v 2.420

HSDPA Design Details & System Engineering

Course Duration:

- 2 days
  or
  3 days with practical exercises

Course Description:

- This course is addressed to all engineers and technicians who need to gain an expert knowledge about the key functions of HSDPA like AMC (Adaptive Modulation and Coding) or HARQ (Hybrid Automatic Repeat Request)

- The course focuses on the necessary extensions of the UTRAN architecture in NodeB and UE which are required for HSDPA. Another focus is on the protocol enhancements like MAC-hs or on the frame protocols on Iub/Iur interface.

- Special emphasis is put on NodeB's and UE's physical layer aspects which allow a higher user data throughput, far beyond conventional 384kbit/s.

  As in all our courses, we integrated several interactive exercises for a perfect learning experience.

Prerequisites:

- Very good understanding of WCDMA networks, protocols, operation and parameters.

- Previous knowledge of UMTS-details from our training course "UMTS Design Details & System Engineering" is required. In addition, we advise our course "UMTS – Signaling & Protocol Analysis (UTRAN & UE)" to be taken in advance. Previous design and/or testing experience with WCDMA-networks and/or User Equipment are favorable.

Course Target:

- The student will be enabled to understand all relevant details of HSDPA within the UTRAN and the UE.

- The student is enabled to develop, test and operate HSDPA hard- and software.

Some of your Questions that will be answered:

- What are the advantages for the subscriber using HSDPA capable Ues?

- What are the implications of using 16-QAM-modulation?

- How do HARQ and Packet Scheduling work?

- What are the differences between IR and Chase Combining?
- How is Rate Matching performed with HS-DSCH?
- How exactly works AMC (Adaptive Modulation and Coding)?
- Under what circumstances are QPSK or 16QAM used?
- What are the impacts of HSDPA in Iub & Iur User and Control Plane?
- What adaptations are required on the UE and network side to provide for HSDPA?
- What is the idea behind CQI reporting and why can the NodeB still pursuit a downlink BLER of about 20% reaching maximum throughput?
- How is the user's mobility maintained in HSDPA?
- How do Softhandover and HSDPA cell change go along?

Who should attend this Course:

- Everybody who needs to design HSDPA capable UEs and network equipment.
- Operators who need a detailed understanding of HSDPA.
- Test engineers who need to integrate HSDPA equipment and UEs.

Table of Content:

HSDPA Principles

⇒ HSDPA High Speed Information
H-RNTI, DL-HSPDSCH-Info, HS-SCCH Info, Downlink Scrambling Coding, HS-SCCH Channelization Code info, HS-SCCH Codes

- **HSDPA Timing Relations**
  Timing between HS-SCCH and HS-PDSCH, Modulation Type and Number of HS-PDSCH's, HARQ Info (Hybrid-ARQ-related Information)

⇒ HSDPA Downlink Timing
DPCH (Dedicated Physical Channel), HS-SCCH (High Speed Shared Control Channel, HS-DSCH (High Speed Downlink Shared Transport Channel)

⇒ HSDPA Uplink Timing

- **DCH / HS-DSCH Comparison**
  Variable Spreading Factor, Fast Power Control, AMC, Multicode Operation, Fast Layer 1 Hybrid ARQ

⇒ DCH / HS-DSCH Comparison – cont'd
16-QAM Modulation / Interleaving / Channel Coding Scheme, TrCH Multiplexing , Static rate matching – DCH versus HS-DSCH, Transport block Concatenation – DCH versus HS-DSCH, Soft(er) Handover

- **Practical Exercise: How does the FACH transport channel compare to DCH and HS-DSCH?**
- **Advantages of HSDPA**
  Advantages of HSDPA, Reduced Latency for Retransmissions, Higher DL Throughput and Peak Throughput Rates up to 14 Mbit/s, Support of Non-Real Time and Streaming Applications, High Spectrum and Code Efficiency due to 16-QAM

⇒ Disadvantages of HSDPA
Higher Processing Power in UE, More Memory in UE due to HARQ, Advanced Receiver for 16-QAM, Higher Vulnerability using 16-QAM

⇒ Disadvantages of HSDPA cont'd
Software and possibly Hardware Upgrade , No Macro-Diversity for HS-PDSCH and HS-SCCH, Power / Interference Increase in uplink and downlink, Higher Linearity Requirement for UE's uplink Power Amplifier, Signaling Overhead caused by HS-SCCH (dl)

- **Rel. 6 HSDPA Enhancements**

The Physical Layer of HSDPA

- **Uplink HS-DPCCH Frame Structure**
  HARQ-Ack, Channel Quality Indication

⇒ HS-DPCCH Spreading
Spreading, DPCCH / DPDCH / HS-DPCCH, Gain Factors

⇒ Uplink Power Control including HS-DPCCH

⇒ Uplink HS-DPCCH Coding Chain
Channel Coding for HS-DPCCH, Channel Coding for HARQ-Ack, Channel Coding for CQI

⇒ Uplink Transmission Delay T(0)
Uplink / Downlink Timing at UE, Uplink Fast Power Control – Reason for T(0)

⇒ HS-SCCH / HS-DSCH and HS-DPCCH Timing (1)

⇒ HS-SCCH / HS-DSCH and HS-DPCCH Timing (2)
Uplink HS-DPCCH, T(TX_diff)

⇒ Practical Exercise: Please determine the five different T(TX_diff) times between DL DPCH and the related HS-DSCH subframes:

⇒ Delta ACK / NACK and ACK-NACK Repetition Factor
DeltaAck, DeltaNack, ACK-NACK-repetition-factor

⇒ Delta Ack / Nack and CQI Power

⇒ HS-DPCCH ACK / NACK and DTX Recognition

⇒ CQI Description and Tasks
TFRC (Transport Format and Resource Combination) Info, Out of Range Signaling, Power Reduction Factor Δ, Measurement Power Offset Γ, CQI Reporting Cycle

⇒ HS-DPCCH Measurement Feed Back Info- CQI
Measurement Power Offset Γ, CQI Feedback cycle, k, CQI-Repetition-Factor, DeltaCQI

⇒ CQI Reporting Principle
UE measures the downlink channel quality, NodeB TFRC (Transport Format and Resource Combination) decision, CQI Algorithm in UE

⇒ CQI Mapping Table – UE Category
UE Category, CQI value , Transport Block Size, Reference Power Adjustment, N(IR) and X(RV), CQI Mapping Table for UE Categories 1 to 6, CQI mapping table for UE Categories 1-6, 7-8, 9 and 10, Example for a CQI Report – Cat 6 with CQI (15), CQI and Ack/Nack Considerations, HS-DPCCH Power Control during Soft Handover, CQI Repetition, Intra NodeB Softer HO

⇒ CQI Reporting – Feedback Cycle and Repetition
Ack/Nack Repetition Factor, Trade off between Ack/Nack/CQI Repetition and long Feedback Cycles

- **HS-SCCH Frame Structure**
  Part 1, Part 2, TFRC and HARQ parameter

⇒ HS-SCCH Coding Chain
RV Coding, MUX of HS-SCCH Part 1, MUX of HS-SCCH Part 2, HS-SCCH Channel Coding and Rate Matching, UE specific Masking of Part 1 bits

⇒ UE Specific CRC Attachment
HS-SCCH Power Control

⇒ UE Specific Masking for Part 1

⇒ HS-PDSCH Code Allocation through HS-SCCH Part 1

- **TFRI - Transport Block Size Mapping**
  QPSK
- **TFRI - Transport Block Size Mapping**
  16-QAM

⇒ Stop & Wait HARQ Transition Diagram – NodeB
HARQ in Idle State, HARQ in WAIT State, 1-Channel Stop and Wait

⇒ HARQ Processes with N-Channel Stop and Wait
Preconditions:, HS-SCCH Signaling, HS-DSCH Transmission and Retransmission

- **HARQ Process and New Data Indicator**
  HARQ Process, New Data Indicator

- **HS-PDSCH Frame Structure**

  ⇒ HS-DSCH Channelization Code Tree

  ⇒ HSDPA Code- and Time Multiplex Operation
  Resource Sharing in Code as well as Time Domain, UE procedure for Receiving HS-DSCH

  ⇒ HSDPA during Compressed Mode Operation

  ⇒ Consequences of Using 16-QAM
  Higher Throughput Rates, Increased Spectrum Efficiency, Higher Interference Vulnerability, Smaller Decision Space, 16-QAM Constellation Rearrangement, 16-QAM Constellation Rearrangement for b = 2 and b = 3

  ⇒ Power Sharing between HSDPA and DCH
  Node B Transmit Power, Maximum Transmission Power, UE Transmit Power

  ⇒ Benefits of AMC

- **Adaptive Modulation and Coding – Principle**
  AMC Scheduling Function, Layer 1 Processing Chain

  ⇒ Physical Layer Processing Chain of AMC
  Methods of selecting the suitable MCS, AMC Processing Chain

  ⇒ AMC Liabilities
  UE's measurement inaccuracy, Delay in CQI Reporting, Limited Granularity for Data Rate Selection, NodeB Processing and Scheduling Delay

  ⇒ HSDPA HARQ Types
  Chase Combining, Partial IR, Full IR

  ⇒ Operation of Chase Combining

  ⇒ Operation of Partial IR

  ⇒ Operation of Full IR
  HARQ Transmissions / Retransmissions Comparison, HARQ Type III – Partial IR and Chase Combing

Forward and Backward Error Correction in HSDPA

- **Turbo Coder Principle**
  Turbo Coder Principle, RSC Encoder, Interleaver

  ⇒ Turbo Coder Structure
  Trellis Termination for Turbo coder, Turbo Code internal Interleaver

  ⇒ Iterative Decoding Principle

  ⇒ HARQ Retransmission – Comparison with Legacy Releases
  DCH, HS-DSCH

  ⇒ Redundancy Version and Constellation Version

  ⇒ HSDPA Category and Reference Combinations
  Number of HARQ Processes versus IR Memory

- **Practical Exercise:**

- **HARQ Information**
- **HS-DSCH HARQ Functionality**

  ⇒ HARQ Parameters for Retransmissions
  Transmission Parameters = Retransmission Parameters, Transmission Parameters <> Retransmission Parameters

  ⇒ Rate Matching Tasks
  First Rate Matching, Second Rate Matching

  ⇒ First RM Stage
  Puncturing Algorithm

  ⇒ Second Rate Matching Function

  ⇒ RM Pattern Determination
  Bit Repetition, Rate Matching Patterns

  ⇒ Example for Initial Transmission – Self-decodable with 1st RM
  1st RM Puncturing, 2nd RM Puncturing

  ⇒ Example for Retransmission – Non-self-decodable

  ⇒ Example for Chase Combining
  2nd RM – Parameter Calculation Self-Decodable, 2nd RM – Bit Position Calculation Self-Decodable, 2nd RM – Self-Decodable Transmission followed by Full IR (1), 2nd RM – Self-Decodable Transmission followed by Full IR (2), 2nd RM – Parameter Calculation Non-Self-Decodable (3), 2nd RM – Bit Position Calculation Non-Self-Decodable (4)
- **Practical Exercise:**

  ⇒ HARQ Performance Enhancement Techniques
- **HS-DSCH Interleaving**
  DTX Indication Bits

HSDPA Protocol Enhancements and Extensions

- **Packet Scheduler in NodeB**
- **AMC Scheduler Function**

  ⇒ Comparison of Basic Packet Scheduler Methods
  Scheduling Rate, Serve Order, Allocation Method, FT (Fair Throughput) , P-FR (Proportional Fair Resources), M-C/I (Maximum C/I)

  ⇒ Packet Scheduling Strategies

  ⇒ Multi-User Selection Diversity – Dynamic Scheduling
- **MAC-hs with co-incident CRNC and SRNC**
  MAC-hs - co-incident CRNC and SRNC, HS-DSCH RNTI
- **HSDPA Architecture – Evolution from Rel. ’99 / Rel. 4**
  Protocol Structure, HS-DSCH Characteristics

  ⇒ MAC-hs Tasks

⇒ HS-DSCH MAC PDU
General, MAC-hs SDU, MAC-hs Header of MAC-hs PDU

⇒ MAC-hs Entity UTRAN Side

⇒ MAC-hs Entity UE Side

⇒ HS-DSCH MAC Architecture – UTRAN Side
Overall Architecture, MAC-c/sh (optional), MAC-d Flow in UTRAN

⇒ HS-DSCH Architecture – UE Side
Overall Architecture, MAC-d Flow in UE

- **HS-DSCH Bit Rate Measurement**

⇒ HARQ Process Details in UE – TSN, NDI and TBsize Index
Split HS-DSCH Block Functionality

⇒ Transmitter and Receiver Stall Avoidance
Timer-Based Scheme, Window Bases Scheme, HARQ Activity Scheme (not specified by 3GPP)

⇒ Timer and / or Window Based Stall Avoidance
Window Based Scheme, Timer Bases Scheme

⇒ UE MAC-hs Other Functions
Disassemble Entity, MAC-hs Reset

- **RRC Protocol Enhancement – New IE's with HSDPA**

⇒ HS-PDSCH and DL TrCH Information
Downlink Transport Channel Type

⇒ Added or Reconfigured MAC-d Flow

⇒ Uplink DPCH Power Control Info and Others

- **HS-DSCH Data Frame on Iub/Iur**

⇒ HS-DSCH Capacity Request Control Frame

⇒ HS-DSCH Capacity Allocation Control Frame

- **NBAP - HSDPA Message and IE Overview**
HS-DSCH Resources Information, HS-DSCH's MAC-d Flow To Rearrange, HS-DSCH FDD Information, HS-DSCH MAC-d Flows To Add, HS-DSCH Information To Modify, HS-DSCH MAC-d Flows To Delete

⇒ NBAP - HSDPA Common Measurement Report
HS-DSCH Required Power Value Information, HS-DSCH Required Power Per UE Information, HS-DSCH Provided Bit Rate Value Information

⇒ NBAP – HSDPA Radio Link Parameter Update Indication

⇒ NBAP - HS-DSCH Related IE's (1)
Allocation / Retention Priority, Priority Flow Information

⇒ NBAP - HS-DSCH Related IE's (2)
MAC-d PDU Size

⇒ NBAP HS-DSCH Info Response
HS-DSCH Initial Capacity Allocation, HS-SCCH Specific Information Response, HARQ Memory Partitioning Information

⇒ HS-PDSCH and HS-SCCH Power and Code Information

⇒ HSDPA Cell Configuration – AUDIT

⇒ HSDPA Data Transfer Procedure (1)

⇒ HSDPA Data Transfer Procedure (2)

HSDPA Mobility Procedures

- **Introduction to HSDPA Mobility Procedures**
  Serving HS-DSCH Cell Change

⇒ Best Serving HS-DSCH Cell Measurement
Change of best Cell, HS-DSCH Handover

⇒ Intra NodeB Synchronized HS-DSCH Cell Change
MAC-hs Preservation

⇒ HSDPA Reconfiguration during HS-DSCH Cell Change
H-RNTI during HSDPA Reconfiguration, MAC-hs Reset during HSDPA Reconfiguration, Reconfiguration of HARQ Processes and Reconfiguration of HARQ Memory Partitioning, Reconfiguration of DPCH timing offset ΓDPCH, n for HS-DSCH serving cell, Change of HS-DSCH Serving Cell, Reconfiguration of transmission gap pattern sequence, Reconfiguration of Scrambling Code of uplink DPCH, Intra NodeB Synchronized HS-DSCH Cell Change Procedure

⇒ Inter NodeB Synchronized Serving HS-DSCH Cell Change
Inter NodeB HS-DSCH Cell Change – Hard Handover (1), Inter NodeB HS-DSCH Cell Change – Hard Handover (2)