User-behavior Driven Video Caching in Content Centric Network

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ABSTRACT

This paper studies the user-behavior driven CCN caching jointly investigating the video popularity and video drop ratio. As far as the authors understand, this is the first paper taking the video drop ratio into consideration in CCN caching scheme design. The preliminary simulation results show that the proposed caching scheme can achieve better performances over the competing caching scheme.

CCS Concepts

•**Information systems** → *Multimedia streaming;* •**Networks** → *Network protocols; Network services;*

Keywords

ICN, CCN, caching, video popularity, video drop ratio, user behavior

1. INTRODUCTION

One major difference between Content Centric Network (CCN) [1] and traditional networks is that CCN's routers have caching abilities. The inherent problem is what should be cached in each router (defined as the *caching decision*) and how to replace the cached content when a new content is cached in a full cache (defined as *cache replacement*).

Orthogonally, video dominates the network traffic and how to cache the video efficiently is an important topic. By considering video users' behaviors, the caching performance can be improved. One typical work is the caching scheme aware of the video popularity [2], where each video content is associated with some popularity, and the popularity indicates the requested times among all the video requests. Then by caching the popular contents closer to users, the server hit rate and average transmission hops needed can be reduced.

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Another important observation is that video consumers do not always watch the video till the end, i.e. there exists video drop ratio. But as far as the authors understand, there is no literature work taking the video drop ratio into consideration in the CCN caching scheme design. In this paper, we study the user-behavior driven CCN caching jointly investigating the video popularity and video drop ratio, which is also applicable to other *Information-centric Network* (ICN). The preliminary simulation results show that the proposed scheme can achieve better performances comparing with the caching scheme without considering the drop ratio.

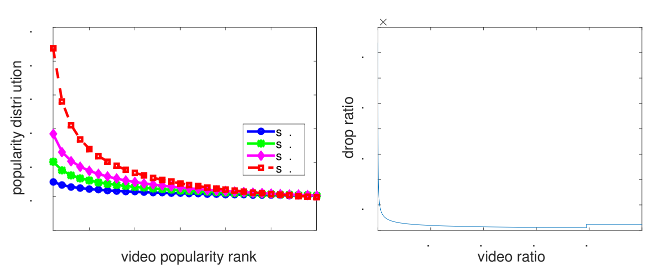
2. SYSTEM AND CACHING POLICY

We consider the intra-domain caching in CCN system, which is composed by servers/repositories, routers and users. Routers in CCN can cache content and content store (CS) of each router acts as a buffer memory.

2.1 Popularity and video drop ratio model

Two video user behaviors are considered, i.e. the video popularity [3] and video drop ratio [4, 5]. We assume k_i is ith video's item popularity rank based on the request times. Smaller rank instance number indicates higher popularity. Zipf's law [3] is used to model the video popularity with parameter s, which is the exponent characterizing the distribution and is referred to the skewness of popularity, as shown in Fig. 1 (a). Then out of a population of N video elements, the frequency of element i with rank k_i could be calculated as follows:

$$r_{k_i,s,N} = \frac{1/k_i^s}{\sum_{n=1}^{n=N} 1/n^s} \tag{1}$$



(a) popularity distribution: N=100 (b) user video drop ratio

Figure 1: User behavior illustration.

The video drop ratio model [4] used is based on 540 million viewing records, and the viewing ratio distribution could be expressed as:

$$p_c = \begin{cases} vc^{\alpha} & 0 < c \leq 1-u \\ \frac{1-\int_{y=0}^{1-u} vc^{\alpha}dy}{u} & 1-u < c \leq 1 \end{cases} \quad (2)$$

where c stands for the viewing ratio in terms of percentage. v and α are constants for the *Power Law distribution* to model the early departures. The completed views are assumed to end within a short span (in terms of viewing ratio), denoted as u. And these views are uniformly distributed within the life span of u. Fig. 1 (b) shows this distribution with $u = 0.21, \alpha = -0.48, v = 0.063, \int_{y=0}^{1-u} vc^{\alpha}dy = 0.25$, and the granularity of the watch ratio is 0.001. These parameters are cited from [4] and used in the simulations. We can observe that beginning part has higher drop ratios.

2.2 Caching policy

The proposed intra-domain caching policy used in the topology known network is shown in Alg. (1). Along the path from users to server, there are M level routers, denoted as level $1, 2, ..., M$, and level 1 router is the closest to users. Cache size of level j router is x_j chunks, and chunk i's size is δ_i chunks. Chunk i's rank k_i^* is calculated first based on R_i, which is the corresponding item popularity times the viewing ratio. The general idea of Alg. (1) is that chunk i is cached in level j router if and only if the higher ranking chunks than i can be stored in the routers with router levels no larger than j, and the lower level routers cannot cache all the chunks with ranking higher than $k_i^* + 1$. This algorithm can be proved optimal in terms of average transmission hops needed and server hit rate in network with cascade topology when the video popularity and viewing ratio are fixed. The proof is omitted due to page limit.

This policy is feasible since video popularity table could be exchanged periodically among routers, given communication between routers is not that expensive. Additionally, level j router will receive all the requests except what are satisfied by lower level routers, i.e. level j router has enough necessary information to cache the most popular contents among all the requests arrived at level j router.

Algorithm 1 Caching policy

Require: δ_i, k_i^*, x_j
for each chunk i arriving at router j **do**
  if $\sum_{\forall p \in N, k_p^* \leq k_i^*} \delta_p > \sum_{q=1}^{j-1} x_q$ & $\sum_{\forall p \in N, k_p^* \leq k_i^*} \delta_p \leq \sum_{q=1}^{j} x_q$ **then**
    cache the chunk i
  else
    do nothing
  end if
end for
return caching decision

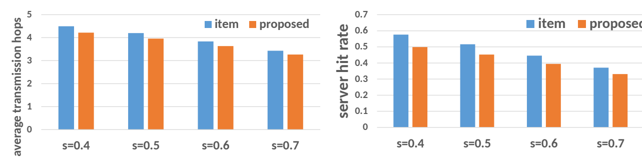
3. SIMULATION RESULTS

The parameters used to simulate the network are shown in TABLE 1, where we follow [2, 6] and design this small-scale simulation. We assume the videos are identical in size but with different item popularity ranks to simplify the implementation.

Table 1: Detailed network parameters

Parameters	Values
total request rate:	120 content items/s
# of different content items:	6.9×10^3 items
content size:	690 chunks (6.9 MB)
cache size of each router:	2×10^5 chunks (2GB)

The average transmission hops traversed by each chunk and server hit rate are used as the evaluation metrics. The network topology used is the cascade topology with five levels and the results are shown in Fig. 2. The competing scheme *item* [6] does not take the video drop ratio into consideration and different chunks of the same video content have the same rank. From the results, we could observe that by considering the video drop ratio and popularity, the caching performance is enhanced.



(a) average transmission hops (b) server hit rates

Figure 2: Performance evaluation.

4. CONCLUSION

Caching is one fundamental issue in CCN and users' behaviors should be embedded in the caching scheme design. This paper studies the user-behavior driven CCN caching jointly investigating the video popularity and video drop ratio, which also works in other ICN. The preliminary simulation results show that the proposed scheme can achieve better performances comparing with the caching scheme without considering the video drop ratio.

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