commsquare

TRAINING CATALOGUE

Hands-on excellence in wireless technology

Our mission and vision

- Commsquare's mission is to make mobile telecom service providers excel in terms of quality of service towards their customers.
- Our vision is that value is created through excellence, and excellence is a result of dedication and talent.

Our values

- **Excellence**: We strive towards the highest standards and are committed to deliver the best possible service.
- **Flexibility**: We adapt and tailor towards our customers' specific needs.
- **Team**: Together and with a multi-disciplinary team we can achieve more.
- **Innovation**: We create new insights and go beyond what already exists.
- **Passion**: We like what we do.

Features

- **Hands-on**:
  After explaining technology principles most of the time is spent on guided exercises and case studies.
- **Your Data, Your Tools**:
  Our trainers build guided exercises with data taken from your network. The students will complete these exercises using your tools.
- **Field-proven Methodologies**:
  Commsquare courses teach field-proven methodologies on how to plan, optimise and trouble shoot your network and services.
- **Experienced Trainer Engineers**:
  Commsquare trainers have substantial operator / vendor experience. They stay up to date with advances in technology through Commsquare consultancy projects.
- **Tailored Content**:
  The Commsquare trainer will conduct a training-needs-analysis prior to delivering the course and will customise the course content accordingly.

We teach best-practise methodologies using your data and your tools

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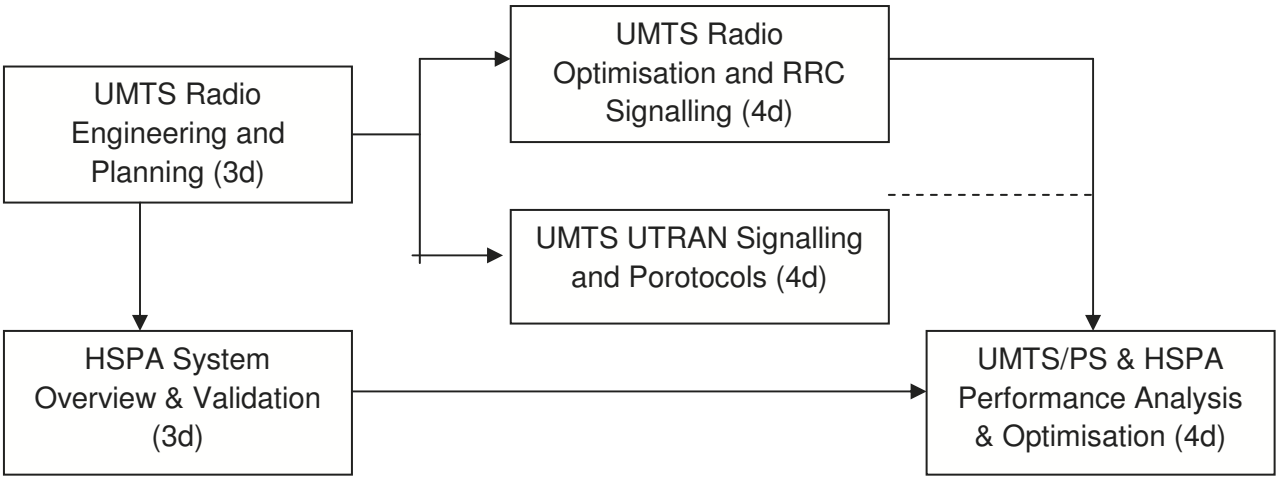
Overview of UMTS Courses



UMTS Radio Engineering and Planning

The course is aimed at engineers involved in UMTS planning and design validation. Following topics are covered: introduction to UMTS (WCDMA basic theory, link budget, radio resource utilisation), UMTS cell planning and design validation.

UMTS Radio Optimisation and RRC Signalling

The course focuses on radio interface and the use of scanner and drive test data to detect poor radio design and network problems. Explains how to improve radio network design and optimise network performance.

UMTS UTRAN Signalling and Protocols

Signalling procedures in the circuit-switched and packet-switched domain: RRC (Uu), NBAP (lub), RANAP (lu, RNSAP (lur) and ALCAP; RRC Connection Establishment & Release, RAB & Radio Bearer Setup & Release, Handover, Radio Link Setup & Deletion. 3G/2G Handover. All procedures are demonstrated with the operator's own data.

HSPA System Overview and Validation

A training course aimed at providing engineers with detailed technology principles and operational knowledge on HSPA networks. In the course students analyse trace data from live HSPA networks, demonstrating technology principles, and learn the principles of HSPA performance validation.

UMTS/PS & HSPA Performance Analysis and Optimisation

The course explains methodologies to analyse the UMTS and HSPA packet switched bearer and services. The course addresses RAB setup and parameters, bearer upgrades and downgrades, UMTS/PS and HSPA mobility, round trip time measurements, throughput measurements, ping, file transfer, streaming and web browsing.

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UMTS Radio Engineering and Planning (3 days)

Objectives

- Understand the architecture of a UMTS network, role of the different network elements, principles of WCDMA and UMTS radio interface
- Be able to apply operator specific UTRAN design and planning guidelines
- Have a basic understanding of how to use drive test scanner data for initial tuning and optimisation of the network

Features

- Hands-on, based on exercises (50%)
- Using your data and tools
- Methodology on how to validate & optimise performance
- Experienced trainer engineers
- Tailored content

Outline

WCDMA introduction

- Basic concept of spread spectrum
- Codes in a WCDMA system: practical example, correlation and orthogonality
- Two stage coding in WCDMA: OVSF codes and scrambling codes, concept and usage of code tree
- Signal to noise ratio and processing gain for a WCDMA system (Eb/No and Ec/No)
- Capacity of a WCDMA cell: isolated cell and cell in a network
- Concept of load: uplink load, downlink load, noise rise and pole capacity

Coverage and capacity

- WCDMA radio network dimensioning
- Link budget strategy for uplink and downlink, assumptions
- Uplink link budget calculation: basic equation, quality margin, receiver sensitivity, service and load assumptions
- Extensive guided exercises on link budget, including the effect of TMA, different services and traffic load
- Calculation of planning tool thresholds for specific service and traffic load

Cell planning

- UMTS RF planning procedure: 2G/3G approach, high sites, fased roll-out, pilot pollution optimisation
- Details on Monte Carlo simulation
- Guided exercise on Monte Carlo simulation plots
- Power planning for common DL physical channels
- TMAs in UMTS
- Repeaters in UMTS: pilot pollution and hot spot scenario
- Introduction of UMTS 900

Basic concepts of RRC Application Protocol

- UMTS Protocol Model: Services and Application Protocols
- RRC connection setup/release procedure
- Radio bearer setup/release procedure
- Overview of a Mobile Originating Call

Radio Resource Utilisation - Handovers

- Handover types
- Analysis of different events regarding soft(er) handover
- Overview of Active Set Update procedure
- Inter-system handover
- Concept of compressed mode

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Outline-Cont'd

Introduction to Radio Optimisation

- Functionality and use of a scanner
- Use of scanner measurements in radio optimisation
- Pilot pollution, missing neighbours, coverage and quality problems
- The radio optimisation procedure: cluster definition, quality and coverage target thresholds
- Results from the radio optimisation procedure and possible optimisation actions
- Guided exercises using scanner measurements
- Application of the radio optimisation procedure using the scanner measurements

UE in Idle Mode - Cell selection and reselection

- Initial 3G cell selection: procedure, cell search procedure and S-criterion parameters
- 3G cell reselection: measurement rules, S-criterion, R-criterion and triggering parameters
- 2G➞3G cell reselection: algorithm and parameters
- Typical cell selection and reselection problems
- Guided exercise using cell selection and reselection parameters taken from traces

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UMTS Radio Optimisation and RRC Signalling (4 days)

Objectives

- Understand the main issues involved in the tuning and optimisation of the WCDMA air interface
- Be able to detect typical radio network problems and take corrective actions
- Concepts of RRC protocol
- Identify normal and abnormal RRC signalling behaviour and use this information for trouble shooting and tuning the radio network

Features

- Hands-on, based on exercises (60%)
- Using your data and tools
- Methodology on how to validate & optimise performance
- Experienced trainer engineers
- Tailored content

Outline

Scanner Data

- Functionality of a scanner
- Pilot pollution, missing neighbours, coverage and quality problems
- Different steps of the optimisation procedure
- Description of possible optimisation actions
- Definition of cluster polygon for statistical analysis
- Performance analysis and definition of KPIs
- Guided exercises using scanner measurements

UMTS network model & protocol stack

- Network model: network elements and their logical role
- UMTS service protocols and application protocols
- UTRAN control plane and user plane
- Concept of RRC connection

Concepts of RRC signalling

- RRC connection setup/release procedure
- Radio bearer setup/release procedure
- Detailed analysis of Mobile Originating Call
- Detection of abnormal signalling behaviour
- Guided exercises on the analysis of RRC signalling

Handover procedures: 3G soft(er) handover

- Description of different soft(er) handover cases
- Detailed analysis of events regarding soft(er) handover
- Neighbour list definition
- Detailed analysis of Active Set Update procedure
- Advanced parameters to tune handover behaviour
- Guided exercises on 3G soft(er) handover concepts and dropped call analysis

Handover procedures: 3G-2G intersystem handover for CS services

- 3G-2G handover principles
- Description of compressed mode
- Detailed analysis of 3G-2G intersystem handover algorithms and concept of handover signature
- Performance analysis for different vendor implementations
- 3G-2G intersystem handover tuning for special cases
- Guided exercises on 3G-2G intersystem handover concepts

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Outline-Cont'd

Cell selection and reselection

- Initial 3G cell selection procedure
- 2G →3G cell reselection algorithms and parameters
- 3G cell reselection: measurement rules, S-criterion, R-criterion and trigger
- Typical cell selection and reselection problems

Introduction to PS services

- Introduction to key PS procedures
- RRC state model and actual implementation
- RRC state transitions and influence of parameters settings
- Bearer upgrades and downgrades
- Inactivity timer tuning: impact on response time and UE power consumption
- Guided exercises on 3G PS service analysis

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UMTS UTRAN Signalling and Protocols (4 days)

Objectives

- Understand the interworking between the different protocols (RRC, RANAP, NBAP and ALCAP)
- Understand the content of the different messages, and relate it to CDMA & UTRAN principles
- Be able to identify normal and abnormal signalling behaviour and to use signalling information for trouble shooting and tuning the network

Features

- Hands-on, based on exercises (35%)
- Using your data and tools.
- Methodology on how to validate & optimise performance.
- Experienced trainer engineers.
- Tailored content.

Outline

UMTS network model & protocol stack

- Network model: network elements and their logical role
- UMTS service protocols and application protocols
- UTRAN control plane and user plane
- Concept of RRC connection

Basic concepts of RRC signalling

- RRC connection setup/release procedure
- Radio bearer setup/release procedure
- Detailed analysis of Mobile Originating Call
- Detection of abnormal signalling behaviour
- Introduction to counters and statistics
- Guided exercises on the analysis of RRC signalling

Handover procedures: 3G soft(er) handover

- Description of different soft(er) handover cases
- Detailed analysis of events regarding soft(er) handover
- Neighbour list definition
- Detailed analysis of Active Set Update procedure
- Advanced parameters to tune handover behaviour
- Guided exercises on 3G soft(er) handover concepts and dropped call analysis

Handover procedures: 3G-2G intersystem handover for CS services

- 3G-2G handover principles
- Description of compressed mode
- Detailed analysis of 3G-2G intersystem handover algorithms and concept of handover signature
- Performance analysis for different vendor implementations
- 3G-2G intersystem handover tuning for special cases
- Guided exercises on 3G-2G intersystem handover concepts

Transport network protocols

- ATM cells, characteristics and connections
- ATM service classes and adaptation layers (AAL2 & AAL5)
- ATM in UMTS
- ALCAP: setup & release of AAL2 connections
- SCCP connection establishment on Iu and Iur

UTRAN network interface protocols

- NBAP application protocol on Iub: radio link setup, addition, deletion, restoration, failure, reconfiguration
- Common / dedicated NBAP measurement procedures

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Outline-Cont'd

- RANAP application protocol on Iu: RAB setup & release, Iu signalling connection setup & release, RNC relocation
- RNSAP application protocol on Iur: radio link setup, addition, deletion
- Guided exercises: analysis of combined Iub-Iu traces

Introduction to PS services

- Introduction to key PS procedures
- RRC state model and actual implementation
- RRC state transitions and influence of parameter settings
- Bearer upgrades and downgrades
- Inactivity timer tuning: impact on response time and UE power consumption
- Guided exercises on 3G PS service analysis

PS services: GMM & SM procedures

- Mobility Management: GPRS attach/detach and routing area update procedure, overview of other procedures
- Session Management: activate / deactivate PDP context procedure and overview of other procedures
- Guided exercises: definition of performance counters for GMM and SM procedures

PS services: 3G-2G handover procedures

- Signature for 3G→2G and 2G → 3G handover
- Calculation of user plane interruption
- Guided exercise: analysis of radio logfiles and TCP/IP traces for 3G-2G PS handover

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HSPA System Overview and Validation (3 days)

Objectives

- Be able to explain in detail the operation of HSDPA and HSUPA.
- Understand the impact of HSDPA/HSUPA on the R99 UMTS network
- Be able to find and explain new signalling information in logfiles taken on HSPA enabled networks

Features

- Hands-on, based on exercises (30%)
- Using your data and tools.
- Methodology on how to validate & optimise performance.
- Experienced trainer engineers.
- Tailored content.

Outline

HSDPA principles

- HSDPA data rate evolution
- Targets and characteristics
- Changes compared to R99
- Introduction to and basic operation of new channels, including multicode operation
- HSDPA setup
- Cell HSDPA capability and UE categories
- Measured throughput and latency
- Applications and disadvantages
- 3GPP specifications

HSDPA enhancements and extensions

- Control plance vs user plane
- The intelligent node B: MAC-hs entity
- Packet scheduling strategies and impact on performance: Maximum Throughput Scheduling, Fair Throughput Scheduling, Fair Time/Fair Resource Scheduling (including Round Robin and Proportional Fair)
- Iub Flow Control

HSDPA physical layer

- Detailed description of physical channels (HS-SCCH, HS-PDSCH, HS-DPCCH) and calculation of the physical channel transmission capacity of the downlink shared resource
- HSDPA modulation and constellation rearrangement
- Quantifying the radio environment with CQI (including mapping tables and live network behaviour)
- Description of HARQ (including retransmission combining), AMC and MPO
- Throughput at different layers
- Degradation of Ec/No with load
- Physical channel timing relationships
- Guided exercises on HSDPA operation and signalling

HSDPA mobility

- Description of different mobility implementations
- Analysis of different mobility cases: intra-node B, inter-node B, inter-RNC and HSDPA-R99 handover
- Measured impact of mobility on throughput
- Guided exercises on HSDPA mobility signalling

HSUPA principles

- HSUPA data rate evolution
- Targets and characteristics

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Outline-Cont'd

- Changes compared to R99
- Introduction to and basic operation of new channels, including multicode operation
- Detailed description of the scheduling mechanisms: Serving/Absolute/Relative Grant including Absolute Grant Value Table and Scheduling Grant Table
- Specified HSUPA UE categories, availability and related performance
- Additional functionalities of the node B
- Applications and disadvantages

HSUPA physical layer

- Detailed description of physical channels (E-DPDCH, E-DPCCH, E-AGCH, E-RGCH and E-HICH)
- Physical channel transmission capacity for the uplink user data
- Concept of Dedicated Physical Channel Configuration
- Usage of HARQ processes in HSUPA
- Guided exercises on HSPA specific signalling

2nd Carrier Implementation

- 2nd carrier implementations: drivers, advantages/ disadvantages compared to single carrier, different scenarios and approaches, impact on network planning, interfrequency handover and mobility management, carrier benchmark
- Guided exercises on 2nd carrier performance analysis: impact of inter-frequency mobility management implementation

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Training

HSPA Radio Fundamentals and Performance Analysis (3 days)

Objectives

- Be able to explain in detail the operation of HSDPA and HSUPA
- Be able to find and explain new signalling information in logfiles taken on HSPA enabled networks
- Be able to analyze the radio performance of HSPA traces

Features

- Hands-on, based on exercises (30%)
- Using your data and tools
- Methodology on how to validate & optimise performance
- Experienced trainer engineers
- Tailored content

Outline

HSPA principles

- Changes compared to R99
- Introduction to new channels and basic operation of HSDPA / HSUPA
- Cell HSPA capability and UE categories
- Calculation of throughput at different layers
- Rel.7 (HSPA+) fundamentals and enhancements

HSDPA physical layer

- Detailed description of physical channels (HS-SCCH, HS-PDSCH, HS-DPCCH)
- Channel Quality Indicator and Measurement Power Offset
- HSDPA modulation and constellation rearrangement
- Degradation of Ec/No with load
- Physical channel timing relationships
- Guided exercises on HSDPA operation and signalling

HSDPA functionalities

- Control plance vs. user plane
- The intelligent NodeB: MAC-hs entity
- Packet scheduling strategies and impact on performance, Adaptive Modulation and Coding, HARQ techniques, Iub Flow Control
- Guided exercises on HSDPA performance analysis

HSUPA physical layer

- Detailed description of physical channels (E-DPDCH, E-DPCCH, E-AGCH, E-RGCH and E-HICH)
- Absolute/Relative Grant, Happy bit, Scheduling Information
- Guided exercises on HSPA specific signalling

HSUPA operation

- MAC-e & MAC-es entities
- Usage of HARQ processes in HSUPA
- Packet Scheduler: Serving Grant and E-TFCI selection
- Guided exercises on HSUPA performance analysis

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Outline-Cont'd

HSPA mobility

- Description of different mobility implementations
- Analysis of different mobility cases: intra-NodeB, inter-NodeB, inter-RNC and HSDPA-R99 handover
- Measured impact of mobility on throughput
- Guided exercises on HSPA serving cell change signalling

2nd Carrier Implementation

- 2nd carrier implementations: drivers, advantages/ disadvantages compared to single carrier, different scenarios and approaches, impact on network planning, interfrequency handover and mobility management, carrier benchmark
- Guided exercises on inter-frequency mobility management implementation

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Training

Overview of GPRS & EDGE Courses

GPRS & EDGE Performance Analysis and Optimisation

The course explains how to measure GPRS radio and system performance, identify causes for poor performance, improve it and set up test scenarios to validate the solution. One day is spent on GRPS RLC/MAC radio analysis, one day on Gb trace analysis, one day one IP/TCP analysis and one day on the inter-working and end-to-end service analysis. Typical test cases studied are: ping "delay" analysis, file up- & download, web browsing, impact of TCP/IP on GPRS performance.

GPRS & EDGE Advanced Workshops

Commsquare offers a number of customised and advanced workshops on GPRS RLC/MAC radio

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GPRS & EDGE Performance Analysis and Optimisation (4 days)

Objectives

- Understand how the different network elements and protocol layers affect GPRS performance
- Be able to measure, monitor and identify good and poor performance
- Be able to identify causes for poor performance
- Understand and be able to apply the mechanisms that exist to improve GPRS performance

Features

- Hands-on, based on exercises.
- Using your data and tools.
- Methodology on how to validate & optimise performance.
- Experienced trainer engineers.
- Tailored content.

Outline

GPRS System Overview Refresher

- Network model: different network elements & their logical role
- Protocol stack: different protocol layers & principles of data encapsulation
- Performance: main procedures, protocols & network elements affecting performance

GPRS Mobility & Session Management Procedures

- Mobility Management: details of GPRS attach/detach procedures, routing area update procedure, overview of other procedures
- Session Management: details of Activate/deactivate PDP context procedure, overview of other procedures
- Guided exercises: Um and Gb trace analysis of GMM procedures. Definition of performance counters and KPIs

Gb Protocols & Gb Trace Analysis

- Overview of protocol stack and basic functionality of each protocol layer: NS, BSSGP, LLC, SNDCP
- BSSGP radio-related procedures: description of typical good and poor performance: cell update, Gb flow control, flush procedure, discard procedure, radio contact lost
- BSSGP other procedures: suspend/resume, network stability verification
- Gb Statistical analysis: KPI construction based on Gb message count, identify areas of poor performance
- Guided exercises: Use of protocol analyser on Gb interface. Gb message breakdown, Radio related procedures analysis (Flush LL/Flow Control).

Radio Link & Medium Access Control

- Um interface principles: logical channel types, multi-frame structure, coding schemes, MM states and RR modes.
- TBF Signalling: TBF establishment, operation & release, UL/DL scheduling and sharing principles, TFI and USF usage
- RLC/MAC: data block format, RLC Ack mode of operation, Acknowledgment window and bitmap and procedures
- Signalling: packet transfer procedure, cell update, 1-phase vs 2-phase access

Edge System Overview

- Physical layer & Channel coding: Modulation and Coding Schemes (MCS), GMSK vs 8-PSK. Data block families, incredemental redundancy, puncturing techniques
- Link Quality Control: Link Adaptation, Incredemental Redundancy, link quality estimate (BEP)

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Outline-Cont'd

- EDGE RLC/MAC: changes in SI 13, RLC window size, compression of Ack bitmap, extended polling, ARQ-I (re-segmentation vs ARQ-II (incredemental redundancy)

Guided Exercise "Ping Analysis"

- Goal and limitations of ping (latency) tests. Overview of different "ping" options.
- Ping delay analysis, ping signature analysis, ping success analysis, study of TBF keep alive mechanism using test mobile, TCP sniffer and Gb trace data.

TCP/IP Protocol Suite over GPRS/EDGE

- TCP/IP 5-layer model, IPv4 characteristics, datagram format & IP fragmentation, UDP characteristics & segment format.
- TCP characteristics, segment format, TCP establishment & release, acknowledgement strategy, flow & congestion control, round trip time & timeout
- Applications: domain name system (DNS), internet control messages (ICMP, "ping"), web browsing (HTTP), file transfer (FTP), performance enhancement proxies (PEP).
- TCP-GPRS/EDGE interworking: importance of TCP parameter tuning for maximising performance. TCP RWIN setting, Bandwith Delay Product etc.
- Guided exercises: use of IP sniffer (Wireshark) SW at MS side and on Gi interface. Analysis principles for TCP traces of various test cases: ping, FTP upload & download, web browsing.

Guided Exercise "FTP File Download" - "FTP File Upload"

- Performance analysis of static FTP tests using test mobile, IP sniffer and Gb trace data.
- Does measured throughput reach theoretical system limits? If not, where are the limitations?

Guided Exercise "FTP Drive Test"

- Performance analysis of drive FTP tests using test mobile, IP sniffer and Gb trace data
- Impact of Cell Reselection delay and interaction with TCP settings

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GPRS & EDGE Advanced Workshops (2-3 days)

Objectives

- Understand how different network elements and protocol layers affect GPRS/EDGE performance and appreciate the importance of end-to-end approach that applies to PS data
- Establish a methodology for testing and optimising GPRS/EDGE performance based on existing customer tracing and post-processing tools.
- Identify causes for poor performance and use available optimisation techniques to improve GPRS/EDGE performance
- Independently apply the methodology above to their daily work

Features

- Hands-on, based on exercises.
- Using your data and tools.
- Methodology on how to validate & optimise performance.
- Experienced trainer engineers.
- Tailored content.

Outline

Testing, Analysis & Optimisation Methodology

- Testing the user experience; what kind of tests need to be performed to reflect typical network customer usage. Where to trace.
- Commsquare proposed analysis methodology, suggest KPI's
- How to perform analysis and post processing exploiting fully the capabilities of existing tools

Test Scenario "GMM Analysis"

- Um and Gb trace analysis of GMM procedures. Definition of performance counters and KPI's

Test Scenario "Gb Analysis"

- Use of protocol analyser on Gb interface. Gb message breakdown, Radio related procedures analysis (Flush LL/Flow Control).

Test Scenario "Ping Analysis"

- Goal and limitations of ping (latency) tests. Overview of different "ping" options
- Ping delay analysis, ping signature analysis, ping success analysis, study of TBF keep alive mechanism using test mobile, TCP sniffer and Gb trace data.
- Comparison between GPRS and EDGE

Test Scenario "FTP File Download"

- Performance analysis of static FTP DL tests using test mobile, IP sniffer and Gb trace data
- Does measured throughput reach theoretical system limits? If not, where are the limitations?
- Comparison between GPRS and EDGE throughput

Test Scenario "FTP File Upload"

- Performance analysis of static FTP UL tests using test mobile, IP sniffer and Gb trace data
- Does measured throughput reach theoretical system limits? If not, where are the limitations?
- Comparison between GPRS and EDGE throughput

Test Scenario "Web browsing"

- Goal and limitations of web browsing tests using test mobile, IP sniffer and Gb trace data.
- How to analyse web browsing sessions. HTTP & browser version. Boosters or accelerators
- Analysis of abnormal cases (depends on data provided by the operator)

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Outline-Cont'd

Test Scenario "FTP Drive Test"

- Performance analysis of drive FTP tests using test mobile, IP sniffer and Gb trace data.
- Impact of Cell Reselection delay and interaction with TCP settings
- Comparison between GPRS and EDGE

Test Scenario "UDP/Streaming"

- Performance analysis of UDP/Streaming using test mobile, IP sniffer and Gb trace data
- Impact of Cell Reselection delay and comparison with FTP/TCP testing

Test Scenario "EDGE link Quality Control"

- Evaluation of LQC algorirthm efficiency vs MCS usage for given link quality (measured BEP)
- BLER performance vs LQC
- Drive FTP download tests to be analysed

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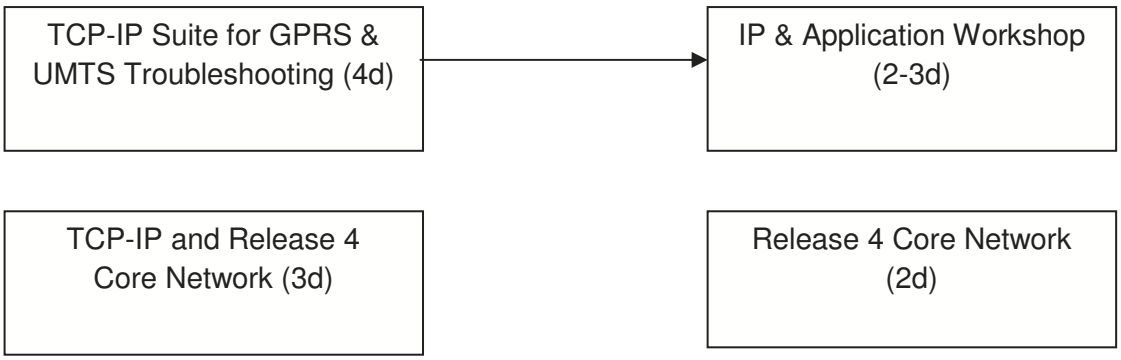
Overview of Core Network Courses



TCP-IP Suite for GPRS and UMTS Troubleshooting

The course gives an overview of all IP protocols relevant in GPRS and UMTS networks, study cases of good and poor performance and methodologies to analyse IP and service performance. In addition, specific services can be addressed in the course, such as WAP, MMS, streaming, video-telephone, VoIP, etc.

IP & Application Workshops

Commsquare offers a number of customised and advanced workshops on applications such as WAP, MMS, etc.

TCP-IP and Release 4 Core Network

This course gives a TCP/IP technology overview in combination with R4 Core network.

Release 4 Core Network

This course explains the difference between R4 and R99 network, gives an overview of the SCTP protocol and explains how to understand and analyse different R4 implementations.

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TCP-IP Suite for GPRS and UMTS Troubleshooting (4 days)

Objectives

On completion of the training course, the student will:

- Be able to explain TCP/IP technology principles and understand the most common applications running over IP
- Understand the inter-working between the bearer (GPRS or UMTS) and the application
- Be able to identify normal and abnormal behaviour and trouble shoot it.

Features

- Hands-on, based on exercises.
- Using your data and tools.
- Methodology on how to validate & optimise performance.
- Experienced trainer engineers.
- Tailored content.

Outline

TCP/IP Suite (+ Ethereal/Wireshark)

- TCP/IP 5-layer model
- Basic principles and filtering and taking IP traces with Wireshark
- IPv4 characteristics, Datagram format, IP fragmentation
- ICMP: “ping”; usage of ping to test network performance; round trip time. Example of “ping” analysis.
- UDP characteristics, UDP segment format
- TCP characteristics, segment format, TCP establishment & release, acknowledgement strategy, flow & congestion control, round trip time & timeout (including Karn’s algorithm), Windows 2000 implementation, selective ack (SACK)
- Guided exercises: IP, Ping, TraceRoute, UDP, TCP establishment, TCP establishment failures, TCP normal and abnormal release, TCP timeouts, etc.

Applications running over IP

- DNS—Domain Name Service
- File transfer: FTP. FTP-data versus FTP-control. Example: FTP file transfer to test throughput. Demonstration of bandwidth-delay product.
- Web browsing: HTTP. HTTP version 1 versus 1.1. Persistent connectiona and pipelining. Example of web browsing sessions.
- E-mail: SMTP/POP3/IMAP. Example of background activity.
- Streaming: RTP/RTCP/RTSP
- SIP & IMS. Example of a call setup

The packet-switched core network

- Core network architecture and network elements: SGSN, GGSN, RADIUS, DNS server, PEP
- Logical role of the different network elements; Buffering in the different network elements; packet drops in the different network elements.
- Core network interfaces: Gn, Gi, Gp, Gr.
- Protocols on the different network interfaces: GPRS tunnelling protocol GTP.
- Examples of Gn traces.

Procedures in the packet-switched domain

For each of the procedures listed below:

- How does it work?
- What does it do?
- What can go wrong?
- What are the differences (if any) between GPRS and UMTS

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Outline-Cont'd

Procedures:

- GPRS Mobility Management: GPRS Attach, GPRS Detach, Routing Area Update, GMM Service Request
- Session Management: PDP Activation, PDP Deactivation; quality of service parameters. + Q0S UMTS

IP over GPRS

- Principles of GPRS end-to-end (MS to SGSN) IP transport: LLC acknowledged and unacknowledged mode of operation; SNDCP segmentation, header compression and data compression.
- Implementation on the Gb-interface: basics of Frame relay and Gb protocol stack.
- Role of the PCU: buffering; timer supervision; packet drops; cell changes.
- Principles of GPRS radio-interface signalling: RLC acknowledged mode of operation.
- Guided exercises using TEMS and Ethereal traces: ping over GPRS; file download over GPRS; cell change/ update during file download; web browsing session over GPRS.

IP over UMTS

- Principles of UMTS end-to-end (UE to SGSN) IP transport: Radio Access Bearer. The PDCP protocol. Segmentation; header and data compression.
- Implementation on the Iu-CS interface.
- Role of the RNC: principles of load and congestion control. Packet scheduler. Example: principles of Nokia implementation and impact on end-user perceived throughput.
- Principles of UMTS radio-interface signalling: principles of transport format, transport format combination set, etc.; RLC/MAC segmentation and reassembly.
- UMTS state transitions and timer supervisory. Technology principles. Simple simulation model to better understand trade-offs.
- Guided exercises: ping over UMTS; ping triggering state transitions; handover during PS-session in cell-DCH mode; file upload and download with radio access bearer up- or downgrade.
- Internet background radiation traffic. Impact on data volume and throughput. Impact on network capacity.

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R4 Core Network

(2 days)

Objectives

On completion of the training course, the student will:

- Be able to explain the differences between the R4 and R99 core network
- Be able to understand and analyse SCTP - the new transport protocol used in Release 4 core network.
- Be able to understand and analyze different R4 core network implementations (e.g. Over ATM or over IP)

Features

- Hands-on, based on exercises.
- Using your data and tools.
- Methodology on how to validate & optimise performance.
- Experienced trainer engineers.
- Tailored content.

Outline

Network overview:

- CS: Circuit Switched
- PS: Packet Switched

Stream Control Transmission Protocol - SCTP

- Introduction
- SCTP vs. UDP/TCP
- Packet Format
  - Common Header
  - Chunks
- Association Setup and Shutdown
  - INIT, INIT-ACK, COOKIE-ECHO and COOKIE-ACK chunks
  - SHUTDOWN, SHUTDOWN-ACK, SHUTDOWN-COMPLETE and ABORD chunks
- Data Transfer:
  - DATA and SACK chunks
  - Fragmentation, Streams and Reliablility
- Other Signaling chunks
  - HEARTBEAT, HEARTBEAT-ACK and ERROR
- Multihoming

R4 Core Network Presentation

- Split Architecture
- R99-R4 differences
  - Motivations
  - New Interfaces: Mc, Nc and Nb
  - Network Element: MGW, SGW and MSC-Server
- R4 over ATM
  - SS7: Adaptation Layers MTP-ATM
  - The Iu Interface example
- R4 over IP
  - SS7: Adaptation Layers MTP-IP
  - The VoIP example
- BICC, the new ISUP
- H.248/MEGACO
  - Contexts and Terminations
- E2E Call Control Example
- TrFO: Transcoder free operation
- TFO: Tandem free operation
- The evolution to R5 - IMS

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Training

TCP/IP and Release 4 Core Network (3 days)

Objectives

On completion of the training course, the student will:

- Be able to explain TCP/IP technology principles and understand the most common applications running over IP
- Be able to understand and analyse SCTP - the new transport protocol used in Release 4 core network.
- Be able to understand and analyze different R4 core network implementations (e.g. Over ATM or over IP)

Features

- Hands-on, based on exercises.
- Using your data and tools.
- Methodology on how to validate & optimise performance.
- Experienced trainer engineers.
- Tailored content.

Outline

Network overview:

- CS: Circuit Switched
- PS: Packet Switched

IP + basics of routing and switching

- IPv4 characteristics, Datagram format, IP fragmentation
- Routing and Switching
- IPv6
- ICMP:

  -Error Notifications: Time to Live, MTU Size

  -"ping"; usage of ping to test network performance; round trip time. Example of "ping" analysis.

Hands-on working with Wireshark

- Configuring Wireshark to take traces
- Basic principles on filtering and taking IP traces with Wireshark
- Traffic analysis

UDP, TCP & Applications

- UDP characteristics, UDP segment format
- TCP characteristics, segment format, TCP establishment & release, acknowledgement strategy, flow & congestion control, round trip time & timeout
- Guided exercises: IP, Ping, TraceRoute, UDP, TCP establishment, TCP establishment failures, TCP normal and abnormal release, TCP timeouts, etc.
- DNS—Domain Name Service
- File transfer: FTP. FTP-data versus FTP-control.
- Web browsing: HTTP. HTTP version 1 versus 1.1. Persistent connection and pipelining. Example of web browsing sessions.

Stream Control Transmission Protocol - SCTP

- Introduction
- SCTP vs. UDP/TCP
- Packet Format
  - Common Header
  - Chunks

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Outline-Cont'd

- Association Setup and Shutdown
  - INIT, INIT-ACK, COOKIE-ECHO and COOKIE-ACK chunks
  - SHUTDOWN, SHUTDOWN-ACK, SHUTDOWN-COMPLETE and ABORD chunks
- Data Transfer:
  - DATA and SACK chunks
  - Fragmentation, Streams and Reliablility
- Other Signaling chunks
  - HEARTBEAT, HEARTBEAT-ACK and ERROR
- Multihoming

R4 Core Network Presentation

- Split Architecture
- R99-R4 differences
  - Motivations
  - New Interfaces: Mc, Nc and Nb
  - Network Element: MGW, SGW and MSC-Server
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IP Advanced Course (5 days)

Objectives

On completion of the training course, the student will:

- Have a complete understanding of the classical 5 OSI-layers stack.
- Be able to explain TCP/IP technology principles and understand the most common applications running over IP.
- Understand the difference between routing and switching.
- Be able to identify normal and abnormal behaviour and trouble shoot it.
- Have a better vision on how to improve a networks thanks to MPLS or QOS implementation.

Features

- Hands-on, based on exercises.
- Using your data and tools.
- Methodology on how to validate & optimise performance.
- Experienced trainer engineers.
- Tailored content.

Outline

Network Overview

- CS: Circuit Switched
- PS: Packet Switched

IP Basics

- Network Layer – IPv4: characteristics, Datagram format, IP fragmentation
- Network Layer – IPv6
- Link Layer – Ethernet and ARP
- Transport Layer – ICMP: Error Notifications: Time to Live, MTU Size & “ping”; usage of ping to test network performance; round trip time. Example of “ping” analysis

Switching

- Network Topologies
- The hub
- Spanning Tree
- Virtual Local Area Network
- Rapid Spanning Tree
- Multiple Spanning Tree

VRRP & HSRP

Dynamic Routing

- Static
- Distance Vector
- RIP
- Link State
- OSPF
- BGP

MPLS

- The label swapping forwarding paradigm
- Integrating label swapping and IP
- Destination based packet forwarding
- QoS support

QoS

- Flow identification
- Packet Marking
- Buffer acceptance
- Scheduling

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Training

Overview of GSM Courses

GSM Radio Optimisation and Um Signalling (4d)

GSM BSS Signalling & Protocols (4d)

GSM Optimisation using Abis and A-interface data (3d)

GSM Frequency Planning Strategies (3d)

GSM Radio Optimisation and Um Signalling

The course is aimed at RF engineers that will get involved in optimisation. The students will learn how to analyse drive test data for trouble shooting, identify problems and define corrective actions. Course topics are: drop call analysis, cell overlap and dominant server verification, handover behaviour, interference & lack of coverage, radio signalling.

GSM BSS Signalling & Protocols (Um, Abis, A)

The course is aimed at radio and system engineers who need to fully understand Radio (Um), Abis and A-interface signalling. Upon completion, students will be able to identify normal and abnormal signalling cases, causes for poor performance and define corrective actions.

GSM Optimisation using Abis and A-interface data

The course is aimed at optimisation engineers that need to go beyond trouble-shooting using drive test data. The course explains the principles of the Abis and A-interface and demonstrates how crucial these data sources are for radio and system optimisation.

GSM Frequency Planning Strategies

The course explains different frequency planning strategies: hopping vs. non-hopping, base-band vs. synthesizer hopping, 1x1 vs. 1x3 vs. multiple reuse pattern. Frequency planning in multi-layer and multi-band net-

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GSM Radio Optimisation & Um Signalling (4 days)

Objectives

- Understand how the different design processes affect GSM performance
- Be able to recognise good and poor performance
- Be able to identify the root cause for poor performance
- Be able to define and implement corrective actions

Features

- Hands-on, based on exercises.
- Using your data and tools.
- Methodology on how to validate & optimise performance.
- Experienced trainer engineers.
- Tailored content.

Outline

Introduction

- Channel concept: logical and physical channel definition
- Control & traffic channels
- Burst structure and mapping of logical onto physical channels
- Permitted channel combinations and their use: choice of BCCH configuration; SDCCH , paging and access grant capacity

Radio Design Analysis using drive-test data

- Use of the drive-test data; definition of attributes (RxLev, RxQual, timing advance, radio link time-out etc.)
- Drive-test analysis; verification of coverage, quality
- Identify interference and lack of coverage
- Confirm frequency and neighbouring planning
- Handover performance

Um Signalling; message flow and comparison with message sequence from drive-test

- Protocol overview: Call Control (CC), Radio Resource (RR) and Mobility Management (MM)
- Mobile originating call (MOC), Mobile Terminating Call (MTC)
- Location updating request, handover attempt, mobile originating/terminating SMS

Mobile station (MS) tasks in idle mode

- Cell selection and reselection
- Location area updating
- Paging groups
- Downlink signalling failure
- System information type messages

MS tasks in dedicated mode

- Measurement reports
- Radio link time-out principle
- System information type messages

Key performance indicators (KPI)

- KPI definition and typical values used
- Use of KPI: performance monitoring and quality benchmarking
- Examples include: call setup success rate, call completion rate, handover success and failure rate, neighour list statistics, SDCCH and TCH seizure rate etc
- Compare drive-test KPIs with network statistics

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Outline-Cont'd

Abis measurement reports for radio optimisation (introduction only)

- Using Abis measurement report data for radio optimisation: advantages and limitations
- Collection of Abis data; tracing equipment vs built-in features by vendor
- Examples of Abis analysis: timing advance distribution, up-link and down-link quality and level distribution, detection of coverage splashes

Trouble Shooting

- When to use of drive-test data, network statistics and Abis measurement reports
- Comparison of the information provided by each resource

Traffic Engineering

- Introduction: Erlang-B formula, Grade of Service (GoS), busy hour traffic
- SDCCH and TCH dimensioning according to traffic areas; impact of SDCCH dimensioning in location area borders
- Trade-off between paging, access grant capacity and location updating load

Cluster frequency planning and optimisation

- Principles of frequency planning: from capacity requirements and neighbouring planning to validation
- Frequency planning aspects: local (new site or performance improvement) and global retunes
- Importance of cluster optimisation day to day process

Dual-band design

- Introduction of "other" frequency band: propagation and coverage design scenarios
- Engineering strategies: re-use of existing sites, concentric vs "filling null" cells, use of dual-band antennas and the corresponding tilting
- Access layer vs capacity layer and frequency planning aspects
- Vendor portfolio: hierarchical cell structures, single BCCH cells, handover and traffic management features etc.

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GSM BSS Signalling & Protocols (4 days)

Objectives

- Identify compliant and poor signalling performance on the different interfaces
- Pin-point the network element causing (signalling) performance problems, or the protocol layer or procedure lacking compliance
- Use the relevant GSM and ITU specifications to further study message contents and verify signalling procedures

Features

- Hands-on, based on exercises.
- Using your data and tools.
- Methodology on how to validate & optimise performance.
- Experienced trainer engineers.
- Tailored content.

Outline

GSM system overview and radio interface (Um) refresher

- Logical roles of the different network elements
- Protocol model used for GSM
- Um refresher; topics can be re-defined prior to the start of the course

Radio Interface (Um) signalling

- Protocol architecture
- Layer 1: Radio interface brief description
- Layer 2: LAPDm purpose, frame structure and mode of operation
- Layer 3: call control (CC), mobility management (MM) and radio resource management (RR) messages, layer 3 frame structure
- Message flow for: mobile originating call (MOC), contention resolution, mobile terminating call (MTC), location updating request/accept/failure etc
- Comparison with signalling cases from the log-files

Abis signalling

- Protocol model
- Layer 1: Physical layer, interface and layout
- Layer 2: LAPD operation; the radio signalling link (RSL), the operation and maintenance link (OML) and the layer 2 management link (L2ML)
- Layer 3: frame structure and fields, message types (traffic management, O&M and layer 2 configuration messages)
- Important Abis messages: eg Connection Failure Indication, Error indication etc
- Abis data collection; practical approach and tips
- Use of Abis data in RF optimization (introduction only)

A-interface signalling cases

- A-interface principles: protocol stack and physical implementation
- A-interface configuration: direct transfer application part (DTAP) and BSS management application part (BSSMAP)
- Protocol model: signalling system 7 (SS7), message transfer part (MTP) and signalling connection control part (SCCP)
- A-interface messages and their message flow; eg assignment Request / Complete / Failure
- A-interface data collection

Case studies and guided exercises

- Signalling cases from selected trace files (Um, Abis and A-interface)
- Reference cases for successful and failed procedures
- Mobile originating / terminating call; success and failure
- Call release
- Location updating; success and failure
- Handover;intra-cell handover success / failure, intra-BSC handover success / failure / return to old channel and inter-BSC handover success / failure
- KPI calculation (eg call set-up success rate, dropped call rate, location update analysis etc.)

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GSM Optimisation using Abis & A-Interface data (3 days)

Objectives

- Advantages and limitations of Abis and A-interface data for GSM optimisation
- Optimisation of GSM network using Abis and A-interface data

Features

- Hands-on, based on exercises.
- Using your data and tools.
- Methodology on how to validate & optimise performance.
- Experienced trainer engineers.
- Tailored content.

Outline

Abis data for radio optimisation: Introduction

- Protocol model; layer description and information sent over the Abis interface
- Abis data for RF optimisation: advantages and limitations
- Abis configuration
- Abis data collection: practical approach and tips
- Important Abis messages: message description and contents

Abis data for radio optimisation: Practical analysis

- Sensitivity and link balance analysis
- Cell planning verification, coverage and quality distribution, cell overlap analysis, interference distributors
- Frequency plan validation and interference verification
- Handover analysis and power control verification
- Trouble shooting dropped-calls and poor quality areas

A-interface data for optimisation: Introduction

- Protocol model, information sent over the A-interface
- A-interface data for RF optimisation: advantages and limitations
- A-interface configuration
- A-interface data collection: practical approach and tips
- Useful A-interface messages: description and contents

A-interface data for optimisation: Practical analysis

- Handover cause analysis
- Call set-up performance
- Dropped-call analysis
- Location updating analysis
- Roaming analysis

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GSM Frequency Planning Strategies (3 days)

Objectives

- Advantage and limitations of different frequency planning strategies
- Select the most appropriate strategy
- Preparation and validation of a new frequency plan

Features

- Hands-on, based on exercises.
- Using your data and tools.
- Methodology on how to validate & optimise performance.
- Experienced trainer engineers.
- Tailored content.

Outline

Introduction

- Retune options: single transceiver, single cell/site, cluster of cells, global retune
- Frequency hopping system and equipment requirements: baseband vs synthesizer hopping
- Advantages and limitations of frequency hopping
- Band splitting in single layer and multi-layer networks
- Cross-border frequency coordination

Frequency Hopping Strategies

- Non-hopping
- Baseband hopping
- Reuse 1x1
- Reuse 1x3
- Exercises on different scenarios: advantages, limitations and comparison of the above implementations

Automated frequency planning: the process

- Identify need for returne
- Input data: capacity and neighbouring plan requirements
- Frequency plan generation: estimate quality of new plan and identify potential problem areas
- Implementing the new frequency plan
- Validation of the new frequency plan
- AFP tools considerations

Principles of traffic engineering

- Circuit-switched dimensioning: Erlang-B
- Traffic extrapolation and forecast
- Traffic density maps
- Impact of traffic management algorithms in the BSS

Capacity roadmap - Planning for future capacity needs

- Justification and need for capacity roadmap planning. Goal of the process
- How to plan to meet future capacity requirements? Input and output of the process
- Capacity enhancement techniques: multi-band, traffic management (e.g. Hierarchical cell structures, underlay-overlay, single BCCH cells), capacity and reuse sites, micro-and pico-cells for capacity, etc.

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Long Term Evolution - LTE Overview (3 days)

Objectives

- Introduction to LTE technology and architecture (3GPP Rel.8)
- Key radio technologies for LTE: basic principles of OFDM/SC-FDMA physical layer and MIMO antenna technologies.
- Physical layer channels, interfaces, protocols (RRC, RLC and MAC) & basic signaling procedures
- LTE functionalities, algorithms & LTE QoS

Features

- Hands-on
- Using your data and tools
- Experienced trainer engineers
- Tailored content
- Real LTE traces from operational LTE networks

Outline

LTE technology basics

- Background and motivation for LTE
- Major requirements for LTE
- 3GPP network evolution
- LTE network architecture and terminology
- LTE nodes, key parameters & RF bands
- Interworking with legacy 3GPP access networks
- CS voice fallback

OFDMA and SC-FDMA fundamentals

- Principles of OFDMA (DL) and SC-FDMA (UL)
- Subcarrier spacing
- Cyclic prefix
- Resource blocks and resource elements
- Benefits and drawbacks

MIMO fundamentals

- Introduction of MIMO antenna technologies
- Transmit diversity, Beam-forming & Spatial Multiplexing
- SU-MIMO vs. MU-MIMO
- Open-loop vs. Closed-loop MIMO
- LTE MIMO schemes
- Pre-coding Matrix Index (PMI) & Rank Indicator (RI)

Physical Layer basics

- Frame structure (FDD)
- Radio frames, TTI and slots
- Duplex methods
- Modulation schemes
- UE capabilities
- Peak data rates

Physical channels and signals

- Downlink signals (SCH, reference symbols)
- Downlink data channels (PBCH, PDSCH)
- Discontinuous reception (DRX) and paging channel (PCH)
- Downlink control channels (PCFICH, PHICH, PDCCH) & control information (DCI)
- Uplink signals (reference symbols, channel sounding)
- Uplink data channels (PRACH, PUSCH)
- Uplink frequency hopping
- Uplink control channels (PUCCH)
- Uplink control information (UCI)
- Comparison of UCI transmission (PUSCH vs. PUCCH)

We teach best-practise methodologies using your data and your tools

Outline-Cont'd

Protocols & Signalling

- Protocol stack (control / user plane)
- S1 and X2 functions
- Signalling Radio Bearers and RRC states
- PDCP, RLC and MAC layer
- Logical, transport and physical channels mapping
- Initial cell search
- System information
- Random access procedure
- Timing advance
- Mobility
- Security architecture

LTE functionalities

- Adaptive modulation & coding
- Channel Quality Indicator (CQI)
- Hybrid ARQ
- Power control
- Interference coordination and cancellation techniques

LTE Quality of Service

- QoS architecture
- EPS bearer types and label concept
- QoS Class Indicator (QCI)
- Comparison of QoS attributes (R97 vs. R99 vs. LTE)

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Training

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LTE / SAE Introduction: E-UTRAN & Evolved Packet Core (4 days)

Objectives

- Introduction to E-UTRAN architecture (3GPP Rel.8) and key radio technologies selected for LTE e.g. OFDM and MIMO
- Understand physical layer channels, interfaces and protocols (RRC, RLC and MAC)
- Introduction to Evolved Packet Core (EPC) architecture, nodes, interfaces, protocols procedures and the new QoS concept
- Understand the access transport evolution to all IP architecture and interoperability between EPC and legacy networks

Features

- Hands-on
- Using your data and tools
- Experienced trainer engineers
- Tailored content
- Real LTE traces from operational LTE networks

Outline

Day 1 – LTE Fundamentals & Physical Layer Procedures

- LTE network architecture and E-UTRAN nodes
- Frequency bands
- OFDM basics
- OFDMA downlink and SC-FDMA uplink transmission
- Fundamentals of MIMO techniques
- UE classes
- Downlink synchronization and cell search
- Downlink physical signals and channels (SCH, PBCH, PDSCH, PMCH)
- Downlink control information (PCFICH, PHICH, PDCCH)
- Uplink physical signals and channels (PRACH, PUSCH)
- Uplink reference symbols and channel sounding
- Uplink control information and quality reporting (CQI, PMI, RI, PUCCH)

Day 2 – Radio Interfaces, Protocols & Signalling

- S1 and X2 interfaces
- User and control plane architecture
- Logical & Transport channels
- E-UTRAN protocol stack
- NAS Protocols – EMM and ESM
- Radio resource control (RRC)
- Medium access control (MAC) and radio link control (RLC)
- Tracking Areas
- Initial access, connection set-up and bearer configuration
- Handover procedure
- Mobility between EPS and legacy 3GPP networks (UTRAN and GERAN)

We teach best-practise methodologies using your data and your tools

Outline-Cont'd

Day 3 – Evolved Packet Core architecture

- Overview of 3GPP legacy GPRS core Network
- Introduction to EPC; Architecture and Nodes
- Mobility and Session Management: Key functions of MME node
- S1-MME and S11 interfaces and protocol stack
- EPS Security management
- Gateway functionality: Key Functions of the S-GW and P-GW nodes
- S1-U, S5/S8, SGi interfaces and protocol stack
- Information Storage and Addressing. Context stored in MME, S-GE, P-GW and HSS nodes
- VOIP and IMS Service architecture
- TCP/IP protocol suite and DiffServ
- IMS protocols: SIP, SDP, RTP and RTCP

Day 4 – QoS, EPC Signalling Procedures and Interworking

- The new SAE QoS concept. Bearer level parameters
- Policies and Charging: Key functions of PCRF node
- Gx/S7 interface and protocol stack
- Selected NAS signaling Procedures : Initial Attach, TAU, Service Request, S1 Release and Detach, Session Management and QoS, E-UTRAN Handover
- S3, S4, S12 interfaces and protocol stack
- Interworking with 3GPP legacy GPRS core Networks
- Interworking NAS signaling examples: Routing Area Update, E-UTRAN to UTRAN Handover
- EPC Backhaul requirements: MPLS architecture and components, QoS mechanisms

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LTE - SAE Introduction: Evolved Packet Core (3 days)

Objectives

- Introduction to Evolved Packet Core (EPC) architecture, nodes, interfaces, protocols procedures and the new QoS concept
- Understand the access transport evolution to all IP architecture and interoperability between EPC and legacy networks
- Understand basic EPC signaling procedures

Features

- Hands-on
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Outline

Evolved Packet Core architecture

- Overview of 3GPP legacy GPRS core Network
- Introduction to EPC; Architecture and Nodes
- Mobility and Session Management: Key functions of MME node
- S1-MME and S11 interfaces and protocol stack
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- Gateway functionality: Key Functions of the S-GW and P-GW nodes
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- Interworking NAS signaling examples: Routing Area Update, E-UTRAN to UTRAN Handover
- EPC Backhaul requirements: MPLS architecture and components, QoS mechanisms

Exercises based on Traces from Live Networks

- Typical Signaling procedures
- Examination of message content

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LTE E-UTRAN Hands-on: Radio, Protocols, Functionality & Examples from Real LTE Networks (3 days)

Objectives

- Introduction to LTE technology and architecture (3GPP Rel.8)
- Key radio technologies for LTE: basic principles of OFDM/SC-FDMA physical layer and MIMO antenna technologies.
- Physical layer channels, interfaces, protocols (RRC, RLC and MAC) & basic signaling procedures
- LTE functionalities, algorithms & LTE QoS

Features

- Hands-on
- Using your data and tools
- Experienced trainer engineers
- Tailored content
- Real LTE traces from operational LTE networks

Outline

LTE technology basics

- Background and motivation for LTE
- Major requirements for LTE
- 3GPP network evolution
- LTE network architecture and terminology
- LTE nodes, key parameters & RF bands
- Interworking with legacy 3GPP access networks
- CS voice fallback

OFDMA and SC-FDMA fundamentals

- Principles of OFDMA (DL) and SC-FDMA (UL)
- Subcarrier spacing
- Cyclic prefix
- Resource blocks and resource elements
- Benefits and drawbacks

MIMO fundamentals

- Introduction of MIMO antenna technologies
- Transmit diversity, Beam-forming & Spatial Multiplexing
- SU-MIMO vs. MU-MIMO
- Open-loop vs. Closed-loop MIMO
- LTE MIMO schemes
- Pre-coding Matrix Index (PMI) & Rank Indicator (RI)

Physical Layer basics

- Frame structure (FDD)
- Radio frames, TTI and slots
- Duplex methods
- Modulation schemes
- UE capabilities
- Peak data rates

Physical channels and signals

- Downlink signals (SCH, reference symbols)
- Downlink data channels (PBCH, PDSCH)
- Discontinuous reception (DRX) and paging channel (PCH)
- Downlink control channels (PCFICH, PHICH, PDCCH) & control information (DCI)
- Uplink signals (reference symbols, channel sounding)
- Uplink data channels (PRACH, PUSCH)
- Uplink frequency hopping
- Uplink control channels (PUCCH)
- Uplink control information (UCI)
- Comparison of UCI transmission (PUSCH vs. PUCCH)

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Outline-Cont'd

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- Comparison of QoS attributes (R97 vs. R99 vs. LTE)

Exercises based on Traces from Live Networks

- SIB Info
- Attach & Default Bearer Activation Signaling
- Throughput & latency performance over LTE
- Adaptive modulation & coding
- Intra-LTE Handover

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