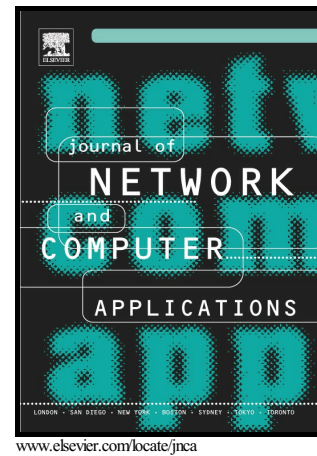


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Abstract

Internet usage has evolved toward the delivery of rich multimedia content to users who are interested in the content itself rather than its address or location. To address this, the Named Data Networking (NDN) architecture has been designed based upon a content-centric communication model rather than the traditional host-centric communication model. NDN has the distinctive features of receiver-driven, connectionless communication, and stateful forwarding transport. These features enable multicast-natured, multi-source, and multipath content deliveries, but they raise new challenges regarding congestion control mechanisms. **We found that there is no existing study that satisfies all the following requirements: low queuing delay, fast loss recovery, efficient multipath usage, and low control overhead.** In this paper, we present an active request management (ARM) scheme to proactively control congestion by taking advantage of the NDN stateful forwarding property. ARM allows routers to randomly drop request packets instead of dropping data packets, and to utilize multipath transport efficiently without requiring high overhead operations such as rate limiting per flow (or per name prefix). Using an ndnSIM simulator based on NS-3, we evaluated ARM with previous related works. ARM showed the shortest flow completion time for retrieving small-size content, while concurrently achieving the highest throughput for large-size content transfers. In terms of multipath communication, ARM presented a higher aggregate and had better stability. We also demonstrated that when using the stateful forwarding property it is easy to implement producer-driven differentiated services.

Keywords: Named Data Networking, Active Request Management

1. INTRODUCTION

The Internet has been widely utilized to facilitate ubiquitous interconnectivity starting from its creation in the 1960s. However, the content-centric communication paradigm has recently attracted significant attention as an alternative to current host-to-host communication, with the main reason for Internet usage having largely shifted toward the delivery of rich multimedia content to users who are interested in the content itself rather than its address or location.

Named Data Networking (NDN) has been proposed for efficient content delivery [1]. In terms of transport, NDN has the distinctive characteristics of receiver-driven and connectionless communication as well as stateful forwarding. Users send request packets using the content (or data) names without any address information indicating the location of the content. Routers forward the request packets to any candidate content sources such as in-network caches or original content producers. After forwarding the request packets, routers maintain the states of the pending request

packets to allow the requested data packets to return to the users (requesters).

NDN's stateful forwarding makes it easy to select alternative paths in a short period of time. By monitoring pending request packets until data packets arrive, each router can measure the data delivery performance such as the round-trip time (RTT) and throughput per content name or per name prefix. This enables the forwarding plane to execute intelligent behaviors such as selecting an alternative path by adjusting to short-term network condition changes (e.g., link failures or congestion). It is also possible to utilize multiple paths concurrently to improve throughput.

Although NDN enables multicast-natured, multi-source and multi-path content deliveries, it raises new challenges regarding congestion control mechanisms. For example, data packets may come from different sources or paths. It causes RTTs and packet arrival orders to be irregular. Therefore, traditional congestion indicators such as RTT-based time-outs or out-of-order packet deliveries cannot be used directly. Moreover, to utilize multi-source/path transport dynamically according to network condition changes, we need to decide which request packet will be forwarded to which path.

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