PREFERENCES OF SMARTPHONE USERS IN MOBILE TO WI-FI DATA TRAFFIC OFFLOAD

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Abstract: *Smartphone users generate data traffic using mobile and Wi-Fi access networks. The development of smartphones and the evolution of access networks has changed the behavior of smartphone users in generating data traffic. Data traffic offload is defined as a switch from the mobile to the Wi-Fi access network. Smartphone users offload large amounts of data traffic from mobile to Wi-Fi networks. This paper will show preferences of smartphone users that affect user's propensity and desire to offload data traffic from mobile to Wi-Fi networks.*

Keywords: *smartphone, data traffic offload, mobile networks, Wi-Fi, user's preferences*

1. Introduction

Mobile data services are necessities for many smartphone users. Smartphones are bringing Internet experience to the mobile devices. According to [1], increased smartphone usage has changed consumers' behavior, because it has encouraged and facilitated their need to be connected all the times. Average smartphone usage grew 43 % in 2015 and smartphones will cross four-fifths of generated mobile data traffic by 2020 [2]. In parallel, the use of Wi-Fi is exploding as more mobile devices are Wi-Fi enabled, the number of public hotspots expands and user acceptance grows [3].

Data traffic offload refers to traffic from dual-mode smartphones (i.e., supports cellular and Wi-Fi connectivity) over Wi-Fi networks. Mobile data offloading refers to the use of Wi-Fi network for delivery of data originally targeted for mobile networks. According to [4], Wi-Fi offloading occurs when mobile data-enabled devices use Wi-Fi instead of a cellular connection to transmit and receive mobile data.

The increase in data traffic on cellular networks has caused an immediate need for offloading traffic for optimum performance of both voice and data services [5]. The majority of mobile data terminals such as smartphones are Wi-Fi enabled, making Wi-Fi an obvious choice for providing additional capactiy where traffic demand is high [6].

This paper presents a summary of smartphone users preferences for mobile to Wi-Fi data traffic offload. User preferences are the reasons and motives of smartphone users to switch from mobile to Wi-Fi access network to transmit and receive smartphone data traffic.

2. Review of previous research

There is not many research papers about how smartphone users are actually using Wi-Fi access network and what drives a user to connect a device to the Internet using Wi-Fi rather than mobile network. Recent studies have shown that Wi-Fi networks are carrying a majority of smartphone data traffic.

The main objective of the research [5] is to provide the state of the art in mobile data offloading, covering both technological and business aspects. Lee in [7] presents a study on the performance of 3G mobile data offloading through Wi-Fi networks, and results present that Wi-Fi already offloads about 65 % of the total mobile data traffic and saves 55 % of battery power without using any delayed transmission. Deng in research [8] compared LTE and Wi-Fi for transfers of different sizes along both directions (i.e. the uplink and the downlink) using a crowdsourced mobile application run by 750 users over 180 days in 16 different countries. Analysis of Ericsson in [9] of smartphone on-device measurements in the US, Japan and South Korea indicates an 80 % growth in cellular data usage between July 2014 and October 2015 for smartphone video streaming apps; corresponding Wi-Fi data growth is more than double this. Teshager in [10] outlines the needs of the mobile community in how it would like to utilize Wi-Fi offload to help promote and develop the usefulness and availability of its services. Kaisar in [11] compares traffic generated over Wi-Fi and cellular networks. Such comparisons are helpful for predicting usage patterns in a mixed Wi-Fi/cellular service context. Bakhit in [12] proposed a 3G to Wi-Fi offloading Android-based application. The proposed application measures the download speed of an online page on both Wi-Fi and 3G networks simultaneously. After comparing the results, the device gets switched to the best network. Aijaz in [13] carried out a survey of the practical challenges faced by operators in data traffic offloading to Wi-Fi networks and also provided recommendations to successfully address these challenges. Hoteit in [14] evaluated the capacity and energy saving gain that one can get by offloading cellular data traffic over Wi-Fi hotspots. Sani in [15] examined data consumption behavior in the lab comparing different access networks (Wi-Fi and mobile). The research [16] shows how smartphone data usage is changing as 4G services are deployed alongside existing 3G services, and as Wi-Fi coverage continues to expand in homes, businesses and public spaces.

According to the most of the research papers, the proportion of data traffic from smartphones carried over Wi-Fi ranges between 50 % and 80 % of all data traffic. Previous literature shows only a few of users preferences individually that affect mobile to Wi-Fi smartphone data traffic offload. The knowledge about the smartphone users preferences which affect the data traffic offload has a great importance to mobile operators in the form of network capacity optimisation and the development of customer tailored tariff plans and services.

3. Smartphone data traffic growth

Mobile data traffic continues to grow and the growth in data traffic is being driven both by increased smartphone subscriptions and a continued increase in average data volume per subscription [9], [17]. By 2020, aggregate smartphone traffic will be 8.8 times greater than it is today [2]. Smartphone usage of both cellular and Wi-Fi networks

tends to increase with the added (and improved) connectivity [18]. 3G/4G mobile networks are currently overloaded, due to the increasing popularity of various applications for smartphones [4]. Figure 1 shows a comparative overview of the increase of data traffic generated by smartphones in 2015 and 2020 by region in the world, with an emphasis on the highest growth in the region APAC (Asia Pacific).

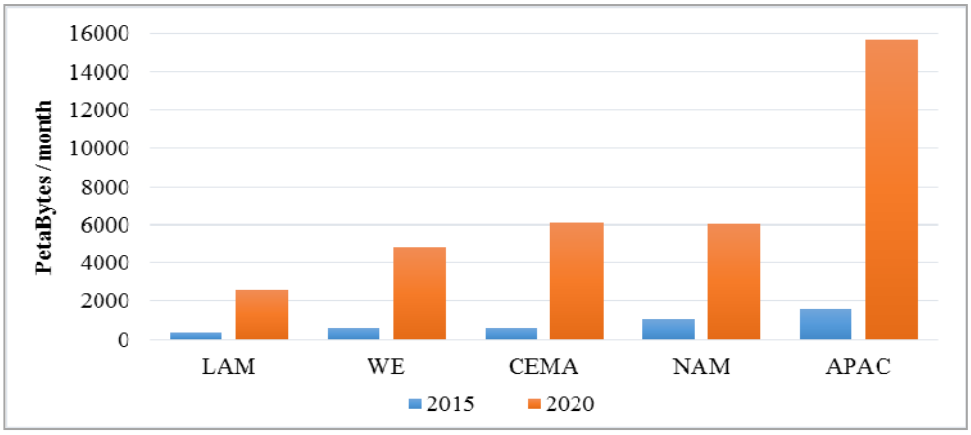

Figure 1. *Smartphone data traffic growth per region*

This smartphone data traffic growth trend will continue in the coming years. According to [9], in 2021 monthly smartphone data usage per active subscription in North America (22 GB) will be 1.2 times that of Western Europe (18 GB) and 3 times that of Asia Pacific (7 GB). Western Europe will experience a nine fold growth in monthly smartphone data usage per user between 2015 and 2021. Due to the growth in the number of subscriptions, the Asia Pacific region will have the largest share of total smartphone traffic in 2021.

4. Smartphone mobile to Wi-Fi data traffic offload

Although cellular data usage on smartphones is growing, Wi-Fi data growth is dramatically outpacing it [9]. Technology and market changes have generated a boom in Wi-Fi offloading, which is now becoming the dominant access technology for smartphones [4]. Mobile offload exceeded cellular traffic for the first time in 2015. According to [2], 51 % of total mobile data traffic was offloaded onto the fixed network through Wi-Fi or femtocell in 2015. The basic idea behind Wi-Fi offloading is whenever a Wi-Fi access point is available, some or all of the traffic is routed through the access point, thus offloading the cellular access network [19].

Wi-Fi is the most important wireless technology in the world based on the volume of data traffic it carries [20]. Wi-Fi accounted for 80 % of data consumption on smartphones and tablets, compared to cellular with 20 %. Wi-Fi has cemented its position as the dominant wireless access technology, with cellular playing a vital yet supporting role [20]. Offloaded traffic is expected to account for around three-quarters of total mobile data traffic originating from small-screen and connected mid-screen devices in

2013 and around 85 % by 2017. Also, the vast majority of offloaded traffic originates from people's homes and places of work [4].

As a percentage of total mobile data traffic from all mobile-connected devices, mobile offload will increase from 51 % (3.9 exabytes/month) in 2015 to 55 % (38.1 exabytes/month) by 2020 (Figure 2) [2].

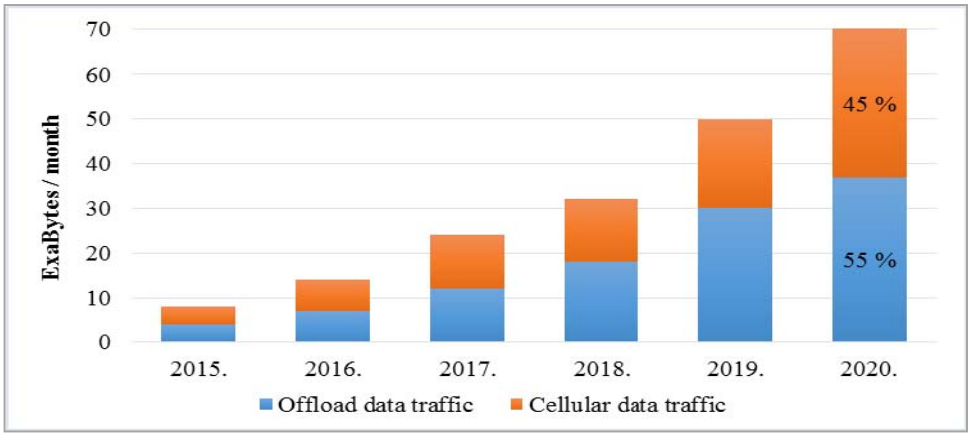

Figure 2. *Smartphone data traffic offload growth,* [2]

Monthly Wi-Fi data usage is much greater than cellular usage on 3G and 4G smartphones, and is growing much faster [16]. Wi-Fi has firmly established itself as the most heavily-used wireless technology ever deployed in terms of the volume of data traffic transmitted over networks using Wi-Fi [20]. Also, it is widely accepted and popular because it doesn't require a licensed spectrum. It's cheap equipment and very large number of compatible devices [4]. Globally, total public W-Fi hotspots (including homespots) will grow sevenfold from 2015 to 2020 [2]. With a lot of mobile device viewing time spent indoors, it should come as no surprise that over 85 % of data traffic generated by the use of smartphone video apps goes over Wi-Fi [9].

Research shows that broadband usage patterns and user behavior are changing. According to Aijaz in [13], Wi-Fi comes as a natural solution for offloading due to built-in Wi-Fi capabilities of smartphones. Marcus in [21] presents that the high percentage of data offload which is already taking place is stunning and not altogether expected.

5. Preferences of smartphone users data traffic offload

3G and Wi-Fi technologies are complementary. Cellular networks provide wide-area coverage, chiefly outdoors and on the road, whereas Wi-Fi is a shorter-range technology, but offers higher speeds, low cost and self-installation [10]. Wi-Fi looks like a win-win proposition for both consumers and mobile operators [22]. As is often the case with technology, there seems to be a huge gap between the technical reality and user perception across the key distinguishing attributes of the two access networks [23].

The text bellow identifies all the relevant preferences of smartphone users that affect on the mobile to Wi-Fi data traffic offload. The perception by the end user and

their motivation for using a Wi-Fi network instead of mobile network is based on decision criteria in the text bellow.

5.1. Wi-Fi network speed

The desire for faster, more reliable connectivity is the principal driver of Wi-Fi usage over cellular mobile [24]. According to [25], it is useful to compare Wi-Fi network speeds with available cellular network speeds in the USA. It can be seen in figure 3 that Wi-Fi, on average, offers faster speeds than cellular connections (averaged across the four national providers), including 4G LTE.

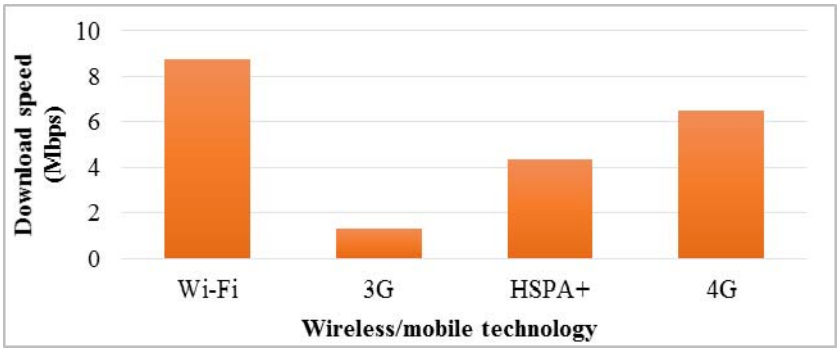

Figure 3. *Comparison of download speed of wireless and mobile technologies,* [25]

The top reason for choosing Wi-Fi, however, is that respondents find it much faster than mobile networks [26]. More than 70 % of users consider Wi-Fi faster [23].

5.2. Unlimited data traffic

According to [23], the biggest perceived benefits of Wi-Fi offload are all cost-related and one of the most important is unlimited data. Consumers choose to consume applications or services that have high bandwidth requirements, but which are often of lower overall perceived value to them, on Wi-Fi networks [20]. Rebbets in [18] says that clear majority of subscribers would switch to a provider offering unlimited public Wi-Fi connectivity as part of the contract. The attraction of unlimited Wi-Fi access is even greater for 4G subscribers. A higher portion of 4G subscribers would switch to a provider offering unlimited public Wi-Fi connectivity than for the market as a whole.

5.3. Low cost access

More than 70 % of users consider Wi-Fi more cost efficient [23]. According to [27], Wi-Fi access is often free of charge or inexpensive. Cellular data traffic is typically expensive and Wi-Fi data is perceived as free, particularly in the home. A related point is that users often perceive Wi-Fi access to be free, but in reality it typically relies on a fixed-broadband service with a monthly fee [16]. Very few users are actually paying for public Wi-Fi. Two-thirds of regular Wi-Fi users enjoy free access to public hotspots [23]. Users can access free Wi-Fi in more than 50 % of U.S. hotels and cafés [28].

5.4. Quality of service/experience

Consumers are rapidly realizing the benefits of Wi-Fi for higher speed, good coverage, and a better user experience [28]. Due to degradation of cellular services in overloaded areas, an increasing number of users are already using Wi-Fi to access Internet services for better experience [13]. According to [20], 60 % of users believe Wi-Fi is more reliable and offers optimal performance for their application [23]. 58 % of operators, including 47 % of mobile operators, believe Wi-Fi hotspots are either very important or crucial to enhance their customers' experience. By selectively offloading traffic from mobile to Wi-Fi networks better end user quality of experience is achieved [10].

5.5. Wi-Fi availability in user devices

Most of current mobile devices, such as smartphones, tablets, and laptops are equipped with Wi-Fi interfaces [27]. Wi-Fi has become a standard feature in virtually every smartphone sold today [29]. Wi-Fi offers the availability of user devices that support the technology [30]. Now, nearly all personal mobile devices, including smartphones, tablets, cameras, and game consoles, are Wi-Fi enabled [20], [28].

5.6. Widely deployed infrastructure

Wi-Fi offers widespread existing deployments [30]. Despite the existence of various solutions, offloading to Wi-Fi proves to be an optimal one as it takes advantage of the resources that Wi-Fi offers in terms of availability of deployed hotspots [12]. Worldwide public Wi-Fi hotspot deployments reached a total of 5.7 million locations in 2014, and predicts that access point growth will reach 13.3 million by the year 2020 [31].

Wi-Fi hotspots are widely deployed in many urban areas. It is shown that Wi-Fi access is available 53 % of the time while walking around popular sites in some large cities [27]. According to [31], 88 % of consumers saw Wi-Fi as a commodity that should be available everywhere, all the time.

5.7. Quality of mobile network signal

Almost a fifth of users (19 %) connect to a public Wi-Fi network because no mobile signal is available. This data is slightly higher for 4G users (23 %) [18]. According to Ding in [32], the most likely explanation for the prevalence of poor signal strength experienced by a significant fraction of users is the compound effect of geographic variation in cellular network coverage and the fact that a user principally stays in a few locations through out a day.

Research [33] shows that with poor cellular coverage in an apartment, users would often resort to using communication apps over Wi-Fi as a replacement for voice calls, or using email and chat apps.

5.8. Automated login

Where it is available, Wi-Fi remains the default choice of the consumers. It is perhaps largely down to the tendency of the device to switch automatically to "home" or "preferred" hotspots whenever in range [20]. If a user has turned on the automatic Wi-Fi connection, the mobile device can be automatically connected to Internet access.

In general, the free open one will be connected automatically to the Internet than those with passwords [34]. The fact that network handover is automatic would suggest that, unless they check, users are unaware when they switch from cellular to Wi-Fi [35]. Traffic distribution share between cellular and Wi-Fi networks is primarily driven by the ease of device-led automatic Wi-Fi network selection [20].

5.9. Security

Despite the technical superiority of cellular mobility in the area of security, people clearly do not make this distinction, as 55 % believe Wi-Fi is more secure [23]. Subscribers considered security to be comparable in Wi-Fi and cellular networks [36].

5.10. Lower battery drain (when close to AP)

Weak wireless signal strength can result in smartphone apps consuming significantly more energy than under good signal strength [32]. Though wireless access traffic of smartphones is routed through cellular and 802:11 based Wi-Fi data networks, UMTS based 3G cellular data networks typically require more energy with less data rates compared to Wi-Fi based networks [37]. Measurements in the research [38] confirm that the transmission energy consumed by Wi-Fi is significantly smaller than both 3G and GSM, especially for large transfer sizes. On-the-spot offloading alone (without any delayed transfer) can achieve about 55 % energy saving for mobile devices because Wi-Fi offloading can reduce the transmission time of mobile devices substantially [39].

5.11. International roaming

The use of Wi-Fi whenever possible while out of the country is very usual. Smartphone could automatically use Wi-Fi for all its Internet needs. People can use data services when travelling; however, data usage is usually not included in their tarif plan while roaming. In order to keep roaming costs down, international smartphone travelers adapt their behavior whilst abroad. 88 % seek Wi-Fi whenever possible and 23 % switch off their phones. It is the ability to save on roaming charges when traveling [33].

5.12. Improved indoor coverage

Urban areas need faster data speeds with improved deep indoor coverage [9]. Wi-Fi enables operators to encourage customers to use Wi-Fi in order to provide a better data experience than 3G alone, especially in indoor locations [29]. Wi-Fi is the main Internet connection for 60 % of smartphones and 90 % of smartphone and tablet users connect to the Internet using Wi-Fi at home [24].

6. Conclusion

Smartphone data traffic offloading happens on the user or device level when one switches from a cellular connection to Wi-Fi. It is uncertain how much smartphone data traffic will be offloaded from cellular to Wi-Fi networks in the future and the answer is partly dependent on decisions taken by the mobile operators with regard to the pricing of data traffic. If mobile operators will be able to understand the differences in data traffic usage across cellular and Wi-Fi networks, they can use these insights to build more targeted propositions for their users.

This research provides a systematic review and identification of users preferences for smartphone mobile to Wi-Fi data traffic offload. The trend towards more smartphone mobile to Wi-Fi offloading also helps mobile operators to plan investments in their networks at specific points where congestion is high. Results of the research clarify the reasons that influence on smartphone users to switch from a cellular to Wi-Fi access network. The paper increases the awareness of users and mobile operators about the motivation of smartphone users in mobile to Wi-Fi data traffic offload.

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Sadržaj: *Korisnici pametnih telefona generišu saobraćaj podataka pristupom mobilnim i Wi-Fi mrežama. Razvoj pametnih telefona i evolucija pristupnih mreža promenila je ponašanje korisnika u načinu generisanja saobraćaja. Prebacivanje saobraćaja podataka definiše se kao promena pristupne mreže s mobilne na Wi-Fi mrežu. Korisnici pametnih telefona velike količine saobraćaja podataka prebacuju s mobilnih mreža na Wi-Fi mreže. U ovom radu biće prikazane korisničke preference koje utiču na sklonost i želju korisnika za prebacivanjem saobraćaja podataka pametnih telefona sa mobilnih na Wi-Fi mreže.*

Ključne reči: *pametni telefon, prebacivanje saobraćaja podataka, mobilne mreže, Wi-Fi, preference korisnika*

PREFERENCE KORISNIKA PAMETNIH TELEFONA U PREBACIVANJU SAOBRAĆAJA PODATAKA S MOBILNIH NA WI-FI MREŽE

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