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Wi-Fi Offloading Strategies for Facing Mobile Data Traffic Challenges

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Abstract- Mobile data traffic has been experiencing a significantly continuing growth throughout the last decade. It is imposing the mobile network operators with the challenge of offering higher capacities and speeds in response to an ever-growing demand. As a straight-forward reaction of increasing the traditional 3G/LTE network capacities would not always be economically beneficial, alternative solutions have been discussed and/or developed. This paper reviews Wi-Fi offloading, as a simple strategy of increasing network capacities, in comparison to other proposed methods. After performing some real-life mobile data rates measurements in different areas of the city of Tirana, we will give some recommendations on deploying a Wi-Fi offloading strategy regarding the feasibility and the area-specific necessity behind this method.

Keywords - *Mobile data traffic, Wi-Fi offload, data optimization*

1. Introduction

Many recent studies have been focused on the extensive growth of mobile data traffic in the last years. According to CISCO [1], global mobile data traffic grew 63% in 2016, while it has experienced an 18-fold growth over the last five years. They forecast that 20% of total IP traffic by 2021 will be mobile and the global mobile traffic will increase sevenfold between 2016 and 2021. This exponential growth is driven by many factors. Besides the technological development of mobile networks that is enabling this growth, the extensive deployment of mobile applications for our daily life activities has increased the scope of online activities. Furthermore, the evolution towards Internet of Things, brings additional data traffic to mobile networks, as a much wider range of devices compared to “traditional” mobile phones, lap-tops, tablets will be connected.

Considering this projection of the current situation and the future of our networks, mobile operators are tending increasing their capacities through novel architectures. Operators would tend on developing strategies for transferring large files nor through their network because these files cause longer occupancy of resources and heavier traffic. A balance of the distributing the data traffic between operators’ licensed spectrum with the open unlicensed spectrum might be considered, by using the cellular network for transmitting user requests for specific type of content and unlicensed spectrum for the actual data delivery.

This paper gives the results of researching the perspective of mobile data traffic in the world and our region, as well the features of Wi-Fi offloading as a technical solution for high data demand. A proposed strategy for Wi-Fi offloading will be first discussed, as well as its advantages/disadvantages in comparison to other solutions developed concurrently. To obtain a picture of a real mobile network performance, we performed some mobile data rate measurements in the city of Tirana. The results presented in this paper follow the measurements of our previous work in [2], by further exploring the differences between the results in 3G and LTE networks. We base our recommendations for Wi-Fi offloading strategies deployment in these results.

The rest of this paper is structured as follows: In Section II, a comparison between different general offloading strategies is presented and Wi-Fi is reviewed in detail, while in Section III our measurements methodology and results are presented. Section IV concludes.

2. Offloading Solutions

2.1 Small cells for Indoor Offloading

Femtocells are small cells, deployed by access points placed indoor, operating in low power and designed for residential/business environments [5]. Some users of the mobile network will transit from macro- to femtocells, bringing a reduction of the total traffic on main Base

Stations and lowering interference. This strategy is advantageous as femtocells do not require any specific hardware implementation because they operate on the same licensed spectrum. Nevertheless, base stations operating in a shorter range will need to be deployed.

2.2 Opportunistic Peer-to-Peer Offloading

In Opportunistic Peer-to-Peer offloading [3] an initial group of users is chosen. They receive first the content to be sent and afterwards forward the data to other users through short range wireless connectivity like Bluetooth. For obtaining better data delivery efficiency, further features may be implemented, like identifying its users' social networks and customize delivery to specific groups.

2.3 Wi-Fi for Outdoor Offloading

Wi-Fi is today a ubiquitous technology deployed by operators or users in small areas. It operates in the unlicensed spectrum and thus it is advantageous as it does not interfere with 3G/LTE cellular networks. Spectrum issues are a big concern of the network developments and the challenge of not enough spectrum for future mobile broadband is present. As a scarce resource, spectrum value is high and adequate strategies in exploiting the most out of it should be implemented.

Other advantages of Wi-Fi hotspot offloading strategy are related to the fact that the number of Wi-Fi hotspots is increased globally and in national level. In national level, it is helpful for local traffic offloading, while globally it is beneficial for data roaming. From user's perspective, Wi-Fi is used to avoid a bill shock from data roaming high tariffs. Moreover, the establishment of Wi-Fi hotspots is easier and cost effective compared with large networks deployment and upgrades [4].

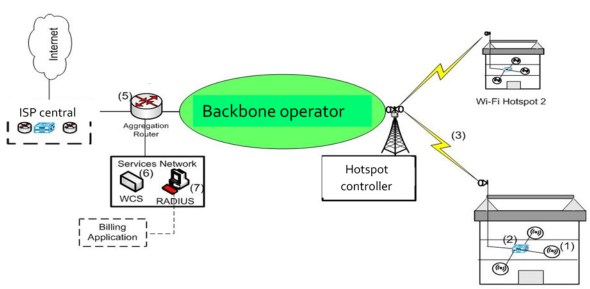

Figure 1: A simplified Wi-Fi diagram

A simplified diagram of Wi-Fi network [2] is presented in Figure 1. Its main components and their analogy with the main parts of a mobile network are as follows:

(1) Access point, with the functionalities like a BTS or NodeB/eNodeB
(2) Small hub
(3) IP Wireless link (FO alternatively)
(4) WLC (Wireless LAN Controller) functionalities like BSC or RNC
(5) Aggregation Router
(6) WCS (Wireless Control System) for Wi-Fi management
(7) RADIUS for authorisation and accounting

3. Evaluating offloading needs through data rate measurements

3.1 Measurement Methodology and Results

To observe the need for deploying offloading strategies, we performed a set of data rates measurements in different sites in the city of Tirana. Equipment used include a conventional smartphone, supporting LTE connectivity, connected with one of the national mobile operators providing LTE connectivity. The test is taken through an application named "iDrive Test", which enables measuring of data speeds, simulating the actual drive test procedures followed by mobile operators. The results show the average and maximum data speed achieved in Mbit/s, for a corresponding number of samples, depending on the driving length for each measurement. The colored map presents the quality of connection throughout the drive. Three different measurements were performed and the results are shown in Figure 2 and 3, for two different urban sites, respectively. The results of a non urban case are shown in Figure 4.

Figure 2: Data rates results for 1st urban case

The figure 2, gives the results of test done in urban area in Tirana in the afternoon. The quality of service is good with few spots with lower data speed with light green color.

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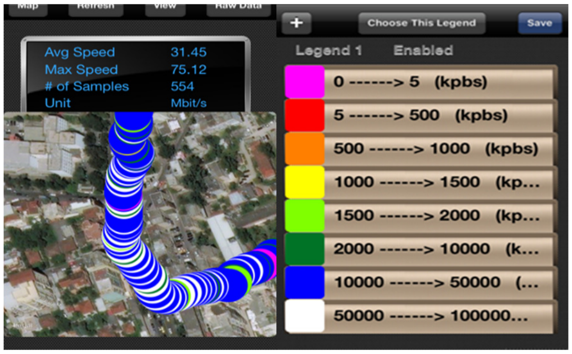

Figure 3: Data rates results for 2nd urban case

The figure 3, gives the results of test done in urban area in Tirana in midday during weekend. The quality of service is good with only one-two spots with low data speed (violet color).

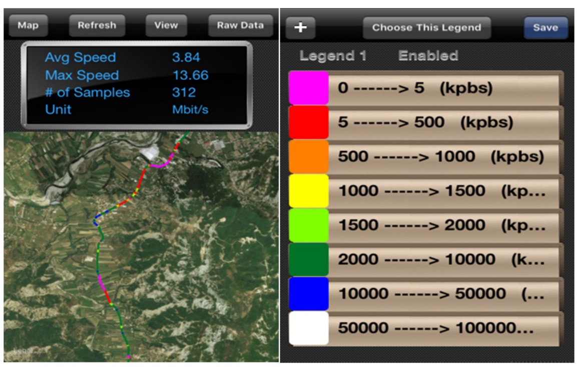

Figure 4: Data rates results for non urban case

The figure 4, gives the results of test done in non urban area. The quality of service is poor with data speed under 500kpbs (red color) and in some zones the service is missing (violet color).

As it can be observed, in the urban case the results are generally satisfying. This results from qualitative network deployment and high investments from the operators. However, there can still be found spots with poor connection quality and low data rates for the end users. This was observed in 1st case in roughly 4 spots and in the 2nd case in 2 spots. For these regions, deployment of a new LTE base station would not be very beneficial, in terms of costs and physical implementation feasibility. These spots correspond to high density regions, e.g. area surrounding a shopping mall, and deploying a new base station would be challenging. On the other hand, employing Wi-Fi base stations in a similar manner to the proposal in Figure 1, would be easier for the operators and also beneficial to the end users, which would profit data rates as high or higher than LTE connectivity.

On the other hand, results for the rural area show a poor quality in terms of the achieved data rates. Wider regions were experiencing problems, in comparison to sporadic spots found in the urban case. Nevertheless, Wi-fi hotspots would not be and advantageous solution for this case as their implementation would not be economically profitable. Since wider regions are in outages, multiple hotspots are needed to be deployed, since Wi-Fi has a relatively short range of coverage area. A numerous implementation of Wi-Fi access points would thus not be appealing as a substitute for an LTE eNodeB implementation in terms of costs.

Figure 5 shows the results of our measurements presented in [2], following the same methodology, but using 3G connectivity.

Figure 5: 3G connectivity case

The figure 5, gives the results of test done in urban area in Tirana made in 2012. The average speed is 2.86Mbps. There are few spots with no coverage, and also spots with very good data speed for 3G connectivity.

Comparing our latest result under LTE connectivity with these results of 2012, major improvements are observed, as expected.

4. Conclusions and future work

In this paper, we reviewed the advantages of using Wi-Fi hotspots as an offloading strategy. Wi-Fi is mainly advantageous as it operates in the unlicensed spectrum and its deployment is cost-efficient. We analyzed real-life measurements of an LTE network and we observed the presence of spots inside the city, in which the capacity provided by the operator is not sufficient. Following our observations, we reached into the conclusion that in urban areas that suffer outages or very high user densities, covering with Wi-Fi hotpots would be a feasible solution. Mobile Operators experiencing these scenarios might consider Wi-Fi hotspots as an efficient offload strategy in their future optimizations, as it can be beneficial even for an LTE network in specific cases. Future work on this topic can be focused on the efficiency of Wi-Fi offloading in terms of achieved data rates and seamless user experience during transition from 3G/LTE to Wi-Fi network. A seamless transition between the two technologies should be the goal of an operator deploying this or a similar offloading approach. Furthermore, new offloading strategies like LTE-U [6] and MultiFire [7] being developed recently should be reviewed and compared with the Wi-Fi offload strategy proposed in this paper. The most discussable issue regarding extending LTE in the unlicensed spectrum consists on the interference it might cause to legacy technologies like Wi-Fi. Protection of Wi-Fi networks should be one of the major criteria while developing other technologies operating in the same spectrum.

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