Avoiding Content Storm Problem in Named Data Networking

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***Abstract*—Recently, methods are studied to overcome various problems for Named Data Networking(NDN). Among them, a new method which can overcome content storm problem is required to reduce network congestion and deliver content packet to consumer reliably. According to the various studies, the content storm problems could be overcame by scoped interest flooding. However, because these methods do not considers not only network congestion ratio but also the number another different paths, the correspond content packets could be transmitted unnecessary and network congestion could be worse. Therefore, in this paper, we propose a new content forwarding method for NDN to overcome the content storm problem. In the proposed method, if the network is locally congested and another paths are generated, an intermediate node could postpone or withdraw the content packet transmission to reduce congestion.**

***Index Terms*—Named Data Networking, Congestion Control**

I. Introduction

Nowadays, due to the development of various applications, the amount of data transmission on the Internet is saturated. In particular, due to the increase in cloud services, this phenomenon is accelerated as a number of terminals frequently request and receive data through the Internet. As an attempt to solve this problem, Internet capacity is continuously improved, but it is not a fundamental solution. Therefore, various future Internet technologies such as content-centric networking are studied.[1-2]

In these techniques, a consumer broadcasts an Interest packet to it's neighbor nodes. In this Interest packet, it contains the context name which the consumer nodes would like to receive. When a node received an Interest packet, it first looks up CS(Content Store). If the node successfully finds the context information CS, it returns a Data packet to previous node who sent Interest packet.

Otherwise, if the node cannot find the context information in its CS, it looks up PIT(Pending Interest Table) in order to check whether it received the same Interest packet or not previously. If the node finds no Interest packet information in PIT, it records <context name, received interface> information in PIT, else, drop the Interest packet. After the PIT is filled up with context name and interface information, the node selects a forwarding interface refer to FIB(Forwarding Information Base) and records <context name, forwarding interface> information. If a node contains the context corresponding to the context name written in Interest packet, it replies Data packet to the previous node using Interest packet received interface.

When a node received Data packet, first, it looks up PIT table in order to check whether it received an Interest packet corresponding to the context written in Data packet. If the node finds received Interest packet information in PIT, it stores context data in CS and forward the Data packet to previous node using received interface information from PIT. If not, the node discards Data packet and it will not forward Data packet further.

However, such NDN technique suffers from data storm problem that huge data packets are transmitted instantaneously in a narrow area. In more detail, when a consumer sends an Interest packets, various nodes which receive the Interest packet checks their CS(content store)s. Every nodes which have the requested content might broadcast the requested content(Data packet). Hence, as the density of nodes with the requested content increases, the amount of Data packet transmission is also increased. The consumer could receive two or more duplicated data packets and network resources are spent. Since the network resources are limited, such unnecessary transmission should be reduced.

In order to overcome this problem, various researches are studied. Among them, in our previous works RUFS[3], a consumer writes a TTL(time to live) information in its Interest packets. The TTL is deceases by one when intermediate nodes relay the interest packet and the Interest packet is dropped if the TTL becomes 0. If the content is not arrived at the consumer, it increases the TTL and floods again. In this method, the data storm problem could be reduced, the Data packet reception time is increased.

Moreover, Data packet transmission processes in the NDN is not always a drawback. Among these processes, intermediate nodes could receive new contents and store the content in their CSs. If an another node(a new consumer) requires this content and the intermediate nodes are located nearby the new consumer, the new consumer can receive the requested contents fast. However, in [3], these intermediate node could not be made because they cannot receive the Interest packet due to the limited scope of the Interest packet.

Therefore, in this paper, we proposed a new method namely AVS(Avoiding Data packet Storm problem) to avoid the data storm problem. In our method, an Interest packet is flooded in whole networks likely NDN. If nodes which receive the Interest packet have the requested context in their CSs, they try to transmit the corresponding context. During this process, the provider and intermediate node check not only regional congestion ratio but also the number of expected number of duplicated context transmission using their PIT and FIB tables. The corresponding context could be sent when the regional congestion ratio is low enough to participated the Data packet transmission and reliability of the Data packet transmission is low. Otherwise, if the provider and intermediate nodes are not stable to participate Data packet transmission, they suppress their Data packet transmission to avoid Data packet storm problem.

II. Related Works

In this section, firstly, we introduce detail information about RUFS[3] mentioned above. The problem statement in [3] is that every vehicles who received Interest packet searches CS, PIT, FIB and if they does not find contents, Interest packets will rebroadcast to neighbors. This operation occurs congestion, delay and Interest/Data packet duplication. Therefore, we controlled the Interest packet flooding mechanisms so that Interest packet forwarder does not force all neighbors to rebroadcast Interest packets.

Proposed scheme in [3] operates as follows. Every vehicle exchanges beacon messages including Recent Satisfied List3(RSL) with its neighbors, periodically. RSL includes a list of satisfied interests for contents C with additional information; time since the recent satisfaction of each content Ci $\in$ C, the number of hops from where Ci was received, current velocity, and the Interest Satisfaction Rate (ISR).

When a vehicle received RSL, it updates Neighbor Satisfaction List(NSL) which represents a list of contents satisfied by its neighbors. NSL contains following information : 1) for any required content with properties such as satisfaction time, 2) current velocity, 3) hop count, 4) ISR. If there is only one vehicle satisfied forwarding contents, it becomes the forwarder to be selected by Interest packet forwarder. Else, if there are more than 2 vehicles satisfied forwarding contents, Interest packet forwarder outranks the potential forwarder among those vehicles.

Secondly, we introduce the concept of a successor of RPL(RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks) which will utilize for our proposed scheme[4]. RPL operates as follows. A node who would like to create DODAG for RPL communication broadcasts DIO(DODAG Information Object) message to downlink. Mostly, in underwater RPL, sink node initiates this step. Nodes who received DIO message responses DAO message(Destination Advertisement Object) to DIO message transmitter. If the DIO message and DAO message exchange is successfully done between 2 nodes, they create virtual link for RPL communication. The node who transmitted DIO message becomes parent node(in RPL, we call this as successor). 4) If a node received more than 2 DIO messages, it can select sub-sucessors for the case of connection loss with immediate successor node.

III. Proposed Method

A. Interest Flooding Phase

If a consumer node requires a new content, it broadcasts a new Interest with hop count. If intermediate nodes which not have the required content records the information of the Interest at their PIT table. After then, it monitors that which neighbor nodes broadcast the same interest messages (regardless the interfaces) and the hop count of the same interest messages. They count the number of neighbor nodes which broadcasts the same Interest messages with low or same hop count with themselves. In this paper, the number of neighbor node is defined as NIS (Number of Immediate Successors).

If NIS is bigger than 1, the interest message is flooded along multiple paths around this intermediate node. Hence, although this intermediate node doesn't participate the content packet (data packet), the content packets could be transmitted along different paths. It mean that as the network is locally congested, the transmission of the content packets should be delayed to support another content packet transmission. This concept is same with the concept of immediate successors of RPL. In the other words, as the interest messages are flooded along multiple paths, the NIS is increased.

Meanwhile, all nodes in the networks monitors the local congestion ratio Continuously. The method and equation for calculating the local congestion ratio is out of scope. In this paper, we assumes that the local congestion ratio(LCR) is calculated as following equation.

$$LCR_i = \alpha * OCR_i/TC_i + (1-\alpha) * LCR_(i-1) \quad (1)$$

In the above equation, OCR and TC are occupied transmission capacity and total transmission capacity among all interfaces of this node, respectively. The α is a weight factor. According to this equation, the node participates in next forwarding only when the number of other neighboring nodes to store the packet is less, and the probability that this packet will be transmitted through another path is low.

B. Congestion Control Phase

During the Interest Forwarding Phase, one or more provider which have the requested content at their CS reply the requested content according to the information of their PIT and FIB tables. Moreover, intermediate nodes try to participate the content reply process when they receive the content packet and the corresponding Interest information is store at their PIT and FIB tables.

At this time, each intermediate node check the NIS and the current LCR. If LCR of this intermediate node is lower than a threshold, the intermediate node participate the content packet relay process immediately since it means that degree of the congestion around this node is low to relay the received content packet. Otherwise, if the LCK of this node is higher than the threshold, the intermediate node sets an content holding timer. The timer is increased by integer multiples with the NIS. After expiration of the content holding timer, the content packet could be transmitted to reduce local network congestion.

During the content holding timer, the node monitors content packets transmitted from its neighbor nodes. If a same content packet is received, the node increase the holding timer by two times to avoid network congestion. When the holding time increased doubly is expired, the intermediate node checks the current LCR again. If the current LCR is worse than the previous LCR, the node suppress the content to overcome local network congestion fast.

IV. Performance Analysis

Through the NS-2.34 simulator, we evaluated the feasibility of our proposed scheme AVS with RUFS. In this simulation, 200 nodes are deployed randomly at locations in square of 2000m x 2000m. A consumer and 4 provider nodes are randomly chosen with hop counts 7 between consumer and provider nodes. In order to make local network congestion, 16 video streaming traffics which decide their traffic pattern between minimum 2Mbps(720, 24fps) to maximum 5.5Mbps(1080, 60fps).

Fig 1. shows the Interest Satisfied Delay (ISD) according to the total amount of requests. The ISD means that how long time is required to receive the requested data packet. As the number of requests increases, the ISD consistently increases in both AVS and RUFS since the network congestion ratio was increased. Moreover, proposed AVS shows low ISD than RUFS because intermediate nodes in AVS delays the transmission of packets that transmitted along another paths.

Fig 2. shows the Satisfied Interest Packets according to the total amount of requests. As the number of the total amount of requests increases, the number of Satisfied Interest Packets decreased regardless of the scheme due to the random loss and network congestion. Moreover, if the amount of requests is lower than 140, RUFS shows better satisfied interest packet than AVS since the AVS could suppress the received content when local network is continually congested. Since the RUFS doesn't have content packet suppression process, satisfied interest packet could be increase. Whenever the total amount of requests is bigger than 140, the proposed AVS has better satisfied interest packet than the RUFS because the AVS could overcome the network congestion. In the other words, the AVS not only transmit at least one content packet toward the consumer node but also propound or suppress the content packets when network is logically congested.

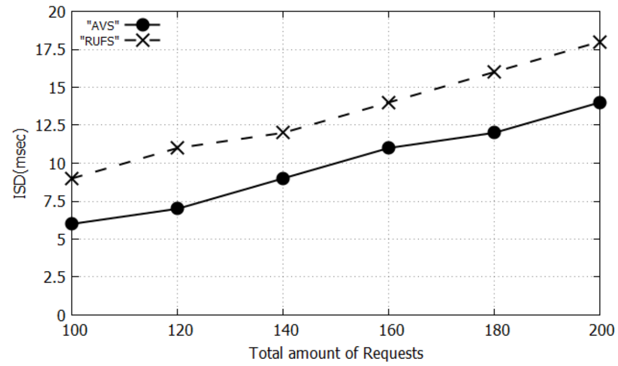

Fig. 1. The throughput according to number of flows

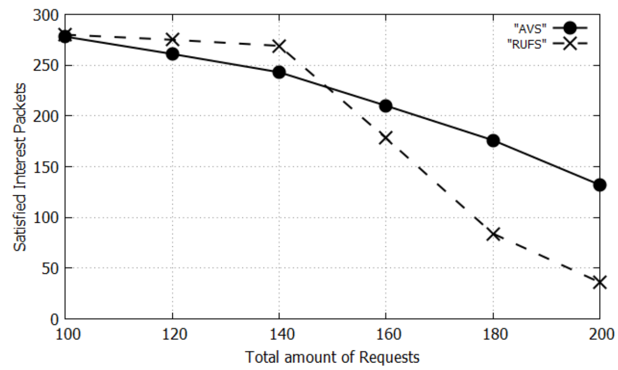

Fig. 2. The fairness index according to number of flows

V. Conclusion

In this paper, we propose a enw method namely AVS(Avoiding Data packet Storm problem) which controls content packet transmission based on local network congestion ratio for NDN. In the AVS, an intermediate node which receives a new interest measures that how many neighbor node would be participated the content packet transmission process. Moreover, the intermediate node measures local network congestion ratio. After this process, if the node receives correspond content packet, it checks the number of multiple paths and local network congestion ratio. If the congestion ratio and the number of multiple paths are low, it participates content reply process likely NDN. Otherwise, the congestion ratio and he number of multiple paths are high, it postpones or gives up the content packet to remove local network congestion when another copies of content packet could be forwarded along different paths.

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References

[1] S. H. Ahmed, S. H. Bouk, M. A. Yaqub, D. Kim and H. Song, "DIFS: Distributed Interest Forwarder Selection in Vehicular Named Data Networks," *IEEE Transactions on Intelligent Transportation Systems*, vol. 19, no. 9, pp. 3076-3080, Sept. 2018

[2] M. Amadeo, C. Campolo, G. Ruggeri, A. Molinaro and A. Iera, "Understanding Name-based Forwarding Rules in Software-Defined Named Data Networking," *ICC 2020 - 2020 IEEE International Conference on Communications (ICC)*, 2020, pp. 1-6

[3] S. H. Ahmed, S. H. Bouk and D. Kim, "RUFS: RobUst Forwarder Selection in Vehicular Content-Centric Networks," *IEEE Communications Letters*, vol. 19, no. 9, pp. 1616-1619, Sept. 2015

[4] "RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks," *RFC[6550]*,