v2.200

UMTS
Design Details & System Engineering

Course Duration:

- 3 days

Course Description:

- This course addresses the needs of engineers and technicians who have already a general understanding of UMTS.
  - This course continues our first UMTS course “Inside UMTS – Technology & System operation” and it provides a thorough understanding of the UMTS Radio Access Network (RAN), of its system functions and its technical operation on a high level of details.

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

Pre-Requesites:

- Good understanding of prerunning mobile communication systems GSM and GPRS and the generic GSM to UMTS environment. If required, we advise our course “Inside UMTS – Technology & System operation” to be taken upfront.
- Previous knowledge of SS 7 protocol know how is favourable. If required, we advise our course “GSM - Signaling & Protocol Analysis” to be taken in advance.

Course Target:

- The student will be enabled to understand all relevant details of UMTS-procedures within the RAN and the mobile station.
- The student will achieve a thorough understanding of the UMTS Radio Access System and will be enabled to immediately contribute to system development in a strong manner.

Some of your questions that will be answered:

- How are the initial parameters (e.g. access slot number) for network access be selected by the UE?
- In which way is blind transport format detection performed?
- What are the functions of the SSCOP protocol in the transport network protocol?
- What is the meaning of the N_Max_frames parameter?
- How are the dedicated and the common channels handled in the user plane on the Iub interface?
- What parameters are added to the Authentication quintet, how is integrity protection performed?
- What kind of different identifiers are used in CELL_FACH, CELL_PCH and URA_PCH for adressing?
- How is an AMR speech connection established and reconfigured, how is the codec mode change controlled?

Who should attend this class?

- Everybody who needs to understand UMTS system details and operation procedures
- System designers and development engineers of UMTS network equipment and UMTS mobile stations
- Network Planners who need to establish UMTS and/or joined GSM / UMTS networks
- UMTS network operators for network design and planning, system installation, and/or system operation
- Software engineers engaged in signal processing flow and/or protocol stack software development

Table of Contents:

⇒ Terminal Technology
⇒ UE Radio Access Capabilities

Understanding CDMA and W-CDMA

SDMA (Space Division Multiple Access)
⇒ Cellular topology
⇒ Sectorization
⇒ Adaptive antennas
Principle of Adaptive antennas

FDMA (Frequency Division Multiple Access)

TDMA (Time Division Multiple Access)

Hybrid TDMA / FDMA

CDMA (Code Division Multiple Access)
⇒ Characteristics of Spread Spectrum Systems
Multiple access capability
Low Probability of Interception
Privacy
Interference rejection
⇒ Frequency Hopping Spread Spectrum (FH-SS)
⇒ Direct Sequence Spread Spectrum (DS-SS)

Spreading Codes

Spreading and Despreading
⇒ Spreading
⇒ Despreading

CDMA Correlation Receiver
⇒ Spreading Gain

Code Properties
⇒ Pseudo Noise Code
⇒ Orthogonal Code

Data transmission in UTRAN FDD
⇒ Channelization
⇒ Scrambling

Impact of Channelization
⇒ Chip rate

⇒ Spreading Factor (SF)

Scrambling
⇒ Improved synchronization
⇒ Preserved crosscorrelation
⇒ Signal separation
⇒ Code reuse

Channelization vs. Scrambling

Codes and Data rate
⇒ Downlink
⇒ Uplink

UMTS Terrestrial Radio Access (UTRA)

UTRA Radio Interface Architecture
⇒ Signaling Radio Bearers (SRB)
⇒ User Plane Radio Bearers (RB)

Channel concepts in UTRAN
⇒ Logical Channels
⇒ Transport Channels
⇒ Physical Channels

Logical Channels
⇒ Control Channels
⇒ Traffic Channels

Transport Channels
⇒ Common Transport Channels
⇒ Dedicated Transport Channels:
BCH (Broadcast Channel)
FACH (Forward Access Channel)
PCH (Paging Channel)
DSCH (Downlink Shared Channel)
RACH (Random Access Channel)
CPCH (Common Packet Channel)
DCH (Dedicated Channel)

Logical Channel Mapping

Selection of Transport Channel Type
⇒ Service type
⇒ Load of Common Channels

⇒ Interference Level
⇒ Data Amount

Code Division versus Time Division
⇒ Code Division
⇒ Time Division

Data Transfer on Transport Channels
⇒ Transport Block
⇒ Transport Block Set
⇒ Transport Block Size
⇒ Transport Block Set Size
⇒ Transmission Time Interval (TTI)

Transport Format (TF)
⇒ The dynamic part
⇒ The semi-static part
⇒ Transport Format Set (TFS)
⇒ Transport Format Indicator

Transport Channel multiplexing

Example for RB and SRB configuration
⇒ SRB #1
⇒ SRB #2
⇒ SRB #3
⇒ SRB #4

Main Functions of the Physical Layer
⇒ Channel Coding
⇒ Transport Channel Multiplexing
⇒ Mapping of Transport Channels onto Physical Channels
⇒ Spreading and Modulation
⇒ Power Control

Uplink Data Processing Path
⇒ CRC Attachment
⇒ Transport Block Concatenation / Code Block Segmentation
⇒ Channel Coding
⇒ Radio Frame Equalization
⇒ 1st Interleaving
⇒ Radio Frame Segmentation
⇒ Rate Matching

Channel Coding

Interleaving

Data Processing Path for 28.8 kbps bearer

Data Processing Path for 3.4 kbps signaling bearer

Transport Channel Multiplexing

Physical Channels
⇒ Specific carrier frequency
⇒ Scrambling code
⇒ Channelization code
⇒ Time duration

Physical Channels carrying Transport Channel
⇒ Common Physical Channels
⇒ Dedicated Physical Channels
⇒ DPDCH
⇒ PRACH
⇒ PCPCH
⇒ P-CCPCH
⇒ S-CCPCH
⇒ PDSCH

Mapping of Transport Channels onto Physical Channels

Physical Channels needed for System Operation
⇒ DPCCH
⇒ CPICH
⇒ SCH
⇒ AICH
⇒ CSICH, AP-AICH and CD/CA-ICH
⇒ PICH

Frame Structure of UL DPDCH / DPCCH
⇒ DPDCH
⇒ DPCCH

Data rates on Uplink DPDCH

Realization of Variable Bit Rate in Uplink

Frame Structure of Downlink DPDCH / DPCCH
⇒ DPDCH
⇒ DPCCH

Data rate on Downlink DPDCH

I/Q Code Multiplex versus Time Multiplex
⇒ I/Q Code Multiplex
⇒ Time Multiplex
⇒ Time Multiplex QPSK
⇒ I/Q Code Multiplexed QPSK

Uplink Spreading and Modulation

Combining Uplink Physical Channels
⇒ Uplink

Downlink Spreading and Modulation

Combining Downlink Physical Channels
⇒ Downlink

Power Control
⇒ Uplink Power Control
⇒ Downlink Power Control
⇒ Open Loop Power Control
⇒ Closed Loop Power Control
Outer Loop Power Control
Inner Loop Power Control

Soft and Softer Handovers
⇒ Soft Handover
⇒ Softer Handover

Site Selection Diversity Transmission (SSDT)

Relocation

UTRAN Physical Layer Details

Channel Types for Data Transfer
⇒ Dedicated Channels
⇒ Common Channels
⇒ Shared Channels
⇒ Uplink Radio Frame Structure
⇒ Downlink Radio Frame Structure

Cell Search Procedure
⇒ CPICH
⇒ P-SCH

⇒ P-CCPCH
⇒ Slot synchronization
⇒ Frame synchronization and code group identification
⇒ Scrambling code identification
⇒ Differences between the codes

System Information Blocks (SIB)
⇒ SIB Scheduling
⇒ SIB Transmission
⇒ System Information Messages
⇒ SIB Schedule Example
⇒ Data Processing Path for System Information Message

RACH Procedure
⇒ RACH Access Slots
⇒ RACH Preamble Code
⇒ PRACH / AICH Timing
⇒ AICH Signature
⇒ PRACH Message Code

CPCH Access Procedure

Radio Frame Timing

Uplink / Downlink Timing at UE

Rate Matching
⇒ Rate Matching Attribute
⇒ Rate Matching Procedure
Determination of the Spreading Factor and the number of Physical Channels needed
Calculation of the number of bits to be Punctured / Repeated
Repetition / Puncturing of Bits

Compressed Mode
⇒ Dual Receiver:
⇒ Frame Structures for Compressed Mode
Frame structure in Uplink:
Frame Structure in Downlink:
⇒ Transmission Gap Position
Single-frame method:
Double-frame method:
⇒ Methods for Compressed mode
Transmission time reduction by Puncturing:
Transmission time reduction by splitting the spreading factor:
Transmission time reduction by higher layer scheduling:
⇒ Impact of Compressed Mode

Transmission time reduction by Puncturing:
Transmission time reduction by splitting the spreading factor:
Transmission time reduction by higher layer scheduling:
⇒ Slot formats for Compressed mode
Downlink:
Uplink:

Lower Layer Functions and Protocols

UTRAN Radio Interface Protocol Reference Model

⇒ Control plane
⇒ User plane
⇒ Physical Layer
⇒ Layer 2 (RLC and MAC) Data Flow

Media Access Control (MAC) Layer

⇒ MAC Services
Data transfer
Reallocation of radio resources and MAC parameters
Reporting of measurements
⇒ MAC Functions
Mapping of logical channels on transport channels, transport format selection depending on the instantaneous source rate
Priority handling of data flows of one UE and between several users
Multiplexing of PDUs to/from common and dedicated transport channels
Traffic volume monitoring
Dynamic transport channel type switching
Ciphering for transparent RLC transfer mode
Access service class selection
⇒ MAC Layer Architecture
MAC-b
Mac-c/sh
MAC-d
⇒ MAC Layer Data Processing
⇒ Traffic Monitoring
⇒ Buffer Control
⇒ MAC PDU Header
UE-Id type
UE-Id
C/T field
Target Channel Type Field
⇒ MAC Header Formats
⇒ MAC Header and Channel Mapping
⇒ MAC Header Allocation

Radio Link Control (RLC) Layer

⇒ RLC Services
Transparent mode
Unacknowledged mode
Acknowledged mode
⇒ RLC Functions
Segmentation and Reassembly
Concatenation
Padding
Error correction
Insequence delivery and duplicate detection
Flow Control
Ciphering
⇒ RLC Layer Data Processing (acknowledged mode)
⇒ RLC PDU Frame
Transparent mode
Unacknowledged mode
Acknowledged mode
⇒ RLC AMD Status and Padding Indication

Radio Resource Control (RRC) Layer

⇒ RRC Services
General control
Notification
Dedicated control
⇒ RRC Functions
Management of RRC connections and of radio bearers
Cell information distribution
Control of QoS
Paging and notification handling
Power control
Cell selection and reselection
Ciphering control
Mobility function
⇒ RRC Message Encoding

Packet Data Convergence Protocol (PDCP)

⇒ PDCP Services
Header compression
Transfer of user data
Support of lossless SRNS relocation
⇒ Header Compression of IP Data Streams
⇒ Lossless SRNS Relocation
⇒ PDCP PDU Frames
PDCP-No-Header PDU
PDCP Data PDU
PDCP SeqNum PDU

Broadcast / Multicast Control (BMC)
⇒ BMC message Frame

UTRAN Protocols (Iub, Iur, Iu)

Abstract Syntax Notation One (ASN.1)
⇒ Packed Encoding Rules (PER)
⇒ Encoding Rules Comparison (Example)

UTRAN Generic Protocol Layer Structure
⇒ Radio Network Layer – User Plane
⇒ Radio Network Layer – Control Plane

Iub Frame Protocol (Iub FP)
⇒ DCH FP Services
⇒ DCH Data PDU Frame
⇒ DCH Control PDU Frame
⇒ Common Channel FP Services
⇒ CCH Data PDU Frame
⇒ CCH Control PDU Frame

Node B Application Part (NBAP)
⇒ NBAP Functions
⇒ NBAP Interfaces

Iu Frame Protocol (Iu FP)
⇒ Iu FP Functions
Transparent mode
Support mode
⇒ Iu FP PDU Frame
Support Mode Frame Types
⇒ Time Alignment

Radio Access Network Application Part (RANAP)
⇒ Dedicated control messages
⇒ General control services
⇒ RANAP Functions

Iur Frame Protocol (Iur FP)
⇒ Iur FP Functions for CCH
⇒ CCH Data Frame (at Iur)
⇒ Control Frame (at Iur)
⇒ Radio Network Subsystem Application Part (RNSAP)

Transport Network Protocols

UTRAN Generic Protocol Layer Structure
⇒ Transport Network Structure
⇒ Transport Network Protocols
⇒ ATM Layer

ATM Adaptation Layers - AAL
⇒ Transport Network Protocols (at Iub)
⇒ AAL2 Sublayers
AAL2 Service Specific Segmentation And Reassembly
AAL2 Common Part
⇒ AAL5 Sublayers
AAL5 Common Part
AAL5 Segmentation And Reassembly Sublayer
⇒ Service Specific Connection Oriented Protocol (SSCOP)
SSCOP PDU Types
SSCOP Assured Transmission
SSCOP Messages Formats
⇒ Coordination Functions
⇒ Transport Network Layers Data Handling

Access Link Control Application Part (ALCAP)
ALCAP Initialization Parameters
ALCAP Messages
ALCAP Messages Parameters
ALCAP Message Example
ALCAP Message Frame

Transport Network Protocols (at Iu – CS Domain)

Transport Network Protocols (at Iu – PS Domain)
⇒ Alternative Transport Network Protocols (at Iu – PS Domain)

Mobility Management, Quality of Service and Security

Mobility Management Procedures
⇒ Location concepts
Location Area
Routing Area
UTRAN Registration Area (URA)
UTRAN Registration Area Example
⇒ UE Identifiers in UTRAN
C-RNTI
S-RNTI

S-RNC Identifier
U-RNTI
⇒ User Equipment Registration
⇒ Mobility Management State Model
⇒ Service States and RRC Modes (Example)
⇒ RRC States
CELL_DCH
CELL_FACH
CELL_PCH
URA_PCH

QoS Handling

⇒ Quality of Service Classes
Conversational class
Streaming class
Interactive class
Background class
⇒ QoS attributes
QoS classes and attributes
Release 99 attributes
⇒ QoS Attributes Setting (Examples)
Maximum Bit rate
Delivery of erroneous SDU
⇒ Example for Background Class
The File Transfer Protocol (FTP)
⇒ Example for Conversational Class
Voice over IP (VoIP)

Security Procedures

⇒ 2G Security Challenge
⇒ Security Features
User identity
Authentication
Confidentiality
Data Integrity
⇒ Authentication and Security Parameters
⇒ Authentication Vector (Quintet)
⇒ User Authentication
⇒ Network Authentication
⇒ Ciphering
Cipher sequence number
Direction
Radiobearer
Length
⇒ Integrity Protection
Integrity sequence number
Direction

Message
Fresh

Connection Management and Selected Scenarios

Signaling Connection Management

Non Access Stratum Messages Exchange

Elementary Procedures

Mobile Originated Call Establishment
⇒ RRC Connection Setup
⇒ Iub Bearer Establishment
⇒ Signaling Connection Establishment
⇒ Authentication
⇒ Security Mode Setup
⇒ CS Call Establishment
⇒ Radio Access Bearer Establishment
⇒ Radio Bearer Establishment
⇒ Iu Bearer Establishment
⇒ Iu Support Mode Establishment
⇒ CS Call Release
⇒ Radio Access Bearer Release
⇒ RRC Connection Release
⇒ Iu Bearer Release
⇒ Iub Bearer Release

AMR Speech Connection Establishment
⇒ AMR Codec Modes
⇒ RAB Subflow Assignment
⇒ RAB Subflow Combination Set
⇒ Iu FP Initialization
⇒ Downlink AMR Data Transfer
⇒ AMR – AAL2 Transmission

Packet Data Transaction Establishment
⇒ RRC Connection Establishment
⇒ Signaling Connection Establishment
⇒ Authentication and Ciphering
⇒ PDP Context Activation
⇒ Transport Channel Establishment
⇒ Radio Bearer Setup

Soft Handover

⇒ Measurement Reporting
⇒ Radio Link Addition
⇒ Active Setup Update
⇒ Active Setup Update Remove
⇒ Radio Link Deletion

Solutions for the Practical Exercises

List of Acronyms