Evolution of High Speed Download Packet Access (HSDPA) Networks

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Abstract: HSDPA (High Speed Downlink Packet Access) is a data communication technology which is considered as an extension of the 3G technology and specified in the 3rd Generation Partnership Project (3GPP) release 5; it supports speed of up to 14 megabits per second, although it is increased up to 336Mbps in 11th release this is sufficient for mobile TV streaming, and other high-end data transfers. HSDPA requires a different hardware and protocol than GSM or GPRS for working hence to use with any device (like phone) it must support the technology. HSDPA is based on common channel sharing transmission and its main features include multi-code transmission, higher order modulation, short transmission time (TTI), fast link adaptation and scheduling with the fast Hybrid Automatic Repeat Request (HARQ). This paper presents a review on the evolution from different variants of the HSDPA system with their functionality.

Keywords: WCDMA (Wideband Code Division Multiple Access), HSDPA, HSUPA (High Speed Uplink Packet Access).

1. INTRODUCTION

High-Speed Downlink Packet Access (HSDPA) is an improved 3G (third-generation) mobile communications system also known as High-Speed Packet Access (HSPA) system, it is also referred 3.5G, 3G+ or turbo 3G, which increases the capability of the networks based on Universal Mobile Telecommunications System (UMTS) to a higher data transfer rates and capacity. Up to 2013 the practically established HSDPA can support downlink speeds of up to 42.2 Mbit/s. The HSPA release 11 offering speeds of up to 337.5 Mbit/s.

To enhance the performance of 3GPP for HSDPA, is been developed under UMTS Release 5. The improvements are achieved by the development of a new transport layer channel.

1. High-Speed Downlink Shared Channel (HS-DSCH)

And three new physical layer channels named

2. The high-speed shared control channel (HS-SCCH) informs the user that the data on the High-Speed Downlink Shared Channel (HS-DSCH), 2 slots are sent ahead.

3. The Uplink High Speed Dedicated Physical Control Channel (HS-DPCCH) carries acknowledgment information and current Channel Quality Indicator (CQI) of the user which is used as feedback to adaptively select the proper modulation and coding rate.

4. The High Speed Physical Downlink Shared Channel (HS-PDSCH), the channel on which the above HS-DSCH transport channel is associated with that carrying the actual user data.

On the complementary for this HSUPA (High Speed Uplink Packet Access) is developed, if even for mobile devices is rarely mentioned are considered more important than download speeds. Together, the two technologies will make HSPA (High Speed Packet Access).

2. DEVELOPMENT OF HSDPA

The central idea of the concept is to increase packet data throughput of already existing system like Global System for Mobile Communications (GSM) / Enhanced Data known Prices for global evolution (EDGE) standards, using link adaptation and fast physical Layer (L1) retransmission. The physical layer retransmission handling was considered as a major problem and the long delays inherent in the existing radio network controller (RNC) based automatic repeat request ARQ architecture. Hence structural changes are necessary to arrive to reduce memory requirements as well as the control time for link adaptation on the radio frequency interface. The new transport channel is developed for carrying user data with HSDPA operation referred to as High-Speed downlink shared channel (HS-DSCH). A comparison of the basic properties and components of the HS-DSCH and DSCH is carried out in Table 1. A simple illustration of the general functionality of HSDPA is provided in Figure 1.

Table 1: HS-DSCH and DSCH Comparison

Feature	DSCH	HS-DSCH
VSF	Available	Not-Available
FPC	Available	Not-Available
AMC	Not-Available	Available
HARQ	Not-Available	Available
MC	Available	Available-Ext.
TTI	10 or 20ms	2ms
MAC	On RNC	Node-B

VSF: = Variable Spreading Factor
FPC: = Fast Power Control
AMC: = Adaptive Modulation and Coding
HARQ: = Hybrid Automatic Repeat Request
MC: = Multi-code Operation
TTI: = Transmission Time Interval
MAC: = Media Access Control

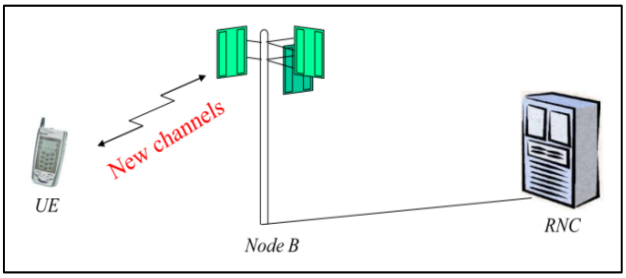

Figure 1: Functionality of HS-DSCH

The functionalities of Node-B for the HS-DSCH are

1. Fast Retransmission $HARQ_{MAC}$
2. Adaptive Modulation and Coding

The Functionalities of RNC are

1. Scheduling
2. Retransmission ARQ_{RLC}

The Node B (in Figure 1) estimates the channel quality of each active user, on the basis of power control, ACK/NACK ratio, Quality of Service (QoS) and HSDPA specific User feedback. Scheduling and link adaptation are then quickly performed at Node-B on the basis of active scheduling algorithm and the user priority scheme. The HSDPA is generally called an software upgrade of WCDMA because it replaces two most fundamental features of WCDMA, variable SF and quickly Disable power control by adaptive modulation and coding (AMC), Extensive multi-code operation and fast retransmission technique.

HSDPA uses link adaptation function and AMC to selecta coding and modulation combination that provides optimal throughput, which is available for the user close to the Node B (or with good interference/channel conditions in short-termsense). This leads to additional user throughput. Extension of parallel usage of multi-codes up to 15 enables a large dynamic range of the HSDPA link adaptation and to maintain a good spectral efficiency. The use of more robust coding, fast Hybrid Automatic Repeat Request (HARQ) and multi-code operation removes the need for variable SF.

3. HSDPA PHYSICAL LAYER

As discusses earlier to improve the performance of HSDPA release 4, many modifications has been proposed and developed this section describes the functionality and requirements of these features.

3.1 Adaptive Modulation and Coding

In HSDPA the functionality of the fast power control and replace VSF by adaptive modulation coding and multi-code which provides a wide dynamic range according to the Channel quality variations experienced in the UE (including fast and Distance dependent variations). The adaption is actually the Adjusting the code rate, modulation methods, the Number of multi-codes are used, and the transmission Power per code. The HS-DSCH coding scheme based on the release 99, 1/3 turbo encoder but adds functionality by puncturing and repetition to get effective code rate of about 1/6 to 1/1. To facilitate very high peak data rates HSDPA Concept adds to the adaptions of 16QAM in existing QPSK scheme available in Release 4/99th. The combination of variable code rate and modulation technique provides many combinations to get the optimum utilization of channel according to their conditions for example, 16QAM and 3/4 Rate channel coding allows a peak data rate of 712 kbps per code (SF = 16) for good channel conditions and for Higher robustness (in adverse channel conditions) a QPSK with rate ¼ can be used but at 119 kbps data rate per code. A modulation and coding combination is sometimes called a transport format and reuse Source combination (TFRC). TFRCs available on the HS-DSCH are shown in Table 2 which shows that at sufficiently good channel conditions , a single user at a time receive up to 15 parallel multi-code leads to very high Peak data rates of up to 10.8 Mbps. This is the maximum peak voltage Data rate supported by the HSDPA concept, the only be achieved in a very favorable environments or with Advanced transmission and reception technology.

Table 2: Available TFRCs for HS-DSCH

TFRC	Modulation	Code Rate	Data-Rate (Kbps) for multi-codes		
			1	5	16
1	QPSK	¼	119	600	1800
2	QPSK	½	237	1200	3600
3	QPSK	¾	356	1800	5300
4	16QAM	½	477	2400	7200
5	16QAM	¾	712	3600	10.8

3.2 Retransmission Techniques

The Stop and Wait (SAW) HARQ protocol is selected for HSDPA. In SAW, the transmitter remains on the transmission of the current block until it has been successfully received from the UE. To avoid long waiting times for acknowledge element, N parallel SAW-ARQ processes set for the UE, so that different processes separately transmitted on different TTI. The value of N can be up to 8, but in practice, the delay between the original and the first retransmission is expected to be in the order of 8-12ms. The controller L1 is the HARQ in the MAC-hs, so that the storage of unacknowledged data packets and the following scheduling of retransmissions do not involve the

RNC. Hence, Iub signaling is avoided and the resulting retransmission delay of HSDPA becomes much lower than for conventional RNC retransmissions.

The HSDPA retransmission method is thus several orders of magnitude faster than the conventional RNC based ARQ implementation and allows the use advanced retransmission strategies with low delay jittering and higher spectral efficiency, for the delay sensitive services such as streaming.

The HSDPA concept supports both the incremental Redundancy (IR) and Chase Combining (CC) proliferation Strategies. The basic idea of CC scheme is a transfer identical version of an erroneously detected data packet and then for the decoder to combine the received copies of weighted the SNR prior to decoding. With the IR scheme, additional redundant information transmitted incrementally if decoding is not the first attempt.

3.3 Channel Quality Indicator (CQI)/Link Adaption (LA)

Is the overall concept of the HS-DSCH link adaptation (LA) shown in Figure 1. The Node B tracks the radio channel Quality in the downlink direction by monitoring the transmit power on the downlink DCH associated with it (adjusted over Commands on the associated uplink DCH). The UE may also be asked to replay with a specific message called Channel Quality Indicator (CQI) on the uplink high-speed dedicated physical control channel (HS-DPCCH). This CQI value is used to properly select the TFRC.

4. RELEASES OF HSDPA

After the initial proposals of HSDPA there are many improvements have already implemented and they are numbered after 5. (Listed in Table 3).

Table 3: Release of HSDPA and their supported Features

3GPP Release	Cat.	Multi Codes	Modulation	MIMO/Multi-Cell	Code Rate	Data Rate Mbps
Release 5	1	5	QPSK/16-QAM		.76	1.2
Release 5	2	5	QPSK/16-QAM		.76	1.2
Release 5	3	5	QPSK/16-QAM		.76	1.8
Release 5	4	5	QPSK/16-QAM		.76	1.8
Release 5	5	5	QPSK/16-QAM		.76	3.6
Release 5	6	5	QPSK/16-QAM		.76	3.6
Release 5	7	10	QPSK/16-QAM		.75	7.2
Release 5	8	10	QPSK/16-QAM		.76	7.2
Release 5	9	15	QPSK/16-QAM		.70	10.1
Release 5	10	15	QPSK/16-QAM		.97	14.0
Release 5	11	5	QPSK		.76	0.9
Release 5	12	5	QPSK		.76	1.8
Release 7	13	15	QPSK/16-QAM/64-QAM		.82	17.6
Release 7	14	15	QPSK/16-QAM/64-QAM		.98	21.1
Release 7	15	15	QPSK/16-QAM	MIMO 2x2	.81	23.4
Release 7	16	15	QPSK/16-QAM	MIMO 2x2	.97	28.0
Release 7	19	15	QPSK/16-QAM/64-QAM	MIMO 2x2	.82	35.3
Release 7	20	15	QPSK/16-QAM/64-QAM	MIMO 2x2	.98	42.2
Release 8	21	15	QPSK/16-QAM	Dual-Cell	.81	23.4
Release 8	22	15	QPSK/16-QAM	Dual-Cell	.97	28.0
Release 8	23	15	QPSK/16-QAM/64-QAM	Dual-Cell	.82	35.3
Release 8	24	15	QPSK/16-QAM/64-QAM	Dual-Cell	.98	42.2
Release 9	25	15	QPSK/16-QAM	Dual-Cell + MIMO 2x2	.81	46.7
Release 9	26	15	QPSK/16-QAM	Dual-Cell + MIMO 2x2	.97	55.9
Release 9	27	15	QPSK/16-QAM/64-QAM	Dual-Cell + MIMO 2x2	.82	70.6
Release 9	28	15	QPSK/16-QAM/64-QAM	Dual-Cell + MIMO 2x2	.98	84.4
Release 10	29	15	QPSK/16-QAM/64-QAM	Triple-Cell	.98	63.3
Release 10	30	15	QPSK/16-QAM/64-QAM	Triple-Cell + MIMO 2x2	.98	126.6
Release 10	31	15	QPSK/16-QAM/64-QAM	Quad-Cell	.98	84.4
Release 10	32	15	QPSK/16-QAM/64-QAM	Quad-Cell + MIMO 2x2	.98	168.8
Release 11	33	15	QPSK/16-QAM/64-QAM	Hexa-Cell	.98	126.6
Release 11	34	15	QPSK/16-QAM/64-QAM	Hexa-Cell + MIMO 2x2	.98	253.2
Release 11	35	15	QPSK/16-QAM/64-QAM	Octa-Cell	.98	168.8

Release 11	36	15	QPSK/16-QAM/64-QAM	Octa-Cell + MIMO 2x2	.98	337.5
Release 11	37	15	QPSK/16-QAM/64-QAM	Dual-Cell + MIMO 4x4	.98	168.8
Release 11	38	15	QPSK/16-QAM/64-QAM	Quad-Cell + MIMO 4x4	.98	337.5

4.1 Latest Release

HSPA Release 11 raises the performance of HSPA systems significantly by offering the following features:

1. 8 carrier aggregation, giving up to eight time's better user performance.
2. 4x4 MIMO in the downlink, increasing peak data rates and improving system performance.
3. Uplink beam forming, 2x2 MIMO and 64 QAM. Uplink improvements increase the peak data rate, user performance and cell capacity.

4. CONCLUSION

This paper presented some of basic concept used for the evolution of 3GPP system to HSDPA the paper also explains the behavioral details and the realized outcomes of these concepts and these studies help us to conclude that the HSDPA offers a significant capacity gain for cell package Data traffic in WCDMA and is therefore can be considered as an important part of continuous 3G evolution. The HSDPA concept offers improved code efficiency and dynamic data rates which can further be improved in the future using advanced communication techniques, including equalizer, multi-user or multi-code interference Cancellation, and advanced multiple inputs multiple outputs (MIMO) techniques. Therefore, it may be regarded as a key concept for high speed data communication although and performance and cost/complexity Issues need to be further revised for improvements.

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