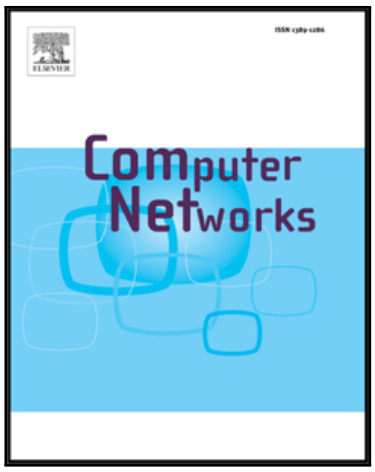

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Content search and routing under custodian unavailability in information-centric networks

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Abstract

Dealing with the sudden unavailability of content custodians (origin servers) in a network has received limited attention in information-centric networks (ICN). We consider a scenario where the content custodians in an ICN are temporarily unavailable, possibly due to reasons such as device malfunctioning, power outage or Denial of Service (DoS) attacks. In contrast to the traditional host-centric Internet, users can still be served in an ICN as content is cached at in-network nodes. We begin by making the observation that if caches continue to operate using their native cache insertion and eviction policies after the content custodians become unavailable, over time the network content diversity decreases. Therefore, we recommend freezing network caches once the custodians become unavailable. We then propose a routing and search algorithm, Content Exploration under Server Unavailability (CESU), that uses breadcrumbs to effectively locate content cached at in-network nodes and serve user requests when the custodians are unavailable. We perform extensive simulations on real Internet topologies in the Icarus simulator and demonstrate that CESU can efficiently locate content cached in the network. CESU outperforms shortest path routing in terms of content requests served by 56% on average, and achieves up to 98.5% of the total request serving potential.

1. Introduction

The rapid and ever-increasing growth of content in recent years has led to the development of information-centric networking (ICN) that aims to evolve today's host-centric Internet to a content-centric one. By caching content at storage-enabled network nodes, requests for content can also be served from intermediate caches in addition to the content custodian (origin server), thereby improving user performance. In contrast to prior work, in this paper, we consider a scenario where content custodians are currently unavailable. Despite taking preventive measures such situations could arise due to a number of reasons including device malfunctioning, power outage and more importantly Denial of Service (DoS) attacks. For example, the recent DoS attack carried out by a diverse network of bots comprising of commercial IoT devices caused widespread disruption [1].

In today's traditional host-centric Internet, content custodian unavailability can have devastating consequences as user requests cannot be served. Contrasting this with the content-centric architecture in ICN, even if content custodians are unavailable, requests for content could potentially be served from other in-network nodes that might have a cached copy of that content. *In this paper, our goal is to design a content search and routing algorithm for ICN that leverages in-network caching to serve user requests when the content custodians are unavailable.*

The problem is challenging due to the following reasons. Firstly, in an ICN, network nodes adopt some cache insertion (e.g., Leave Copy Everywhere (LCE)) [2] and cache eviction (e.g., Least Recently Used (LRU)) policy. If the network continues to operate in the same manner when the content custodians become unavailable, network content diversity could potentially decrease as evicted content cannot be obtained until the custodians are restored, which in turn could adversely impact the number of requests served.

Secondly, if users continue to route requests using only their underlying routing policy when the content custodians are unavailable, their requests will not be served unless the requested content is available in the caches en route to the custodians. This is problematic because the requested content might be cached elsewhere in the network and thus available at some other nodes. Therefore, the routing policies have to be adapted to search widely within the network to locate the requested content. An important point to note here is that when the custodians are unavailable, the primary performance metric is the fraction of requests served, while user-level metrics such as delay and throughput are of secondary importance.

The main contributions of this paper are summarized below.

- We consider a scenario where the content custodians in a network are currently unavailable. We first demonstrate empirically that if caches continue to operate using their native cache insertion and eviction policies after content custodians becomes unavailable, the percentage of unique content cached in the network decreases quickly. We observe that over time relatively less popular content is evicted from the caches, leaving popular content cached universally. This is undesirable because if piece of content is evicted from all network caches, it is impossible