Transmission Characteristics Analysis of VCCN using SUMO and ndnSim

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Abstract

Car-to-car network becomes one of the popular research fields due to the emergence of self-driving car industry and advanced communication technology. VANET is an extension of an ad hoc network in which each and every car play a role of a sender, a forwarder, as well as a receiver to communicate each other. Drivers and passengers need safe driving, route information, traffic condition, accident reports, gas price and nearby hotel information. Traditional TCP/IP inherently has some difficulty in providing these services due to the unawareness of the data source and the inefficiency of data sharing. This paper shows that VCCN (VANET over CCN) is one of the suitable alternatives for providing those services. CCN searches data content by name not by the identification of a data source. According to the simulation result, when several clients request the data to the content source, the clients receive enough data and the overall accumulation of data even exceeds the wireless transmission bandwidth.

Keywords: *Car-to-car network, VANET, VCCN, ns-3, SUMO, ndnSim*

1. Introduction

Automobile becomes one of the indispensable machines in our life and there are huge number of advanced technologies such as electric vehicles and self-driving cars. They attach several types of sensors and install software for safe driving and nearby traffic information. In near future, cars communicate with surrounding cars and RSUs (Road Side Unit) in order to collect information like traffic condition, nearby car accident, gas price, and hotel information. Vehicular ad hoc network (VANET) may provide these services to both drivers and passengers by instantly forming ad hoc networks with neighboring cars and road-side traffic infrastructures. Research work suggests that VANET utilizes telecommunication networks, WiMax, WiFi, and DSRC (Dedicated Short Range Communications) channels [1].

Traditional TCP/IP requires server identification such as an IP address and a port number to access data from the server. In addition, client location information should be provided to the server to acquire nearby traffic information. It may be common that many nearby car drivers want the same traffic information such as traffic jam and car accident. However, the client may not know where to send the request for the traffic information. Furthermore, the content server may reply with the same data transmission multiple times to each client.

Content centric network (CCN) adopts content-naming scheme rather than using the destination address of the content source in order to fetch data [2, 3]. CCN has several features such as named-data scheme, in-network caching, and support of multicast transmission. Clients send an interest packet which is forwarded toward the content source. The content source node replies with the corresponding data packet to the client. When an intermediate node receives the data packet, it stores the content to its local content store. Next time, any node including the content source node and/or intermediate node(s) may reply the same

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content request from its locally cached content store. In addition, when several clients want the same content such as traffic condition and accident information, in-network caching helps improving the data delivery rate and reducing the duplicate transmissions. VCCN (VANET over CCN) uses CCN rather than TCP/IP for constructing ad hoc networks for communicating among the nearby driving cars and road-side infrastructure. In order to modeling the communications between cars over VCCN, this paper uses SUMO and ns-3.

SUMO (Simulation of Urban Mobility) is an open source package to simulate road construction, route selection, traffic light control, and communication among cars [4]. Users may define cars, roads, speed and movement of cars. The movement information is generated by SUMO and the information can be used ns-3 discrete network simulator. Ns-3 is a well-known network simulator that provides many kinds of wired and wireless network stacks such as TCP/IP, LTE, WiFi, WiMax, and more [5]. This paper models a real road in a south part of Seoul and generates a car traffic movement with SUMO which is exported to ns-3 for measuring the performance of data transmission. According to the simulation result, when multiple clients request the same content to a content source, it is more suitable to use VCCN rather than traditional TCP/IP network. Furthermore, the ccumulative data received by the participating cars exceeds the wireless channel bandwidth. This result implies that VCCN is more acceptable than VANET over TCP/IP.

This paper is organized as follows. Section 2 describes related work. Simulation environment is described in section 3. Simulation results with SUMO and ns-3 are shown in section 4. Finally, chapter 5 concludes the paper.

2. Related Work

VANET may provide diverse surrounding information to both drivers and passengers such as accident, traffic congestion, parking lot, gas price, and nearby hotel room availability. Diverse research is in progress to measure the performance of routing algorithms with SUMO and ns-3 [6]. Recently, several research works are presented to replace TCP/IP protocol stack with CCN for VANET. CCN does not require and specific identification of the content source. That is, content naming based request as well as in-network caching and inherent multicasting features are very suitable for wireless VANET environment. In [7], clients efficiently choose one of the multiple content provides over CCN. The authors in [8] introduce a mechanism to select minimum number of forwarders for maximizing transmission throughput. When many packets are flooded, data transmission performance degrades drastically. In order to mitigate the broadcast storm problem in VCCN, [9] proposes a controller data propagation algorithm which uses hop count to limit the propagation of copying packets.

3. Simulation Environment

VANET is an infrastructureless ad hoc network for vehicles in order for drivers and passengers to provide useful information. In order for modeling the VANET, this paper utilizes SUMO and ns-3. SUMO is an open source package to simulate car movement and route selection of cars. Ns-3 is also an open source package for event driven network simulator. Furthermore, in order to implement VANET over CCN, this paper adopts ndnSim[10] which implements the transmission of Interest and Data packets.

This paper utilizes SUMO with which car movement and path selection are able to be modeled. It selects a part of map in south area of Seoul, and defines roads and routes on the segmented map. The size of the simulation area is about 540 meters by 460 meters. There are 10 routes defined and 30 cars are participated to drive on one of the routes. Each car drives along the given route at 30 Km/s and the movement data of all cars are stored for used by the network simulator.

Ns-3 is an event-driven discrete-time general network simulator. In order to implement CCN stack, this paper uses ndnSim which adds CCN features on ns-3. Each car works as a CCN node. Every CCN node keeps three data structures such as PIT (Pending Interest Table) for keeping interest packet information, CS (Content Store) for storing data, and FIB (Forwarding Information Base) for managing route information for content store. When a node wants a specific content such as traffic jam or a nearby accident, it broadcasts an Interest packet with the content name. Any intermediate node keeping the content in CS including content source(s) reply with a Data packet. If it has no such data stored, it forwards the Interest packet toward the content source. The number of Interest sending nodes varies from 1 up to 8. Each and every participating node uses 802.11a with WiFi channel bandwidth of 6 Mbps and 12 Mbps. The data packet payload size is set to 1024 byte. Each simulation runs 150 seconds.

4. Simulation Result

Figure 1 illustrates the simulation result of the TCP and UPD data transmission performance. One to three receivers request data from the same sender. In case of UDP, the sender transmits data at a constant rate of 2 Mbps. When there are three receivers, the sender delivers three copies of the data to the receivers at 2 Mbps each. In case of TCP, there is no constant rate to exchange data defined. The left side of Figure 1 shows the accumulative data reception by 1 to 3 UDP receivers at CBR of 2 Mbps over 6 Mbps wireless channel. When there is only one sender and one receiver, the data reception rate maintains at 2 Mbps. However, when two transmission pairs exchange packets, the accumulative reception rate reaches to 4 Mbps with some fluctuation due to transmission contention and car movement. When three pairs are participated, more fluctuations occur and the reception rate reaches up to 5 Mbps. The right side of Figure 1 presents the result with 1 to 3 TCP transmission pairs over 12 Mbps channel. It shows a quite constant delivery rate for a single transmission pair at an average of 7.76 Mbps. When more transmission pairs are involved in the network, the fluctuation gets larger. The standard deviations of two and three pairs involved are 0.57 Mbps and 0.77 Mbps respectively.

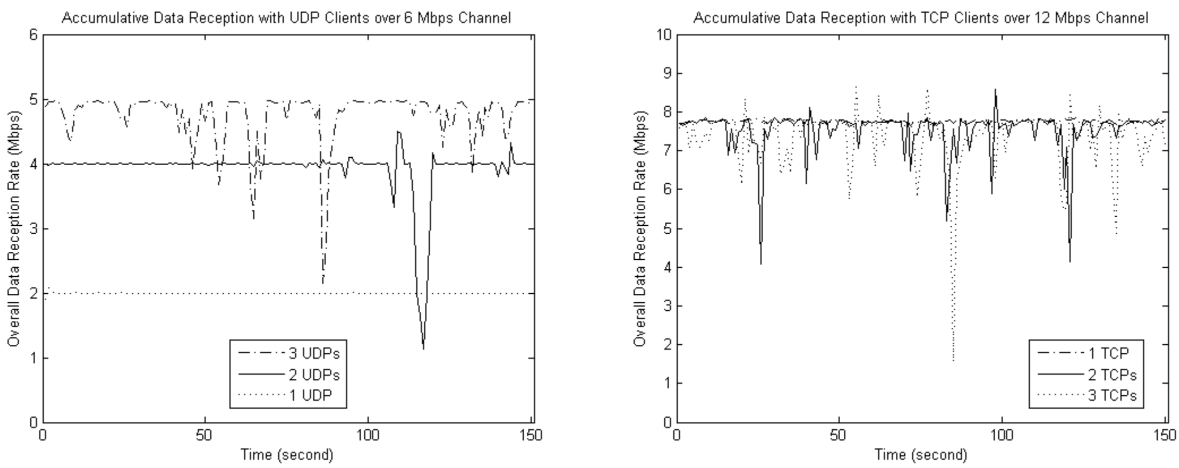

Figure 1. Data Reception Rate with TCP and UDP

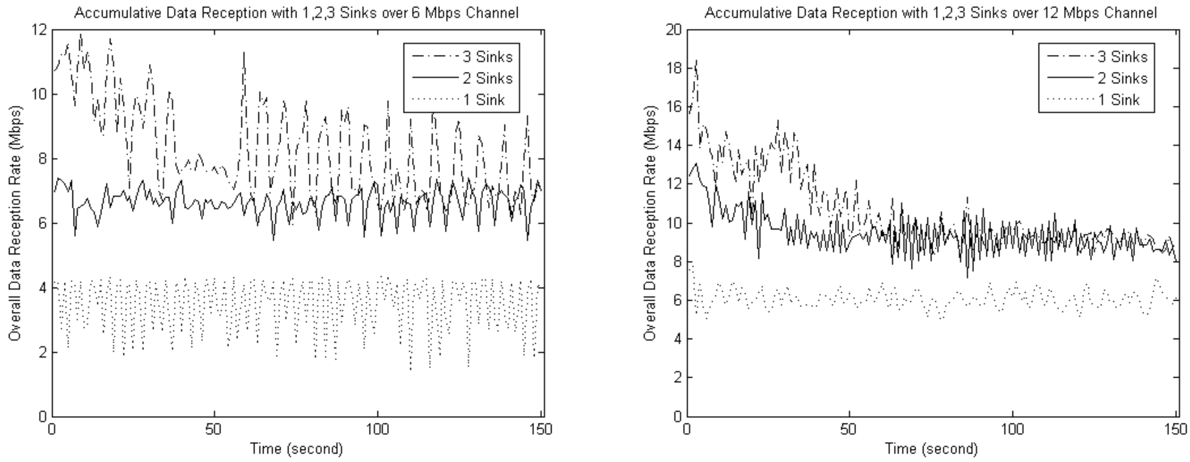

Figure 2. Data Reception Rate with small # sink nodes over VCCN

Figure 2 presents the simulation result of the data reception rate with VCCN. There are one to three sink nodes that issue Interest packets to the data source. The simulation environment includes that one source node is able to satisfy all Interest packets and to transmit data packets to all sink nodes. Each sink node transmits Interest packets at 2000 times per second. The left side of Figure 2 shows the result of cumulative receiving data packets by one to three sink nodes over 6 Mbps channel. The average reception rates of 1 to 3 sink nodes are 3.47, 6.64, and 8.25 Mbps, respectively. This result means that the more the transmission pairs, the larger the data reception rate. In addition, by sharing and caching the content by the intermediate nodes, the cumulative reception rate exceeds the physical bandwidth of the wireless channel. The right side of Figure 2 illustrates the cumulative reception rate of one to three nodes over 12 Mbps channel. In case of a single source/sink pair, the data transmission looks stable with the average rate of 6.07 Mbps. However, as the number of source/sink pair increases, both the reception rate and its fluctuation become larger. The average reception rates of two and three sinks are 9.45 and 10.56 Mbps respectively. One interesting feature is that as the number of source/sink pair increases, the reception rate converges at a certain point. At the beginning of the simulation, many Interests are satisfied and the sink nodes get more Data packet. When a lot of Interest packets are forwarded and rebroadcasted, Data packets may not be properly delivered to its corresponding sink nodes, which degrade the data delivery performance.

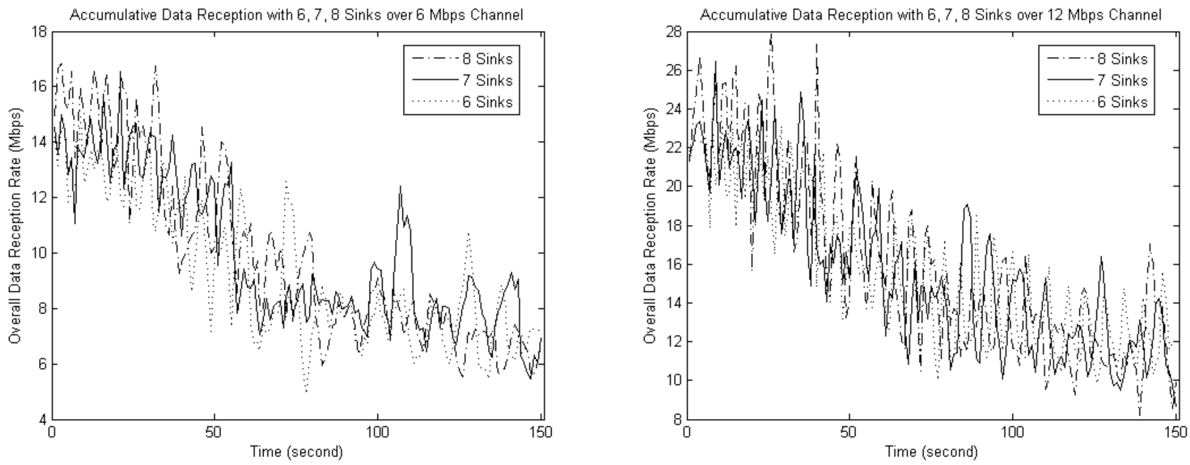

Figure 3. Data Reception Rate with large # sink nodes over VCCN

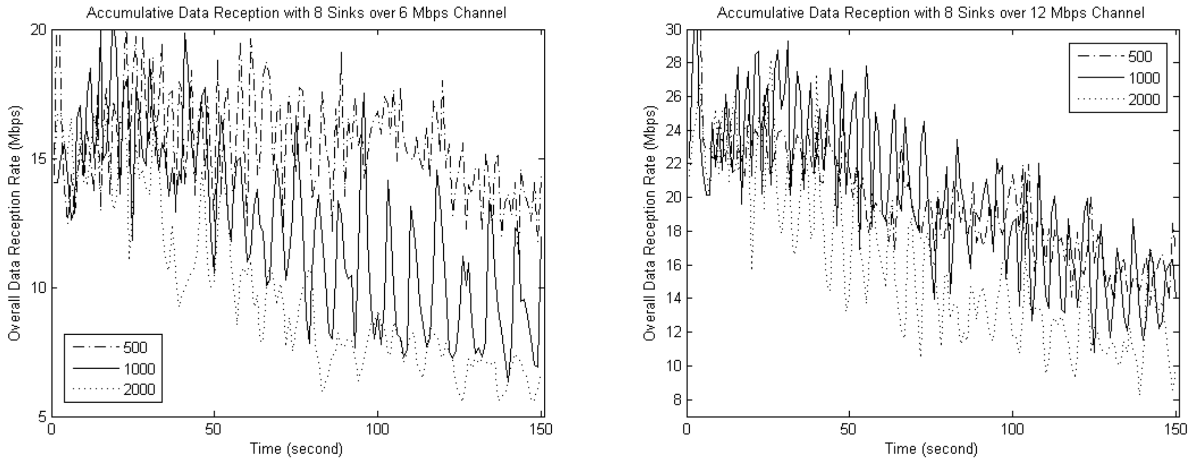

Figure 4. Data Reception Rate with varying Interest packet frequency over VCCN

Figure 3 shows the simulation result of six to eight source/sink pairs over VCCN. As the number of transmission pairs increases, so does the fluctuation of data reception rate. At the beginning of the time, the received data rate reaches to the highest point. After that, until about 60 seconds, the reception rate decreased gradually. Then, the rate converges at a certain rate. The left side of Figure 3 depicts the reception rate over 6 Mbps channel. On the contrary to the results displayed in Figure 2, more transmission pairs do not result in the increment of the reception rate. The average rates from 60 to 150 seconds for the case of 6, 7, and 8 transmission pairs are 7.59, 8.09, and 7.72 Mbps, respectively. The right side of Figure 3 illustrates the result of the data reception rate over 12 Mbps wireless channel. There is no distinct separation of graphs among 6 to 8 transmission cases. When the simulation time passes to 100 seconds, the graphs become stable and converge to a specific rate.

Figure 4 presents the reception rate changes when each sink node issues smaller number of Interest packets per second. The dotted line at the bottom is the graph in Figure 3 labeled “8 Sinks” in which each sink node sends Interest packets at 2000 times per second. As the Interest packet transmission rate decreases to 1000 or 500 per second, the data reception rate increases in both 6 Mbps and 12 Mbps wireless channel. In addition, the convergence rate increases as the Interest issue frequency decreases.

5. Conclusion and Future Work

This paper introduces several simulation results using SUMO and ndnSim (ns-3) in order to analyze the transmission characteristics of VANET over CCN. SUMO is a traffic modeling package that generates car movement information. Ns-3 is a network simulator package to simulate diverse network environment. NdnSim is an open source package to implement CCN over ns-3. The simulation in this paper defines routes and car movement, and measures the transmission performance between cars in VANET over CCN. Traditional TCP/IP requires identifying the data source by the sink node, which might be inappropriate for VCCN. Further, when multiple sink nodes wants the same data from the source, the source node has to generate duplicate packets delivered to the sink nodes. In case of VCCN, named-data scheme, in-network caching and inherent multicasting properties relieve the problems and enhance the transmission performance.

The simulation result indicates that when the network is saturated with large number of packets, data reception rate of the networks converges to a certain rate. In TCP/IP network, the cumulative data reception does not exceed the physical channel bandwidth even though there are enough source/sink nodes are involved. The overall data reception rate increases as the number of transmission nodes increases in VCCN. The cumulative data reception rate exceeds the wireless channel bandwidth. However, it may require a mechanism to regulate the Interest packet forwarding in order to reduce transmission contention and to enhance data reception performance.

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