

Time-based Forwarding Control in Content Centric Networking

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Abstract—Content Centric Networking(CCN) is using similar principle such as that of ICN, CDN, NDN which are the next generation of the Internet. Forwarding control is one of the important mechanism for the performance in content centric networking. When there is congestion in the network, the consumer have to adapt the alternative path in order to download the Data packet. If the consumer keeps the current path, the probability of packet loss will increase. For this situation, we will check the performance of time-based forwarding control to increase the consumer's throughput with reduced packet loss.

Index Terms—CCN, Forwarding Control, Future Internet, NDN, ICN, CDN

I. INTRODUCTION

WITH the development of network technology, content networking which is different from IP-based network technology has become an important issue. The examples include ICN (Information Centric Network) [1], CDN(Content Delivery Network) [2], NDN (Named Data Network) [3], etc., and these techniques are not based on the destination address but on content that is based on the user who requires data. CCN is one of the technologies that are emerging as the next generation of the internet in the future technology that is using the content name for networking. It supports to provide the required content to the users in wired and wireless networks. The basic unit to transmit in CCN is Interest packet and Data packet as a pair. The user requires Data packet by sending Interest packet. It is an automatically adjusted flow balance[4] mechanism. Because of this, end-to-end flow control is not required[5]. CCN is working on the basis of hop by hop[4] method not previous end-to-end method. Once user sends Interest packet, Data packet will be sent to consumer passed by intermediate cache of CCN node. If the data size is bigger, Data packet can be handled by the unit chunk even though it sends Interest and Data packet as a pair[7]. The congestion control in CCN is necessarily similar to TCP due to transmission demand from multiple users and overflow of intermediate router's cache[8]. Various aspects of congestion control have been researched. For example, new congestion control mechanism based on hop-by-hop Interest shaping[8] and the study about modified window and timer for consumer-based Interest control protocol to enhance reliability,

efficiency, fairness[9], and the study concerning flow control by using segment index in Interest header for under-utilization problem[5], etc. There are various forwarding methods like multicasting, best-routing, etc for congestion situation. If some node is down, the other node will be alternative, so it has the flexibility[6]. This is because the consumer can receive the Data packet from the alternative node with changing PIT(Pending Information Table) path. The common strategy of CCN is best route strategy that forwards an Interest to the upstream with lowest routing cost. However when there is congestion in lowest routing path, the performance of the consumer will decrease.

In this paper, we propose a time-based forwarding control method using comparison between Interest packet transmission time to Data packet receiving time to solve bottleneck symptom caused by transmission demand from multiple users. This paper is organized as follows: Section II. describes what is the time-based forwarding control. Section III. describes performance evaluation with complex topology. Finally, in section IV, we will discuss the conclusion of this paper.

II. TIME-BASED FORWARDING CONTROL

CCN node is composed of CS(Content Store), PIT(Pending Information Table), and FIB(Forwarding Information Base). Cache(CS) is the repository, that stores Data packet that the user requested by sending Interest packet.

PIT table is matching table to transmit the Data packet to the requested user. FIB table decides the direction to forward Interest packet. We will check the sent time($Stime$) for Interest packet in FIB table. As shown in Fig. 1, once Interest packet is received by CCN node, the CCN node checks prefix and then does duplicate data check by confirming Nonce record. If it is not duplicate data, it will search for the data in the cache and if it exists, Data packet will be sent to the consumer after that the related record will be deleted from the PIT table. If there is no related data in the cache, the information of the Interest packet will be saved in PIT table and also receiving time($Rtime$) for the Data packet will be checked in PIT match step. Forwarding strategy to transmit the Interest packet will be decided through FIB table. If the Data packet is received from CCN node, CCN

node will check whether the information from Data packet matches to Interest record in PIT table after checking the prefix. If it matches, the information will be saved in the cache, after that the Data packet will be sent to consumer node. The parameter Stime, Rtime will be used for checking the duration between nodes when Data packet download time. The least frequently used chunk in intermediate CCN node's cache will be excluded(LRU or LFU)[8]. This is for the efficiency of cache volume.

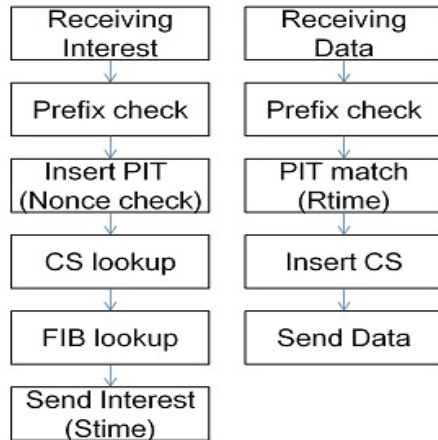


Figure 1. Receiving data from CCN node

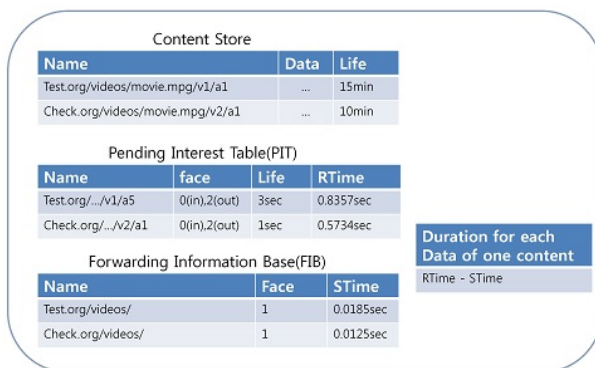
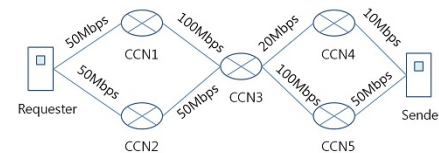


Figure 2. The structure of CCN node

Fig. 2 describes table fields in CCN node. Stime and Rtime fields are added to FIB, PIT table. Each CCN node recognizes packet arrival time at each location through FIB and PIT entry and save the current information in the previous CCN node. CCN nodes use this information to transmit a data packet. The consumer, intermediate CCN node and producer use sending time for Interest packet and receiving time for Data packet. The consumer checks receiving time of Data packet for Interest packet. The intermediate CCN node checks receiving time of data packet and records the information. When the Interest packet is needed to be transmitted, the forwarding direction is decided by FIB table. The forwarding direction decides the path of receiving Data packet. This is important to control congestion, because PIT table saves the received Interest packet path. When the Data packet is received at such CCN node, it will use the reverse path of PIT table.

If congestion occurs, the path of face in FIB table will be changed and the information of PIT table in the next CCN node will also be changed. Therefore, transmission strategy decides receiving strategy. Stime is the transmission time for Interest packet in the CCN node. Rtime is the receiving time with same prefix at that CCN node. We compare Rtime with Stime. If the gap between them is more than minimum transmission delay consecutively, the transmission path will be adjusted by controlling face in FIB table in order to prevent congestion among flows. If Rtime is too slow, FIB table considers changing forwarding address. This is for assigning packet transmission to high bandwidth. If the bandwidth is low, the count of data transmission will be small. Fig. 3 describes the advantage of suggested method. If the consumer sends the Interest packet to the producer through the path Consumer->R1->R3->R5->Producer, the performance will be slow. but if the path is Consumer->R2->R3->R4->Producer, the arrival time of the Data packet will be shorter than the above path. Therefore, the throughput will be increased. Stime and Rtime values will be used for path decision.



The duration of CCN1 = Receiving time for the specific prefix in CCN1 – Sending time for the prefix in CCN1
 The duration of CCN2 = Receiving time for the specific prefix in CCN2 – Sending time for the prefix in CCN2
 The duration of CCN3 = Receiving time for the specific prefix in CCN3 – Sending time for the prefix in CCN3
 The duration of CCN4 = Receiving time for the specific prefix in CCN4 – Sending time for the prefix in CCN4
 The duration of CCN5 = Receiving time for the specific prefix in CCN5 – Sending time for the prefix in CCN5

Figure 3. Network Diagram

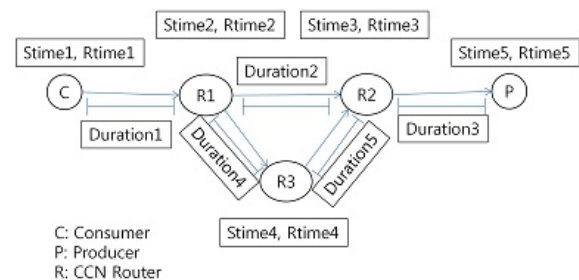


Figure 4. Transmission time and receiving time

Interest packet in CCN acts like ACK in TCP mechanism[8]. TCP's RTT(Round Trip Time) what is used in congestion scenario means mainly end to end transmission time. The each CCN node estimates RTT to control flow for congestion situation. When the consumer sends Interest packet, the intermediate CCN router records Stime for Interest packet and Rtime after receiving Data packet and then calculates the minimum RTT. Let minimum RTT value be equal to the time when the first Data packet arrives in the CCN node. (the minimum RTT = Data packet arrival time in the CCN node - Interest packet transmission time in the CCN node). If the next RTT is smaller than the previous one, the

RTT value will be changed. If the waiting time is growing after sending Interest packet consecutively, such CCN node checks if the node is congested. The forwarding address in FIB table will be changed. Stime1 in Fig. 4 is the initial Interest packet request time, Rtime1 is the final packet arrival time. The duration time(Duration2) on node 2 will decide whether the duration of the current path is longer or not. Therefore, if the congestion on the path increases, node 2 will decide to change the path.

III. PERFORMANCE EVALUATION

In this paper, we tested the proposed time-based forwarding control method using ndnSIM 2.0[10]. The experiment topology is shown in Fig. 5. The proposed method is tested for comparison between sent time for Interest packet(Stime) and received time for Data packet(Rtime). The packet count for transmission is 100. If each consumer requests same prefix data, the receiving time will be shorter. Therefore, each consumer requests different prefix data. The payload size is 1040 byte in consumer node and producer node. The transmission delay is 20ms. We set the bandwidth as 10Mbps, 1Mbps for bottleneck interval. The cache size is 1000. To prevent packet loss in queue, the queue size is set to 500 for the testing. The consumer 3 and consumer 4 are configured for traffic flows. The consumer 1 is set to the proposed forwarding method. The consumer 2 is set to the common best-route strategy for comparison. Queue size and cache can affect the arrival time, so we set those parameters to large values.

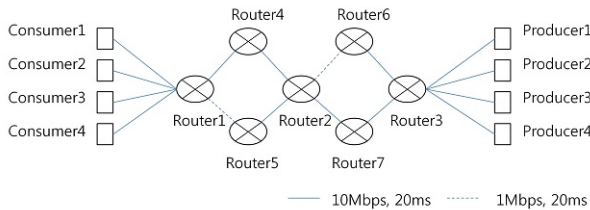


Figure 5. Simulation Topology

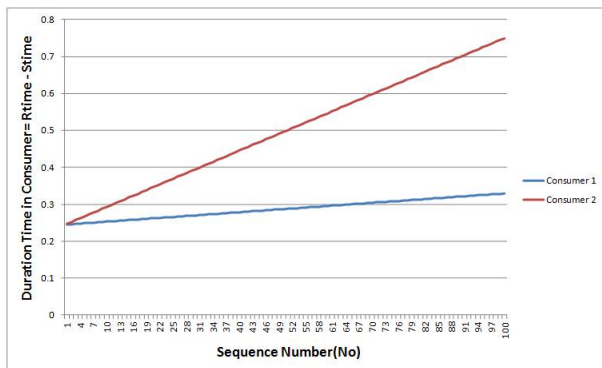


Figure 6. Duration time comparison of consumer

Fig. 6 describes the total time duration comparison between consumer 1 and consumer 2(Rtime for Data packet - Stime for

Interest time). The path of consumer 1 is C1->R1->R4->R2->R7->R3->P1. The path of consumer 2 is C2->R1->R5->R2->R6->R3->R2. The total duration time of consumer 2 is much higher than consumer 1. The forwarding path is changed by the duration time on each CCN node, therefore the arrival time of Data packet in consumer 1 is faster than before, hence the throughput also increases.

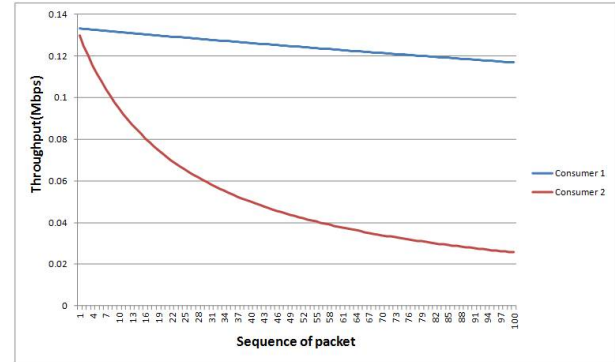


Figure 7. The comparison of throughput

Fig. 7 describes the comparison of throughput for each flow. The throughput of consumer 1 is relatively higher than consumer 2 which is using best-route strategy.

IV. CONCLUSION

In this paper, we checked the performance of a time-based forwarding control method in content centric network. The Stime, Rtime value were used to check the duration between nodes and decide a forwarding path to avoid the congestion. We tried to decentralize the network usage. The proposed forwarding control method is expected to enhance the performance when there is a high network congestion.

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