A Cache Replacement Strategy Based on hierarchical Popularity in NDN

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***Abstract*— NDN(Named Data Networking,NDN)which is one of the next generation network architectures based on named-data, uses in-network caching. Cache has limited capacity, so the cache replacement policy determines which content is evicted when the cache space is full.This paper analyzes some cache replacement strategies in NDN,and puts forword a cache replacement strategy based on hierarchical popularity,then compares the effect of different cache replacement strategies to the cache performance through simulation experiments.Cache performance is evaluated in provision of cache hit ratio.**

Keywords—named data networking; cache replacement strategy; hierarchical popularity;

I. Introduction

With the increase of Internet traffic, TCP(Transmission Control Potocol,TCP) / IP(Internet Protocol,IP) architecture based on end-to-end argument can not meet the increasing demands of users on scalability, security, and dynamism. In 2010, the National Science Foundation set up the Future Internet Architectures (FIA) program and funded four projects in different directions dedicated to the future network architecture.Among them NDN[1-2] concerned about the data identified by its name instead of its location. Driven by the request,the specific communication process is as follows, consumer sends an interest packet to request a data packet. If the intermediate node that receives the interest packet buffers the data locally,then returns the data to the consumer. If the data is not available in the local buffer, then the interest packet according to the routing policy forward until finding the node that owns the data.

In NDN, a data packet is identified by its name and can be reused for another request which is the same as the data packet. Cache is one of the core components of NDN which uses In-Network cache. The design of cache not only reduces the bandwidth occupied by the network,decrease the time spent on resource acqusition , but also reduces the load on the resource publishing server. Therefore,cache is crucial for the improvement of network performance.However, because of the limited capacity of cache , some outdated or less important content must be replaced, for making a room for more popular content in order to meet the interest packet that arrives later.

In NDN, cache strategies and cache replacement strategies are used to manage the cache. Cache strategies,cache replacement strategies and cache sizes have an important effect on cache performance, so different cache replacement strategies have an impact on cache performance when cache policies and cache sizes are the same.

The rest of this paper is organized as follows. Section presents the related work. The detailed cache replacement strategy is illustrated in section and the simulation environment is shown in Section . Finally, Section concludes the paper.

II. RELATED WORK

The cache replacement policy manages caching by deciding whether to keep or replace cached content. Different cache replacement strategies have different cache replacement guidelines. [5]show that caching "less" content can achieve better performances because it reduces the load on the cache. The goal of an efficient cache replacement strategy is to improve cache performance when cache space and cache policy are the same.

In NDN, according to the different cache replacement guidelines, there are cache replacement strategies based on last accessed time interval as LRU (Least Recently Used,LRU), in place of the last unused data object in memory with the most recently arrived data object.LRU algorithm is the simplest and most common cache management approach which is easy to implement.[3]There are cache replacement strategies based on the frequency of the data object being accessed, such as LFU(Least frequently Used,LFU), which replaces data objects based on the frequency of the data object being accessed over the past period. A major disadvantage of LFU is some data objects possess their place in cache for a long time even without using them again[3]. There are cache replacement strategies based on first in, first out, named FIFO(First In First Out,FIFO). The above are three cache replacement strategies with no additional cost.

Allowing for additional costs,there are cache management based on social information. [4] proposes that data packets provided by different users can not be treated equally,that is the data packets provided by influential users should be given priority. Cache replacement strategy combined with social-aware information can improve network cache performance, but also increase the overhead.How to improve cache performance without additional information is crucial to cache replacement strategy.

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III. CACHE REPLACEMENT STRATEGY

This section introduces the cache replacement strategy on the assumption that the future network architecture is NDN. A major problem is choosing unpopular data objects to replace out of cache. So each data packet needs an extra data structure to record its popularity.

A. content popularity

Popular is a kind of general social psychology phenomenon, which is a kind of special collective behavior, which refers to the process that thing in the society are gradually accepted by people until disappeared[7].Users pursue popularity, hoping to be satisfied with the satisfaction of other individuals as society changes

Therefore it is important for cache replacement strategies to leave limited cache space for content with higher popularity. Users request data in the network generally follows the Zipf distribution[8-9], that is, most requests for a small amount of content.

B. cache replacement strategy

The replacement strategy make sense when cache evictions take place.That is, a cache has been full, while new data needs to be stored in it. Therefore, there are two assumptions in this paper.

- the total capacity of the cache is fixed and smaller than the capacity of all the data packets.
- all data packets take up the same amount of cache space.

Then this paper divides content popularity into five levels, Because the popular phenomenon can not be simply divided to popular and unpopular.Then assigns popularity according to the different degrees of the content importance, and dividing them into PL1, PL2, PL3, PL4 and PL5 from low to high. Each data packet belongs to a popularity level, allowing multiple data packets belong to the same level of popularity.

Cache replacement strategy based on hierarchical popularity is that when a buffer is not full, a new data packet arrives in the cache, giving a popularity value and inserting it in the appropriate location on the linked list sorted by popularity. When the cache is full, the lowest popularity packets in the cache are replaced .The operation of replacement is shown in Table Ⅰ.A additional variable smallest popularity is need to record the popularity value of the most unpopular data packets.

TABLE I. THE DESCRIPTION OF STRATEGY

```
Pseudo code:strategy
for (received data packet)
  {
     Get the popularity of data packet;
     If(Cache is not full)
          {  Inser data packet to cache;
             Sort cache;
          }
     Else if(the popularity of data packet>smallest popularity )
          {  replace the lowest popularity packets in the cache;
             Inser data packet to cache;
             Sort cache;
          }
  }
```

IV. SIMULATION EXPERIMENT

In oder to evaluate some cache replacement strategy in NDN,this paper uses ndnSIM[6],a NS-3 based network simulator dedicated to named data networking,and analyzes the cache performances.

A. Simulation Parameter Setting

This paper chooses LRU,LFU,FIFO as a comparison cache replacement strategy and the popularity of data packets is modeled following the Zipf's law[8-10]. Zipf's law indicates that the product of content appearance frequency and its rank is constant.p(x) is the frequency of content ranked x,and constant C is normalization factor for zipf distribution. τ is a parameter that determines the degree of change in content popularity.

(1)

The datail experimental parameters are discribed as Table Ⅱ. This paper sets the same cache space for each node and chooses Always cache strategy that is cache all the data packets in all intermediate nodes.

TABLE II. SIMULATION PARAMETER SETTING

parameter	value
Number of Content	100
Request Rate	10 req/s
Number of content stored per cache	20
Cache strategy	Always
Forwarding strategy	BestRoute
Zipf exponent parameter	α=1
Simulation time	1200 s

This paper conducts simulations on topo-tree-25-node topology which are described as follows. The topology conforms to the structure of computer network in the real world. The leftmost nodes are the data requesters(Client),while the rightmost nodes are the data provider(Server).Data requester send interest packets to request data,data provider provide server. There are a lot of Clients and Servers in the network, connected by the router. The number of routers is less than host nodes because Routers connect a large number of hosts to form a network, and gateway connect networks.

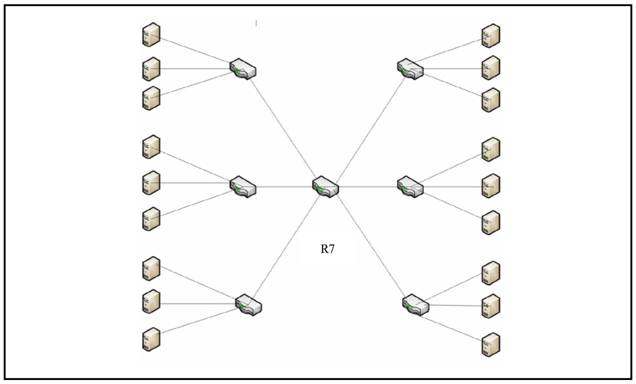

Fig. 1. topo-tree-25-node topology.

B. Performance Metrics

Cache hits make sense for caches in NDN. The experiments in this paper use Cstracer(Content Store,CS) to record the number of cache hit and cache miss for each node. cache hit and cache missare variables whose initial value is 0.If a node receives a interest packet buffers the data locally, the cachehit value of this node increases by 1,otherwise, the cachemiss value of this node increases 1. After the execution of the program, CStracer returns the value of these two variables.Then this paper calculate cache hit ratio of four cache replacement strategy to evaluates the cache performance of the caching replacement strategies .

cache hit ratio =

C. Performance results

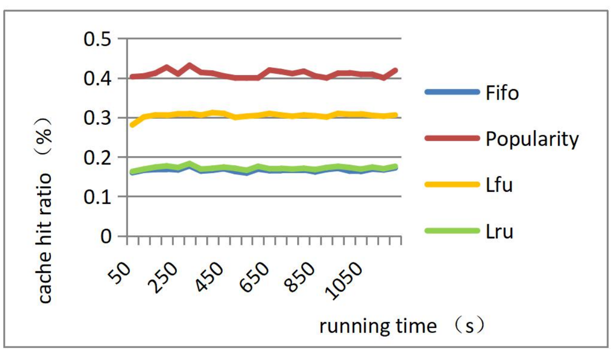

Fig. 2. cache hit ratio.

figure.2 shows the result of a comparison of the cache hit ratio of LRU,LFU,FIFO and popularity cache replacement strategy. The values of cache hit ratio for all cache replacement strategies are less than 50%. This paper can draw conclusions from the analysis of the experimental topology.Router R7 is the bottleneck of the topology.Because this paper sets the same cache space for each node, the load on router R7 is large, and cache replace may occur frequently. This will have an impact on all of the cache replacement strategies.In this case,the cache hit ratio of popularity cache replacement strategy is higher than the other three ones.

V. CONCLUSION

This paper puts forword a cache replacement strategy based on hierarchical popularity in NDN according to the popularity of data packets to be replaced.The simulation results show that the cache replacement strategy based on hierarchical can improve cache hit ratio compared with LRU,LFU and FIFO.

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