Hybrid Reversion Caching and Search in Information-Centric Networking

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Introduction

- Information-Centric Networking (ICN)
  - Advocate the departure from the traditional host-to-host communication paradigm to an information/content-centric one
  - Caching becomes an intrinsic property of routers
  - A good cache management scheme needs to take fully account of its adaptation and coupling effect of caching and routing

Contribution

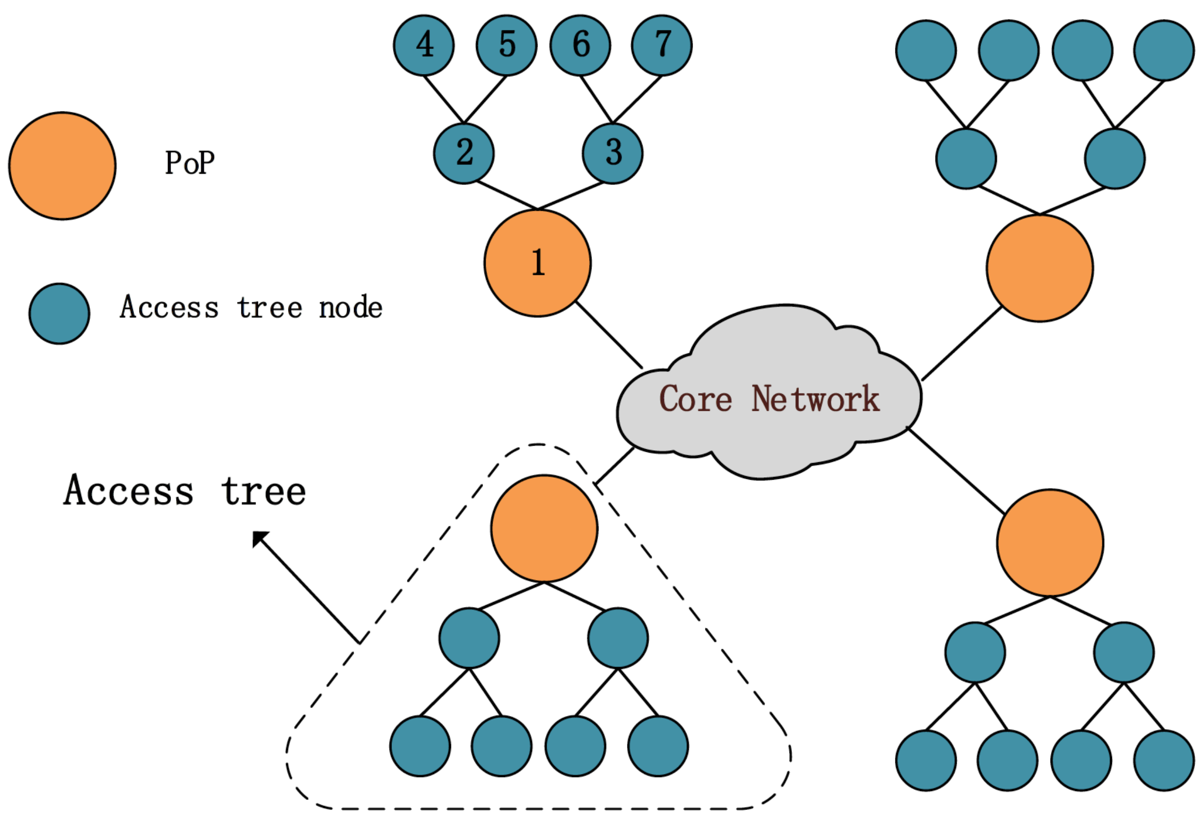
- They analyze the limitations of existing caching management schemes in ICN
- The proposed in-network caching scheme is a hybrid of on-path and off-path cache coordination, and their policy yields a better balance between user experience and network resource utilization
- Their schemes tightly couple content placement and request routing, and are suitable to scale in large ISPs

Hybrid Reversion Caching and Search (HRCS)

- A hybrid of on-path and off-path cache coordination
- The cache network is partitioned into a core area and several edge areas
  - The nodes with highest betweenness centrality can play the role of PoP node in edge area
  - Hash-based cache coordination scheme is used in the core network. Only one copy is stored in the core area can maximize the cache diversity
  - Each of the edge areas apply reversion caching coordination scheme. Reduce content placement nodes and make the placement related with content popularity

Hybrid Reversion Caching and Search (HRCS)

- Use information of content placement and content forward to dynamically guide request routing
  - Popular content can be pulled closer to the user cache nodes, meanwhile same content could be avoided being cached redundantly in one access network



Content placement

- Push popular contents closer to users by giving priority to caching on the access nodes, in the meantime, push less popular content back to PoP nodes

Algorithm I Content Placement:

```
for each node receives a data packet
    if it is PoP node
        if the content is evicted object
            then do LRU and cache(content)
        else create binary tuple tag
            forward request to next hop
    else
        if local space is enough for the content
            then cache(content)
        else do LRU and cache(content)
        create index and push evicted content
```

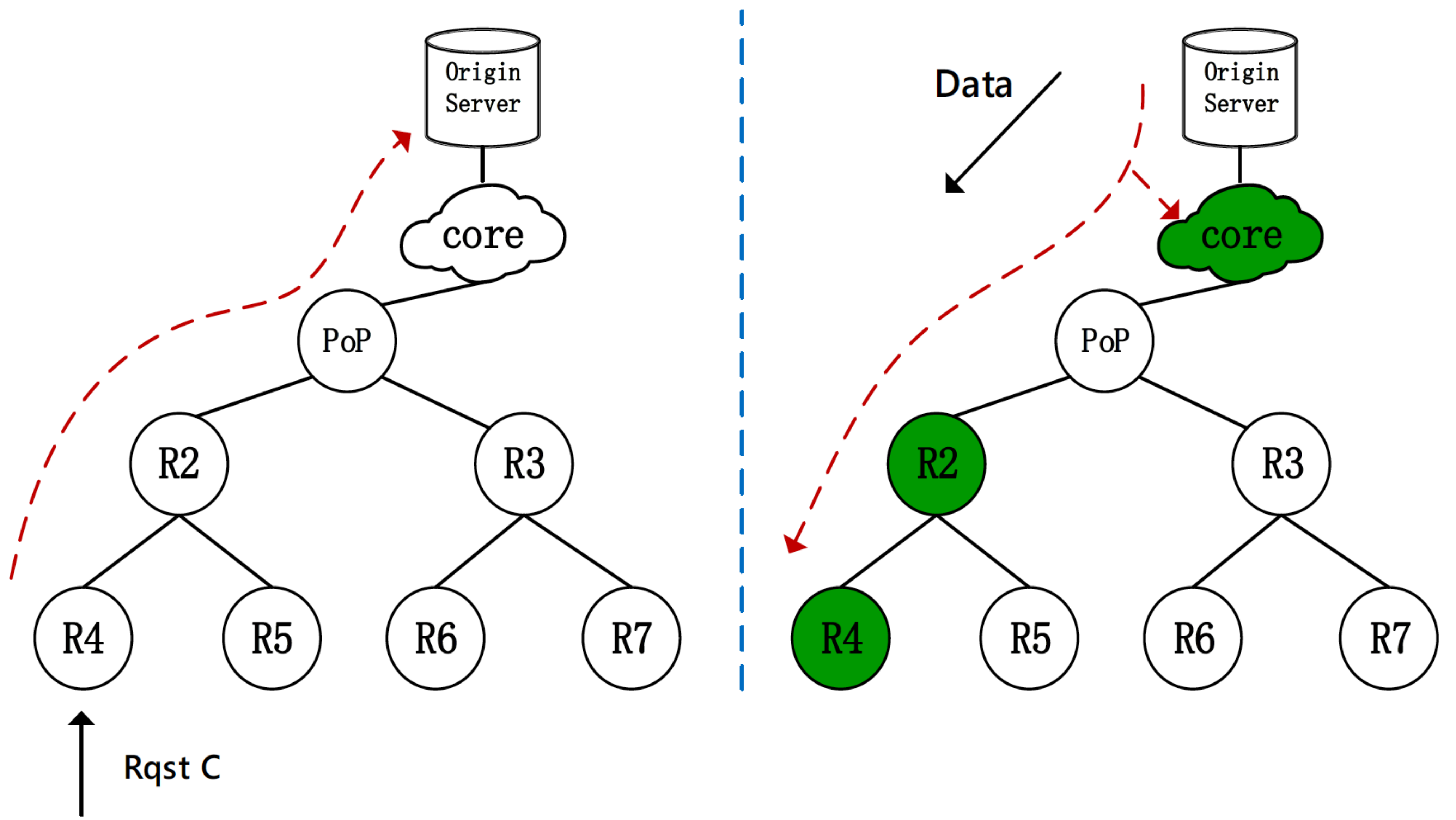
Request routing

- Making use of binary tuple tag group created by PoP nodes to find corresponding access node
- Binary tuple tag for the content (CID,NextHop). Uniquely identification of the content, and the router ID of next hop

Algorithm II Request Routing:

for each *node receives a request packet*
  Iterates over local storage space
  if *there is cache in local*
      then return(content)
  else if *the node is PoP node*
          then look up binary tuple tag
          if *CID matches and NextHop isn't previous hop*
                  then forward to *NextHop*
          else
                  forward to origin server
        else
            forward the request to PoP node

Request routing and cache placement



Performance evaluation

- The average download delay Delay(r)

$$Delay(r) = \sum_{r=1}^{R} \sum_{q=1}^{Q} delay_{u_q}(f_r)$$

where $delayuq$ (fr) is download delay of client uq for content fr

- The average cache hit rate $Hit\_ratio(r)$

$$Hit\_ratio(r) = \sum_{n=1}^{N} \frac{CacheHits(v_n)}{CacheHits(v_n)+CacheMisses(v_n)}$$

where N is the total number of system nodes

- The average hop count $Hop\_count(r)$

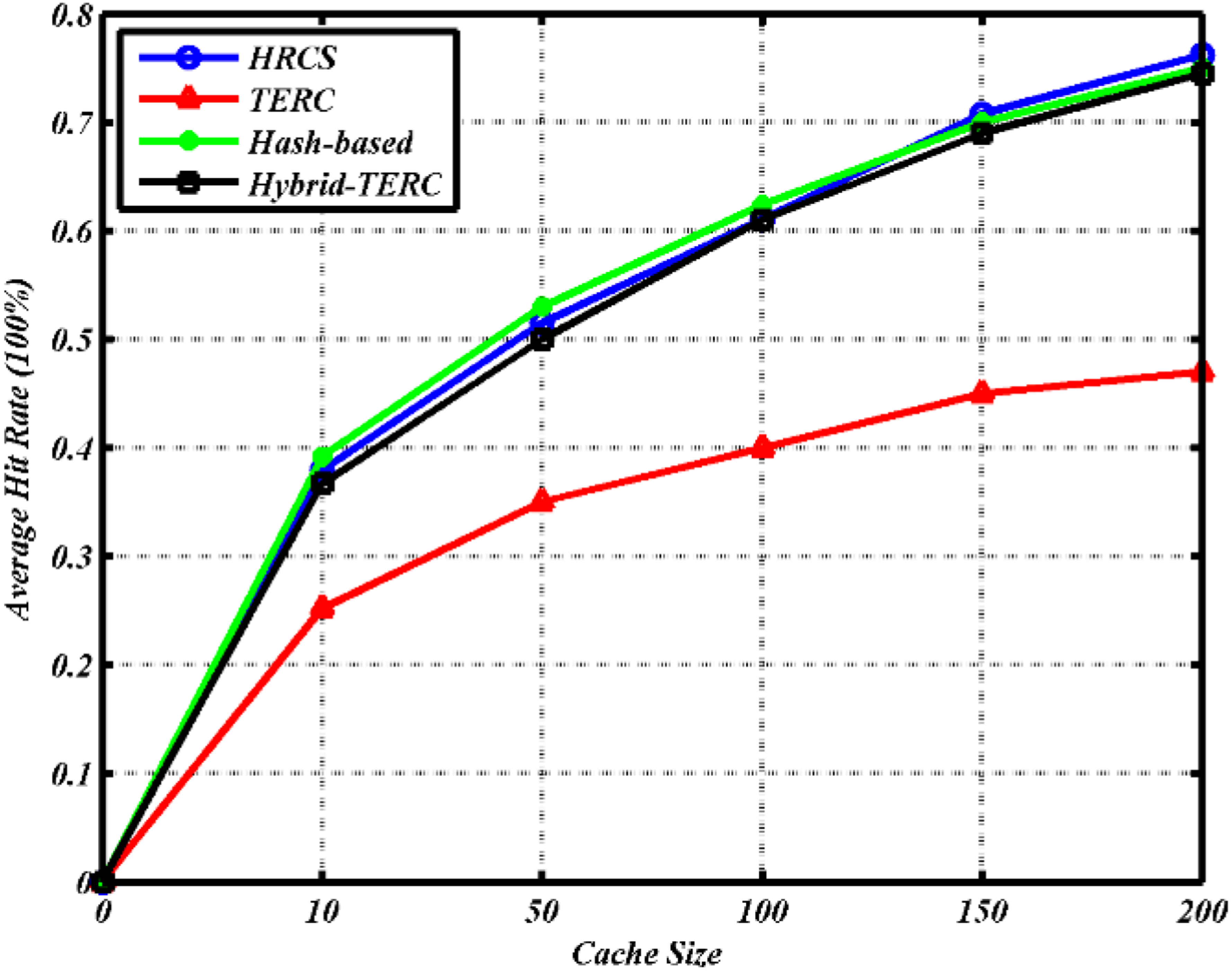
$$Hop\_count(r) = \sum_{r=1}^{R} \sum_{q=1}^{Q} hop\_count_{u_q}(f_r)$$

where $hop\_countuq$ (fr) is hop counts of client uq for contentfr

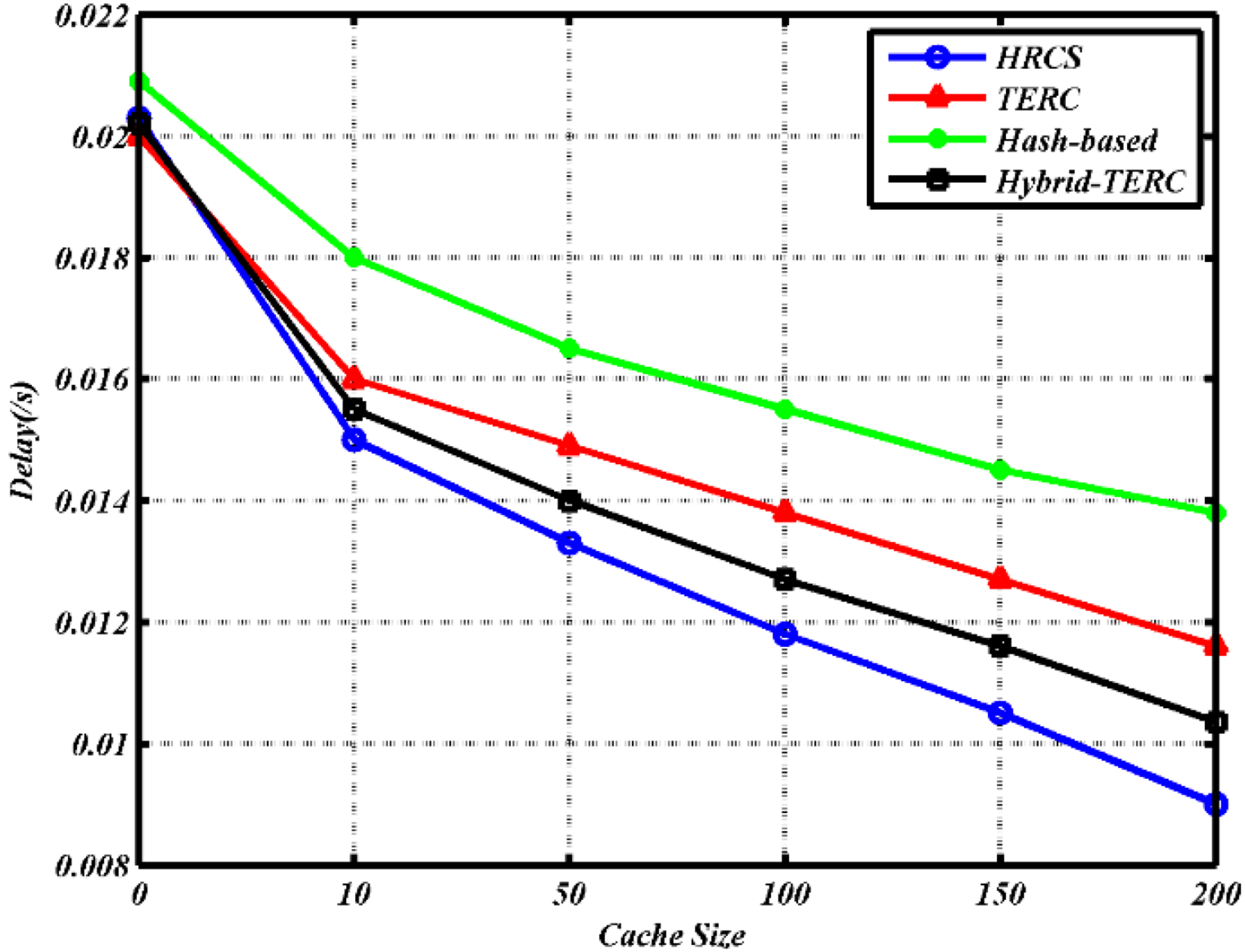
Cache management policies

- HRCS
  - Their hybrid reversion caching management scheme, which can fully exploit in-network caching by content-space partitioning and coupling effect
- TERC
  - Pure TERC in the whole domain and the shortest path algorithm is used for request routing in access area
- Hash-based
  - Pure hash-based cache coordination in the whole domain
- Hybrid-TERC
  - Using hash-based cache coordination in core area and TERC in edge area

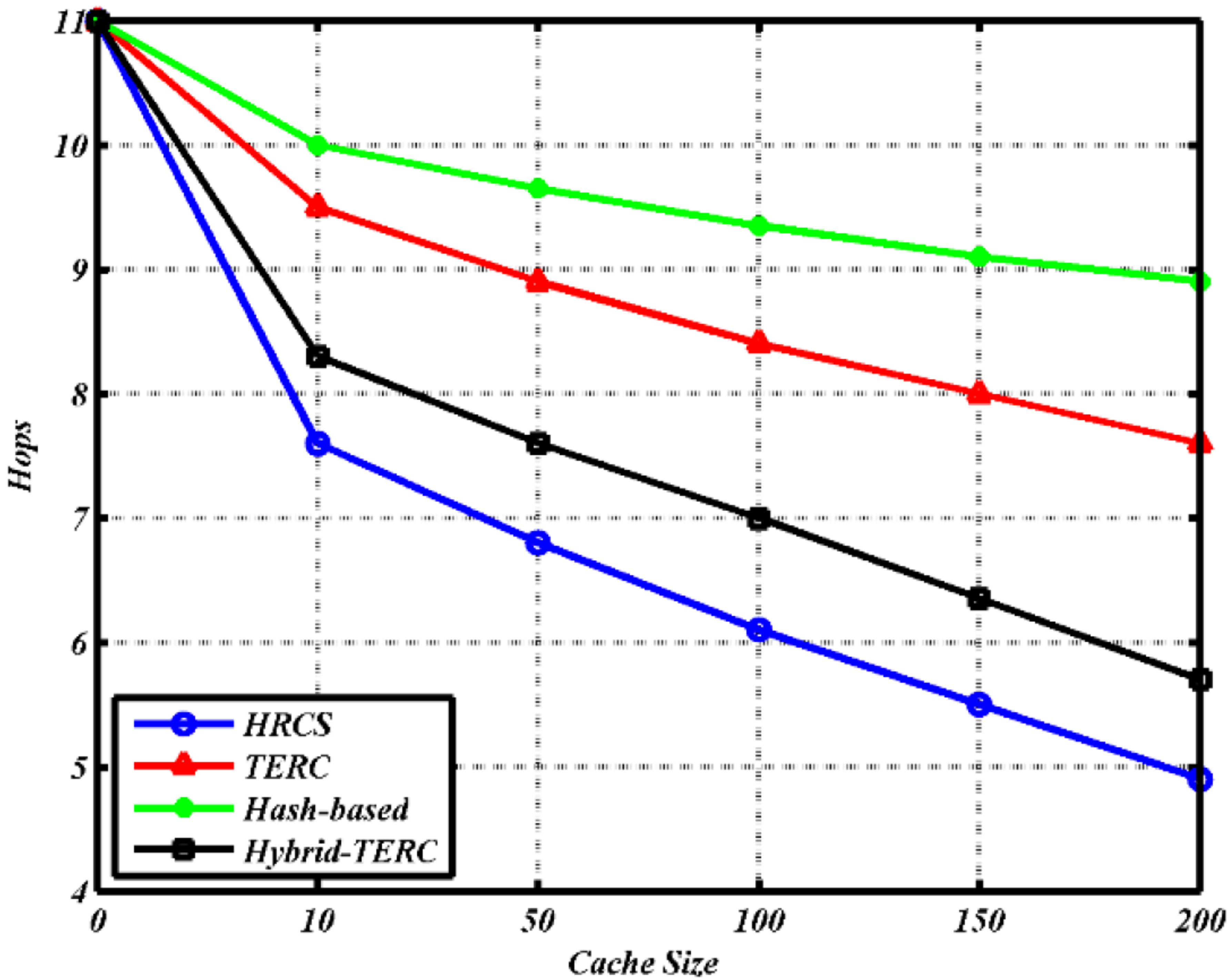
Average hit rate with varying cache size



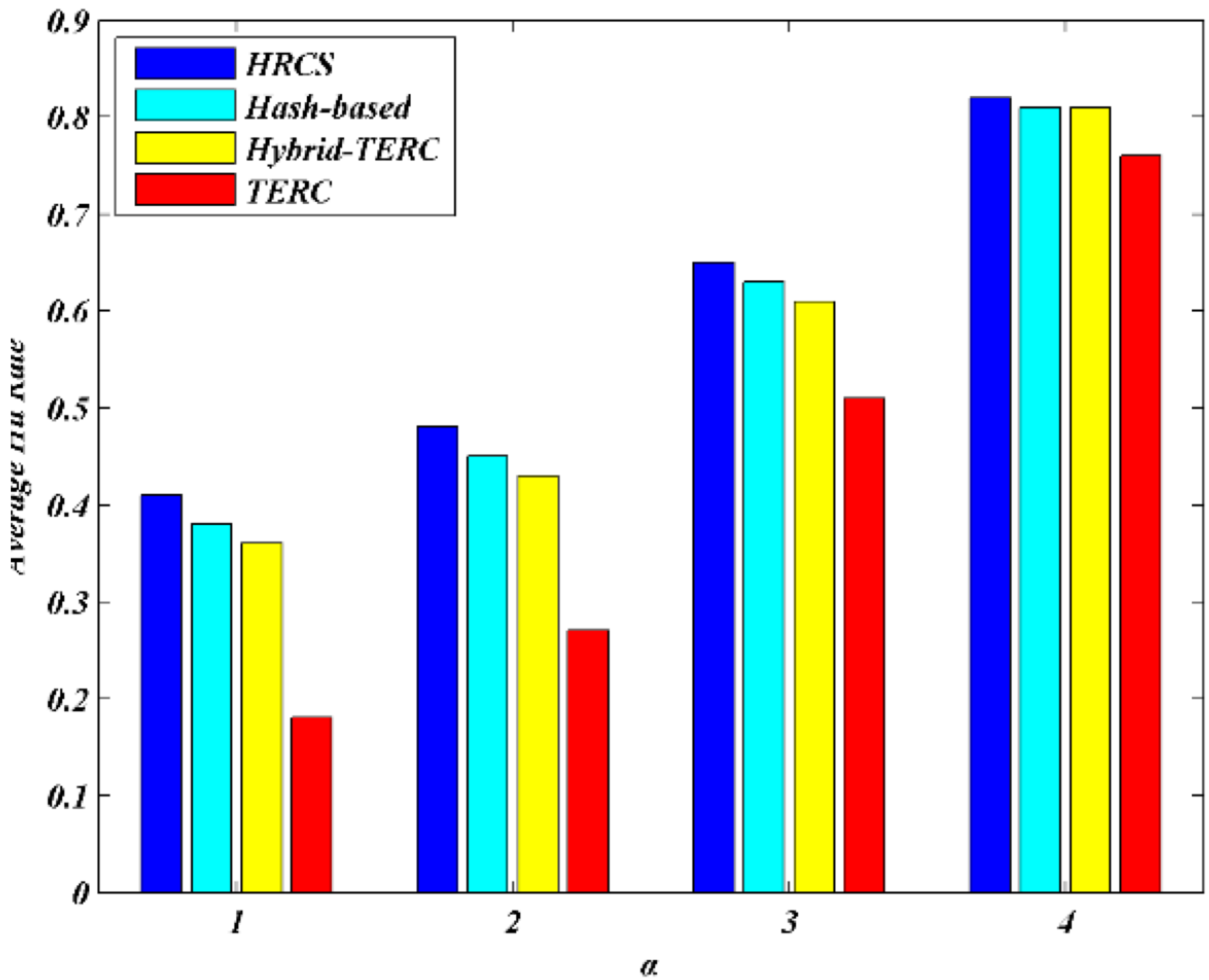
Average download delay with varying cache size



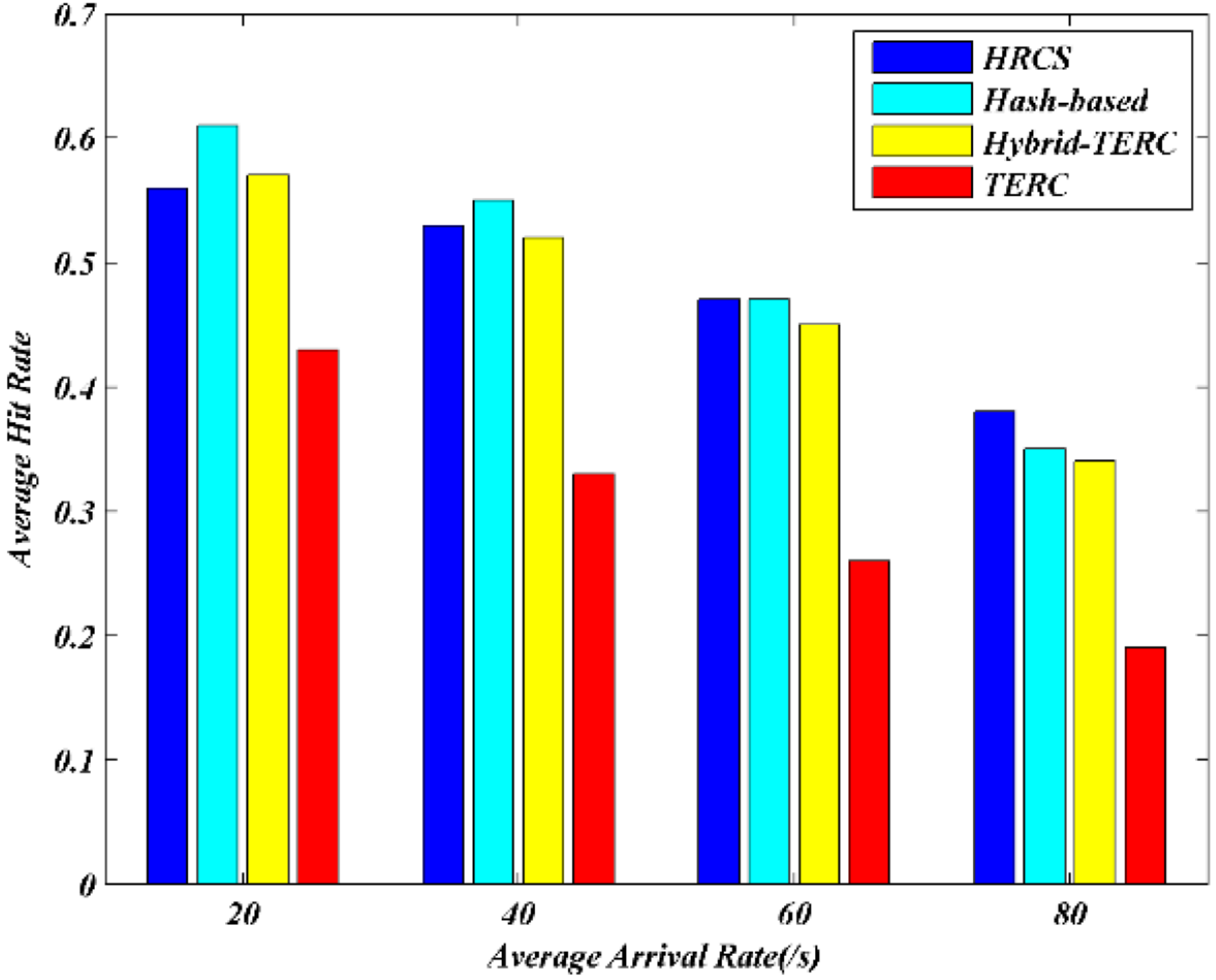
Average download hops with varying cache size



Average hit rate with varying popularity factor α



Average hit rate with varying requests arrival rate



Conclusion

- This paper proposed novel hybrid reversion caching and routing schemes, which fully exploit content-space partitioning and tightly couple content placement and request routing
- Through simulation and comparison, they demonstrate that hybrid schemes yield a good tradeoff between network-centric performance