Cache Decision for Scalable Video Streaming in Information Centric Networks

Saeed Ullah, S.M. Ahsan Kazmi, Kyi Thar, Tuan LeAnh, and Choong Seon Hong*
Department of Computer Engineering, Kyung Hee University, South Korea
{saeed, ahsankazmi, kyithar, latuan, cshong}@khu.ac.kr

Abstract

Ability of caching the content is one of the most important feature of Information/Content Centric Network's (ICN/CCN) nodes. In this paper we proposed a new idea that ensures to cache the base layer of a scalable video near to the users, which is mandatory layer for decoding any video and is needed by all the users with any datarate budget, and consequently cache the higher layers in the upper nodes in the CCN/ICN. Our proposed scheme reduces traffic inside the network and improve response time to the users.

1. Introduction

Information/Content Centric Network (ICN/CCN) [2] is a future internet architecture that changes the internet from location specific to information centric in order to provide better quality of experience to the users. Ability of the ICN/CCN nodes to cache the contents in its memory for to provide it to the users for near future requests makes this architecture more suitable for providing better service to the users. By using the cache memory intelligently and efficiently we can provide better quality services to the users.

On the other hand Scalable Video Coding (SVC) [3] encode the video in layers to provide scalability to the users according to their device capability and/or available link speed and their budget. In SVC the video is encoded into one base layer and several enhancement layers. Base layer is the mandatory layer for decoding any video. Similarly enhancement layer 1 is required for enhancement layer 2 to be used and enhancement layer 3 can only be useful if enhancement layer 1 and enhancement layer 2 are already present. Each enhancement layer is used to improve the video quality.

Here in this paper we are proposing a method that will cache the base layer in the nearest router to the users and the enhancement layer in upper layer ICN nodes according to their layers in increasing order. Our proposed cache decision model ensure to cache each layer within a predefined RTT limit.

2. System Architecture and Assumptions

Our proposed scheme can be applied to arbitrary ICN topology that is consisted of two types of nodes the edge nodes and the intermediate nodes. The edge nodes are connected to the outside world i.e., servers and ICN users. While the intermediate nodes are capable of forwarding the interests and data chunks between the users and servers and also can cache the data. Combination of the nodes that links a specific user to a specific server is called a path. A potential path between user U1 and server S1 is shown in bold lines in figure 1. Here we assume that each node in the ICN network is capable of knowing the video layer information of the passing content chunk i.e., can find that it is base layer or enhancement layer 1 or 2 etc. In the extended version of this paper we will show in detail how a node will extract layer information from a data/interest packets.

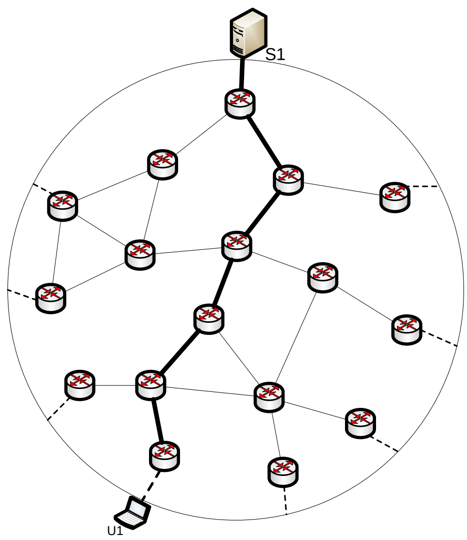

Figure 1: System Architecture

Like our previous proposal in [1] we are proposing extra field in the interest packet header and data packet header. Time Since Inception (TSI) value field is added in the interest packet header while the data packet header been added with TSI value, Time Since Birth (TSB) value and Cache Status (CS) values. Usage of these values been discussed in section 3.

Algorithm 1: Cache Decision for Interest Packet

Begin
  If *current node is edge node* then
    If *the requested data item is present in cache* then
      Reply with the data item
    else
      Initialize the TSI value with 1
      Set the α_k value
      Calculate RTT using formula in eq (1)
      Forward interest towards the server
  else
    If *the requested data item is present in cache* then
      Fix the TSI value
      Initialize the TSB value with 1
      Set the CS value to 00
      And reply with the data item
    else
      Increment TSI by 1
      Forward the interest packet towards the server
End

We also assume that interest packet carries the RTT value between the edge node and the last node. We will present the detailed structure of this proposal in the extended version of this paper.

3. Proposed Scheme

In CCN a user generate interest packet whenever it needs some data and send it towards server in order to get that data item. The first CCN node that receive this interest packet, we call it edge node. This edge node set the TSI value just like in [1] and also set the α_k value, k represent the video layer that is requested in the interest packet. In [1] we proposed that TSI value is fixed at the server but here in our this proposal TSI value is fixed by the CCN node where the actual RTT~=α_k.

In our proposed scheme every ICN node calculate current RTT for the last hope with the help of interest packet using the following formula.

$$RTT_{(i-1\to i)} = 2\left(\frac{Interest-packet-length}{Transmission-time_{(i-1\to i)}}\right) ---(1)$$

Here we assume that datarate is the same in both the direction and remains unchanged for the period of a unit data transfer (i.e., for the period of interest and data chunk in the response). Every node aggregates RTT for all the previous nodes and compare it with α_k if the node has the requested data item and is within

Algorithm 2: Cache Decision for Data Packet

Begin
  If *CS value is not 00* then
    Forward data packet to the next hope
  else
    If *the node is in* α_k *range*
      Cache the content with P_c (eq2)
      If *probability is true (means content is cached)*
        Change CS value to 11
      else
        Decrement TSB by 1
    else
      Forward data packet to the next hope
End

the α_k limit it reply with the data item with fixing the TSI value and initializing the TSB value just like we did in [1]. If $RTT_{(e\to i)} \cong \alpha_k$ and the requested data item is not present in the current node (N_i) cache it fixes the TSI value and forward the interest packet towards the server. When the same node N_i, that has fixed the TSI value, receive the responded data item it initialize the TSB value in the data packet header and calculate the caching probability P_c with the following formula (just like we did in [1]).

$$P_c = \begin{cases} \frac{TSB}{TSI}, & if\ CS = 00 \\ \frac{TSB}{2(TSI)}, & if\ CS = 01 \\ 0, & Otherwise \end{cases} \qquad ------------- \quad (2)$$

The node will cache the data item if the probability is true in the formula and will change the CS value from 00 to 01 otherwise it forwards the data item in the downward direction. The proposed scheme is explained in detail in algorithm 1 and algorithm 2.

4. Numerical Results

In this section we numerically analyze our proposed cache decision policy with ProbCache [4]. We compare both the schemes on the basis of average number of hopes traveled for getting the requested contents. For this comparison we are taking a network path between the user and server as 20 hops and showing the results for the second time request of the contents and the second call is within such short period of time that the first call contents are not replaced in the cache by other contents. For simplicity purpose we are taking the assumptions that delay on each link is the same and remain unchanged for the time of experiments. For our proposal we take α_0 (base layer) equal to 2 hops. α_1 (Enhancement layer1) equals 3 hops (routers at hope 3, 4 and 5) α_2 (Enhancement layer2) is equal 5 hopes (router 6-10) and α_3 (Enhancement layer3) is equal 10 hops (router11-20). Results are shown in Figure 2. The base layer that is mandatory layer for any video to be decoded and is requested by all user who want to watch the video regardless of the network situation and users' budget requirements. In the figure we see that our proposed scheme outperform ProbCache for base layer as well as for the first two enhancement layers. For enhancement layer 3 (EL3) the performance of ProbCache is better than our proposed scheme however this layer is requested by a few users. To have a look at the enhancement layer 3 a user under ProbCache scheme will have to access 40 routers in total (since BL, EL1, EL2 are must to be present to decode EL3) will need to access 40 CCN nodes on average while for our proposed scheme will need to access only 27 CCN nodes on average.

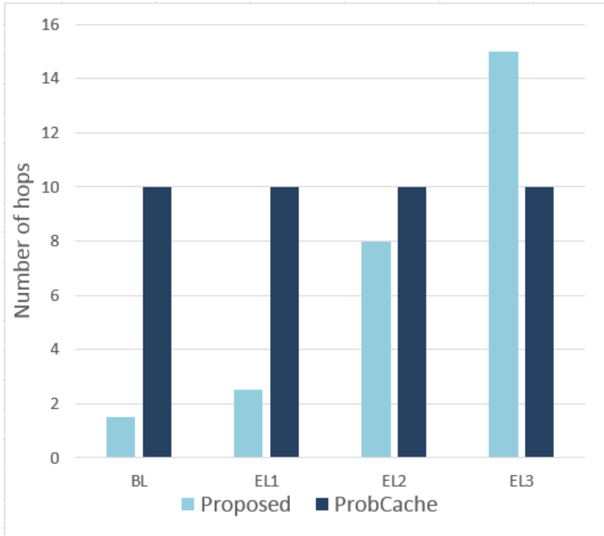

Figure 2: Comparison of proposed scheme and ProbCache

5. Conclusion and Future Work

In this paper we presented a new cache decision policy for video contents in which scalable video contents are cached on the basis of their layer. Base layer contents are store near to the user and enhancement layer contents are store away from the users and nearer to the server on the basis of their increasing order. In this short paper we presented only the cache decision process and we intent to extend this proposal to the cache replacement policy. Also in the extended version of the paper we intend to provide more complete and numerical and simulation analysis with relaxed assumptions.

6.Acknowledgement

This research was supported by the MSIP (Ministry of Science, ICT & Future Planning), Korea, under the ITRC (Information Technology Research Center) support program (NIPA-2014(H0301-14-1020)) supervised by the NIPA (National IT Industry Promotion Agency). *Dr. CS Hong is the corresponding author

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