Chapter 14

Performance Analysis of Traffic and Mobility Models on Mobile and Vehicular Ad Hoc Wireless Networks

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ABSTRACT

Advances in wireless communication technology and the proliferation of mobile devices enable the capabilities of communicating with each other even in areas with no pre-existing communication infrastructure. Traffic and mobility models play an important role in evaluating the performance of these communication networks. Despite criticism and assumption from various researches on Transmission Control Protocols (TCP), weaknesses on Mobile Ad Hoc Network (MANET), and Vehicular Ad Hoc Network (VANET). A simulation was carried out to evaluate the performance of Constant Bit Rate, Variable Bit Rate and Transmission Control Protocol on MANET and VANET using DSR routing protocol. CBR, VBR, and TCP have different manufacturer operation mechanisms and these differences lead to significant performance of CBR and VBR over TCP with better throughput and less average maximal end-to-end delay. DSR was able to respond to link failure at low mobility which led to TCP's performance in packets delivery.

INTRODUCTION

Mobile Ad Hoc and vehicular ad hoc networks plays a vital role within the field of network communication. The recent developments in wireless technologies have made Vehicle-to-Vehicle communication (V2V) and Roadside Unit (RSU) achievable in mobile ad hoc networks. This has given birth and brought a new concept of Mobile Ad Hoc Wireless Network known as the vehicular ad hoc network. Vehicular Ad hoc Networks are self-organizing communities of wheeled mobile units consisting of large number of vehicles and a small number of fixed infrastructure nodes

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such as roadside access units within radio communication range to each other. The initiative behind VANET is to facilitate road safety, traffic management and infotainment dissemination for drivers and passengers. In a domain which lacks communication infrastructure or where the existing infrastructure is inconvenient to use, mobile users can communicate through the formation of a temporary wireless Mobile Ad hoc Network. The nodes are mobile and free to move propagating packets freely and randomly without the need for any infrastructure. The application of these networks are highly needed in areas like battlefields, emergency rescue services, lecture theatres conference halls and other places where deployment of network infrastructures becomes difficult.

Due to the fact that their topology/location changes rapidly and unpredictably, these networks need network routing protocol as well as traffic model that can withstand these unpredicted topological changes immediately. These protocols are categorised into pro-active, reactive and hybrid routing protocols (Qasim *et al.,* 2009) and the identification of the most appropriate routing protocol to be used depends on different factors, namely: a) traffic and mobility models b) scalability and c) quality of service.

Despite the fact that considerable simulation work has been done, still more investigation is needed to evaluate the performance of the traffic and mobility models on MANET, VANET and comparison between them. Most of the researches such as (Rajagopalan *et al.,* 2006) evaluate only the performance of TCP traffic model using AODV routing protocol without considering the DSR protocol with CBR, TCP or VBR traffic models. Our work focused on the performance analysis of CBR, VBR and TCP traffic models on MANET and VANET networks using DSR protocol.

DYNAMIC SOURCE ROUTING PROTOCOL

Dynamic Source Routing (DSR) is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes which operate entirely on demand, and works on two mechanisms i.e. route discovery and route maintenance. The route discovery is initiated if and only if the routes to destinations are not known, for which it initiates a route discovery by sending a route request (RREQ) to all its neighbouring nodes containing the IP address of both sender and receiver in the packet header allowing the routing packet overhead of DSR to scale automatically to only what is needed to react to changes in the routes currently in use (Broach *et al.,* 1998). Performance evaluation conducted on both proactive and on demand protocols by Qasim *et al.* (2009), Kumar *et al.* (2008), and Raju and Mungara (2010) showed that DSR performed better than AODV and other proactive protocols in terms of throughput, less end-to-end delay, as well as less packets drop. The DSR performance was attributed to its characteristics of having multiple routes to other destination. In case of link failure, it does not require a new route discovery processes. Because of this, end-to-end delay is reduced as well as less packet dropping. Hence, the DSR protocol was chosen as genial candidate for carrying out further research

BACKGROUND OF THE STUDY

Various on demand, proactive and hybrid ad hoc routing protocols have been studied analytically and simulation method using TCP (Transmission Control Protocol), CBR (Constant Bit Rate) and VBR (Variable Bit Rate) traffic models (Rajagopalan & Shen, 2006; Triantafyllidou *et al.,*2007; Bakalis & Lawal, 2010). Analysis revealed that TCP traffic models performed poorly by misinterpretation of packet losses, link failure, and late acknowledgement as a sign of network congestion (TCP was designed for static wired networks). Explanations of what causes the packet losses in MANET have not fully been given and which routing protocol from all categories is the best to respond to the link failure and packet loss before the TCP's algorithm response is also unknown. According to (John Wiley, 2009), mobility, high bit error rate, unpredictability of the mobile node movement, variability and congestion are the main factors that affect the performance of TCP traffic model in MANET and VANET. Most researches (Abdullah *et al.,* 2008; Sesay *et al.,* 2004; Anisur *et al.,* 2009) used CBR traffic model due to the assumption and criticism of the TCP's weaknesses in these networks.

VANET networks are identical to MANET network in that they rapidly and dynamically change network topologies due to the fast motion of vehicles but differ because of the regular change in vehicular density, relative high speed of vehicular nodes, congestion on roads, traffic control mechanism and the mobility of vehicles are constrained by predefined roads. In (Garoui, 2005) presented an analysis of network traffic in ad hoc networks based on the Destination Sequenced Distance Vector (DSDV) protocol with an emphasis on mobility and communication patterns of the mobile nodes. The goal of the author's simulations was to measure the ability of (DSDV) routing protocol to react to multi-hop ad-hoc network topology changes in terms of scene size, mobile nodes movement, number of connections among mobile nodes, and also the amount of data each mobile node transmits. To measure this, the basic methodology was defined to a set of traffic and mobility communication patterns and applied to an ad hoc network. Different simulations were examined by changing the parameters for mobile nodes movement scenarios and their connection patterns. Increasing the number of connections among fixed number of nodes enhanced the routing overhead and the packet delivery rate. Increasing the transmission rate in an ad hoc network with fixed size and number of mobile node increased the number of transmitted packets in different groups (Sent, Received, Dropped and Forwarded). (Kumar *et al.,2008*), (Chan and Leung, 1988), revealed that despite the popularity of the most common routing protocols such as AODV, DSDV, DSR and OLSR, research efforts had not focussed much in evaluating their performance when applied to variable bit rate (VBR).

One of the major worries of Mobile ad hoc and Vehicular ad hoc networks is about their traffic and mobility models. Traffic and mobility models designed for Mobile Ad Hoc Networks (MANET) needs to be experimented on VANET to evaluate its performance in vehicular scenarios. However, conducting real experiments on roads for VANET network are dangerous and expensive. A real experiment might require the need to rent many vehicles (cars, Lorries, trucks, vans and so on), purchase communication gadgets and employ experimenters. At times, vehicles need to move on a high speed scenario which poses a possible danger such as collisions with other vehicles and even pedestrians. For this reason simulation model is used to carry out the research.

SIMULATION PARAMETERS

We start out by giving the detailed about the simulation model and environment which are presented in the rest of this section. In order to evaluate the performance of different traffic models (CBR, VBR and TCP on MANET and VANET networks, simulations were carried out using Ns-2 simulator [Online]. The topology consists of 1000 X 1000 meters with 50 mobiles nodes and 50 vehicles moving around using the random way point mobility model. Constant bit rate, Variable bit rate as well as Transmission Control Protocol agents were used for generating traffic in the network. Each simulation scenario was repeated six (6) times for over a period of 500 seconds real time, which enabled the simulations to converge for accurate result. The basic parameters used for the simulations are summarized in Table 1.

SIMULATION RESULTS

In this section, we present simulation results for the performance analysis of (CBR, VBR and TCP) on MANET and VANET networks. Figures 1 and 2 shows the end to end delay against throughput of receiving information bits in a vehicular network. This illustrates what happens to vehicle's delay in motion as the throughput of receiving information is being received. At the beginning of the route discovery, the network with VBR traffic model experienced an average delay of 0.11 seconds as compared to 5.0 x 10^{-3} seconds delay with CBR traffic model. When the route is discovered, the throughput broadcasted increases to 2.5 x 10^5 bits for VBR (see Figure 1) and 1.0 x 10^4 bits for CBR traffic model (see Figure 2) and the delay fell drastically to 0.01 and 0.001 seconds respectively. When VBR generated data traffic of 5.0 x 10^5 bits was received, there was a broken link and an alternative route needs to be taken. Instead of starting all the process afresh, the route had to re-initiate another route discovery process in which a delay was triggered to about 0.1 second. This shows that, as throughput of receiving bits of CBR generated traffic increases, the vehicles nodes stabilises and the delay tends to drop at interval.

Table 1. Simulation parameters

Simulation Parameters	
Parameters	**Values**
Network Simulator	NS2-2.29.2
Ad Hoc Routing Protocol	DSR
Simulation Area	1000 x 1000 metres
Simulation Time	500 seconds
Number of vehicles	50
Number of Mobile nodes	50
Number of trials	6
Speed (VANET)	70 miles per hour
Speed (MANET)	0-20 meter per second
Node Placement	Random way point
Traffic Model	CBR,VBR, TCP
Mac Protocol	IEEE 802.11
Propagation Model	Two-ray Ground reflection model
Packet Size	532 bytes
Channel Type	Wireless Channel
Antenna Model	Omni directional

Figures 3 and 4 shows CBR and TCP's traffic models performance on MANET network. From the figures it has been observed that at low mobility, CBR performed better than TCP with high throughputs of receiving packets and less end-to-end delay of 0.19 seconds compared to 0.41 seconds of TCP. The rise in the delay is due to the initial routing discovery process of the DSR routing protocol.

Due to the fact that, the network topology/location changes rapidly and unpredictably,TCP traffic model was unable to withstand the stress, which leads to route failure and consequently packets drop. It therefore, considers the failure to be a sign of network congestion and immediately applies congestion control mechanism, which increases the end–to-end delay exponentially and decreasing the throughput of receiveing bits as compared to CBR traffic model performance in the network (See Figures 3 and 4).

Figure 1. (VBR) end to end delay vs. throughput of receiving bits

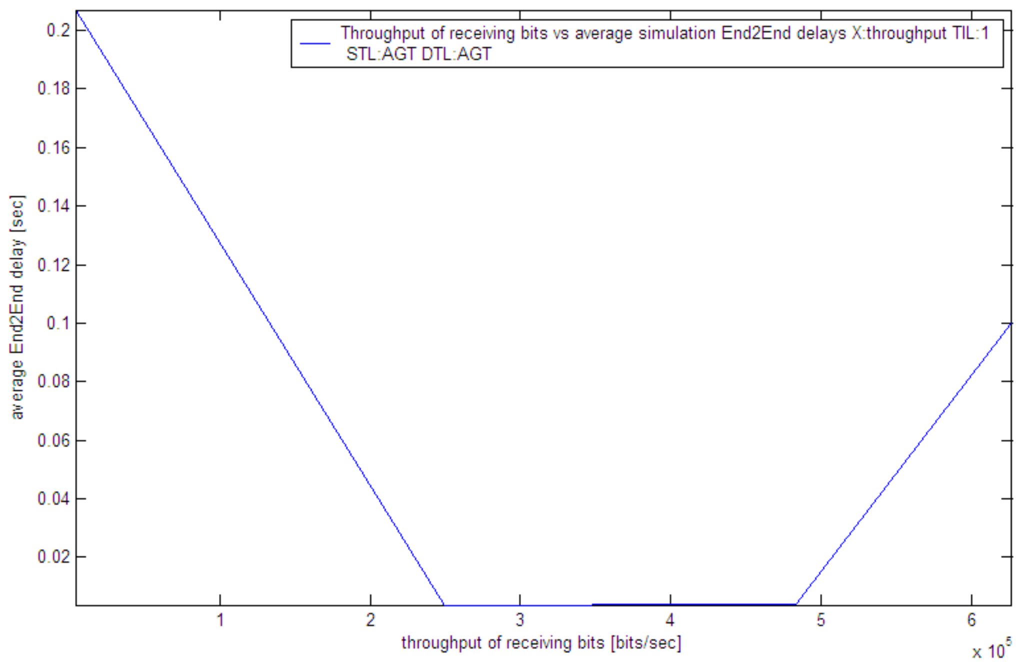
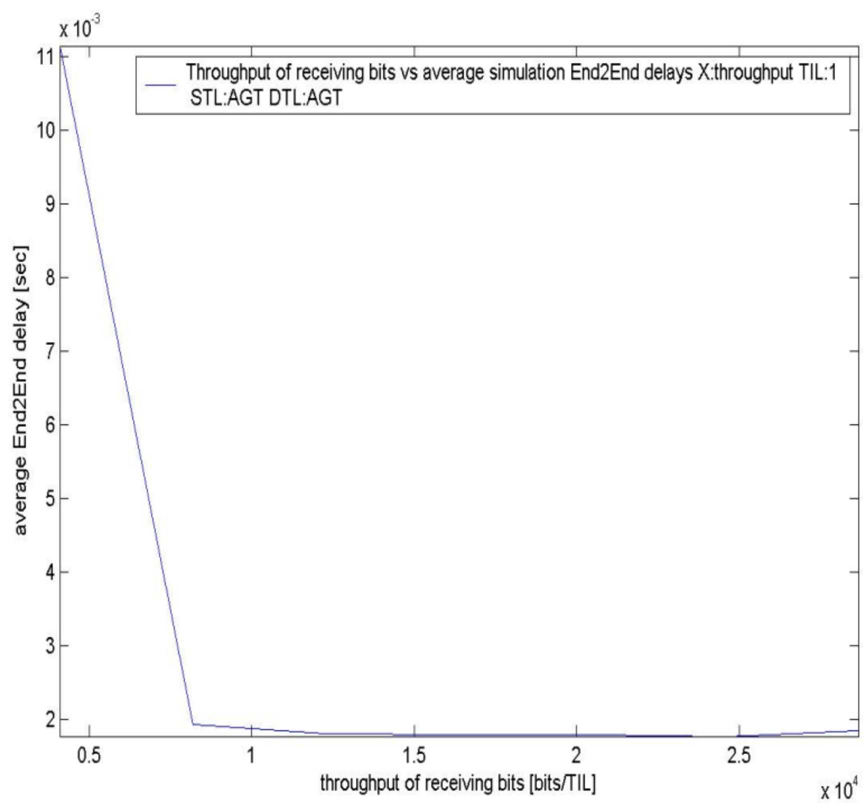


Figure 2. (CBR) end to end delay vs. throughput of receiving bits



KEY TERMS AND DEFINITIONS

CBR, VBR, and TCP: These are traffic mobility models used for the purpose of measuring the rate at which the encoding of the data takes place.

DSR: This is an ad hoc routing protocol used for routing data/packets from one node to another.

End-to-End Delay: The time (in seconds) taken for packets in bits to be transmitted across the network from one end-to-another.

MANET: A short term communication between mobile devices without using network infrastructure such as router or access point.

Throughput: This represents the total number of successful packets in (bits/sec) received at destination from all nodes in the network over a period of network simulation time.

VANET: Self-organizing communities of wheeled mobile units consisting of large number of vehicles and a small number of fixed infrastructure nodes such as roadside access units within radio communication range to each other.

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But there is considerable good response of DSR routing protocol to link failure at both low mobility before the TCP's congestion mechanism responds, and packets were successfully delivered while packets lost is due to increased in end-to-end delay, time-to- live (TTL) of routing protocol expiration and end of simulation time. Also, the simulation results revealed that, TCP traffic model can perform better in smaller networks, where unpredicted topology/location changes are less.

CONCLUSION

Based on the traffic and mobility models used, simulation results revealed that CBR, VBR performed better than TCP at low and high mobility with high throughput of receiving bits, less end-to-end delay and less packets dropped. DSR routing protocol was able to respond quickly to link failure which avoids TCP's congestion control algorithm response at low mobility. It is believed that most packets dropped are due to high end-to-end delay, Time-To-Live (TTL) expiration of the routing protocol and end of simulation time.

FUTURE RESEARCH

Future work should compare other ad hoc on demand routing protocols such as AODV and TORA, in order to analyse how effective and efficient these protocols are in response to TCP's weaknesses on MANET and VANET networks.

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Figure 3. (CBR) end to end delay vs. throughput of receiving bits

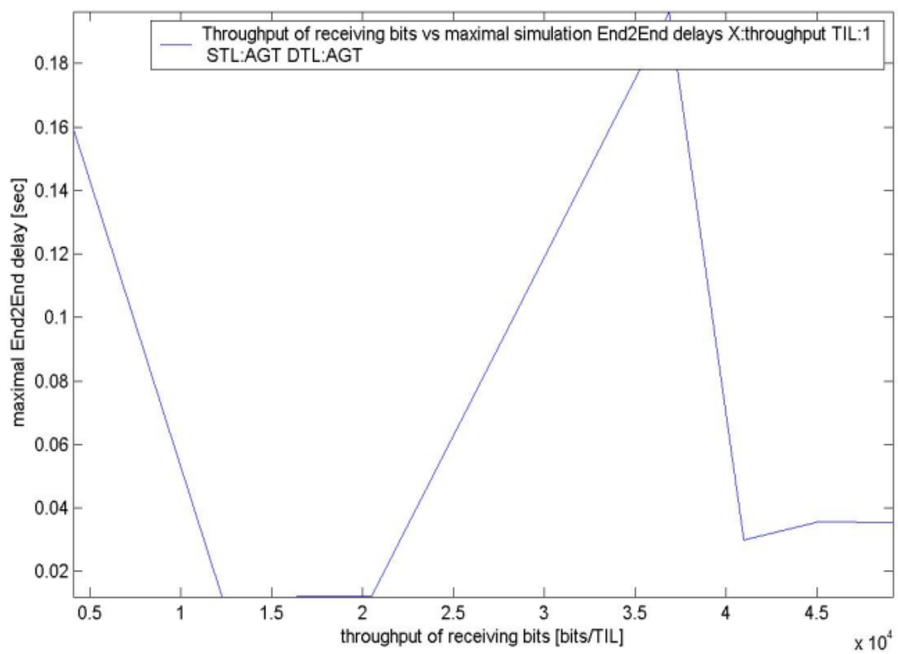

Figure 4. (TCP) end to end delay vs. throughput of receiving bits