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High Speed Packet Access Broadband Mobile Communications

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INTRODUCTION

Mobile broadband communications systems have already become a fact during the last few years. The evolution of 3G Universal Mobile Telecommunications Systems (UMTS) towards HSDPA/HSUPA systems have already posed a forceful solution for mobile broadband and multimedia services in the market, making a major step ahead of the main competitive technology, that is, WiMax systems based on IEEE 802.16 standard. According to the latest analyses (GSM Association, 2007; Little, 2007), while WiMax has gained considerable attention the last few years, HSPA is expected to dominate the mobile broadband market. The main reasons behind this forecast are:

- HSPA is already active in a significant number of operators and is going to be established for the majority of mobile broadband networks worldwide over the next five years, while commercial WiMax systems are only making their first steps.
- Mobile WiMax is a competitive technology for selection by operators in only a limited number of circumstances where conditions are favourable. Future mobile WiMax systems may potentially achieve higher data transfer rates than HSPA, though cell coverage for these rates is expected to be substantially smaller. In addition, WiMax technology is less capable in terms of voice traffic capacity, thus limiting market size and corresponding revenues.
- In order to overcome the aforementioned disadvantages, WiMax commercial launches are expected to introduce a relative CAPEX disadvantage of at least 20–50% comparing to HSPA, in favorable cases, while there are indications of an increase by up to 5–10 times when accounting for rural areas deployments.

The short commercial history of HSDPA (based on Rel.5 specifications of 3GPP) started in December of 2005 (first wide scale launch by Cingular Wireless, closely followed by Manx Telecom and Telekom Austria). Bite Lietuva (Lithuania) was the first operator that launched 3.6 Mbps. HSUPA was first demonstrated by Mobilkom Austria in November 2006 and soon launched commercially in Italia by 3 in December 2006. Mobilkom Austria launched the combination of HSDPA at 7.2 Mbps and HSUPA in February 2007. By September of 2007, less than two years after the first commercial launch, 141 operators in 65 countries (24 out of 27 in EU) have already gone commercial with HSDPA with 38 operators among them supporting a 3.6 Mbps downlink. In addition, devices supporting HSDPA/HSUPA services are rapidly enriched. 311 devices from 79 suppliers have already been available by September 2007, including handsets, data cards, USB modems, notebooks, wireless routers, and embedded modules (http://hspa.gsmworld.com).

WIDEBAND CODE DIVISION MULTIPLE ACCESS (WCDMA) IN 3GPP R'99 AND REL.4

Air Interface Description

WCDMA frequency division duplex (FDD) has been established as a mature technology during the last few years through 3G mobile communications commercialization. In UMTS, WCDMA is implemented with direct sequence (DS) technique, which is based on multiplication of the information symbols with faster codes (spreading process) with low cross-correlation. The number of code pulses (chips) used for spreading each information symbol is called spreading factor (SF). Spreading is realized through channelization and scrambling. Channel symbols are spread by the channelization code (orthogonal Hadamard codes) and then chip by chip multiplication with the scrambling code takes place. The chip rate of both channelization and scrambling codes is constant at 3.84 Mchip/s.

In uplink, each user is assigned a unique scrambling code. Channelization codes are used for separating data and control streams between each other. Parallel usage of more than one channelization codes for high uplink data rates (multicode operation) is allowed only with SF=4 but has not been commercially applied in R'99 and Rel.4 realizations. Downlink separation is twofold: Cells are distinguished between each other by using different primary scrambling codes (512 available) while users in each cell are assigned a unique orthogonal channelization code. The same channelization code set is used in every cell in downlink and every user in uplink. In order to achieve various information rates (by different SF length ranging from 4 to 256) while preserving orthogonality, the channelization codes form an orthogonal variable spreading factor (OVSF) code tree. While codes of equal length are always orthogonal, different length codes are orthogonal under the restriction that the longer code is not a child of the shorter one (Figure 1).

Source information arrives in transmission time intervals (TTI) of 10, 20, 40, or 80 ms. Information bits are organized in blocks and CRC attachment, forward error correction (FEC) coding, rate matching, interleaving, and information multiplexing are applied (Holma, 2002). FEC can be convolutional of rate 1/2, 1/3, or turbo of rate 1/3, depending on the information type. Transmission of dedicated channels (DCH) is organized in frames of 10 ms (38400 chips), consisting of 15 timeslots (TS). Each TS contains user information data (DPDCH) and physical layer signaling (DPCCH) (3GPP TS 25.211, 2007-05), as shown in Figure 2. DPDCH and DPCCH are quadrature multiplexed before scrambling in uplink and time multiplexed in downlink. Modulation at the chip level is quadrature phase shift keying (QPSK) in both uplink and downlink and demodulation is coherent. The occupied bandwidth is 5 MHz for both uplink and downlink.

Physical Layer Procedures

The most important new procedures defined for WCDMA are soft handover and power control. Soft handover is the situation when a mobile station (MS) communicates with more than one cell in parallel, receiving and transmitting identical information from/to the cells. Combination of cells' signals takes place in MS RAKE receiver in downlink and in the base station RAKE (in the softer case) or in the RNC (signal selection through CRC error counting) in uplink. Soft handover results in enhanced quality reception in cell limits and reduces interference. The drawback is the

Figure 1. Example of OVSF channelization code tree usage