packet Delivery ratio for DSDV

9.4. packet delivery ratio for DSDV, AODV & DSR

Figure 11 shows the analysis of packet delivery ratio for DSR, AODV and DSDV protocols. Here it is noticed that the responsibility of DSR protocol is better among three protocols. When the number of nodes increases, the DSDV and DSR yield almost constant value but in the case of AODV protocol, the delivery ratio is high for 25 nodes and this value decreases when the number of nodes increases.

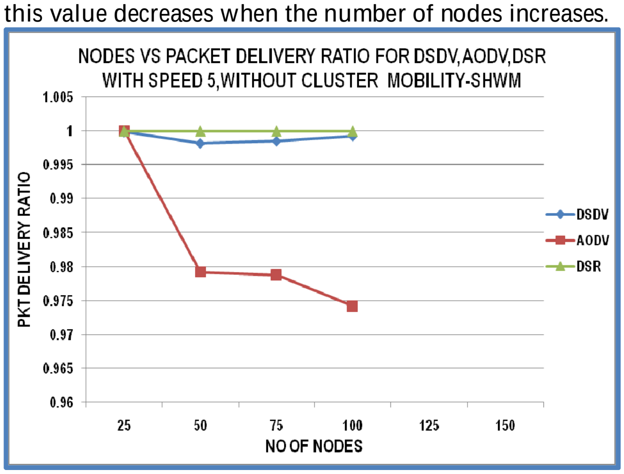

Figure 11:Packet Delivery ratio for AODV, DSDV & DSR

9.5. Packet receiving time for DSDV,AODV&DSR

Figure 12 shows how the packet receiving time for DSDV protocol decreases when the speed of the vehicle increases and the packet receiving time reaches very high value when the number of nodes is above 25.

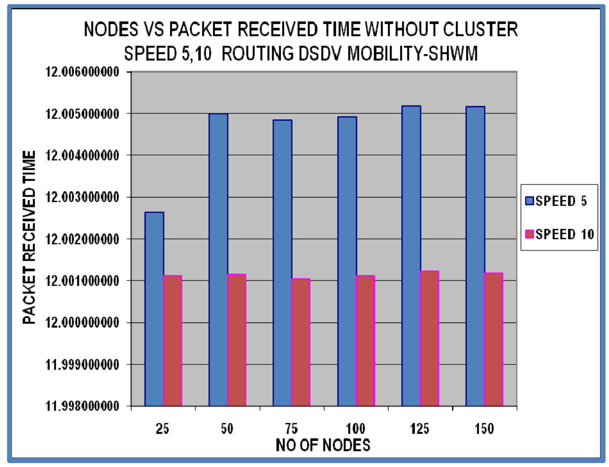

Figure12: Packet receiving time for DSDV

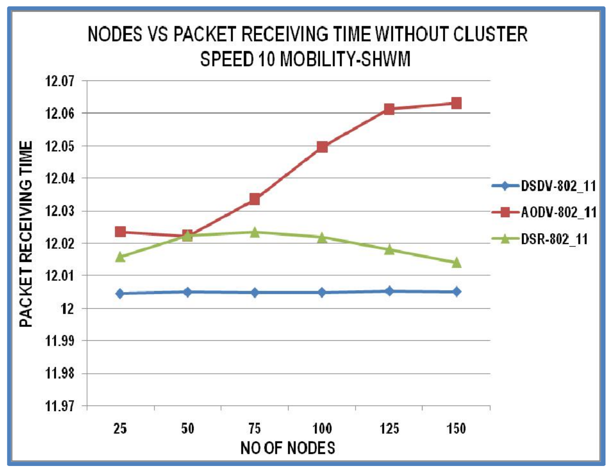

Figure13: Pkt receiving time for DSDV,AODV&DSR-802.11

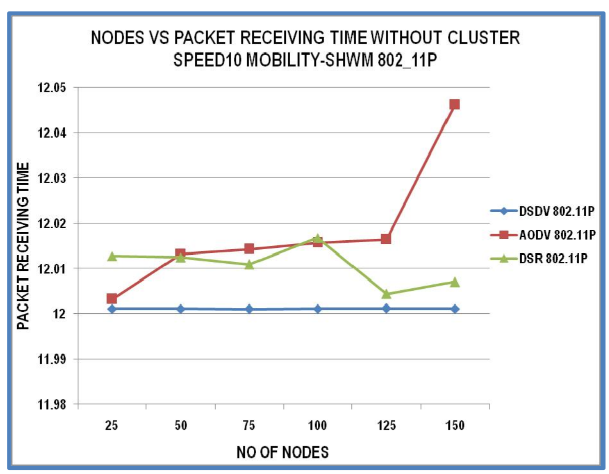

Figure14: Pkt receiving time for DSDV,AODV&DSR-802.11p

ISSN 2229-5518

The performance of packet receiving time for various routing protocols without using cluster concepts and with speed 10 and standard 802.11 and 802.11p is shown in the Figure 13 and 14. For both standards, the AODV protocol yields better packet receiving time than DSDV and DSR. When the number of nodes increases the performance of AODV protocol also increases in 802.11 and 802.11p.

9.6. Packet receiving time for DSDV,AODV &DSR with 802.11 & 802.11p

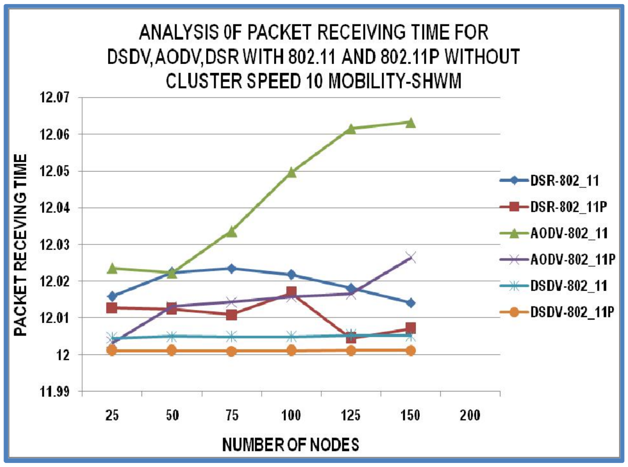

Figure15: Packet receiving time for DSDV,AODV&DSR

With 802.11p & 802.11 – sans cluster network

Figure 15 shows the overall performance of packet receiving time for various routing protocols in sans cluster network with 802.11 and 802.11p technology. From this graph it is noted that very low packet receiving time is observed when DSDV protocol with 802.11p is used in the given scenario. All the routing protocols with 802.11 standards give less performance than the routing protocols which use 802.11p.

9.7. Average packet delay time

The Average packet delay time for AODV protocol with various speeds is given in Figure16. It is noticed that average packet delay time for AODV is less for node with speed 5. It is also observed that the average packet delay is low for node 25 and it increases initially when the number of node increases and then decreases.

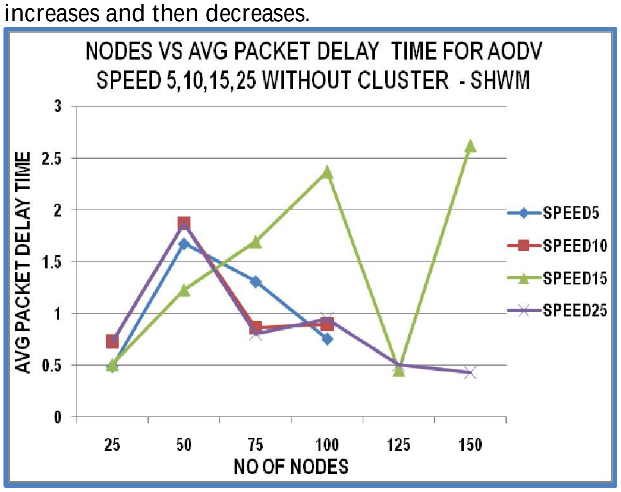

Figure 16:Average Pkt time for AODV-speed 5,10,15&20

9.8. Packet receiving time for DSDV, AODV & DSR with cluster and sans cluster

Packet receiving time for various protocols without using cluster concepts is compared with the protocol which uses the cluster concepts. This is shown in Figure 17. The packet receiving time for DSDV with cluster 8 yields lesser value than other protocols. The performance of routing protocols with cluster-based SHWM model gives better response than sans cluster model.

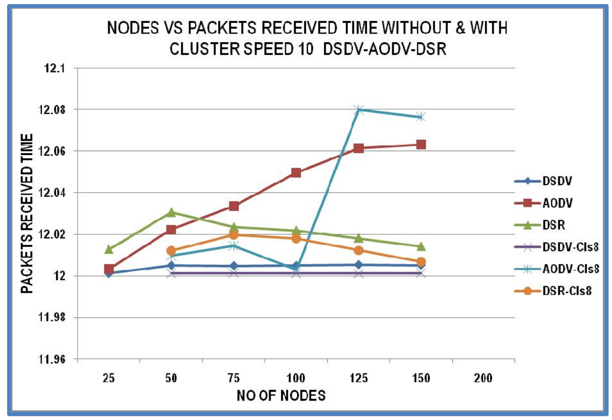

Figure17: Packet receiving time for DSDV,AODV&DSR

With 802.11p – cluster & sans cluster SHWM

9.9. Packet delay time for cluster and sans cluster with 802.11 & 802.11p

The packet delay time for DSDV,AODV and DSR with sans cluster model is shown in Figure 18 and Figure 19. Here it is observed that AODV with 802.11p yields better performance than the other protocols using 802.11 and 802.11p. The packet delay time for various protocols with cluster and without cluster concepts and standard 802.11 and 802.11p are shown in Figure 20. From this graph it is noted that the packet delay time is low for routing protocols which use cluster concepts and 802.11p technology.

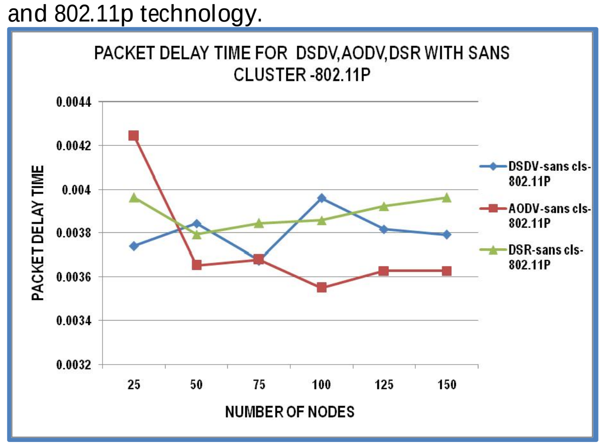

Figure 18:Packet delay time for DSDV,AODV&DSR

With sans cluster – 802.11p

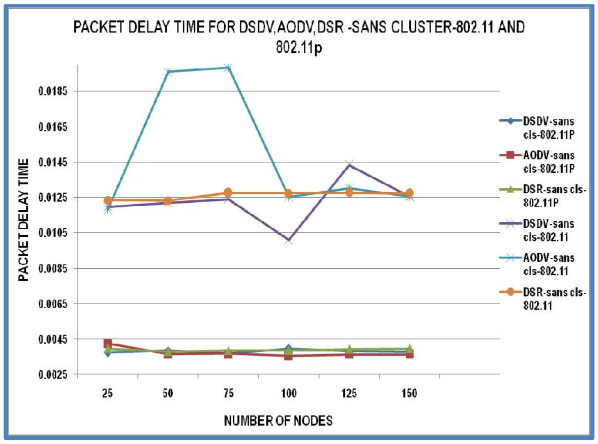

Figure 19:Packet delay time for DSDV,AODV&DSR

With sans cluster – 802.11p & 802.11

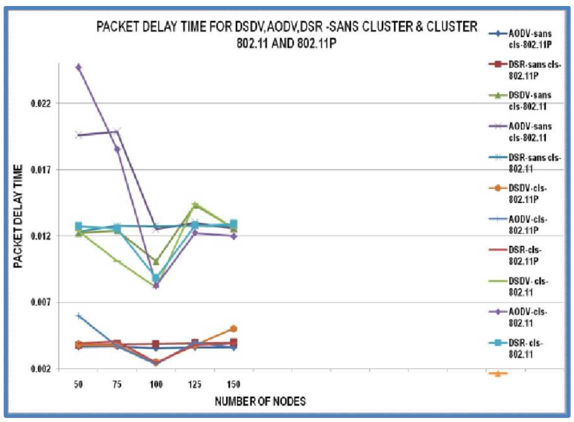

Figure 20:Packet delay time for DSDV,AODV&DSR

With cluster & sans cluster – 802.11p & 802.11

10. PERFORMANCE OF ROUTING PROTOCOLS

The various network parameters considered for analyzing the routing protocols performances in this papers are packet delivery ratio, packet receiving time, packet throughput, average packet delay time and packet delay time of two consecutive packets. From this simulation result, it is noticed that the proactive routing protocol DSDV has a better packet receiving time among the three in a given simple highway scenario. But AODV offers better performance in terms of packet throughput, packet forwarded ratio and packet delay time. The link failure requires new route discoveries in AODV since it has almost one route per destination vehicle in its routing table. The delay in AODV is less than DSR because AODV creates routes only when it is needed.

11. CONCLUSION

This paper presents the study of an efficient routing protocol for vehicular communication in highway environment. The earlier VANET models discussed only the communication between vehicles through the RSU. Most of the researchers used standard 802.11 for VANET model with the movements of mobile nodes within the city area. The proposed new SHWM model without using cluster concept and the standard 82.11p outperforms the existing models that use roadside units. For efficient data communication the protocol used in the given model is important. Thus the familiar routing protocols are compared with each other and it is concluded that the routing protocols with 802.11p yields better performance than 802.11. The new cluster concept introduced by the author [ ] is used to compare the performance of routing protocol, which gives better efficiency than the routing protocol without using cluster concepts.

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