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Computer Networks 49 (2005) 325–340
Computer Networks
www.elsevier.com/locate/comnet

High Speed Downlink Packet Access (HSDPA)—Enhanced Data Rates for UMTS Evolution

Ingo Forkel [a,b,*], Hartmut Klenner [a,b], Andreas Kemper [a]

[a] *Chair of Communication Networks, RWTH Aachen University, Germany*
[b] *P3 Solutions GmbH, Aachen, Germany*

Available online 4 June 2005

Abstract

The increasing demand for capacity in order to provide high data-rate multimedia services in wireless environments necessitates enhanced radio transmission techniques and network protocol functionality. Such techniques have to be added to already existing mobile cellular networks, e.g., as provided by *Enhanced Data Rates for GSM Evolution* (EDGE). For 3rd generation UMTS networks based on WCDMA, *High Speed Downlink Packet Access* (HSDPA) is being introduced to meet this demand and to improve spectral efficiency. This technique is based on well-known *Link Adaptation* (LA) by using various modulation and coding schemes and with this realising several different data rates for downlink transmission. Moreover, fast scheduling techniques based on shortened radio frames enable efficient and flexible sharing of the radio resources among different users and services. This article gives a detailed overview on the integration of HSDPA in UMTS networks and provides a detailed performance evaluation for a realistic scenario comprising a multi-cellular environment with various types of applications.

Keywords: HSDPA; UMTS; WCDMA; Network Performance; Link Adaptation

1. Introduction

The success of 3rd generation wireless cellular networks is mainly based on an efficient provisioning of the expected wide variety of services requiring different *Quality of Service* (QoS) with respect to data rate, delay and error rate. Especially high-speed, high data-rate applications are seen as the most promising tenor of a potential 3rd generation *Universal Mobile Telecommunications System* (UMTS) success story [1].

In order to improve support for high data-rate packet-switched services, the *3rd Generation Partnership Project* (3GPP) is currently developing an evolution of UMTS based on *Wideband Code*

* Corresponding author. Tel.: +49 241 80 27915; fax: +49 241 80 22242.
E-mail address: ingo.forkel@ieee.org (I. Forkel).
URL: www.comnets.rwth-aachen.de/~ifl (I. Forkel).

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doi:10.1016/j.comnet.2005.05.012

Division Multiple Access (WCDMA) known as *High Speed Downlink Packet Access* (HSDPA) which is included in the Release 5 specifications. HSDPA is targeting increased capacity, reduced round trip delay, and higher peak data rates up to 10 Mbps. To achieve these goals, a new shared downlink channel, called the *High Speed Downlink Shared Channel* (HS-DSCH) is being introduced. In addition, three fundamental technologies are foreseen, which are tightly coupled and rely on rapid adaptation of the transmission parameters to the instantaneous radio conditions. Fast link adaptation techniques based on multiple *Modulation and Coding Schemes* (MCS) enable the use of spectrally efficient higher order *Quaternary Amplitude Modulation* with 16 states (16 QAM) when channel conditions permit. Alternatively, these revert to conventional and more robust *Quaternary Phase Shift Keying* (QPSK) modulation for less favourable channel conditions. Fast *Hybrid Automatic Repeat Request* (HARQ) algorithms rapidly request the retransmission of missing data entities and combine the soft information from the original transmission and any subsequent retransmissions before another attempt is made to decode a data packet. Fast scheduling shares the HS-DSCH among the users. This technique, which exploits multi-user diversity, strives to transmit to users with favourable radio conditions. Moreover, the time interval considered for scheduling is no longer based on radio frames of 10 ms but shortened to a 2 ms interval in FDD-mode and 5 ms interval in TDD-mode.

The different aspects of HSDPA in UMTS are explained in Section 2. In the remainder, modulation and coding schemes as defined for HSDPA are described in Section 3. Section 4 highlights the realisation of the HS-DSCH and its control channels. Results of a simulative performance evaluation are given in Section 5 and Section 6 finally concludes this paper.

2. HSDPA in WCDMA UMTS

HSDPA is essentially modifying the existing protocol architecture, which affects different protocol layers as illustrated in Fig. 1 according to the *Medium Access Control* (MAC) layer specification in [2].

Foremost, the *Physical Layer* (PHY) at the Uu-interface has to be enhanced to enable data rates up to 10 Mbps. This can be realised by means of fast link adaptation using *Adaptive Modulation and Coding* (AMC), which has to be implemented within both, the *User Equipment* (UE) and the Node B. Complementary to the increased PHY capabilities, a specialised *MAC high speed* (MAC-hs) entity with enhanced control functionalities has to be set-up on top in both, UE and Node B. It provides HARQ mechanisms and fast scheduling, facilitating the efficient usage of the radio resources in adaptation to the instantaneous channel conditions and network load. The performance of HSDPA MAC protocols is discussed in, e.g., [3]. In addition to the protocols located at the

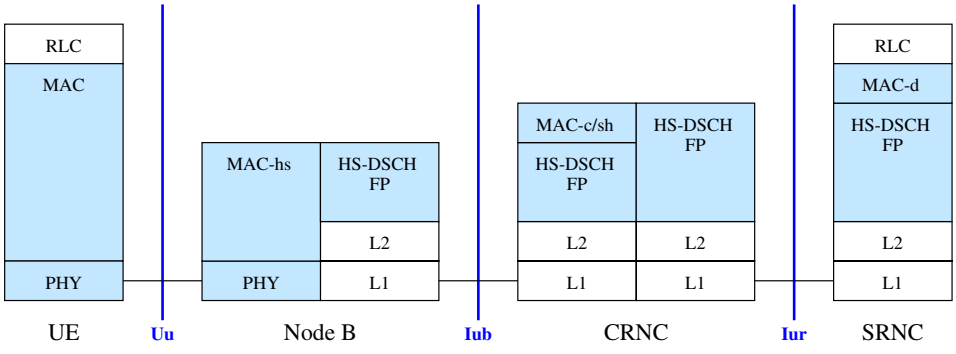

Fig. 1. HSDPA protocol architecture, modified parts highlighted.