Features of Applications for Measuring Smartphone Generated Data Traffic

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Abstract—**End-user devices have the ability of accessing data networks and thereby generate data traffic. The amount of generated data traffic depends on many factors, including features of the device and the services it uses. Data access network is also one of the key determining factors of the amount of generated data traffic. In this paper, authors compared the amount of generated data traffic resulting from reproducing the same media content using a YouTube application during equal time frames. Three different applications were used to measure data traffic volume: GlassWire, My Data Manager, and 3G Watchdog. The measurements were performed via Wi-Fi and through mobile communication network. The results were compared in terms of how the amount of generated data traffic was displayed on each of the applications.**

Keywords- smartphones, data traffic, data traffic measurement, applications

I. INTRODUCTION

Smartphones are devices located at the end part of any telecommunications network, hence the name. Their fundamental role is to convert information into signals that are suitable for end-to-end transmission through telecommunication networks. The smartphones have the ability to connect to all types of telecommunications networks. As a result, smartphones generate a certain amount of data traffic. In addition, generated data traffic refers to the amount of data traffic generated when uploading and downloading data via a smartphone connected to the Internet.

Today, the largest share in global internet traffic has mobile data traffic generated from smartphones used on a daily basis. As well, there is an increase in the number of smartphone users, thus resulting with an enormous increase in the volume of generated data traffic. This is primarily because of plethora of many factors, including users, information-communication network, type of the device, resolution and size of the display, installed applications, operating system (OS), and device settings. [1].

The rest of the paper is organized as follows. Section 2 surveys the work related to data traffic measurements. In Section 3 the features of smartphones are described. Section 4 outlines the main application for measuring data traffic. In Section 5 we the main results are presented and discussed. In Section 6 we conclude.

II. REFERENCES REVIEW

A growing body of literature has investigated the features and measurement methods of generated data traffic. For example, the authors in [2] conducted a survey based on the amount of data generated in a 1-year period during they downloaded the data from the network of Covenant University in Nigeria. Research has been carried out using the following software: FreeRADIUS, Radius Manager and Mikrotik Hotspot Manager.

In addition, research from [3] has been carried out on a continuous increase in the average volume of data traffic per subscriber that affects the overall increase in mobile data traffic globally. Also, this study explains ways that affect the amount of generated data traffic from a smartphone.

In [4], the authors investigated the amount of generated data traffic between the two end user devices. As a result, they allowed the users to search information on various types of data traffic from and to user device.

Authors in [5] performed measurements on the amount of data traffic when the device was connected to mobile network. Furthermore, another research [1] argued that the amount of generated data traffic is affected by different types of network access (for example, via cable, mobile and Wi-Fi network). This is because various type of access generates different amount of data traffic. This paper, for example, compares the amount of data traffic generated from different types of end-user devices during reproducing the same media content.

Research from [6] states that different operating systems have different effect on the amount of generated data traffic. They performed analysis on similarities and features of operating systems and their effect on generated data traffic. In addition, they measured the amount of generated data traffic from reproducing the same media content by using 3G and 4G mobile networks.

This paper deals with the measurement of the amount of generated data traffic with three different applications. A comparison of the obtained measurement results was made. The results show certain discrepancies in measured data traffic from different applications.

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III. Features of Smartphones and Generated Data Traffic

Today's technology development is accelerated, resulting in changes in habits and communication needs of users. Also, it is becoming hard for users to spend the day without using smart phones, and some users use multiple devices on a daily basis.

Smartphones share certain features and technical capabilities with personal computers. Users use them everyday for private and business purposes. Their development also brings new ways of communication through the Internet. Consequently, the smartphone users use them for communication purposes and various data-based functions (such as downloading, browsing or publishing various content over the Internet) resulting in a global increase in totally generated data traffic.

A. *Features of smartphones*

In contrast to a classical mobile phone, smartphones refer to a device that includes a broader range of features in terms of data storage and connectivity. They also have a stronger central processor unit (CPU), a larger touch screen display, more data storage, Internet access, built-in sensors for retrieving information from the environment. Also, smartphones are using operating systems that have an upgrade ability and thus they can improve their capabilities, [7]. Further, smart phones are considered to be extremely practical due to their dimensions, allowing users to access the content they are interested in at any time, regardless of where they are located. They are multipurpose devices, used primarily for communication, location tracking, and reproducing multimedia content.

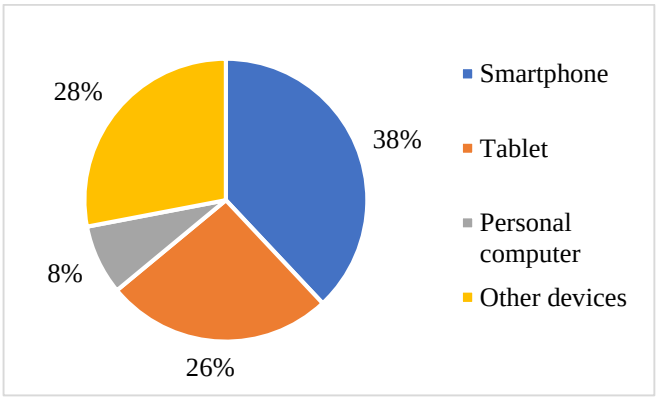

Figure 1. Most used end-devices [8]

During the last several years, smartphones are the most used end-user devices, followed by tablets, other end-user devices such as smart watches, smart glasses, notebook and personal computers (Figure 1). In addition, the development of smartphone technology has resulted in a rise in the number of purchased smartphones. Consequently, their development gives users a wider range of advanced and novel features that make smartphones even more interesting to end users. As a result, an increase in the number of smartphone users amounted to 2.32 billion users in 2017, and by the 2020 it is expected to reach 2.87 billion users (Figure 2).

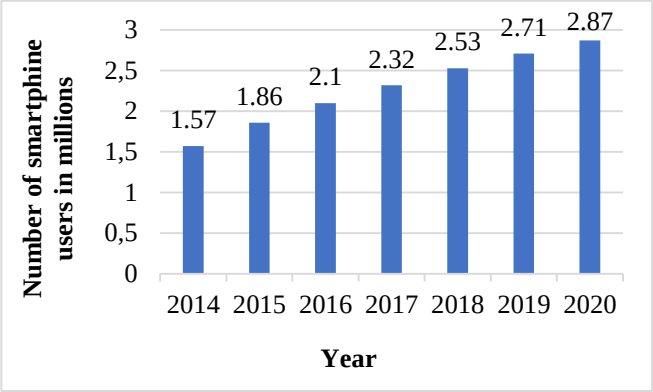

Figure 2. Number of smartphone users on a global level for 2014-2020 [9]

Furthermore, the number of smartphones is expected to grow on a global level according to a research from IDC (*International Data Corporation*). The first significant increase of smartphone users was experienced in 2016 when there were more 1.74 billion users than in 2015. Additionally, the number of smartphone users it is expected to constantly grow by 1.7 billion in 2021., [10].

B. *Data traffic generated by smartphones*

On a daily basis, users use smartphone differently in order to exchange information including the transfer of multimedia content such as images, voice, video, text messages. Consequently, today's applications are developed for private and business purposes. Some of the numerous applications allow users to use social networks, mobile chat, voice and video calls, and mobile tracking over the Internet, resulting in an enormous increase in generated data traffic. In 2016, generated data traffic amounted to 7 exabytes[1] per month and it is expected to continue to grow to 49 exabytes per month in 2021 (Figure 3).

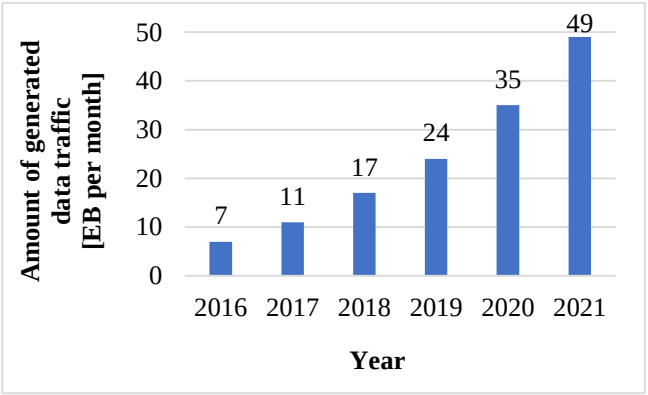

Figure 3. Prediction of generated data traffic for 2016-2021 [11]

In the future, data traffic is expected to grow even further, as a result of the development of new types and possibilities of applications that require Internet access to operate. For example, social networking applications are generating, on average, three to seven times more data traffic than messaging or games related applications. One of the major causes of increase of user's generated data traffic is increase in the use of real-time video

[1] Exabyte – One exabyte = billion gigabytes

communication via smartphones, with the share of 45-55% of the total generated data traffic, [8].

There are various reasons affecting the use of smartphones by users. For example, 52.9% of users use smartphones because of their features. Furthermore, 30.4% of users use smartphones to perform everyday work such as browsing, sending and receiving SMS, MMS, e-mail, social networking, and 16.7% of users are using smartphones only for messaging, e-mail and making calls. For most of these activities Internet is a basic prerequisite which, in turn, generates data traffic, [12].

IV. Applications for measuring Data traffic

Today there are two billing methods for services: (1) prepaid and (2) postpaid. As a result, there are various cell phone plans on the market that include free minutes, SMS messages and data units which is something that is considered to be important when choosing cell phone plan and smartphone, as well. This is because the Internet is essential for most private and business user's needs. Therefore, users wishing not to paying extra cost, need to track the spent free amount of data traffic included in cell phone plan, [13].

Consequently, a large number of applications have been developed whose purpose is to measure generated data traffic using a mobile or Wi-Fi network. Such types of applications provide users an insight on the amount of data traffic generated by the smartphone applications used on a daily basis, as well as keeping the track of spent data traffic. Smartphone users are not fully aware that some of smartphone applications generate data traffic even then when they are not active. Such applications can display the amount of data traffic differently, such as through charts, shares, tables, which can prove to be very beneficial to users.

During the installation of the application to measure the generated data traffic, certain settings must be set in accordance with the user's smartphone settings. This is necessary primarily in order to correctly measure the amount of generated data traffic. One of the main advantages of this type of applications absence of installation fee and the ability to contact customer service for any troubleshooting. As we mentioned previously, there are various applications for measuring generated data traffic on smartphones. For the purposes of this paper we used applications such as GlassWire, My Data Manager, and 3G Watchdog that are described in following text.

A. *GlassWire application*

GlassWire application provides options to monitor generated data traffic and sending notifications to users when reaching given threshold. Additionally, real-time data consumption can be displayed on the smartphone status bar.

Users have insights to generated data traffic from other applications on a smartphone other than GlassWire itself, that require Internet connection, via Wi-Fi or mobile network (home or visited when in roaming). In addition, the amount of data traffic can be monitored on different basis, such as daily, weekly, monthly, or yearly. The GlassWire application can be supported by various types of networks such as 3G, 4G, EDGE, GPRS, Wi-Fi [14].

B. *My Data Manager application*

My Data Manager application enables its users to continuously monitor the volume of generated data traffic. Mentioned application, in the form of an alarm, has the ability to alert users in the case of a sudden overrun of the pre-set dana traffic usage which is set after launching the application.

My Data Manager application allows users to track the amount of generated data traffic by connecting the device to a mobile, Wi-Fi or roaming network. It is also possible to display the history of the generated data traffic. Furthermore, the amount of realized data traffic is displayed using a graph and one of the possibilities of this application is the ability to display the amount of realized data traffic separately by applications that are installed on the user's device and generate data traffic [15].

C. *3G Watchdog application*

The purpose of 3G Watchdog application is the ability to measure the amount of generated data traffic on user's smartphones. Mentioned application provides insights into the amount of generated data traffic by the applications installed on the user's smartphones.

Downloading this application is not charged but an enhanced version called 3G Watchdog Pro is charged. The 3G Watchdog application provides visibility in the status bar of the user's smartphone, but it can also be adapted to the user's needs.

The above-mentioned visibility feature in the status bar also provides the ability to view (with different colors) the type of network that the user is connected to. Accordingly, if device is connected to a mobile network, the green color is highlighted in the status bar. Furthermore, if the smartphone is connected to a Wi-Fi network, the blue color is highlighted in the status bar. In case of approaching the predetermined boundary of the amount of generated data traffic, the status bar is highlighted in orange color.

The settings of this application allow users to choose the mode of displaying the amount of generated data traffic. The amount of generated data traffic can be displayed using the graph or numerically expressed by the names of applications that generated this same data traffic. The key role of the graph is the ability to visualize the amount of data traffic generated by users [16].

D. *Features of the applications*

In order to achieve better visibility of a large number of features and easy connection between GlassWire, My Data Manager and 3G Watchdog applications, table 1 is presented below.

TABLE I. Comparative analysis of the features of the applications

Features	GlassWire	My Data Manager	3G Watchdog
Free download	+	+	+
Data privacy	+	-	-

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Incident report	+	-	+
Alarm	+	+	+
4G, Wi-Fi, Roaming data	+	+	+
Graphic display	+	+	+
Applications details view	+	+	+
Graphs update	-	-	+
Visibility in the status bar	+	+	+
Data usage history	+	+	+
Automatic network disconnect	-	-	+
Upgraded version with additional charge	-	-	+
Summary	**9/12**	**7/12**	**11/12**

As it was already mentioned, in the table 1 is possible to see the features of mentioned applications. The features shown by „+“ are features that applications contain and the features shown by „-“ are features which applications do not have. The last row contains a summary number of all the features that each and every application contains.

V. Comparative Analysis of Applications

In this paper, an experiment which involve measurement of the amount of generated data traffic, is conducted. Quantity of generated data traffic is measuring by GlassWire, My Data Manager and 3G Watchdog application. Using these three applications are enabling detaile insight into the amount of generated data traffic.

Table 2 shows the conditions of the experiment which carry out to measure the amount of generated data traffic. HTC Desire 728 dual sim model which uses the Android 5.1 operating system is a smartphone which is using for the experiment. Furthermore, the smartphone was connected to a Wi-Fi and the mobile network (4G), while the location of the experiment was unchanged.

Also, the experiment included browsing the video clip called „Bon Jovi - It's my life“ for 3 minutes via the YouTube application. As already mentioned, the amount of generated data traffic was measured by GlassWire, My Data Manager and 3G Watchdog applications, and each of mentioned applications was tested six times in order to obtain the most precise results. In the experiment process, resetting data measurement applications was performed before each re-measurement and all other applications on the device were inactive.

TABLE II. Experiment conditions

Experiment conditions	
Smartphone	HTC Desire 728 dual sim
Operating system	Android 5.1
Measurement location	45°49'03"N 15°56'18"E
Network type	Wi-Fi, mobile network (4G)
Time period	3 minutes
Content viewing app	YouTube
Content type	Video
Content name	Bon Jovi – It's my life
Measurement applications	GlassWire, My Data Manager, 3G Watchdog
Number of measurements carried out	6
Measured results which are included	The average result of all measurements per application
Measuring applications reset	Yes, before each re-measurement
Other applications activity	Inactive during measurement

From the attached Figure 4 it is possible to see the results of the experiment carried out. Furthermore, results of the data of generated data traffic were almost equally distributed across all three applications when the smartphone was connected to the mobile network (4G). The deviation was present in the results of the data of generated data traffic obtained when the smartphone was connected to a Wi-Fi network.

The results measured by GlassWire and My Data Manager show that the amount of generated data traffic is larger when the device was connected to a Wi-Fi network. It is apparent that only the 3G Watchdog application has measured that the amount of

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generated data traffic is less when the device was connected to a Wi-Fi network than the amount of generated data traffic when the device was connected to a mobile network (4G).

Accordingly, the Figure 4 shows that the results of generated data traffic were approximately equal when a smartphone was connected to a mobile network (4G) for all three applications. Significant difference came from the results of generated data traffic obtained for measurements in which the device was connected to the Wi-Fi network.

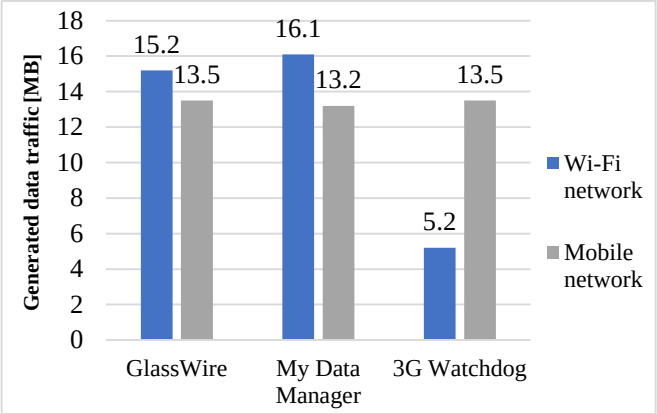
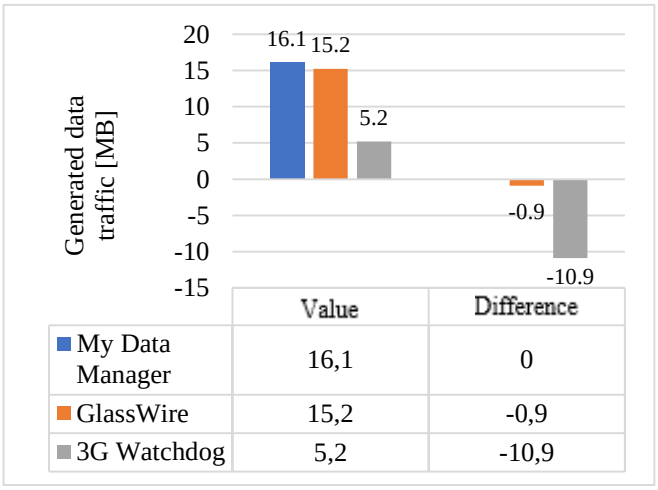


Figure 4. Comparison of the amount of generated data traffic measured by three different applications on the mobile and Wi-Fi network

For better visibility, the difference in the resulting data of generated data traffic are shown in the Figure 5 and 6.



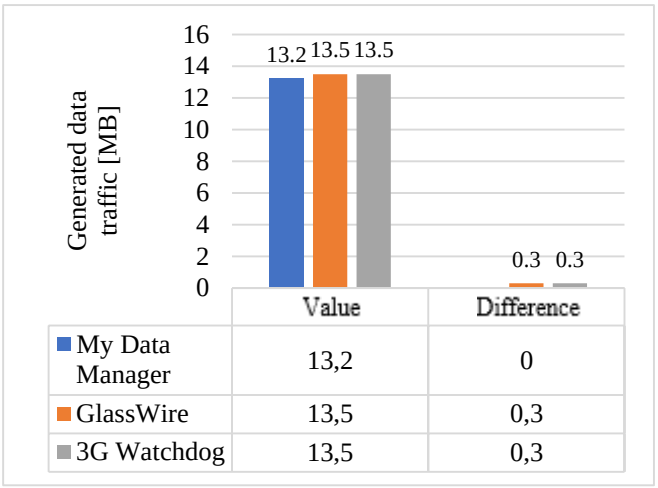
	Value	Difference
My Data Manager	16,1	0
GlassWire	15,2	-0,9
3G Watchdog	5,2	-10,9

Figure 5. Amount of generated data traffic measured by three different applications (Wi-Fi network connection)

The results of generated data traffic of the experiment (when the smartphone was connected to the Wi-Fi network) are shown in Figure 5. A column called "Value" refers to the results obtained by measuring the amount of generated data traffic by mentioned applications. Furthermore, the column called "Difference" shows the differences between the measured results obtained from each application.

The results obtained by My Data Manager and GlassWire applications are minimal, while the smallest amount of data traffic has been measured by the 3G Watchdog application. Because of the greater visibility of the difference in the result of the amount of generated data traffic, the reference result was taken as a result measured by My Data Manager application that was accentuated by blue dye in the Figure 5.

Figure 5 shows that the result measured by the GlassWire application differs by -0.9 MB of generated data traffic from the reference result, while the result measured by the 3G Watchdog application differs by -10.9 MB of generated data traffic from the reference result of My Data Manager application. Also, the average value of the generated data traffic measured by all three applications is 12.2 MB.



	Value	Difference
My Data Manager	13,2	0
GlassWire	13,5	0,3
3G Watchdog	13,5	0,3

Figure 6. Amount of generated data traffic measured by three different applications (mobile network connection)

Figure 6 shows the results of the experiment when the smartphone was connected to the mobile (4G) network. Within the figure there is a table containing two columns. A column called "Value" refers to the results obtained by measuring the amount of generated data traffic by mentioned applications. Furthermore, the column called "Difference" shows the differences between the measured results obtained from each application.

It is evident that the results of the amount of generated data traffic measured by all three applications differ minimally. For a more detailed view of the difference, the reference value was taken as the measurement result of the My Data Manager application. Based on these results, differences in results were calculated for the other two applications. It is obvious that the results measured by GlassWire and 3G Watchdog applications differs by +0.3 MB of data traffic compared to the My Data Manager application's reference result. Also, the average value of the generated data traffic measured by all three applications is 13.4 MB.

VI. Conclusion

The amount of generated data traffic of the smartphone is affected by the network to which it is connected, but there are numerous other factors. Some of these factors are: the smartphone operating system, resolution and screen size, communication technology etc. In order to measure the amount of generated data traffic there are a large number of applications that provide insights to smartphone users.

During the experiment of measurement of the amount of smartphone generated data traffic, the following applications were used: GlassWire, My Data Manager and 3G Watchdog. They provide the ability to measure generated data traffic when a smartphone is connected to a mobile, Wi-Fi, or roaming network. Also, one of the advantages of these applications is that when installing it, the user can set the limit in terms of generated data traffic. By approaching the set boundary, an alert activation occurs which informs the user about the possibility of exceeding the amount of generated data traffic.

When performing the experiment using the aforementioned applications different results were obtained in terms of the generated amount of smartphone data traffic. Each experiment was performed under the same conditions.

When smartphone was connected to the mobile network (4G), all three applications measured almost equal amount of generated data traffic. Differences in the results of the applications occurred when a smartphone was connected to a Wi-Fi network. Additionally, multiple experiments under the same conditions were performed, with the same differences. The biggest difference came from the results obtained by the 3G Watchdog application that measured the smallest amount of data traffic.

Due to the differences that occurred during the experiment, the relevance of the tested applications was brought into question. Therefore, to determine which of the applications is actually the most accurate in terms of measuring the amount of generated data traffic, a continuation of this research will be carried out.

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