CLONE: An NDN Architecture for Content Distribution at Remote Tourist Sites - a TCP/IP and NDN Comparison

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ABSTRACT

This demo provides a comparison between the content-oriented *Named-Data Networking (NDN)* architecture supported by cache cloudlets, called *CLONE*, and the existing location-oriented TCP/IP architecture. CLONE aims to address the challenges of poor mobile network coverage and/or high data roaming charges for tourists at remote tourist sites. To achieve this, CLONE places cloudlets at the edge of an NDN network, close to end-users. The comparison between CLONE and TCP/IP is based on the *Discover Places* Android application, a virtual tour guide that delivers both audio and visual content to tourists in popular locations in Ireland. This demo aims to explore the *Quality-of-Experience (QoE)* of end-users under both network architectures over the 2G, LTE and Wi-Fi technologies.

CCS CONCEPTS

• **Networks** → Network architectures; Network experimentation;

KEYWORDS

Named-Data Networking, Wireless Content Distribution

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1 INTRODUCTION

According to a recent study by the Irish telecommunications regulator ComReg, almost 30% of Irish people nationally encounter service interruptions with 3G/4G data coverage [1]. In remote tourist locations, such as Glendalough in Co. Wicklow, or Bunratty Castle in Co. Clare, these issues are particularly noticeable. These sites, and similar across Ireland, have 2G mobile network coverage at best. Furthermore, where adequate data network services exist, international tourists are likely to experience high roaming charges for content download. For an economy that benefits by approximately 6.5 billion annually from tourism, an improvement of the *Quality-of-Experience* (QoE) of end-users at these remote locations is of major importance. To overcome these challenges, a modification of the original *Named-Data Networking (NDN)* architecture is being proposed in the form of cache cloudlets, called *CLONE*.

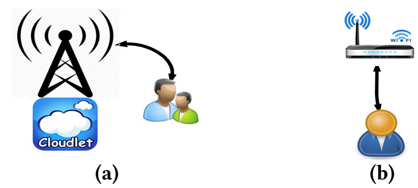

Figure 1: Cache cloudlet placed at: a.) a LTE base station, b.) a Wi-Fi AP, located at the edge of an NDN network.

NDN has been proposed as an alternative to the TCP/IP architecture. Based on the publish-subscribe paradigm, and a hierarchical naming scheme, NDN ensures time, space and synchronization decoupling between publishers and subscribers, an important advantage in challenged wireless communication environments [3]. NDN naturally supports in-network caches compared to the conventional TCP/IP architecture which we incorporate in CLONE through the use of cache cloudlets. Cache cloudlets are small cache repositories located at the edge of the Internet infrastructure, close to end-users, that host named chunks of data [4], see Fig. 1a and 1b. To identify the benefits of CLONE, this demo provides a comparison of the QoE of end-users under both CLONE and TCP/IP over the 2G, LTE and Wi-Fi wireless network technologies.

2 SYSTEM

To support both network architectures, a number of technologies and tools had to be installed and configured at the Iris testbed in Trinity College Dublin using the jFed Fed4FIRE+ toolkit. These include: i) the LTE element, which is supported by the srsLTE eNodeB, and the srsLTE Evolved Packet Core (EPC) with HSS, MME, SPGW, utilising the National Instruments USRP X310 radio hardware and standard KVM virtual machine images, ii) the Wi-Fi element, which is supported by a standard commercial 802.11 Wi-Fi device. The first element is used to showcase content retrieval from an NDN cache cloudlet over a LTE network, as shown in Fig. 1a. The second element is used to showcase content retrieval from an NDN cache cloudlet over a Wi-Fi network, as shown in Fig. 1b.

Besides the aforementioned technologies and tools: i) the *NDN-CXX library*, a C++ library implementing the NDN primitives that supports the development of NDN-based applications, ii) the *NDN Forwarding Daemon (NFD)*, a network forwarder that implements the NDN communication protocol, i.e. the Interest and Data packet formats, iii) the *NDN Repo-Ng*, an implementation of an NDN data

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Figure 2: NDN cloudlet, as configured at the Iris testbed to support both the LTE and the Wi-Fi wireless network technologies.

repository supporting the Repo protocol have also been installed at the Iris testbed to support CLONE. The Repo protocol performs the operations of reading, insertion and deletion of objects in the repo. It also responds to requests received for the objects it possesses.

The subject of this demo is the Tara Hill National Park Teo *Discover Places* Android application; a virtual tour guide that delivers both audio and visual content to tourists in popular locations in Ireland. Discover Places typically operates with TCP/IP. Hence, for the purpose of this demo an extension of the Discover Places application has been developed using the NDN-CXX library and the NFD Android toolkit to support content retrieval and media playing with NDN. The consumer has been instructed to request NDN chunks sequentially, supported by a custom built NDNMediaDataSource player and the NDN Android SegmentFetcher.

To evaluate the two architectures, the metrics of: i) *start-up time*, and ii) *download time* have been used. The startup-time is the time interval from the expression of an Interest for an object, until the retrieval of this object is complete. The download time is the time required for a buffer to fill up and start playing. Both metrics are measured in seconds. It is worth noting, that since the goal of this demo is to compare the QoE of end-users under both network architectures, the evaluation metrics have been chosen to be independent of both the physical and the application layer of an architecture [2]. Moreover, both metrics have been used in past studies to measure the QoE of end-users in dynamic environments [5].

3 DEMO SETUP/EXPERIMENT DESCRIPTION

To set up this demo, both the NFD daemon and the NDN Repo-Ng have been configured to run on a standard Ubuntu 16.04 Dell Laptop. This machine represents the NDN cloudlet server for the CLONE architecture. The NDN repo has been configured with a 659K audio file, segmented and named in 8K-chunks. The NFD daemon has been integrated with the Discover Places application to represent the end-user/tourist running on an Android phone - one for each wireless network technology. The Android phones used are standard Xiaomi Redmi 5 phones.

4 RESULTS AND NEXT STEPS

Fig. 3 presents the average start-up time and standard deviation of an end-user for 100 experiments, as described in section 3, for both CLONE and TCP/IP over the 4G and Wi-Fi wireless network technologies. Fig. 4 presents the average download time and standard deviation of the same end-user, for the same network architectures and wireless technologies. The results concluded for both CLONE and TCP/IP architectures over commercial 2G networks have been omitted, as we observed 100% failure rate for both architectures. According to the results, both the start-up time and the download time are higher for the CLONE architecture, compared to TCP/IP. We attribute this difference to the window size of the flow control

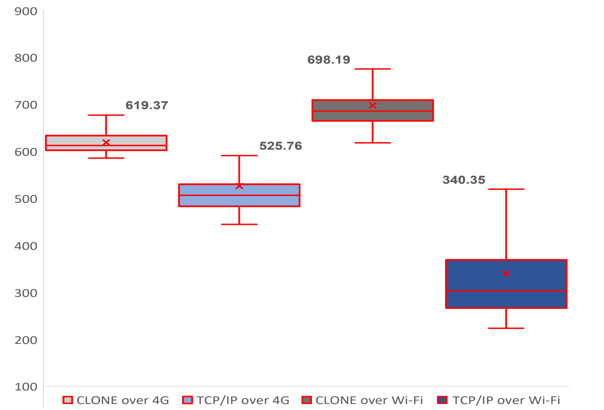

Figure 3: Average start-up time and standard deviation for both CLONE and TCP/IP over the 4G and Wi-Fi wireless network technologies

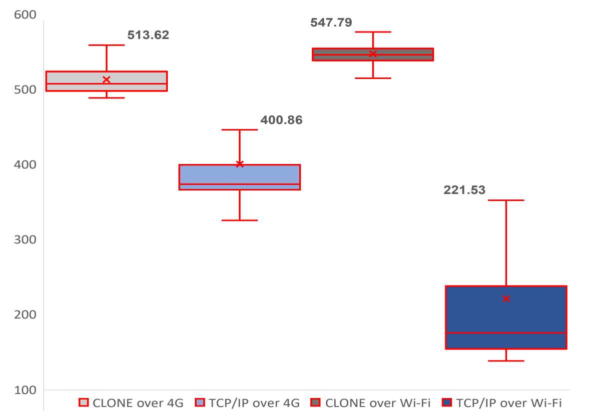

Figure 4: Average download time and standard deviation for both CLONE and TCP/IP over the 4G and Wi-Fi wireless network technologies

protocol used by each architecture. Recalling section 2, the window size for CLONE has been set to be equal to one, while the window size for TCP/IP has been dynamically adjusted according to the available bandwidth, i.e. window scaling. An investigation of the impact of different flow control protocols for both CLONE and TCP/IP is subject to future work.

ACKNOWLEDGEMENTS

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