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LeafPop: Leaf-Popular Caching Strategy for Information-Centric Networking

Hizbullah Khattak[1]*, Noor Ul Amin[2], Ikram Ud Din[3]

[1,2] Department of Information Technology, Hazara University Mansehra, K-P, Pakistan
[3]Department of Information Technology, University of Haripur, K-P, Pakistan
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ABSTRACT

Caches are employed in information-centric networking for content availability and reducing latency of information retrieval. However, caches have limited storage capacity in sizes. The key aspects should be to distribute the contents in caches that reduce latency to the end users and minimizing redundancy in the network. The present study aimed at finding out ways to reduce redundancy and efficient utilization of content caching in Information-Centric Networking. This paper proposes a LeafPop caching strategy for ICN to reduce redundancy and resources consumption. Our analyses prove that this caching strategy is efficient in terms of reducing redundancy and latency in ICN.
KEYWORDS— Information-Centric Networking; Popularity, Cache

INTRODUCTION

Traffic of internet has been growing rapidly. According to a recent technical paper of CISCO [1], annual traffic of internet is expected to increase 1.4 zettabytes in size till the end of 2017 and 80 % traffic is predicted to be consumed in videos only as their usages are increasing more and more. The current host centric model of internet architecture focuses on end to end transfer of information between client and server. However, technology and patterns of usages of internet have changed and now people are more concerned with the distribution and retrieval of contents instead of communicating with the server. This difference between current internet architecture and usage patterns resulted new challenges in terms of scalability, muti-homing, mobility, performances and caching [2]. Different architectures have been proposed for ICN such as CCN, NetInf, SAIL, PURSUIT but Content Centric Networking has attracted researcher's community more due to its features of in-network cache at every node, coupled name resolution and data forwarding and unified naming scheme.

Caching has been added main feature of information-centric networking for minimizing overall network traffic, improving quality of service (QoS), and preventing denial of service (DOS) attacks, network congestion and availability of contents [3]. Default caching policy in information-centric networking is *CacheAll* strategy, where routers cache all the contents that pass through them. But this strategy creates a huge redundancy in the networks though it is fast and need not any more processing for the routers. It will also require a huge storage space and high performance. Anyhow, if we assume to have such large storage capacity still there will be performances issue as it would create large processing delay for look up the contents on matching the large prefix basis. Moreover, this assumption is still not valid for all types of networks i.e. Wireless Adhoc Networks. This limitation and the drawback of processing delay of a large size cache create a need for designing a more sophisticated cache strategy that create a minimum redundancy, better performance in a limited cache storage[4].

In this paper we propose a LeafPop caching strategy for ICN. Our solution in this paper consists of two part; first, cache the one-timer object on one level down and on leaf node; second, cache content on all the connected nodes and on leaf node when number of requests exceed at specific threshold. The analysis proves that our propose scheme are better in terms of reducing redundancy and resource consumption.

LITERATURE REVIEW

Researchers have proposed different caching strategies for accessing the contents in ICN. Some of them are listed as here: Jacobson et al [2] have proposed Leave Copy Everywhere (LCE) policy for caching content. This policy proposes to leave the copy of content at every node of the traversing path. LCE is the benchmark strategy for all the caching strategies in ICN. But it causes a huge redundancy and resource consumption in networks.

***Corresponding Author:** Hizbullah Khattak, Department of Information Technology, Hazara University Mansehra, K-P, Pakistan
Email: hizbullahkhattak@yahoo.com

D. Rossi and G. Rossini [5] propose a Leave Copy Down (LCD) caching strategy for ICN. LCD was first proposed for web caching problem as a replacement to LCE [6]. According to this policy every time when a cache hit occurs, the content is copied in the direct next downstream node. Though this policy is very simple and it avoids large number of copies of same objects but this strategy need several requests to pull down the content to the edge node of networks.

To overcome the problem of cache pollution problem popularity based caching strategies have been proposed that are based on content popularity [7], [8], [9]. The aim behind this idea is that popular contents will satisfy higher number of requests and only popular content will be cached.

Bernardini et al [10] proposed most popular content (MPC) strategy to cache popular content. It proposes to distribute the popular content towards the neighbor node rather than delivery paths only. For achieving this object MPC distributes suggestion messages. However, no details about the exact format of this message have been given. In addition, this policy requires more number of requests to bring content near to the end users.

Our paper distribution is as such, third section discusses proposed strategy for caching, fourth section discusses analysis of the given strategy and the last section gives a summary.

PROPOSED MODEL

We propose LeafPop caching strategy for ICN caching architecture. We assume to have nodes N1, N2,…, N10. Subscriber connected at node N1 sends an interest packet for content. When any node having a content for this interest receives a request packet and a hit occurs, for example hit occurs at node N7, it cache a copies of this content one level down i.e., at node N6 and at the leaf node N1 that is nearer to the subscriber as shown in Figure 1 below. This definitely minimizes redundancy of content in the network if we do not put copies of contents at every node. Single or lesser requests mean content is not popular enough and there is no need to cache content at every node.

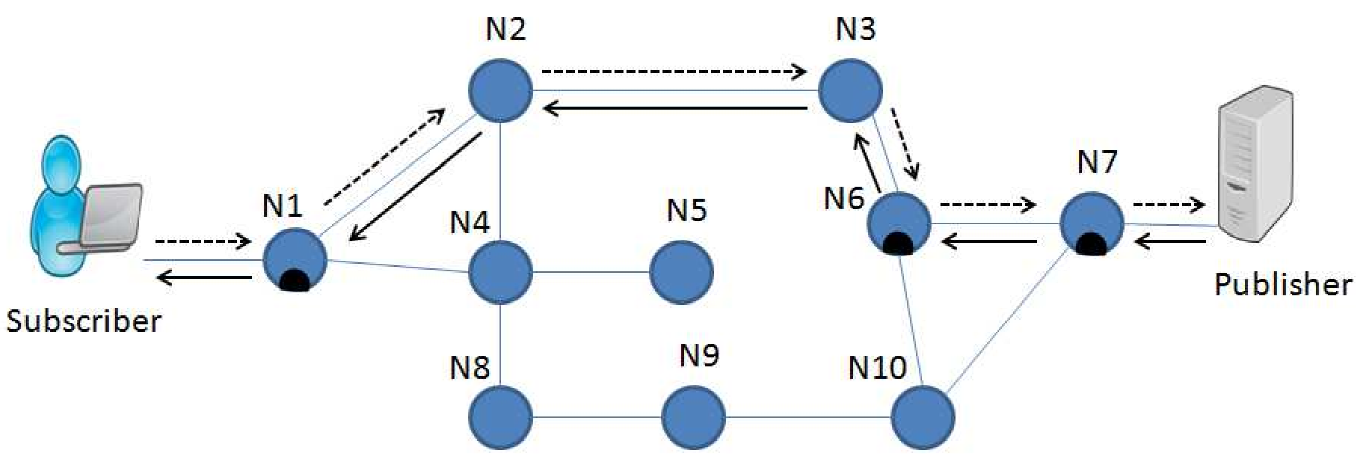

Fig. 1 LeafPop Caching Strategy for Single Interest

Preferable caching strategy should reduce the server or node overhead and next part of our strategy proposes a solution for minimizing server or node overhead. Second part of our scheme proposes a strategy for multiple requests for content that are getting popular. When multiple interests arrive for a specific content and number of interests' increases from a specific threshold i.e., 10 on a node then node cache copies of this content on all the connected nodes and on leaf node. For example, if on node N7 the numbers of requests received for content2 are 12 that are greater than the threshold value, in this case N7 will cache content2 on nodes N6, N10 and N1 and N8. In Figure 2, node N7 has cached copies of this popular content at nodes N6, N10 and N1, N8. Furthermore, these nodes that have received this copy will use same caching strategy for the upcoming interests for contents. In our caching mechanism, we use least recently used (LRU) replacement policy for content eviction when cache of nodes get fulfilled.

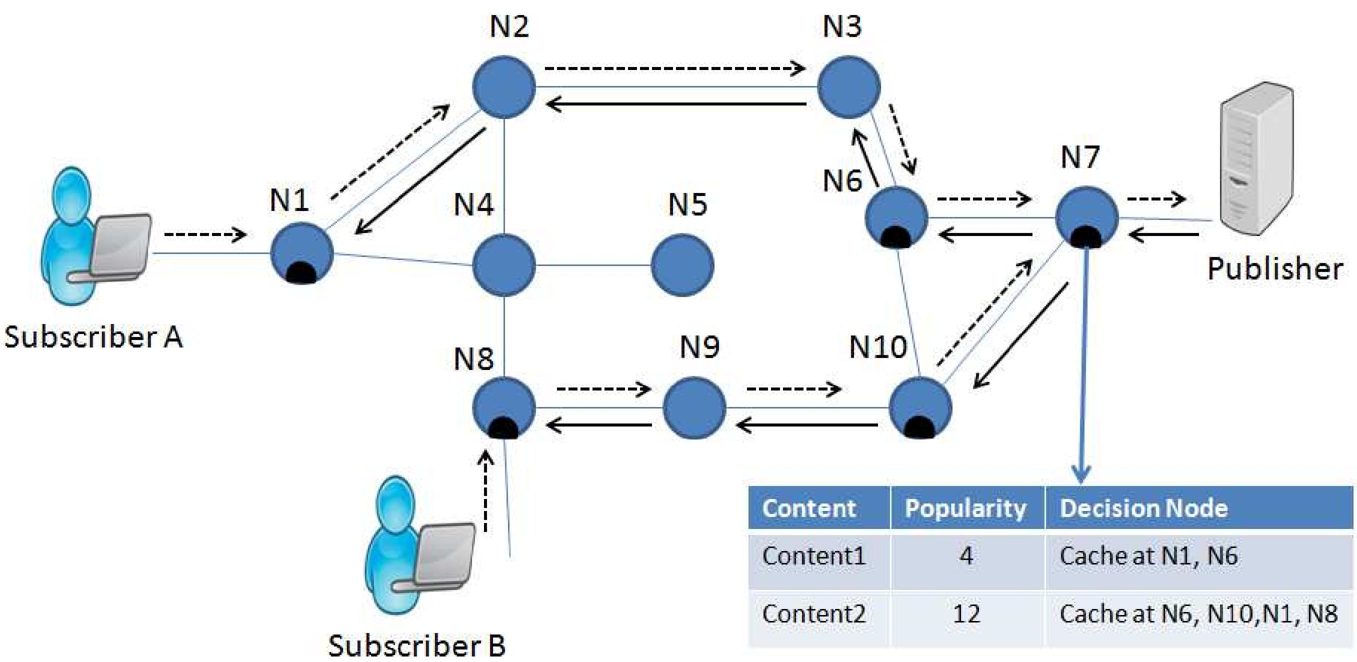

Fig. 2 LeafPop Caching Policy for Multiple Interests

The conceptual model of the proposed scheme is illustrated in Figure 3. Subscriber sends an interest packet for content to the publisher. After receiving interest for content, node checks its cache for availability of content. If the node contains this content, it checks further the condition that if popularity of this content is greater than threshold value then it cache this content on all the connected nodes and on the leaf node; otherwise, cache it on one level down node and on leaf node. If a node receiving interest does not contain content, it forwards this interest to next node towards publisher.

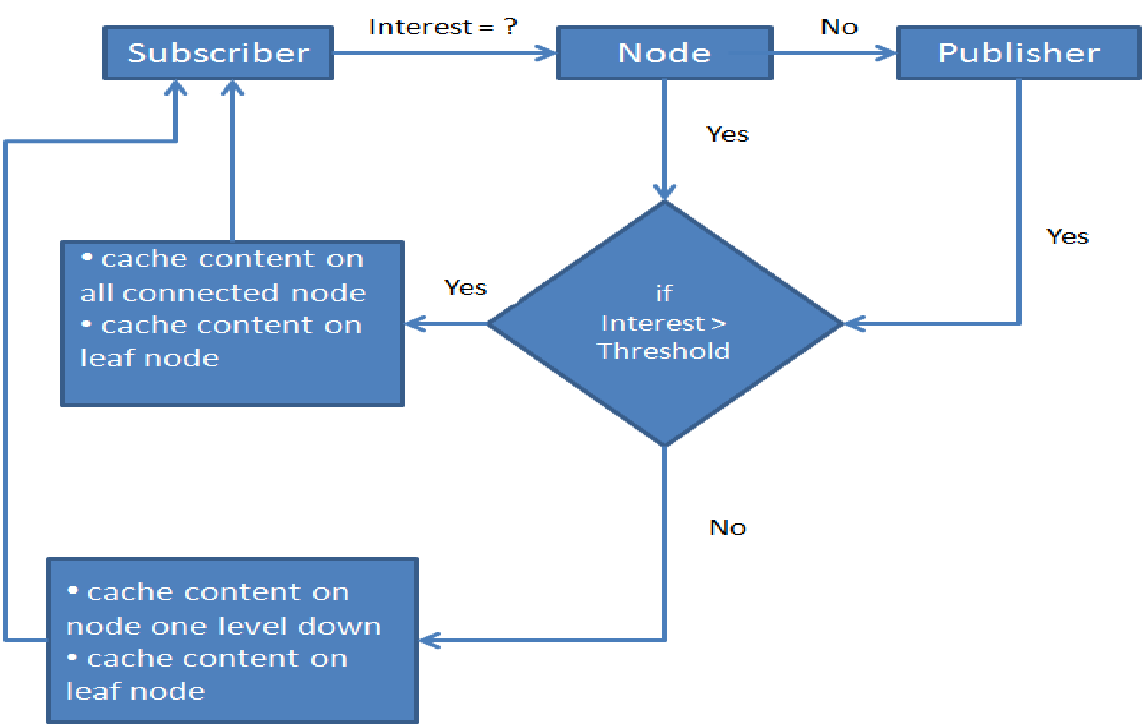

Fig. 3 Workflow Diagram of Leaf-Pop Caching Policy

ANALYSIS

The proposed scheme minimizes redundancy by not caching contents on every node. Though it seems that redundancy get increases with passage of time but we argue here that after some time, copies of contents from caches of nodes start evicting on basis of LRU replacement policy. The proposed caching mechanism depends upon popularity so; as the content will get popular it will spread in the network. It reduces traffic on the main server. The overhead on server or any node will not get increase from a specific limit as node receiving more requests for any specific contents cache copies of content on all its connected nodes and this way, distribute its overhead in the network. Several advantages we have achieved in proposed policy by caching copies on all connected nodes; One, we have decreased load on a server or a node and second, we have distribute the content on different nodes as different interests are received for a particular content from different nodes and not from a single node. The scheme serves many purposes; single request is served on the leaf node that reduces redundancy and bandwidth consumption. The load on a server or any node does not increase from a specific limit as contents spread in network when it gets popular and is removed or evicted when it popularity decreases.

CONCLUSION

From the analysis we can conclude that the proposed caching strategy minimizes redundancy, resource consumption and load on a server or nodes. The load does not increase from a specific limit on any node. The contents remain in the networks till it is popular and evicted when its popularity decreases. In future, the proposed modeled will be mathematically modeled and simulated in a simulation environment.

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