Highspeed Packet Access (HSPA)

Tobias Glocker, University of Vaasa

p87915@student.uwasa.fi

1. INTRODUCTION

HSPA has been designed to enhance the data packet traffic transmission on both uplink and downlink. It is an evolution of the existing 3rd Generation Partnership Project (3GPP) Wideband Code Division Multiple Access (WCDMA) Release 99 (R99) standard. Furthermore, it increases throughput and capacity. With HSPA the delay of the system could be reduced and higher instantaneous per user data rates are possible. Both High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA) use Hybrid Automatic Repeat Request (H-ARQ) for recovering erroneous packets. In addition, the scheduler was moved from the Radio Network Controller (RNC) to the Node B to achieve a faster scheduling and a shorter Transmission Time Interval (TTI) of 2ms is used. The Soft Handover (SHO) is only supported in HSUPA. In HSPDA the Adaptive Modulation and Coding (AMC) is applied to adapt the modulation rank and coding rate to the radio channel condition of each user. (Zaki, Weerawardane, Li, Timm-Giel & Malafronte 2008.)

2. SERVICE REQUIREMENTS FOR VOICE OVER INTERNET PROTOCOL (VoIP)

Service requirements for VoIP are set by the mobile circuit switched services (CS) available today. The most important services are quality, coverage and capacity. A CS speech service has a high quality when the end-to-end delay is less than 220ms and if the speech frame loss is not higher than 2%. Not only the optimization of the radio network performance is essential but also the nodes in the chain that are shown in **Figure 1**. The delay time within these network node chain should be kept low. (Wänstedt, Ericson, Sandlund, Nordberg & Frankkila 2006.)

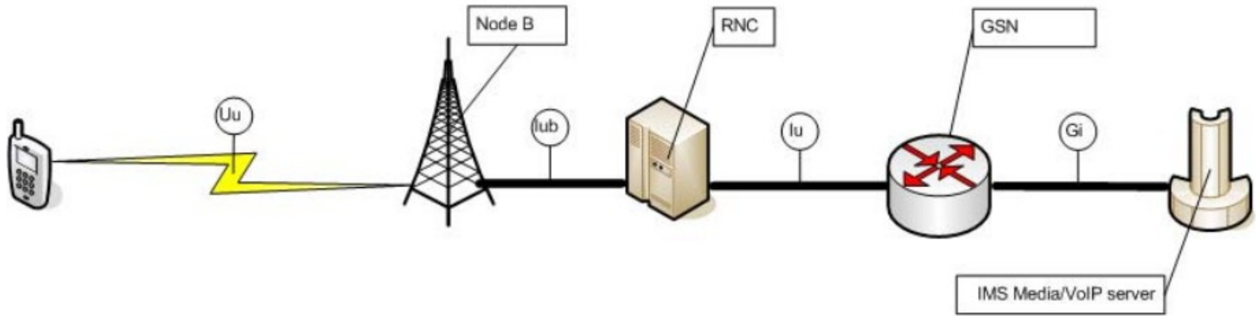

Figure 1. Network nodes (Wänstedt et al. 2006).

3. HSPA REALIZATION FOR VoIP

In chapter 2 the service requirements for VoIP were discussed. We know that VoIP as a real-time service requires the transmission and reception within a reasonable time. The following sections describe methods that improve the speech quality, the reliability and the throughput in a HSPA network.

3.1 Multiple Input Multiple Output (MIMO)

For increasing the data rates it is necessary to have multiple parallel transport blocks to a single user. This can be achieved with multiple antennas on the transmitter and the receiver side which is often referred to MIMO. (Peisa, Wager, Sågfors, Torsner, Göransson, Fulghum, Cozzo & Grant 2007.)

Figure 2 illustrates a common structure of MIMO schemes in a TD-HSPA+ System in which the base station (BS) and the user equipment (UE) are both equipped with two antennas. The data flow is demultiplexed into two data streams each with a lower rate at the BS side. Depending on the channel condition of each transmission antenna, different modulation and coding schemes (MCS) can be applied. If it is necessary the two data streams can be precoded before they are spread, scrambled and mapped to the two transmit antennas. Through the MIMO detector the UE has the possibility to separate different data streams and it can measure the channel quality of each transmit antenna. The channel quality information is then fed back to the BS. (Hu, Li, Peng & Wang 2009.)

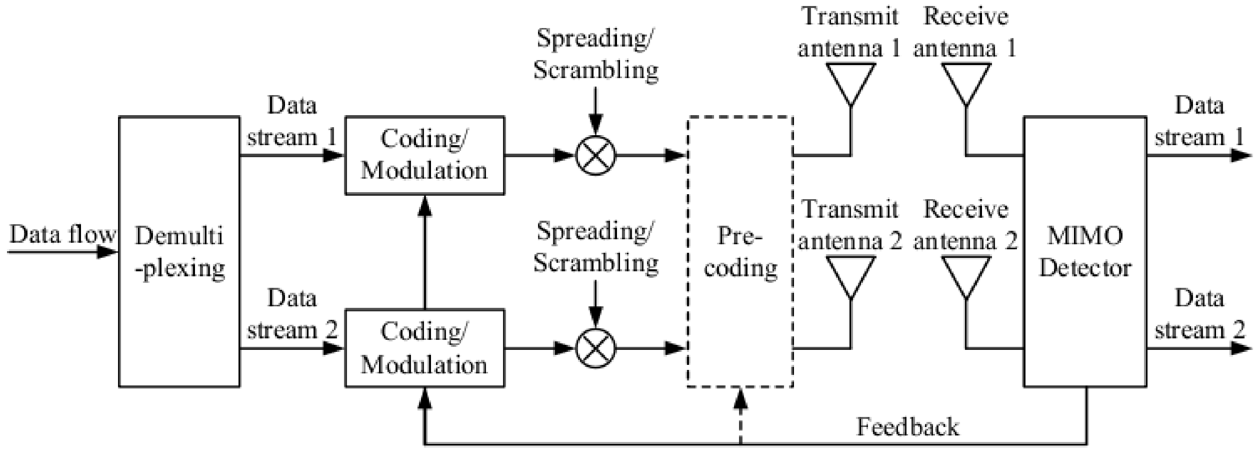

Figure 2. Common structure of MIMO schemes in TD-HSPA+ system (Hu et al. 2009).

3.2 Hybrid Automatic Repeat Request (H-ARQ)

Error control in R99 provides retransmission at the Radio Link Control (RLC) level while HSPA adds the capability for retransmission at the physical layer under the control of Node B. This leads to the advantage that many errors can be corrected quickly because the RLC and the Radio Network Controller (RNC) are not needed in this process. HSPA uses H-ARQ retransmission method which is a step beyond the traditional ARQ Approach. The receiver rejects an erroneous message and sends a retransmission request. In comparison to the traditional ARQ, the H-ARQ does not assume that a correct message after a number of retransmission attempts will be received. Hence, it makes use of all received transmissions to recover the original message. HSPA uses turbo coding for error correction. The coding bits are sent with the data bits. To avoid that the whole packet needs to be retransmitted, H-ARQ can be configured so that only the coding bits are transmitted again (Mulvey 2007.)

3.3 Internet Protocol (IP) Header Compression

A full Internet Protocol version 6 (Ipv6) header together with Real-Time Protocol (RTP) / User Datagram Protocol (UDP) header contains 60 bytes while the size of a voice packet is only 30 bytes. This means that 2/3 of the packet data are just used for storing header information. To improve the efficiency of VoIP traffic in HSPA, it is necessary to compress the header. With the robust header compression (ROHC) method it is possible to push the header size down to a few bytes. **Figure 3** displays the benefit of a Robust IP header compression. (Holma, Kuusela, Malkamäki, Ranta-aho & Tao 2006.)

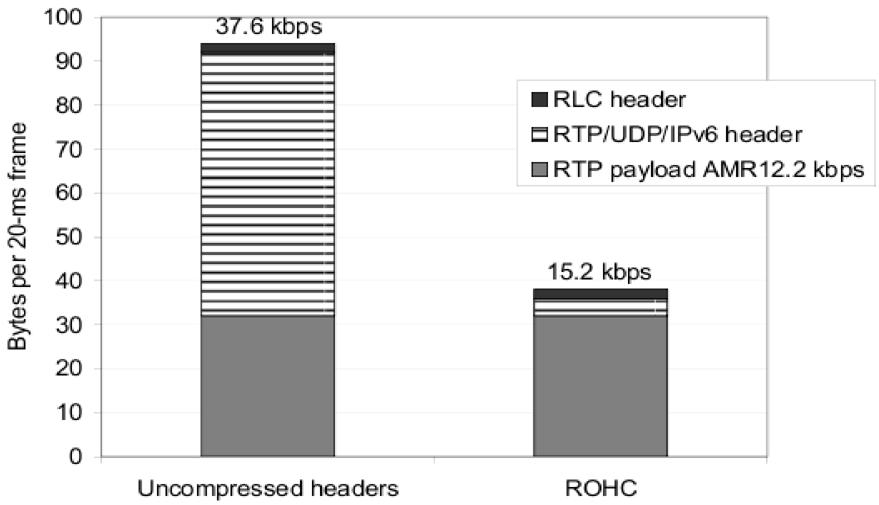

Figure 3. Benefit from Robust IP header compression (ROHC) with 12.2 kbps VoIP (Holma et al. 2006).

3.4 Scheduling

Scheduling schemes are very important in HSPA systems. The goal of the packet scheduler is to satisfy the Quality of Service (QoS) of the users by maximizing the network throughput. In the non-scheduled mode, the UE has to decide when and how much data it transfers to Node B. Since there is a mixed traffic in the network, the scheduling of different UEs should be priority based. Traffic with lower priority is scheduled only when there is no higher priority traffic in the queue of the scheduler. (Rui, Min, Ericson & Wänstedt 2007.)

In the downlink (HSDPA) the scheduling algorithm can take advantage of the instantaneous channel variations and can temporarily raise the priority of the favorable users.

Fairness plays a very essential role in scheduling. There are three basic degrees of fairness. The carrier to interference ratio (C/I) based scheduling is based on a C/I policy of users that have the best radio channel conditions in the resource allocation process. This strategy maximizes the system capacity but users with a poor radio channel are only served when users with a better channel quality have no data to transmit. Another scheduling strategy is called “Fair Resources” where the cell resources (codes, power and allocation time) is equally distributed among all users in the cell. In comparison to the C/I based scheduling strategy this strategy shares the resources equally. The aim of the so called “Fair Throughput” scheduling is to give all users the same throughput regardless of their channel quality. It is a form of inverse C/I scheduling because users with a lower C/I must allocate more resources to get the same amount of throughput. (Gutiérrez 2003: 73-74.)

3.5 Higher order modulation

The 6th release supports the use of 16 Quadrature Amplitude Modulation (QAM) in the downlink and Quadrature Phase Shift Keying (QPSK) in the uplink. These modulation schemes should provide satisfied data rates.

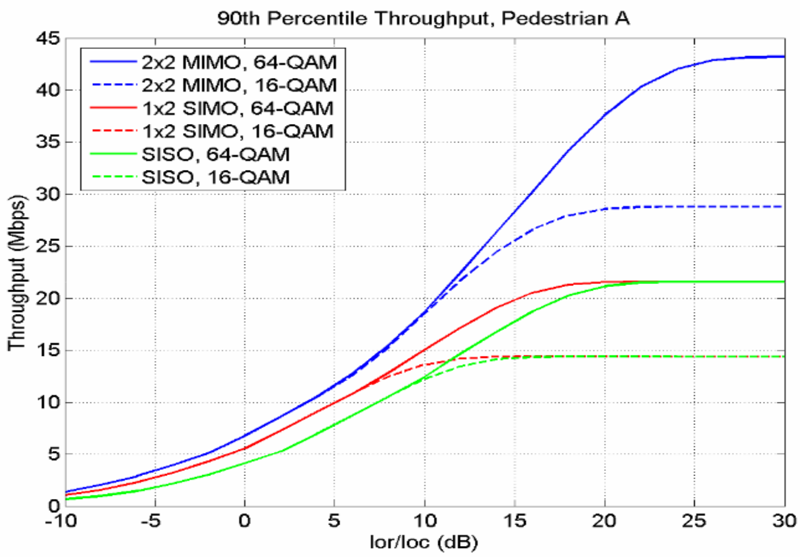

Figure 4. 90th percentile throughput in Pedestrian A channel for Higher Order Modulation (HOM) and MIMO (Peisa et al. 2007).

Figure 4 represents the 90th percentile throughput of the downlink for 1000 realizations of the Pedestrian A dispersive channel. MIMO with 16QAM doubles the peak rate to 28.8 Mb/s, while the combination of MIMO and 64QAM increases the peak rate to 43.2 Mb/s. (Peisa et al. 2007.)

4. CONCLUSION

HSPA is a mobile broadband technology applied in many commercial networks. It offers very good voice services and broadband speeds that meet the expectations of the users. It is built on the firm foundation of the 3GPP family. Existing Global Systems for Mobile Communication (GSM) / WCDMA are functioning with HSPA. In combination with dual-mode terminals this technology ensures nationwide coverage for voice (GSM/WCDMA) and data (HSPA/Enhanced Data Rates for GSM Evolution (EDGE)). The main advantage of HSPA is that it offers a single network for multiple services like Short Message Service (SMS), Multimedia Messaging Service (MMS) or voice.(Ericsson 2009.)

Evaluations show that VoIP over HSPA has the potential of matching or exceeding CS speech capacity and coverage. In the future HSPA will be the best choice for mobile broadband services.

REFERENCES

Ericsson (2009). HSPA, the undisputed choice for mobile broadband. Building on existing HSPA networks is the best way to establish mobile broadband that can be delivered to a global mass market everywhere.

Gutiérrez, Pablo José Ameigeiras (2003). Packet Scheduling and Quality of Service in HSDPA. Denmark: Aalborg University.

Holma Harri, Markku Kuusela, Esa Malkamäki, Karri Ranta-aho & Chen Tao (2006). VOIP OVER HSPA WITH 3GPP RELEASE 7. 1-4244-0330-8/06 ©2006 IEEE.

Hu Chunjing, Yong Li, Mugen Peng & Wenbo Wang 2009. SYSTEM-LEVEL EVALUATION MIMO PERFORMANCE IN TD-HSPA+ SYSTEM. 978-1-4244-4817-3/09 ©2009 IEEE.

Mulvey, David (2007). HSPA. DAVID MULVEY EXPALINS HOW 3G HIGH SPEED PACKET ACCESS WORKS. IET Communication Engineer.

Peisa J., S. Wagner, M. Sågfors, J. Torsner, B. Görsansson, T. Fulghum, C. Cozzo & S. Grant (2007). High Speed Packet Access Evolution – Concept and Technologies. Ericsson Research. 1550-2252 ©2007 IEEE.

Rui Fan, Wang Min, Mårten Ericson & Stefan Wänstedt (2007). EVALUATION AND ANALAYSIS OF SIP AND VOIP PERFORMANCE WITH PRESENCE TRAFFIC OVER HSPA. 1-4244-1144-0/07 ©2007 IEEE.

Wänstedt Stefan, Mårten Ericson, Kristofer Sandlund, Mats Nordberg & Tomas Frankkila (2006). REALIZATION AND PERFORMANCE EVALUATION OF IMS MULTIMEDIA TELEPHONY FOR HSPA. 1-4244-0330-8/06/ ©2006 IEEE.

Zaki Yasir, Thushara Weerawardane, Xi Li, Andreas Timm-Giel & Gennaro Ciro Malafronte (2008). Effect of the RLC and TNL Congestion Control on the HSUPA Network Performance. MIC-CCA 2008.