Overview of AMC in LTE

Gwanmo Ku

Adaptive Signal Processing and Information Theory Research Group

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Outline

LTE Basic

- Why LTE
- LTE Network / Resources / Frame Structure
- LTE in US (Verizon)

AMC in LTE

- Why AMC?
- Channel Condition : CQI Reporting
- MCS associated with CQI

References

LTE Basic

Why LTE?

Continuity of Competitiveness of 3G System

Higher Data Rate QoS

Packet Switch Optimized System

LTE

High Spectral Efficiency

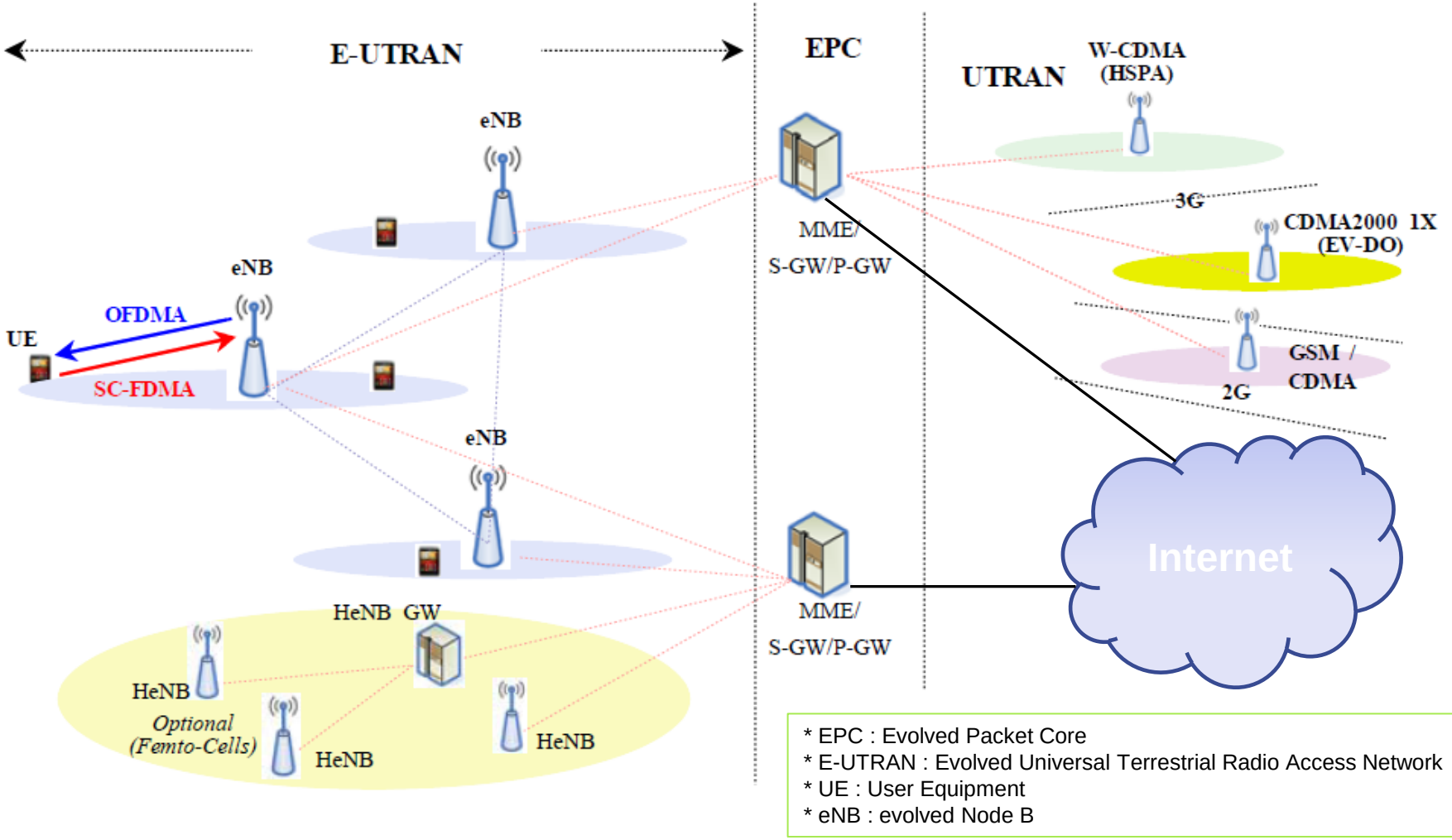
Very Low Latency

Support of Variable Bandwidth

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

LTE Network

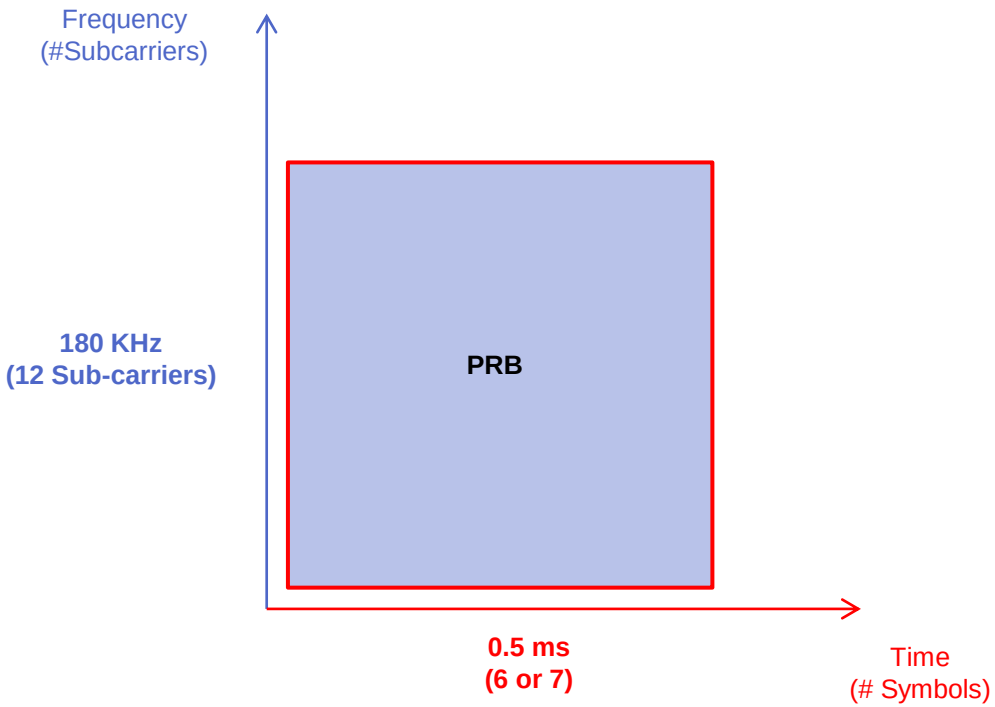
- **LTE Network**



* EPC : Evolved Packet Core
* E-UTRAN : Evolved Universal Terrestrial Radio Access Network
* UE : User Equipment
* eNB : evolved Node B

LTE Resource (Unit)

- **Physical Resource Block (PRB)**
  - ✓ **The Smallest User Assignment Resource Unit (12 Sub-carriers)**



LTE Resource (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]		30.72					

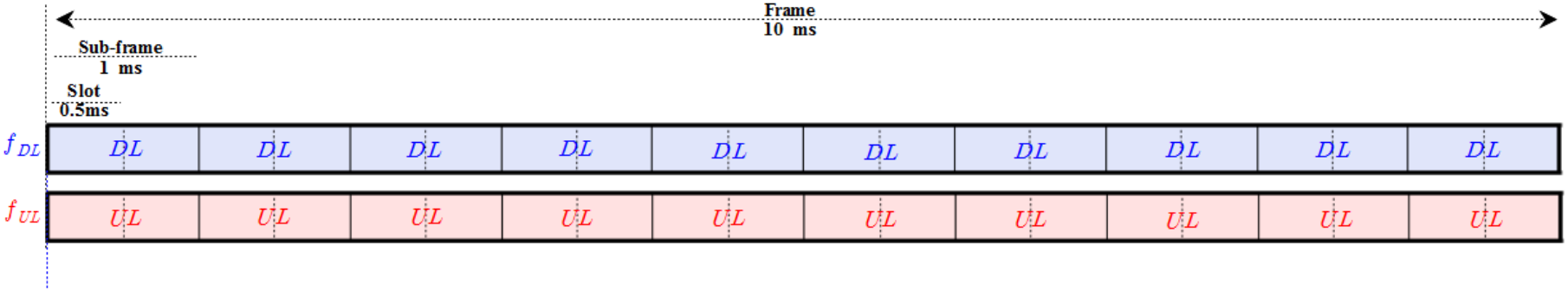
Subcarrier Spacing $\Delta f = 15\ kHz$ UL/DL, $\Delta f^* = 7.5\ kHz$ DL only

Parameters used by Verizon in US

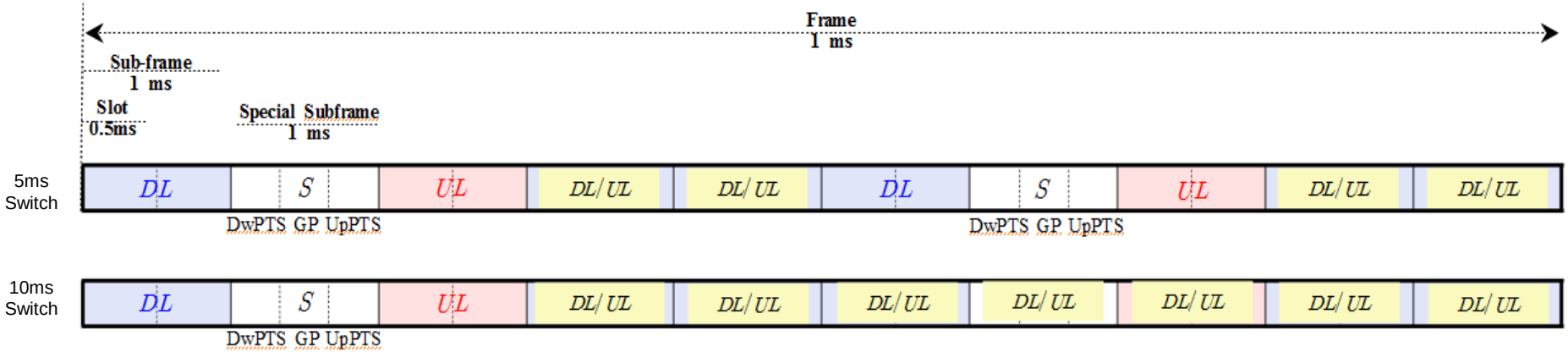
(Reference : 3GPP TS 36.101 V8.15.0 (2011-09))

LTE Frame Structure

Frame Structure Type 1 : FDD



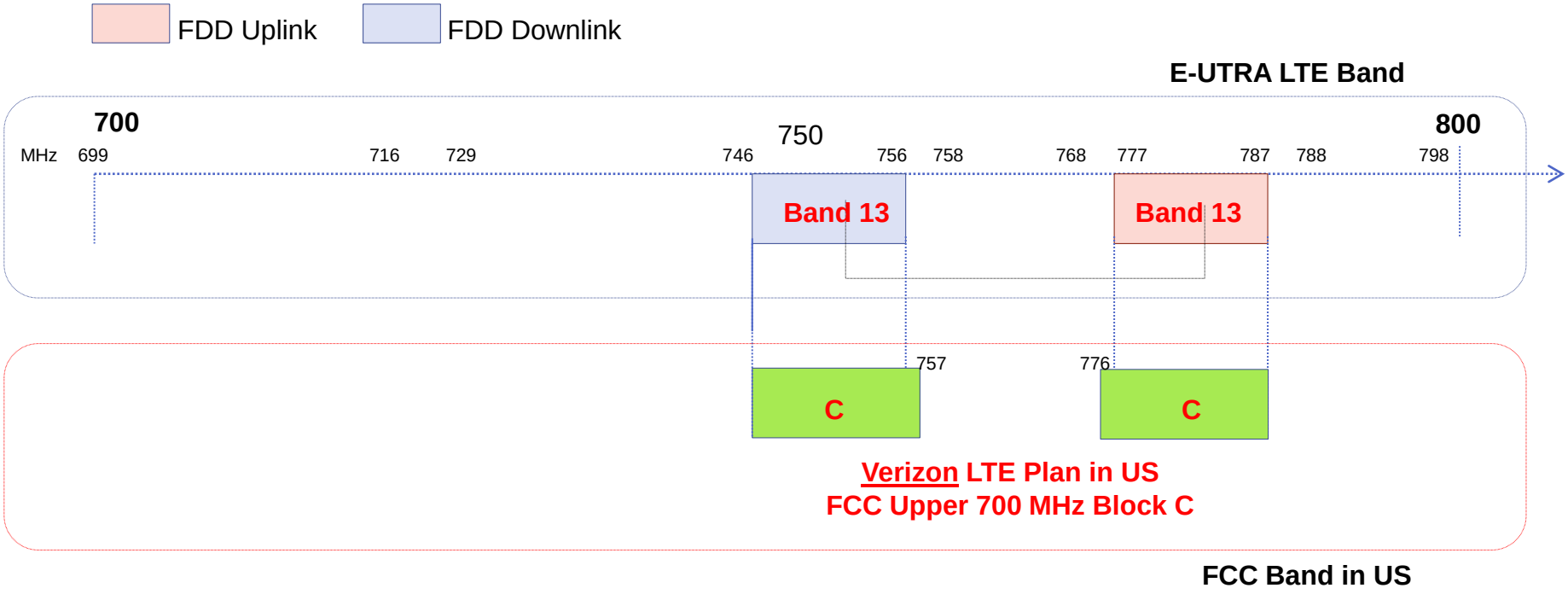
Frame Structure Type 2 : TDD



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

LTE Service in US (Verizon)

- **LTE Operating Band (Verizon)**

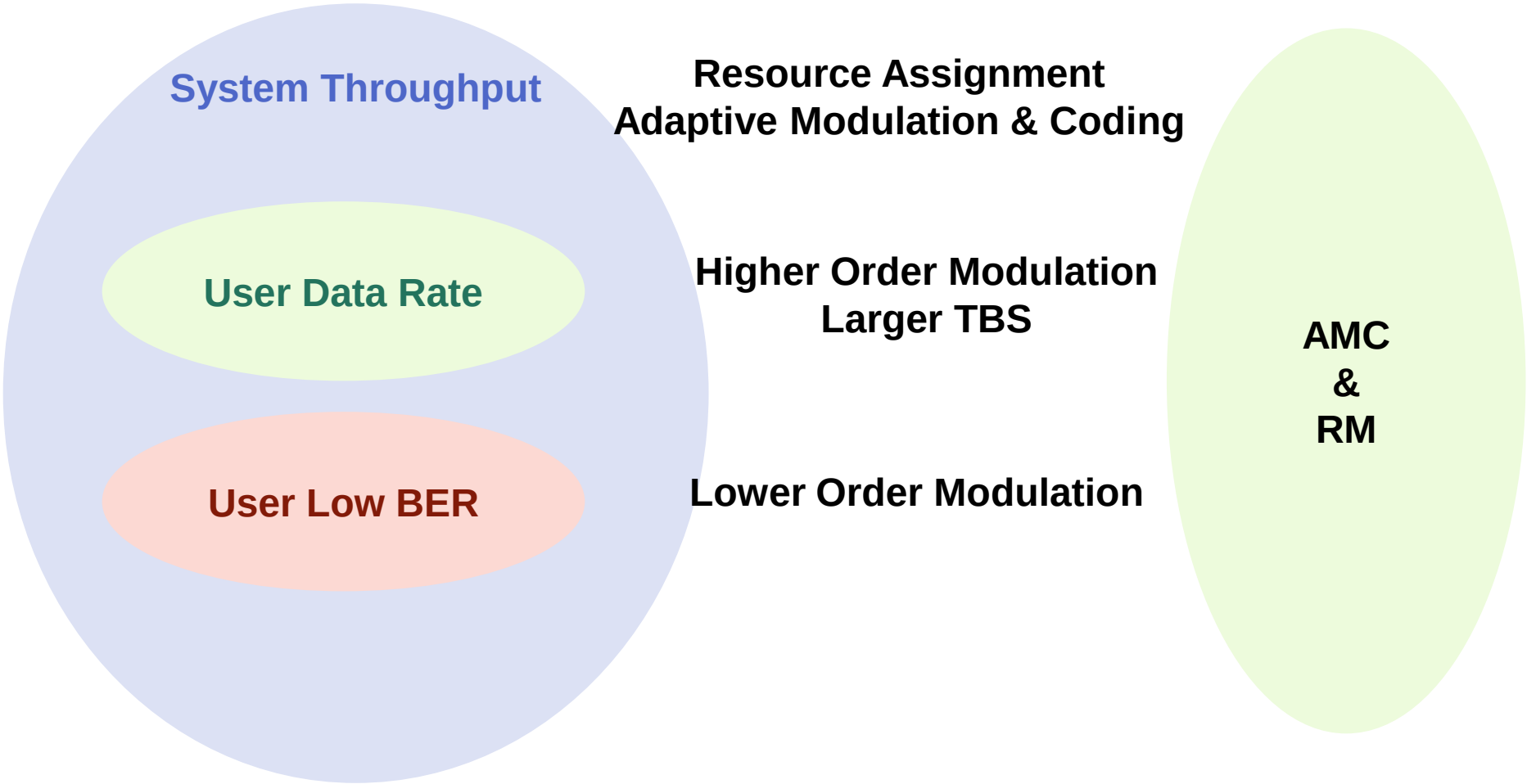


✓ **BW 10 MHz, 600 Sub-carriers (50 PRBs)**

Adaptive Modulation & Coding

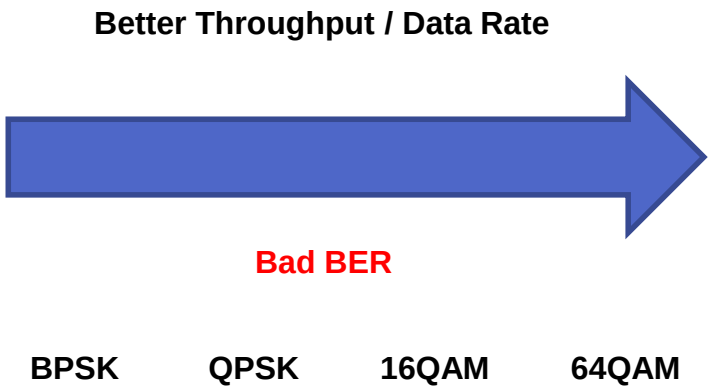
Why AMC?

- **Needs in Communication**



Adaptive Modulation & Coding

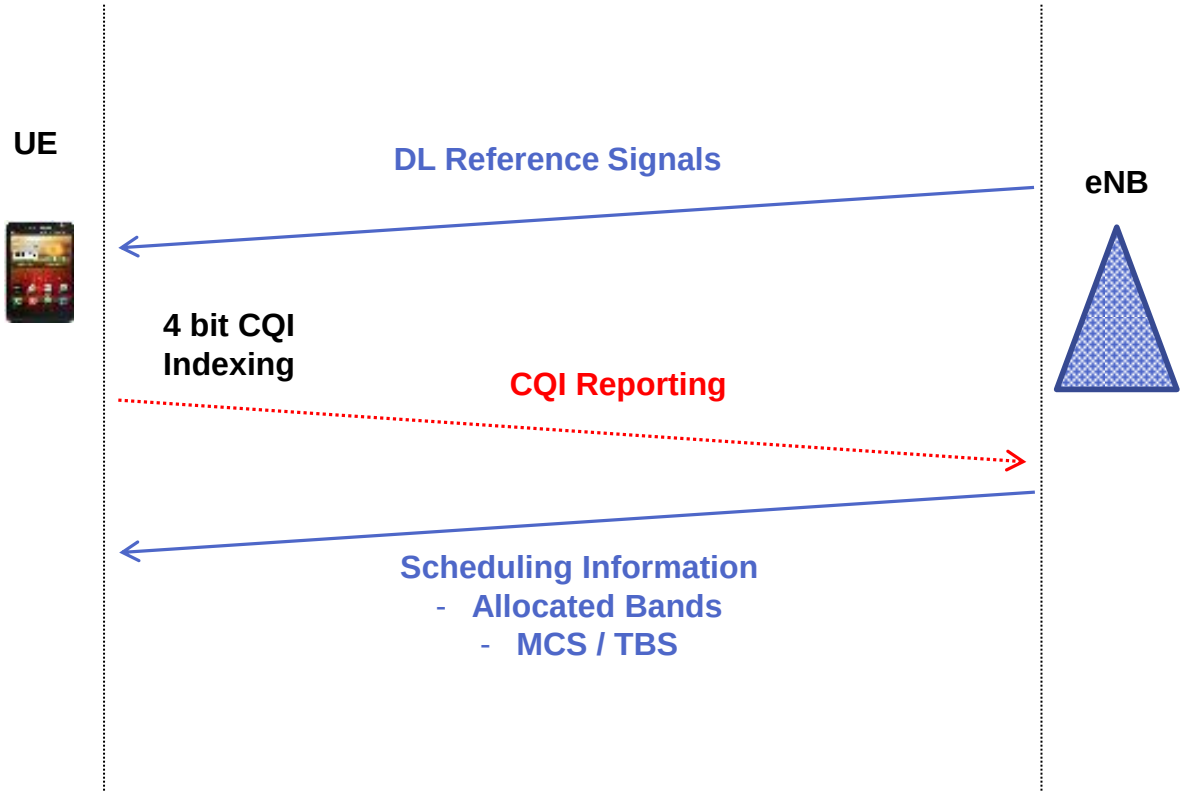
- **Modulation Order & BER** (without channel coding)



- **Channel Coding** : Better BER
- **Rate Change by Rate Matching**
  - ✓ Better Data Rate

Channel Condition

- **CQI Reporting Process**



CQI Table

- **4-bit CQI Table**

CQI	Modulation	Spectral Efficiency
0	Out of Range	
1	QPSK	0.1523
2		0.2344
3		0.3770
4		0.6016
5		0.8770
6		1.1758
7	16 QAM	1.4766
8		1.9141
9		2.4063
10	64 QAM	2.7305
11		3.3223
12		3.9023
13		4.5234
14		5.1152
15		5.5547

Spectral Efficiency
Throughput

$$Tr = \alpha \cdot S(SNR)$$

$S(SNR) = \log_2(1 + SNR)$ [bps/Hz]
α : *Practical Attenuation Factor*

MCS associated with CQI

- **5-bit MCS**

MCS	CQI	Modulation	Spectral Efficiency	MCS	CQI	Modulation	Spectral Efficiency
0	2	QPSK	0.2344	16		16QAM	2.5684
1			0.3057	17		64 QAM	2.5684
2	3		0.3770	18	10		2.7305
3			0.4893	19			3.0264
4	4		0.6016	20	11		3.3223
5			0.7393	21			3.6123
6	5		0.8770	22	12		3.9023
7			1.0264	23			4.2128
8	6		1.1758	24	13		4.5234
9			1.3262	25			4.8193
10		16 QAM	1.3262	26	14		5.1152
11	7		1.4766	27			5.3349
12			1.6953	28	15		5.5547
13	8		1.9141	29		QPSK	Reserved
14			2.1602	30		16QAM	
15	9		2.4063	31		64QAM	

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.**
  - ✓ http://www.3gpp.org/ftp/Specs/latest/Rel-8/36_series/