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z-Normalized Download and Upload throughput on UMTS Networks

J. Akanni[1], A. A. Isa[2], C. T. Thomas[3], R. A. Alao[4], A. Abdullahi[5], A. S. Adeshola[6]
[1,2,4,5,6]Department of Electrical and Electronics Engineering, University of Ilorin, Ilorin, Kwara State Nigeria
[3]Department of Electrical and Information Engineering, Achievers University, Owo, Ondo State, Nigeria
[1]jimaka2005 @ gmail.com, [2]abdurrhaman49 @ gmail.com, [3]cornelt.elect @ yahoo.com, [4]rasaq4prosper @ yahoo.com,
[5]aabdullahi09001 @ gmail.com, [6]abimbolaonnet @ gmail.com

Abstract— *Wireless data networks as become the most efficient and reliable telecommunication services for providing internet services to most people around the globe. Over 50 billion wireless devices is expected to be connected by the end of 2020, all of which are likely going to demand access to the internet making the demand for wireless connectivity, coverage, capacity and services to continually expanding; all of which can be evaluated based on end user satisfaction. The end users demand reliable, accurate, consistent tools and methodology that help them to measure the download and upload throughput; also the operators are interested to predict the future throughput based on historical data from the past. In this research, we come up with a methodology to effectively and accurately measure the download and upload of the UMTS data network in a real wireless environment from end users point using three selected operators on the University of Ilorin main Campus. We normalized mathematically the measured value and compare the performance with the minimum value for UMTS wireless network and there after compare each operator to provide the end user with an effective decision tool in order to acquire maximum satisfaction. Based on the result we suggested an app should be develop similar to that used in the study and then the measurement period should be increased for better prediction by operators and to provide more data information for the end users to aid their decision thereby increasing their satisfaction.*

Keywords— *Normalized, RantCell, throughput, UMTS.*

I. INTRODUCTION

Communication is the transfer of information from one place to another; it can either be guided type (using a wire or cable) or unguided type (wireless). Mobile communication is a type of wireless communication which is used for transfer of information over long distances without the use of physical electrical conductors [1].

Network throughput is the key critical norm in performing and evaluating network effectively for communication that has direct impacts on end-user experience in form of data services [2], but network throughput is the rate of successful data delivery over a communication channel both in the forward and backward direction and this amount of data processing on the channel and the bandwidth have a significant influence on the network performance and the energy consumed. [3], [4].

There have been a substantial increase in the number of wireless users and applications; this tremendous increase in the number of wireless users, as well as the evolution from rudimentary communication services to more sophisticated and quality-sensitive applications, requires the care design of mechanisms and policies to improve the network performance at all the layers protocol stack [5]. In order to design mechanism capable of improving network throughput capacity and capabilities, such as desirable download and upload rate; it is highly fundamental to have accurate measurement and analysis of the system conditions.

The third Generation (3G) mobile communications systems were developed in order to have higher bit-rate services that enable high-quality images and video to be transmitted, and to provide access to Internet with higher data rates. A 3G standard is the Universal Mobile Telecommunications System (UMTS) which boosts considerable data usage; UMTS data growth is driven by high-speed ratio capability, flat-rate pricing schemes, and simple device installation, and its introduction has marked the transition of mobile communications from voice dominated networks to packet-data ones [6].

In addition, studies have shown that mobile data services are penetrating mobile markets rapidly; mobile subscribers rely heavily on data services to ease the performance of daily activities; and with the evolution of the wireless technology; reliable packet service network is critical to the mobile operators to maintain their core competence in data service market [7].

The remaining of this paper is organized as follows. In the second section we present the related concept by discussing the architecture of UMTS network and some related research work. Third section gives a detail approach on the methodology employed to conduct the research. In the fourth section we show the result and discussed upon. Finally, the last section provides concluding remarks and possible future work.

II. RELATED CONCEPT

A. Scope of UMTS Network

The UMTS network architecture standardized by the 3GPP TS 25.401[8] distinguishes the UMTS access network, i.e., the UMTS Terrestrial Radio Access Network (UTRAN), and the UMTS core network. Although research conducted by [9] and [10] classified UMTS network into three main sections: core network (CN), UTRAN and Mobile Station (MS) [11] as shown in Fig. 1. The UTRAN provides all of the functions related to the radio network. CN is the heart of the mobile communication networks; by processing all the voice and data services related functions in the UMTS core system and also implementing the switching and routing functions with

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external networks entity. CN provides capabilities such as: mobility management, call and session control, and billing and security. The CN is further classified into Circuit Switch (CS) domain and Packet Switched (PS) domain [12], [13].

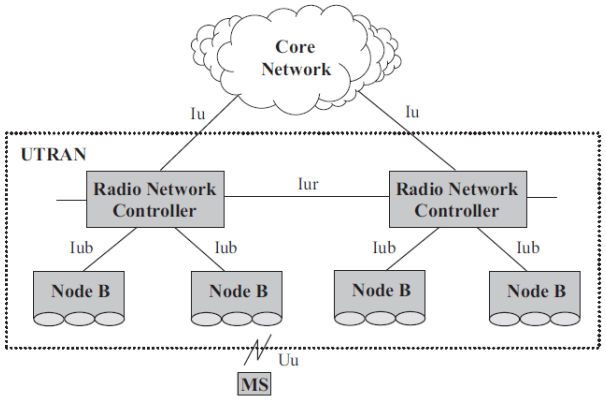

Figure 1: Architecture of UMTS Network [14](Lindemann *et al.* 2002).

Multiple access such as Time Division Multiple Access (TDMA) - different users communicate during different times but on the same frequency -, Frequency Division Multiple Access (FDMA) - different users communicate over different frequencies but during the same time - and Code Division Multiple Access (CDMA) - each user has a spreading code which is used to transform the signal before it is transmitted, on reception the original signal can be received using the same code again. The users transmit using the same time and frequency but with different codes- are implemented in mobile network to allow several users to have access to the mobile network. In UMTS a special version of CDMA is used known as Wideband Direct-Sequence CDMA (WCDMA) [15].

B. Related Works

Several studies have been put forward to evaluate the performance of UMTS networks which are usually performed on the basis of what type of UMTS network performance they studied, where and how the measurement they studied are performed. In this work we carried out a field measurement of the download and upload rate of UMTS network from users devices.

Authors of [16] and [17] performed an experiment on a UMTS operator by collecting data from the provider to evaluate their performance, although there occurs to be success in debugging the infrastructure components latency but from this perspective user satisfaction cannot be actually ascertain. [18] measured the throughput, delay, and jilters of HSDPA and WCDMA networks operators in Finland using laptop; a single provider was also considered for each network making difficult for users to make decision on which network to consider for their mobile broadband (MBB) activities.

Also [19], [20] and [21] performed an active measurement at user ends for a single operator to study the TCP performance in CDMA2000 networks; which is a variant of UMTS network used in United State of America (USA). In addition [20] goes further to investigate the steady-state TCP performance over CDMA 1x EV-DO downlink/uplink for a Korean Operator.

Conversely, [22] investigate the performance of three Norwegian operators by conducting active measurement at the user end devices studying the impact of the packet size on the minimal one-way delay for uplink 3G mobile network; the limitation of the study is that they only consider forward direction (upload).

Furthermore [23] conduct an experiment on the University of Ilorin Main Campus to show the characteristics of 3G UMTS networks by comparing the performance of three selected operators and they established that from the data collected; there is need for considerable improvement for the operators to improve the users' satisfaction by increasing the size of their data rate. This research is a follow-up of that study which differs from existing related work because the study is normalization, continuous, iterative data gathered from user devices. In contrast, some existing studies collected network traffic from cellular infrastructure and most time it is limited to a single operator hindering ability to conduct meaningful comparisons between operators [16], [17].

III. METHODOLOGY

University of Ilorin cited in Ilorin city, Kwara State, Nigeria is the study location which lies within latitude 8.48^o N and 8.49^o N and longitude 4.44^o E and 4.54^o E. It covers an approximated land mass of 5000 hectares. It is characterized by complex terrain due to presence of hills and valleys and forest within the Campus. The University possess a staff strength of about 4, 474 with over 48, 000 undergraduate and over 5, 000 postgraduate students [24]. The points were selected labelled X (8^{o}28'46.24" N and 4^{o}40'24.73" E) Y (8^{o}29'1.26" N and 4^{o}40'28.19" E) and Z (8^{o}29'1.38" N and 4^{o}40'17.68" E). Also three network operators named A, B and C are chosen for the study.

The materials used to conduct the research includes three Infinix T627 android smart phones with three GSM SIM cards which served as the gateway in accessing the network service providers, the RantCell App for measuring and obtaining the download and upload rate of a UMTS GSM network, a Global Position System (GPS) for obtaining coordinates as well elevation of the study location. A Personal Computer (PC) was also used to import the data measured by the Infinix T627 smart phones.

Two scenarios were considered for the measurement. The first case called the morning phase, measurement was carried out at 12 am and 7 am with measuring equipment at the three selected locations. In this case the download and upload rates of the three service providers were measured for thirty days. The objective was to obtain an average download and upload rate of the service provider for better evaluation. In the second case called the afternoon phase, measurement was conducted at 12 noon and 4 pm with the measuring equipment. The download and upload rates were also measured and recorded and there after imported to a PC. For unbiased, independent and reliable data, several tests were conducted in different days, at selected time on the study location. Fig. 2 shows the flowchart for the data acquisition for the experimental procedures used to conduct the study.

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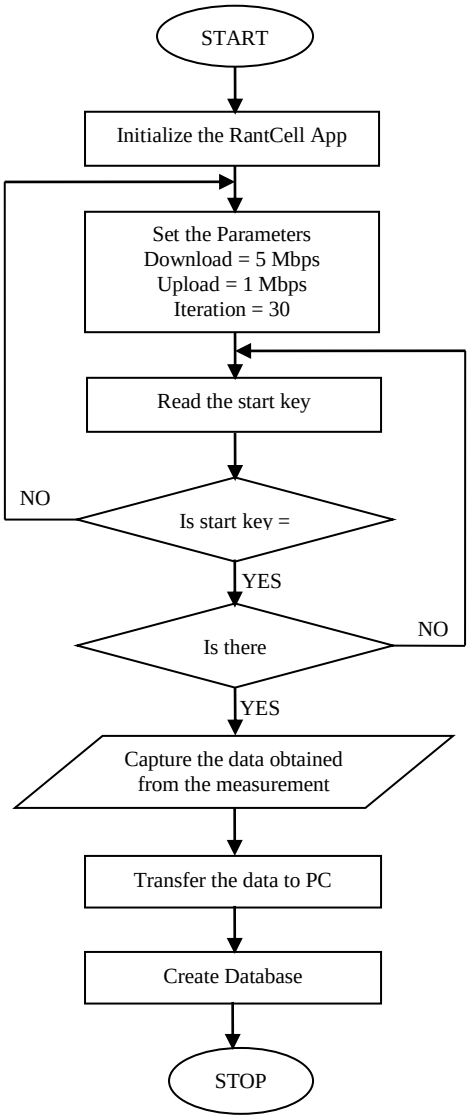

Figure 2: Data Acquisition Flowchart

The z-Normalized Download Rate (NDR) and z-Normalized Upload Rate (NUR) were calculated using equ. (1) and (2) respectively

$$NDR = \frac{384 - \bar{x}}{\sigma} \quad (1)$$

$$NDR = \frac{144 - \bar{y}}{\sigma} \quad (2)$$

$\bar{x}$= *average download mean*
$\bar{y}$ = *average upload mean*
σ = *Standard deviation*

The value 384 is the minimum download rate for a 3G network and at this rate basic internet operation are satisfactory while 144 is the minimum upload rate that also support basic internet operation in the forward direction.

IV. Results and Discussion

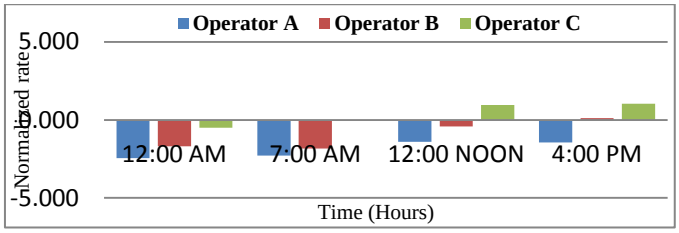

Figure 3: Location X Download Normalized Rate

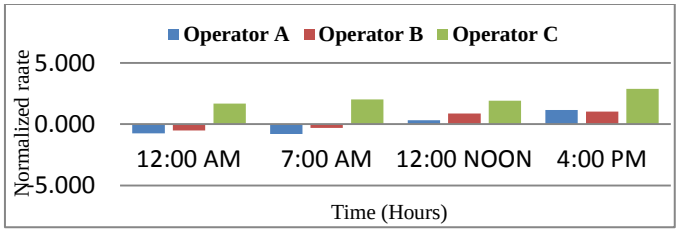

Figure 4: Location X Upload Normalized Rate

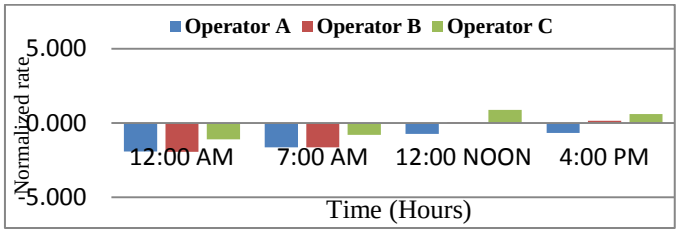

Figure 5: Location Y Download Normalized Rate

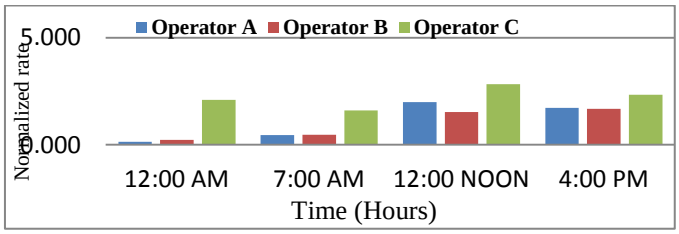

Figure 6: Location Y Upload Normalized Rate

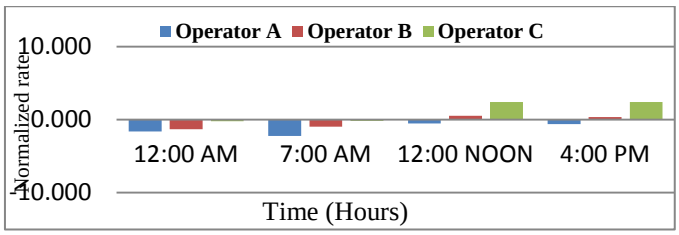

Figure 7: Location Z Download Normalized Rate

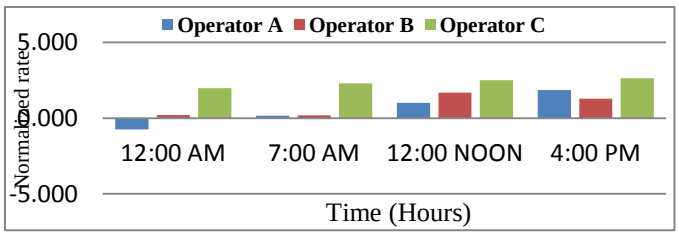

Figure 8: Location Z Upload Normalized Rate

From Fig. 3 through Fig. 8 in terms of the z-normalized rate, Operator A performance is above the minimum value

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quoted for the network because it has a higher negative value of normalized rate but this also decreases along the period of measurement; in the morning phase the value is high partly due to a low number of users on the university campus while there is a decrease in the afternoon phase value. The upload normalized rate is mostly poor for all operators for all period of measurement. Operator B performance is fairly better in terms of download while Operator C performance is worst during all selected period of measurement.

V. CONCLUSION

In this report, we devise a methodology to accurately measure UMTS wireless network throughput in terms of upload and download rate at user end. To demonstrate effectiveness and efficiency of the proposed methodology, 30 set iteration measurement were performed at each selected point during each period for a 30 days period in a real UMTS network environment using RantCell android app. The result indicates that not the all the operators have the require throughput expected for a UMTS network. The z-normalized was introduced to compare the measured value with minimum value quoted by 3GPP for such a network and to also break the value into a more visible and concise scale for effective interpretation. For more accurate result and throughput prediction purpose, we suggest that the measurement period should be increased which is highly cost effective or a similar app should be developed and deployed for a longer period measurement.

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