LTE PHY Overview

Gwanmo Ku

Adaptive Signal Processing and Information Theory Research Group

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Outline

LTE Introduction

LTE PHY Standard Descriptions

- Protocol Architecture
- Standard Docs.
- Parameters
- Frame Structures
- PHY Resources
- Modulation, Channel Coding, and Physical Channels

References

LTE Introduction

Why LTE?

Continuity of Competitiveness of 3G System

Higher Data Rate QoS

Packet Switch Optimized System

LTE

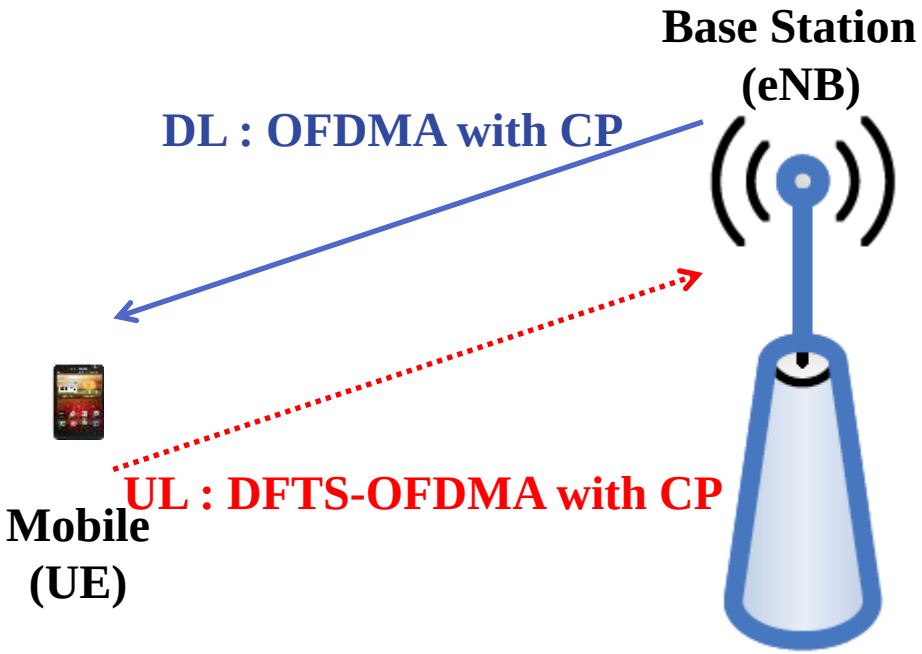
High Spectral Efficiency

Very Low Latency

Support of Variable Bandwidth

(Reference: http://www.3gpp.org/LTE)

LTE Multiple Access



DL (Downlink), UL (Uplink), **CP** (Cyclic Prefix)

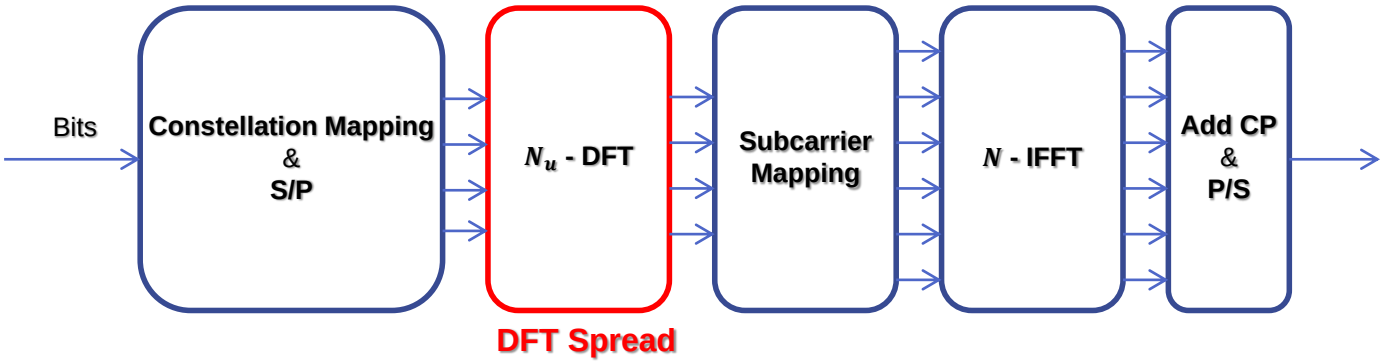
eNB (e Node B), **UE** (User Equipment)

DFTS-OFDMA (DFT Spread OFDMA) : also called as **SC-FDMA** (Single Carrier FDMA)

(Reference : p7, 3GPP TS 36.201 V8.3.0 (2009-03))

OFDMA & SC-FDMA

OFDMA



+ **SC-FDMA (DFT Spread OFDMA)**

S/P (Serial to Parallel Conversion), **P/S** (Parallel to Serial Conversion)

N_u : Used Subcarriers

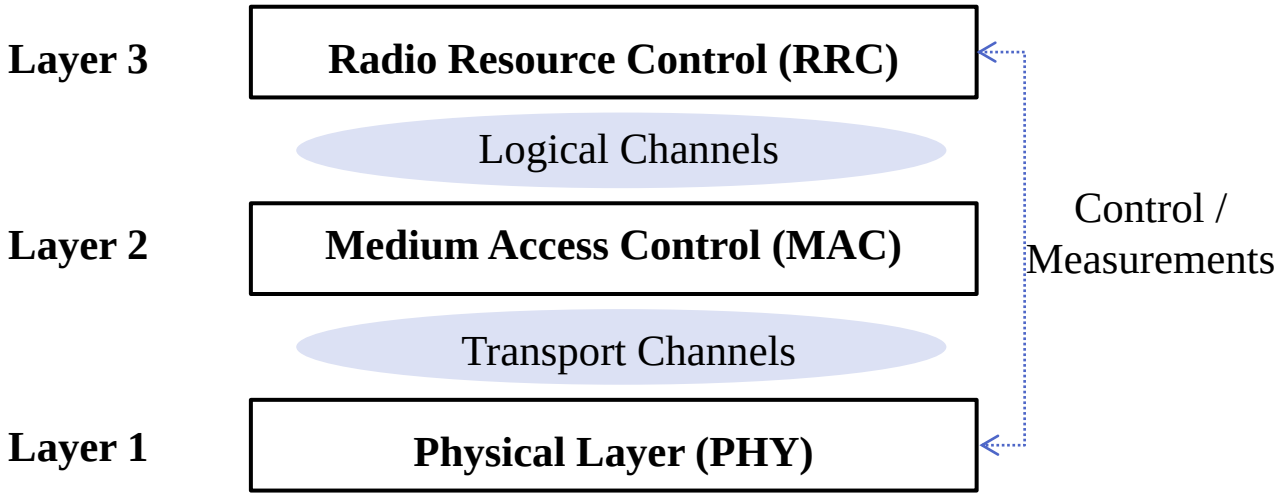
N : Total Subcarriers

(Reference : p. 71, 3GPP TR 25.814 V7.1.0 (2006-09))

LTE PHY Standard Descriptions

LTE Protocol Architecture

- **LTE Protocol Architecture around PHY**

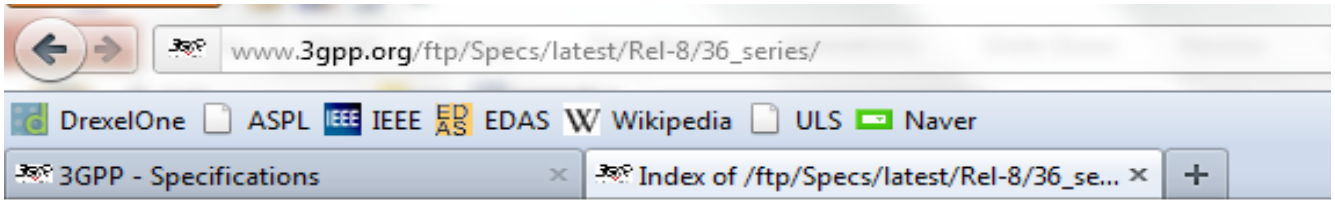


Logical Channels : Type of information transferred

Transport Channels : How the information is transferred

(Reference : p. 7, 3GPP TS 36.201 V8.3.0 (2009-03))

LTE PHY Standard Docs.



Index of /ftp/Specs/latest/Rel-8/36_series

	Name	Last modified	Size	Description
	Parent Directory		-	
	36101-8f0.zip	03-Oct-2011 02:52	897K	
	36104-8c0.zip	21-Jun-2011 13:13	467K	
Requirements	36106-860.zip	06-Jan-2011 04:32	287K	
	36113-830.zip	07-Jan-2011 06:52	83K	
	36124-820.zip	07-Jan-2011 06:52	94K	
	36133-8f0.zip	03-Oct-2011 02:52	1.2M	
	36141-8b0.zip	20-Jun-2011 02:16	743K	
	36143-840.zip	07-Jan-2011 06:53	331K	
	36201-830.zip	13-Mar-2009 20:43	184K	
	36211-890.zip			
Layer 1	36212-880.zip			
	36213-880.zip	19-Sep-2009 22:53	660K	
	36214-870.zip	19-Sep-2009 22:54	155K	
	36300-8c0.zip	20-Apr-2010 10:05	2.3M	
	36302-820.zip	18-Jun-2009 07:13	1.7M	
	36304-8a0.zip	21-Jun-2011 23:32	239K	
Layer 2 & 3	36306-880.zip	21-Jun-2011 23:08	157K	
	36307-840.zip	03-Oct-2011 02:53	170K	
	36314-830.zip	28-Dec-2009 12:12	178K	
	36321-8a0.zip	28-Sep-2011 12:33	582K	
	36322-880.zip	16-Jun-2010 15:10	931K	

Rel-8 36 Series : LTE

Rel-9 36 Series : LTE with Enhancement

Rel-10, 11, … 36 Series : LTE Advanced

Rel-8 362XX : LTE PHY Technical Spec.

- **36201 : LTE PHY General Descriptions**
- **36211 : Physical channels and modulation**
- **36.212 : Multiplexing and channel coding**
- **36.213 : Physical layer procedures**
- **36.214 : Physical layer Measurements**

PHY Parameters

DL/UL Parameters

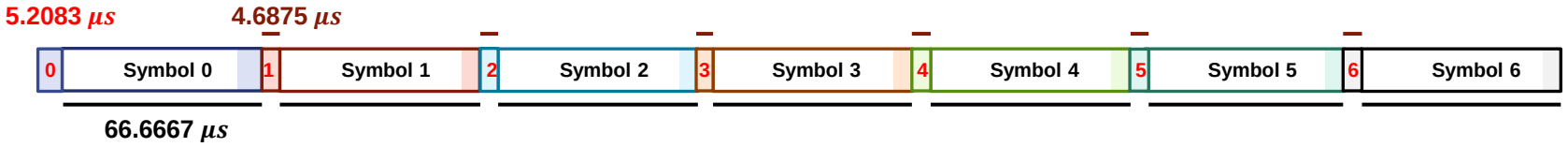
System BW [MHz]		1.4	3	5	10	15	20
# Resource Blocks N_{RB}		6	15	25	50	75	100
FFT Size N	$\Delta f = 15KHz$	2048					
	$\Delta f = 7.5KHz$	-					4096*
# Subcarriers per RB N_{sc}	$\Delta f = 15KHz$	12					
	$\Delta f = 7.5KHz$	-					24*
# Used Subcarriers N_u	$\Delta f = 15KHz$	72	180	300	600	900	1200
	$\Delta f = 7.5KHz$	-					2400*
Sampling Rate [MHz]		1.92	3.84	7.68	15.36	23.04	30.72

Subcarrier Spacing $\Delta f = 15\ kHz$ UL/DL, $\Delta f^* = 7.5\ kHz$ DL only

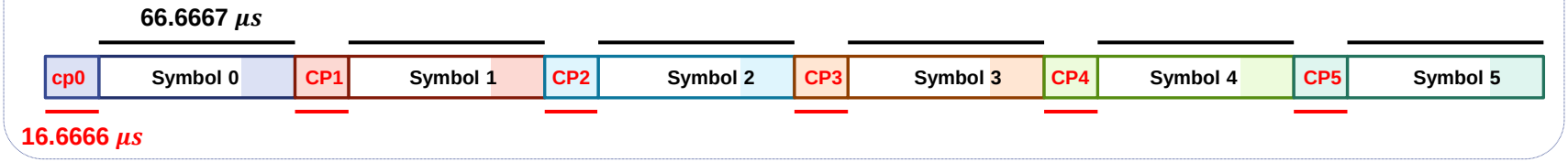
(Reference : 3GPP TS 36.101 V8.15.0 (2011-09))

PHY Parameters – CP Length

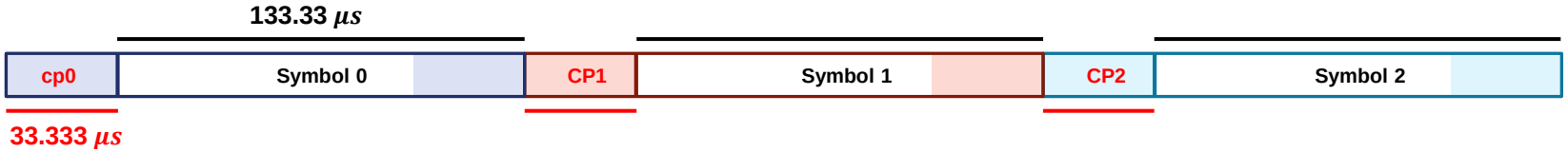
DL/UL Normal CP



DL/UL Extended CP with Freq. Spacing 15 KHz

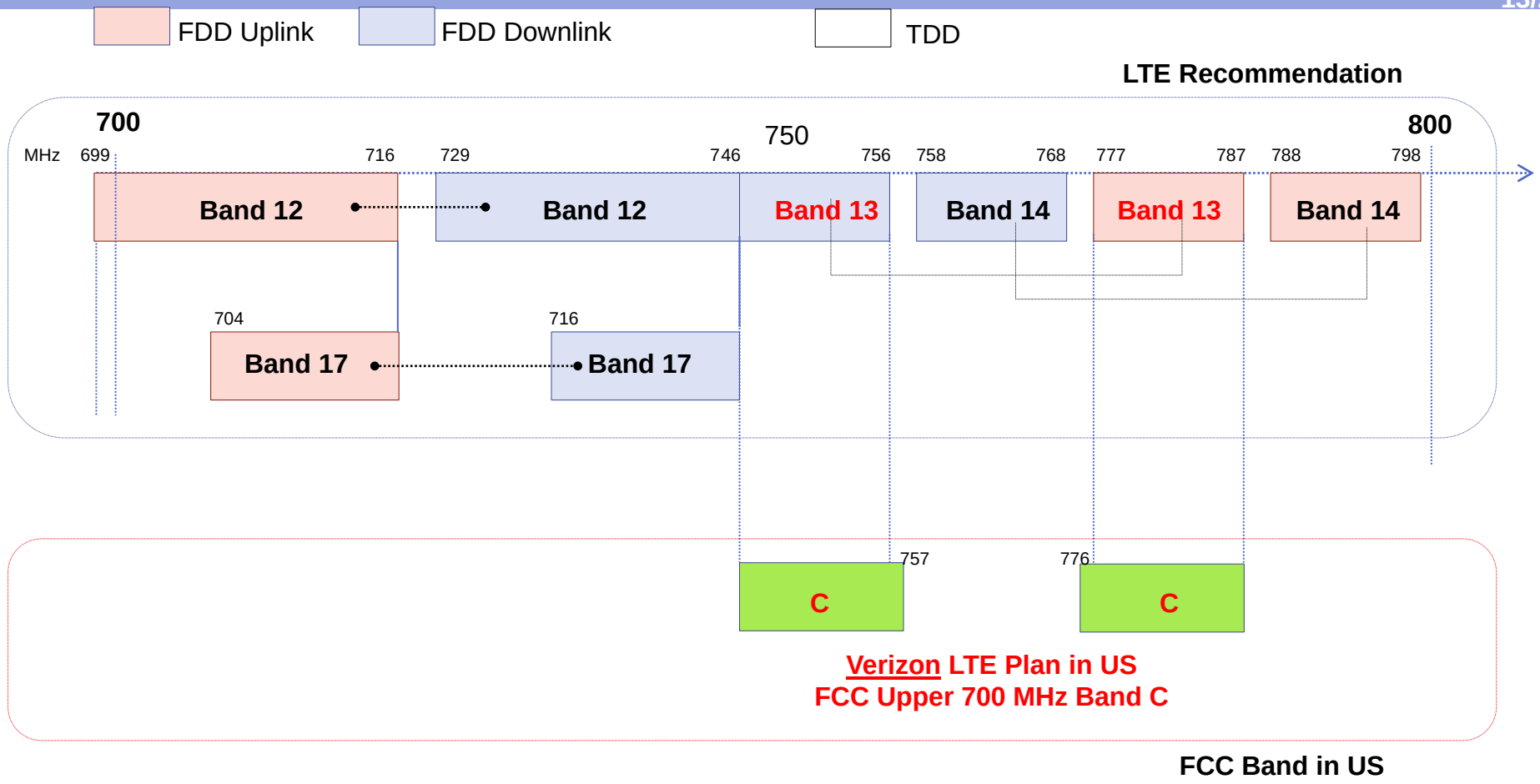


DL Extended CP with Freq. Spacing 7.5 KHz



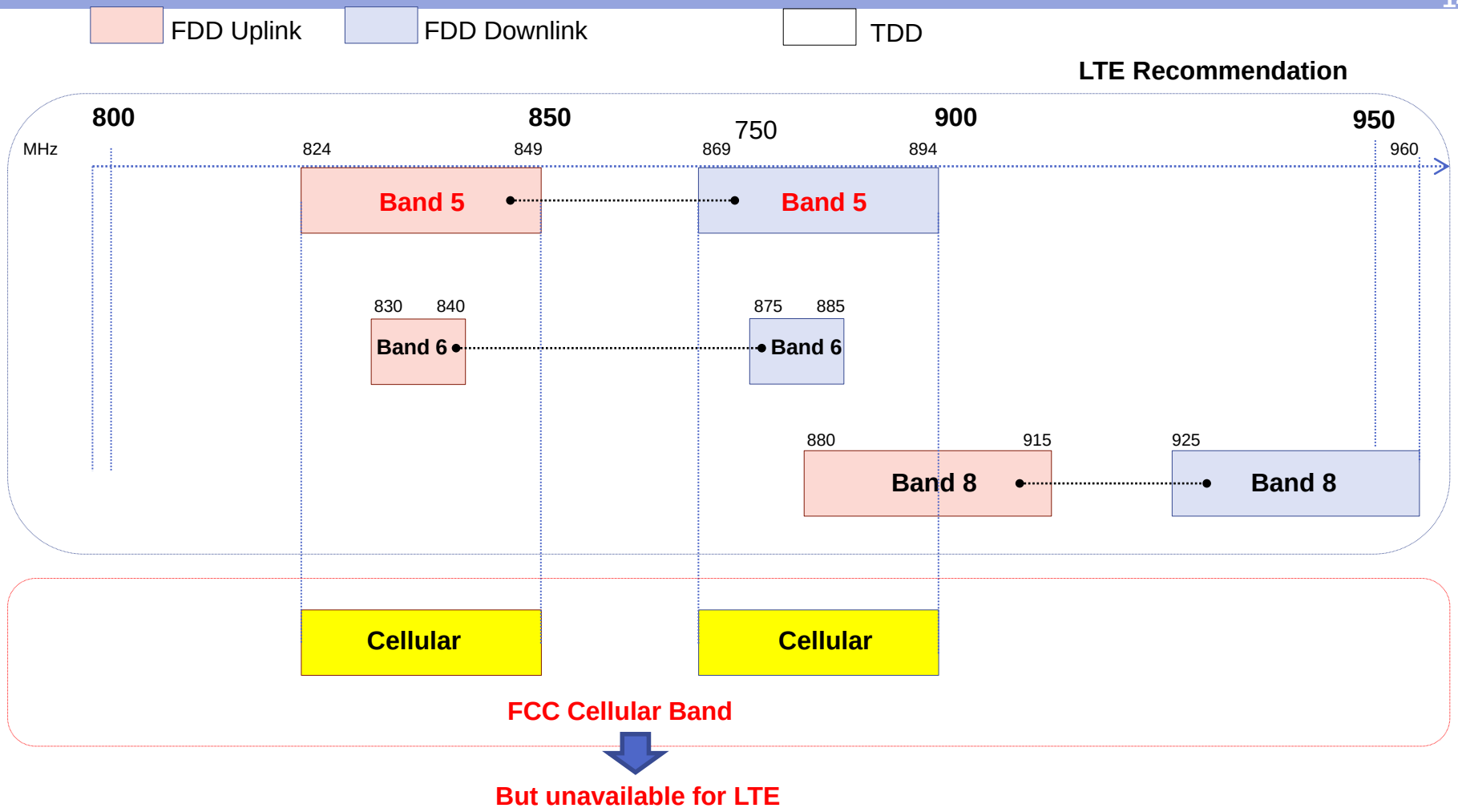
(Reference : 3GPP TS 36.211 V8.9.0 (2009-12))

Operating Bands (700 MHz)



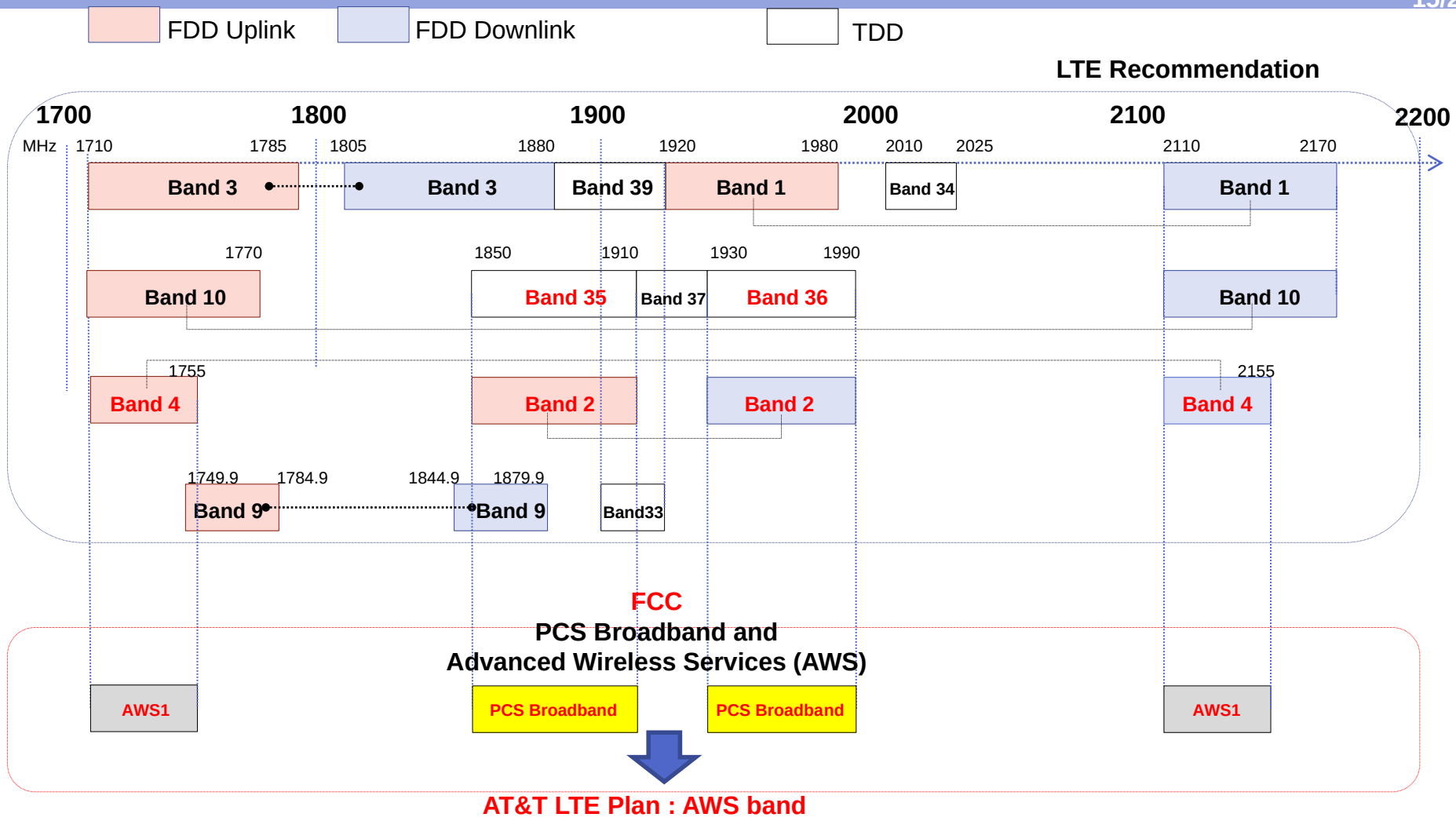
References : [1] 3GPP TS 36.101 V8.15.0 (2011-09)
[2] FCC Doc. : http://transition.fcc.gov/Daily_Releases/Daily_Business/2011/db0630/FCC-11-103A1.pdf

Operating Bands (800 MHz)



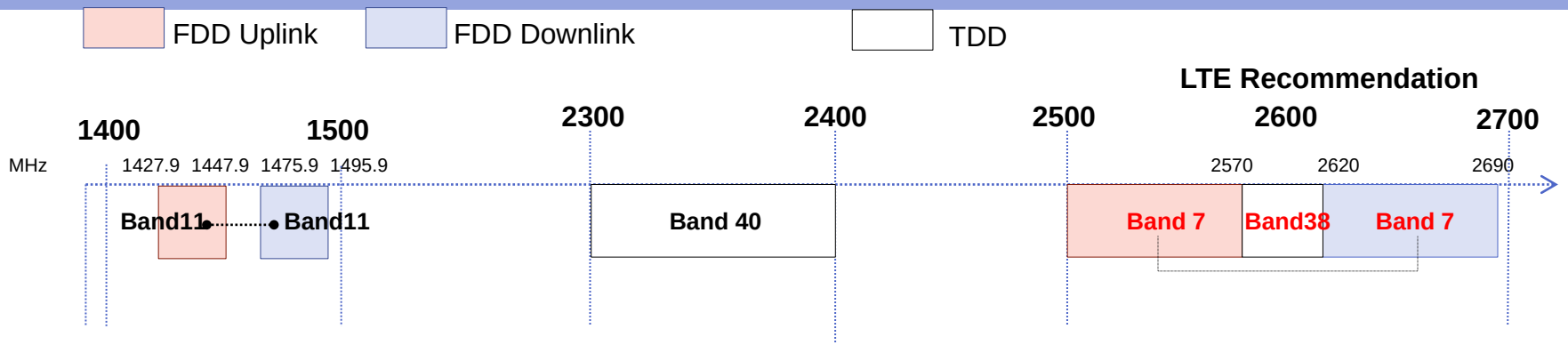
References : [1] 3GPP TS 36.101 V8.15.0 (2011-09)
[2] FCC Doc. : http://transition.fcc.gov/Daily_Releases/Daily_Business/2011/db0630/FCC-11-103A1.pdf

Operating Bands (1700-2200 MHz)



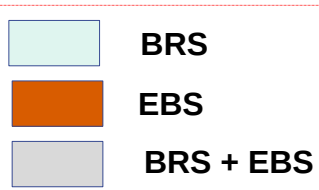
References : [1] 3GPP TS 36.101 V8.15.0 (2011-09)
[2] FCC Doc. : http://transition.fcc.gov/Daily_Releases/Daily_Business/2011/db0630/FCC-11-103A1.pdf

Operating Bands (1400 & 2300-2700 MHz)

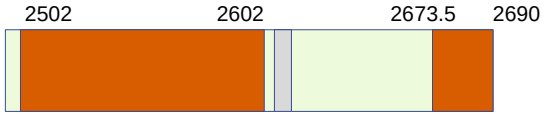


FCC

Broadband Radio Service (BRS) and Educational Broadband Service (EBS)



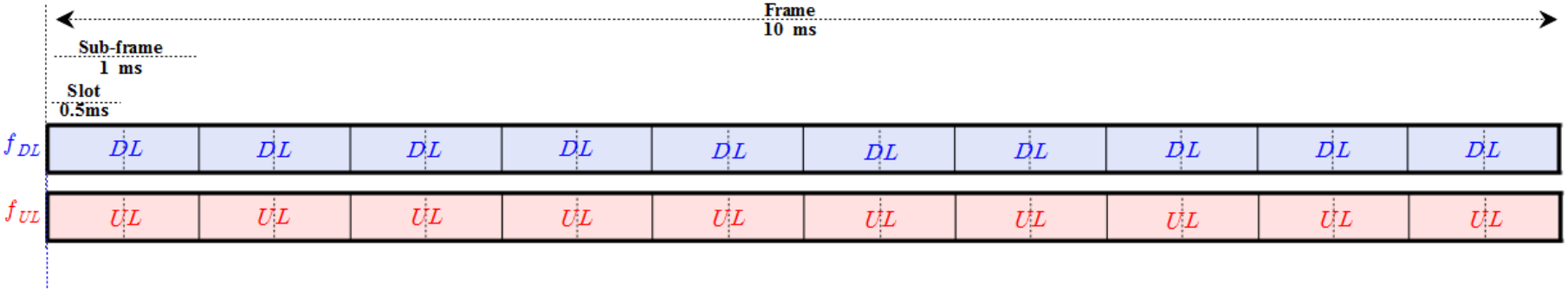
But
LTE available
BW upto 5MHz



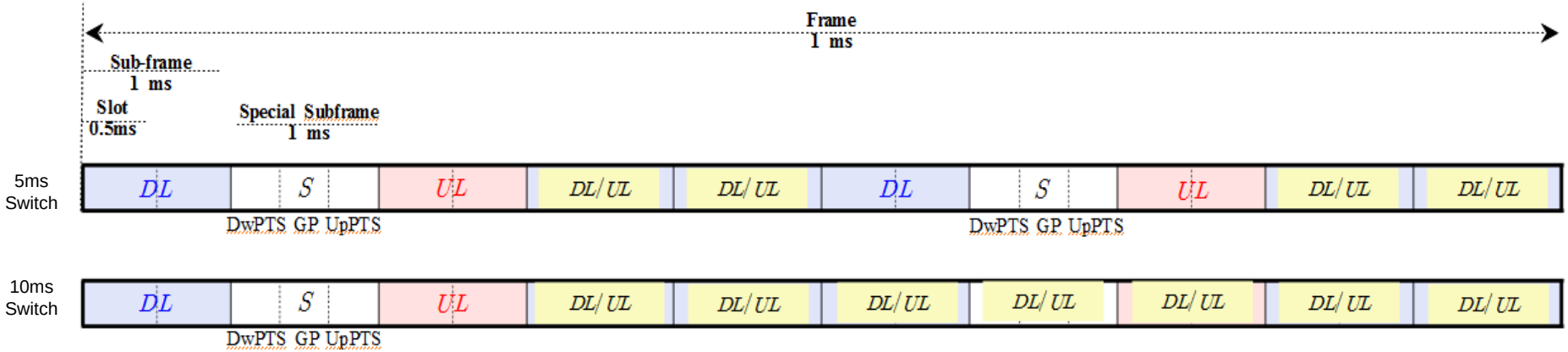
References : [1] 3GPP TS 36.101 V8.15.0 (2011-09)
[2] FCC Doc. : http://transition.fcc.gov/Daily_Releases/Daily_Business/2011/db0630/FCC-11-103A1.pdf

Frame Structure

Frame Structure Type 1 : FDD



Frame Structure Type 2 : TDD



(Reference : 3GPP TS 36.211 V8.9.0 (2009-12))

Frame Structure – TDD (Cont.)

UL/DL Configurations

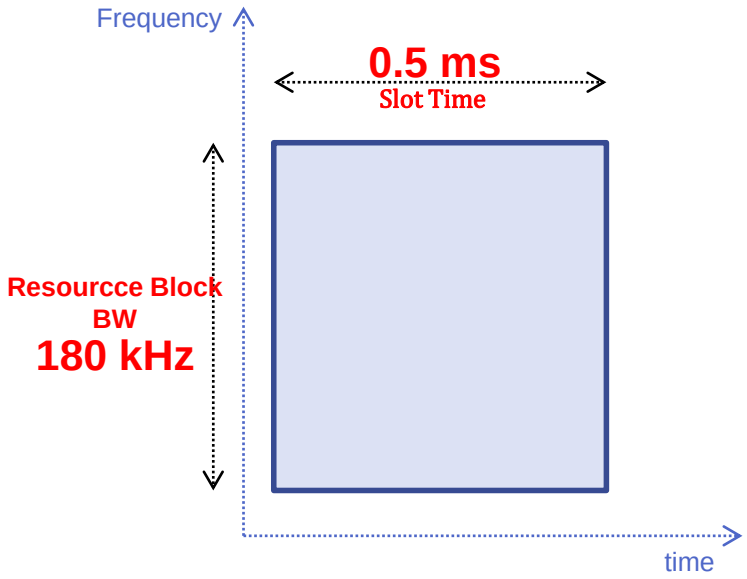
UL-DL Configuration	DL to UL Switch Point Periodicity	Sub-frame Number									
		0	1	2	3	4	5	6	7	8	9
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

Subframe Index : D (Downlink), U (Uplink), S (Special)

(Reference : 3GPP TS 36.211 V8.9.0 (2009-12))

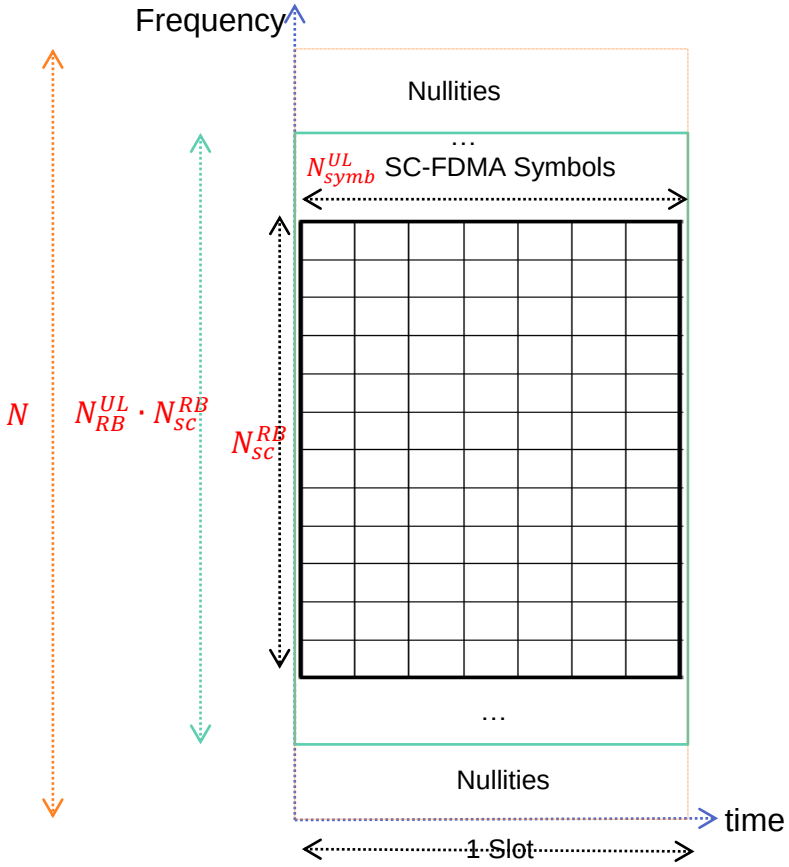
PHY Resources

- **Resources in LTE**
  - ✓ **Resources : # Usable Subcarriers**
  - ✓ **Resource Block & Slot**



(Reference : 3GPP TS 36.211 V8.9.0 (2009-12))

PHY Resources – UL Slot Structure



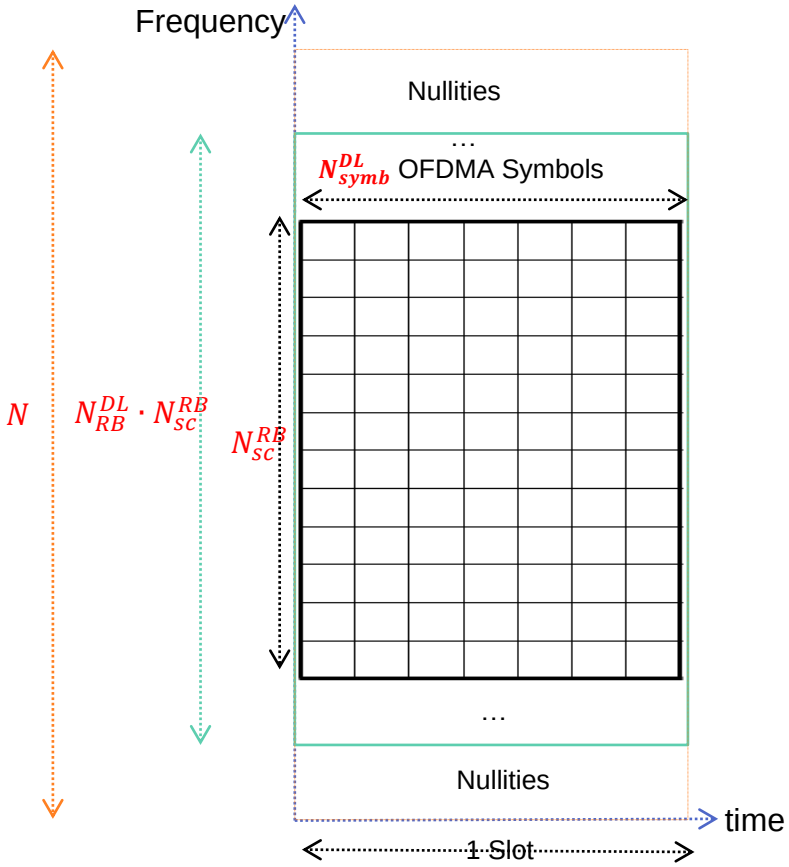
BW [MHz]	1.4	3	5	10	15	20
N_{RB}^{UL}	6	15	25	50	75	100
N	128	256	512	1024	1536	2048

Configuration	N_{sc}^{RB}	N_{symb}^{UL}
Normal CP	12	7
Extended CP	12	6

Configuration	CP Length
Normal CP	**160** for 0th Symbol
	144 for 1~6th Symbol
Extended CP	**512** for 0~5th Symbol

(Reference : 3GPP TS 36.211 V8.9.0 (2009-12))

PHY Resources – DL Slot Structure



BW [MHz]	1.4	3	5	10	15	20
N_{RB}^{DL}	6	15	25	50	75	100
N	128	256	512	1024	1536	2048

Configuration		N_{sc}^{RB}	N_{symb}^{DL}
Normal CP	$\Delta f = 15\ kHz$	12	7
Extended CP	$\Delta f = 15\ kHz$	12	6
	$\Delta f = 7.5\ kHz$	24	3

Configuration		CP Length
Normal CP	$\Delta f = 15\ kHz$	**160** for 0th Symbol
		144 for 1~6th Symbol
Extended CP	$\Delta f = 15\ kHz$	**512** for 0~5th Symbol
	$\Delta f = 7.5\ kHz$	**1024** for 0-2nd Symbol

(Reference : 3GPP TS 36.211 V8.9.0 (2009-12))

Modulations, Coding, Physical Channels

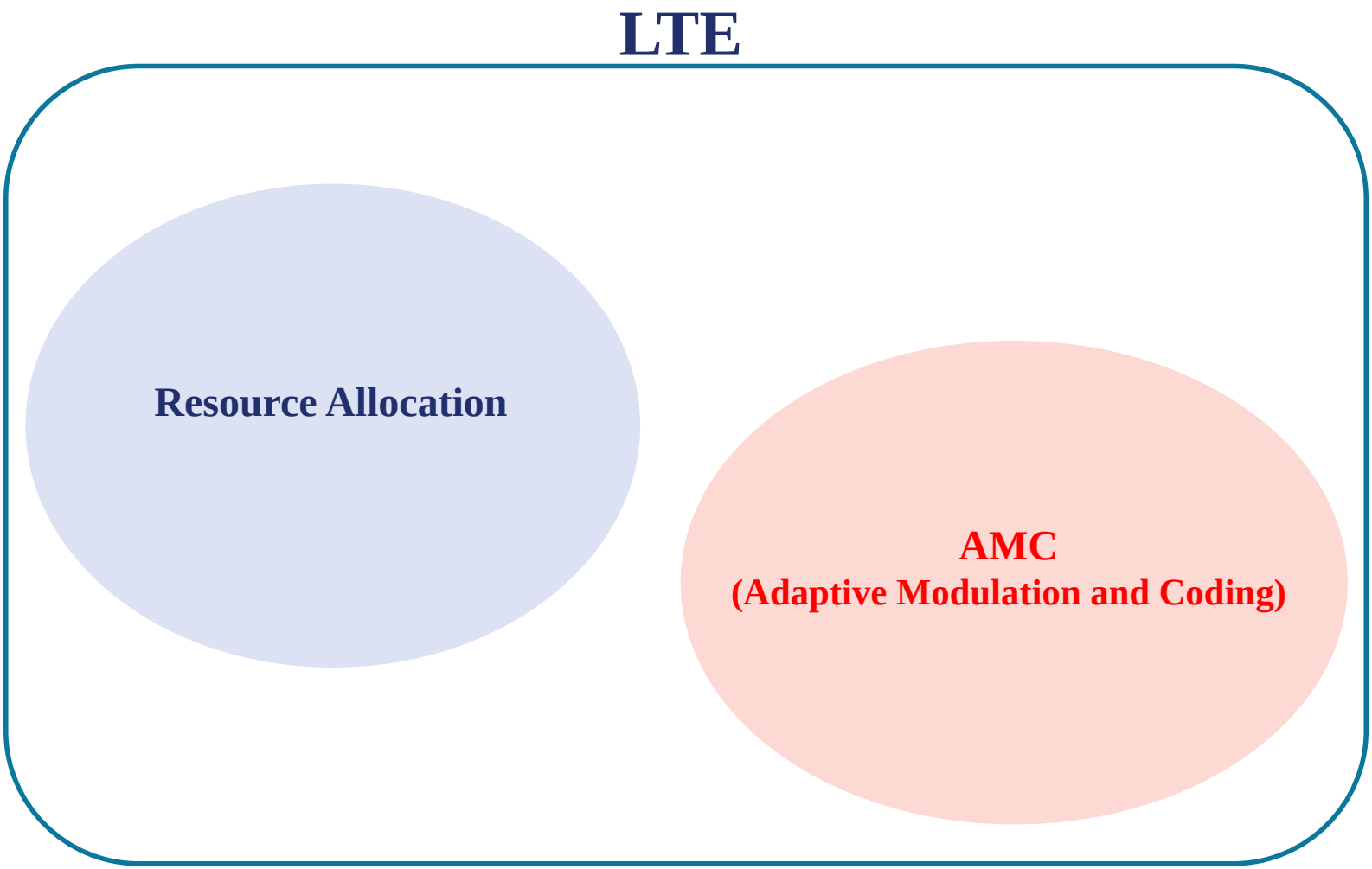
- **Modulations**
  - ✓ **QPSK, 16QAM, 64QAM**
- **Channel Coding**
  - ✓ **Turbo Coding**
- **Physical Channels**
  - ✓ **DL Physical Channels**

    PDSCH, PDCCH, PCFICH, PBCH, PMCH, PHICH
  - ✓ **UL Physical Channels**

    PUSCH, PUCCH, PRACH

(Reference : 3GPP TS 36.212 V8.8.0 (2009-12))

Future Work (Next Talk)



References

References

- **LTE related Webpages**
  - ✓ http://www.3gpp.org : 3GPP Standard Web
  - ✓ http://www.fcc.gov/ : FCC
  - ✓ http://wireless.fcc.gov/uls/ : FCC Band License Search
- **LTE Standard Docs. – Release 8 Technical Specs.**
  - ✓ http://www.3gpp.org/ftp/Specs/latest/Rel-8/36_series/
- **FCC Useful Doc. – 15th Report**
  - ✓ http://transition.fcc.gov/Daily_Releases/Daily_Business/2011/db0630/FCC-11-103A1.pdf
- **DFTS-OFDMA (SC-FDMA)**
  - ✓ http://sites.google.com/site/hgmyung/scfdma