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Employing Working Set Model for the Content Store in Content-Centric Network

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Abstract. Content-Centric Network (CCN) is one of the future Internet architecture models in which data can be retrieved using its name rather than a server address. In addition, CCN routing nodes perform content caching and multicast transmission. The node contains pending interest table (PIT), content store (CS), and forwarding information base (FIB) to efficiently deliver data packets. Clients may send an *interest* packet in order to request a corresponding *data* packet. The content server or any intermediate node that caches the data responds by transmitting the data. When several clients request the same content, the caching in CS helps improving the transmission performance of the content flow. If an intermediate node allocates a proper memory size in CS for the content flow, it increases the transmission performance of the content flow. When the memory size for the flow is less than the appropriate size, it suffers from degrading the performance. This paper proposes the necessity of maintaining the suitable size in CS, called a *working set size*, for a content flow, as well as deciding the proper replacement algorithm.

Keywords: Content-Centric Networks, Content Store, Working Set Model.

1 Introduction

Content Centric Network (CCN) is one of the future Internet architecture models in which data can be retrieved not by the server address but by the data name itself. CCN model comes from one of the Named Data Networking (NDN) [1] project supported by NSF, and named by Xerox PARC [2]. Every CCN node contains content store (CS), pending interest table (PIT), and forwarding information base (FIB). Any client can send an *interest packet* and any node holding the matching data in CS will transmit the *data packet* to the client.

CS keeps some content based on the expectation that the content will be requested in near future. It would be beneficial if several clients request the same content and

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nearby CCN node caches the content in CS, because the node is able to satisfy all the requesting clients. However, if it is small for the allocation size of the CS for the content flow and the network delay is large between a client and the node, it results in the degradation of the transmission performance. This paper proposes a necessity of the working set model to manage CS for the shared content.

This paper is organized as follows. Section 2 describes a working set model for CS. Section 3 shows the simulation results of the working set model. Finally, section 4 concludes this paper.

2 CS Replacement Algorithms and Working Set Model

A content server initially divides a file or content into several fixed-sized chunks and puts a unique name for each chunk. A client transmits a series of *interest* packets including the unique names in order to request the content. The content server replies the chunks by transmitting *data* packets. When a CCN node receives a data packet, it checks whether the data is in its CS. If not, the node stores the data into the CS for a while to serve other clients requesting the same content. When the CS is full and new data needs to be inserted, one element in CS will be replaced with the new data. This paper employs four replacement algorithms including LRU, LFU, Random and FIFO.

The CCN supports in-network caching and multicast which are important features for improving transmission performance. Any intermediate CCN node may cache a popular content in its CS that will be multicasted to other clients requesting the same content. Due to the network delay and the initiating time differences between clients requesting the same content, the transmission performance fluctuates depending on the allocation size in CS, called a *working* set similar to [3,4], for the content flow. When a CCN node maintains reasonable allocation size in its CS, it results in providing a reasonable transmission performance.

3 Simulation and Results

In order to show the necessity of the working set model in CS, this section briefly describes the simulation and the results about the working set model. This paper employs the ndnSim [5] over ns-3 network simulator. The network topology includes four clients, two routing nodes, and one content server. All communication links are set to 10 Mbps and 5 ms delay except that the link delay between two routers is set to 100 msec. Fig. 1 illustrates the topology used in this simulation.

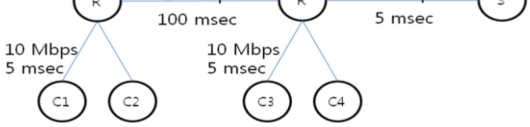

Fig. 1. Simple network topology used in the simulation

The four clients download the same content from the server. They send 1000 interest packets per second to their directly connected routing nodes. The data packet size is 1024 bytes. Each client starts transmitting the interest packets with different intervals. For example, C1 starts to send the first interest packet at simulation time 0 second, C2 at 0.5 second, C3 at 1.0 second, and C4 at 1.5 second. The size of the CS varies from 1000 data entries to 1400 entries. The CS replacement algorithms used in this simulation are LRU, LFU, FIFO, and Random.

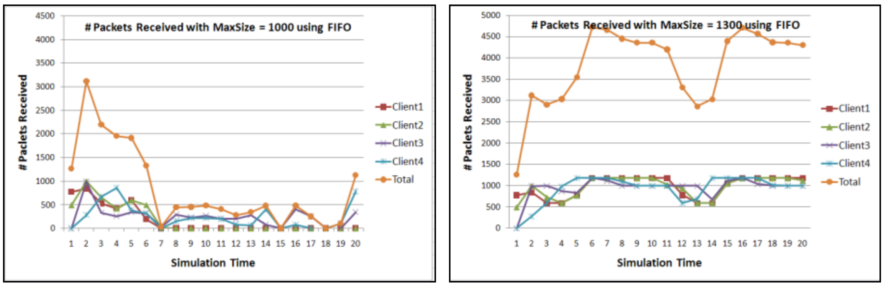

Fig. 2. The number of packets received when the size of CS is 1000 entries and 1300 entries.

Fig. 2 shows the number of data packets received in 20 seconds by the clients. The "Total" in the legend indicates the total number of packets received by the four clients in each second. Client1 did not receive data packets from 7 second, and so did Client2 from 8 second. It is due to the timeout of the PIT entry which contains the route information of the data packet back to the client requesting the packet. The left side of Fig. 2 indicates that, when the size of the CS for the flow stores only 1000 data entries, most of the data packets are lost at time 7 and thereafter. If the size of the CS becomes 1300, most packets are delivered to the clients but with fluctuating delay, which shows in the right side of Fig. 2. When a multimedia data is received with high delay and delay jitter, the quality of the multimedia degrades ungracefully.

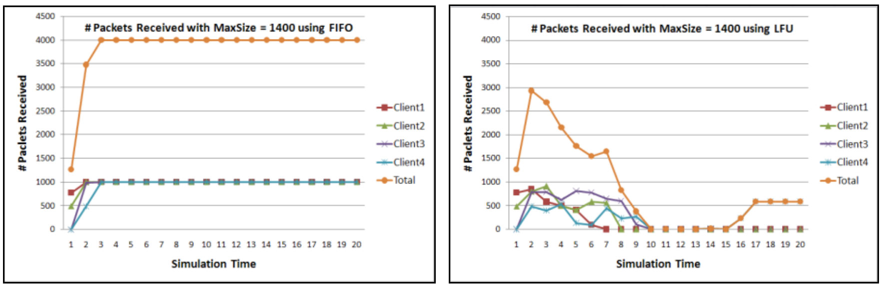

Fig. 3. The number of packets received with 1400 entries with using FIFO and LFU

Fig. 3 illustrates the results of the simulation in which the CS in each routing node contains 1400 elements of data packets. The left side of Fig. 3 employs FIFO for its CS replacement algorithm and LFU for the right side of the figure. In case of FIFO, all clients receive 1000 data packets for each second. On the contrary, LFU algorithm selects a replacement data entry that might be requested in near future, which results in decreasing the number of received packets as time goes by.

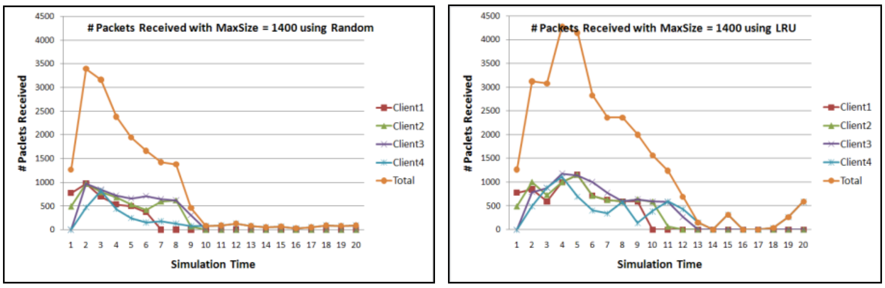

Fig. 4. The number of packets received with 1400 entries by using Random and LRU

Fig. 4 illustrates the results of the simulation with the similar condition as in Fig. 3 except that the random replacement algorithm is used in the left figure and the LRU is used in the right. Both replacement algorithms also suffer from degrading the performance and need larger working set size in the CS.

4 Conclusions

This paper shows that, when CCN nodes deliver popularly shared content such as real-time broadcast or video conferencing, the content store management requires a working set model for each content flow. The replacement algorithm for each flow prefers FIFO rather than LRU or LFU. When the CS reserves a suitable size for the sharing content, the involved clients receive the requested data packets properly and the network delivers small number of data packets as well. The size of the working set in the CS depends on the network delay and initiating time gap of the clients. The future work will focus on deciding the proper size of the memory allocation for each flow in the content store.

References

1. Jacobson, V., Smetters, D. K., Thornton, J., Plass, M., Briggs, N., Braynard, R.: Networking Named Content. ACM CoNEXT 09, 2009, pp.1-12 (2009)
2. Jacobson, V., Smetters, D. K., Briggs, N., Plass, M., P. Stewart, Thornton, J., Braynard, R.: VoCCN: Voice Over Content-Centric Networks. ReArch '09, pp. 1-6 (2009)
3. P. Denning.: The working set model for program behavior. Communications of the ACM, Volume 11, Issue 5. pp. 323-333 (1968)
4. Brown, J., Porter, L., Tullsen, D.: Fast Thread Migration via Cache Working Set Prediction. IEEE High Performance Computer Architecture (HPCA), pp. 193-204 (2011)
5. NS-3 based Named Data Network (NDN) simulator: http://ndnsim.net.

