שם הקורס:	LTE מתקדם (חמישה ימים)
מספר הקורס:	1060
משך זמן מומלץ:	40 שעות
קהל היעד:	מהנדסי תקשורת המעוניינים **בהכרה יסודית של טכנולוגית LTE** בהיבט של ה- Radio Access, הרשת, ותכנון המערכת.

רקע

טכנולוגית LTE הפכה להיות הטכנולוגיה הסלולרית המובילה ברחבי העולם. הצפי הוא שבטווח של 3 שנים יהיו מרבית המערכות הסלולריות מבוססות LTE. טכנולוגית LTE משלבת מכלול טכנולוגיות תקשורת מתקדמות הן בהיבט של ה- Radio Access והן בהיבט של ארכיטקטורת הרשת ונעשה בה שימוש בתחום האזרחי, הצבאי והצבאי למחצה (כוחות ביטחון והצלה).

בקורס יסקרו לעומק המנגנונים המרכזיים של טכנולוגית LTE: ממשק האוויר, הגישה לערוץ, מנגנוני הניידות ה-QoS וה- Security,מרכיבי גרעין הרשת, מבנה הרשת הממשקים והפרוטוקולים שלהם. ילמדו תהליכי הקמת Session, ניידות, תמיכה בשירותי דיבור במערכת LTE, איכות השירות, QoS ועקרונות תכנון מערכת במערכות סלולריות אזרחיות ובמערכות ייחודיות.

תוכנית הקורס

(עקב ריבוי המונחים הלועזיים, נתונה תוכנית הקורס באנגלית. הקורס עצמו ניתן בעברית)

1) Introduction to LTE

- The evolution of the 3GPP cellular standards towards LTE
- LTE highlights and advantages over 3G
- LTE Spectrum allocations world wide
- LTE 3GPP releases and sub generations
- LTE status world wide- LTE subscription and road map

2) Refreshment – Review of Few Principles of Radio Communications

- The radio channel characteristics
- Multipath, group delay, fading, inter-symbol interference
- Bit Rate Capacity - Shannon's Theorem on maximum channel capacity

3) OFDMA and SC-FDMA in LTE

- Principles of OFDMA
- The Cyclic Prefix
- The OFDMA resource grid
- The PRB (Physical Resource Block)
- FDD radio frame structure in LTE
- Principles of SC-OFDMA
- UL Transmission structure
- TDD Radio Frame
- Downlink and uplink Physical Resources handling
- Coding Schemes in LTE
- The MCS (Modulation Code Schemes) in LTE
- Link adaptation
- Transmission bandwidths and throughput
- Examples for peak throughput calculation

4) The eNB and the UE Stack Elements and their Role

- PHY
- MAC
- RLC
- PDCP
- RRC

5) More on MAC Functionality

- The scheduler and its functionality
- HARQ (Hybrid ARQ)

6) Multi-Antenna Techniques Specified for LTE ("MIMO")

- Benefits of multi-antenna techniques
- The MIMO principle
- Open loop and closed Loop MIMO
- CQI, RI and Precoding Matrix Indication (PMI)
- Receive/transmit diversity
- Spatial multiplexing
- MIMO configurations in LTE

7) LTE Main Specifications

- Base Station transmitter Specs.
- Base Station Receiver Specs.
- User Equipment (UE) transmitter Specs.
- User Equipment (UE) Receiver Specs.

8) LTE signals and channels

- LTE Signals:
  - Primary and Secondary synchronization signals
  - Reference signals
  - UL Sounding (SRS) and Demodulation (DRS) signals
- DL Channels
  - PDSCH, PDCCH, PMCH, PBCH
- UL Channels
  - PUSCH, PUCCH, PRACH

9) LTE-EPC Network Architecture

- System Elements: MME, S-GW, P-GW, HSS, PCRF, eNB
- Main interfaces and their protocols (e.g. S1, S5/S8, S6, X2)
- Key features and services
- Roaming and non-roaming architecture
- Distributed Core vs. Centralized Core
- A Core in a box/ a system in a box

10) More on LTE Interfaces and Protocols

- The LTE system protocol stack
- S1 (U and C), S5/S8, S10, S11, S6
- Diameter
- GTPv2-C and GTP-U
- IPv4 / IPv6

11) LTE-EPC Signaling Fundamentals
- Network and UE identities
- EPS and signaling bearers
- PDN connections and APNs

12) Security in LTE-EPC
- Security architecture
- Authentication and Key management (AKA)
- NAS and AS security (Keys derivation, Keys life time)
- Data Integrity and Ciphering schemes
- Use of IPsec in LTE

13) Network Access in LTE-EPC
- Initial attach procedure,
- PLMN and Cell selection
- Random Access
- UE and eNB timing alignment
- RRC connection setup
- MME, S-GW and P-GW selection
- PDN connectivity
- Default EPS bearer setup
- IP address allocation
- Cell Reselection

14) Session Establishment
- Service request and session establishment
- Dedicated EPS bearer setup
- Dedicated bearer deactivation
- Dedicated bearer modification
- The Paging process

15) Mobility Management Overview
- Mobility management in IDLE mode
  - Tracking area and TIDs
  - Crossing Tracking Areas and resulted Location Update
- Mobility in ACTIVE Mode
  - Establishment of neighbor list
  - Signal measurement and reporting
  - Intra LTE mobility S1 and X2 based handover
  - Security aspects of Mobility
  - Mobility with other non-3GPP access systems
  - Inter (3GPP) system mobility
  - IP Mobility issues and solutions in LTE networks

16) QoS Framework in LTE-EPC
- PCC (Policy and Charging Control) architecture
- Main QoS determination entities: AF, PCRF, PCEF, SPR
- QoS class identifiers
- Traffic flow templates
- End to End QoS management

17) LTE Support of Voice and SMS

- Circuit-Switched Fallback (CSFB)
- The IMS architecture
- IMS network elements: I/P/S CSCF, Media Gateway (MGW), MGLF, HSS
- VoLTE over IMS
- SMS in LTE
- Voice Call Continuity (VCC)
- Single Radio Voice Call Continuity (SRVCC)

18) Deployment Considerations

- Network design consideration
- Design for coverage and capacity

19) Highlights of LTE advanced and LTE Pro

- Rel. 10-15 highlights
- Carrier Aggregation
- MU-MIMO and Beamforming
- eICIC
- CoMP (Coordinated Multipoint) flavors
- Joint Transmission
- DPS – Dynamic Point Selection)
- CB/CS (Coordinated Beamforming and Coordinated Scheduling)
- Small cell and HetNet
- LTE Integration with non 3GPP (e.g. WiFi) networks
- SON for LTE
- D2D (Device-to-Device) Communication

20) Summary and Future Generations

- LTE future enhancements
- 5G main use cases and technology highlights