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A CONTENT EVICTION MECHANISM FOR INFORMATION-CENTRIC NETWORKING

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ABSTRACT

Information-Centric Networking, which is also called Content-Centric Networking (CCN), is the vowing candidate for the Future Internet. ICN has many aspects, e.g., Naming, Routing, and Caching, etc. but in the past five years, caching gained a tremendous attraction by the research community. In ICN, caching is of two types, i.e., off-path caching and on-path caching. On-path caching is also known as in-network caching, where routers cache content items for some time before sending them to the desired destination(s). For ICN caching, many strategies have been proposed, for example, Leave Copy Everywhere (LCE), Leave Copy Down (LCD), Centrality-based caching, Most Popular Caching (MPC), and many more. The authors of MPC claim that it outperforms all existing strategies, however, it utilizes maximum memory during content caching. In this paper, we propose a mechanism for content caching, named Content Eviction Mechanism (CEM), and compare our results with LCE and MPC in OPNET Modeler 18.0. Our simulation results show that CEM predominantly outperforms LCE and MPC.

Keywords: information-centric networking, caching, memory utilization.

INTRODUCTION

Content-Centric Networking (CCN) is an architecture that efficiently distributes popular contents to a possible number of clients [1, 2]. A fundamental characteristic of CCN is cache management with replacement policies and caching strategies, which determines what to cache and where, and if the cache is full, the content to be replaced respectively.

Generally, most recent studies have focused on cache replacement strategies [3, 4], for example First-In First-Out (FIFO) and Least Recently Used (LRU) over various topologies as educational ISP [5] and binary trees [6]. Relating to caching policies, some work demonstrates that, to achieve high caching performances, huge cache memory is required [7] while other [8] opposes that storing fewer contents can attain similar results by only placing contents in a subset of routers along the delivery path. Content storing and replacement schemes play a vital role in the CCN's overall performance. The Least Frequently Used (LFU) and Least Recently Used (LRU) replacement policies were mainly proposed for CCN, but these policies suffer from low efficiency, i.e., LRU uses a time stamp of the content while LFU calculates distribution frequency of the content. In both policies, content popularity is ignored, which causes inaccuracy in recognizing the degree of a newly incoming content. As a result, insufficient content replacement may happen, i.e., new unpopular content may replace the old popular one.

In order to tackle the above inadequacy and enhance the accuracy of content replacement decision, a new caching strategy, named Most Popular Content (MPC), was proposed in [9]. This strategy produced better results than LCE [1, 10], which is known as the CCN-default strategy. In LCE, the contents are stored in all network nodes on the path from the publisher to the subscribe, while in MPC strategy, only popular contents are cached. In MPC, every router locally calculates the number of requests for each content name, and caches both content name and popularity count into a Popularity.

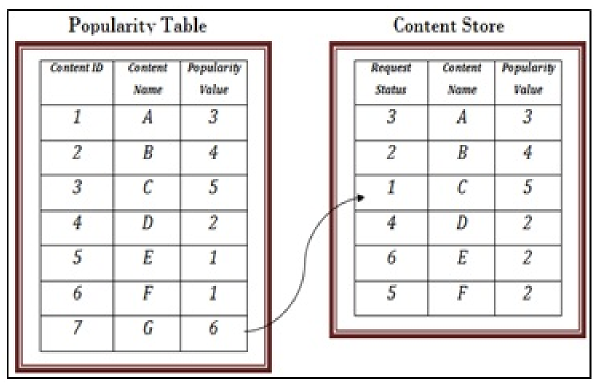

Figure-1. An example of popular content replacement.

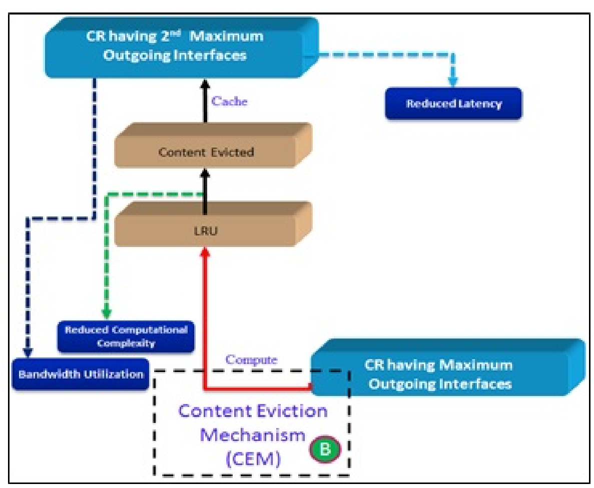

Figure-2. Workflow of the proposed mechanism.

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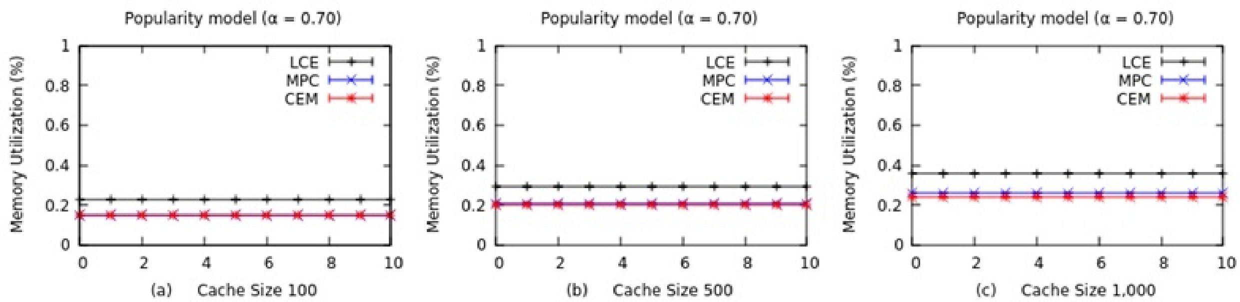

Figure-3. Comparison of memory utilization in different caching strategies with probability model α = 0.70.

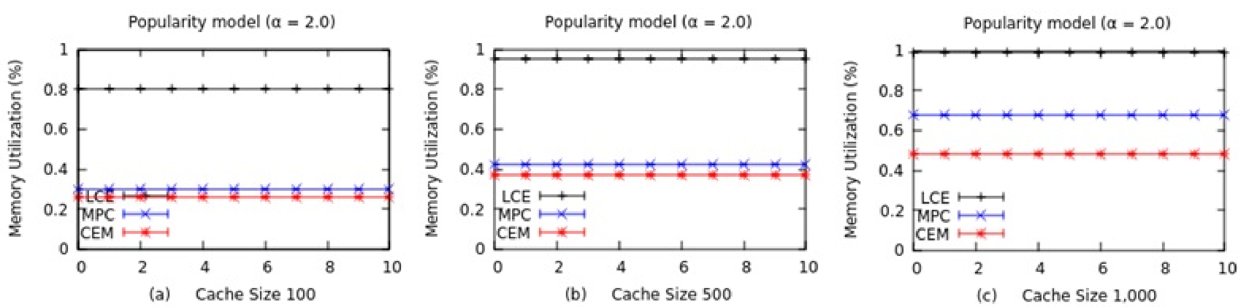

Figure-4. Comparison of caching strategies against memory usage with α = 2.0.

Table the content name is labeled as being popular if it reaches a *Popularity Threshold* locally. And if a router holds the content, it suggests its neighbors for caching it with a new *Suggestion* message. The suggestion may or may not be accepted due to local policies, for instance, resource availability. In order to prevent flooding, (for example, if the popularity of content is decreased with time after the suggestion process) the popularity count is reinitialized according to a *Reset Value*. With storing only popular content, MPC reduces computational overhead during cache operations, and in turn achieves a higher hitting ratio in comparison to LFU and LRU.

Even though MPC achieves some higher cache utilization, but bandwidth and memory consumption during suggestion messages is typically high. To alleviate the above limitations, we propose a novel replacement mechanism, named Content Eviction Mechanism (CEM), which replaces contents if the memory is full and there is no space for the new arriving content. Because CEM is popularity-based caching mechanism and the evicted content should also be popular, therefore, the content is not deleted but cached at another location to reduce latency and efficiently utilize bandwidth as well as memory.

Content eviction mechanism

In CEM, the popularity threshold for storing content is set to 2, i.e., if the popularity value of a content V_p >=2 then it is cached on a router having maximum outgoing interfaces as in [8]. The popularity threshold is set to 2 to increase cache hit ratio. If this threshold is set to a higher value then some popular contents will not contribute in the cache hit rate. On the other hand, if V_p is kept very low, e.g., 1, then cache may become overflowed and hence, some non-popular contents will replace popular ones during eviction process. For eviction process CEM uses LRU policy, and according to the nature of LRU, there is a possibility of evicting the most popular content by a least popular one. As shown in Figure-1, the popularity of content C at time t_1 and time t_2 is 5. Similarly, the popularity of E and F at time t_1 is 1, but at time t_2 their popularity is 2. Here, the popularity of C is higher than E and F but it is the least recently used, therefore, it will be replaced by the new popular content G whose popularity is 6. For this reason, CEM recommends the evicted content to a router which has the second highest outgoing interfaces. The workflow example of CEM is given in Figure-2, where it shows the replacement process after the contents are already cached on the router having maximum outgoing interfaces.

RESULTS AND DISCUSSIONS

Memory utilization plays an important role in the performance of ICN in terms of content retrieval delay. That is, if the memory is full and the new request arrives for a content, but the content is not cached locally, then the request is forwarded to the server and therefore takes more time in accessing. In this paper, we compare the performance of our proposed scheme with LCE and MPC. All the scenarios ware simulated for 10 times. In both Figure-3 and Figure-4, the X-axis shows the number of simulation runs and the Y-axis shows the percentage of utilized memory. Figure-3 shows the average percentage usage of memory for all network nodes. The scenarios have been tested using Abilene topology with Facebook against cache size 100, 500, and 1,000 elements, respectively. In the evaluated scenarios, the α parameter of the Zipf probability distribution varied between 0.70 and 2.0. In low popularity scenario (α = 0.70) the percentage of utilized memory for LCE was recorded 23% for cache size 100, while there was a slight improvement in MPC and CEM, which was almost the same, i.e., 15% (see Figure-3(a)). As the cache size was increased from 100 to 500 and 1,000 elements, LCE utilized 29% memory with cache size 500 and 36% with cache size 1,000, respectively. However, CEM got almost the same results as MPC, i.e., for cache size 500, MPC utilized 21% and CEM 20% memory, and for the cache size 1,000, MPC used 26% while it was recorded 24% for CEM, as shown in Figure-3(b) and 3(c), respectively. Furthermore, with the increase of α parameter from 0.70 to 2.0, CEM outperformed both LCE and MPC in all cache sizes. Refer to Figure-4, with cache size 100, the utilization of memory was recorded as following: LCE = 80%, MPC = 30%, and CEM = 26% (see Figure-4(a). With cache size 500, LCE used 95% memory, MPC was recorded with 42%, and CEM was improved with 37%, as shown in Figure-4(b). With cache size 1,000, as demonstrated in Figure-4(c), the usage of memory was recorded as follows: LCE = 100%, MPC = 68%, and CEM = 48%.

Hence it showed that with high popularity scenarios and higher cache sizes, the memory utilization can be noticeably minimized using CEM and therefore content retrieval delay can be significantly reduced.

CONCLUSIONS

In this paper we presented CEM: a popularity-based content eviction mechanism for ICN. CEM has been designed to overcome the disadvantages of the existing cache replacement strategies which made them unsuitable for memory management and bandwidth utilization. We compared our work with MPC: a popularity-based caching strategy, which outperforms the existing caching schemes, and the CCN default strategy known as LCE. Our results show that CEM is the best candidate for memory utilization compared to LCE and MPC.

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