Performance Evaluation of Modified AODV Routing Algorithm using WiMAX in VANET Environment

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ABSTRACT

Vehicular Ad-hoc Network is a leading technology to improve driving experience in terms of providing applications such as safety applications, comfort applications and commercial applications similar to the ad-hoc network. In VANET each vehicle performs as a mobile node. There are two types of communications; vehicular-to-vehicular and vehicular-to-infrastructure which is supported by wireless network technologies. Choosing a routing protocol is a very important part of any network because finding the best convenient route through which a source node can send the data to the destination node, is the biggest challenging task. Broadcast storm, network partition, and temporal fragmentation are some issues in the Vehicular ad-hoc network. A modified AODV routing algorithm has been proposed to conquer these issues. In this algorithm, we use WiMAX base stations instead of using RSUs. The simulation of this modified algorithm has been done using the NS-2 simulator. The performance of the modified AODV algorithm has been evaluated by performance matrix which includes: packet delivery ratio, throughput and average end-to-end delay with respect to the number of nodes. The results of the modified AODV algorithm are compared with AODV which shows significant improvement.

Keywords: VANET; WiMAX, MANET; RSU; architecture; AODV; NS-2

1. INTRODUCTION

Vehicular Ad-hoc Network is used to enhance the traffic security and travel convenience of drivers and travellers. VANET is one of the kinds of MANET. The advantage of using these wireless ad-hoc networks is that to make the deployment of these networks easy in the area where the installation of the required infrastructure is not suitable. In VANET each vehicle performs as a mobile node with having the proprietary of mobility and ability to communicate with neighbouring vehicles. Vehicles are communicated with each other by using Wi-Fi 802.11p and WiMAX 802.16. There are two categories of communication between the mobile nodes in the VANET. First is vehicle-to-vehicle communication and second is vehicle-to-infrastructure communication. In this communication vehicles directly can communicate with each other without using any type of fixed infrastructure. In vehicle-to-infrastructure communication, vehicles communicate with each other by using roadside infrastructure (RSU). The main provocation in the VANET is how to efficiently distribute the information among the vehicles, considering the randomly changed topologies of vehicles. There are some characteristics, issues, and applications of VANET as follows:

1.1. Characteristics of VANET

1.1.1. Dynamic topology: Because of the high speed of vehicles on the road the topology of vehicles is not fixed it changes randomly according to the movement of vehicles.

1.1.2. Real-time processing & self-organizing: Real-time information processing that does not acquire much time to exchange information correctly is the commitment of VANET communication. Since the nodes are mobile in nature, the network in the VANET is self-organizing.

1.1.3. Frequently disconnected network: Highly dynamic topology results in the frequently disconnected network. In the area where the vehicle density is low, there is the highest probability of network disconnection.

1.1.4. Sufficient power and storage: Since mobile nodes in the VANET are the vehicles so that each mobile node has sufficient power and storage to do communication or exchange information to each other.

1.1.5. Various communication environments: There are two types of the communication environment in the VANET; highway environment and city environment. In highway environment, communication among vehicles is simple and direct. While in the city environment the communication among vehicles is much more complex as compared to highway environment, because of the roads in the city are usually scattered by buildings, trees, and other obstructions.

1.1.6. Interaction with onboard sensors: To configure communication links and routing in the VANET it is speculated that the vehicles are assembled with onboard sensors (For example; GPS) to accommodate information to the other vehicles [4].

1.2. Issues in VANET

1.2.1. Broadcast storm problem: When numerous mobile nodes want to send the data to other mobile nodes at the same time, results in immense data traffic, network profusion, packet demolishment and extra delay at MAC layer, is called broadcast storm problem. Many observations have been suggested to overcome this problem.

1.2.2. Temporal network fragmentation problem: The network disconnection is the momentary and short duration in temporal network fragmentation problem. The reason behind occurring this problem is high mobility of mobile nodes and because of packet losses & packet demolishment.

1.2.3. Network partition problem: The reason of occurring network partition is when the various mobile nodes in the significant area are not enough to execute data distribution across the neighbouring groups of vehicles, which results in extra time delays, high overhead and improper delivery of messages across the partitions [7].

1.3. Applications of VANET

1.3.1. Safety-oriented applications: In order to help the drivers by preventing from apparent dangerous at the time of exchanging information among the mobile nodes, safety-oriented applications are used. For example; electronic brake warning, traffic signal violation warning and lane exchange warning etc.

1.3.2. Commercial-oriented applications: To synthesize travelling more convenient and profitable by providing internet connections, commercial-oriented applications are used. For example; remote diagnosis, media or map download and service announcement etc.

1.3.3. Convenience-oriented applications: To conserved driver's time & money and to enhance the adequacy of roads, convenience-oriented applications are used. For example; electronic toll collects, parking availability notification and congested road notification etc [4].

WiMAX is a composition of "Worldwide Interoperability for Microwave Access". WiMAX is a wireless dissemination system that is designed for wireless metropolitan area networks (WMAN), is also known as IEEE 802.16 [13]. WiMAX is a standard based wireless broadband technology that provides high throughput and high bandwidth up to thirty to forty megabit per second data rates broadband connections over a long distance with 2011 update transferring up to one Giga bits per second for fixed networks. WiMAX has many advantages in transmission speed and coverage area as compared to WLAN. WiMAX was constructed by the WiMAX forum, which was developed in June 2011 to avail observance and interoperability of the standard. The forum narrates WiMAX as "a standard based technology enabling the delivery of last mile wireless broadband accesses as an alternative to cable and DSL" [11]. The earliest variant of WiMAX is established on IEEE 802.16 and is amended for fixed and roaming access, which is further elongated to support portability and mobility established on IEEE 802.16e, also known as Mobile WiMAX [16]. WiMAX can be set up for various applications such as Cellular Backhaul, Last Mile, Broadband 'On-Demand', residential broadband, hotspots, and high-speed internet access for networks users and underserved areas. WiMAX has many advantages like full support for WMAN services, improved user connectivity, longer range, higher throughput, ensures interoperability, easy installation, higher quality of services (QoS) and no requirement for line-of-sight (LOS). WiMAX also has some disadvantages like some environmental conditions (weather, Terrain, and large buildings) can reduce maximum range of communication, reduction in data throughput by interfering other wireless electronics in WiMAX connections, for long distance communication (5-30 mile) line-of-sight (LOS) is required [11].

The paper is coordinated as: the literature review considered in this paper is given in Section 2 and Section 3 gives the overview of modified AODV routing algorithm. Simulation parameters are given in Section 4. The results discussed in Section 5 and the conclusion of work is given in Section 6.

2. LITERATURE REVIEW

Ravi Shankar Shukla et al. [1] with this paper author bring forward a composite network of VANET and cellular network. The benefits of this composite network consist of firstly the high speed of transmission of VANET and secondly the large scale cellular system. Also, this network overcomes the drawbacks of the cellular and ad-hoc network. Without any extra network price, authors are advancing a routing method for hybrid networks. The results indicate that the modified routing algorithm has minimized the transmission time and request block rate.

Shilpy Agrawal et al. [2] in this paper a novel position based routing algorithm called PB-SCR (Position Based Seamless Connectivity Routing) has been proposed to offer seamless connectivity to the passengers travelling on rural highways through heterogeneous wireless network architecture. This algorithm has been simulated using the NS-2 simulator and evaluated the performance in terms of packet delivery ratio, end-to-end delay, and average path length.

The results of this algorithm show significant performance improvement, compared with AODV and GPSR routing protocols. This proposed work helps in improving user experience, reduces bottlenecks in radio access networks (if any), and helps in the intelligent routing of data packets from source to destination.

Souaad Boussoufa-Lahlah et al. [3] in this paper authors proposes a position-based routing approach for VANETs which pursuits to deal with obstructions and voids initiate in a city environment. This proposal method uses the map-street information and the examination of the traffic density to choose the optimal route between the source and the destination node. In this study, the routing solution shows a high packet delivery ratio and a low end-to-end delay, for all traffic densities, compared with GPCR and AODV. However, the packet delivery ratio does not reach 100%.

U D Prasan et al. [4] here authors present a survey on Vehicular Ad-hoc Networks. VANETs are composed of vehicle-to-vehicle and vehicle-to-infrastructure disseminations based on wireless local area network technologies. The proposed applications of VANET are classified into three main groups as comfort-oriented applications, convenience-oriented applications, and safety-oriented applications.

B. Ayyappan et al. [5] this article provides information about VANET and the related challenges such as routing, security and privacy and some applications of VANET such as accidental alert system, traffic congestion alert system, roadside hotspots and parking management system. Being a broadcast based messaging system it needs more efficient methods for broadcasting a message.

Aakash Luckshetty et al. [6] in this paper authors have gone through the comparative study of applications, attacks, security, and privacy. Authors started their study with by giving a brief introduction to VANETs, its architecture followed by security requirements and its attacks. As applications play a vitally important role in the safety of the drivers in future VANETs but these applications must be protected so security comes into picture for providing communication between the vehicles in the more secure way. The highest possibility is that whenever communication exists privacy of the vehicle is major concerned so the privacy of the driver must be protected in order to safeguard for fool proof vehicles.

Leandro Aparecido Villas et al. [7] several perspectives for data communication in VANETs have been currently proposed in the research. However, more work needs to be done since most of the proposed explanations do not efficiently address some or all of the main disputes in these scenarios such as the network partition, broadcast storm and temporal network fragmentation. In this paper, authors present an extensive and analytical review of proposed approaches for data communication in VANETs and determine the main disputes in this extent. For this, the author first defines suitable criteria to classify and organize some existing solutions. Next author identifies and discuss some open issues and concludes with possible future research directions.

Sardar Muhammad Bilal et al. [8] in this paper, author survey state of art routing protocols previously used in vehicular networks, present open research challenges and possible future direction. Based on vehicle's disseminating mode (V2V and V2I), the author classified protocols into two main categories regardless of vehicle's simulation environment (highway or urban). Both vehicle-to-vehicle and vehicle-to-infrastructure dissemination provide connectivity based on multi-hop pattern in a seamless way. The author explains advantages and disadvantages for routing protocols associated with each category. By doing a qualitative comparison of routing protocols, it is observed that hybrid communication would be the better choice for both communication mode operable in either a city environment or an open environment.

Hiren Kathiriya et al. [9] this paper gives detail information about road side unit (RSU) and V2R protocol architecture for many applications like surrounding area information, curve speed warning and traffic signal violation warning, RSU periodically broadcasts information associated with the status of traffic signal and timing, type of road surface, weather conditions, information on demand etc. VANET is an important field for ITS and can be the largest ad-hoc network. VANET gain too much attraction from academia, industry and government. However, a lot of research is required to build a perfect system. Better algorithms and protocols required for various purposes in VANET can be the future research topics.

Vishal Sharma et al. [10] this work is an attempt to figure out the challenges in VANET comprehensively in conjunction with the recommended routing protocols by comparing the existing routing protocols with respect to existing challenges. In this paper, it has been observed that in the implementation of VANETs, the designers have to take care of a number challenging issues like fast route variations, hasty and uncertain deviations in network topology, hidden terminals, broadcast storm problem, confidentiality, a secure & high mobility and network scalability. To combat these issues, researchers have recommended a number of routing algorithms depending upon different scenarios. It has been concluded that a position based- and geographical protocols are best-suited protocols over table driven- and reactive- routing algorithms.

Prof. R. M. Shende et al. [11] this paper presents the aspects of the Worldwide Interoperability for Microwave Access (WiMAX) technology and for th coming applications of WiMAX. A consideration is given by correlating WIMAX with DSL (Digital subscriber line) & Cable and Wireless Fidelity (Wi-Fi). Wireless Local Area Network (WLAN) that uses the IEEE 802.11 standard and WiMAX (Worldwide Interoperability for Microwave Access) that uses the IEEE 802.16 standard are networks that author wants to explore. Compared to WLAN, WiMAX has many advantages in transmission speed and coverage area. This paper will introduce these two technologies and make comparisons between WiMAX and WiFi.

Lovejit Kaur et al. [12] this paper analyzes the performance of mobile nodes during handover under different speed in mobile WIMAX network. There are a number of parameters to measure the performance like Throughput, WIMAX delay, Handover delay, MOS value etc. In this paper, it has been shown that during handover performance of node mobility is higher when the speed of mobile node is less. So the performance of node mobility degrades with the increase in the speed of mobile nodes which means performance depends on speed.

Madhusrhee B et al. [14] investigated the performance of three routing protocols (AODV, DSDV, and AOMDV) for a wired-cum-wireless WiMAX scenario and also implement the structures of physical and MAC layer including 802.16e mobility extension. The performance analysis for each routing is based on throughput with a different number of mobile nodes or subscriber stations. According to their observation, the throughput of the protocol increases initially and varies over the transmission range. If the number of mobile nodes connected to the base station disseminating with wired nodes (sink) increases then the throughput of the protocol decreases. DSDV gives the highest throughput and AOMDV protocol gives the lowest throughput.

Ojasvi Chaniwal et al. [15] simulated a comparison between AODV and DSDV in WiMAX environment based on packet delivery ratio, residual energy overall throughput and average delay. The authors analyzed the performance of routing protocols by creating WiMAX scenario in NS2 and then create different routing protocols using performance matrix. The analysis of packet delivery ratio in the WiMAX module with low-to-high node density shows that the MAODV gives better performance than AODV and DSDV. In terms of end to end delay with low-to-high node density, AODV has the low end-to-end delay as compared to MAODV and DSDV, and in terms of throughput, MAODV gives higher throughput as compared to DSDV and AODV for the same WiMAX module. From these results, it is clear that AODV performs better than DSDV and MAODV.

Stuti Shrivastava et al. [16] investigated a comparison on the performance analysis of seven routing protocols (AODV, DSR, OLSR, ZRP, TORA, GRP, and DSDV) for mobile WiMAX scenario. The performance matrix includes end-to-end delay, packet delivery fraction, the numbers of packets dropped, and throughput were identified. NS2 is used for the comparison and performance analysis of these protocols. The performance analysis of various routing protocols is done by taking different limitations in WiMAX environment.

Kamal Kumar et al. [17] simulated a comparison of different routing protocols- AODV, DSDV and DSR under various conditions of mobility, speed and network load based on the performance matrix which includes throughput, packet delivery ratio and a number of packets dropped. The experimental results have shown that DSR has the optimum performance in terms of speed, mobility and small scale network (less network load). As the network load increases the performance of DSR protocol decreases. AODV has shown consistent results irrespective of network load, speed, and mobility. AODV maintains its performance even in large scale networks but it fails to outperform DSR in small scale networks. DSDV performs well when the mobility is low and in small scale networks. Hence, it is concluded that DSR is the first preference in terms of small scale networks with any mobility or speed and AODV is considered when the load of the network is increased.

Bhagyashri Gawande et al. [19] discussed the research challenge of the different routing protocol in VANETs and compared all routing protocols and distinguish efficient routing protocol for VANETs. There are various parameters (like mobility model, driving environment) on which the performance of VANET routing protocols depends. Thus, this paper has come up with the comparison of different classes of VANET routing protocols and the comprehensive survey. From the review, it is clear that cluster-based, geocast and position based protocols are more predictable for most of the applications in VANET.

Sandeep Kumar et al. [20] examined and analyze the performance of Ad-hoc On-Demand (AODV), Destination-Sequenced Distance Vector (DSDV), Dynamic Source Routing (DSR) routing protocols over Constant Bit Rate (CBR) by using different speeds and a number of nodes. The performance measurements include packet delivery ratio, average throughput and average end-to-end delay are observed in terms of speed and number of nodes. The objective of this study is to find the best routing protocol for security purpose so that it can be further used. Based on their validated results, AODV performs the best among from all three protocols.

Annu at al. [21] presents the study of the various routing protocols considered under MANET and VANET on the basis of their architectures and their performance analysis provides that the protocols which are suitable for a MANET will also be suitable for the VANET but their performance varies with varying traffic densities and conditions.

3. PROPOSED HYBRID NETWORK ARCHITECTURE

The proposed hybrid network architecture consolidates the aspects of the Vehicular Ad-Hoc network and WiMAX network as shown in Figure 1 where each mobile node equips with the Ad-Hoc and WiMAX network interface. The coverage area of each WiMAX base station is up to 50 km and base stations are distributed along the roadside, to form a hybrid environment. In this hybrid network architecture, each WiMAX base station and mobile node have their unique ID which is usually IP address.

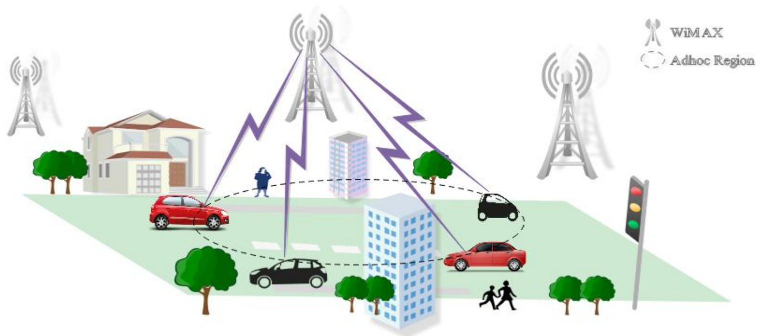

Figure 1 Proposed Hybrid Network Architecture.

The hybrid network architecture is used for vehicular applications (safety-oriented, convenience-oriented and comfort-oriented applications [4]) and many factors (availability, consistency, scalability, and output) requires for data transmission to improve the performance of a routing algorithm. There are two major issues in existing network we need to consider:

1) The data communication only between the two communicating nodes is supported by existing VANET heterogeneous networks. An efficient routing path is made on the basis of above-measured aspects, as there are many routing paths exists through which the determinant node can send the data to the target node.

2) To enhance the throughput and providing more important facilities to the mobile nodes. There is a requirement of a self-decision based distributing system for traffic.

This hybrid network architecture attempts to resolve those above- mentioned issues. In hybrid network architecture, each vehicle is equipped with GPS and dissemination between the determinant node and the target node is made directly or via the WiMAX base stations, depending on the gap between the determinant node and the target node. The network formed by the mobile nodes (vehicles) is considered as the homogeneous network or the Ad-Hoc network and the communication between the vehicles through the use of WiMAX base stations is considered as a heterogeneous network.

3.1. Communication Strategy

There are two possible cases in hybrid network architecture:

3.1.1. When source and destination vehicles form an Ad-Hoc region: When source and destination vehicles form an Ad-Hoc network under the same of the different WiMAX base station, the source vehicle deliver the data packets to the destination vehicle using the multi-hop routing (Figure 2).

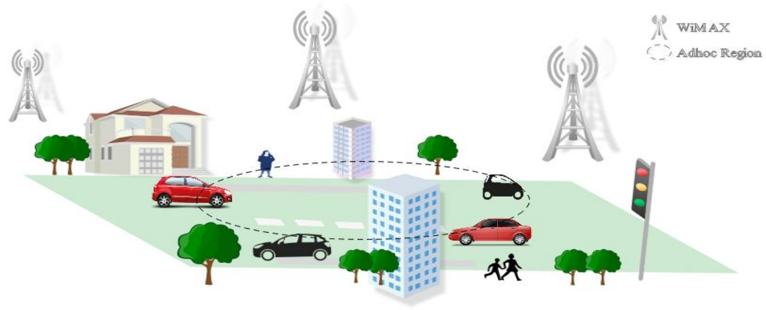

Figure 2 Source and destination vehicle form an Ad-Hoc region

3.1.2. When source and destination vehicle do not form Ad-Hoc region: In V2V communication, vehicles can easily get disconnected as the vehicles are moving with different speed. So there is a possibility of dynamically changing network topology. For example, when source vehicle under one WiMAX base station sends the data packets (alarm or warning messages) to the destination vehicle which is under the different WiMAX base station, in this situation the source vehicle uses the WiMAX network to deliver the data packets to the destination vehicle. This type of data communication uses a reactive routing protocol (Figure 3).

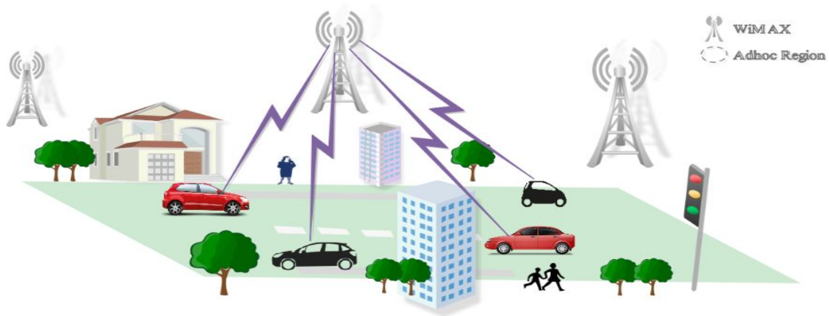

Figure 3 Source and destination vehicles do not form Ad-Hoc region

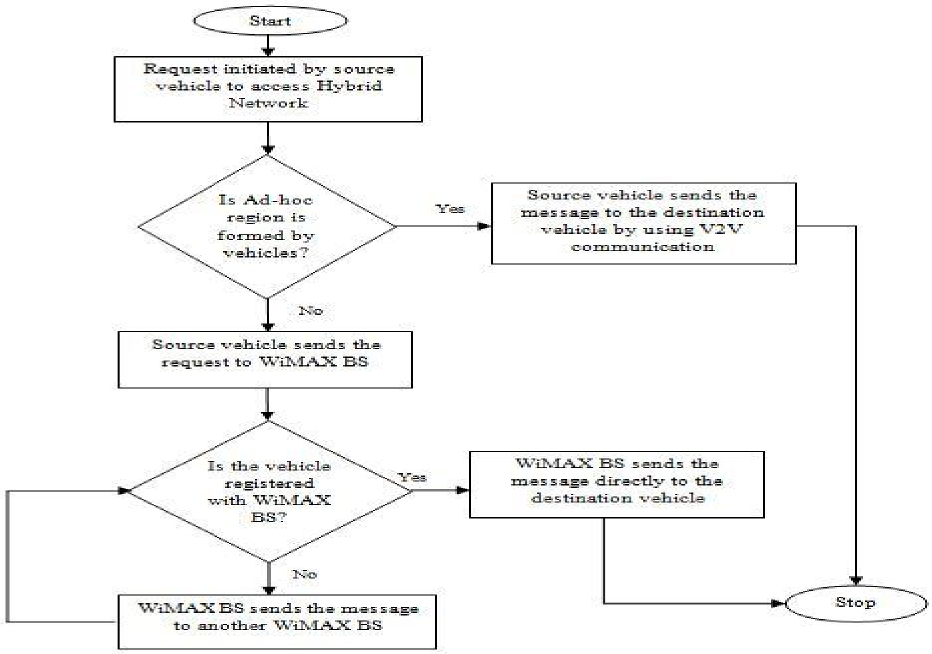

Figure 4 Flowchart of complete algorithm

The request is initiated by the source vehicle to access the hybrid network. If there is an Ad-Hoc region formed by the vehicles, then the source vehicle sends the message to the destination vehicle by using V2V communication. If the vehicles do not form the Ad-Hoc region, then the source vehicle sends the request to their nearby WiMAX base station. WiMAX base station checks whether the vehicle is registered with the WiMAX base station, if the vehicle is registered with WiMAX base station, then the WiMAX base station sends the message directly to the destination vehicle. If the vehicle is not registered with the WiMAX base station then, sends the message to another WiMAX base station. Repeat the process until the message initiated by the source vehicle delivered to the destination vehicle.

4. SIMULATION PARAMETERS

Simulation parameters are as follows:

Table 1: Simulation Parameters

Channel type	Wireless Channel
Radio Propagation Model	OFDMA
MAC Type	802.16
Antenna Model	OmniAntenna
Radio Range	1000 m
Routing Protocol	AODV
Dimensions	3500 m × 3500 m
Number of Nodes	4-32
Simulation Time	35 ms
Packet Size	512 bytes
Vehicle Speed	50-100 km/h

5. RESULT ANALYSIS

5.1. Packet Delivery Ratio: This is defined as the ratio of the number of data packets received at the destination to the total number of data packets sent to the destination. The higher the value gives the better result. Figure 5 represents the comparison of packet delivery ratio with respect to the varying number of nodes. The X-axis enacts the number of nodes and Y-axis enacts the packet delivery ratio. The result shows that the modified AODV routing algorithm performs better than the AODV routing protocol. The reason behind the better performance of modified AODV routing algorithm is that we use WiMAX BS for delivering the data packets from the determinant node to the destination node when the vehicles are unable to communicate with each other by using ad-hoc region.

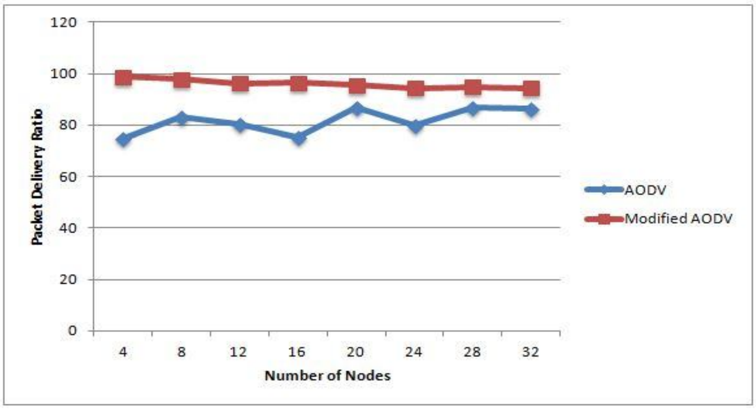

Figure 5 Packet Delivery Ratio vs. Number of Nodes.

5.2. Average End-to-End Delay: The average end-to-end delay is a delay that a data packet takes to travel from the determinant node to the destination node. Figure 6 represents the comparison between the designed routing algorithm and AODV in premises of end-to-end delay with respect to the varying number of nodes. The X-axis enacts the number of nodes and Y-axis enacts the average end-to-end delay. AODV results in maximum delay because of the node solidity due to damaged paths or setting up new paths to the destination nodes. The modified AODV routing algorithm performs better than because of using WiMAX BS when the ad-hoc region is not formed between the determinant and the target node.

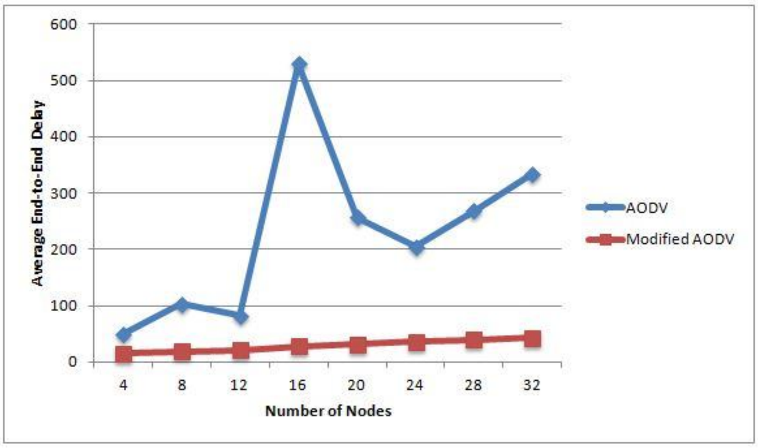

Figure 6 Average End-to-End Delay vs. Number of Nodes.

5.3. Throughput: Throughput is the measure of effectiveness. Throughput is the number of bits delivered successfully per second to the destination. Throughput is expressed as bytes or bits per second. Figure 7 depicts the comparison of the modified AODV routing algorithm and AODV in terms of throughput with respect to the number of nodes. The X-axis enacts the number of nodes and Y-axis enacts the throughput. The modified AODV routing algorithm gives better results than the AODV because the PDR of modified AODV routing algorithm is higher.

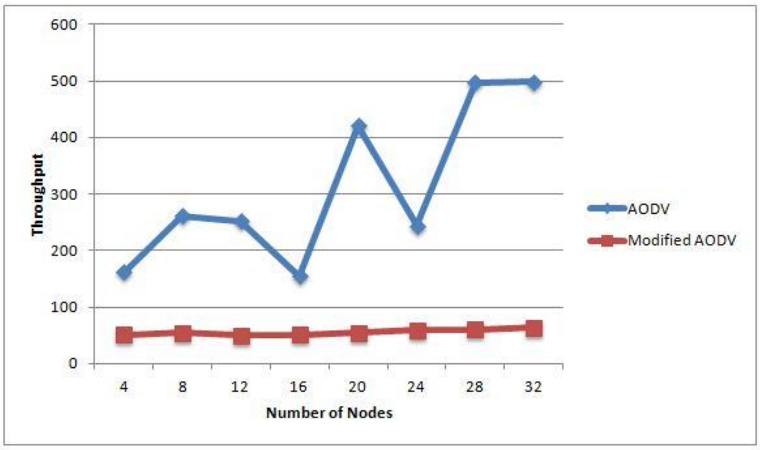

Figure 7 Throughput vs. Number of Nodes.

6. CONCLUSION

In the Vehicular Ad-hoc Network, the network connectivity is the prime consideration because of VANET's dynamic topology, vehicle's speed and density on the roads. Routing is a salient factor in vehicular-to-vehicular communication and vehicular-to-infrastructure communications. In this paper, we have recommended a reformed routing algorithm, which is a composition of a WiMAX network and the VANET. However retaining legitimate broadcasts is still an open question. In VANET, time plays a crucial role because if the information does not deliver on the particular time then this system becomes useless. The modified AODV routing algorithm has been evaluated using performance matrix. The result shows that the modified AODV routing algorithm gives higher packet delivery ratio, refined throughput and minimizes the time delay in contrast to AODV routing protocol. This work can be augmented to assess the simulation of other VANET routing protocols with more performance metrics and more parameters can be further added to the simulation to enhance the execution of the routing algorithm.

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