Modifying NFD for NDN Experimentation: A Review

Egil Olsen
University of Bergen

***Abstract*—NFD is the most popular Named-Data Networking (NFD) router software. In this paper, we present how community researches have experimented and modified NFD to enable experimentation with NDN in different cases and applications.**

I. Introduction

Information-Centric Networking (ICN) and Named Data Networking (NDN) [1] are popular network architectures for future Internet. Many researchers have worked on experimenting and improving the design of NDN Forwarding Daemon (NFD) [2] to do their research. Here, he present application cases that researchers have used to improve NFD and its design.

A. NDN Performance

NDN brings several properties, including security and content sharing. The measurement of such properties needs a deep analysis of forwarding behavior during the runtime. The analysis presented in this paper stands on two pillars: the logs/traces generation and the big data analysis. This paper proposes an instrumentation framework composed by an extension of the dumping tool ndndump. This extension generates big data friendly logs that are essential to capture the behavior of NDN forwarding and tools for hardware performance measurement. [3]. The performance of the NDN forwarder - called Name Forwarder Daemon (NFD) - is one major challenge faced by the NDN community especially due to the complex structures of both the naming prefixes and the forwarding tables. High-performance NFD is a major requirement to enable Big Data processing over NDN due to the scale of the exchanges used in real life applications. This paper proposes an approach to overcome the actual limitation of the packets processing capability of the NFD [4]. In [5], researchers say that very few works have shown the real-world capacity of NDN over different types of network links. In this work, we benchmark the performance of NDN in various real network settings and make side-by-side comparisons with TCP/IP based approaches. We also demonstrate the strong capabilities of flexible forwarding strategies through prioritizing critical traffic over the network. Authors mentioned in [6] that current network equipment cannot be seamlessly extended to offer NDN data-plane functions. To address this challenge, available NDN router solutions are usually software-based, and even the highly-optimised designs tailored to specific hardware platforms present limited performance, hindering adoption. In addition, these tailor-made solutions are hardly reusable in research and production networks. The emergence of programmable switching chips and of languages to program them, like P4, brings hope for the state of affairs to change. In this paper, we present the design of an NDN router written in P4. We improve over the state-of-the-art solution by extending the NDN functionality, and by addressing its scalability limitations. A preliminary evaluation of our open-source solution running on a software target demonstrates its feasibility.

B. Edge Computing

Researchers have experimented with NFD to do edge computing because this is a hot research area. In [7], [8], researchers look into main edge computing challenges, namely service discovery, service invocation, and user mobility management, to highlight NDN's architectural advantages for edge computing systems. In [9], researchers design and prototype Information-Centric edge (ICedge). ICedge runs on top of named-data networking, a realization of the information-centric networking vision, and handles the "low-level" network communication on behalf of applications. ICedge features a fully distributed design that: 1) enables users to get seamlessly on-boarded onto an edge network; 2) delivers application invoked tasks to edge nodes for execution in a timely manner; and 3) offers naming abstractions and network-based mechanisms to enable (partial or full) reuse of the results of already executed tasks among users. In [10], authors implement framework based on architecture and comprises of three main Tiers. The NDN is located at the Tier1 (Things/end devices) and comprises of all the basic functionalities that connect Internet of Things (IoT) devices with Tier 2 (Edge Computing), where we have deployed our Edge node application. The Tier 2 is then further connected with Tier 3 (Cloud Computing), where our Cloud node application is deployed on cloud. I

In [11], researchers collaborated to talk about the current networking challenges both quantitatively (by analyzing AR/VR network interactions of head-mounted displays) and quantitatively (by distributing a targeted community survey among AR/VR researchers). In [12], researchers design a computation graph representation for distributed programs, realize it using Conflict-free Replicated Data Types (CRDTs) as the underlying data structures, and employ RICE as the execution environment. In [13], enabling ICN with edge computing in Radio Access Network (RAN) can improve the efficiency of content distribution and communication performance by reducing the distance between users and services. In line with this assertion, in this paper, we propose an ICN-capable RAN architecture for 5G edge computing environments that offers device to device communication and ICN application layer support at base stations. Algorithms for data reduction in time series (one of the most common types of data in IoT) need to be developed to work posteriori upon big datasets, but they cannot make decisions for each incoming data item. Also the state of the art lacks systems that can apply any of the possible data reduction methods without adding significant delays or major reconfigurations. [14].

C. *In-Network Caching Strategies*

Caching strategies have been realized in NFD and compared. There are many researches in caching in NDN and ICN. In [15], routers in a NDN domain share cached data and coordinate to make caching decisions, entitled cooperative caching, and make it a optimization problem. The Lagrangian relaxation and primal-dual decomposition method is applied to fix the optimization problem into object placement subproblems and object locating subproblems. [16] finds difficult to improve cache efficiency for a distributed approach, thus a lot of cooperative caching methods have been proposed to enhance the cache efficiency. Authors researched a distributed cache management, which is based Push-based Traffic-Aware distributed Cache management (P-TAC). P-TAC improves cache hit rate by using the links having a margin in a transmission band for push traffic. In [17], researchers show a caching strategy of Named Data Networking that segments each file and spreads them among NDN caches, and: (1) It reduces redundant copies and cache pollution by unpopular content. (2) It reduces the number of futile checks on caches, thus reducing the delay from memory accesses. (3) It increases hit rates in the core without reducing hit rates at the edge (thus improving overall hit rates) and balances the load among caches. (4) It decouples the caches, so there is a simple analytical performance model for the network of caches. Many more works have been done [18], [19], [20]. In [21], [22], researchers present Realtime Data Retrieval (RDR), a simple protocol that enables applications to discover the latest data, but ignore bad, old data in cache. In [23], solving cache pollution attacks is a prerequisite for the deployment of NDN, which is considered to be the basis for the future Internet and present CoMon++, a framework for lightweight coordination that protects from cache pollution and further attacks in NDN. In [24], normal users take more time to obtain contents due to the attack. There are some countermeasures against cache pollution attack in NDN, but most of them focus on full content names. Using full names needs a large amount of storage cost. In this paper, we propose a cache protection method against cache pollution attack based on hierarchy of content name prefixes in Named Data Networking (CPMH). Most of these strategies use ndnSIM [25], [26] for evaluation and realization to get results.

D. Mobility

People have modified with NFD to do producer mobility. In [27], the mobility support for ICN was generally divided into three categories, the consumer mobility, producer mobility and network mobility. Producer mobility is the support for the mobile content provider, source or producer to relocate without disrupting content consumer and intermediate router for content name and its location. Researchers reviews an analysis of producer mobility support in some popular ICN approaches and summarizes some of its features, which provide support during mobility. In [28], in ICN, name-based addressing and in-network caching allow content to be efficiently distributed/accessed. These properties of ICN have been researched in the arena of wireless domain to implement light-weighted communication protocols. Specifically, researchers present an ICN-based content delivery scheme for Internet-of-Things (IoT), and show how the proposed scheme support seamless hand-off. In [29], KITE a trace-based producer mobility support that further exploits the stateful forwarding plane of NDN. It follows soft-state approach to create hop-by-hop path between reachable rendezvous server and mobile producer through authenticated Interest-Data exchanges. In [30], the Broadcasting Approach is proposed as a solution to the problem of the mobile producer in NDN. Consequently, the result may solve the inherited problems of triangular routing in NDN network mobility and have significant implication to support the integration of 5G, Mobile Ad hoc Networks (MANET), Delay-Tolerant Network, Vehicular Ad hoc Networks (VANET).

E. Share Data

People have extended NFD for sharing data. In [31], [32], it is important to design a network that can maintain a normal service using the remaining network resources, such as base stations and user terminals, even if the central servers are no longer available because of disconnections among servers. [33] present a peer-to-peer application for live streaming of video content encoded at multiple bit rates. The application enables a small set of neighbouring cellular/Wi-Fi devices to increase the quality of video playback by using the Wi-Fi network to share the portion of the live stream downloaded by each peer via the cellular network. In [34], peer-to-peer file sharing applications envision a world, where peers will communicate in terms of the data that they are looking for. In this world, peers will be able to retrieve the desired data from any other peer that can provide it, without the need of specifying the location that this data can be found. Some peer-to-peer applications, such as BitTorrent, also provide data-centric security primitives by verifying the integrity of the downloaded data through cryptographic hashes. However, the current point-to-point TCP/IP network architecture poses a number of challenges to the design and implementation of peer-to-peer systems both in infrastructure-based and mobile ad-hoc networks.

II. Conclusions

In this paper, we explained how people have modified and enhanced the NDN Forwarding Daemon (NFD) to do research. We described different applications, such as in-network caching, mobility, edge, and of course the performance of NDN networks.

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