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A Robust Visualization of QoS in VANETs Using Diversified Traffic Flows

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ABSTRACT

Vehicular Adhoc Networks (VANETs) have paved a novel path way to the future research in wireless sphere. It is rather essential to classify the hitches encountered in VANETs and then endorse solutions consequently. Researchers are at work to provide real time streaming and video on demand type of services in these networks, by striving to reduce the delay and packet loss that upshots due to the high speed of the vehicles. Hence, rendering such a good Quality of Service (QoS) is a colossal challenge for the service providers on pondering the techniques to manage the resources in VANETs. In this paper, we have scrutinized the complete QoS in VANETs by allowing various traffics to flow. Moreover, different categories of traffics have been compared with varying speeds of vehicles establishing VANETs. Hence forth, we conclude by suggesting the appropriate networking conditions and the type of traffic which may run ideal in different scenarios. Furthermore, the facts on the occurrences of delay, packet loss and other parameters are realized as the traffic flows are analyzed in this paper.
KEYWORDS: QoS, VANETs, Traffic, Mobility

1. INTRODUCTION

Vehicular Adhoc Networks (VANETs) are novel wireless networks which are deployed inside the vehicles and are presently the fetching need of hour. Nowadays, utmost of the vehicles are having VANETs in order to provide different type of services to the users. Indeed, this innovative type of network will play a vital role in future as communication inside vehicles and among the vehicles will be possible. It will render significant information about accidents, hazards, worse road conditions, weather updates so on and so forth. [8] Introduced a mechanism based on multi hop backbone network. In this scheme, some vehicles are elected as backbone nodes and are used for forwarding the data based on their destination address. Researchers exhibited that the overall capacity of the system is increased with this technique and end-to-end delay is also improved. [5] Formulated a new protocol to be used in VANETs to provide video delivery with minimum loss and delay which had incorporated cognitive radio in their system. This protocol successively inspects the existing available channels to ensure whether they are dedicated or cognitive radio based. Eventually, as more resources are required for content delivery it selects the best available channel and then forwards the data using that channel. Authors claimed that because of this protocol, the ratio of video delivery is enhanced. A new application layer protocol is designed in order to make forwarding mechanism better [19]. Segment based techniques were used to enhance the reliability of the packets. At the end, the authors sued that this application layer protocol not only progresses the overall reliability but also can recover the transmission failure swiftly. Simulated results were presented to second their claims. [20] Worked on the storage capability of the VANETs systems in both city and urban scenarios. Scholars had finally discovered that, exact storage capacity will depend on the size of coverage and the region itself. The lifetime will also depend on the region being covered and size of the area. Furthermore, simulations revealed the mean time for deleting the information and storage as well. Researchers claim that, in future applications can be built using the storage analysis as modeled in their study. [11] Worked on multiprotocol label switching (MPLS) to improve packet delivery ration. Investigators had implemented MPLS in backbone network which is compatible with any layer 2 technology and forwards the packets faster than IP routing. Henceforth, it was highlighted that MPLS integration with VANETs improves the end-to-end delay and jitter, and escalates the performance of VANETs. Finally, simulations revealed that the outcome of this technique provides better results as compared with traditional IP based routing. [12] did a survey on topology based protocol and positon based protocol for routing purpose. Nodes in VANETs keep moving due to which the routing related to their position play an important role while increasing the performance. Simulations were exhibited while targeting particular areas

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e.g. urban and highway situations. Finally, these researchers concluded that position based routing is better for VANETs. [1] Analyzed between 802.11p that is IEEE standard for VANETs and 802.11n that is general IEEE standard for WLAN. Likewise 802.11n provides 300 Mbps data rates. Authors conducted simulations using these two standards in urban areas for optimizing multimedia traffic. Their outcomes show that performance of 802.11n is better for multimedia flows as compared with 802.11p for BER (bit error rate). Survey on the security of VANETs has been done by [10]. Researchers have made a comprehensive survey on security and threats potentially imposed to VANETs, where subsequently nodes in these networks are moving vehicles and are connected with others vehicles and Road Side Units (RSU) so frequently that there is a clear chance of sniffing, hacking etc. In this paper, the author had gathered the possible threats which may lead to security lapse. The nature of security breaches may be different in different scenarios like urban and rural. [21] Communicated about IPv6 address dissemination through Access Points (APs) using hierarchical structure of IPv6 to avoid duplication of addresses. In this scheme, a range of IPv6 addresses is allocated to all the APs and these APs can assign unique IPv6 addresses to the vehicles demanding it. Consequently the problem of address duplication is resolved this way. Scholars have moreover proposed an algorithm for recovery of addresses so that APs can recover and get addresses using the proposed novel algorithm. Detection of misbehavior vehicles has been done by [13], this issue may cause huge loss if not addressed properly. Such vehicles may send wrong information about the incident to forge information about the incident which never occurred. As in VANETs all vehicles may communicate with each other, some vehicles may transmit fake information in order to damage the infrastructure or any other drive. So detection of these nodes are very important, which the authors have disclosed appropriately. The graphs shown second their claim.

2. RELATED WORK

[7] Implanted wireless mesh network for VANETs in order to offer a fair scheme for uploading and downloading. Researchers were at work to optimize the target throughput by constantly monitoring the essential needs on the available bandwidth and later balance the load among different Access Points (APs). An innovative algorithm was proposed which would handle the selfish APs and gateways and forwards the traffic accordingly. Simulations indicated that this technique works well. [14] Discussed the scenario where data was drawn from clouds which develops more critical issues. Scholars debated on the need of a proper QoS to fetch data from clouds, as different service providers have different Service Level Agreements (SLAs) which has to be fulfilled to satisfy the users. In this paper, scholars worked to evaluate QoS when clouds are involved, furthermore they checked that which parameters may be more perturbed when data is fetched form clouds. Finally, few optimized parameters were proposed to service providers to improve the QoS. [4] worked on location based routing to improve the performance of the network. Some routing protocols work on the source of locations and disseminate information based upon the location of nodes. Getting location information of nodes and then routing are two different processes which are handled separately. In this paper, the authors have proposed systems which are better in terms of cost and complexity. Parameters like ratio of packet delivery, delay and jitter are improved. [3] Enhanced the working of VANETs using new coding scheme for Medium Access Control (MAC). This scheme coordinates properly in order to assign recourses to different vehicles depending upon their QoS needs. Thus, the total number of transmissions are controlled using this new technique. The mechanism of Automatic Repeat request (ARQ) is used in this technique to make the scheme more stable and better. [16] Proposed a cross layer algorithm for on-line gaming while addressing the QoS needs. The number of moving nodes is increasing rapidly and number of users demanding multimedia services is also increasing. Previously layer MPEG-2 was being used for coding in Adhoc networks. In this paper, the authors have devised a novel algorithm to cater the ever demanding need of QoS. Later, investigations and simulations were made using high speed moving nodes. A new routing protocol was proposed by [17] to provide reliable routing in VANETs. Disruption of links has always been an issue in VANETs due to frequent connection and disconnection with different vehicles which may be moving fast. Hence, finding a stable and reliable path is really a thoughtful issue. The authors checked the presence of relay nodes and the time of the link offered by them. If the average time of the link up time is moderate then this link may be used by their routing protocol for data forwarding, otherwise any other link may be selected. [18] has developed a new geo-graphical routing protocol that can be used in VAENTs. This protocol not only removes routing loops in urban areas, where many routes may exist to the destination and as a consequence

routing loop may occur, but improves the packet delivery ratio along with latency. The protocol also uses few hops to deliver the data, as it has the geo graphical information about the nodes as well, therefore there is less chance that data will be lost and best routes are selected for forwarding. Functionality of 802.11p has been enhanced by [2]. Initially 802.11p was developed to cater for the security needs of the vehicular networks, but now QoS is becoming important because users expectation are being increased e.g. internet. Subsequently, the authors made some enhancements to existing 802.11p to address the needs of QoS demanded by the users. It coordinates between the vehicles and uses their physical location information in order to enhance the QoS. [9] Formed a hybrid network of Worldwide Interoperability for Microware Access (WiMAX) and Dedicated Short Range Communication (DSRC). The features of WiMAX were used for backbone traffic forwarding which not only increases the range but also provide fast communication and reduces delay. The authors had used relay stations to properly forward the traffic, internet access server to provide internet facility along with WiMAX base stations. Their study shows that this integrated scheme offers more stability and robustness to VANETs as compared with only DSRC or WiMAX. The network backend protocol provided better accessibility to the vehicles forming VANETs. [15] Proposed a new scheme based on affinity propagation for formation of cluster, as clustering is becoming popular in designing MAC and routing protocols. VANETs are highly dynamic and may face severe channel conditions while moving. Therefore, robust clustering mechanism are required in order to suitably form a cluster with more reliability and stability. While forming a cluster, authors examined few parameters like average time as member of cluster, average time as cluster head, average data forwarded etc. Their simulations revealed that the proposed algorithm is better for high mobility VANETs. A new data dissemination scheme has been proposed by [6], as 802.11p has some known shortcomings regarding their coverage and congestion. Coverage can be extended using multi hop communication, but in that case delay is increased. In this paper, the authors have proposed an extension in existing 802.11p scheme to increase the coverage provide and also reduce the delay occurred when multi hop communication is done.

3. PROPOSED SCHEME

In this paper, we have examined the QoS in VANETs with different moving speeds and types of traffic, as it is essential to identify the issues in existing network and then optimal solutions can be proposed. We formed a VANET network as shown in Figure 1. Here the network size is 500*500 Km. Vehicles will be moving as per the trajectory shown in Figure 1. Different type of traffics will be allowed to flow i.e. Best Effort, Background, Standard, Excellent Effort, Streaming Multimedia, Interactive Multimedia and Interactive Voice. All these traffics will be flowing with the vehicle speeds of 90 km/h, 110 km/h, and 130 km/h. Simulation time will be 6 hours for all the scenarios.

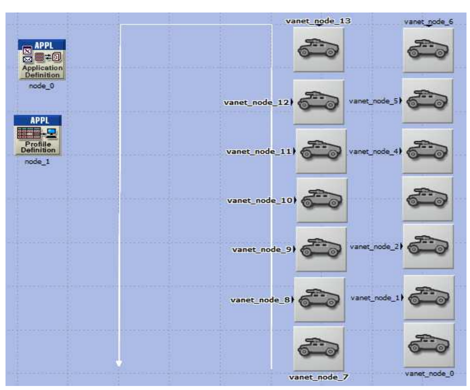

Figure 1. VANET trajectory

3.1 Vehicles with the Speed of 90 km/h:

When we adjust the vehicles speed at 90 km/h as shown in the Figure 1, then different types of traffics will be allowed to flow and packets drop ratio and delay will be calculated for the arbitrarily selected vehicles.

3.1.1 Best Effort Traffic:

Node 1 and node 7 have been selected in order to check the performance of best effort traffic with the speed of 90 km/h as shown in the Figure 2 and 3 respectively. The focus is laid on two parameters for performance evaluation i.e. data dropped and delay. Observations noted, reveal that data dropped in these two nodes varies from 0.0 to 0.060 having average of .030 and peak value of 0.060. As far as delay is concerned, it varies from 0.0006 to 0.0010 having average values of 0.0008 and peak value of 0.0010. As a whole there is no big data drop in the best effort traffic while moving with the speed of 90 km/h.

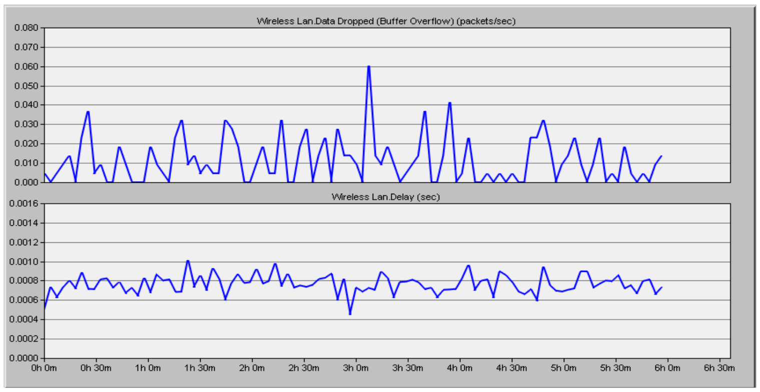

Figure 2. Best Effort Traffic for VANET node 1

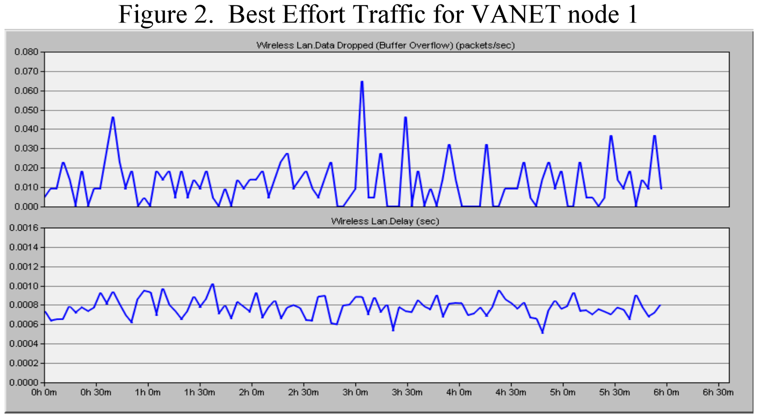

Figure 3. Best Effort Traffic for VANET node 7

3.1.2 Background Traffic:

The background traffic in Figure 4 and 5 with randomly selected nodes of 3 and 9 and movement speed of 90 km/h. It is seeming very evidently that the data dropped ratio is high and many peaks are noticed with high values starting from 0.000 to 0.060. Due to these peaks the average value is also increased. Nevertheless, there is no big change in delay in background traffic, meanwhile it varies from 0.0006 to 0.0010 and average is identical.

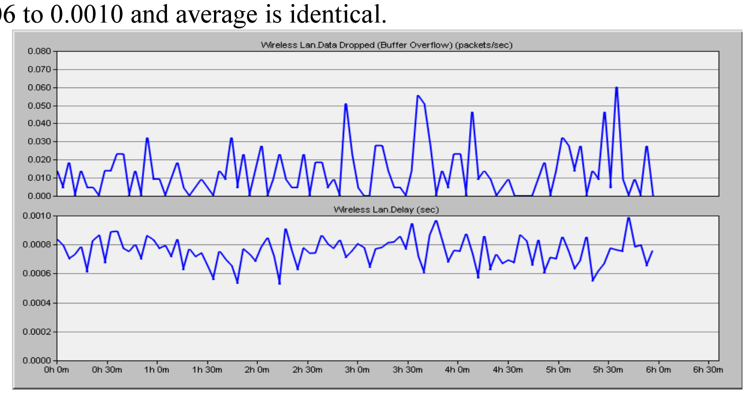

Figure 4. Background for VANET node 3

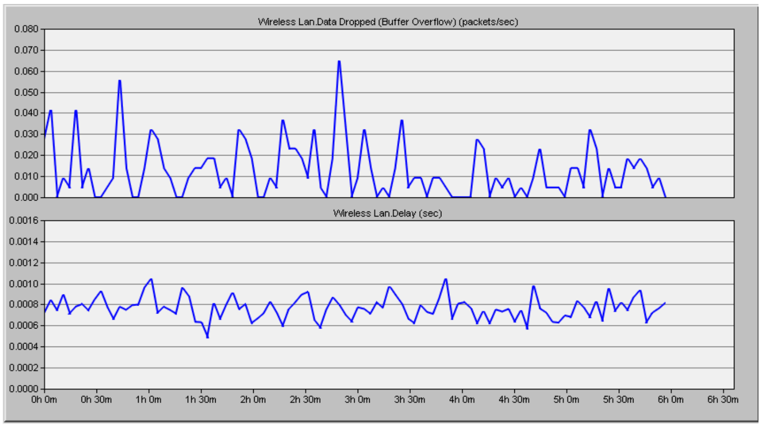

Figure 5. Background for VANET node 9

3.1.3 Standard Traffic:

Standard traffic is depicted in Figure 6 and 7 with randomly selected nodes of 1 and 11 respectively. The results are almost the similar as that of the background traffic. As data dropped varies from 0.0000 to 0.060 and delay varies from 0.0006 to 0.0010. Therefore vehicles moving with the speed of 90 km/h have matching outcomes with the background traffic and standard traffic.

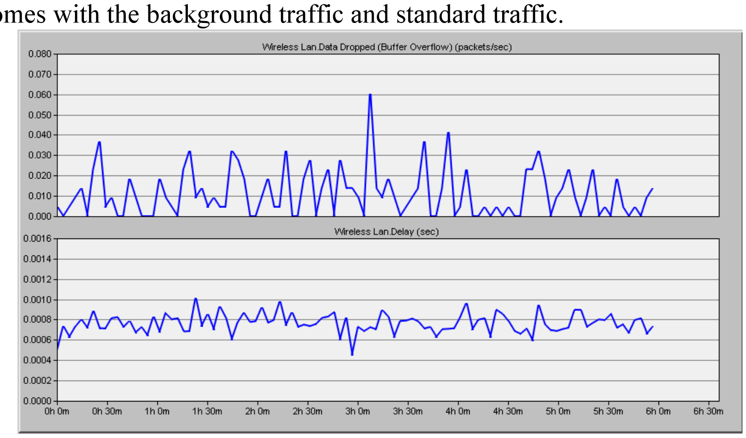

Figure 6. Standard Traffic for VANET node 1

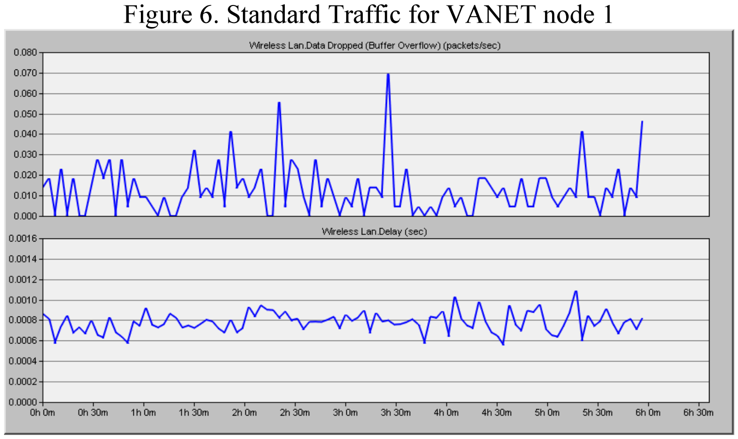

Figure 7. Standard Traffic for VANET node 11

3.1.4 Excellent Effort Traffic:

Envisaging the excellent effort traffic in Figure 8 and 9 with the nodes of 5 and 13. It is precise from the Figure that average and peak value of data dropped is little high, going up to 0.070 and average value is also high. Nonetheless, there is no major change in delay i.e. It fluctuates from 0.0006 to 0.0010.

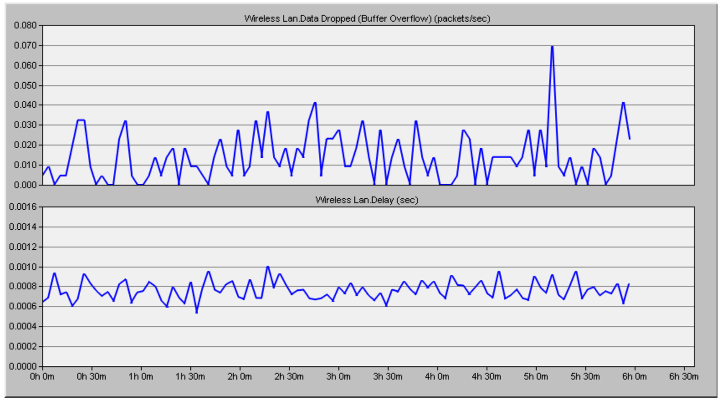

Figure 8. Excellent Effort Traffic for VANET node 5

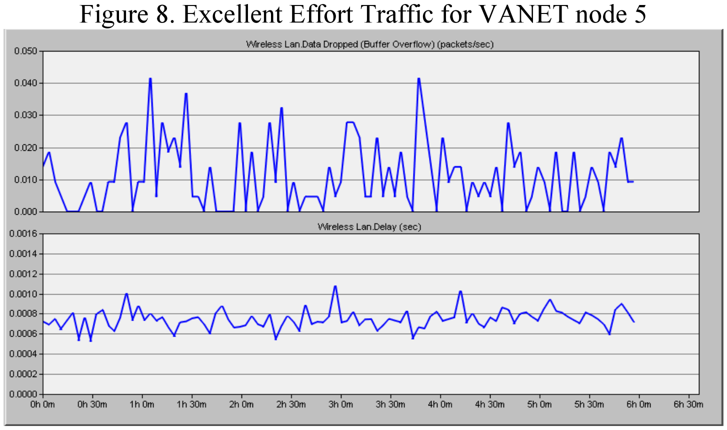

Figure 9. Excellent Effort Traffic for VANET node 13

3.1.4. Streaming Multimedia Traffic:

In case of streaming multimedia traffic as shown in Figure 10 and 11 respectively with nodes 3 and 9, it is observed that data drop ratio has been boosted marginally i.e. it crosses 0.060 but the delay faces no vast disparities among both of these two arbitrarily designated nodes.

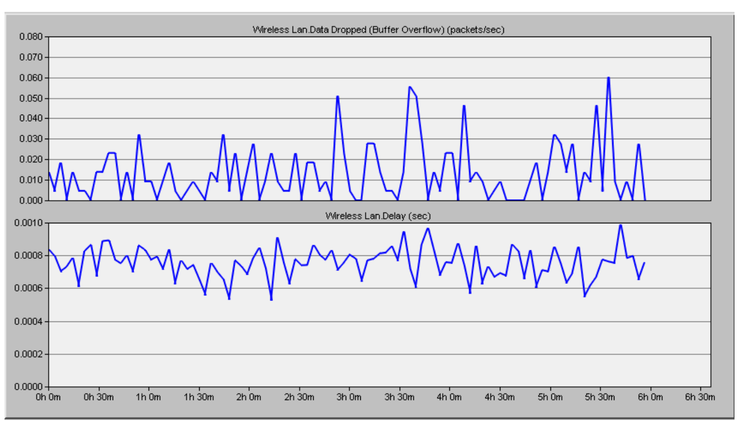

Figure 10. Streaming Multimedia Traffic for VANET node 3

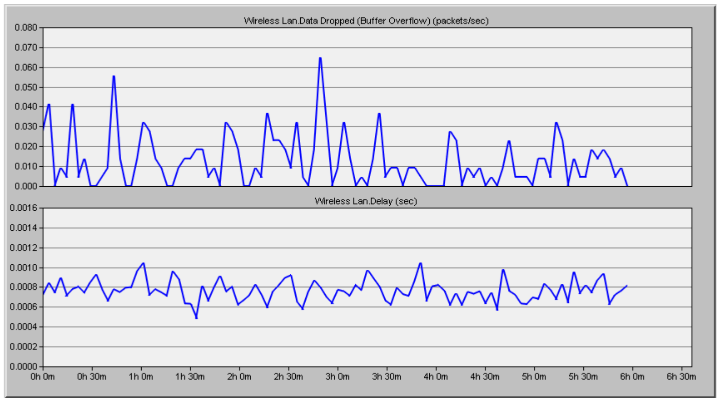

Figure 11. Streaming Multimedia Traffic for VANET node 9

3.1.5 Interactive Multimedia Traffic:

The data drop ratio as shown in Figure 12 and 13 for randomly selected nodes 11 and 13, is the highest for vehicles moving with the speed of 90 km/h i.e. 0.070 and average also approaches to high values because of many high peaks. As far as delay is concerned, it does not suffer from immense variations.

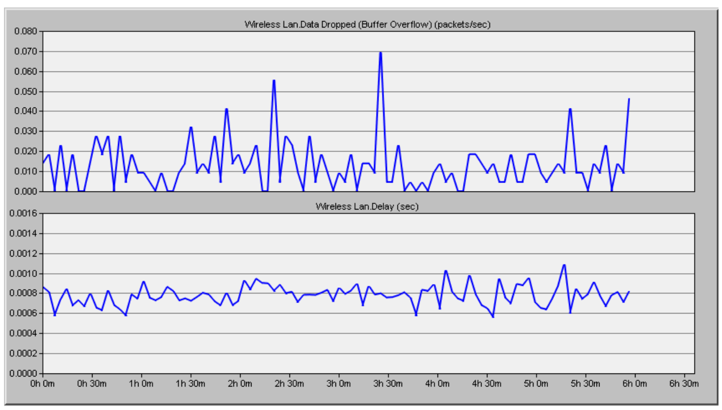

Figure 12. Interactive Multimedia Traffic for VANET node 11

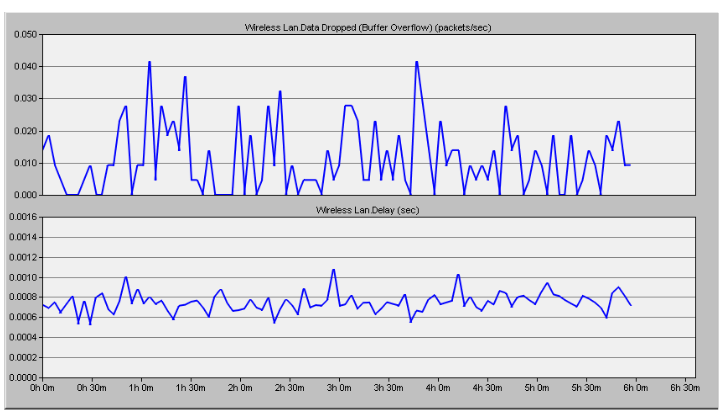

Figure 13. Interactive Multimedia Traffic for VANET node 13

3.1.6 Interactive Voice Traffic:

Interactive voice traffic for nodes 7 and 11 is shown in Figures 14 and 15 respectively. Now, data drop ratio is also high as it touches the 0.070 but overall average is not high. However, the delay faces no main difference from other type of traffics.

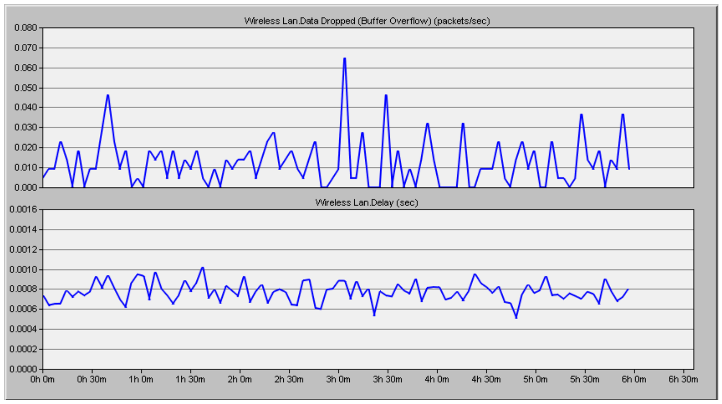

Figure 14. Interactive Voice Traffic for VANET node 7

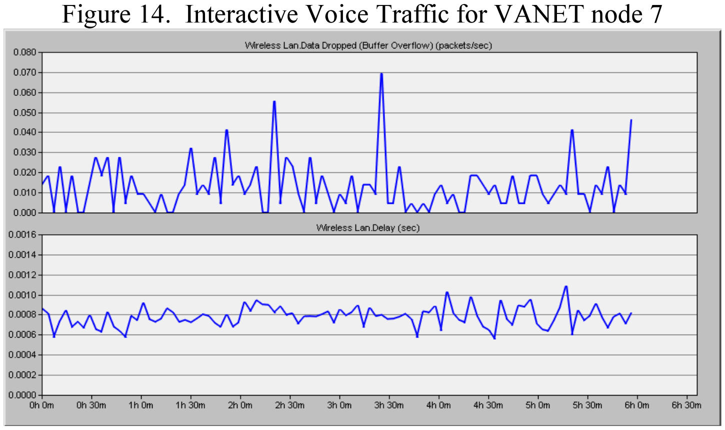

Figure 15. Interactive Voice Traffic for VANET node 11

3.2 Vehicles with the Speed of 110 km/h:

The speed of the vehicles is accustomed to 110 km/h and different kinds of traffic will be allowed to flow. The two parameters i.e. data drop and delay will be calculated for erratically selected vehicles.

3.2.1 Best Effort Traffic:

In case of best effort traffic with vehicles moving with the speed of 110 km/h having randomly selected nodes 16 and 17 respectively for evaluation, it is noted that the data drop maximum value is 0.060 and average is almost 0.030 and for delay it varies from 0.0006 to 0.0010. The simulated fallouts witness that these values are the same as for speed 90 km/h. So if vehicles speed is increased from 90 km/h to 110 km/h, there seems to be no major fluctuations faced in terms of data drop and delay.

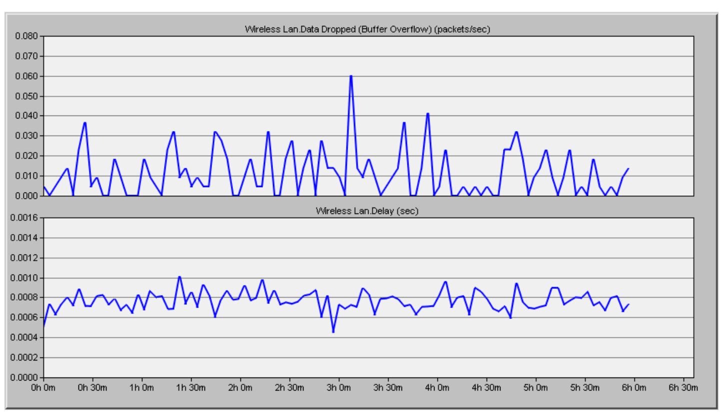

Figure 16. Best Effort Traffic for VANET node 1

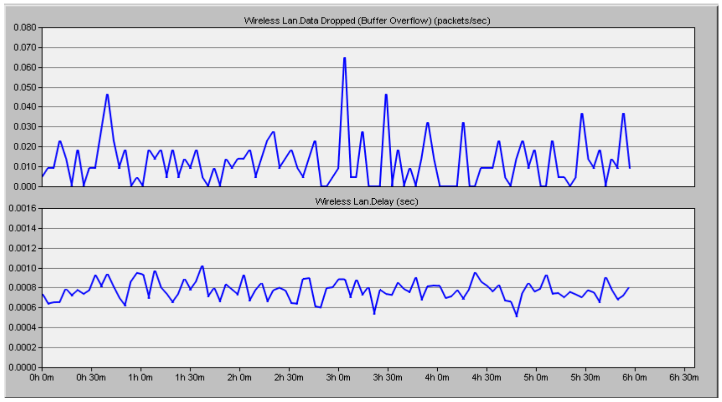

Figure 17. Best Effort Traffic for VANET node 7

3.2.2 Background Traffic:

In order to evaluate the background traffic with the speed of 110 km/h, selection of node 3 and 13 are prepared. It is clear from the Figures 18 and 19 respectively that average of data drop is slightly high here as compared with best effort traffic but peak is 0.060. Nonetheless, there is no change in case of delay for this traffic flow.

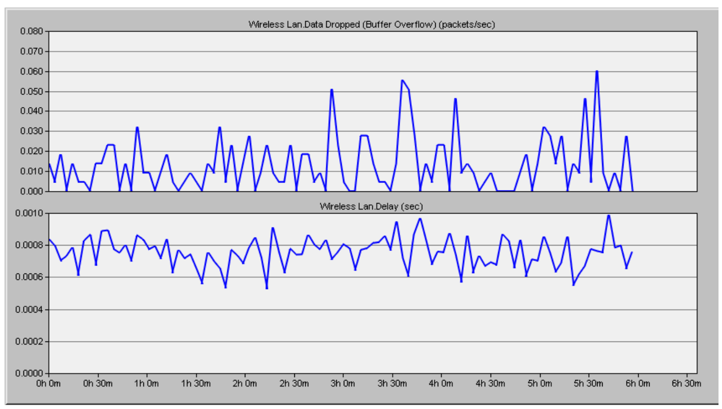

Figure 18. Background Traffic for VANET node 3

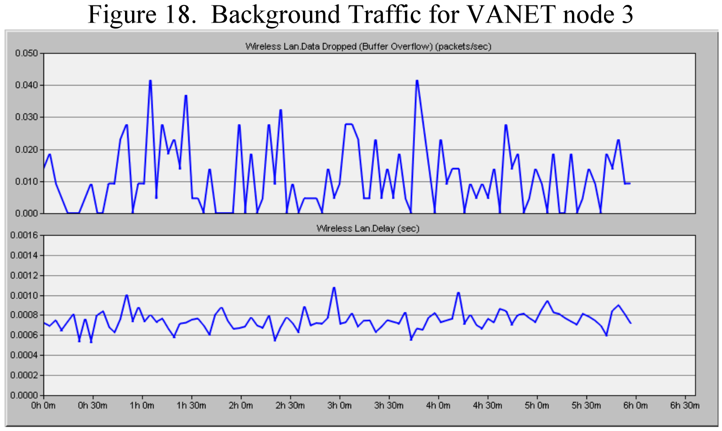

Figure 19. Background Traffic for VANET node 13

3.2.3 Standard Traffic:

When standard traffic is allowed to flow through VANETs, we can spot the results using arbitrarily selected nodes i.e. 5 and 9 as revealed in Figure 20 and 21 separately. It indicates that the data drop values maximum is currently 0.070 and average is also marginally increased. While there is no big change in case of delay for this traffic flow. Thus, we can say that with the speed of 110 km/h, if standard traffic is allowed to flow then only data drop ratio is changed and it does not affect the overall delay.

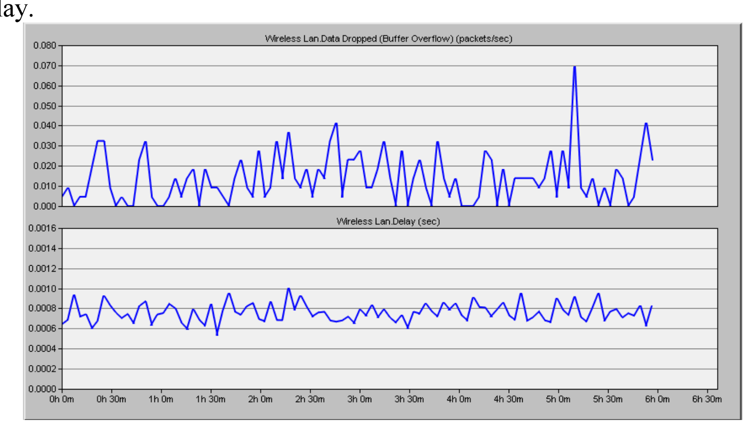

Figure 20. Standard Traffic for VANET node 5

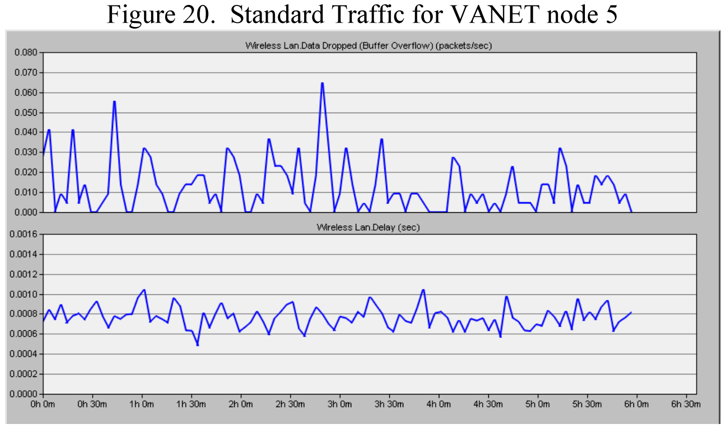

Figure 21. Standard Traffic for VANET node 9

3.2.4 Excellent Effort Traffic:

When excellent effort traffic is flowing in the VANETs, it is perceived that the data drop and delay changes with vehicle nodes 7 and 11as presented in Figure 22 and 23 respectively. It is clear that data drop peak value is fairly increased i.e. more than 0.060, but average is more or less alike. As the discussion is made on the delay for this traffic, we can witness that it also increases the time i.e. more than usual value 0.010. Hence, it can be concluded that excellent effort traffic is affected if vehicles are moving with the speed of 110 km/h.

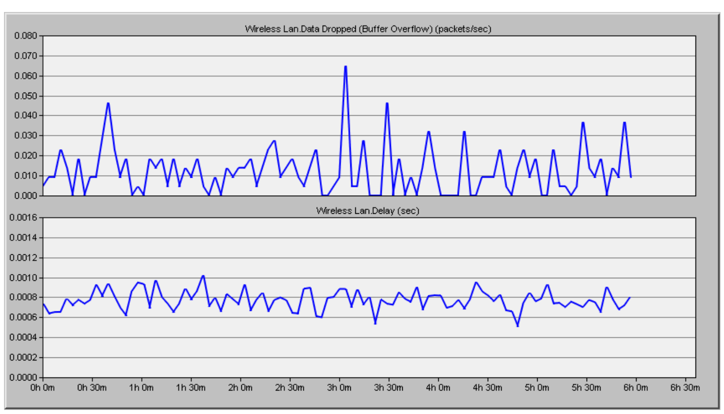

Figure 22. Excellent Effort Traffic for VANET node 7

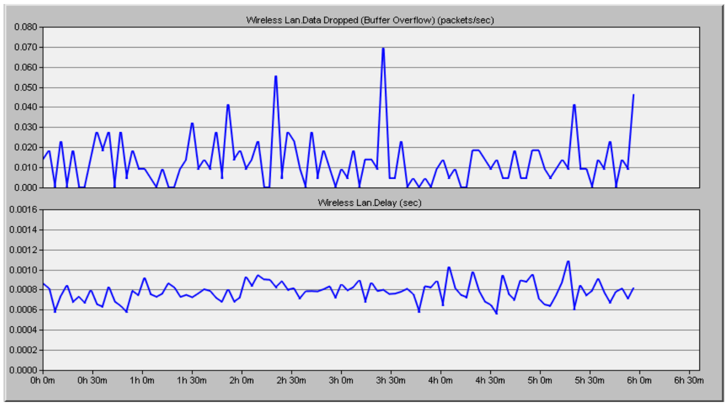

Figure 23. Excellent Effort Traffic for VANET node 11

3.2.5 Streaming Multimedia Traffic:

Effect in streaming multimedia traffic can be observed in Figure 24 and 25 with the vehicles 1 and 11. Graphs show that both data drop and delay is increased marginally from their usual value i.e. from 0.060 to 0.070 data drop and in case of delay it is more than 0.010. Subsequently, if vehicles are moving with the swiftness of 110 km/h, it will affect the performance of streaming multimedia traffic.

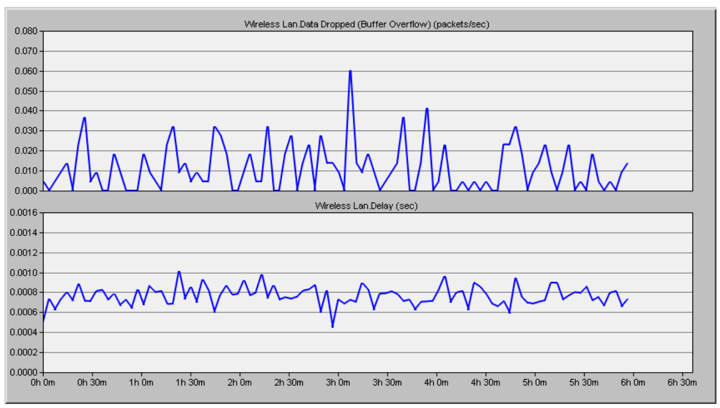

Figure 24. Streaming Multimedia Traffic for VANET node 1

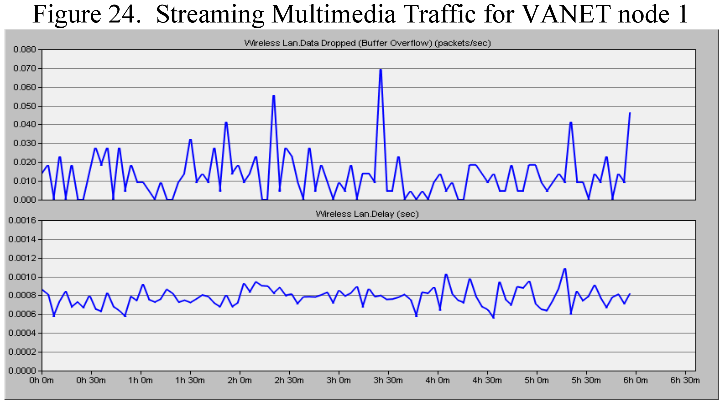

Figure 25. Streaming Multimedia Traffic for VANET node 11

3.2.6 Interactive Multimedia Traffic:

We can witness the performance of interactive multimedia traffic for node 3 and 7 in Figure 26 and 27. It can be perceived that this traffic type is not mainly affected by the vehicle speed of 110 km/h. Peak value for data drop is 0.060 but average is a bit high and for delay there is no change in values.

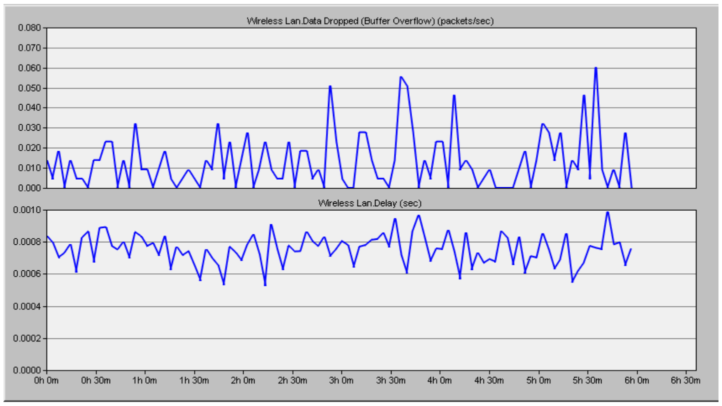

Figure 26. Interactive Multimedia Traffic for VANET node 3

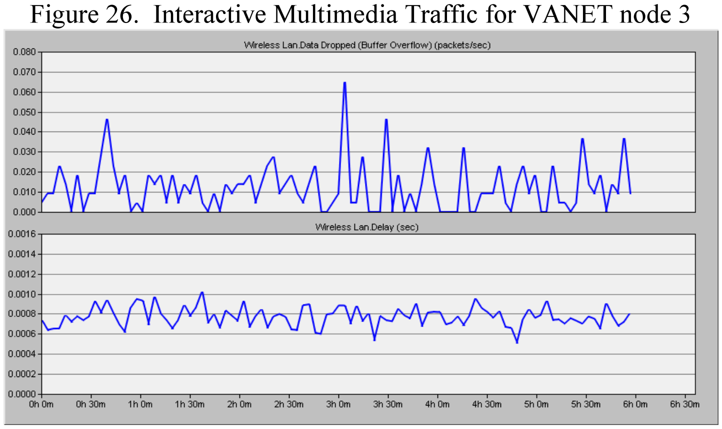

Figure 27. Interactive Multimedia Traffic for VANET node 7

3.2.7 Interactive Voice Traffic:

Performance evaluation of the traffic interactive voice can be analyzed in Figure 28 and 29 separately with erratically selected nodes 5 and 7. The average of data drop and delay is not expanded but the peak value is more than the usual value i.e. higher than 0.060. Nevertheless, in case of delay the overall value is reduced less than 0.0006.

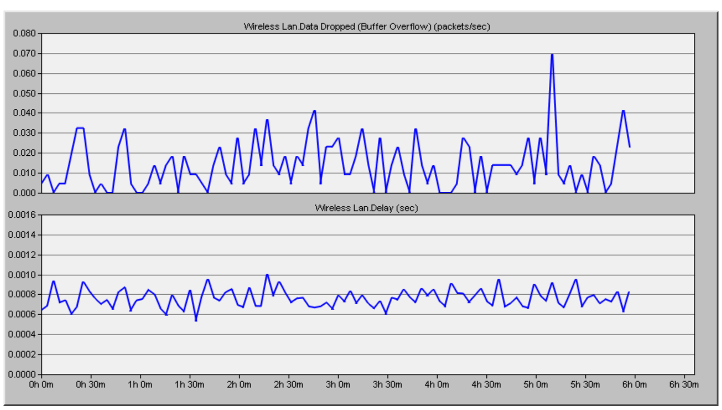

Figure 28. Interactive Voice Traffic for VANET node 5

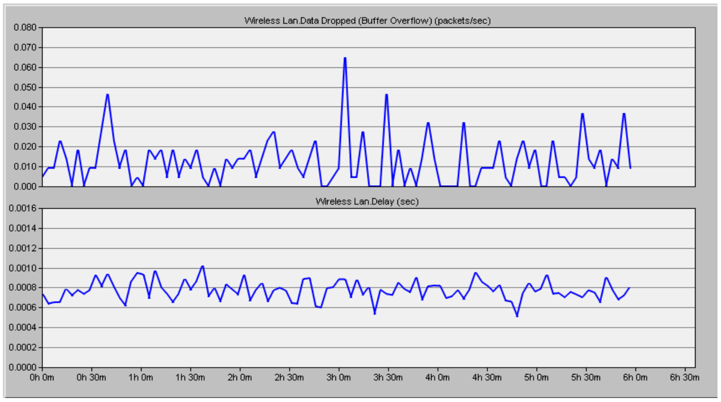

Figure 29. Interactive Voice Traffic for VANET node 7

3.3 Vehicles with the Speed of 130 km/h:

Analysis of different traffics with the vehicles, while moving with the speed of 130 km/h has been deployed in the following. Simulation time is 6 hours for all the traffics.

3.3.1 Best Effort Traffic:

First of all we will check the performance of best effort traffic with the vehicle speed of 130 km/h. The flow in the Figure 30 and 31 respectively for the randomly selected nodes 5 and 9 is exposed. The maximum value for data drop seems to cross the usual value 0.060. However, the average is not effected. As far as delay is concerned there is no vast alterations in the values.

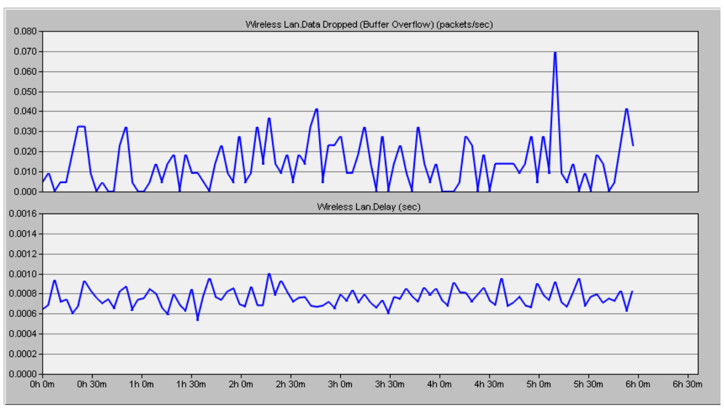

Figure 30. Best Effort Traffic for VANET node 5

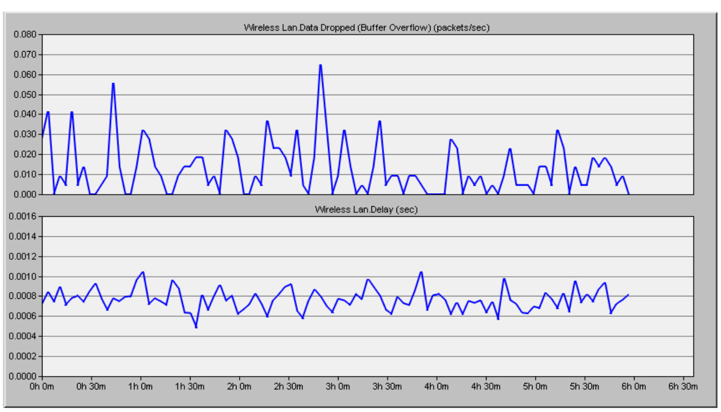

Figure 31. Best Effort Traffic for VANET node 9

3.3.2 Background Traffic:

In case of background traffic data drop peak value is reduced taking little high average. Then, we can realize that the delay is little increased for this traffic with the swiftness of 130 km/h i.e. more than 0.010. Graphs are shown in Figures 32 and 33 respectively for nodes 0 and 4.

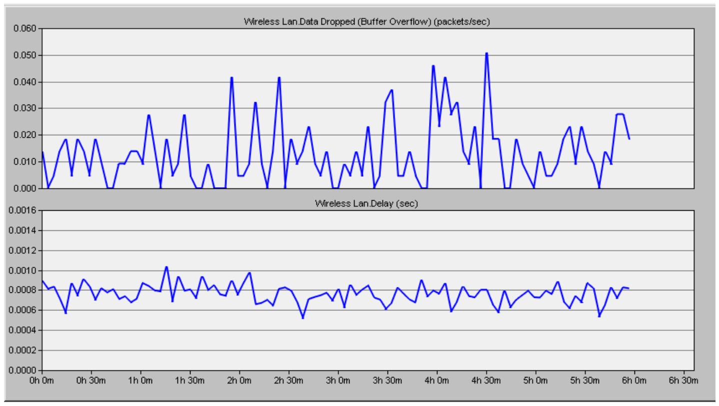

Figure 32. Background Traffic for VANET node 0

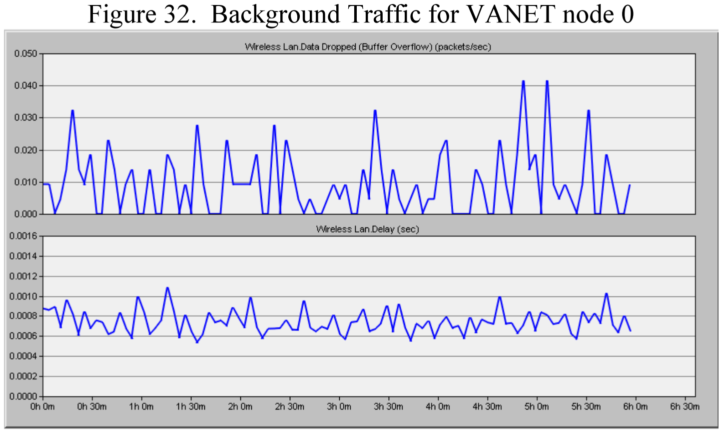

Figure 33. Background Traffic for VANET node 4

3.3.3 Standard Traffic:

In case of standard traffic with the vehicle speed of 130 km/h, the overall data drop is not bothered and it reaches to maximum value of 0.060. Whereas, there is no change in delay as shown in Figure 34 and 35 separately.

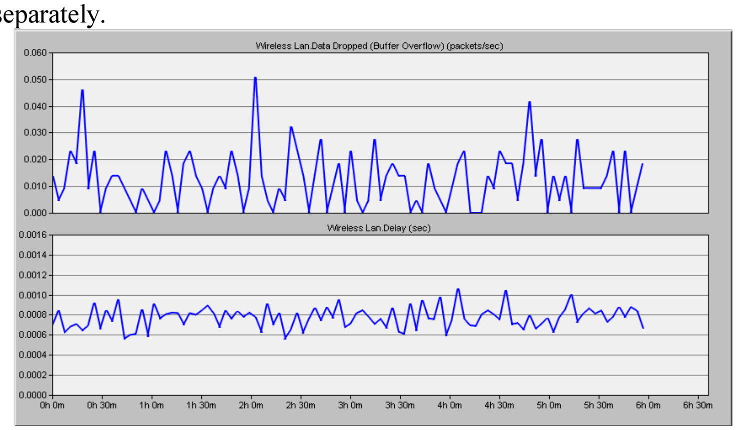

Figure 34. Standard Traffic for VANET node 2

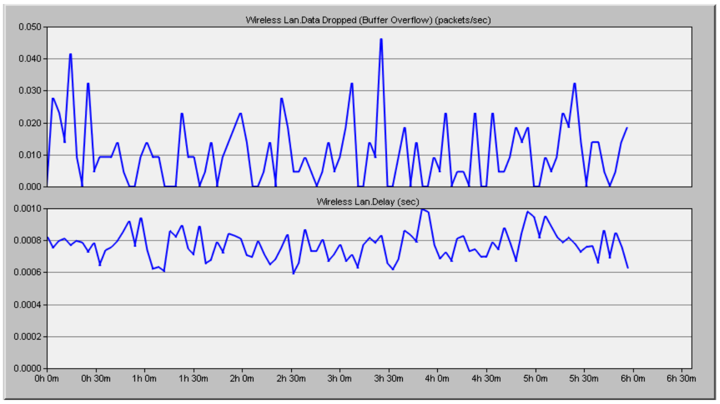

Figure 35. Standard Traffic for VANET node 8

3.3.4 Excellent Effort Traffic:

Performance of excellent traffic is shown in the Figure 36 and 37 respectively with the arbitrarily selected nodes 6 and 10. It is precisely noted from the Figures that, data drop has maximum peak of 0.060 despite the fact having average of almost 0.020. By way of discussing upon delay, it is not effected with the high speed of vehicles. It varies from 0.0006 to 0.0010.

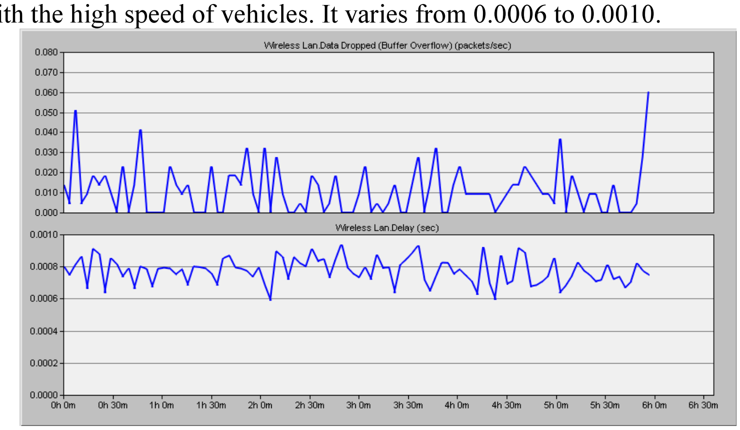

Figure 36. Excellent Traffic for VANET node 6

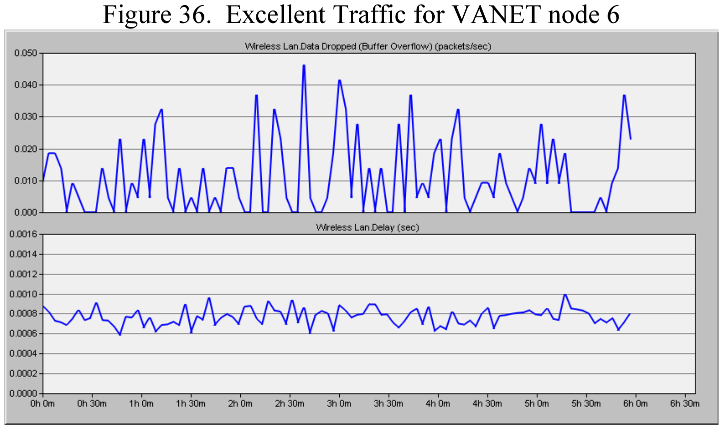

Figure 37. Excellent Traffic for VANET node 10

3.3.5 Streaming Multimedia Traffic:

When streaming multimedia traffic is allowed to flow then the peak value of data drop is 0.050 having average of about 0.020, while delay faces no key change in its value with this type of traffic is shown in Figure 38 and 39 separately.

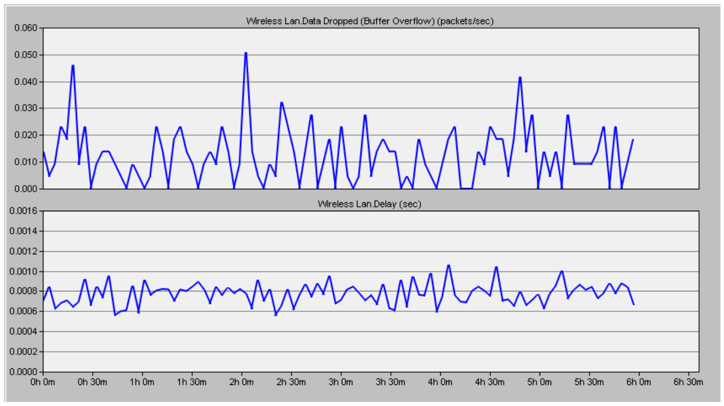

Figure 38. Streaming Multimedia Traffic for VANET node 2

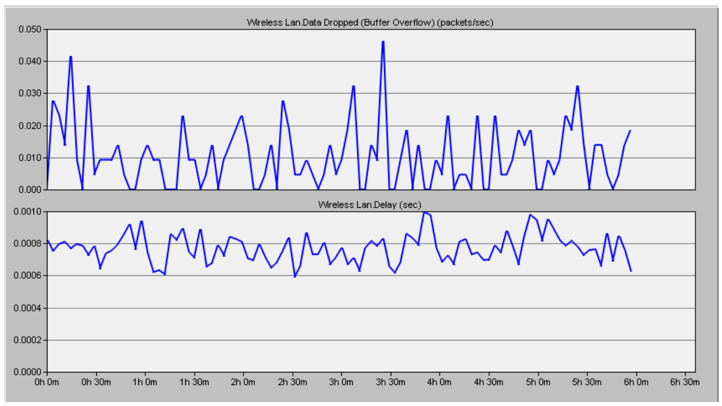

Figure 39. Streaming Multimedia Traffic for VANET node 9

3.3.6 Interactive Multimedia Traffic:

In case of interactive multimedia traffic both data drop and delay are increased than their usual values as shown in Figure 40 and 41 for the arbitrarily selected nodes 6 and 12. Data drop value is more than 0.070 and delay value is more than 0.010. Accordingly, we can say that interactive multimedia traffic is seriously disturbed, if vehicles are moving with the speed of 130 km/h.

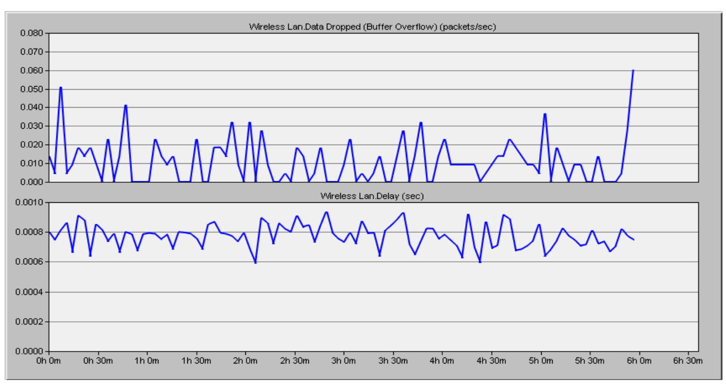

Figure 40. Interactive Multimedia Traffic for VANET node 6

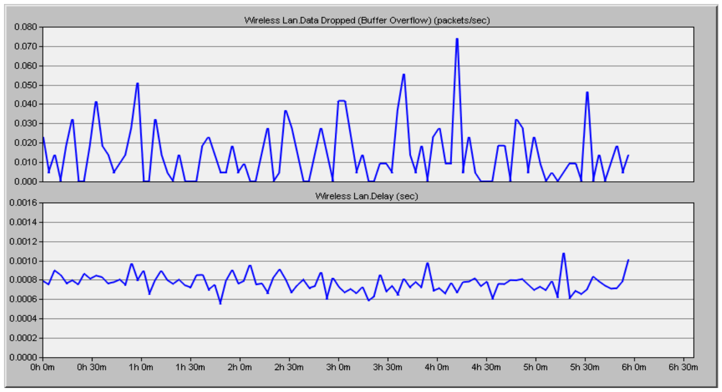

Figure 41. Interactive Multimedia Traffic for VANET node 12

3.3.7 Interactive Voice Traffic:

In order to observe performance of interactive voice traffic, we see the Figure 42 and 43 respectively with the randomly selected nodes 4 and 5. We conclude that, the peak value of data drop is marginally higher than 0.040 taking an average of about 0.020, despite the fact that delay faces no modification in values.

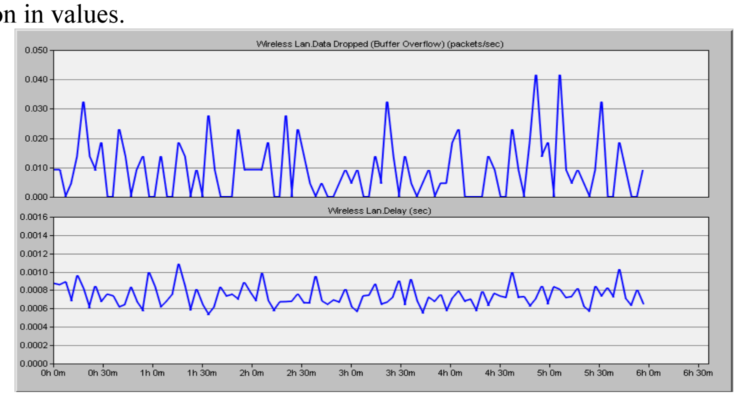

Figure 42. Interactive Voice Traffic for VANET node 4

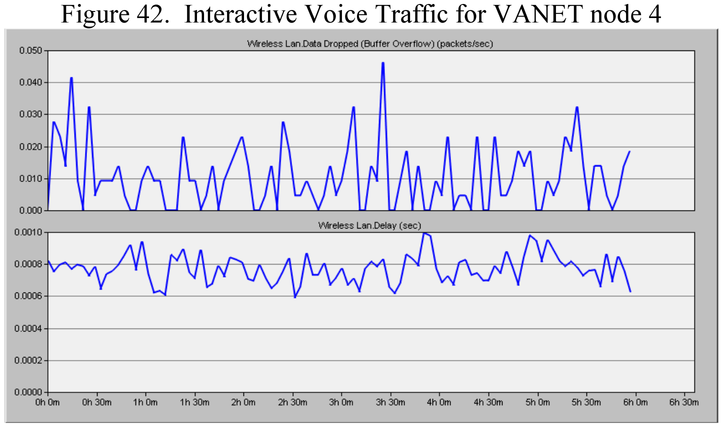

Figure 43. Interactive Voice Traffic for VANET node 5

4 RESULTS

In this paper, we have assessed the performance of six different categories of traffics for three varying speeds of vehicles movement. The detailed outcomes are presented and discussed along with appropriate pictorial representations. The analysis henceforth, has helped us to select the type of traffic for any particular speed of vehicles in movement. The enactment of that traffic for the said speed is well known in due case.

The QoS visualization indeed will assist the researchers in future as they try to optimize the performance, throughput and delay in VANETs.

5 FUTURE WORK

In this paper, we choose six categories of traffics for analysis applied over three diverse speeds of vehicles. Moreover, further unpredictable traffics can be selected with more vehicular speeds in order to have a better analysis for the future research which can lead to an improved optimization.

REFERENCES

1. Akbar, M. S., et al. (2014). "Evaluation of IEEE 802.11 n for Multimedia Application in VANET." Procedia Computer Science **32**: 953-958.
2. Amadeo, M., et al. (2012). "Enhancing IEEE 802.11 p/WAVE to provide infotainment applications in VANETs." Ad Hoc Networks **10**(2): 253-269.
3. Antonopoulos, A., et al. (2013). "Network coding-based cooperative ARQ scheme for VANETs." Journal of Network and Computer Applications **36**(3): 1001-1007.
4. Ayaida, M., et al. (2014). "Joint routing and location-based service in VANETs." Journal of Parallel and Distributed Computing **74**(2): 2077-2087.
5. Bradai, A., et al. (2014). "ViCoV: Efficient video streaming for cognitive radio VANET." Vehicular Communications.
6. Chakroun, O. and S. Cherkaoui (2014). "Overhead-free congestion control and data dissemination for 802.11 p VANETs." Vehicular Communications.
7. Chuang, M.-C. (2014). "An incentive-based mechanism for fair bidirectional transmissions in wireless mesh networks." Computers & Electrical Engineering.
8. Cuomo, F., et al. (2014). "Enhanced VANET broadcast throughput capacity via a dynamic backbone architecture." Ad Hoc Networks.
9. Doyle, N. C., et al. (2013). "Complete architecture and demonstration design for a new combined WiMAX/DSRC system with improved vehicular networking efficiency." Ad Hoc Networks **11**(7): 2026-2048.
10. Engoulou, R. G., et al. (2014). "VANET security surveys." Computer Communications **44**: 1-13.
11. Fathy, M., et al. (2012). "Improving QoS in VANET Using MPLS." Procedia Computer Science **10**: 1018-1025.
12. Fonseca, A. and T. Vazão (2013). "Applicability of position-based routing for VANET in highways and urban environment." Journal of Network and Computer Applications **36**(3): 961-973.
13. Ghosh, M., et al. (2010). "Detecting misbehaviors in VANET with integrated root-cause analysis." Ad Hoc Networks **8**(7): 778-790.
14. Guérout, T., et al. (2014). "Quality of Service Modeling for Green Scheduling in Clouds." Sustainable Computing: Informatics and Systems.
15. Hassanabadi, B., et al. (2014). "Clustering in vehicular ad hoc networks using affinity propagation." Ad Hoc Networks **13**: 535-548.
16. Igartua, M. A., et al. (2011). "A game-theoretic multipath routing for video-streaming services over Mobile Ad Hoc Networks." Computer Networks **55**(13): 2985-3000.
17. Kim, J.-H. and S. Lee (2011). "Reliable routing protocol for vehicular ad hoc networks." AEU-International Journal of Electronics and Communications **65**(3): 268-271.
18. Lee, K. C., et al. (2010). "GeoCross: A geographic routing protocol in the presence of loops in urban scenarios." Ad Hoc Networks **8**(5): 474-488.
19. Li, J.-S., et al. (2013). "Intelligent Adjustment Forwarding: A compromise between end-to-end and hop-by-hop transmissions in VANET environments." Journal of Systems Architecture **59**(10): 1319-1333.
20. Liu, B., et al. (2012). "Analysis of the information storage capability of VANET for highway and city traffic." Transportation Research Part C: Emerging Technologies **23**: 68-84.
21. Wang, X. and S. Zhong (2013). "Research on IPv6 address configuration for a VANET." Journal of Parallel and Distributed Computing **73**(6): 757-766.