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LTE-M / Cat-M1/M2

Design Details & System Engineering

Course Duration:

- 2 days

Course Description:

- This course addresses the needs of technical engineering staff who require a thorough understanding of of Cat-M / LTE-M.

- Cat-M is considered as a minor upgrade of existing LTE-A network and UE software but the understanding of the details and the operation of LTE-M is very complicated.

- This course has been designed to meet the requirements of both: engineering experts to design and test Cat-M related equipment, in particular on the UE-side and operations staff who require detailed knowledge about Cat-M network configuration.

- The course starts out with a short overview of long range IoT-technologies like NB-IoT and compares them with each other.

- This chapter ends with a detailed description of the various 3GPP-endorsed UE-categories for machine type communication.

- The whole next chapter is dedicated to a bit level elaboration of Cat-M operation.

- Starting with a thorough description of the details and meaning of CE-levels and CE-modes, the course continues with a detailed description as to how a BL-UE finds and reads the Cat-M related system information, namely but not limited to SIB1-BR.

- This chapter leaves no questions unanswered w.r.t. random access in Cat-M, resource allocation through MPDCCH and HARQ-operation.

- We also dedicated quite some focus on MCL-calculation for different channels under different circumstances to enable operators to come up with suitable repetition numbers.

- This chapter terminates with the calculation of achievable throughput rates in Cat-M, both uplink and downlink, to allow you benchmarking your own results from the field or from the lab.

- Focus of the next chapter is higher layer operation and starts out with the description of DRX-operation for Cat-M, distinguishing I-DRX and C-DRX. This part is a nice introduction for the following part: the detailed description of eDRX and its use in Cat-M.

- We will continue with a description of the specifics of the attach procedures for Cat-M, including an analysis of power saving modem its comparison with eDRX.

- The course ends with a description of control plane and user CioT-optimizations, their use cases and specifics.

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Prerequisites:

- This is a bit-level course: The students should have detailed knowledge of LTE and LTE-Advanced prior to visiting this course.

Some of your questions that will be answered:

- What are the differences between CE-level and CE-mode?

- How can blind retransmissions improve the overall system performance?

- How does the Cat-M UE find and read the BL-specific system information?

- How does the random access procedure work in LTE-M?

- How does a cell allocate resources in Cat-M? How does the MPDCCH operate?

- How does HARQ operate in LTE-M?

- What are achievable throughput rates in Cat-M in both directions?

- How does DRX operate for LTE-M?

- Which impact on DRX does eDRX have w.r.t. LTE-M?

- How do attachment and bearer setup work for LTE-M?

- How does PSM operate and how does it correlate with eDRX?

- How do CIoT-optimizations operate?

Course Target:

- The students be enabled to design, test and operate Cat-M enabled networks and UE's in the field and in the lab.

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Table of Content:

- **Maximum Coupling Loss (MCL) and CE-Modes**
  Free Space Path Loss, Calculation of the MCL, Link-Budget, Receiver Sensitivity, MCL Calculation for Various Channels, Understanding the Positive Effect of Blind Retransmissions, Weighing of Reception Events based on Channel Estimation, Superpositioning of the received Signals, Coverage Gain through Repetition

- **Reading MIB / Locating SIB1-BR in Time and Frequency**
  Step 1: MIB Transmission / Retransmissions
  Step 2: Interpretation of schedulingInfoSIB1-BR
  Step 3: No of Retransmissions of SIB1-BR
  Step 4: How to determine in which radio frames and subframes SIB1-BR is transmitter
  Step 5: How to determine in which narrow-bands SIB1-BR is transmitted (always hopping!)
  Step 6: TBS, MCS & Start-Symbol Determination for SIB1-BR
  Contents of SIB1-BR revealed
  View of the UE on the Cell after reading SIB1 / SIB1-BR

- **Important Contents of other SIBs for BL-UE's**

- **Putting it together: Cell Selection for BL-UE Cat M1/M2**

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- **Important Contents of other SIBs for BL-UE's (Focus on SIB2 and SIB3)**

- **Putting it together: Cell Selection for BL-UE Cat M1/M2**

- **Resource Allocation & Operation in Cat-M**
  The MPDCCH, ECCE-Options for MPDCCH, Cross Subframe Scheduling, DL-Resource Allocation, UL-Resource Allocation

- **DCI-Formats in LTE-M / Cat-M**
  Format 6-0A, Format 6-0B, Format 6-1A, Format 6-1B, Format 6-2, Transmission Modes and DCI-Formats

- **Random Access for BL-UE**
  Specifics of Cat-M random access, MSG1, 2, 3 and 4, Contention Resolution in Cat-M, reviewing random access specific parameters in SIB2

- **HARQ for BL Operation**
  Downlink Direction, explicit ACK/NACK through PUCCH, timing, channels, uplink direction, implicit ACK/NACK

- **Throughput Rate Calculations for Cat-M**
  Downlink Direction
  Initial Working Assumptions, Throughput Rates with Different No of Retransmissions
  Uplink Direction
  Initial Working Assumptions, Throughput Rates with Different No of Retransmissions

Chapter 3: Higher Layer Operation

- **Discontinuous Reception**
  Distinction of C-DRX and I-DRX with focus on Cat-M

- **Operation of C-DRX**
  Active / Inactive Periods, Termination of C-DRX mode66

- **Applying eDRX to improve I-DRX for BL-UE Operation**
  Configuration, differences between regular DRX and eDRX, differences between eDRX in Cat-M and NB-IoT

- **Attachment and Bearer Setup**
  ATT_REQ and ATT_ACC-messages in case of Cat-M, analysis of parameter settings through UE and response by the network

- **Power Saving Mode (PSM)**
  Negotiation between UE and network, T3324, operation of PSM, comparison between PSM and eDRX.

- **CioT-Optimizations**
  Control Plane CIoT EPS optimization,
  User Plane CIoT EPS optimization,
  configuration, support by UE and network, pros and cons