Flexi WCDMA BTS HSPA Essentials

Nokia Siemens Networks Academy

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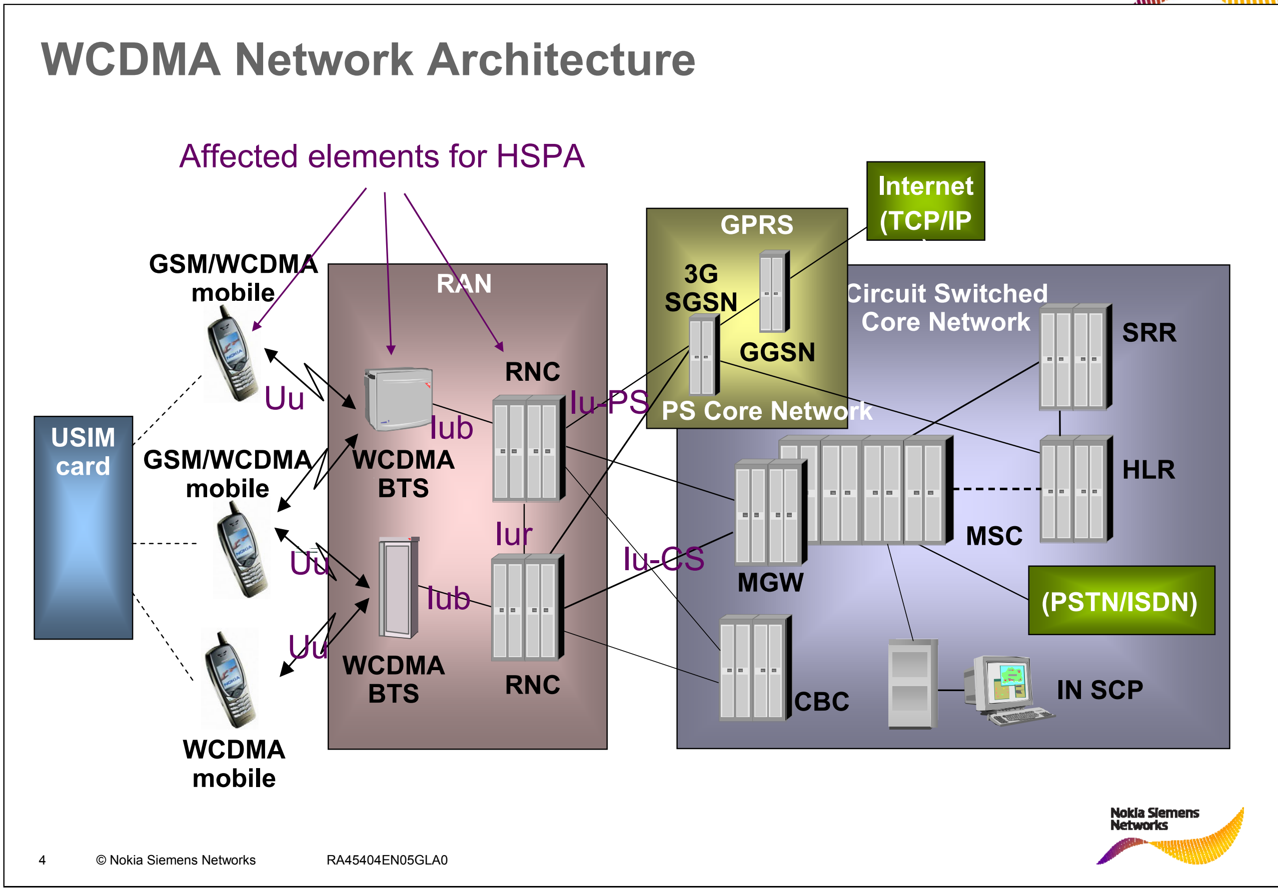
Content

- WCDMA BASICS
- HSDPA In general
- RNC solutions
- HSUPA



RNC handles all aspects of radio resource management
-radio resource management and QoS control
-configuration of Node Bs
-direct transfer
-handover management
-power control
-mobility

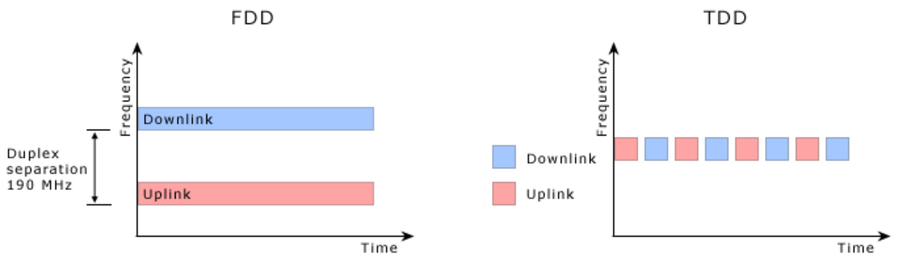
Node B is the radio transmission and reception unit
-handling of logical cells
-radio transmission and reception
-radio resource management

WCDMA Variants

See details in appendix

The 3G solution specified by 3GPP includes two possibilities for separating the uplink and downlink directions (duplexing), namely

- Frequency Division Duplex (FDD), and



In UTRA FDD, the uplink and downlink signals are separated by transmitting simultaneously in different frequency bands. FDD is commonly used in 2nd and 1st generation cellular systems, such as GSM, IS-95, TACS, NMT and AMPS.

In UTRA TDD, the uplink and downlink signals are transmitted in the same frequency band but at different time instants. TDD duplexing has been used, for example, in cordless phone systems.

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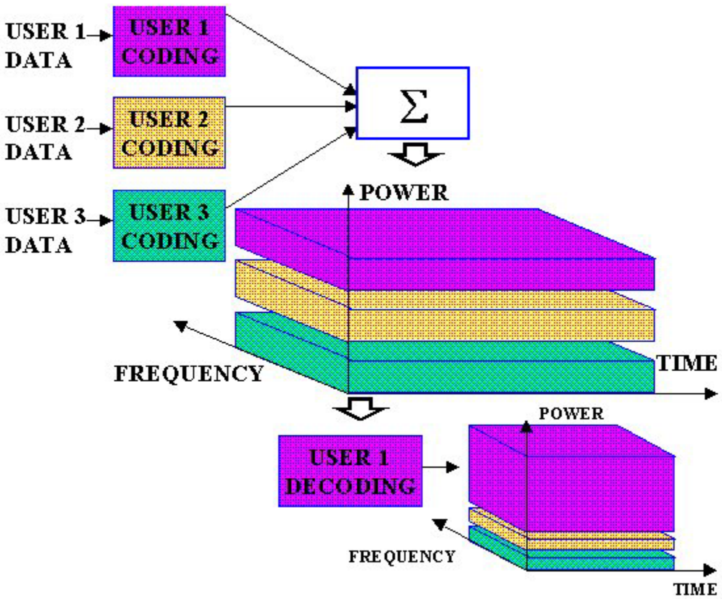
Frame

10ms frame

15 time slots (2/3ms each)

TTI = Transmission Time Interval

WCDMA Theory and Terminology



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5MHz WCDMA carrier (in one direction) with effective bandwidth of 3.84MHz (guard bands for interference)

Sequencing technique

DS = direct sequence

(FH = frequency hopping)

DS-WCDMA-FDD Frame sturcture

10ms frame, 15 slots, 2/3ms each slot – timing structure mainly required for the synchronization signal arrangements

Frames numbered by SFN=system frame number

Air interface – Spreading

The number of chips per data symbol is called the Spreading Factor (SF). The lower the spreading factor the higher the data rate. SF va

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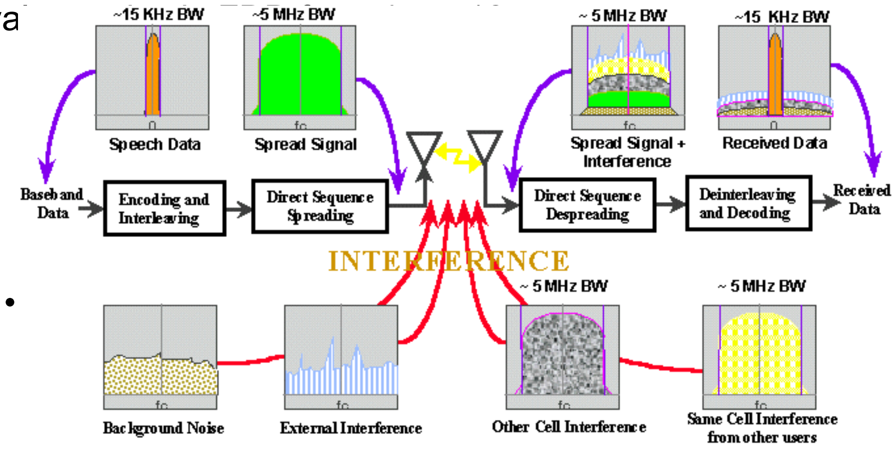

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Spreading Factor

- The spreading factor (also called processing gain) describes how many chips each symbol contains after spreading
- Since the chip rate is fixed and does not depend on the type of signals transmitted over the radio link, a high bit rate signal is associated with a small spreading factor, and a low bit rate signal correspondingly with a large spreading factor.
- Spreading factor = 4 (Example 1) is the smallest spreading factor allowed in WCDMA. Spreading factor = 256 (Example 2) is the largest spreading factor unconditionally allowed in WCDMA (in downlink, a spreading factor of 512 is allowed under certain circumstances).

Spreading factor = chip rate / symbol rate

The chip rate in WCDMA is 3.84 million chips/s

Example 1: Uplink, high channel bit rate (960 Kbits/s)

- Channel bit rate 960 Kbits/s
- Symbol bit rate 0.960 M symbols/s
- Chip rate 3.84 Mchips/s
- Spreading factor 3.84/0.96 = 4

Example 2: Downlink, low channel bit rate (30 Kbits/s)

- Channel bit rate 30 Kbits/s
- Symbol bit rate 0.015 M symbols/s
- Chip rate 3.84 Mchips/s
- Spreading factor 3.84/0.015 = 256

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Channelisation codes

- Channelisation codes are very important in downlink, since they are used for **multiplexing** (at the transmitter) and **separating** (at the receiver) the signals intended for different terminals.
- In uplink, channelisation codes are used for multiplexing the data and control channel (DPDCH and DPCCH) signals transmitted from a single terminal.
- In both directions, the channelisation codes are employed for spreading the channel bits to the final chip rate of 3.84 Mchips/s.
- The required bit rate - and thus the spreading factor - of some services may change over time. The transmitter takes care of changes in the spreading factor among others by changing the channelisation code.
- The channelisation codes are based on the Orthogonal Variable Spreading Factor (OVSF) technique, which allows the spreading factor to be changed without disrupting the orthogonality between different codes of different lengths simultaneously in use.

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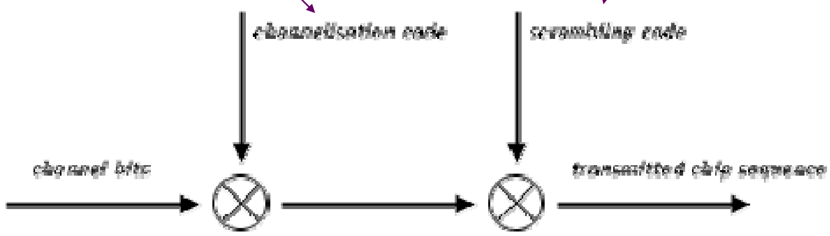
Spreading Codes in WCDMA

In WCDMA, two types of codes are used in tandem for spreading the channel bits into a wideband CDMA chip sequence:

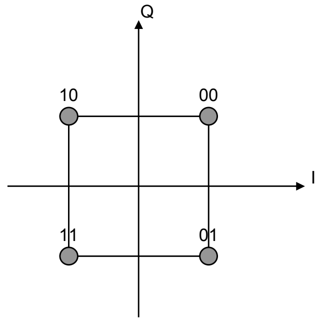
- channelisation codes, and
- scrambling codes.

the channelisation code performs the actual signal spreading to the final chip rate (3.84 Mchips/s)

after spreading the scrambling code only modifies the chip values in the transmitted chip sequence in such a way that the cross-correlation interference in the system is minimised.



Air interface - Modulation



QPSK

2 bits / symbol =
480 kbit/s/HS-PDSCH =
max. 7.2 Mbit/s

R99 uses QPSK = Quadrature Phase Shift Keying

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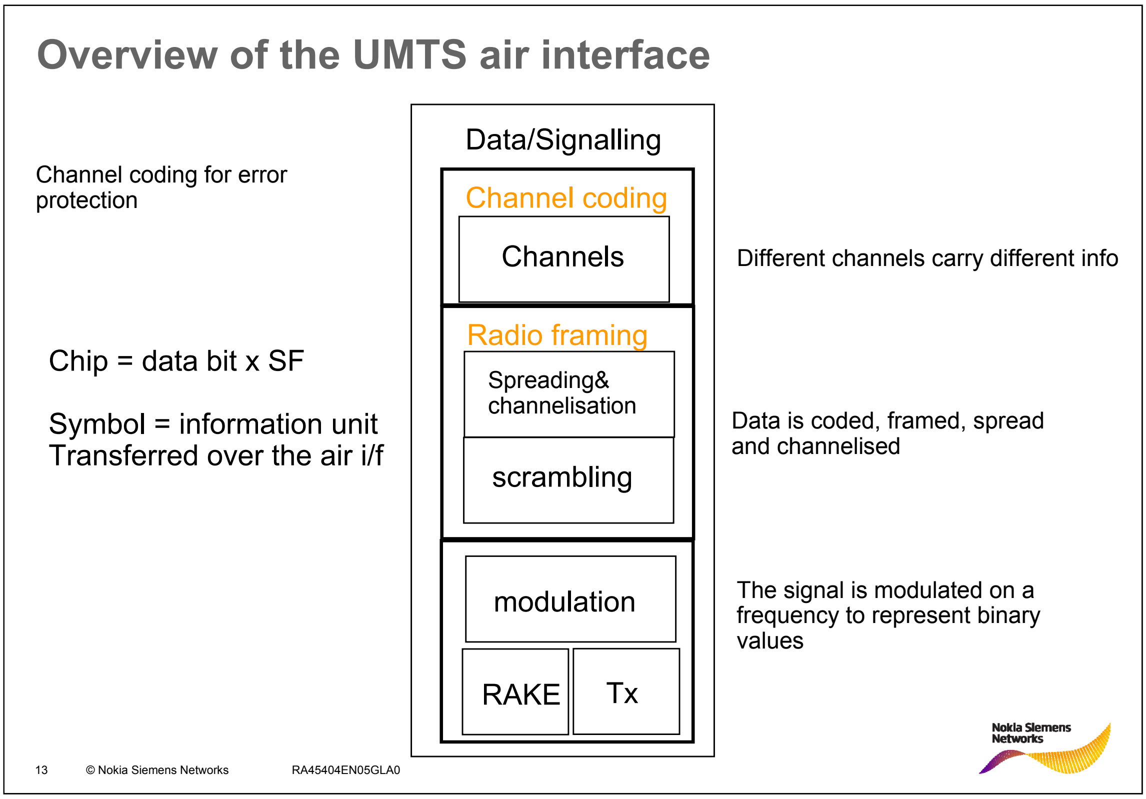
10 = 135 degrees

00 = 45

11 = 225

01 = 315

QPSK = Quadrature Phase Shift Keying



Chips

Channelisation&spreading: apply spreading factor SF, that is multiply the chip with SF# of bits → results in a symbol

SF 4 for data 101 -> 111100001111

SF 4 is an OVSF (orthogonal variable spreading factor) code which is used for multiplication

Scrambling code: UL separation of users, DL separation of cells

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Modulation

QPSK one symbol represent two chips

In 16QAM 1:4

QPSK = Quadrature Phase Shift Keying

Multipath and RAKE receivers

One of the main advantages of CDMA systems is the capability of using signals that arrive in the receivers with different time delays. This phenomenon is called multipath.

Due to its wide bandwidth and rake receivers, CDMA uses the multipath signals and combines them to make an even stronger signal at the receivers.

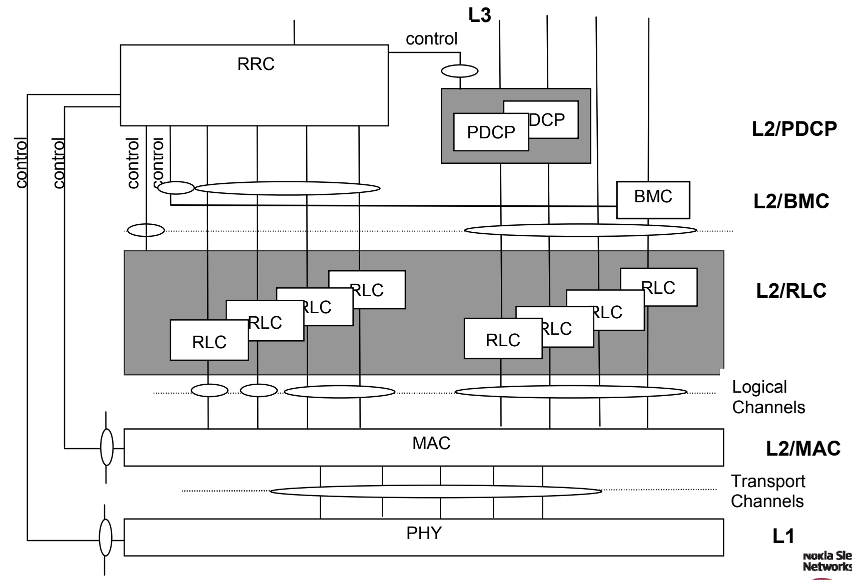
Rake receivers - set of several receivers/fingers. One finger constantly searches for different multipaths and feeds the information to the other three fingers. Each finger then demodulates the signal corresponding to a strong multipath. The results are then combined together to make the signal stronger.

combining techniques:

selection, equal gain combining, maximal ratio combining

Radio Interface Protocol Architecture

More information: 25.301 Radio Interface Protocol Architecture



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RRC (Radio Resource Control) function -- Outer loop power control: The RRC layer controls setting of the target of the closed loop power control.

MAC (Medium Access Control) functions:

Mapping between logical channels and transport channels. The MAC is responsible for mapping of logical channel(s) onto the appropriate transport channel(s).

Selection of appropriate Transport Format for each Transport Channel depending on instantaneous source rate: MAC selects the appropriate transport format within an assigned transport format set for each active transport channel depending on source rate (limited by Transport Format Combination Set).

Priority handling between data flows of one UE: Priority handling between data flows when selecting between the Transport Format Combinations in the given Transport Format Combination Set (according e.g. to attributes of Radio Bearer services and RLC buffer status).

Priority handling between UEs by means of dynamic scheduling (NW): MAC realises priority handling on common and shared transport channels.

Identification of UEs on common transport channels: MAC handles UE identification on common channels.

Dynamic Transport Channel type switching: Switching between common and dedicated transport channels based on a switching decision derived by RRC.

(De)multiplexing of higher layer PDUs into/from transport blocks delivered to/from the L1 on common transport channels: MAC handles service multiplexing for common transport channels, since the physical layer does not support multiplexing of these channels.

(De)multiplexing of higher layer PDUs into/from transport block sets delivered to/from the L1 on dedicated transport channels: The MAC allows service multiplexing for dedicated transport channels. This function can be utilised when several upper layer services (e.g. RLC instances) can be mapped efficiently on the same transport channel.

Traffic volume monitoring: Measurement of traffic volume on logical channels and reporting to RRC. Based on the reported traffic volume information, RRC performs transport channel switching decisions.

Ciphering: Ciphering is performed in the MAC layer for transparent RLC mode.

Access Service Class selection for RACH transmission. The RACH resources may be divided between different Access Service Classes in order to provide different priorities of RACH usage.

More information: 25.301 Radio Interface Protocol Architecture

MAC services:

Data transfer on logical channels: Unacknowledged transfer of MAC SDUs between peer MAC entities (no segmentation/reassembly)

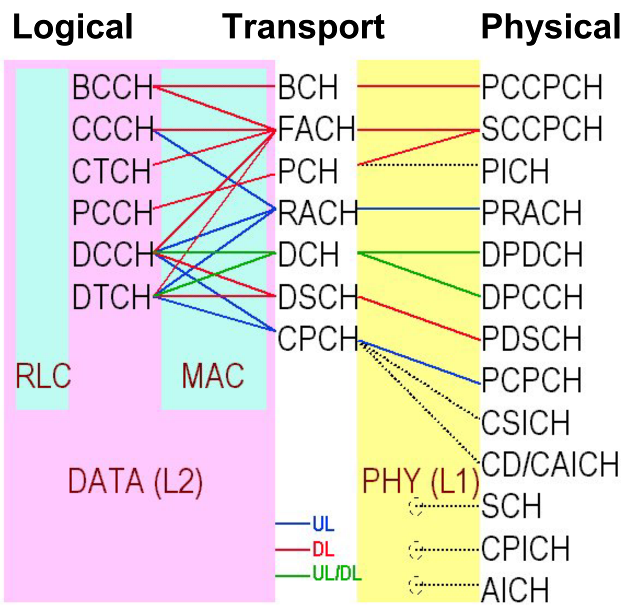
Reallocation of radio resources and MAC parameters: E.g. change of transport format (combination) sets and change of transport channel type.

Reporting of measurements: Local measurements such as traffic volume and quality indication are reported to RRC.

Logical channels -Describe *what* is transported

Transport channels - Describe *how* data is transmitted over the radio interface

Channels



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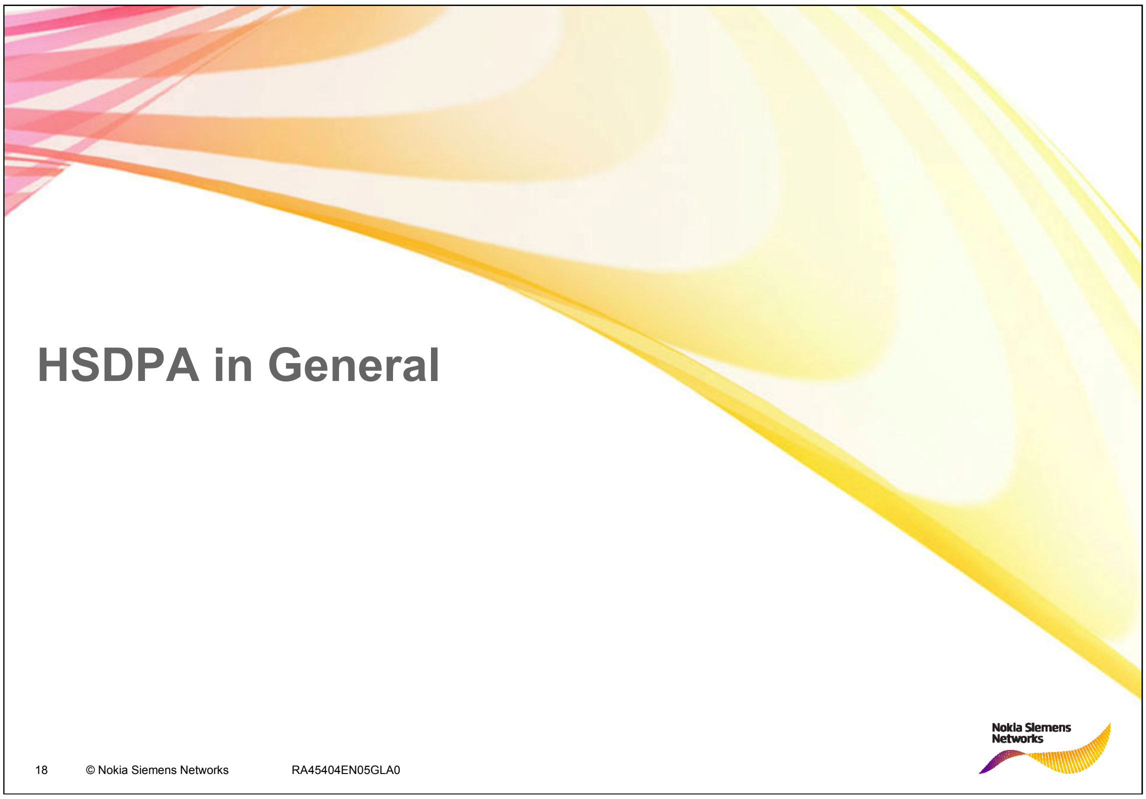
Logical Channels:
Broadcast Control Channel (BCCH), Downlink (DL)
Paging Control Channel (PCCH), DL
Dedicated Control Channel (DCCH), UL/DL
Common Control Channel (CCCH), UL/DL
Dedicated Traffic Channel (DTCH), UL/DL
Common Traffic Channel (CTCH), Unidirectional (one to many)

Transport Channels:
Dedicated Transport Channel (DCH), UL/DL, mapped to DCCH and DTCH
Broadcast Channel (BCH), DL, mapped to BCCH
Forward Access Channel (FACH), DL, mapped to BCCH, CCCH, CTCH, DCCH and DTCH
Paging Channel (PCH), DL, mapped to PCCH
Random Access Channel (RACH), UL, mapped to CCCH, DCCH and DTCH
Uplink Common Packet Channel (CPCH), UL, mapped to DCCH and DTCH
Downlink Shared Channel (DSCH), DL, mapped to DCCH and DTCH

Physical Channels:
Primary Common Control Physical Channel (PCCPCH), mapped to BCH
Secondary Common Control Physical Channel (SCCPCH), mapped to FACH, PCH
Physical Random Access Channel (PRACH), mapped to RACH
Dedicated Physical Data Channel (DPDCH), mapped to DCH
Dedicated Physical Control Channel (DPCCH), mapped to DCH
Physical Downlink Shared Channel (PDSCH), mapped to DSCH
Physical Common Packet Channel (PCPCH), mapped to CPCH
Synchronisation Channel (SCH)
Common Pilot Channel (CPICH)
Acquisition Indicator Channel (AICH)
Paging Indication Channel (PICH)
CPCH Status Indication Channel (CSICH)
Collision Detection/Channel Assignment Indication Channel (CD/CA-ICH)



HSDPA is a concept specified in the Release 5 of the 3G PP standards, which contains a large number of separate features requiring implementation by Nokia to be a gradual inclusion into the Radio Access Network (RAN) over several releases. This approach is made easier by the features of HSDPA being more or less independent; each of which is designed to bring improvements in either performance or network operability. As a concept, HSDPA is a natural extension of the Downlink Shared Channel (DSCH) also building on resource sharing.

The principal objective of HSDPA is to increase the rate at which data can flow over the Radio connection from the base station to the Users Equipment (UE). Indeed, HSDPA will be able to provide very high data speeds for the downlink (the connection from the base station to the user) only. Eventually, payload data delivery speeds can be as high as 14.4 Mbps [1] on the downlink. In practise with the staged Nokia implementation of HSDPA, peak values first seen by individual users will rise from the current 384 Kpbs to 1.8 Mbps. Later releases will bring the higher rates possible with HSDPA. This means 3G WCDMA users will be able to receive mobile broadband data. However initially, users will remain restricted to a maximum of 384 Kbps on the uplink (the connection from the user to the base station). Once the sibling standard High Speed Uplink Packet Access (HSUPA) is implemented and users can purchase HSUPA capable UE, mobile broadband data rates can in time peak at 5.8 Mbps [1] for WCDMA/HSPA user devices. HSDPA is mainly intended for non-realtime traffic, but can also be used for traffic with tighter delay requirements.

The principal features of HSDPA include changes to the radio signal linking the network with the mobile user from the base station to support the dramatic increase of data bandwidth. Fast adaptation of that radio link to respond to the prevailing conditions affecting the quality of the radio signals received by the UE. The base station scheduling and retransmitting packet data over the radio link, if the radio conditions interfere/prevent successful signal reception by the UE. These replace conventional WCDMA features of variable spreading factor and fast power control. Instead the number of multicodes, modulation and coding schemes vary on a fast basis depending on the channel quality feedback from the UE.

Goals/requirements of HSDPA (Rel5)

Support

- simultaneous (RT and NRT) voice, CS-data and PS-data
- Asymmetric services (web browsing) efficiently

Backward compatible with R99

- Use same 5MHz bandwidth

No changes to the network architecture of R99

No changes to CS side

- Maintain call model of R99
- Voice capacity is same as R99

Minimize impact to mobile and infrastructure

14Mbps peak data rate

High Speed Downlink Packet Access (HSDPA)

HSDPA is introduced in 3GPP rel5 specifications.

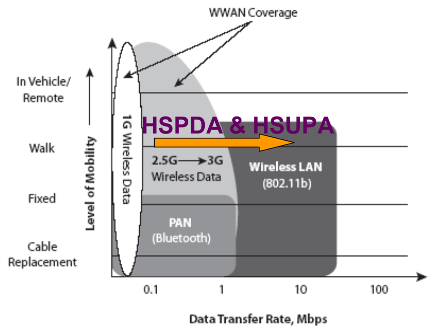
Goals for the design have been in 3GPP:

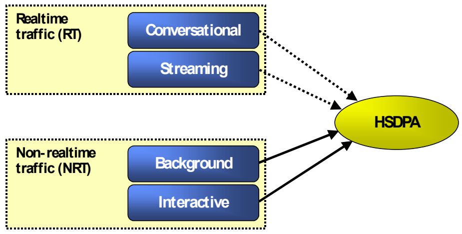
- HSDPA offers a lower cost per bit and potentially opens for new application areas with higher data rates and lower delay variance.
- Peak data rates higher than 2Mbit/s up to 14.4 Mbit/s
- Reduced (re)transmission delays
- Improved QoS control (Node-B based packet scheduling)
- Spectral and code efficient solution for fully loaded sites
  - 50-100% packet data throughput increase over 3GPP release 4
- HSDPA is mainly intended for non-realtime traffic, but can also be used for traffic with tighter delay requirements.

For the system HSDPA introduces:

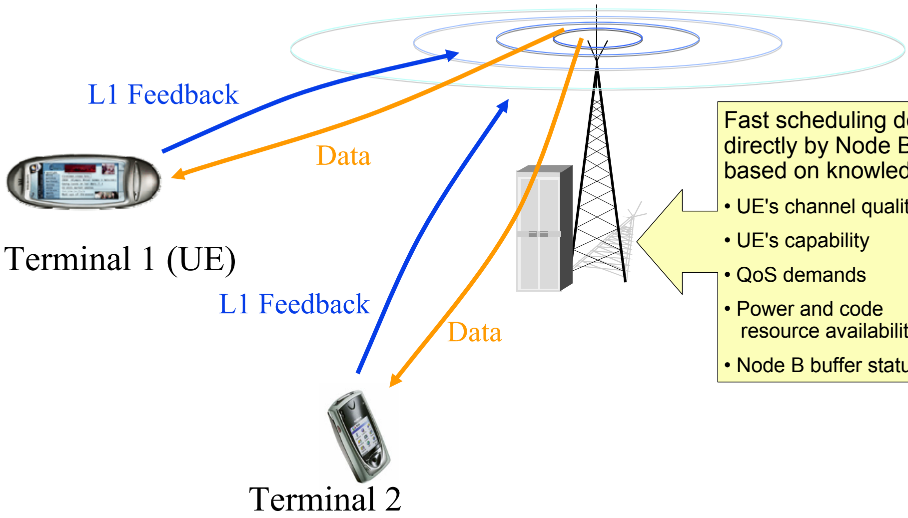
- System of new physical channels for UTRAN.

Figure 1: Mobility vs. Wireless Network Technologies





HSDPA - general principle



Fast scheduling done directly by Node B (BTS) based on knowledge of:

- UE's channel quality
- UE's capability
- QoS demands
- Power and code resource availability
- Node B buffer status

Users may be time and/or code multiplexed

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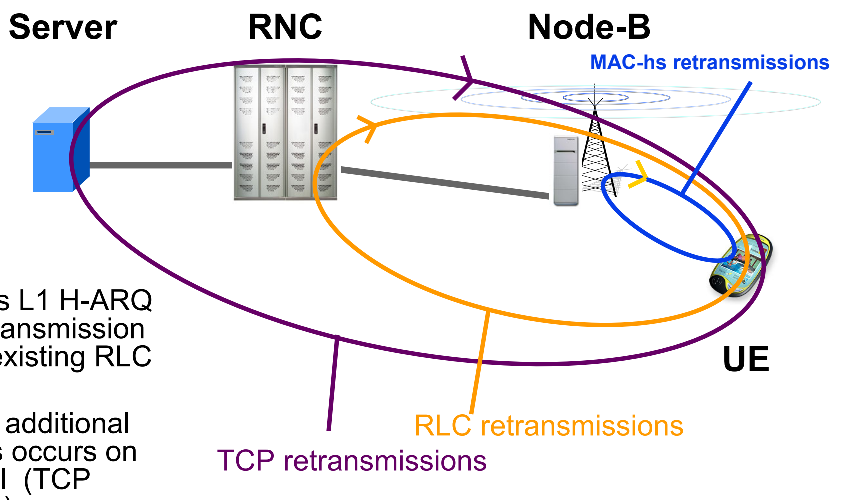
Retransmissions in HSDPA



- HSDPA introduces L1 H-ARQ as first step retransmission along with the existing RLC ARQ.
- For TCP traffic an additional retransmissions occurs on application level (TCP retransmissions)

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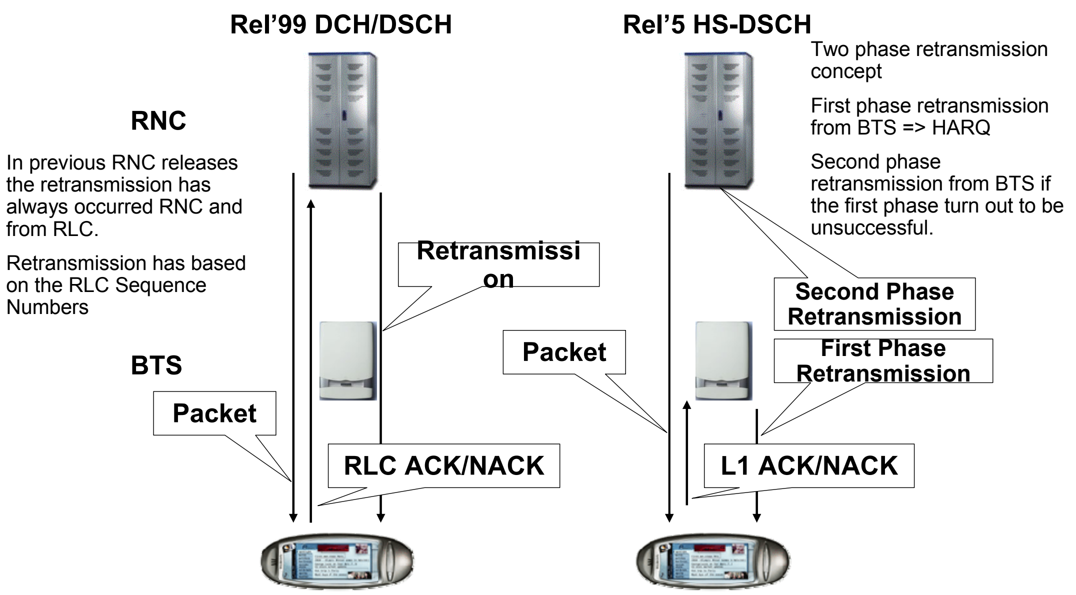
Packet Data: Buffering – Retransmission - Scheduling
Successfully expanding the size of the delivery pipe of packet data to the mobiles creates new issues to be addressed. For instance, what happens to the large amount of packet data coming down to the BTS, if the mobile moves causing the High Speed radio channel quality to drop preventing it's operation? Data will back up with nowhere to go. The need for control of the flow of packet data to and from the BTS is evident. In addition, an amount of packet data has to be stored waiting for the mobile to acknowledge receipt or the request to resend. Packet scheduling issues in the RAN up until now were the responsibility of the RNC. The major paradigm shift for 3G RAN with HSDPA is that the BTS now takes on the responsibility to schedule and buffer packet data using Automatic retransmission request processing to manage the packet data flow through the BTS to the mobile.

The retransmission process uses Hybrid Automatic Retransmission reQuest (HARQ). The component parts of HARQ are the packet scheduler (in the base station), retransmission when data from the base station to the mobile is corrupted during transmission, and the constant feedback regarding channel conditions from the mobile to the serving base station among others.

In generic operation, HARQ uses a Stop and Wait (SAW) mechanism. When the base station sends a packet of data to the mobile, it Stops and Waits to hear from the mobile whether the packet was good or bad. The mobile sends its response back to the base station on the HS-DPCCH. If the packet is good then ACK (Acknowledge) is sent back to the base station to allow the next packet to be sent. Should the mobile receive a corrupted packet, it will send a NACK (Negative ACK), signalling the base station to retransmit the same packet.

Along with an ACK or a NACK, the mobile sends the Channel Quality Indicator (CQI) parameter providing information of the received signal strength at the mobile. The base station can as a result assess the condition of High Speed channel and in turn intelligently schedule packet data rates to the mobile.

Rel'99 vs HSDPA Retransmission handling



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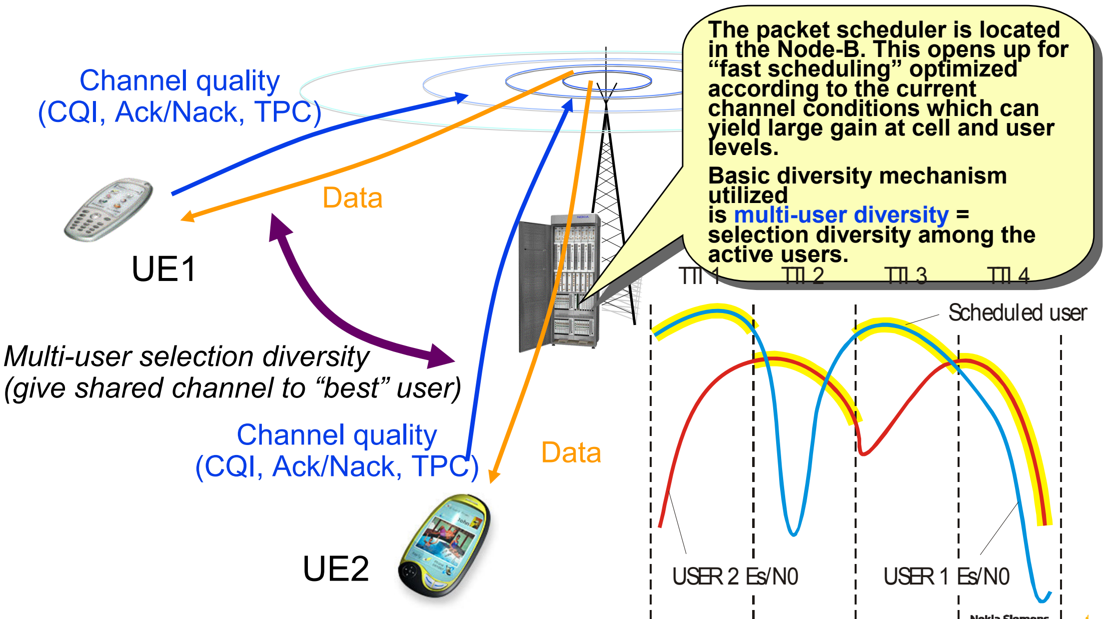
Packet Scheduling



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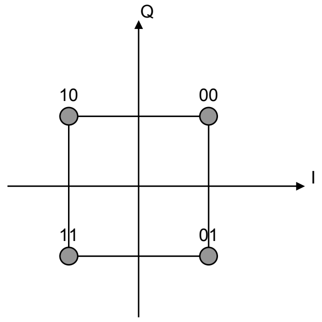
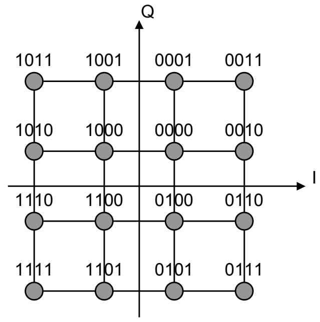
Air interface - Modulation



QPSK

2 bits / symbol =
480 kbit/s/HS-PDSCH =
max. 7.2 Mbit/s



16QAM

4 bits / symbol =
960 kbit/s/HS-PDSCH =
max. 14.4 Mbit/s

10 = 135 degrees

00 = 45

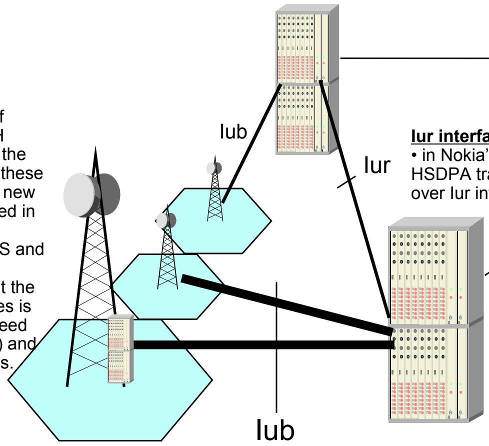
11 = 225

01 = 315

QPSK = Quadrature Phase Shift Keying

HSDPA General Functional Division over RAN

BTS
- The new functionalities of hybrid ARQ and HS-DSCH scheduling are included in the MAC layer. In the UTRAN these functions are included in a new entity called MAC-hs located in Node B.
- Flow control between BTS and RNC is supervised in BTS
- The transport channel that the HS-DSCH functionality uses is called HS-DSCH (High Speed Downlink Shared Channel) and is controlled by the MAC-hs.

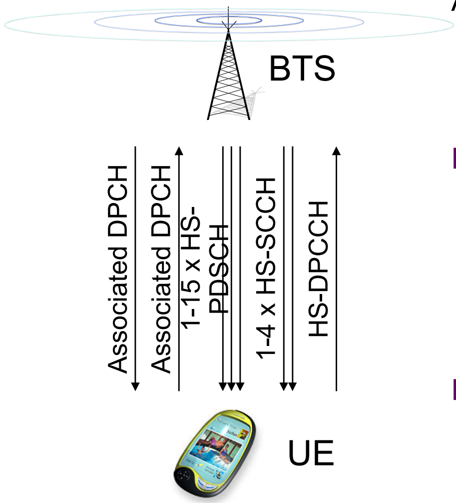


Iur interface
- in Nokia's implementation no HSDPA traffic is supported over Iur interface

RNC
- The HS-DSCH functionality should be able to operate in an environment where certain cells are not updated with HS-DSCH functionality. The PDCP, RLC are unchanged from the Release '99
- On MAC –d –layer in RNC no TTI specific TTI is required
- .RLC can operate only in either AM or UM mode.
- PDCP can be configured either to perform or not to perform header compression.
- MAC-d is retained in the S-RNC. Transport channel type switching is therefore feasible.
- RRM / RRC functions are performed in RNC

Iub interface
- One Iub HS-DSCH data stream is carried on one transport bearer. For each HS-DSCH data stream I.e. MAC-s flow, a transport bearer must be established over the Iub interface.

Physical Channels for One HSDPA UE



Associated DPCH, Dedicated Physical Channel

- DPCH needed for each HSDPA UE.
- Signalling, uplink data.

HS-PDSCH: High-Speed Physical Downlink Shared Channel

- Actual HSDPA data of HS-DSCH transport channel.
- 1-15 code channels.
- QPSK or 16QAM modulation.

HS-SCCH: High-Speed Shared Control Channel

- Informs UE how to receive HS-PDSCH in the same TTI.

HS-DPCCH: High-Speed Dedicated Physical Control Channel

- MAC-hs Ack/Nack information.

HS-PDSCH (High Speed Physical Downlink Shared Channel)
Transmitted from the base station to the mobile (downlink)

•Carries high speed data from the base station to the users being covered by the base station

•As the name states, this channel is shared amongst all the users being served by the base station

•The transport channel used on HS-PDSCH is called HS-DSCH (High Speed-Downlink Shared Channel), which is an extension, with some differences, of the release 99 DSCH

•This channel is designed to be able to carry a maximum of 14.4 Mbps under ideal conditions

Thus, all high-speed applications such as streaming video, song downloads, video conferencing, etc. will be carried to the user from the base station via this channel.

HS-SCCH (High Speed Shared Control Channel)

•This channel is transmitted from the base station to the mobile (downlink)

•Used to carry all the required high speed channel (HS-PDSCH) control signalling

•Used to configure the high speed channel

HS-DPCCH (High Speed Dedicated Physical Control Channel)

•Transmitted from the mobile to the base station (uplink)

•Used to carry constant feedback from the mobiles to the base station

•Feedback provides mobile received signal strength or Channel Quality Indicator (CQI), and acknowledgement to the base station of receipt or not of sent packet data (ACK/NACK)

HSDPA Protocol Model

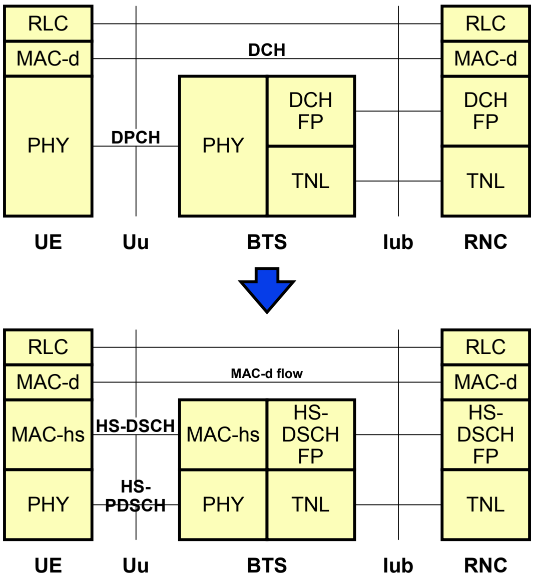
MAC-d flow (between RNC and BTS)
- UE-specific
- 1:1 with FP entity
- 1:1 with AAL2 connection
- Up to 8 MAC-d flows per UE
- RAN05/05.1: 1 MAC-d flow per UE

HS-DSCH (BTS internal ch)
- Transport channel
- Shared by the UEs in the cell
- Controlled by MAC-hs
- Between BTS and UE(s)

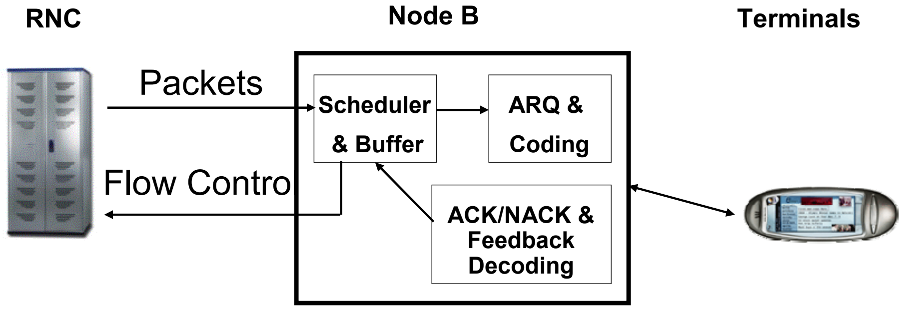
HS-PDSCH (Physical ch)
- 0 to 15 per cell
- RAN05: 5 per HSDPA cell
- RAN05.1: 5 or 10 per HSDPA cell

HS-SCCH, HS-DPCCH

In the figure, the SRNC and DRNC are co-incident. This is always the case since RAN05/05.1/06 HSDPA has no Iur.



Node B enhancements for HSDPA



R99 responsibilities:

Physical layer operations

No dymanic decision making

New Node B functions for HSDPA:

Sophisticated Scheduler:

- **Channel condition report processing**
- **Buffer management**
- **OVSF code management**
- **Terminal scheduling**
- **Modulation selection**

Physical layer operations

- **ARQ Retransmissions Handling**

Flow Control towards SRNC

Node B enhancements

New Sw and HW required to support higher data rates, new channel elements to handle HSDPA channels, increased memory requirements and buffer management.

RRM (radio resource management) in HSDPa is dynamic in nature. It involves power management between existing UMTS R99 channels and the new HSDPA channels.

SF (spreading factor) space management between UTMS R99 and HSDPA channels.

Increased backhaul capacity, currently T1/E1 lines. Need more or higher rate interface.

Node B new algorithms

Packet Scheduler
- new functionality in Node B
- operates per 2 ms
- operates on priority queues
- RAN05: scheduler like Round-Robin
- RAN05.1: Proportional Fair Resource algorithm for multi-user diversity gain

Link Adaptation
- chooses modulation, number of codes and code rate for HS-PDSCH
- uses CQI, Ack/Nack

HS-SCCH Power Control
- corresponds to Link Adaptation on HS-PDSCH
- uses same input as link adaptation

Flow Control
- Node B controls how much RNC can transmit

RNC enhancements for HSDPA

Expected to be a software change, but …

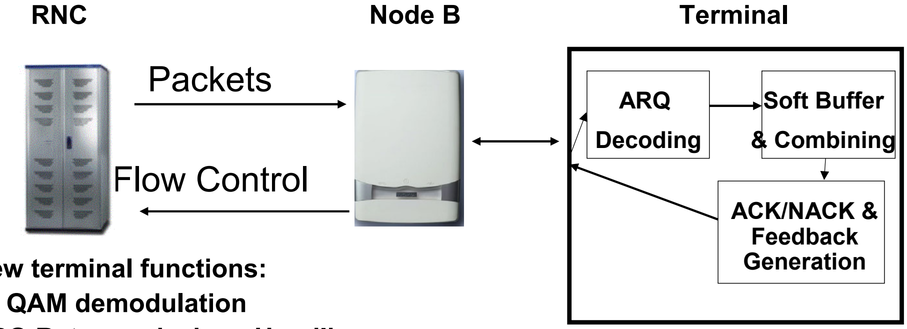
Increased backhaul capacity to Node B

Increased capacity to SGSN

Coordination of radio resources with Node B

- Overall power management
- Active Set management

UE enhancements for HSDPA



New terminal functions:

16 QAM demodulation

ARQ Retransmissions Handling

More memory for buffers

Fast Uplink Feedback Generation & encoding (more processing power)

- **CQI (channel quality indicator)**
- **2ms Tti**
- **Channel coding**

HSUPA

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HSUPA Peak Bit Rates

HSUPA uses BPSK modulation with multi-code transmission to achieve high data rates

Theoretical peak bit rate up to 5.76 Mbps

First phase capability expected at least 2 codes

Coding rate	1 code	2 codes	4 codes	6 codes
1/2	480 kbps	960 kbps	1.92 Mbps	2.88 Mbps
3/4	720 kbps	1.44 Mbps	2.88 Mbps	4.32 Mbps
4/4	950 kbps	1.92 Mbps	3.84 Mbps	5.76 Mbps

High Data rate enablers

Node B controlled scheduling

New channels

- Uplink:
  E-DPCCH (Enhanced Dedicated Physical *Control* Channel)
  E-DPDCH (Enhanced Dedicated Physical *Data* Channel)
  E-DCH (Enhanced Dedicated Channel)
- Downlink:
  E-HICH (E-DCH HARQ Acknowledgement Indicator Channel)
  E-AGCH (E-DCH Absolute Grant Channel)
  E-RGCH (E-DCH Relative Grant Channel)

Key HSDPA Technologies

HSDPA replaces two basic features of WCDMA—the variable spreading factor and fast power control—with adaptive modulation and coding, extensive multi-code operation, and a fast and spectrally efficient retransmission strategies. Let's look at each of these in more detail.

1. Adaptive modulation and coding

In current-generation W-CDMA networks, power control dynamics are on the order of 20 dB in the downlink and 70 dB in the uplink. W-CDMA downlink power control dynamics are limited by potential interference between users on parallel code channels and by the nature of W-CDMA base station implementations. For W-CDMA users close to the base station the power control cannot reduce power optimally, and that reducing power beyond the 20 dB dynamics would have only a marginal impact on capacity.

HSDPA utilizes advanced link adaptation and adaptive modulation and coding to ensure all users enjoy the highest possible data rate. This upgrade technology adapts the modulation scheme and coding to the quality of the appropriate radio link.

While the spreading factor is fixed, the coding rate can vary between 1/4 and 3/4, and the HSDPA specification supports the use of five, 10 or 15 multicodes. This more robust coding, fast HARQ, and multi-code operation eliminates the need for variable spreading factor. This approach also allows users with good signal quality (higher coding rate) typically close to the base station, and those at the more distant edge of the cell (lower coding rate) to each receive an optimum available data rate.

2. Fast Scheduling
While current W-CDMA technology schedules data traffic at the radio controller level, HSDPA moves these decisions to the base station, and thus closer to the air interface. HSDPA uses information about channel quality, terminal capabilities, QoS, and power/code availability to achieve more efficient scheduling of data packet transmissions.

By moving these intelligent network operations to the base station, this approach allows the system to take full advantage of short-term variations, and thus to speed and simplify the critical transmission scheduling process. The HSDPA approach can, for example, manage scheduling to track the fast fading of the users and when conditions are favorable to allocate most of the cell capacity to a single user for a very short period of time.

3 Fast PHY Re-Transmissions
When a link error happens, due to interference or other causes, a mobile terminal immediately requests the retransmission of the data packets. While current-generation W-CDMA networks handle those retransmission requests by the radio network controller, in HSDPA those retransmission requests are managed in the base station.

Using this approach, in packets are combined at the physical (PHY) layer, the terminals stores the received data packets in soft memory. If decoding has failed, the new transmission is combined with the old transmission before channel decoding. The HSDPA approach allows previously transmitted bits from the original transmission to be combined with the retransmission. This combining strategy provides improved decoding efficiencies and diversity gains while minimizing the need for additional repeat requests.

This operation is denoted as a hybrid automatic repeat request (HARQ), which is an operation designed to reduce the delay and increase the efficiency of re-transmitting data. Layer 1 HARQ control is situated in the Node B, or base station, thus removing retransmission-related scheduling and storing from the radio network controller, as illustrated in **Figure 2**. This HARQ approach avoids Iub delay and measurably reduces the resulting retransmission delay.

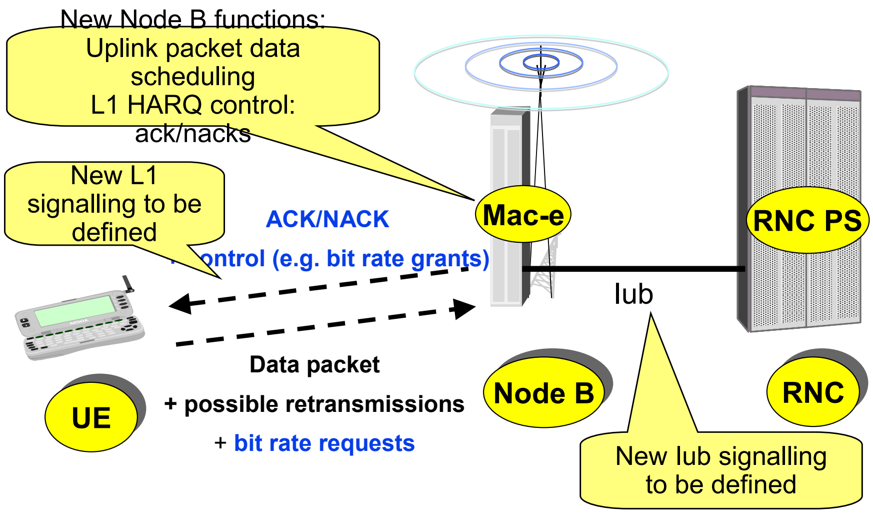
Figure 2: HSDPA principle with Node B-based HARQ.

4. Channel Quality Feedback
At the base station, HSDPA gathers and utilizes estimates of the channel quality of each active user. This feedback provides current information on a wide range of channel variable physical layer conditions, including power control, ACK/NACK ratio, QoS, and HSDPA-specific user feedback.

5. High-Speed Downlink Shared Channel (HS-DSCH)
While Release '99/Release 4 contain the support for the downlink shared channel (DSCH), the HSDPA operation is carried on the high-speed downlink shared channel (HS-DSCH). This higher-speed approach uses a 2-ms frame length, compared to frame lengths of 10, 20, 40 or 80 ms with DSCH. While DSCH utilizes a spreading factor that may vary from 256 and 4, the HS-DSCH uses a fixed spreading factor of 16 with a maximum of 15 codes.

HS-DSCH supports 16-level quadrature amplitude modulation (16-QAM), link adaptation, and the combining of retransmissions at the physical layer with HARQ. HSDPA also leverages a high-speed shared control channel (HS-SCCH) to carry the required modulation and retransmission information. An uplink high-speed dedicated physical control channel (HS-DPCCH) carries ARQ acknowledgements, downlink quality feedback and other necessary control information on the uplink.

Fast Node B Controlled Scheduling in HSUPA (Rel6)



Target is to shorten the packet scheduling period ⇒ packet scheduler is able to track burstiness of source application

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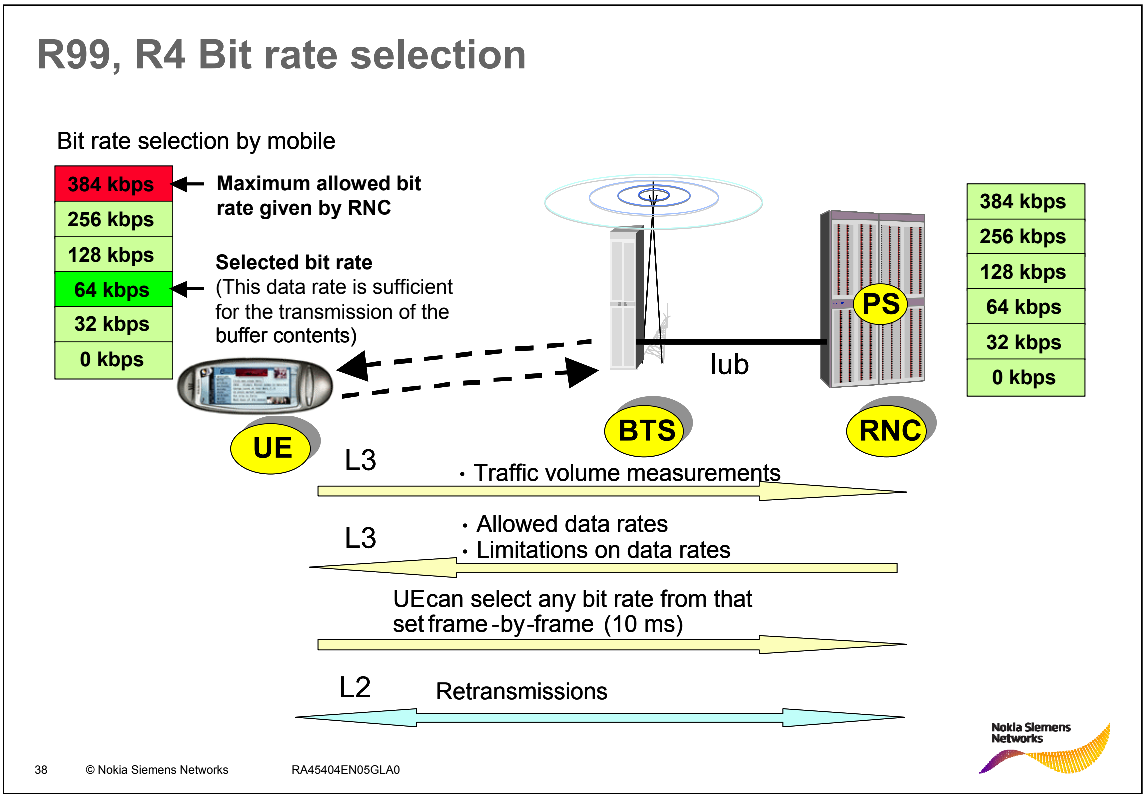
R99, R4 Bit rate selection
Bit rate selection by mobile
384 kbps
256 kbps
128 kbps
64 kbps
32 kbps
0 kbps
Maximum allowed bit rate given by RNC
Selected bit rate
(This data rate is sufficient for the transmission of the buffer contents)
Iub
PS
UE
BTS
RNC
384 kbps
256 kbps
128 kbps
64 kbps
32 kbps
0 kbps
L3
• Traffic volume measurements
L3
• Allowed data rates
• Limitations on data rates
UEcan select any bit rate from that set frame-by-frame (10 ms)
L2
Retransmissions
38
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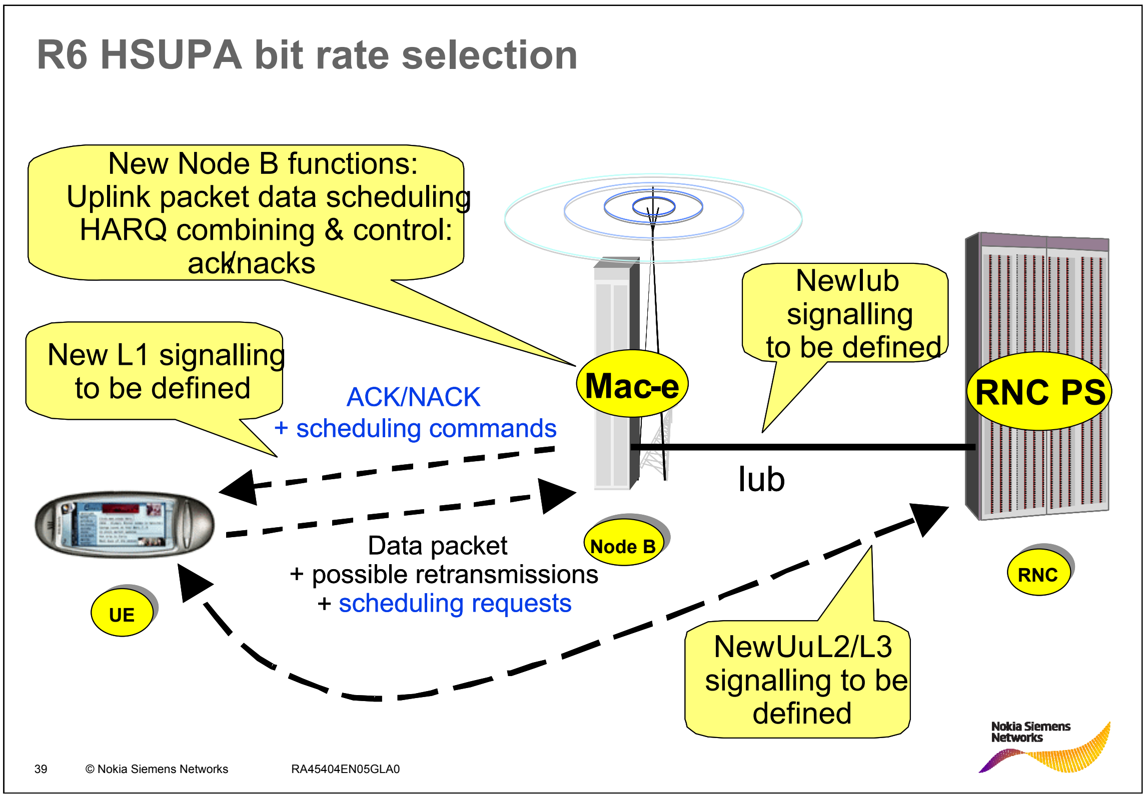
R6 HSUPA bit rate selection
New Node B functions:
Uplink packet data scheduling
HARQ combining & control:
ack/nacks
New L1 signalling
to be defined
ACK/NACK
+ scheduling commands
Mac-e
NewIub
signalling
to be defined
RNC PS
Iub
Node B
RNC
UE
Data packet
+ possible retransmissions
+ scheduling requests
NewUuL2/L3
signalling to be
defined
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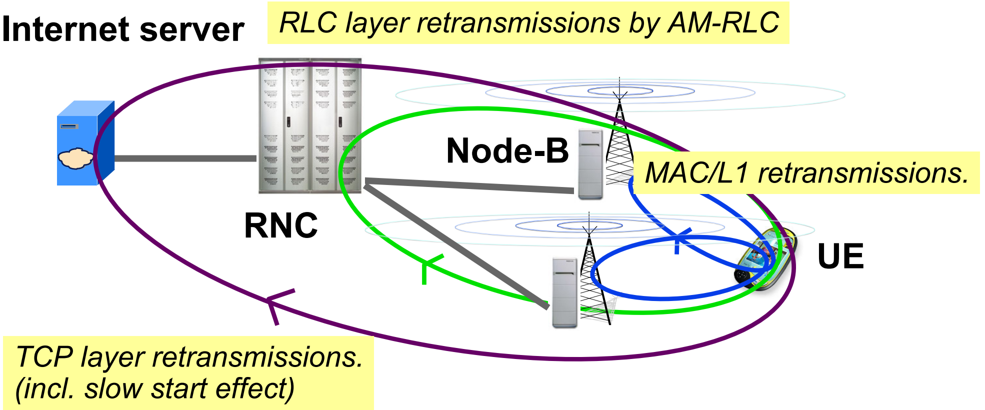
Retransmissions in HSUPA



- To be noted:
  - AM and UM-RLC can be utilised on top of HSUPA
  - Traffic only from PS domain: Conversational, Streaming, Interactive and Background

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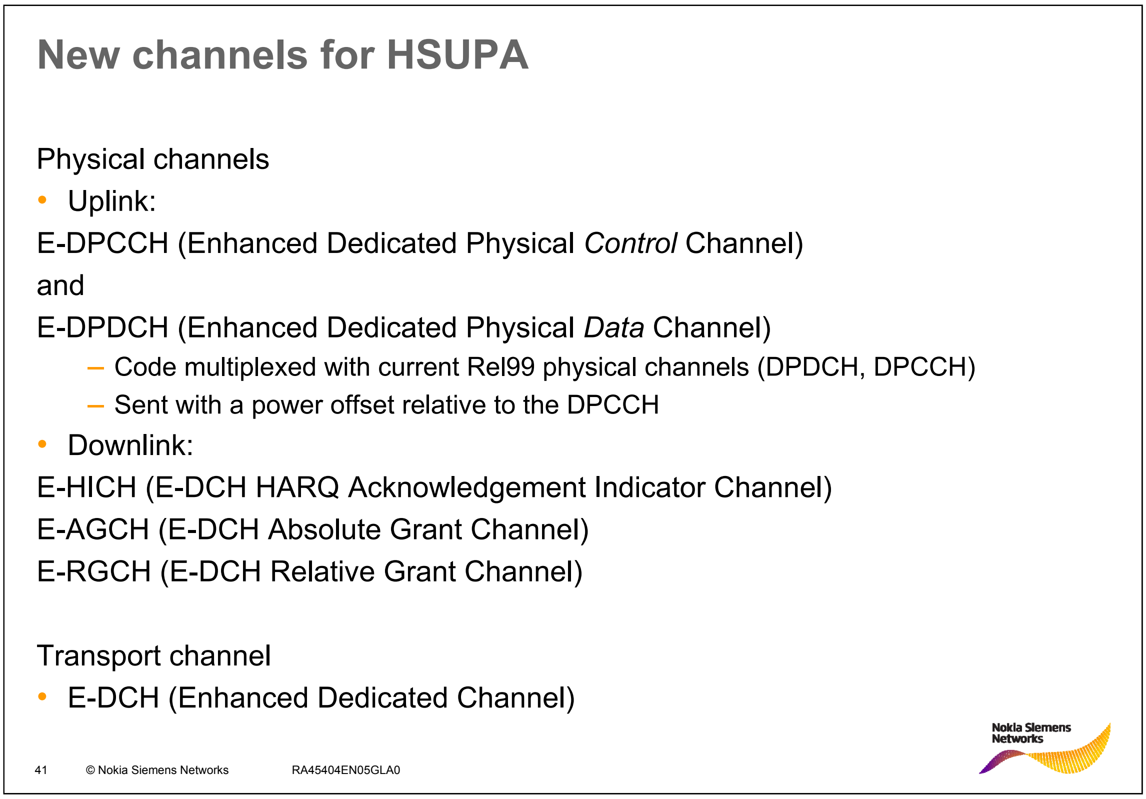


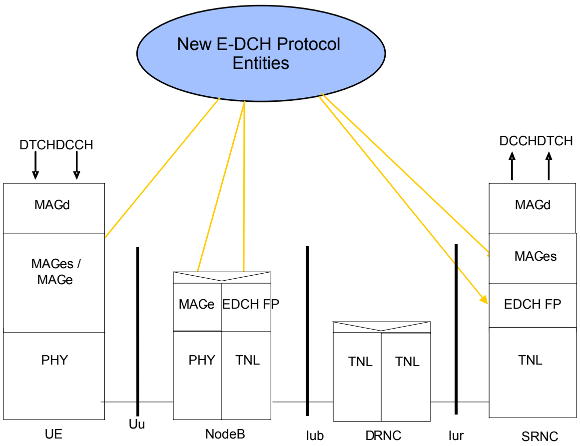
The E-DPCCH is a new control channel, needed to convey E-DCH transport format combination indicators (E-TFCI) size of 7 bits, retransmission sequence number size of two bits and scheduling request one bit.

The E-DPDCH is the new physical data channel for UEs uplink transmission to where the E-DCH transport channel is mapped

The relative power offset is calculated by RNC signalled to UE by RRC and the power offset of E-DPDCH is depending on selected TFC and the QoS profile of the MAC-d flow, which data is being transmitted in given TTI

E-HICH is used to transmit HARQ acknowledgements from each cell of the UEs E-DCH active set

Protocol Architecture for HSUPA



UE

- A new MAC entity: MAC-es/MAC-e
- Located below MAC-d
- MAC- es/MAC-e in the UE handles HARQ retransmissions, scheduling, MAC-e multiplexing, and E-DCH TFC selection.

Node B

- A new MAC entity: MAC-e
- Handles HARQ retransmissions, scheduling and MAC-e demultiplexing.

S-RNC

- A new MAC entity: MAC-es
- Provides in-sequence delivery (reordering) and handles combining of data from different Node Bs in case of soft handover.