CDAVC: Adaptive Video Streaming Friendly Cache Scheme for Information Centric Networks

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Abstract

Efficient delivery of the video in general and adaptive video in particular has been a challenge for the network engineer over the Internet. Main challenging issue is the size of the video content and the dynamics of video encoding. In this paper we are proposing a cache scheme for the Information Centric networks that overcomes the fluctuation in the rate adaptation of adaptive video streaming. We call our proposed scheme as Cache Decision for Adaptive Video Contents (CDAVC). According to the proposed schemes the successive video chunks are cached in the limit of threshold which assist to overcome the fluctuations in the rate adaptation.

1. Introduction and Related Work

Future of the Internet is envisioned to be Information specific rather than location, i.e., "what" rather than where. One of the leading information specific architecture is presented by Van Jacobson et al. [1] which they call Named Data Networking or Content Centric Networking (NDN/CCN). Capability of the CCN node to cache the content in its local memory is one of the most important feature of the CCN node. CCN node provide the contents to the requested node from its cache if it is present there.

Video streaming on the other hand is always been a challenging issue for the network engineers to deal with it because of the large size of the video contents and the complex nature of the video codecs. Adaptive video streaming or Adaptive Video Coding (AVC) is the featured variant of the advanced video codecs. In AVC video is encoded with different data rates and special resolution in order to deliver video to the users according to their device capabilities and network dynamics. A major challenge in the video streaming is the rate adaptation i.e., to select the bitrate of the video which is nearest to the network conditions and the device capabilities.

Due to caching the rate adaptation is a more severe issue in CCN. As the next request for the video chunk is decided on the received chunk so getting the cached content from different locations make it very hard for the user device to choose the correct rate. In this paper we propose a cache scheme that overcome the rate adaptation issue due to caching. Our proposed scheme cache the "β" successive chunks within a limited threshold of RTT that reduces the fluctuation of RTTs between the successive chunks.

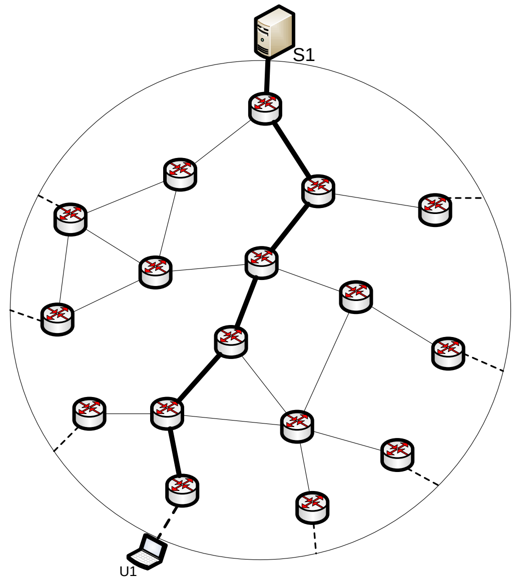

Figure 1: System Architecture for the proposed scheme

Rate adaptation has been intensively researched in the communication network. In the recent fast research community have tried to solve the rate adaptation problem in ICN/CCN. In [2] the authors have tried to manage the rate adaptation of layered scalable video streaming in CCN, which is mainly caused by the cache hit. Their solution is to drop downloading a layer for which the delay is more than a threshold. In [3] the authors have presented a new cache scheme for video streaming in CCN. Their proposal mainly focusses on providing copy of the successive request for the same resources from the cache as much as possible. However, their solution don't ensures the rate adaptation problem. Here in this paper our main focus is to solve fluctuation in the rate adaption for successive chunk requests.

Algorithm 1: CDAVC for Data Packet

```
If  St = 1 & Probability is true according to [5] then
      cache the content
      initialize N = 1
      set first entry to NID
      put tstamp to the chunk and forward it
else
    search own ID in the NID
    If found then
       cache the content with probability 1/N
    else
       diff = tstamp - ctime
       If diff ≤ γ/4 then
           N = N+1
           Put own ID in NID & forward the chunk
       else
           Forward the packet
       end if
    end if
end if
```

Algorithm 2: CDAVC for Interest Packet

```
If first entry in the NID is own ID then
    put timestamp to the chunk and forward it
else
   if tstamp is set then
      Diff = tstamp - ctime
         If diff ≤ γ/4 then
            N = N+1
            Put own ID in NID & forward the chunk
         end if
   end if
end if
```

2. System Architecture and Assumptions

Our proposed scheme can be applied to general mesh topology of ICN network like given in Fig 1. User generates a request (Interest) for their desire data chunk. We assume that the users request the whole video content by generating sequential Interest packets. Upon receiving the Interest packet, the ICN node checks its local Content Store (CS) for the requested data if found is sent on the request path otherwise the Interest is forwarded according to standard CCN forwarding after making an Pending Interest Table (PIT) entry.

We propose an extended header to both the Interest and Data packets we call it CDAVC (Cache Decision for Adaptive Video Content) header. This header is consisted of status bit (St), count of nodes that should cache the contents (N), time stamp (tstamp) field, an RTT range field (ɣ) a number of Node ID fields (NID) and an NID count field (NID_C). We will give detailed structure of the header fields and length in the extended version of this paper.

Value of ɣ is the RTT range that is defined by the user. ɣ is inside the range that will not affect the rate adaptation of a video. Source node i.e., user detach the CDAVC header from data packet and attaches it to the next Interest packet of the same content. Similarly the server node or the node where cache hit occurs detach from Interest packet and attach it to the corresponding Data packet.

3. Proposed CDAVC

Our proposed cache scheme CDAVC is based on Probabilistic In-network chunk marking and caching for information centric networks [5]. According to our previous work in [5] the data chunk is cached probabilistically on the bases of path matric between the user and content server. That scheme is for the general content. If the content is an adaptive video streaming content then by following CDAVC will help to overcome the fluctuation of rate adaptation. Our proposed cache scheme for the adaptive video contents is given in algorithm 1 and algorithm 2. Detailed discuss of the scheme is discussed in the following subsection.

3.1. Cache decision process

When a user send first Interest for a content it set the St bit to 1 and put β value in the CDAVC header. β is the maximum number of successive chunks that should be stored in a limited RTT range. When St bit is set to 1 the nodes take cache decision according to [5]. Whenever at a node the cache probability become true according to [5] it set N to 1, put its ID to the NID field and assign current time to tstamp. N is used for calculating cache probability in the nodes that come under the ɣ range. We assume that clocks at all the nodes are synchronized. The following node when receives the data chunk calculates its distance in terms of RTT from the first node by subtracting current time from the tstamp. If it resides within the RTT limit it puts its ID to the NID field and increments N by 1. The source node when receive the data chunk it detach the CDAVC header from the Data packet and attach it to the next Interest packet. Since video content is usually

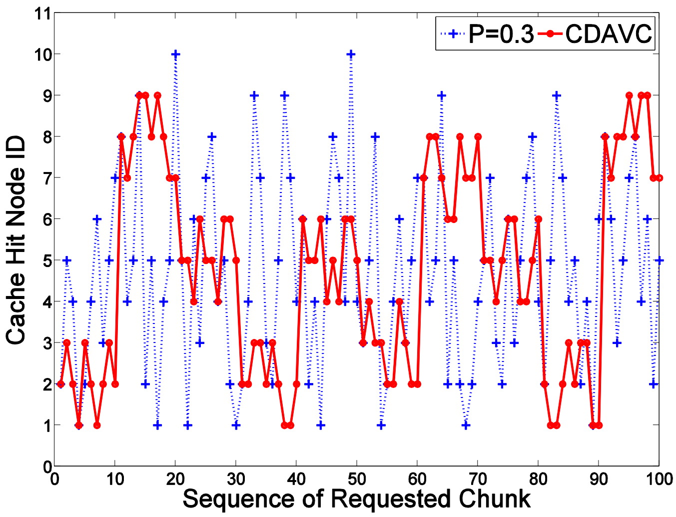

Figure 2: Cache hit locations of successive Packets

having big size so we don't want to dump it at a few nodes and for the load balance we chose β which defines the number of packets to be stored in the ɣ range of the initial cache hit. When NID_C reaches to its β i.e., NID_C = β the source sets the St bit to 1 like new content request and deletes all the NID values, tstamp and NID_C. This Interest is treated just like first Interest for the content in the CDAVC. CDAVC process for both the Data packet and Interest packet is explained Step by step in detail in algorithm1 and algorithm2 respectively.

4. Analysis and Results

In this section we numerically analyze our proposed CDAVC with static probabilistic cache decision with probability P=0.3. We compare both the schemes on the basis of hit distance for getting the successive requested contents. For this we are taking a network path between the user and server as 10 hops. For simplicity purpose, we are taking the assumptions that delay on each link is the same (specifically 50ms) and remain unchanged for the time of experiments/whole content retrieval. For the analysis, we have taken β equals 10 i.e., 10 successive packets are stored within the ɣ range. We have taken ɣ equals 200ms which means for the initial packet cache hit (for which St bit is set to 1) the proceeding 9 packets will be cache in that node or will be cached in its 1 hop neighbors. We take the assumption that source node or user device will have to adjust the rate if the change in RTT of the successive requested chunk is more 200ms or in other words the distance between successive cache hit locations is more than 2 hops.

Figure 1 shows the results for our proposed CDAVC and probabilistic cache scheme with static probability of 0.3 (P=0.3). We have done this simple simulation in matlab and the results are shown in Figure 1. In the figure we see that there is high fluctuation in the successive chunks cache hit location, which means the source will have to adjust the rate for next chunk quite often. While the proposed CDAVC have the cache hit location within 2 hops for 10 successive chunks. The number of successive hit can be increased/decreased by changing the β value.

5. Conclusion and Future Work

RTT fluctuation in the successive data chunks affects the rate adaptation for adaptive video contents. This problem is more severe in ICN due to content caching. In this paper we proposed an adaptive video friendly cache scheme that we call CDAVC. Our propose CDAVC reduces the continuous fluctuation in rate adaptation of video content. We intend to extend our proposal in future and analyze the proposal through intense simulations as well as numerically.

6. Acknowledgement

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7. References

[1] Van Jacobson, Diana K. Smetters, James D. Thornton, Michael F. Plass, Nicholas H. Briggs, Rebecca L. Braynard, “Networking Named Content”, CoNext, Rome, Italy, 2009.

[2] Lee, Junghwan, et al. "SVC-based Adaptive Video Streaming over Content-Centric Networking" KSII Transactions on Internet and Information Systems (TIIS), 2013.

[3] Li, Zhe, and Gwendal Simon. "Cooperative Caching in a Content Centric Network for Video Stream Delivery." Journal of Network and Systems Management, 2014.

[4] Saeed Ullah, et al. "Cache Decision for Scalable Video Streaming in Information Centric Networks," 한국컴퓨터종합학술대회 (KCC 2014)

[5] Saeed Ullah, Choong Seon Hong, "Probabilistic In-Networking Chunk Marking and Caching for Information-Centric Networks," 한국정보과학회 제 40회 추계학술발표회(KIISE 2013).