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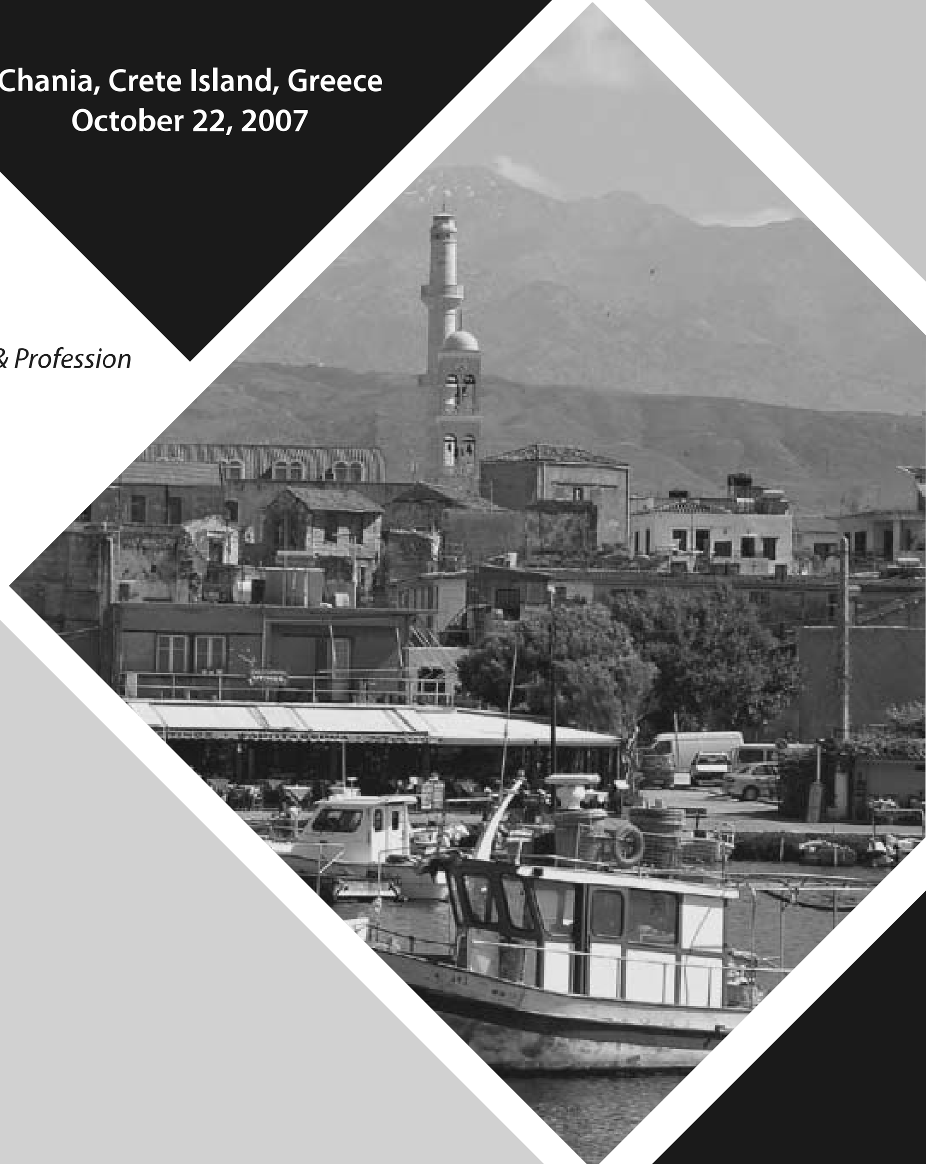

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Session 6: Group Key and Identity Management

Poster Session

QoS Modeling for Performance Evaluation over Evolved 3G Networks

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ABSTRACT

The end-to-end Quality of Service (QoS) must be ensured along the whole network in order to achieve the desired service quality for the end user. In hybrid wired-wireless networks, the wireless subsystem is usually the bottleneck of the whole network. The aim of our work is to obtain a QoS model to evaluate the performance of data services over evolved 3G radio links. This paper focuses on the protocols and mechanisms at the radio interface, which is a variable-rate multiuser and multichannel subsystem. Proposed QoS models for such scenario include selective retransmissions, adaptive modulation and coding, as well as a cross-layer mechanism that allows the link layer to adapt itself to a dynamically changing channel state. The proposed model is based on a bottom-up approach, which considers the cumulative performance degradation along protocol layers and predicts the performance of different services in specific environments. Numerical parameters at the physical layer resemble those proposed for 3GPP Long Term Evolution (LTE). By means of both analytical (wherever possible) and semi-analytical methods, streaming service quality indicators have been evaluated at different radio layers.

ACM Categories and Subject Descriptors

C.4 [**Computer Systems Organization**]: Performance of Systems – *Modeling techniques.*

General Terms

Performance, Algorithms, Measurement.

Keywords

Performance Evaluation, Quality of Service, QoS Modeling, Multiplexing algorithms, LTE, Radio Interface.

1. INTRODUCTION

The QoS experienced by the end user results from a combination of features through the complete protocol stack and over all the components of the entire system. Thus, an assessment of service performance requires analyzing the performance of the whole network. However, the wireless subsystem is usually the bottleneck of the network, since radio bandwidth is low, packet delay is large and the number of errors is high compared to those of wired networks.

This paper focuses on the protocols and mechanisms at the radio interface. A number of papers have recently dealt with the performance evaluation of QoS-scheduling techniques at the radio interface ([1], [2]). Only a few of these works include cross-layer proposals for QoS management over wireless networks ([3], [4]) or describe a general framework for end-to-end QoS control [5]. Moreover, generally the end-to-end performance has been assessed through indicators that are too service dependant, such as response time in web browsing scenarios or file download mean throughput [6].

The analyzed protocol stack includes a cross-layer mechanism that allows the link layer to adapt itself to a dynamically changing channel state. Other mechanisms like adaptive modulation and coding, selective retransmissions and header compression are also considered. We pay special attention to the user multiplexing algorithms and selective retransmission mechanism at the radio link. The proposed model is evaluated for mobile terminals connecting to a streaming server.

The remainder of this paper is organized as follows. The general system model is outlined in section 2. In section 3, a detailed QoS model for the PHYsical (PHY) and Medium Access Control (MAC) layers is provided. Section 4 analyzes the main functionalities at Radio Link Control (RLC) and Packet Data Convergence Protocol (PDCP) layers. Finally, section 5 presents the main conclusions of this work.

2. SYSTEM MODEL

This section presents the general scenario and protocol stack under analysis. This work focuses on the downlink performance along radio protocols below IP, including the PHY, MAC, RLC and PDCP layers (as shown in Figure 1).

dividing R_{L2b} by the average size of an $L2c$-PDU. If the header compression factor is f_c, the amount of data really transmitted must be increased by $(H_{L3}+H_{L4})\cdot(1-f_c^{-1})$, where H_{Li} is the Li-PDU header size. D_{a_j} represents the average delay to send the j $L2b$-PDUs scheduled for (re)transmission in one cycle.

Figure 4 shows the user throughput and the delay results at the PDCP layer for N_{rtx}=3. Comparing delay results at this layer with those at the MAC layer (Figure 3), there are two main factors which explain the delay increment: RLC retransmissions and PDCP reassembly.

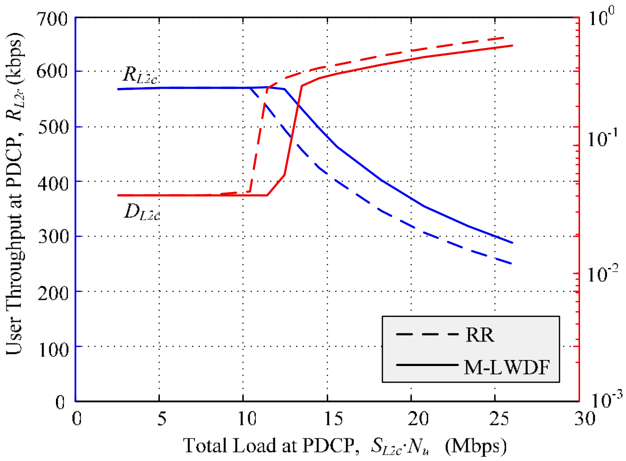

Figure 4: Mean user throughput and delay at PDCP layer

A comparison between source rate and achieved throughput at each layer is shown in Figure 5 for the M-LWDF multiplexing algorithm. The following effects can be observed at layer *i*:

L2a) Mean MAC layer throughput, R_{L2a}, is rapidly degraded above a certain *critical load* point (about 12 Mbps with the scenario settings) due to the impossibility of the radio multiplexer to allocate the required resources to all users.

L2b) RLC layer introduces an additional performance degradation to the RLC throughput (R_{L2b}) due to the retransmission mechanisms, as established in equation (3).

L2c) The use of ROHC decreases the resources needed at lower layers. Hence, after decompression, the PDCP layer may achieve a higher net throughput than lower layers.

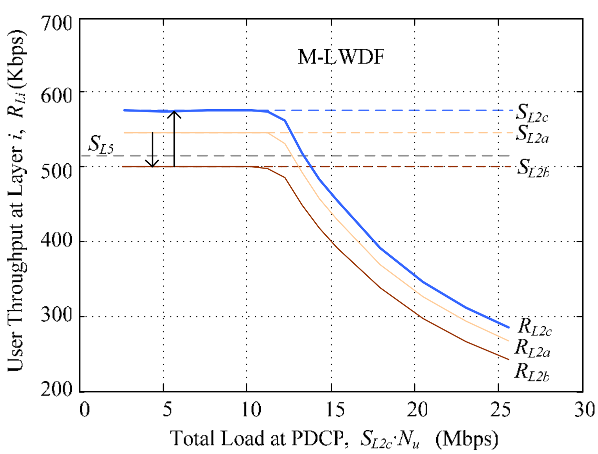

Figure 5: User throughput at different radio layers

5. CONCLUSIONS

In this paper, we have described a QoS model for an evolved 3G radio interface. Such a model provides a clear understanding of the main factors impacting the radio link performance, showing the difference between QoS needs at different layers. We have provided a detailed characterization of the air interface protocol stack, offering a tractable methodology to understand and evaluate the QoS.

The model presented in this paper allows to implement QoS mappings between layers in order to provide seamless streaming services over heterogeneous wireless networks. It could also be useful in areas such as admission control and resource reservation. The framework applied in this work for streaming over LTE technology can be extended to other services (e.g. VoIP) and radio technologies (e.g. WiMax).

Our performance analysis obtains an estimation of the achievable throughput at a particular protocol layer under a certain network load. The multiplexing algorithm at MAC layer has been proved to determine the maximum achievable system throughput, while the maximum number of RLC retransmissions is a key issue to assure the desired reliability at higher layers.

6. ACKNOWLEDGMENTS

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