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MEASUREMENT STUDY ON PACKET SIZE AND PACKET RATE EFFECTS OVER VEHICULAR AD HOC NETWORK PERFORMANCE

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ABSTRACT

A vehicular ad hoc network (VANET) is a type mobile ad hoc network which is developed to increase physical safety of vehicles' derivers. Many parameters affect the performance of VANET. Packet size and packet rate are two important parameters that need to be considered when using VANET. Different values of these parameters provide different network performance. Using large packet size leads to reduce packet header overhead, but may leads to increase packet loss ratio due to packets collision. Therefore the values of these parameters must be chosen carefully. This paper presents an investigation and analysis of using different packet sizes and different packet rates on a VANET consists of wireless nodes distributed along a highway. The investigation and analysis were performed under varying network environments and for several different evaluation metrics. It is a conclusion of this study that using small packet size gives better network performance than using large packet size. Moreover, the slow packet rate can provide better network performance than using faster packet rate in highway VANET.

Keywords: *MANET, Packet Size, Packet Rate, Throughput, VANET*

1. INTRODUCTION

Mobile ad hoc network (MANET) is an infrastructureless wireless network consisting of independent nodes that move and dynamically change network connectivity. MANET represents one of the most important types of next generation wireless networks which can be used for different real world applications such as, military, , disaster relief, delay-tolerant networking and vehicular networks [1]. A vehicular ad hoc network (VANET) is a mobile ad hoc network designed to provide communications among close vehicles and between vehicles and nearby fixed equipment. The main goal of a VANET is to provide safety and comfort for passengers. [2-3]. Although VANETs are promising for the future, they suffer from several challenges such as connectivity, mobility management, network afford load, media access, lack of bandwidth, and power consumption [4-5]. VANETs are faced with the nontrivial task of maintaining connectivity so that a vehicle (a mobile node) may establish a single hop or multihop communication link to any other vehicle in the network. The connectivity of the network is affected by factors that include transmitter power, environmental conditions, obstacles, and mobility.

Vehicle mobility creates a highly dynamic topology. In heavy traffic congestion, vehicles may be within a couple of meters proximity of one another, whereas on a sparsely populated road the distance may be hundreds of meters. Traffic condition may change rapidly between congested and sparse due to traffic jams, accidents, and road constraints which leads to affect network performance [6]. In a VANET environment, and due to vehicle mobility and unpredictable network topology, both ends of a wireless link may move reverse the trend or toward each other at highway speeds, thus considerably increasing the rate of change in the channel quality [6]. Therefore, the efficiency of the packet transfer via a multihop link with variable quality is a factor of the size and the rate of the packet being transmitted. Larger packets require a longer transmission time and suffer a correspondingly larger chance of errors [6].

Using large packet size leads to reduce header overhead, but may leads to increase packet loss ratio due to packets collision or due to

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corruptions in a radio channel or [7]. The transport or link layer use different mechanisms to find errors in each packet, and drops all packets which contain error bits. Large packet size is more prone to be dropped than the smaller one due to packet bit errors or collisions, since the link layer fragments the large packet into smaller parts which lead to increase the packet error probability[8]. The fragmentation can reduce the number of retransmissions caused by collisions or bit errors, consequently, decreases the overhead caused by retransmissions. On the other hand fragments the large packet into smaller parts introduces different kind of overhead. Smaller parts (packets) introduce more overhead on the network too, because every fragmented packet sent from one wireless node to another wireless node requires the receiving node to acknowledge the packet[9]. Depending on the type of protocols and mechanisms which are used in the link and physical layers, bit errors decline the network performance in the form of increased transmission time delay and packet loss rate[7]. Both effects are harmful, especially for real time applications such as safety message in VANET. Whereas, the rate of the packet represents the number of packets generate by a node per second. Packet rate is an important parameter that can affects the efficiency of the network. If a source node pumps more data than that which can be supported by the network, it results in high contention rates at later nodes and will thus degrade network performance by increasing number of lost packets which are dropped due to the packet collisions. Therefore packet size and packet rate optimization (network workload) are an essential research problems in wireless telecommunications and the value of these parameters must be selected carefully in order to obtain a good network performance.

The main paper objective is to investigate, analyze and demonstrate the effects of workload (packet size and packet rate) over vehicular Ad hoc Network (VANET) performance in order to find the best packet size and rate which can be used in this type of network.

The effects of packet size and packet rate over wireless networks are studied and analyzed by many researchers. The authors in [10] explored the optimum duration of data packets (packet rate) by developing a mathematical model based on dynamics of Rayleigh fading. They used the rate of packets transfer through the radio channel as an evaluation metric. They found that In addition to the size of the packet, the packet rate depends on: the speed of the mobile node, the channel bit rate, the header size of the packet as well as the modulation and coding techniques. The authors showed that In any event, the optimum packets are considerably shorter than the 125-byte.

A novel Markov model is constructed in [11] to calculate the packet loss probability and the delay distribution of real-time wireless packets. These packets are transmitted through an erroneous channel modeled by a two-state Markov chain. The authors showed that closed-form solutions are obtained, and simplified expressions assuming highly correlated errors and small error probability are derived. Under these conditions, it is found that the packet loss probability is significantly affected by the delay limit and the transition probability of the channel’s remaining in the failure state. On the other hand, they observed that the probability is almost independent of the arrival rate provided the rate is not close to one. Existing techniques utilizing adaptive packet length in wireless communications were mainly designed to reside in the medium access control (MAC) or link layer. From the network designer’s point of view, it is natural to operate in the MAC layer when issues related to the physical transport channel are considered. However, in many cases, better performance could be achieved if the method for fragmenting data units were optimized for the specific application. Packet fragmentation in the link or MAC layer tends to increase bandwidth usage and it is also likely to cause delay due to segmentation and packet re-assembly operations.

The contribution of this research is investigating and analyzing the impact of using different packet sizes and packet rates on the performance of Highway VANET, in order to find the adequate values which can be used in this type of networks.

The paper remainder is organized as follows: packet size and packet rate analysis is described in Section 2. Network modeling and parameters setup are described in Section 3. The evaluation results and its analysis are demonstrated in Section 4. Finally, the paper conclusions are demonstrated in Section 5.

2. NETWORK WORKLOAD ANALYSIS

Transmitting large packets over wireless network increase the efficiency of the network. In the case of medium and large packets, the

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performance of wireless networks is improved by using some techniques to decrease the number of lost packets which are dropped due to collisions or bit errors, such as RTS/CTS technique which decreases the collision effects and fragmentation technique which reduces the bit errors effects[12]. Both techniques introduce some overhead; therefore, they are not worth using for small packets. Although there are no constrains for small packet sizes, network designer must be aware of the impact of using very small packets. Many disadvantages appear due to using small packets, these are:

- As compared to the payload size, packet header overhead becomes too large.
- Bandwidth requirement becomes high.
- Rate of the packets increases, which leads to produce challenging situations for the network.

The fragmentation is one of the most important techniques which are used to improve network performance. The main advantages of using fragmentation are:

- Decrease packet transmission delay since small packet size need less time to be sent than bigger packet size.
- No need to retransmit the whole data if loss occurs due to packet error in network. One has to just retransmit only lost packet/segment [13].

However, the main disadvantages of using fragmentation are:

- Limiting packet sizes.
- Fragmentation leads to increases the bandwidth requirement, due to additional header overhead.
- Packet transmission time increases due to the operations of segmentation and re-assembly.

Therefore, the network designer should select the packet size and packet rate carefully in order to avoid the fragmentation as well as the limitations of using small packet sizes.

3. SIMULATION SETUP

In this paper, OMNeT++ [14], was used for design the simulation model and perform all the experiments to evaluate and analyze the effects of using different packet sizes and packet rates on the performance of a VANET.

3.1 Highway Model Setup

The model specifications which are used to evaluate and analyze the effects of workload (packet size and packet rate) on the performance on highway VANET scenario as a case study is shown below:

- The simulated area is a 6500m straight highway section with two sides in same direction.
- Fifty fixed hosts placed along each sides of the highway with a 250m separation between each two nodes.
- All fixed nodes in the second side placed 125 meters ahead of the nodes in the first side as demonstrated in Figure 1.
- Six mobile nodes distributed on both sides of the highway with 50m separation distance between each two vehicles.
- The nodes' speed is configured to be 20 m/s.
- Four sizes of data packet are used (0.5, 1, 2 and 4 KB).
- Three values of packet rate are used (1, 2 and 3 packets / sec.).
- All nodes are configured to use UDP transport protocol with constant bit rate (CBR) traffic pattern.
- IEEE 802.11g DCF used as a MAC protocol.
- AODV is used as a routing protocol.
- The simulation time is 500s for each experiment.
- Nodes mobility is configured according to the freeway mobility pattern.

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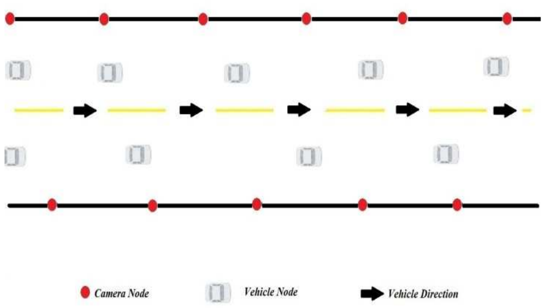

Figure 1: Highway VANET Scenario

3.2 Evaluation Metrics

The evaluation metrics which are chosen to analyze the affects of packet size and packet rate on the performance of a VANET are:

1. Throughput – represents number of bits, sent by the network to a certain destination during a specific period of time.

2. Packet Transmission Ratio (PTR) - represents the efficiency of network protocols to the amount of network workload. It's measured by dividing number received packets to the number of sent packets.

3. Packet Loss- represents total number of dropped packets by the nodes.

4. Packet Transmission delay – represents the average time required by the packets to reach its destination.

4. RESULTS AND ANALYSIS

Different types of tests are performed to evaluate and investigate the effects of using different packet sizes and different packet rates on the Highway VANET scenario. Both experiments performed to find the adequate values of the packet size and rate which provides an efficient network performance.

4.1 Packet Size

Figure 2 depicts the throughput of the network (Kbps) over number of nodes for variable packet sizes. For each packet size, the throughput of network traffic decreases when the number of hops between the source and the destination increases. This is because increasing in the number of hops will increase the packet error probability, causing network throughput to decrease. Furthermore, the decreasing level for smaller packet size is less than the decreasing level for a bigger one, because packet error probability increases as packet size increases due to the packet fragmentation, and this case makes the decrease in throughput larger for 4KB packet size.

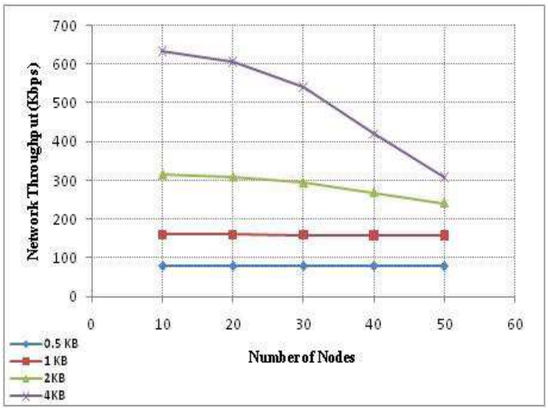

Figure 2: Throughput vs. Number of Nodes between Source and Destination

Figure 3 depicts number of lost packets versus nodes number for variable packet sizes. For each packet size, the number of lost packets increases with an increase in the number of nodes between the source and the destination. Increasing the number of nodes causes an increase in the probability that the packet may be dropped while it competes to access the wireless channel at each node to reach its destination. However, when this increase occurs, the number of lost packets will decrease the PTR as shown in Figure 4. The decreasing level of PTR for smaller packet size is less than the decreasing level of PTR for a bigger one, because packet error probability increases as packet size increases, which leads to an increase in the number of lost packets and this case makes the decrease in PTR larger for 4KB packet size.

Figure 5 shows that the packet transmission time delay for large packet size is greater than the transmission time delay for the small packet size because the transport layer of each node needs more time to transmit a larger packet size than a smaller one. Moreover, increasing the users' number will increase the transmission time delay for all packet sizes because increasing number of users will also increase number of packets waiting in the MAC layer buffer to be sent.

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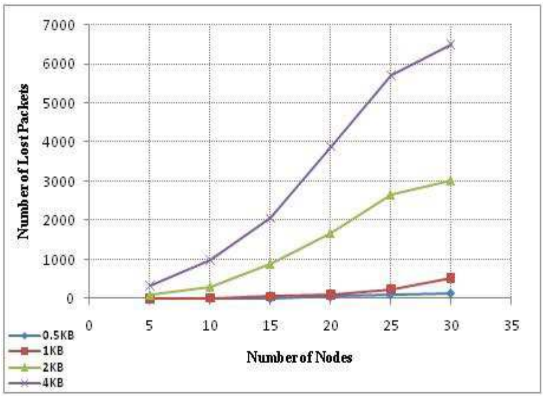

Figure 3: Number of Lost Packets vs. Number of Nodes between Source and Destination

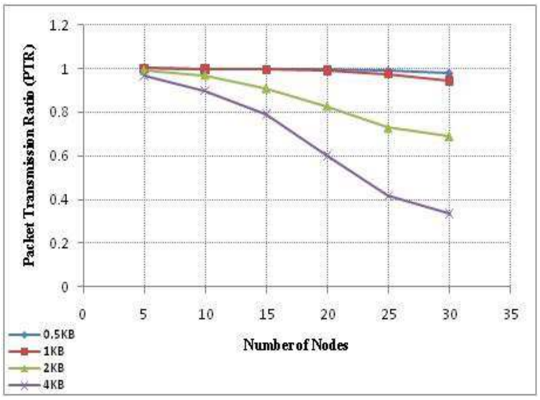

Figure 4: Packet Transmission Ratio (PTR) vs. Number of Nodes between Source and Destination

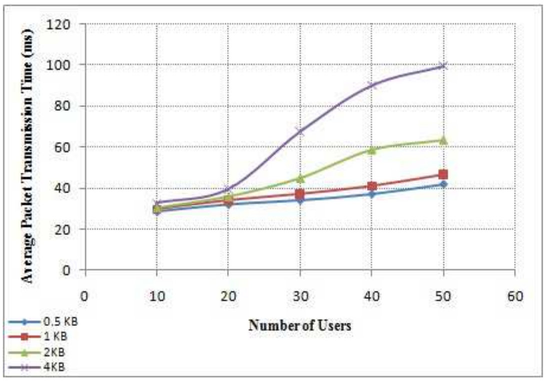

Figure 5: Packet Transmission Time vs. Number of Users

4.2 Packet Rate

Figure 6 shows network throughput (Kbps) versus the number of users for different packet rates. Figure 6 shows that an increasing number of packets (packets generated by the nodes), the so-called 'packet rate', increases the amount of data injected into the network. This data injection leads to an increase in throughput (the larger the packet rate, the higher the throughput). It should be pointed out that the network throughput for all three packet rates decreases as the number of users increases. This is because increasing the users' number means increasing the amount of data pushed into the network, the consequence is more packet collision; consequently network throughput decreases. For comparison purposes, the throughput decrease for the small packet rate is less that the throughput decrease for the larger packet rate.

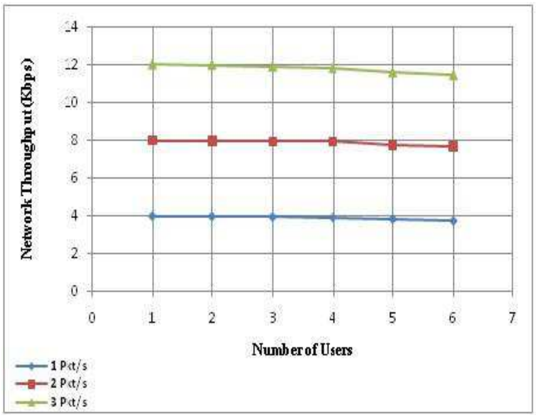

Figure 6: Network throughput vs. number of users for different packet rates

Figure 7 compare packet loss versus the number of users. There are three plots, each indicating a different packet rate. For each packet rate, the number of lost packets increases with an increase in the number of users. Because when the number of users increases, this forces the MAC layer to discard all the overflow packets in its buffer. Also increasing the packet rate increases the number of packets waiting in the MAC layer buffer to be sent. All the packets that exceed their waiting time limit are discarded by the MAC layer. Moreover, the Figure shows that the number of lost packets for the larger rate of packet is higher than number of lost packets for the smaller one because larger packet rates fill the buffer of the MAC layer faster than the smaller one.

Figure 8, depicts the Packet Transmission Ratio (PTR) over number of users for different packet rates. For each packet rate, the PTR decreases when there is an increase in the number of users due to higher channel contention. The Figure shows that the PTR for the higher packet rate is less than the PTR for the smaller packet rate.

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It can be concluded that this is because with the higher packet rate, the transport layer needs more time to transmit the data; consequently, this keeps the transport layer channel busy, which affects the PTR.

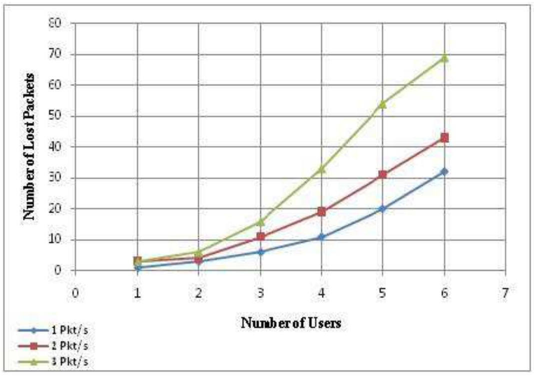

Figure 7: Number of lost packets vs. number of users for different packet rates

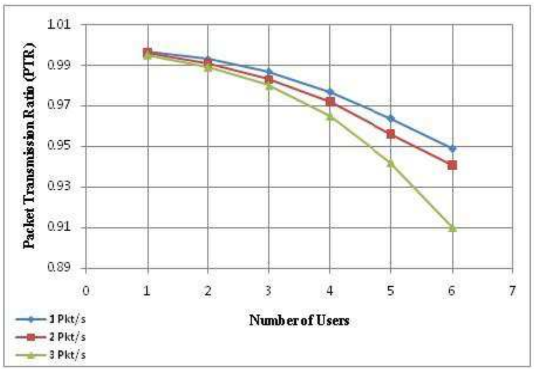

Figure 8: Packet transmission ratio (PTR) vs. number of users for different packet rates

Figure 9 shows packet transmission time over number of users for different packet rates. For each packet rate, the packet transmission time increases with an increase in the number of users. This is due to the fact that with a higher number of users, the transport layer of each node needs more time to send the data, and increasing the packet rate increases the number of packets waiting in the MAC layer buffer to be sent, which in turn leads to an increase in the packet transmission time.

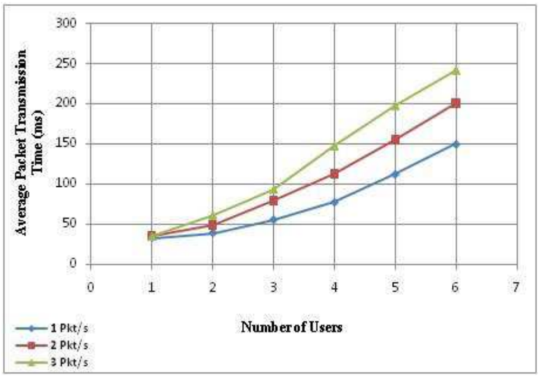

Figure 9: Average packet transmission time vs. number of users for different packet rates

5. CONCLUSION

In a VANET environment, and due to vehicle mobility and unpredictable network topology, both ends of a wireless link may move reverse the trend or toward each other at highway speeds, thus considerably increasing the rate of change in the channel quality. Therefore, the efficiency of the packet transfer via a multihop link with variable quality is a factor of the size and the rate of the packet being transmitted. Larger packets require a longer transmission time and suffer a correspondingly larger chance of errors which leads to affect the VANET performance, consequently the application efficiency and flexibility. This paper presents an investigation and analysis of using different packet sizes and different packet rates on the efficiency of a highway VANET consisting of wireless nodes distributed along a highway. The impact of using different packet size and different packet rate were analyzed under varying network environments and for different evaluation metrics. It has been concluded from the observed results that using small packet size at high node mobility speed is better than using large packet size (>1KB) with respect to packet loss rate and end-to-end transmission delay as well as the packet transmission ratio. On the other hand, number of lost packets increases due to an increase in packets rate which adversely affects the VANET performance. Therefore, it is preferred to use low packet generation rate (less than 3 Packet/s) in heavy traffic congestion and (3 Packet/s in s) in sparsely populated road.

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REFERENCES:

[1] H. Rashvand and H.-C. Chao, Dynamic ad hoc networks: The Institution of Engineering and Technology, 2013.

[2] P. Ghosekar, et al., "Mobile ad hoc networking: imperatives and challenges," IJCA special issue on “Mobile ad hoc networks”, MANETs, 2010.

[3] R. Krishnan and Z. Zhang, "Mobile Ad-hoc Networking (MANET) Formulation Considered Harmful," 2013.

[4] L. Hassnawi, et al., "Measurement study on the end-to-end data transmission in motorways surveillance system using Wireless Ad Hoc Camera Networks (WAHCN)," in Engineering and Industries (ICEI), 2011 International Conference on, 2011, pp. 1-5.

[5] L. Hassnawi, et al., "Performance Analysis of Motorway Surveillance System Based on Wireless Ad Hoc Camera Network (WAHCN)," Journal of Communications & Information Sciences, vol. 2, 2012.

[6] A. Boukerche, ALGORITHMS AND PROTOCOLS FOR WIRELESS AND MOBILE AD HOC NETWORKS. Hoboken, New Jersey: John Wiley & Sons, Inc., 2009.

[7] A. McAuley, et al., "Understanding the delay and loss tradeoffs in large wireless military networks using queuing analysis and MAC models," in MILITARY COMMUNICATIONS CONFERENCE, 2012-MILCOM 2012, 2012, pp. 1-6.

[8] K. K. Kambhatla, et al., "H. 264/AVC video packet aggregation and unequal error protection for noisy channels," in Image Processing (ICIP), 2012 19th IEEE International Conference on, 2012, pp. 1649-1652.

[9] S. Basagni, et al., "Optimized packet size selection in underwater wireless sensor network communications," Oceanic Engineering, IEEE Journal of, vol. 37, pp. 321-337, 2012.

[10] C. K. Siew and D. Goodman, "Packet data transmission over mobile radio channels," Vehicular Technology, IEEE Transactions on, vol. 38, pp. 95-101, 1989.

[11] K. K. Lee and S. T. Chanson, "Packet loss probability for real-time wireless communications," Vehicular Technology, IEEE Transactions on, vol. 51, pp. 1569-1575, 2002.

[12] Y. Li, et al., "Energy modeling and optimization through joint packet size analysis of BSN and WiFi networks," in Performance Computing and Communications Conference (IPCCC), 2011 IEEE 30th International, 2011, pp. 1-8.

[13] A. S. Akella, et al., "Method and node for transmitting data over a communication network using negative acknowledgment," ed: Google Patents, 2012.

[14] A. Varga, "Using the OMNeT++ discrete event simulation system in education," IEEE Transactions, vol. 42, p. 11, 1999.