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Self-Similarity and modeling of LTE/LTE-A data traffic

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ABSTRACT

Forecasting and modeling the network traffic can help optimize it further. Extensive work has been done on Self-Similarity of Ethernet and Ad-Hoc networks data traffic as Self-Similar time-series can be forecasted. This work emphasizes the Self-Similarity of fast growing LTE and LTE-A networks which was left un-explored. It demonstrates Self-Similarity in live LTE and LTE-A networks data traffic. The degree of Self-Similarity is also evaluated and compared. Traffic modeling is very important in optimizing the network with efficient utilization of resources. Modeling of user arrival in live LTE network is performed in this work, which is important since the incoming users are predominantly using data traffic compared to that of traditional voice traffic.

1. Introduction

Long Term Evolution-Advanced (LTE-A) and Long Term Evolution (LTE) are the current trending technologies aimed at providing substantial performance enhancements at reduced cost. The 3rd Generation Partnership Project's (3GPP) LTE represents a major advancement in cellular technology and marks the evolutionary move from third generation (UMTS) to fourth generation mobile technology. LTE is the first cellular communication system supporting packet optimization radio access technology with high data rates and low latencies. Thus, data constitutes to be the pre-dominant traffic when compared to other traditional modes of traffic like the voice.

The statistical characteristics of network traffic have been of interest to researchers for many years, not least to obtain a better understanding of the factors that affect the performance and scalability of large systems such as the internet [5]. This Tele-traffic knowledge of statistics including queuing theory, the nature of traffic, their practical models, their measurements and simulations to make predictions and to plan telecommunication networks helps in providing reliable services at lower cost. To achieve this, modeling of real world traffic can help us understanding the network better and emerging concept of self-similarity can help us in forecasting the traffic better than before.

Self-Similarity is an important concept that, in a way, it is surprising that only recently it has been applied to data communications traffic analysis [8]. This concept helps in forecasting data traffic which in turn helps in optimizing the network [4]. So far, only the self-similarity of Ethernet and Ad-Hoc networks data traffic has been explored extensively by finding the evidence of their self-similarity property and also by calculating the degree of self-similarity for these networks, but the recently evolving LTE and LTE-A networks are still unexplored in this aspect [1,10,11]. This piece of work mainly focuses on the unexplored self-similarity property of LTE and LTE-A networks by finding the evidence of self-similarity property in these trending technologies and also by calculating the degree of self-similarity for both of them. Based on these

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findings, a comparison is made with LTE and LTE-A to already explored Ethernet networks in terms of degree of self-similarity and so the network traffic predictability.

Good network traffic modeling is necessary to better understand and utilize the network resources. In Tele-traffic theory, often the arrival process of customers can be modeled by a Poisson process [6]. All the existing works took into account only the traditional voice traffic from users, and concluded that the user arrival is to follow Poisson arrival process [2]. But this arrival process needs to be validated for fast growing LTE networks where user sessions can include either voice or data or voice over data sessions (VoLTE – Voice over LTE). This work answers the so far missing validation by modeling real world LTE traffic on a live network. This helps in better understanding the fast growing LTE network. This work emphasizes the importance of incoming user traffic evaluation in LTE network, which has high data traffic when compared to traditional voice traffic.

The reminder of this paper is organized as follows. In Section 2, we introduce our LTE/LTE-A data collection process and observations. In Section 3, Self-Similarity of LTE/LTE-A Network Traffics study is presented. LTE User Traffic Modeling results are observed in Section 4; and conclusions and future work are provided in Section 5.

2. LTE/LTE-A data collection and observations

Our preliminary analysis is focused on observing the normal traffic trend on a daily basis on a eNodeB level. Hourly data collected for 4 consecutive weeks in October 2014 excluding weekends is averaged to observe the 24 h daily trend for the number of users and also the downlink throughput usage in LTE networks.

The daily trending of the number of active users and the downlink throughput on hourly basis shown in Figs. 1 and 2 respectively observed in eUTRAN network are similar to what has already been observed in UTRAN network [7]. The daily trend observed in [2,3] are considered as base for this analysis. Comparing 3G data from [2] shows that

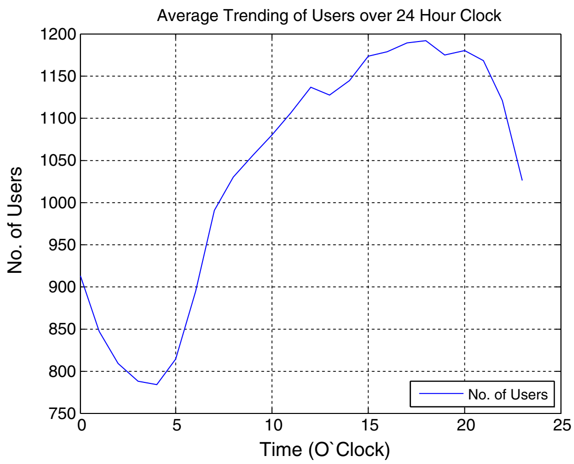

Fig. 1. Trending of LTE Users on 24 h clock.

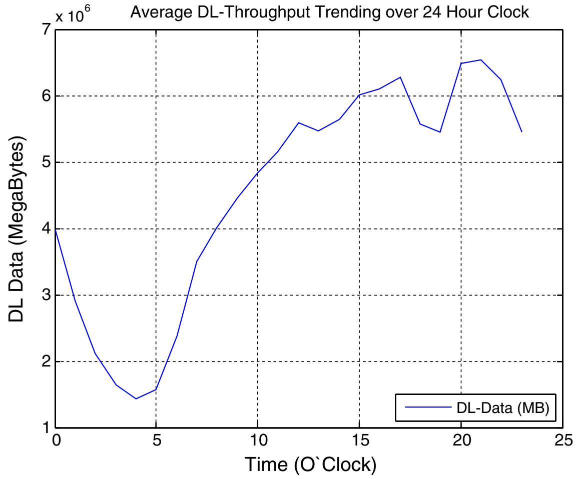

Fig. 2. DL-throughput trending over 24 h clock in LTE.

the average throughput in LTE is much higher when compared to other earlier technologies.

This trending of LTE 'users' and 'data usage' on 24 h clock is considered to be the base of LTE-A daily trending. This signifies that, independent of the wireless technology, user and usage trending patterns can be expected to follow same for all generations in mobile communication systems. The most inactive hour of a day is observed to be around 4 AM and highest active number of users observed during 6 PM–8 PM. The same pattern hold good for the Downlink data usage by the users. It can be expected that the up-coming LTE-A network trending pattern should follow more or less the same.

From this trending, we can observe that 4 AM, 11 AM and 6 PM hours show considerable variation among them in terms of network traffic and so, these timings are preferred to collect data needed for the rest of the work.

2.1. Data collection and constraints

Data sets used for this work are collected from a US based cellular operator's live LTE/LTE-A networks. Data is captured at eNodeB level which contributes to S1/X2 interfaces in LTE system architecture. There is no separation of data sets based on cell sectors. All the data collection is done remotely using an IP traffic collection tool. The captured data includes both the user and control traffic logs. In particular, each data log capture includes all the message header details, type of message, source and destination details of the message and a timestamp associated with the message. The granularity of the data sets is in the resolution of 10 ms. Each traffic packet can be observed with its header details. Each packet has an average size of around 870–880 Bytes. Overall, the data consists of various data traffic log captures with minimum of 10 min duration up to 30 min with 10 ms resolution and with a minimum of 60,000 entries for each data set. All the logs are collected on multiple eNodeBs in Kansas City, MO at various instances of time with normal load traffic conditions on