3.5 G

HSDPA

High Speed Downlink Packet Access

BY:

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Abstract:

In this report we introduce the High-Speed Downlink Packet Access (HSDPA) technology which is the evolution of the W-CDMA. In HSDPA the data rate in the downlink increased and the transmission time interval decreased. also in this report we explain the HSDPA feature which consist of: Hybrid Automatic Repeat Request (H-ARQ), Fast cell site selection (FCSS), HSDPA Physical Channel and Adaptive Modulation and Coding (AMC). After that we talk about the communication evolution and at the end of this report we present the HSDPA terminals.

Introduction:

Data services are expected to have significant growth over the next few years and will likely become the dominant source of 3G traffic and revenue. In order to meet the increasing demand for high data-rate multimedia services, the 3rd Generation Partnership Project (3GPP) has released a new high-speed data transfer feature named High-Speed Downlink Packet Access (HSDPA). HSDPA provides impressive enhancements over WCDMA R'99 for the downlink. It offers peak data rates of up to 10 Mbps, resulting in a better end-user experience for downlink data applications, with shorter connection and response times.

The deployment of HSDPA is very cost effective since the incremental cost is mainly due to Node Bs (or BTS) and RNC (Radio Network Controller) software/hardware upgrades. In fact, in a capacity-limited environment (high subscriber density and/or data-traffic volume per subscriber), the network cost to deliver a megabyte of data traffic is about three cents for a typical dense urban environment, as opposed to seven cents for R'99 assuming an incremental cost of 20 percent. [1]

In the next table we present the comparison between HSDPA & 3G:

	3G	**HSDPA**
Data Rate	2Mbps	10 Mbps
Modulation	QPSK	QPSK&16QAM
Transmission Time Interval	10ms	2ms

Table 1: comparison between HSDPA & 3G

The goals of the HSDPA are:

1- Increasing bit rates in downlink.

2- Reducing delay.

3- Efficient user scheduling.

Short transmission time interval (TTI)

The length of the frame is referred to as Transmission Time Interval (TTI). The HS-DSCH which is added in the HSDPA standard uses this TTI of 2ms than the Release'99 transport channel TTI. This is done to reduce the round trip time, increases the granularity in the scheduling process and for better tracking of the time varying radio channel. Actually the length of the frame is variable and is selected based on traffic supported and the number of supported users. A typical value is 2ms. [2]

HSDPA Features: [3]

A) Hybrid Automatic Repeat Request:

The AMC uses an appropriate modulation and coding scheme according to the channel conditions. Even after AMC, we may land up with errors in the received packets due to the fact that the channel may vary during the packet is on the fly. An automatic repeat request (ARQ) scheme can be used to recover from these link adaptation errors. When the transmitted packet is received erroneous then the receiver requests the transmitter for the retransmission of that erroneous packet. The basic technique is to use the energy of the previously transmitted signal along with the new retransmitted signal to decode the block. There are two main schemes for H-ARQ, Chase combining and Incremental redundancy.

Chase Combining:

It involves the retransmission of the same data packet which was received with errors. Once the re-transmission is received, the receiver combines the soft values of the original signal and the retransmitted signal weighted by the SNR prior to decode the data packet.

Advantages: each transmission and retransmission can be decoded individually (self-decodable), time diversity gain, may be path diversity gain.

Disadvantage: transmission of the entire packet again which is wastage of bandwidth.

Incremental Redundancy (IR):

Incremental Redundancy is used to get maximum performance out of the available bandwidth. Here the retransmitted block consists of only the correction data to the original data that carries no actual information (Redundancy). The additional redundant information is sent incrementally when the first, second … retransmissions are received with errors.

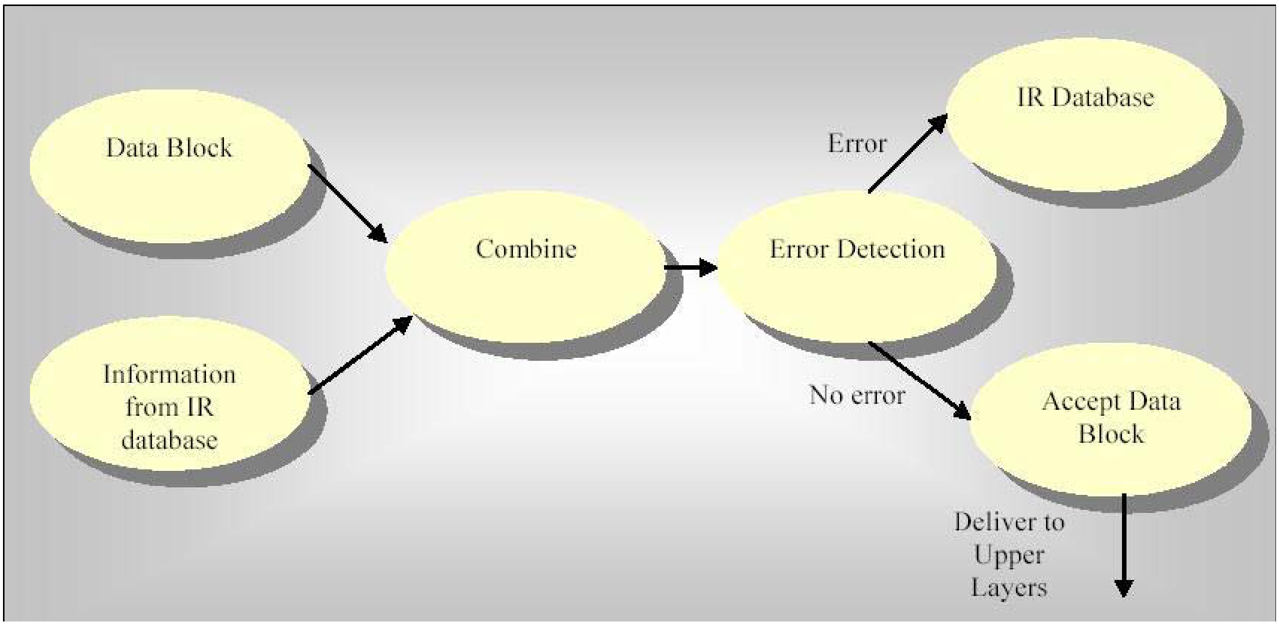

Figure 1: IR–Data Block Retransmission (courtesy: Agilent IR Application note) [3]

Advantages: Reducing the effective data throughput/ bandwidth of a user and using this for another user.

Disadvantage: The systematic bits are only sent in the first transmission and not with the retransmission which makes the retransmissions non-self decodable. So, if the first transmission is lost due to large fading effects there is no chance of recovering from this situation.

Partial Incremental Redundancy:

The Partial IR is the combination of chase combining and IR. The disadvantage with IR is removed here by adding the systematic bits along with the incremental redundant bits (different puncturing bits) in the retransmission. This makes both original and retransmitted signals self decodable.

B) Fast cell site selection (FCSS):

Typically on an average 20-30% of the MS's are in soft or softer handover condition. Soft handover is a handover between two Node-B's where as softer hand over is between sectors of a Node-B. So it's very important to track the active set of Node-B's connected to a UE for communication. FCSS allows a UE to select the Node-B with the best current transmission characteristics [UMTS evolution to HSDPA]. The advantage of this system is that higher data rates can be achieved at most of the time. [HSDPA Important]

C) HSDPA Physical Channel:

Three new physical channels are introduced with HSDPA to enable HS-DSCH transmission. Two are used for control, and a third carries high speed downlink user data as shown in Figure 2. The high-speed shared control channel (HS-SCCH) is a downlink control channel that informs mobile devices when HSDPA data is scheduled for them, and how they can receive and decode it. The high-speed dedicated physical control channel (HS-DPCCH) is an uplink control channel used by the mobile to report the downlink channel quality and request retransmissions.

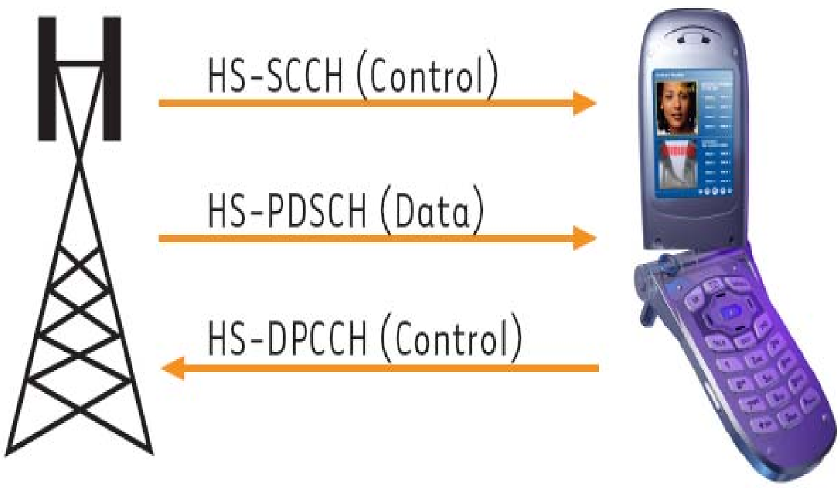

Figure 2. The three new physical channels used by HSDPA. [3]

The high-speed physical downlink shared channel (HS-PDSCH) is a downlink physical channel that carries the HS-DSCH user data. Several HS-PDSCHs are assigned to a mobile for each transmission. The maximum number of HS-PDSCHs that can be allocated ranges from 5 to 15 depending on the category of the mobile device. A list of mobile categories and their characteristics is shown in Table 2 .

Mobile Device Category	Peak Data Rate	HS-PDSCHs Received	Modulation Scheme	Total Number of Soft Channel Bits
11	0.9 Mbits/s	5	QPSK	14400
12	1.8 Mbits/s	5	QPSK	28800
1	1.2 Mbits/s	5	QPSK or 16QAM	19200
2	1.2 Mbits/s	5	QPSK or 16QAM	28800
3	1.8 Mbits/s	5	QPSK or 16QAM	28800
4	1.8 Mbits/s	5	QPSK or 16QAM	38400
5	3.6 Mbits/s	5	QPSK or 16QAM	57600
6	3.6 Mbits/s	5	QPSK or 16QAM	67200
7	7.2 Mbits/s	10	QPSK or 16QAM	115200
8	7.2 Mbits/s	10	QPSK or 16QAM	134400
9	10.1 Mbits/s	15	QPSK or 16QAM	172800
10	14.0 Mbits/s	15	QPSK or 16QAM	172800

Table 2. The 12 categories of mobile device defined for HSDPA. [3]

In HSDPA, each HS-PDSCH has a different OVSF channelization code. In UMTS, allocations of spectrum are assigned with a 5 MHz bandwidth. Channels are created within this spectrum using code division multiple access (CDMA). Each channel has a different orthogonal variable spreading factor (OVSF) channelization code. The number of codes available and the amount of data each can carry depends upon the spreading factor (SF) of the channel. The HSDPA standards specify the use of spreading factor 16 (SF16) channels for the HS-PDSCH and spreading factor 128 (SF128) channels for the HS-SCCH. As illustrated in Figure 3, up to 15 channels with SF16 are allocated for HS-PDSCHs.

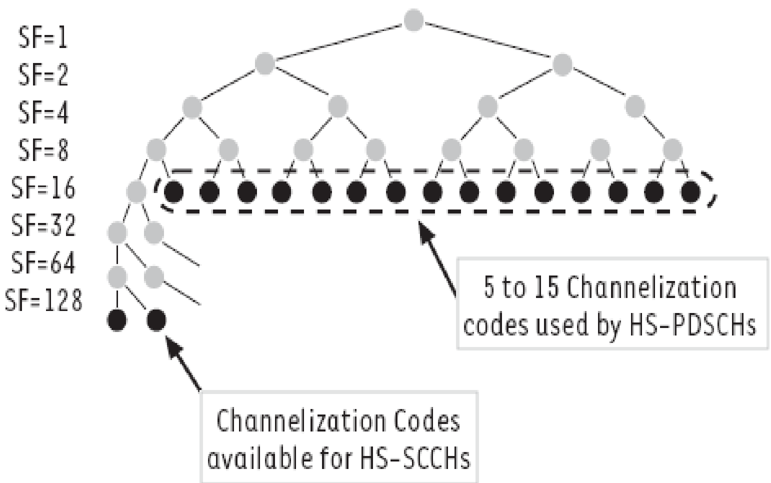

Figure 3: The HSDPA OVSF code tree [3]

D) Adaptive Modulation and Coding:

HSDPA allows the use of 16-QAM modulation on HS-PDSCH channels to double the data rate of transmissions in favourable channel conditions. Release 99 and release 4 UMTS physical channels use the quadrature phase shift keying (QPSK) modulation to transmit two data bits per symbol. For HS-PDSCHs in release 5, 16-ary quadrature amplitude modulation (16QAM) can also be used to transmit 4 data bits per symbol as shown in the constellation diagrams in Figure 4.

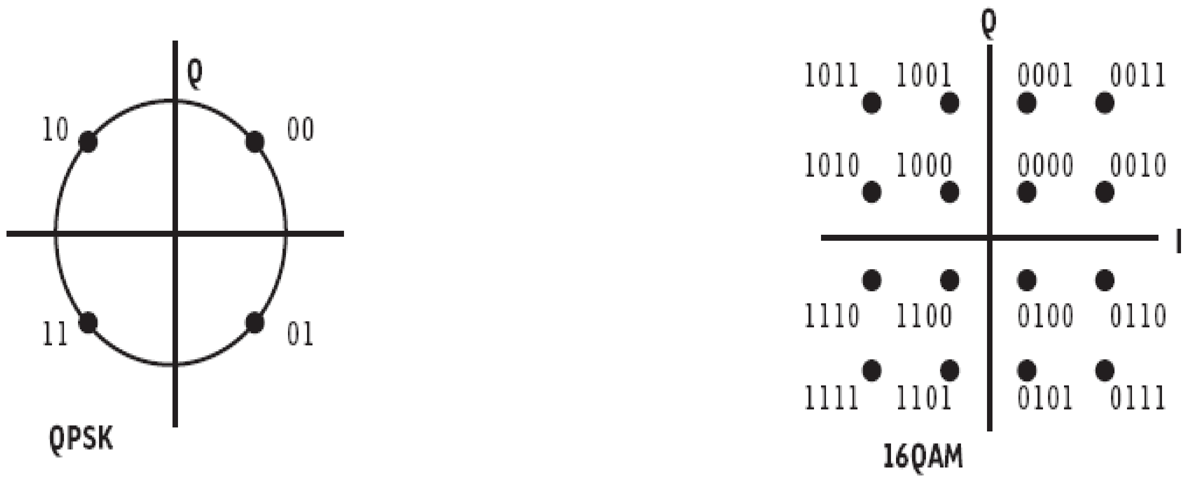

Figure 4. Constellation diagrams for QPSK and 16QAM. [3]

Although 16QAM doubles the potential data rate over the air interface relative to QPSK modulation, 16QAM signals are more susceptible to channel impairments and so the full gains can only be realized in high channel quality conditions. Also 16QAM signals require the use of a higher-performance receiver than QPSK signals. The decision to transmit QPSK or 16QAM is made in the network using channel quality information provided by the mobile terminal via the uplink control channel.

Evolution:

Additional performance improvements are foreseen for HSDPA with the introduction of additional features such as equalization and advanced Multiple-Input Multiple-Output (MIMO) techniques. The benefits of HSDPA as explained in the previous sections apply to the downlink since most of the expected 3G data traffic will be initially downlink driven. Release 6 will include a major feature to improve the uplink as well.

This feature is called Enhanced Uplink (EUL). EUL standardization is still ongoing, with a possible completion date of December 2004. EUL uses similar key features as HSDPA such as HARQ, short TTI and Node B scheduling. Initial simulations performed by QUALCOMM showed:

• 50 to 70 percent improvement of uplink sector throughput

• 20 to 55 percent reduction in user packet delay

• 50 percent increase in user packet call throughput

EUL is a natural evolution step. It will complement HSDPA by improving uplink data transfer. The first commercial deployments of EUL are expected in 2007 as shown in Figure 5. [1]

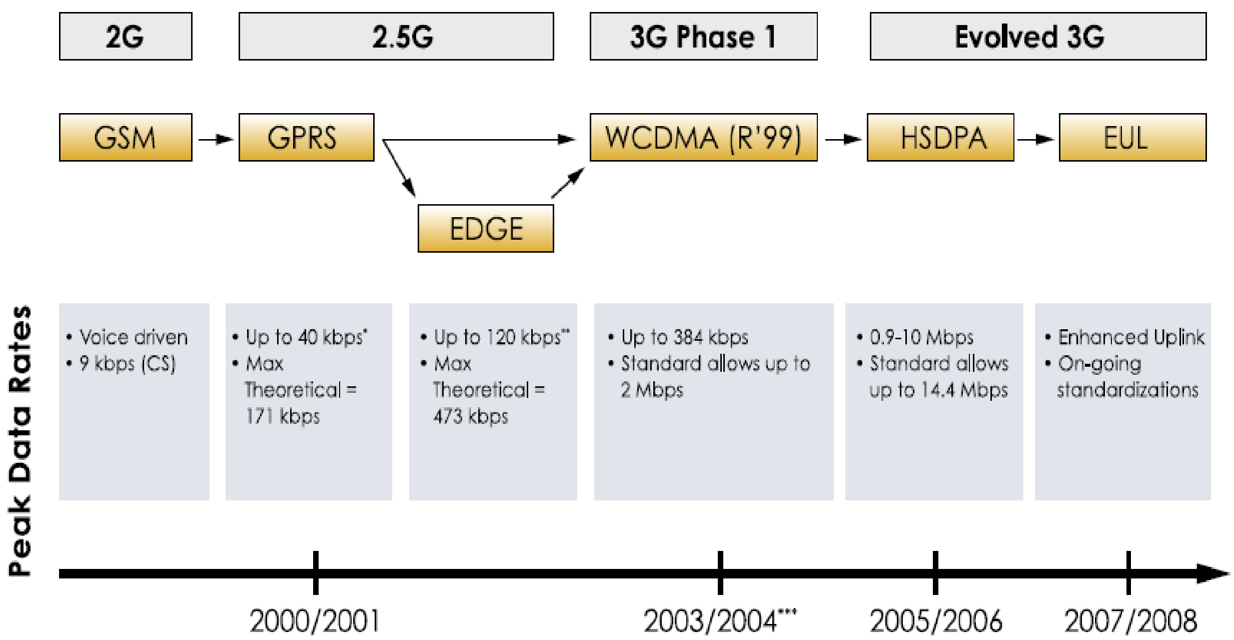

Figure 5: 2G to 3G evolution [1]

HSDPA Terminals:

For the HSDPA we have to use several equipments to reach the downlink speed of data rate. We have more than 13 cat. These are some examples as shown in figure 6:

- Mobile.
- USB Modem.
- Data card.
- Router.
- Laptop.

we have to use SIM with each equipment to access to the net. [4], [5] and [6]

Figure 6: USB Modem, Data card, Router and Laptop [4], [5] and [6]

Conclusion:

HSDPA provides impressive enhancements over WCDMA R’99 for the downlink. It offers peak data rates of up to 10 Mbps, resulting in a better end user experience for downlink data applications (shorter connection and response times). More importantly, HSDPA offers three- to five-fold sector throughput increase, which results in significantly more data users on a single frequency. HSDPA higher throughputs and peak data rates will help stimulate and drive up consumption of data intensive applications that cannot be supported by R’99. In fact, HSDPA allows a more efficient implementation of interactive and background Quality of Service (QoS) classes as standardized by 3GPP. HSDPA high data rates improve the use of streaming applications, while lower roundtrip delays will benefit Web browsing applications. Another important benefit of HSDPA is its backwards compatibility with R’99. This makes its deployment very smooth and gradual on an “as needed” basis.

The deployment of HSDPA is very cost effective since the incremental cost is mainly due to Node Bs and RNC upgrades. In a capacity limited environment, the network cost to deliver a megabyte of data traffic is three cents for a typical dense urban environment, as opposed to seven cents for R’99 (assuming an incremental cost of 20 percent).

The ability to offer higher peak rates for an increasingly performance demanding end user at a substantially lower cost will create a significant competitive advantage for HSDPA operators. Supporting rich multimedia applications and content and more compelling devices at lower user cost will drive higher traffic per user and will enable early movers to differentiate themselves with advanced services — increasing their subscriber growth, data market share and profitability.

References:

[1] QUALCOMM white paper, "HSDPA for Improved downlink Data Transfer."2004.

[2] N. Shankpal "High Speed Downlink Packet Access (HSDPA) Higher Data Rates for UMTS", Proceedings of Seminar on Topics in Communications Engineering in Munich University of Technology, Dec 3 , 2004.

[3] Agere Systems Inc., "HSDPA Mobile Broadband Data A Smarter Approach to UMTS Downlink Data", February 2005.

[4] www.huawei.com.

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