Traffic Modeling and Characterization for UTRAN

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Abstract. This paper presents an analytical approach for characterizing the aggregated traffic carried in the UMTS Terrestrial Radio Access Network (UTRAN). The characteristic of the incoming traffic stream of UTRAN is studied based on the measured trace traffic from the simulations. The main idea of the aggregated traffic modelling is to employ Batch Markov Arrival Process (BMAP) model as an analytically tractable model, which considers different lengths of packets and batch arrivals. In this paper, the setup and customization of the BMAP model for characterizing the aggregated traffic in UTRAN is presented. The accuracy of the BMAP model is demonstrated by comparing with simulations and Poisson traffic model. At the end the potential application of the presented approach and its advantages is briefly discussed.

1 Introduction

The Universal Mobile Telecommunication Systems (UMTS) network, as a third generation of mobile communication networks, provides high-speed mobile access to a great variety of services in a world-wide scope, including voice, data, video, etc. Nowadays high-speed data transferring becomes the major trend in UMTS network. More and more mobile subscribers access UMTS network to request Internet services such as email, file downloading or web browsing. Therefore, UMTS is characterized by a migration from voice-only network to an integrated services IP network. In this paper, we focus on studying the pure IP traffic. For designing the UMTS network, in addition to fulfill the QoS at the user level, in the UTRAN the Iub interface, which is between the NodeB and the RNC, also has to fulfill the strict delay requirements to guarantee the radio frames to be delivered on time to the air interface. Therefore, the QoS at the UTRAN is also a very critical issue to be specifically considered in UMTS network. An essential step to predict the network performance and the achievable QoS in the UTRAN is to study the properties of the aggregated traffic on the Iub link. In UMTS, a number of mobile users are active in a base station area, i.e. NodeB, each of the users generating different traffic streams related to different applications. The traffic from all users served by the same base station is aggregated and then transported via AAL2/ATM at the Iub link. This aggregated traffic can be seen as superposition of traffic streams of all users. The fundamental idea of traffic modeling lies in building models that can capture the important statistical properties of the underlying measured trace data. For this purpose, an analytically tractable model is preferred to accurately capture the properties of the aggregated traffic on the Iub link.

However, the characterization of the aggregated traffic can not be represented with the simple Poisson traffic model any more, since the Poisson model is typically used for studying the classical telephone networks and it is not able to capture any burstiness or self-similarity properties of the IP traffic.

Several approaches for traffic modeling and characterization for UMTS have been outlined by 3GPP [1]. However, these traffic models are not derived from real measurements or simulations and are not analytically tractable. Recently, Alexander Klemm proposes the BMAP model for the aggregated traffic of UMTS in [2]. However, the parameters of the BMAP model are not derived from the measurements of the existing UMTS system, but obtained by the measured Internet traffic at the ISP dial-in modem/ISDN link with certain scaling procedure, which is used to adapt the bandwidth of the dial-in modem/ISDN links to different bandwidth classes with respect to different radio access bearers available in UMTS. Therefore, this approach is only based on investigating the incoming IP packets but does not take into consideration of the influence of the radio aspects on the air interface and the lower layer protocols like FP, and AAL2/ATM layer in UTRAN. The contribution of this paper is two-fold: First, the characteristic of the aggregated traffic of UTRAN network is analyzed on the basis of the trace data measured from the simulations using a UMTS simulation model built with OPNET. The simulation model comprises all basic radio aspects of UMTS and the measured trace data is the observation of arrivals of radio frames of all users to the UTRAN. Second, the BMAP model is implemented and customized to analyze the aggregated traffic of the UMTS network, which considers the different length of radio frames and arrivals. For customizing the model, the Expectation Maximization (EM) method is used to estimate parameters for the BMAP model.

The remainder of the paper is organized as follows: the next section will give a detailed analysis of the characteristics of the aggregated traffic carried in the UTRAN. Section 3 gives an introduction of the BMAP model. Afterwards we will describe the setup and customization of the BMAP model for single user and multiple users, individually. In section 5, the main results of the aggregate traffic model of UMTS using BMAP are presented and a comparison with simulations and Poisson traffic model is given. The end gives an outlook of potential applications of the presented analytical approach and a discussion on the benefit of using the BMAP model.

2 Aggregated UMTS Traffic Characteristics

The protocol structure of the UTRAN is given in Figure 1. After the data arrives at the RNC from the network, the Radio Link Control (RLC) layer will segment the IP packet into appropriate RLC Packet Data Unit (PDU)s and then pass them to the Medium Access Control (MAC) layer. The MAC layer in the RNC schedules the traffic to the UEs for the air interface. Because data loss and excessive delay at the Iub link will result in retransmissions which leads to a waste of radio resources or capacity, all traffic scheduled for the air interface or received from the air interface has to obey real-time QoS requirements. For the purpose of air interface traffic