NAO: A Framework to Enable Efficient Mobile Offloading

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ABSTRACT

Offloading mobile data traffic away from cellular networks has become a main concern for mobile operators to guarantee the quality of service of various applications offered to end-users. Given the explosive growth of smartphone users and mobile data traffic, it is crucial to develop efficient and scalable mechanisms to meet the increasing demand of network capacity. To address the challenge, we propose the Network-Assisted Offloading (NAO), a framework that utilizes network assistance to promote offloading performance and energy saving on mobile hosts. We advocate that an efficient, simple to deploy, and with absolutely minimal or no changes to an end host solution is the key to achieving effective offloading in current and future mobile networks. Compared to solely host-based solutions, our approach explores a new angle to address the offloading challenge through network assistance.

1. INTRODUCTION

With the explosive increase of smartphone users, the mobile Internet is experiencing an unprecedented growth. Following the growth, the flat-rate pricing model combined with the popularity of multimedia services have generated immense pressure on existing cellular networks. For instance, 5000% of traffic surge has been experienced by AT&T during the recent three years [4]. The growing costs of signaling to maintain concurrent session state for millions of users make the situation even more challenging. Such high demand of network capacity results in deteriorating service quality because mobile networks can not cope with the sudden growth [2].

To solve the challenge, mobile data offloading is proposed to redirect the data traffic sourced from and destined to cellular networks to complementary, yet cheaper, networks such as WiFi and opportunistic connections [4]. In this paper, we propose the Network-Assisted Offloading (NAO) to address the offloading challenge from a different angle through network awareness and offloading support. The key feature of NAO is to enable mobile networks to actively trigger and guide the offloading. The framework is extensible and can also be combined with existing methods [1, 2, 3, 4] to improve the overall performance of data transfer and gain better energy savings.

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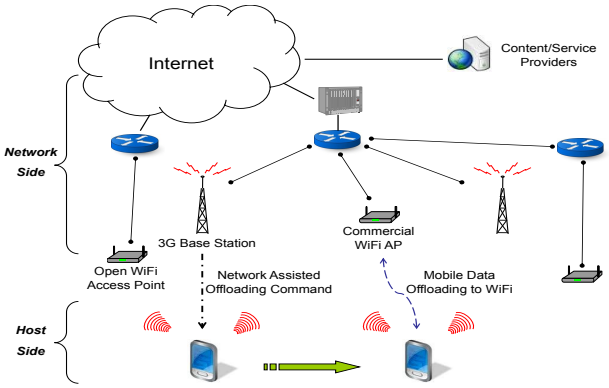

Figure 1: Network-Assisted Offloading

2. NETWORK-ASSISTED OFFLOADING

As mobile operators including AT&T, T-Mobile, and Vodafone start to deploy commercial WiFi access points in the metropolitan area [4], the knowledge from mobile networks such as user location and WiFi Access Point location can be utilized to enhance offloading efficiency. Given that most host-based solutions require interface scanning which leads to high energy costs [2, 4], it is advisable to take the advantage of network assistance and offload such excessive energy consumption away from the resource constrained mobile devices.

The proposed NAO offers a solution to enable such efficient offloading in existing mobile networks. As depicted in Figure 1, the NAO framework consists of three major entities: network side assistance, signaling protocols, and host operations. First, the network side assistance includes offloading preparation and decision supported by the network awareness of user location and WiFi AP location. Second, the signaling protocols function as the bridge between the network and hosts to convey offloading commands and user messages. Third, host operations handle the offloading messages and complete the offloading procedure.

In a typical use case as shown in Figure 1, 3G is chosen as the commanding channel to guide the mobile offloading. Once the offloading decision has been made by the 3G net-

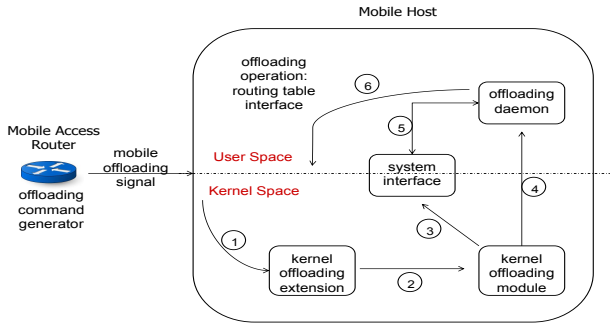

Figure 2: NAO System Architecture

work based on user location and environment context, the proposed offloading command will be sent to the mobile host via a router advertisement packet. Upon receiving the offloading message, mobile host will prioritize the WiFi connection over the 3G according to the indication.

3. SYSTEM ARCHITECTURE

We first implement the offloading command generator, signaling protocol, and host operations following our design guidelines [5]. The system architecture is illustrated in Figure 2. The offloading command generator resides on the mobile access router which is responsible for signaling the NAO option. For signaling protocol, we have modified the networking stack of Linux kernel 3.0 by adding a new offloading option into the router advertisement of neighbor discovery protocol to convey the NAO signal. For host operations, both NAO kernel module and extension are implemented on mobile hosts to trigger the offloading reaction upon receiving the offloading command. In order to minimize the impact on host networking stacks, the major functionality of network side assistance will be supported by the operator networks.

As presented in Figure 2, the deployment of NAO framework depends on the collaboration of network and host side. On the mobile host, it requires interactions between the kernel and user space. By firstly receiving an offloading signal from the mobile access router, the NAO kernel extension will parse the message and notify the kernel module if a NAO option is contained. Based on the option, the offloading module will set up the system interface and record the offloading information. Once recording is completed, offloading module will notify the user space daemon with a pointer to the system interface. The NAO offloading daemon in the user space checks the input and handles the offloading best suited for existing context according to the offloading policy and local settings such as user preference.

By using network assistance, our proposal offers several advantages comparing to the host-based solutions. First, the assistance from the mobile network in terms of user location, WiFi AP location, and user mobility history is valuable to enhance the offloading decision and efficiency. Second, energy efficiency is achieved on mobile hosts due to the shift of offloading preparation to the network side. Given the crucial fact that scanning wireless interfaces is an energy-hungry operation [4], NAO is able to reduce such energy cost and improve the battery life on mobile devices. Third, by following the IETF standard track development, the deployability of our proposal will suffer less incompatibility issues owing to the openness.

Since the NAO framework is also extensible, host-based methods [2] can be combined to optimize the performance of mobility prediction and energy saving. In particular, such collaboration will greatly help in the case of open WiFi access where the history-based prediction independent of the prior knowledge of WiFi AP locations can compensate and extend the offloading to open access areas. Because our proposal is not restricted to WiFi only, the support of opportunistic communication as proposed in [4] can be included to further promote the offloading flexibility.

4. RELATED WORK

The measurements in South Korea show that WiFi offloading without delayed transfer can offload 65% of total traffic load and achieve 55% of energy saving [6]. The MADNet proposal offloads mobile data traffic using both opportunistic communications and WiFi networks [4]. Pre-fetching and predictive methods are proposed to improve download and handoff performance of WiFi access in [3]. By scanning neighboring WiFi access points, Wiffler adopts a history based method to predict future connectivity [2]. Our work also complements the Access Network Discovery and Selection Function (ANDSF) proposed for 3GPP that enables the context exchange between mobile users and network [1].

5. CONCLUSIONS AND FUTURE WORK

We propose the Network-Assisted Offloading (NAO) in this paper as a distributed solution to enable efficient mobile offloading. The main contribution of our work is the NAO framework that is extensible and capable of utilizing network assistance and multiple interfaces on mobile hosts to promote offloading efficiency as well as energy saving. We have completed the first phase NAO implementation. With the support of industry partners in the project, we are planning to test our framework in operator networks and evaluate the offloading performance through real network measurements.

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