

## ***Inside UMTS Technology & System Operation***

### **Course Duration:**

2 Days

### **Course Description:**

- ▶ This course addresses the needs of engineers and technicians who are already experienced in mobile systems and will move to new tasks.
- ▶ This course provides the technical platform for system developers but also for operation services, network planners and technical management.

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

### **Pre-Requisites:**

- ▶ Detailed understanding of GSM and GPRS networks and overall mobile systems operation. If required, we advise our courses "GSM Introduction" and "GPRS from A to Z".

### **Course Target:**

- ▶ The student will be enabled to understand the advantages of the next generation of mobile systems and recognize the major technical differences between UMTS and GSM/GPRS
- ▶ The student will gain a basic comprehension of the new access technology CDMA and its operational behaviour in the UMTS Terrestrial Access Network (UTRAN).

## **Some of your questions that will be answered:**

- ▶ How can a GSM system be upgraded to a 3G network?
- ▶ What are the differences between the GSM/GPRS air interface and UTRA?
- ▶ How do CDMA and WCDMA work ? What are the differences?
- ▶ How does the UMTS Terrestrial Radio Access or UTRA operate?
- ▶ To what degree does UMTS facilitate Multimedia Services?
- ▶ Which new security features are introduced with UMTS?
- ▶ Which role takes Quality of Service (QoS) in UMTS?

## **Who should attend this class ?**

- ▶ Network Operators who need to understand the 3G technology
- ▶ Network Planners who need to understand the implications of WCDMA and UTRA
- ▶ Everybody who needs a thorough understanding of the UMTS concepts without digging through the bits

***“Inside UMTS – Technology & System operation” stays intentionally above the bit level to provide for a top-down approach to UMTS. Nevertheless, the seminar is very detailed and will provide all information that you need to understand UMTS and UTRA, in particular. This course provides the fundament for our expert level technical class “UMTS – Design details & System engineering”.***

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## **Table of Contents:**

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### **What are 3G Mobile Systems**

#### **Changing Environment and 2nd Generation Limitations**

- ⇒ The basis of GSM
- ⇒ Successful Growth and new Service Requirements
- ⇒ GSM's Limitation

#### **Basic 3G Objectives / The View ahead towards IMT 2000**

- ⇒ Early first steps
- ⇒ Major Requirements and Design Targets

#### **Towards the IMT-2000 Family of Standards**

- ⇒ Europe
- ⇒ Japan
- ⇒ Korea
- ⇒ Standardization Activities

#### **Recommendations from Operators Harmonization Group**

- ⇒ Operators Harmonization Group
- ⇒ Family of CDMA modes and core network systems

#### **The IMT-2000 Family**

- ⇒ IMT-DS the wideband CDMA FDD solution
- ⇒ IMT-TC the wideband CDMA TDD solution
- ⇒ IMT-MC the multi carrier solution derived from IS-95 / cdma2000
- ⇒ IMT-SC the single carrier solution derived from IS-136 / UWC-136
- ⇒ IMT-FT the frequency / time solution derived from DECT
- ⇒ Summary of technical parameter

#### **The Frequency Spectrum for IMT-2000**

#### **Standardization Committees**

- ⇒ 3GPP
- ⇒ 3GPP2

#### **What is UMTS?**

- ⇒ The global view

#### **The Global Architecture**

## **UMTS Architecture – Release 1999**

## **UMTS Architecture – Release 4**

## **UMTS Architecture – Release 5**

### **Additional Specific Mobile System Entities**

- ⇒ Group Call Register (GCR)
- ⇒ Gateway Location Register (GLR)
- ⇒ Location Services (LCS)
- ⇒ Virtual Home Environment (VHE)
- ⇒ Super-charger
- ⇒ Turbo-charger

### **The Business Perspective of UMTS**

- ⇒ Voice Services
- ⇒ Just in Time
- ⇒ Needed co-operations !?

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## **Introduction to UMTS**

### **The Core Network in UMTS**

- ⇒ The CS Domain
- ⇒ The PS Domain.

### **The Interconnection of the Various Network Elements**

- ⇒ Interfaces within the NSS
- ⇒ Interfaces within the RNS and towards the NSSs

### **Tasks and Functions of the MSC**

- ⇒ Transmission of voice and data signals between the MSC and the various RNCs (⇔ Circuit Switching)

### **Tasks and Functions of the VLR**

- ⇒ Mobility Management for circuit switched traffic

### **Tasks and Functions of the GMSC**

- ⇒ Interface between the PLMN and external circuit switched networks

### **Tasks and Functions of the SGSN**

- ⇒ Routing of Data Packets between the GGSN and the various RNSs (⇔ Packet Switching)
- ⇒ Mobility Management for packet switched traffic

⇒ Charging (own network resources)

## **The UMTS Mobile-services Switching Center (UMSC)**

### **Tasks and Functions of the GGSN**

- ⇒ Interface between the PLMN and external Packet Data Networks
- ⇒ Anchor Function for Packet Data Transfer
- ⇒ Charging (foreign network resources)

### **Backbone Networks**

- ⇒ The intra-PLMN backbone
- ⇒ The inter-PLMN backbone

### **Charging and Billing**

- ⇒ PS domain
- ⇒ CS domain

## **The Gateway Location Register (GLR)**

### **CAMEL**

- ⇒ CAMEL principle
- ⇒ CAMEL Services (Examples)

## **Mobile station Execution Environment (MexE)**

## **Virtual Home Environment (VHE)**

### **Location Services (LCS)**

- ⇒ Location Services (LCS) Categories
  - Emergency LCS
  - Commercial LCS
  - Lawful Intercept LCS
  - Internal LCS

### **UE Positioning Methods**

- ⇒ Cell ID
- ⇒ Cell Global ID
- ⇒ Observed Time Difference of Arrival
- ⇒ Global Positioning Satellite

## **Location Services Network Architecture**

### **Service Access**

- ⇒ Example

## **The Radio Access Network**

### **The User Equipment in UMTS**

- ⇒ CS mode
- ⇒ PS / CS mode
- ⇒ PS mode

### **Terminal Technology**

#### **Major Changes from GSM to UMTS**

- ⇒ Macrodiversity
- ⇒ RAKE Receiver
- ⇒ Handover Procedures
  - Soft Handover
  - Softer Handover
  - Interfrequency Handover
  - Intersystem Handover
  - Intermode Handover
- ⇒ Cell Breathing
- ⇒ AMR Speech codec

#### **UMTS Network roll out**

- ⇒ New Operator
- ⇒ Incumbent Operator
  - UMTS and EDGE
  - Multimedia Services

### **Virtual Network Operator**

#### **Shared Networks**

- ⇒ Shared UTRAN
- ⇒ Shared Network
- ⇒ Shared Operation
- ⇒ Shared Applications

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## **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

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## **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 Processing Chain**

### **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 Channels**

- ⇒ 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

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## **Uplink Spreading and Modulation**

### **Combining Uplink Physical Channels**

⇒ Uplink

## **Downlink Spreading and Modulation**

### **Combining Downlink Physical Channels**

⇒ Downlink

## **UTRAN Generic Protocol Layer Structure**

⇒ Transport Network Layer

⇒ Radio Network Layer – User Plane

⇒ Radio Network Layer – Control Plane

## **UTRAN Radio Interface Protocol Reference Model**

⇒ Control plane

⇒ User plane

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## **Basic UTRAN Procedures**

### **Power Control Challenge**

#### **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**

#### **Cell Search Procedure**

⇒ CPICH

⇒ P-SCH

⇒ P-CCPCH

⇒ Slot synchronization

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

## **Physical Layer Procedures**

- ⇒ RACH Procedure Access
- ⇒ CPCH Access Procedure

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## **Selected Scenarios**

### **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

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## **Solutions for the Practical Exercises**

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## **List of Acronyms:**