Opportunistic On-path Caching for Named Data Networking

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Outline

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Motivation

- NDN's in-network caching plays an important role in reducing transit traffic and improving data delivery performance
- But if in-network caches indiscriminately cache everything passing by, the caching efficiency may be reduced
  - Object popularity distribution is usually Zipf like and many objects are one-timers
  - The caching of one-timers almost gets no cache hits later
  - The caching of one-timers results in frequent cache replacement which may evict relatively popular content
- Off-path caching in NDN could significantly increase the communication overhead among nodes as the number of in-network caches is considerable
- This work proposes a decentralized and opportunistic on-path caching scheme
  - More popular content would serve a higher proportion of the total requests
  - Caching content near to users would reduce average hops traversed by users' requests

Related Work

- Hash routing technique places a content item by hashing it to a cache
  - Consider nothing about the popularity of content at different routers
  - Users' requests will be firstly directed to the cache in charge of the data
- "Cache Less for more" chooses the node with the highest centrality on the delivery path to cache a specific content item
  - Non-discriminate different content items
- "Probabilistic in-network Caching" suggests a probabilistic caching algorithm to provide fairness regarding the available capacity of the delivery path
  - Non-discriminate different content items
- WAVE proposes to have an upstream router recommend the number of chunks to be cached at its downstream router based on the content popularity seen by the upstream router
  - Routers lose some autonomy in caching
  - The resulted caching may not be fit for the pattern of users' request traffic

Opportunistic On-path Caching

Algorithm 1 Opportunistic On-path Caching (o_i)

```
Input: Interest(o_i) (request for content o_i)
  Update the statistic of o_j's popularity
  if o_i is in Cache then
     forward_data (o_i)
  else
     if there is matching PIT entry then
        Update the matching PIT entry
     else
        Increase the traversed hops c field in Interest(o_i) by 1
        Forward Interest(o_i)
     end if
     get content object o_i back
     if have_enough_space (o_i) then
        add_to_cache(o_i)
     else
        Obtain r_i, x and c
        Compute prob = r_i^β * x/c
        Cache content with the probability prob
     end if
     Increase the value of x field of o_i by 1
     forward_data (o_i)
  end if
```

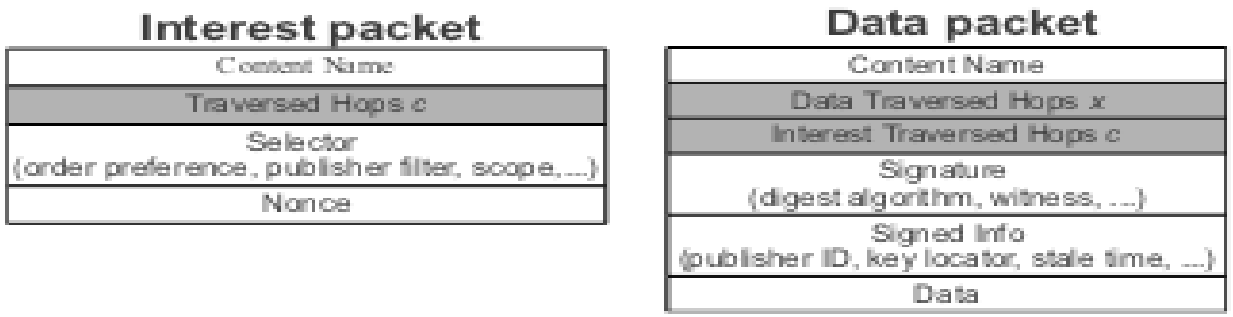
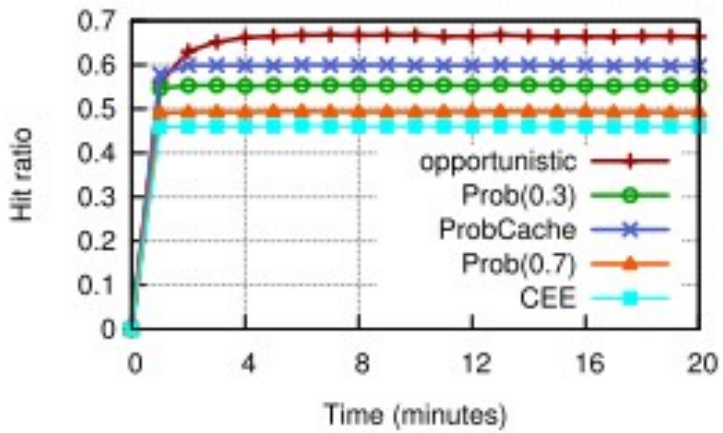


Fig. 1 Modified NDN packet types.

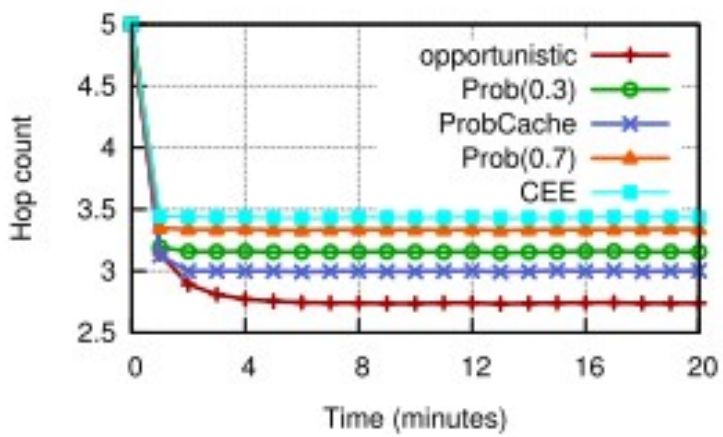
Analysis & Discussion

- Popular content is more likely to be cached
- A specific object is more likely to be cached closer to its requester
- An object that has been cached on the path from the content server to the requester is less likely to be cached by other routers on the path

Evaluations on a binary tree (1/2)

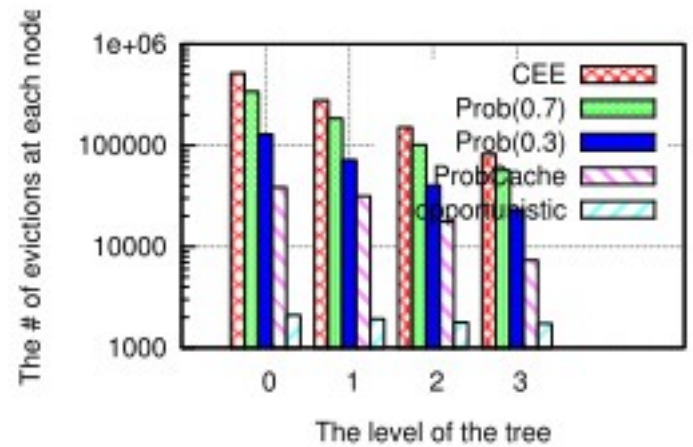


(a) Cache hit ratio.

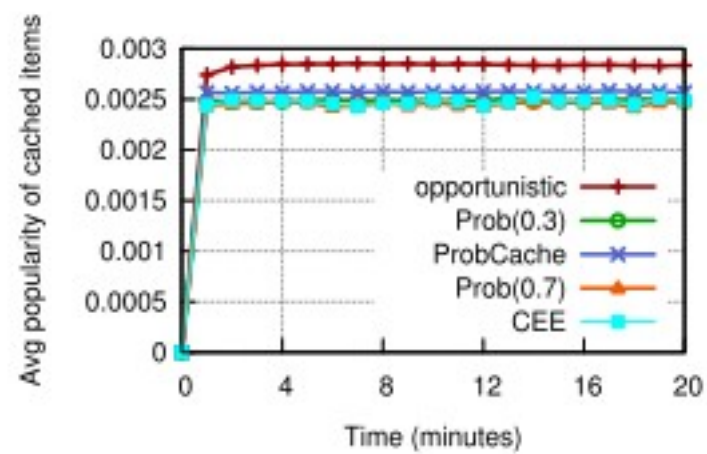


(b) Hop count.

Fig. 2 Cache hit and hop count VS. time



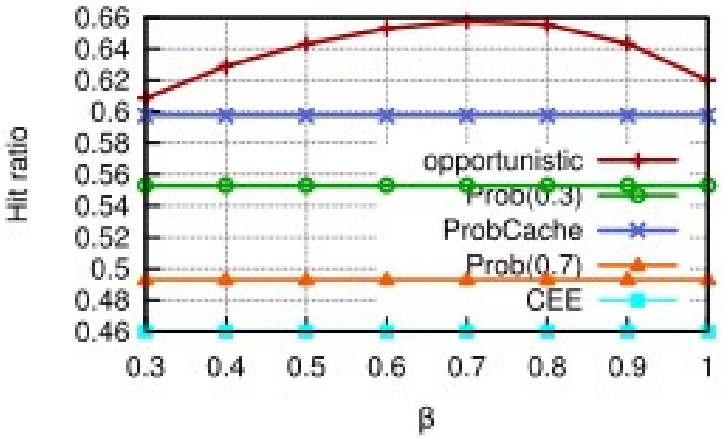
(a) Evictions at each node of tree levels.



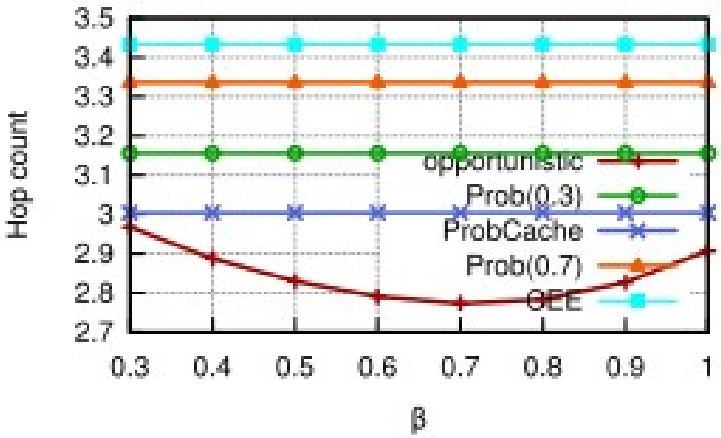
(b) Average popularity of cached content.

Fig. 3 Eviction times and avg populrity VS. time

Evaluations on a binary tree (2/2)

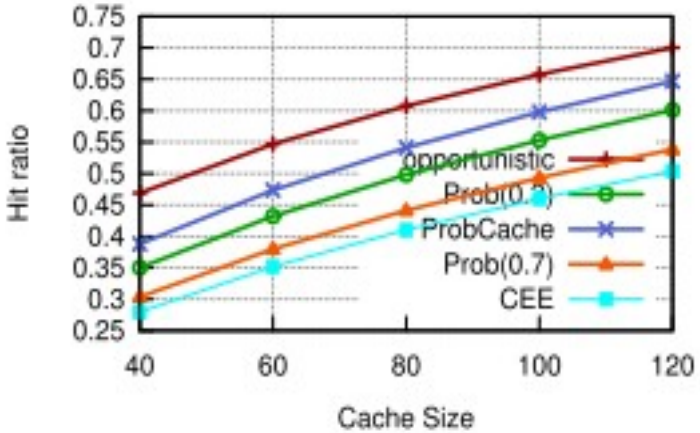


(a) Cache hit ratio.

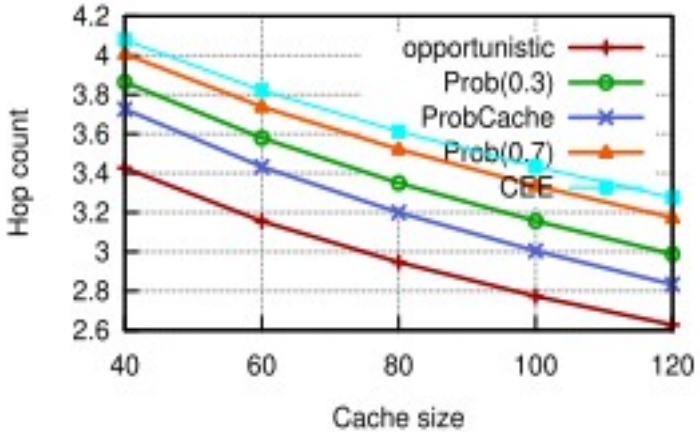


(b) Hop count.

Fig. 4 Cache hit and hop count VS. beta



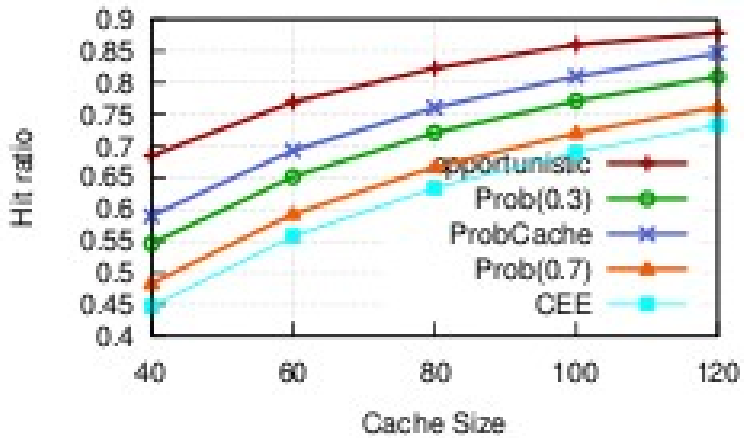
(a) Cache hit ratio.



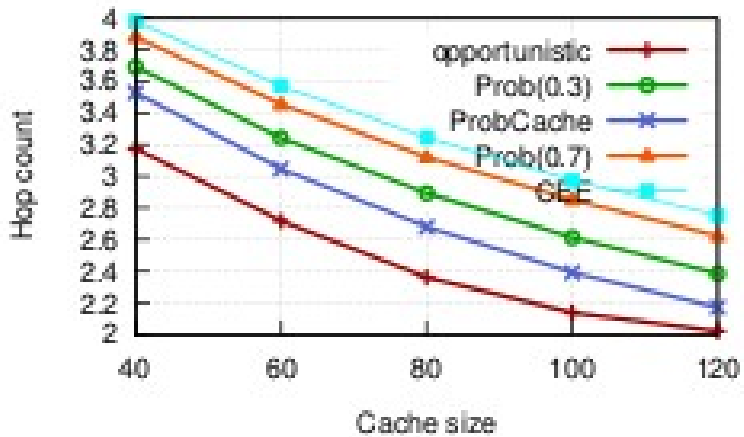
(b) Hop count.

Fig. 5 Cache hit and hop count VS. cache size

Evaluations on SPRINT topology



(a) Cache hit ratio.



(b) Hop count.

Fig. 6 Cache hit and hop count VS. cache size

Conclusion

- This work proposes a decentralized and opportunistic on-path caching scheme for NDN domains to reduce upstream bandwidth demand and improve data delivery performance
- Each en-route router independently decides the probability of caching a specific content item based on the data popularity observed by the router and the distance from the router to the requester such that only popular content is likely to be cached by routers, especially routers near to users
- We verified the effectiveness of our proposed scheme by conducting simulations on both a binary tree and a PoP-level ISP topology with synthetic request traffic and real world web traffic trace