Power-boosting Residential Wired Broadband

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ABSTRACT

Residential users often face performance issues while using wired broadband connection with bandwidth hungry applications such as high-quality video streaming. Despite residential users have both wired (ADSL, cable, fibre) and wireless (3G, 4G) access technology at disposal, there are no applications capable of exploiting all the available capacity across different access technologies. In this demo we present an over the top (OTT) system, able to strategically On-Load a fraction of the data traffic from the wired to the cellular network, providing a power-boost for video streaming application over HTTP. We show that our solution is effective in reducing both pre-fetching and download time.

Categories and Subject Descriptors

C.0 [**Computer Systems Organization**]: System architectures

Keywords

3G, 4G, Broadband, Celular, Networks, Onloading, Power-boost, Wired

1. INTRODUCTION

The recent growth of applications that streams multimedia content over the Internet has posed several challenges to network operators worldwide in providing an acceptable QoS to mobile as well as residential users. Applications such Apple TV, BBC iPlayer, Netflix, etc.., often end up being limited also by the wired access network, especially when delivering high-resolution (HDTV, Full HD) videos.

While the coverage of high speed (30 Mbps or more) wired broadband is on going, most EU countries are still on their way to support 100% basic access (512kbps to 4Mbps) coverage [5]. In the US progress of new wired broadband deployments in rural areas is slowing down, when not completely stalled, and there are no concrete plans to subvert this trend [6].

Fiber To The Home (FTTH) is continuing to grow overall but its penetration is still limited (e.g., France at 13.5%) and operators do not want to deploy these networks because per customer revenue is still low with respect to investment [7].

On the other hand, mobile broadband is taking off at an enormous pace driven by users demand, and will soon pass wireline in total number of connections. In the EU, the highest growth rate is in mobile broadband, where take-up almost doubled in 2011 [3].

Previous work [2] has shown that the cellular network is not constantly loaded, there is high spatial diversity in terms of load between cells, and some cells have left over capacity even during peak hours. Furthermore, the peaks for wired and the cellular are not aligned perfectly [9]. At a specific location (e.g., a household) and when there is free capacity, a cellular network may provide a comparable, if not greater, amount of bandwidth than the overlapping wired network. This points to opportunities for technologies able to bundle available capacity across access technologies, thus enabling users to overcome application bottlenecks.

Previous work on this area [4] proposed a systems named 3G OnLoading (3GOL) that OnLoad data from a wired network onto a cellular network to temporarily boost the capacity of bottlenecked wired Internet accesses by using left-over cellular capacity.

In this paper we present a prototype of 3GOL, implemented as an over-the-top (OTT) service, and capable of being deployed across multiple networks and providers. Our implementation does not require any modification to either the residential gateway, or the cellular infrastructure. We demonstrate the feasibility of such solution and show its benefits using a real application. In order to reduce congestion on the cellular access network, a massive deployment of 3GOL would require to implement it as a network integrated service where one operator, providing both wired and wireless broadband access, offers 3GOL as an additional service.

2. SYSTEM DESCRIPTION

Our OTT system (Fig. 1) is composed by a residential Gateway (GW), that features an 802.11n BSS, a device that needs augmentation – referred to as the "client", and one or more 3G/4G enabled smartphones. As worst case, both "client" and smartphones are connected as stations to the WLAN managed by the residential GW. Alternatively, the "client" could be wired and the phones docked to the GW.

We introduce two new software components. The first one runs on the cellular device and performs the following tasks: i) implements a proxy that pipes incoming connections through the 3G network, and ii) advertises the device

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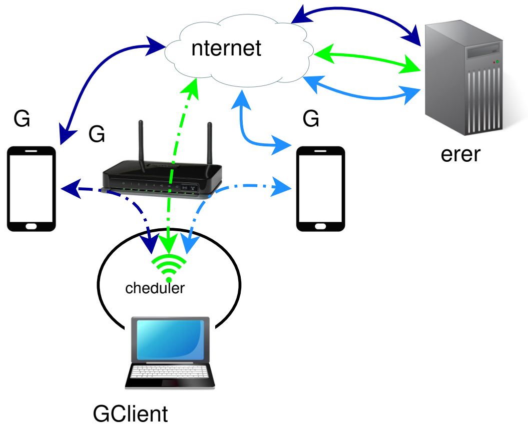

Figure 1: OTT architecture scheme with one client and two 3G smartphones.

availability through a discovery protocol like Bonjour only if the device has data traffic quota available for 3GOL. We assume that the portion of data traffic for 3GOL is selected by the user. We leave the automatic management of the 3GOL allowance that deals with data caps overrun as future work.

The second one runs on the "client" and i) implements a proxy that waits for incoming connections from the applications to be augmented, ii) builds the set of admissible cellular devices (denoted by Φ) by discovering them on the Wi-Fi network, (iii) uses the GW plus the set of admissible cellular devices to transfer required contents using a multipath scheduler, which handle multiple downloads of generic items over multiple paths. We have N available paths, with $N-1$ corresponding to Φ, and M items to download from a given server. The scheduler goal is to transfer the full set of M items minimizing the total transfer time.

3. SYSTEM IMPLEMENTATION

Given that most residential traffic today is HTTP [8], we select one HTTP-based Video-on-Demand (VoD) applications to augment via 3GOL. For its wide and growing adoption we choose Apple's HTTP Live Streaming (HLS) protocol [1] that is supported by all Apple devices, including the Apple TV, and it is also implemented in other video players (Android ≥ 4.0, VLC ≥ 2.0). HLS divides the video in segments of short size that are separately requested by the player with one HTTP GET request for each segment. The list of segments is retrieved through an extended M3U (m3u8) playlist and this is the first downloaded element. Next, the player sequentially requests the segments, one at a time, in the same order in which they will be required by the decoder. The video starts after a pre-buffering phase which is application dependent. We implement the mobile component as an Android application that includes a basic HTTP proxy to serve the requests coming from the Wi-Fi using the 3G interface. Hence, the device must be connected both to the Wi-Fi network and to the 3G network as a client. This operation mode is not natively supported by Android and we had to root the phones to enable it. We implement an HLS aware HTTP Proxy and a multipath-scheduler in the client component that we detail next. The client component intercepts the extended M3U (m3u8) playlist, and using the scheduler it pre-fetches the segments by performing parallel downloads.

Since we are dealing with bandwidth variability over time, the application level goodput of each path could be very dynamic, specially for paths corresponding to the cellular devices. Round-robin cannot be expected to maximize gains due to the different peak capacity between the wired and the cellular broadband connection. One can use history to predict future conditions and to schedule. However, estimating available capacity under rapidly changing network conditions can result in inaccurate estimates [11]. Hence we design a simple greedy scheduling algorithm that can be described as follows. First, an item is assigned to each path. Then, if there are any remaining items ($M \geq N$), they are scheduled by order, on the first available path. It is easy to see that this simple greedy scheduling policy leads to all paths being busy, achieving maximum throughput and minimum download time. Optimal performance will be achieved if all paths end at the same time, which is very unlikely to happen in our case. Hence, when all items have been already scheduled and a path becomes idle before the transaction is completed, we reassign the oldest scheduled item among the ones being transferred by the other $N-1$ paths. We keep doing this until the transaction ends, *i.e.*, until all the items have been transferred. We could modify the scheduler to cover also the playout phase, but given the wide amount of proposals in this area [10], we leave this extension as future work.

During the demo we demonstrate the gains of 3GOL showing that it greatly reduces both the download time and the pre-fetching time.

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