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차량 엔디엔 네트워크 안에 데이터 폭증 현상 실험적 평가

임헌국*

Experimental Evaluation of Data Broadcast Storm in Vehicular NDN

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요 약

NDN (Named Data Networking)과 같은 미래 네트워크 아키텍처는 현재 호스트 중심 네트워크 기술에서 정보 중심 네트워크 기술로 데이터를 전송할 수 있는 방식을 변경하기 위해 탄생하였다. 최근 Vehicular NDN을 커넥티드 차량을 포함한 스마트 차량의 통신 네트워크 기술에 접목하기 위한 많은 연구가 진행되고 있다. Vehicular NDN 환경에서 Interest/Data 패킷 브로드 캐스팅으로 인한 데이터 트래픽 폭증은 VNDN 기반 데이터 통신을 실현하기 위해 해결해야 할 매우 중요한 문제이다. 본 논문에서는 데이터 브로드캐스트 폭풍 현상이 얼마나 심각하게 발생하는지를 보여주기 위해 VNDN 네트워크에서 네트워크 사이즈, 차량 스피드, 인터레스트 패킷 발생 빈도수의 증가에 따른 데이터 패킷 사본 발생을 ndnSIM을 이용하여 실험하고 평가한다. VNDN 안에 커넥티드 차량 수 및 Interest 패킷 발생 빈도수의 증가에 따라 중복된 데이터 패킷 처리량도 증가함을 확인하였다.

ABSTRACT

Future network architectures such as Named Data Networking (NDN) were born to change the way data can be transmitted from current host-centric network technologies to information-centric network technologies. Recently, many studies are being conducted to graft Vehicular NDN to the communication network technology of smart vehicles including connected vehicles. Explosion of data traffic due to Interest/Data packet broadcasting in Vehicular NDN environment is a very important problem to be solved in order to realize VNDN-based data communication. In this paper, the generation of data packet copies according to the increase in network size, vehicle speed, and frequency of interest packets in VNDN network is simulated and evaluated using ndnSIM, in order to show how severe the data broadcast storm phenomenon. The CDP(Copies of Data Packets) increased proportionally in the increase of network size or Interest frequency.

키워드 : 차량 네임드 데이터 네트워킹, 인터레스트/데이터 패킷, 데이터 브로드캐스트 폭증, 엔디엔심

Keywords : VNDN, Interest/Data packet, Data broadcast storm, ndnSIM

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Ⅰ. Introduction

When Vehicular NDN technology is used as a communication technology for the infotainment (information+entertainment) application service of a connected vehicle, data-centric networking technology in which data is the main subject of communication can be realized, in order to overcome vehicle security attacks/hacking, and long-distance data transmission performance degradation. It is possible to innovate the limitations of the current host-centric Internet-based infotainment application service technology, such as performance degradation and frequent data interruption. As in Fig. 1, VNDN uses CS (Content Store), PIT (Pending Interest Table), and FIB (Forwarding Information Base) tables at each node (consumer, producer, and intermediary node) to receive data requested by the consumer vehicle from the producer using name-based forwarding [1-2].

In terms of security of connected vehicles, if the VNDN technology centered on information (data) rather than the existing communication network technology centered on the host (vehicle) is used as the base communication technology, there is no need for a separate identifier (IP address, etc) for vehicle identification, and because it intermittently accesses the VNDN network only when transmitting and receiving information (data) from the vehicle, security issues including hacking of connected vehicles are fundamentally eliminated [3].

In terms of long-distance content data transmission service performance, VNDN uses hop-by-hop congestion control rather than end-to-end congestion control. If it is used as a communication technology, constant transmission performance can be guaranteed regardless of the transmission distance.

Regarding the hand-off problem when moving a connected vehicle, vehicle identification is different from the existing host-centric communication network technology in which the vehicle (host) with a unique identifier (IP/ID) for each vehicle is the subject of communication. In VNDN, which does not require any identifier for hosts, the hand-off problem naturally disappears because information (data) becomes the subject of communication. In other words, it is only necessary to reissue the request for content data from the moved vehicle location.

For these reasons, research work is recently being done to graft Vehicular NDN into the communication network technology of smart vehicles including connected vehicles [4-8].

Among the many research fields in VNDN for vehicle communication, the explosion of data traffic due to Interest/Data packet broadcasting in the vehicular NDN environment is one of the important issues to be solved for realizing VNDN-based infotainment application service. The vehicle broadcasts an interest packet to request the desired data, which causes a data explosion

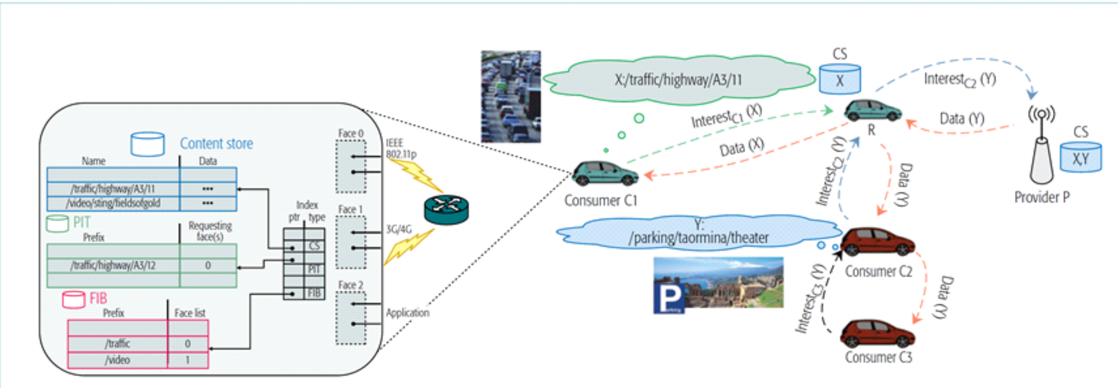

Fig. 1 Interest/Data packet forwarding example in VNDN

phenomenon due to successive intermediaries of the same data from multiple intermediary nodes. This results in data packet loss in the VNDN network, which leads to a decrease in Interest Satisfaction Rate(ISR) and Interest satisfaction delay(ISD).

In this article, we analyze the Data broadcast storm experimentally, with the result of copies of Data packets processed in the VNDN using the ndnSIM network simulator. And we investigate which factors affect on the result of copies of Data packets processed in the VNDN.

Ⅱ. Data Broadcast Storm Problem in Naive VNDN

In the VNDN environment, the vehicle broadcasts an interest packet to request the desired data, which causes a data explosion phenomenon due to successive intermediaries of the same data from multiple intermediary nodes. This data explosion causes the following problems in the VNDN network.

- It causes congestion by quickly consuming network bandwidth due to duplicate data traffic intermediation.
- This results in data packet loss in the VNDN network, which leads to a decrease in Interest Satisfaction Rate (ISR).
- Interest satisfaction delay (ISD) also has significantly worse results.

Therefore, the traffic explosion caused by data broadcasting in the VNDN environment is an important issue that needs to be fundamentally solved for realizing the VNDN-based vehicle infotainment content service. Research activities to solve this problem are at an early stage worldwide, and a few techniques have been introduced to mitigate the data packet explosion in the recent VNDN environment [4-6]. In order to solve the data explosion phenomenon in VNDN more fundamentally, it is necessary to forward interest packets based on a single path to solve the interest packet broadcast problem [7-9].

To show how severely Data broadcast occur in the naive VNDN, we investigate the result of copies of Data packets in naive VNDN network using ndnSIM simulator.

Ⅲ. Experimental Evaluation of Data copies in the Naive VNDN

3.1. Simulation Environment

The ndnSIM was used for the simulation of VNDN networks. The vehicles are moving of 5 km long 3 lane highway in one direction, as shown in Fig. 2. There are 5 consumers and 5 producers communicating in an ad-hoc way, as shown in Fig. 2. 5 consumers broadcast Interest packets for data from the 5 producers. The producer after receiving an Interest packet responds with the required

Fig. 2 Interest/Data forwarding for V2V in VNDN environment

data packet of 1024 bytes.

IEEE 802.11p was used for MAC layer for V2V communication. The transmission range of each vehicle is 250 meters. The number of vehicles varies from 50 to 110 and the speed of vehicles varies from 70 km/h to 110 km/h. We get the results for total number of data packets processed with respect to network size, vehicle speed and Interest frequency. Table 1 summarizes simulation parameters and environment mentioned so far.

Table. 1 Simulation parameters and environment

# of consumers/producers during simulation	5
Data packet size	1024 bytes
MAC layer for V2V communication	1EEE 802.11p
Transmission range of each vehicle	250 meters
# of vehicles	50~110
The speed of vehicles	70 km/h ~ 110 km/h

3.2. Simulation Result

Fig. 3 shows the effect of network size (No. of vehicles) on the copies of data packets processed (CDP). The CDP increases when the network size increases because with increase in network size, more vehicles become involve in rebroadcasting the data packets received. When more vehicles are available in the broadcast domain of a producer, more data packets copies would be received and rebroadcasted. Also we

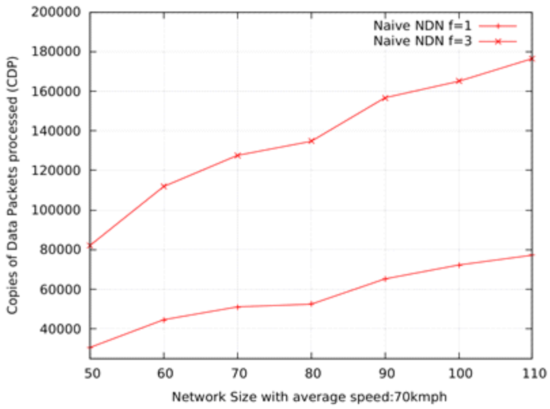

Fig. 3 Copies of Data packets processed with network size

see that with Interest frequency 3 triggers more copies of data packets compare to interest frequency of 1 per second. With 60 vehicles in VNDN, interest frequency of 1 per second resulted in copies of data (CDP) of 46000 while interest frequency of 3 per second resulted in copies of data (CDP) of 113000. On 110 vehicles in VNDN, interest frequency of 1 per second triggered about 80000, while interest frequency of 3 per second triggered in copies of data (CDP) of about 180000.

The vehicle speed has no major effect on the CDP, as shown in Fig. 4. The minor effect of speed is because at higher speed some vehicles are moving out of the range of the producer and hence do not receive data packets copies.

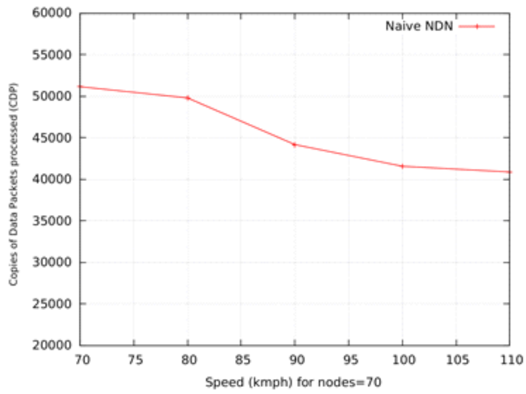

Fig. 4 Copies of Data packets processed with vehicle speed

The CDP increases proportionally with the interest frequency, as shown in Fig. 5. Copies of data packets (CDP) was 127000 on the interest frequency 3 while CDP was 200000 on the interest frequency 7. When the consumer sends more Interests per seconds, it triggers more data packets and hence the Interest packets might receive at different route, More data packets are generated and more vehicle get involve in the data packets forwarding process thus increases the CDP.

Based on the above results we investigated that network size (No. of vehicles) and the interest frequency had major effects on the CDP while vehicle speed has no effect on the CDP. The CDP increases proportionally with the network size or the interest frequency.

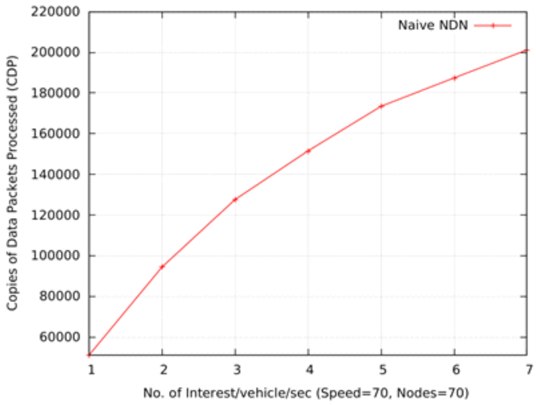

Fig. 5 Copies of Data packets processed with Interest frequency

Ⅳ. Conclusion

The explosion of data traffic due to Interest/Data packet broadcast in the VNDN environment is one of important issues to be solved, in order to realize VNDN-based infotainment application service. We investigated how severely the data broadcast storm occurs, based on the result of copies of data packets processed(CDP) in the naive VNDN using the ndnSIM network simulator. Network size (No. of vehicles) and the interest frequency had major effects on the CDP while vehicle speed has no effect on the CDP. The CDP increased proportionally in the increase of network size or Interest frequency. With 60 vehicles in VNDN, interest frequency of 1 per second resulted in copies of data (CDP) of 46000 while interest frequency of 3 per second resulted in copies of data (CDP) of 113000. Copies of data packets (CDP) was 127000 On the interest frequency 3 while CDP was 200000 on the interest frequency 7.

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