Long Term Evolution (LTE)
Technology Overview

Long Term Evolution (LTE) will ensure the competitiveness of UMTS for the next ten years and beyond by providing a high-data-rate, low-latency and packet-optimized system. Also known as E-UTRA (Evolved Universal Terrestrial Radio Access) and E-UTRAN (Evolved Universal Terrestrial Radio Access Network), LTE is part of 3GPP release 8 specifications. The innovations that LTE brings to the UMTS world include:

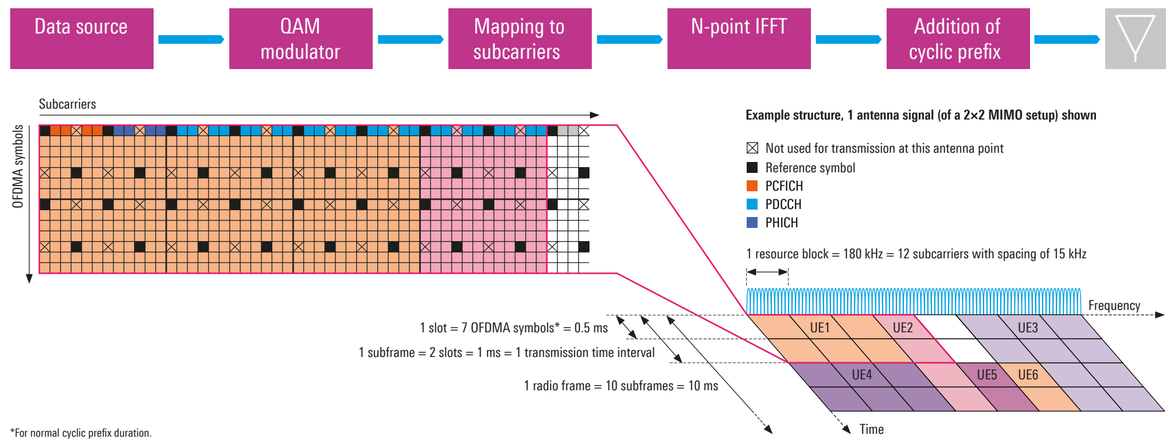
- New multiple access schemes
- Scalable bandwidth up to 20 MHz
- MIMO antenna technology
- New data and control channels
- New network and protocol architecture
- Specific test and measurement challenges

The future will bring even more: The work on LTE-Advanced has already begun in order to pave the way to 4G.

Rohde&Schwarz is the right partner for making your LTE products happen. Our test solutions were the first on the market and since then evolved to a full product portfolio from a single-source supplier, covering applications from R&D up to conformance.

Multiple Access Schemes and Physical Layer Signal Generation

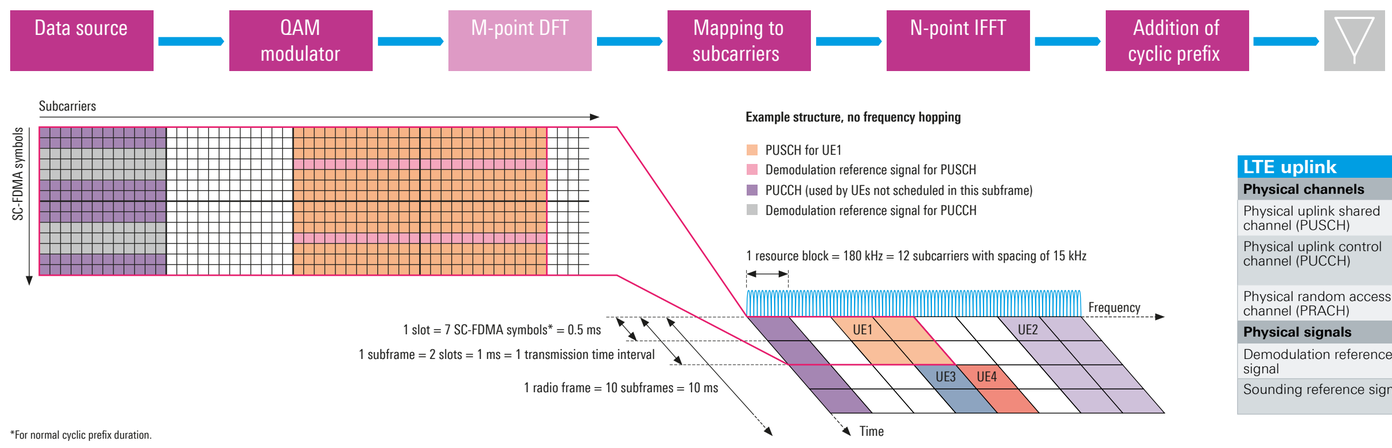
OFDMA in downlink



*For normal cyclic prefix duration.

LTE downlink	
Physical channels	
Physical downlink shared channel (PDSCH)	carries user data
Physical multicast channel (PMCH)	carries MBMS user data
Physical downlink control channel (PDCCH)	carries control information (DCI = downlink control information)
Physical control format indicator channel (PCFICH)	indicates format of PDCCH (CFI = control format indicator)
Physical hybrid ARQ indicator channel (PHICH)	carries ACK/NACKs (HI = HARQ indicator) for uplink data packets
Physical broadcast channel (PBCH)	provides information during cell search, e.g. on system bandwidth
Physical signals	
Primary and secondary synchronization signals	provide acquisition of cell timing and identity during cell search
Reference signal	enables channel estimation

SC-FDMA in uplink



*For normal cyclic prefix duration.

LTE uplink	
Physical channels	
Physical uplink shared channel (PUSCH)	carries user data
Physical uplink control channel (PUCCH)	carries control information (UCI = uplink control information)
Physical random access channel (PRACH)	preamble transmission for initial access
Physical signals	
Demodulation reference signal	enables channel estimation
Sounding reference signal	enables channel quality evaluation

Key parameters

Frequency range (E-UTRA bands)	FDD (in MHz):	TDD (in MHz):
	1) UL: 1920 to 1980; DL: 2110 to 2170	**33)** 1900 to 1920
	2) UL: 1850 to 1910; DL: 1930 to 1990	**34)** 2010 to 2025
	3) UL: 1710 to 1785; DL: 1805 to 1880	**35)** 1850 to 1910
	4) UL: 1710 to 1755; DL: 2110 to 2155	**36)** 1930 to 1990
	5) UL: 824 to 849; DL: 869 to 894	**37)** 1910 to 1930
	6) UL: 830 to 840; DL: 875 to 885	**38)** 2570 to 2620
	7) UL: 2500 to 2570; DL: 2620 to 2690	**39)** 1880 to 1920
	8) UL: 880 to 915; DL: 925 to 960	**40)** 2300 to 2400
	9) UL: 1749.9 to 1784.9; DL: 1844.9 to 1879.9	
	10) UL: 1710 to 1770; DL: 2110 to 2170	
	11) UL: 1427.9 to 1452.9; DL: 1475.9 to 1500.9	
	12) UL: 698 to 716; DL: 728 to 746	
	13) UL: 777 to 787; DL: 746 to 756	
	14) UL: 788 to 798; DL: 758 to 768	
	17) UL: 704 to 716; DL: 734 to 746	
	18) UL: 815 to 830; DL: 860 to 875	
	19) UL: 830 to 845; DL: 875 to 890	

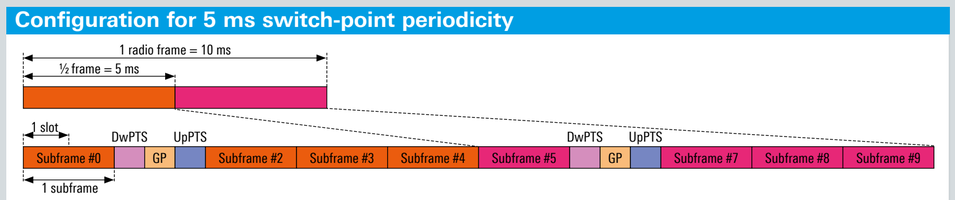
Channel bandwidth	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Resource blocks (RB) (1 RB = 180 kHz)	6	15	25	50	75	100
Modulation schemes	DL: QPSK, 16QAM, 64QAM UL: QPSK, 16QAM, 64QAM (optional for UE)					
Multiple access	DL: OFDMA UL: SC-FDMA					
Peak data rate	DL: 150 Mbit/s (UE category 4, 2x2 MIMO, 20 MHz), 300 Mbit/s (UE category 5, 4x4 MIMO, 20 MHz) UL: 75 Mbit/s (UE category 5, 20 MHz)					

MIMO Antenna Technology

LTE MIMO characteristics	
Number of eNB transmit antennas	1, 2 or 4
Number of UE receive antennas	2 or 4
DL transmit diversity	space frequency block coding (SFBC)
DL spatial multiplexing	codebook-based precoding, maximum of 2 parallel code words
DL cyclic delay diversity	antenna-specific cyclic shifts
UL MIMO mode	multi-user/collaborative MIMO, transmit antenna selection

TDD Frame Structure

Configuration for 5 ms switch-point periodicity



Selection of Rohde&Schwarz LTE Test Solutions

R&S®SMU200A
vector signal generator

- LTE downlink and uplink signal generation for terminal and base station receiver tests
- 2×2 MIMO setup including realtime fading in one box
- Expandable to 4×2 and 2×4 MIMO setups with realtime fading
- Channel coding for uplink and downlink
- Multistandard platform also supporting: HSPA/HSPA+, CDMA2000® 1xRTT/1xEV-DO, GSM/EDGE, WiMAX™, WLAN, etc.

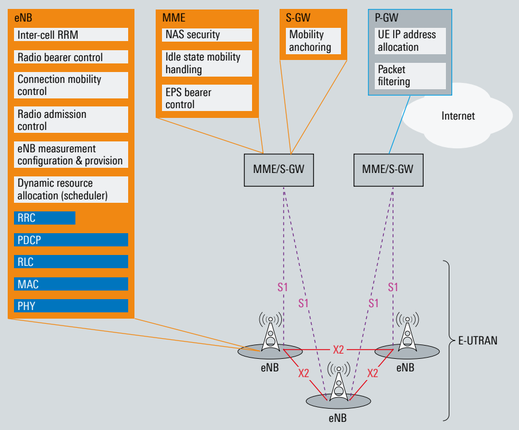
R&S®FSQ
signal and spectrum analyzer

- High-performance analysis of LTE RF characteristics including 4×4 MIMO capability
- LTE downlink and uplink signal analysis for base station and terminal transmitter tests
- Multistandard platform also supporting: HSPA/HSPA+, CDMA2000® 1xRTT/1xEV-DO, GSM/EDGE, WiMAX™, WLAN, etc.

R&S®CMW500
wideband radio communication tester

- One tester for all stages of wireless device testing – from R&D to conformance
- Test of layer 1 to 3 up to user plane
- Full flexibility for test scenario definition
- Scalable one-box hardware setup
- Support of all 3GPP frequency bands
- MIMO and multi-RAT testing

Network and Protocol Architecture



Glossary:
3GPP = 3rd Generation Partnership Project, ARQ = Automatic Repeat Request, DFT = Discrete Fourier Transformation, DL = Downlink, DwPTS = Downlink Pilot Timeslot, eNB = evolved Node B, EPS = Evolved Packet System, E-UTRA(N) = Evolved Universal Terrestrial Radio Access (Network), FDD = Frequency Division Duplex, GP = Guard Period, HARQ = Hybrid ARQ, IFFT = Inverse Fast Fourier Transform, IP = Internet Protocol, MAC = Medium Access Control, MBMS = Multimedia Broadcast Multicast Service, MIMO = Multiple Input Multiple Output, MME = Mobility Management Entity, NAS = Non Access Stratum, OFDMA = Orthogonal Frequency Division Multiple Access, P-GW = Packet Data Network Gateway, PDCP = Packet Data Convergence Protocol, PHY = Physical Layer, QAM = Quadrature Amplitude Modulation, RAT = Radio Access Technology, RLC = Radio Link Control, RRC = Radio Resource Control, RRM = Radio Resource Management, S-GW = Serving Gateway, SC-FDMA = Single Carrier Frequency Division Multiple Access, TDD = Time Division Duplex, UE = User Equipment, UL = Uplink, UMTS = Universal Mobile Telecommunications System, UpPTS = Uplink Pilot Timeslot.

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