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Basics of LTE System

Introduction:

Third-generation (3G) wireless systems, based on W-CDMA, are now being deployed all over the world. W-CDMA maintains a mid-term competitive edge by providing high speed packet access (HSPA) in both downlink and uplink modes. To ensure the competitiveness of the 3G systems into the future, a long term evolution (LTE) of the 3rd Generation Partnership Project (3GPP) access technology is being specified in Release 8 and 9 of the 3GPP standard. Release 10 is being developed as LTE-Advanced.

The LTE radio transmission and reception specifications are documented in TS 36.101 for the UE (User Equipment) and TS 36.104 for the eNB (Evolved Node B). Downlink and uplink transmission in LTE are based on the use of multiple access technologies: specifically, orthogonal frequency division multiple access (OFDMA) for the downlink, and single-carrier frequency division multiple access (SC-FDMA) for the uplink.

The work on the specifications is ongoing, and many of the technical documents are updated quarterly. The latest versions of the 36-series documents can be found at http://www.3gpp.org/ftp/specs/archive/36_series/

Physical layer is described in TS36.211 and TS36.212 releases. 36.211 mentions physical channels and modulation while 36.212 mentions multiplexing and channel coding.

LTE system parameters and Frame structure:

Frame Size=10ms

No. of slots=20.

No of Slots per Sub frame =2.

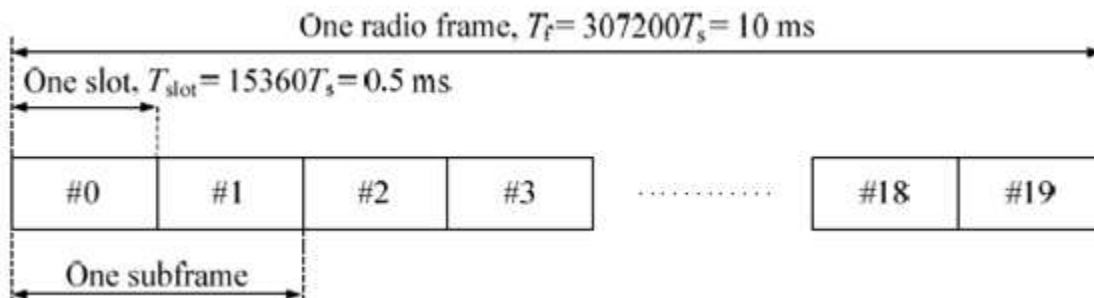
Slot duration=0.5 ms

Sub frame duration=1 ms

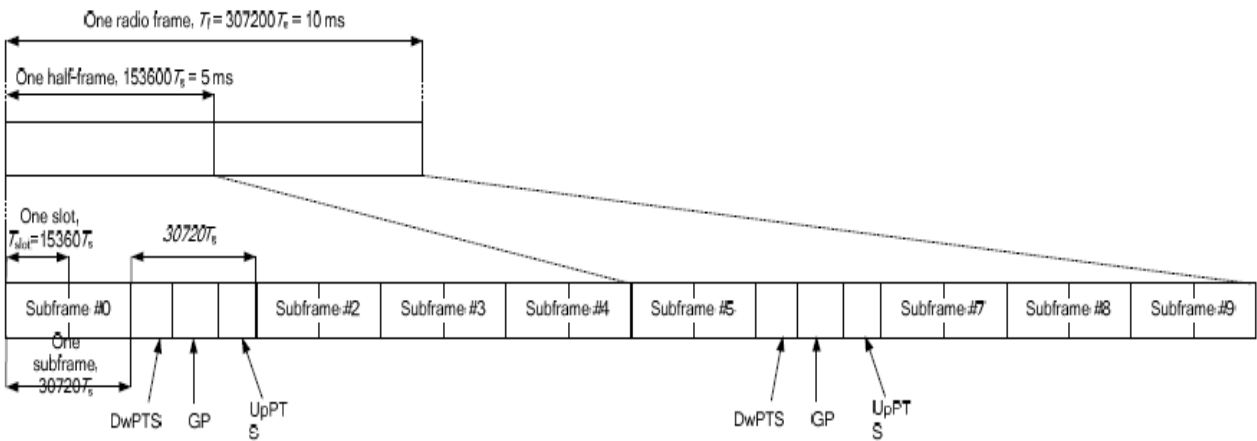
Basic time unit T_s for BW of 20MHz, $1/15000 \times 2048$ seconds equal to 32.55ns.

Transmission BW (MHz)	1.4	3	5	10	15	20
Sub-frame duration	1.0 ms					
Sub-carrier spacing	15 kHz					
Sampling frequency (MHz)	1.92	3.84	7.68	15.36	23.04	30.72
FFT size	128	256	512	1024	1536	2048
Number of occupied sub-carriers	72	180	300	600	900	1200
CP length (μ s)	Normal	4.69 \times 6, 5.21 \times 1				
	Extended	16.6				

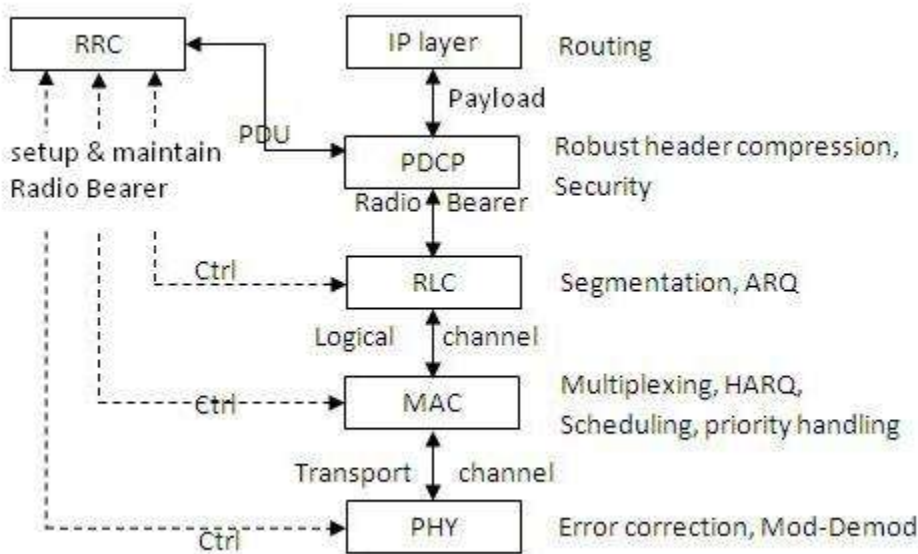
Type 1, applicable to FDD- Here there are total 20 slots, each is 0.5ms. 2 slots constitute 1 sub frame.



Type 2, applicable to TDD- Here there are 10 sub frames, each is 1 ms, sub frame 0 and 5 are dedicated for downlink always while sub frames 1 and 6 are dedicated for control frame. Sub frames 2, 3, 4 and 7, 8, 9 depend on UL/DL configuration table defined in the standard. Following frame is for switch point periodicity of 5 ms.



Protocol Layer with functions:





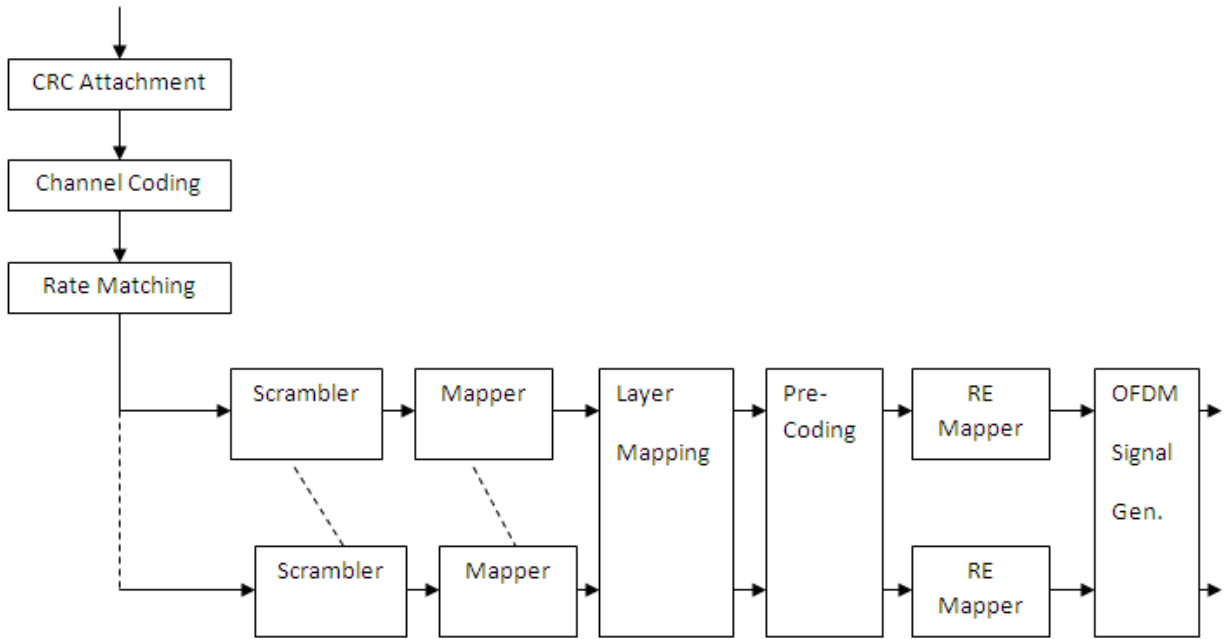
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Physical layer:

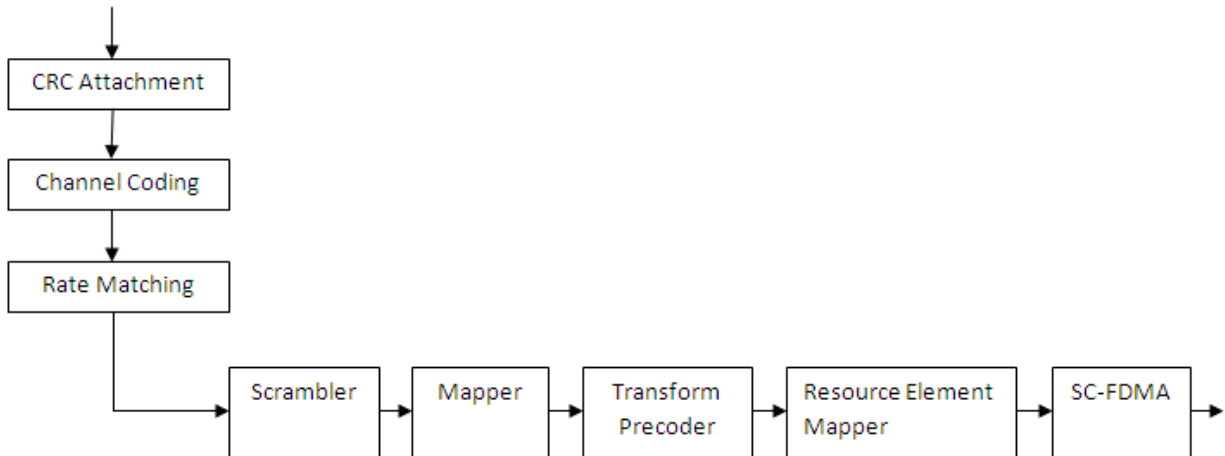
The key features of physical layer are mentioned in the table below.

Features	
Channel Bandwidth	1.4/3/5/10/15/20 MHz
FFT size	128/256/512/1024/1536/2048
Cyclic Prefix	Normal, Extended
DL multiple access	OFDMA
UL multiple access	SC-FDMA
Duplexing	FDD & TDD
Subcarrier mapping	Localized
Subcarrier hopping	Yes
Data Modulation	QPSK/16QAM/64QAM
Subcarrier spacing	15KHz
Channel Coding	convolutional coding and turbo coding
MIMO	2 or 4 at transmit and 2 or 4 at receive side
HARQ	Incremental redundancy

Block schematic of PHY layer eNodeB Transmitter:



Block schematic of PHY layer User Equipment (UE):





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3GPP released documents of LTE and LTE-advanced are available at link, which is summarized here.

<http://www.3gpp.org/ftp/Specs/html-info/SpecReleaseMatrix.htm>

Description	Document Reference
Layer-1	
PHY (channels and modulation)	TS 36.211
PHY (MUX and channel coding)	TS 36.212
PHY (procedures)	TS 36.213
PHY (measurements)	TS 36.214
Layer-2	
MAC	TS 36.321
RLC	TS 36.322
PDCP	TS 36.323
Layer-3	
RRC	TS 36.331
Conformance	
BS Conformance tests	TS 36.141
UE conformance tests Part 1 Radio Tx and Rx	TS 36.521.1
Part 2 ICS	TS 36.521.2
Part 3 RRM	TS 36.521.3
Radio Transmission and Reception	
BS Radio Tx and Rx	TS36.104
UE Radio Tx and Rx	TS36.101
E-UTRAN RAN S1 Application Protocol (S1AP)	
S1-AP	TS 36.413

Terminology:

Subcarrier	A single 15 kHz radio channel
Symbol	A single 66.67 μ s time period
Resource Element	The smallest unit of radio resources, one subcarrier for one symbol
Resource Block	The smallest block of resources that can be allocated, 12 subcarriers for 7 symbols (84 resource elements)
Timeslot	7 consecutive symbols
Sub frame	2 consecutive timeslots
Frame	10 consecutive sub frames, the basic transmission interval



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References:

1. TS 36.201- Evolved Universal Terrestrial Radio Access (E-UTRA); LTE physical layer; General description
2. TS 36.211- Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation
3. TS 36.212- Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding

Document reference links:

<http://www.3gpp.org/ftp/Specs/html-info/36-series.htm>

<http://www.3gpp.org/ftp/Specs/html-info/SpecReleaseMatrix.htm>