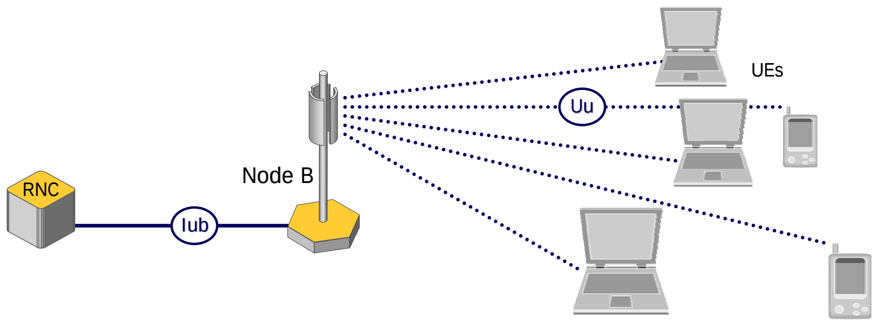
HSDPA Principles: Contents

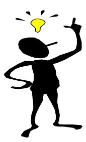
- **Objectives & Standardization**
- Adaptive Modulation and Coding AMC
- Multi-Code operation & Data Throughput
- Network & UE Modifications for HSDPA

A GLOBAL INITIATIVE

HSDPA: Objectives & Standardization

- Network operator demands to:
  - improve Uu resource efficiency, i.e. enhance cell capacity!
  - decrease costs per Megabyte!
  - increase average Uu data throughput!
  - enhance UMTS peak data rates!
  - decrease delays / round-trip-time!
- User request to:
  - reduce time for Download!
  - decrease costs per Megabyte!





HSDPA Objectives

The scope of HSDPA is to improve the overall radio resource efficiency, leading to higher capacity respectively throughput per cell as well as higher peak data rates per user / connection.
Furthermore, the delay for Acknowledged data transmission should be reduced significantly.
For the user this means to receive with higher data rates (beyond 384 kbps) reducing the download times significantly.
All network modifications for HSDPA should be comparable simple / cheap, so that the overall costs per Mbyte could be reduced.

HSDPA Objectives & Standardization

TS 25.308:
HSDPA
Overall
Description

HSDPA
High Speed DL Packet Access

TS 25.890:
HSDPA
Radio Transmission
& Reception

TS 25.877:
HSDPA
Iub/Iur Protocol
Aspects

TS 25.211:
Physical Channels
(FDD)

UMTS
Release 5

Downward compatible to UMTS R'99:

sharing frequency bands with R'99 channels

HSDPA is based on:

- Multi-code operation
- Fast Link Adaptation AMC
- Fast Packet Scheduling
- Fast H-ARQ

to achieve:

- high throughput/resource efficiency
- high peak rates > 2 Mbps
- reduced DL delay
  (→ Streaming services)

AMC:	Adaptive Modulation & Coding
H-ARQ:	Hybrid Automatic Repeat Request

HSDPA (High Speed DL Packet Access)
is a Rel. 5 feature to support the evolution towards more sophisticated networks and multimedia services. The main target is to
- increase the user peak data rates beyond 2 Mbps (theoretically up to 14 Mbps)
- improve the spectral efficiency and the cell throughput (up to 100% & more)
- enhance the QoS (decreasing the delay times) e.g. for Streaming Class services) of DL asymmetric and bursty packet data services.

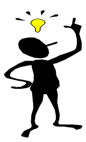
***HSDPA** is based on:*
- fast and complex channel control mechanism including fast link adaptation
- Adaptive (& enhanced) Modulation & Coding AMC
- Multi-code operation
- fast physical layer Hybrid Automatic Repeat Request H-ARQ.

HSDPA is a smooth upgrade from R'99 UMTS. It can co-exist on the same RF carrier with R'99 UMTS, sharing dynamically the code resources between '99 UMTS and HSDPA.

A general description of HSDPA is given in 3GPP TS 25.308.

AMC: Adaptive Modulation & Coding

- Objectives & Standardization
- **Adaptive Modulation and Coding AMC**
- Multi-Code operation & Data Throughput
- Network & UE Modifications for HSDPA



Adaptive Modulation

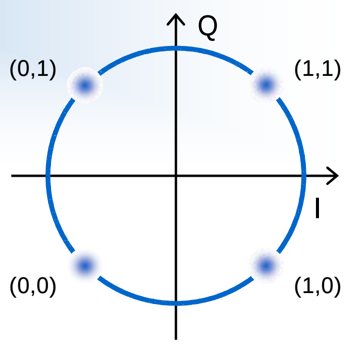
HSDPA uses:

- QPSK
- 16QAM

dynamically based on quality of the radio link

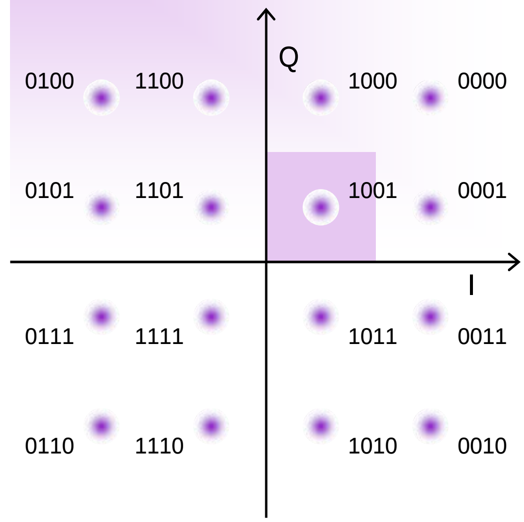
TS 25.201/213: „Physical Layer General Description"; „Spreading & Modulation"

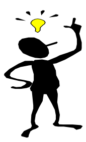
QPSK (4PSK):
2-Bit Keying



QPSK: Quadrature Phase Shift Keying
16QAM: 16 Quadrature Amplitude Modulation

16QAM:
4-Bit Keying





UMTS / HSDPA Modulation

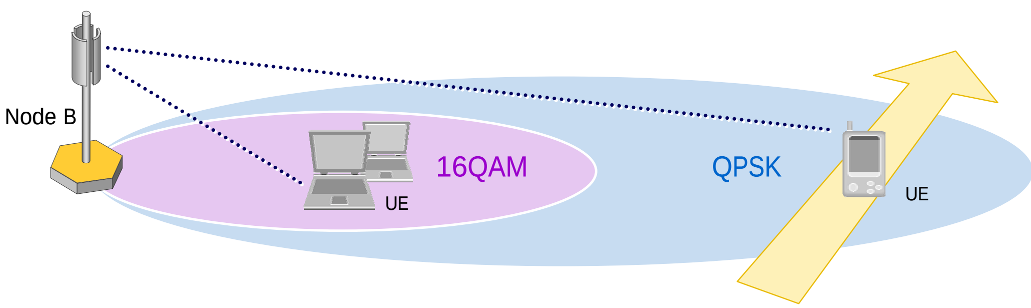
For HSDPA UMTS Release 5 introduces a new modulation scheme: 16QAM. HSDPA is able to use dynamically either QPSK (2-bit keying) or 16QAM (4-bit keying) depending on the quality of the radio link (Ec/Io). QPSK is used at a poor Radio Link Quality, 16QAM at high Radio Link Quality.

Adaptive Modulation (Principle)

HSDPA adapts the Modulation to the current Radio Link Quality (Ec/Io)

HSDPA uses:

- QPSK at low Radio Link Quality
- 16QAM at high Radio Link Quality



Adaptive Modulation (Principle)

HSDPA adapts the Modulation to the current Radio Link Quality (Ec/Io). The adaptation is performed quite fast to compensate Fast Fading effects. A higher valuated modulation scheme is used to improve the throughput and efficiency compared to Rel. 99.

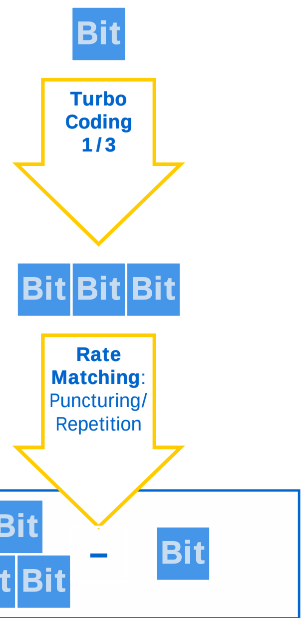
HSDPA uses the Rel. 99 modulation QPSK at low Radio Link Quality and the higher valuated modulation 16QAM at high Radio Link Quality.

AMC: Adaptive Coding

HSDPA Adaptive Coding:

- based on the R'99 1/3 Turbo Coding
- Rate Matching (Puncturing or Repetition) → effective code rate: 1/4 – 3/4 (theoretically: 1/6 – 0.98)
- dynamically based on quality of the radio link

TS 25.212: Multiplexing & channel coding (FDD)

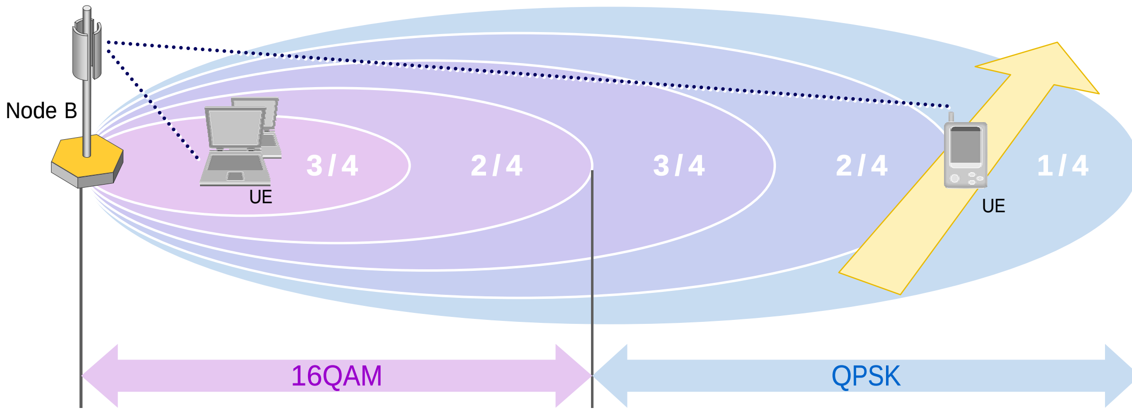


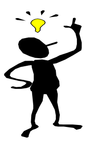
Adaptive Coding

TS 25.212 ‚Multiplexing and channel coding (FDD)' defines that the rate 1/3 turbo coding shall be used for HS-DSCH channel coding.
In the following rate matching uses puncturing or repetition effective coding rates other than 1/3 become available. The effective coding as defined in TS 25.214 may vary between approximately 1/6 and nearly 4/4 (no redundancy). In praxis, effective code rate varying from 1/4 to 3/4 are playing a central role. Varying the code rate, the number of bits per code (and so the throughput) can be increased at the expense of reduced coding gain. The better the radio interface quality (Ec/Io) the higher the possible coding.

AMC: Adaptive Coding (Principle)

- HSDPA adapts the Coding to the current Radio Link Quality (Ec/Io)
- HSDPA varies the Coding between 1/4 – 3/4
  (theoretically 1/6 – 0.98)





AMC: Adaptive Modulation & Coding (Principle)

In HSDPA both, Modulation and Coding, are adapted in a very fast way to the current Radio Link Quality (Ec/Io).

Under good radio link conditions the sophisticated 16QAM modulation is chosen, else the conventional QPSK modulation is selected.

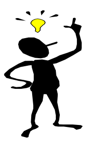
The Coding typically is varied between 1/4 and 3/4. More redundancy up to 1/6 (only in combination with QPSK modulation) is possible under worst case conditions to prevent call drops (TS 25.214), respectively less (nearly no) redundancy is possible (in combination with 16QAM) for high end equipment under extremely good radio conditions.

Multi-Code operation & Data Throughput

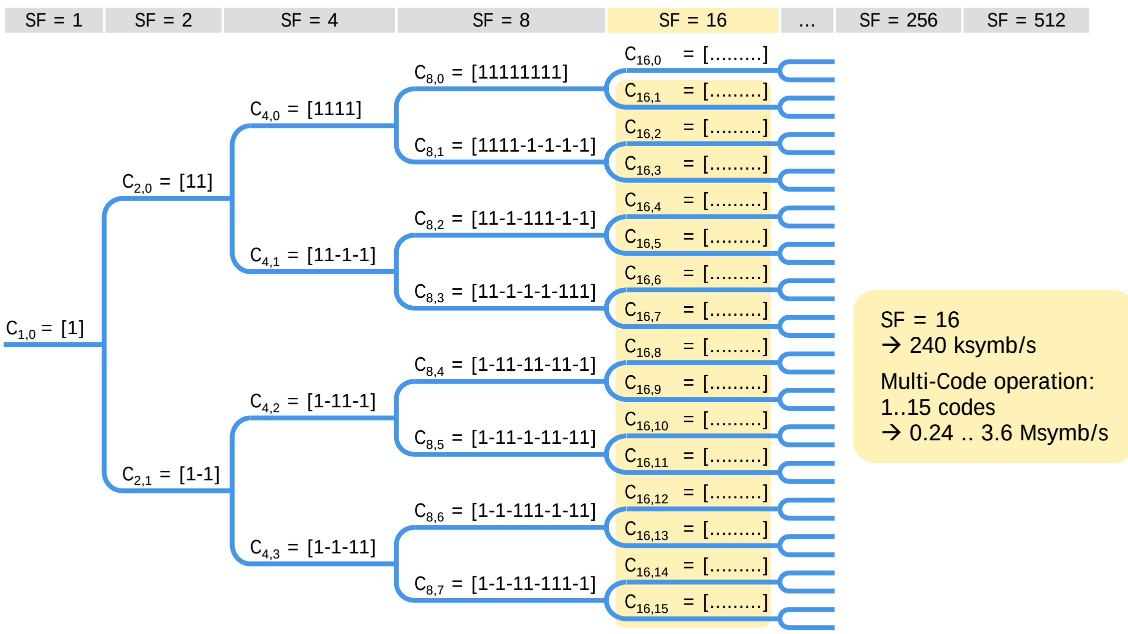
- Objectives & Standardization
- Adaptive Modulation and Coding AMC
- **Multi-Code operation & Data Throughput**
- Network & UE Modifications for HSDPA

HSDPA Transmission is „Stop & Go“ traffic!

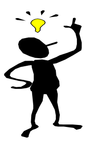
PHY Layer uses (if conditions permit)
peak data rates beyond 2 Mbps –
even if (only) 1 or 2 Mbps negotiated with CN



HSDPA Multi-Code operation

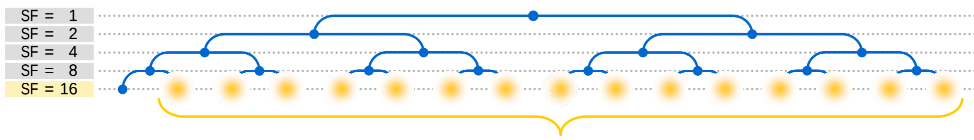


10 | Tektronix



HSDPA Multi-Code operation:
Different to UMTS Rel. 99 in HSDPA the Spreading Factor SF is fixed to SF = 16. SF = 16 allows data rates of 240 ksymbol/s. Higher data rates are possible via Multi-Code operation. Depending on the User Equipment capabilities up to 5, 10 or 15 Codes can be bundled to one connection, resulting in 1.2 Msymbol/s, 2.4 Msymbol/s or 3.6 Msymbol/s.

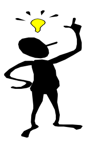
Multi-Code Operation & Data Throughput



SF = 16 → 240 ksymb/s
1 .. 15 codes → 0.24 .. 3.6 Msymb/s
QPSK: 0.48 .. 7.2 Mbps
16QAM: 0.96 .. 14.4 Mbps

Modulation	Coding Rate	Throughput with 5 codecs	Throughput with 10 codecs	Throughput with 15 codecs
QPSK	1/4	600 kbps	1.2 Mbps	1.8 Mbps
	2/4	1.2 Mbps	2.4 Mbps	3.6 Mbps
	3/4	1.8 Mbps	3.6 Mbps	5.4 Mbps
16QAM	2/4	2.4 Mbps	4.8 Mbps	7.2 Mbps
	3/4	3.6 Mbps	7.2 Mbps	10.7 Mbps
	4/4	4.8 Mbps	9.6 Mbps	14.4 Mbps

Effective Code Rate:
1/4 – 3/4



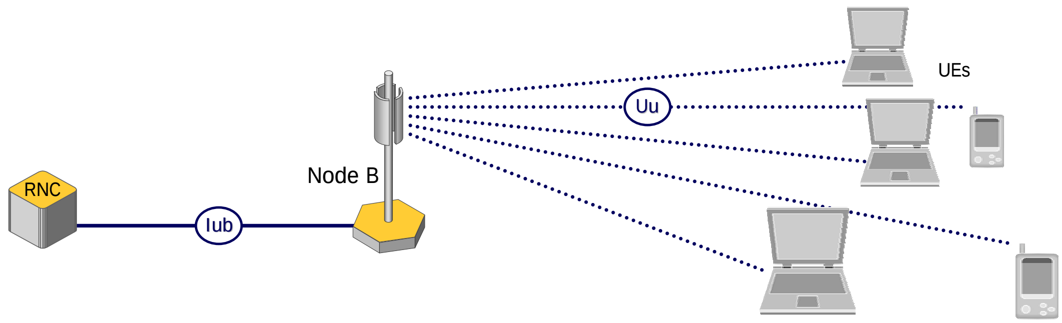
Multi-Code Operation & Data Throughput

To enhance the data rate, a user may utilise up to 15 codes in parallel. The remaining code resources are required for the transmission of control data. Very high peak data rates can be reached combining 5/10 or 15 codes (depending on the mobiles capabilities) under favourable radio link conditions. Using all 15 codes in parallel a radio interface throughput of 3.6 Msymb/s, equivalent to 14.4 Mbps when using 16QAM, is possible. 14.4 Mbps defines the maximum HSDPA throughput.

The table shows the maximum user data rate for a combination of 5, 10 or 15 codes and under variation of coding and modulation.

Network Modifications for HSDPA

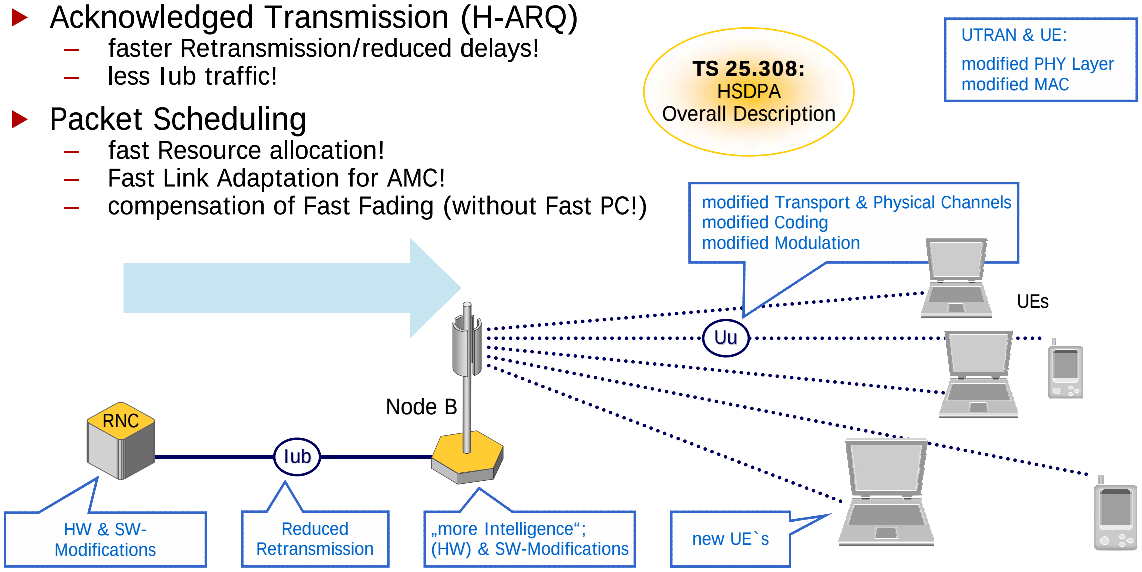
- Objectives & Standardization
- Adaptive Modulation and Coding AMC
- Multi-Code operation & Data Throughput
- **Network & UE Modifications for HSDPA**



Network Modifications for HSDPA

HSDPA: functionalities shifted from RNC to Node B:

- Acknowledged Transmission (H-ARQ)
  - faster Retransmission/reduced delays!
  - less Iub traffic!
- Packet Scheduling
  - fast Resource allocation!
  - Fast Link Adaptation for AMC!
  - compensation of Fast Fading (without Fast PC!)



Modifications to the existing nodes to support HSDPA

UE

New User equipments are necessary. Totally, 12 HSDPA UE classes with different capabilities have been defined. The HSDPA UE has to handle a modified Layer 1 & 2.

Node B

In HSDPA several functionalities have been shifted from the RNC to the Node B. The Node B becomes responsible for:

- Acknowledged Transmission (H-ARQ)

- Packet Scheduling for HSDPA users

- Fast Link Adaptation: Adaptive Modulation & Coding AMC to compensate Fast Fading

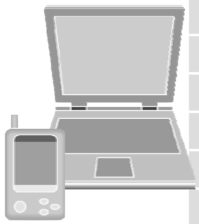
A new MAC entity (MAC-hs) is added in the Node B to handle H-ARQ retransmissions, HSDPA packet scheduling and Link Adaptation.

Radio Network Controller RNC

The RNC has to be modified, handing over functionalities to the Node B's and to correspond to the Node B's for Flow Control.

HSDPA UE capability classes

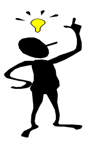
TS 25.306:
UE Radio Access Capabilities



HS- DSCH category	Buffer Size*1 [kbyte]	max. No. of HS-DSCH Codes	min.*2 Inter-TTI interval	max. No. of Bits/TTI*3	total No. of Soft Channel Bits*4	Reference combination Class
1	50	5	3 (6 ms)	7298	19200	1.2 Mbps
2	50	5	3	7298	28800	1.2 Mbps
3	50	5	2 (4 ms)	7298	28800	1.8 Mbps
4	50	5	2	7298	38400	1.8 Mbps
5	50	5	1 (2 ms)	7298	57600	3.6 Mbps
6	50	5	1	7298	67200	3.6 Mbps
7	100	10	1	14411	115200	7 Mbps
8	100	10	1	14411	134400	7 Mbps
9	150	15	1	20251	172800	10 Mbps
10	150	15	1	20252	172800	14 Mbps
11	50	5	2	3620	14400	1 Mbps
12	50	5	1	3620	28800	1.8 Mbps

QPSK only

*1 on RLC & MAC-hs layer
*2 TTI: Transmission Time Interval
*3 Maximum No. of bits/HS-DSCH transport block
*4 for H-ARQ process



HSDPA UE capability classes

12 different categories of HSDPA terminals are defined according to their Physical Layer capabilities. They are separated according to the following parameters:

- Support of 16QAM.
- Minimum total RLC & MAC-hs buffer size (50/100/150 kBytes)

- Maximum number of SF = 16 HSDPA codes (5/10/15).

- Minimal Inter Transmission Time Interval TTI (1/2/3 Sub-Frames =2/4/6 ms)

- Maximum number of bits of an HS-DSCH transport block received within an HSDSCH TTI

- The maximum number of Soft Channel Bits over all the HARQ processes. The capabilities of the HSDPA User Equipment are defined in TS 25.306.