

IEE2620: System Aspects in Communications

Muhammad Mahtab Alam, Professor

Timetable

Timetable calendar

2024/2025Spring

Muhammad Mahtab Alam

(Study week 1-16)

X

Week view

Dates view

Copy URL

Export iCalendar file

■ Other

■ Even

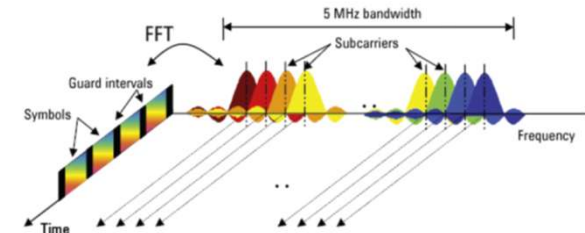
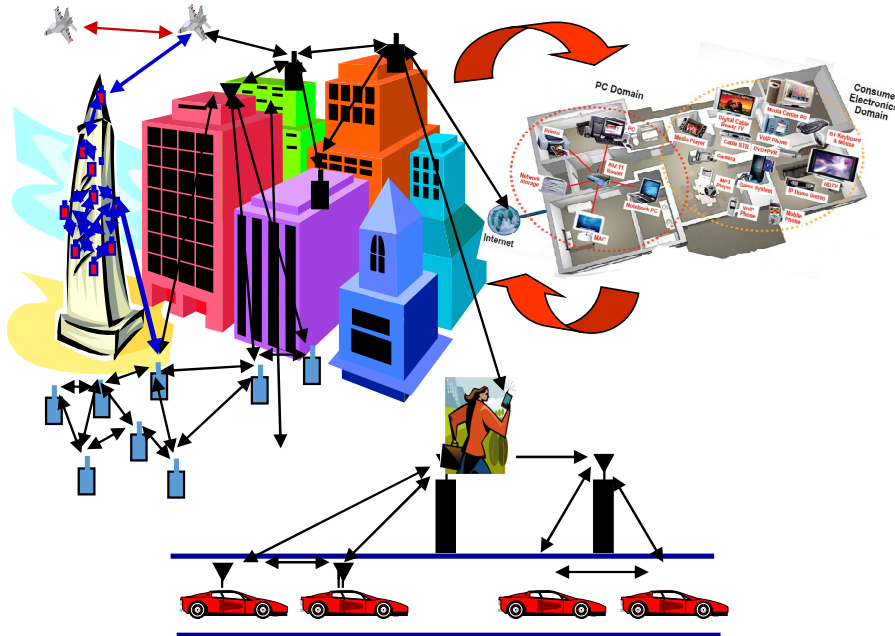
■ Odd

■ 1 - 16

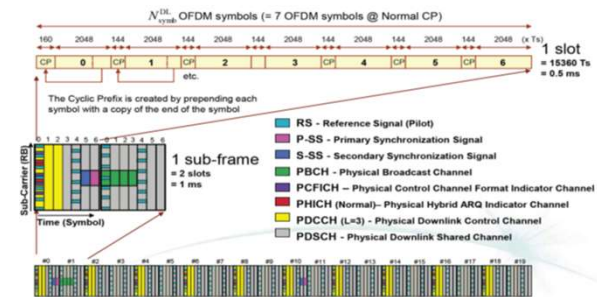
Student group italicized - subject is elective

Student group not italicized - subject is compulsory

Time	Course	Language	Type	Teacher	Room	Study weeks	Student groups	Syllabus	Comment
Monday									
■ 12:00 - 13:30	IEE2620 - System Aspects in Communication	estonian	lecture	Muhammad Mahtab Alam (Tenured Full Professor)	Distance learning	1-16	I/AVM21	View	

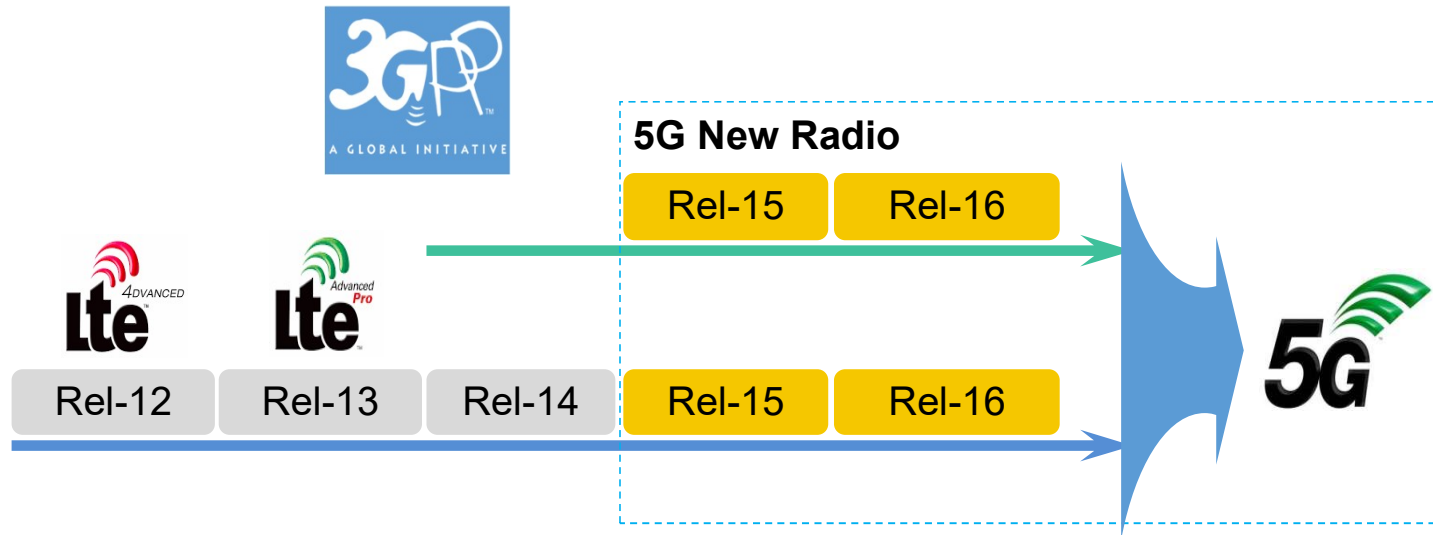


Downlink Frame Structure Type 1



5G Air Interface

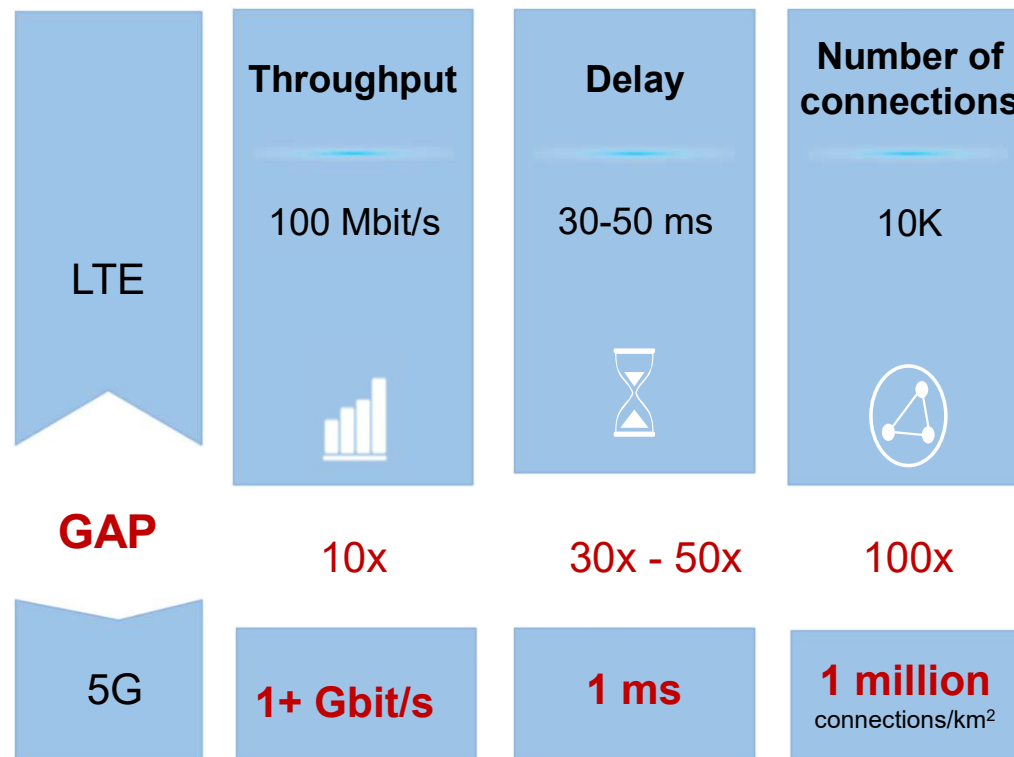
5G Starts from 3GPP Release 15



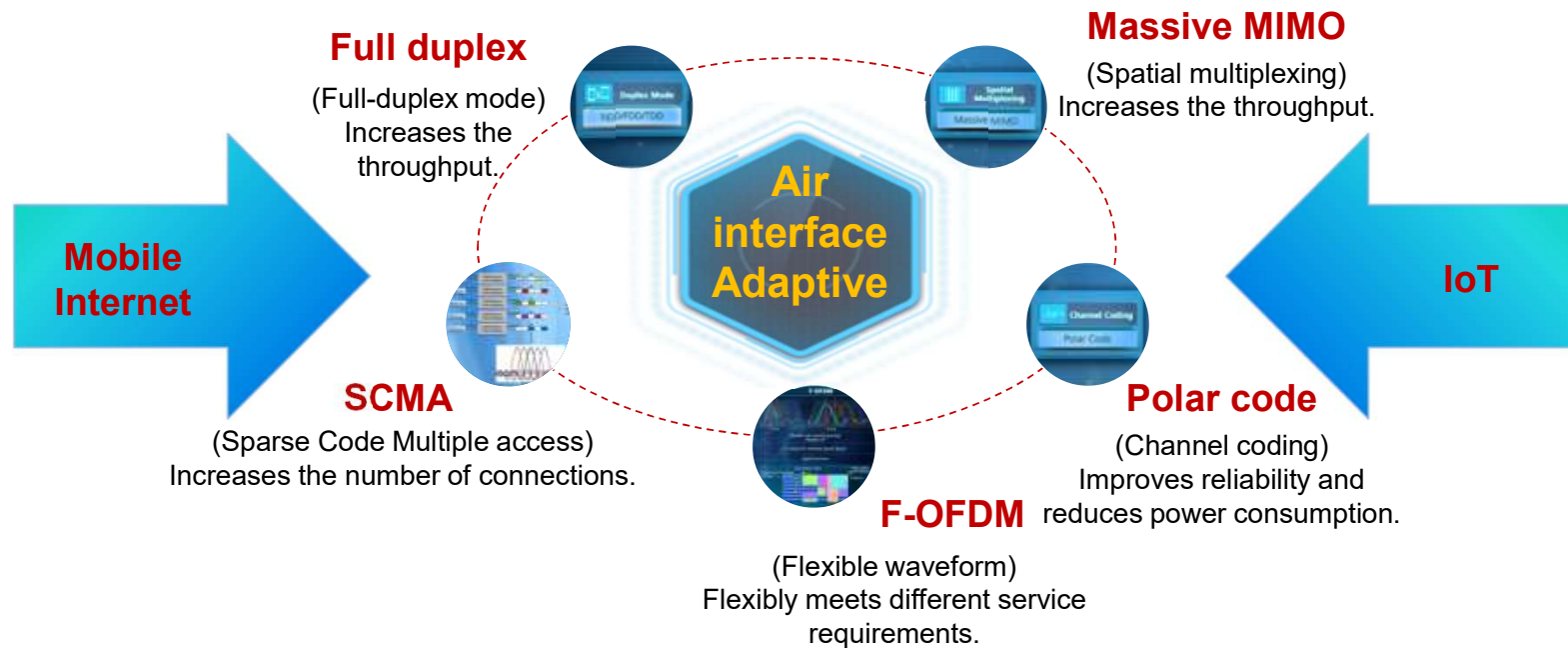
5G includes:

- New Radio
- Next-generation core network
- LTE Advanced Pro evolution
- EPC evolution

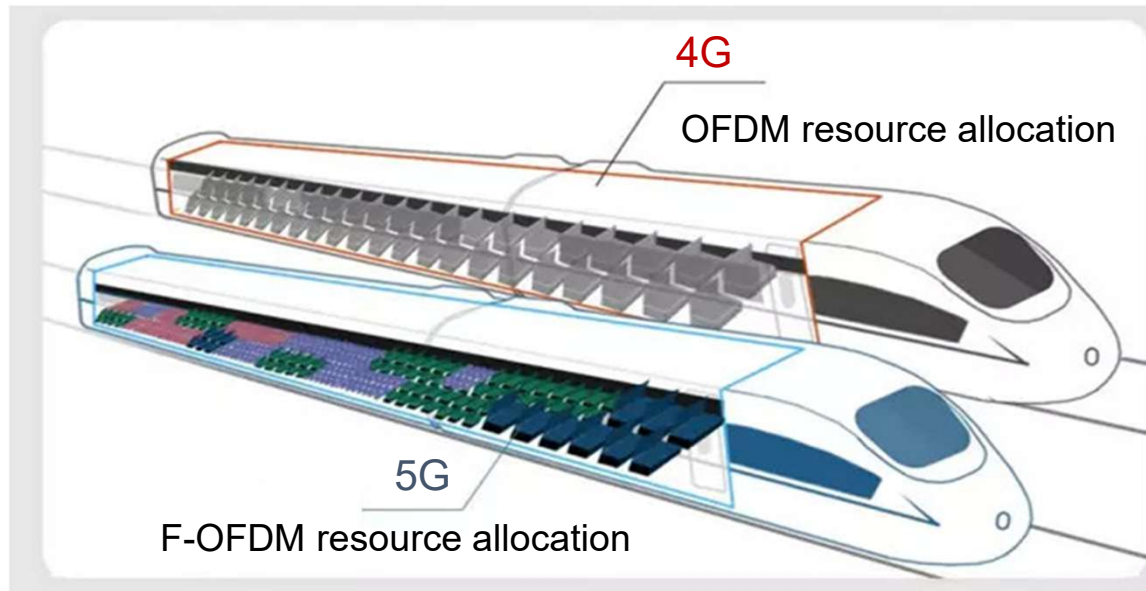
Key Performance Comparison Between 4G and 5G



New Air Interface Technologies



F-OFDM: Adaptive Waveform for Air Interface



4G (OFDM): fixed subcarrier bandwidth of 15 kHz.

5G (F-OFDM): Subcarrier bandwidth can flexibly adapt to the packet sizes of different QoE applications.

	OFDM	F-OFDM
Service adaptation	Fixed subcarrier spacing (SCS) Fixed cyclic prefix (CP)	Flexible SCS Flexible CP
High spectral efficiency	10% of guard bandwidth	Minimum guard bandwidth of one subcarrier

Contents



3GPP Protocol Architecture for 5G



5G NR Physical Resource



5G NR Channels and Signals on 18B Application

3 Main TSGs (Technical Specification Group)

Project Co-ordination Group (PCG)

TSG RAN

Radio Access Network

RAN WG1

Radio Layer 1 spec

RAN WG2

Radio Layer 2 spec

Radio Layer 3 RR spec

RAN WG3

lub spec, lur spec, lu spec UTRAN O&M requirements (transmission interfaces)

RAN WG4

Radio Performance Protocol aspects

RAN WG5

Mobile Terminal Conformance Testing

RAN WG6

Legacy RAN radio and protocol

TSG SA

Service & Systems Aspects

SA WG1

Services

SA WG2

Architecture

SA WG3

Security

SA WG4

Codec

SA WG5

Telecom Management

SA WG6

Mission-critical applications

TSG CT

Core Network & Terminals

CT WG1

CT WG3

Interworking with external networks, policy and billing control

CT WG4

Core Network Protocols

CT WG6

Smart Card Application Aspects

**TSGs are responsible for
3GPP standard finalization.**

TSG SA Protocol Architecture

- **TR: Technical Report**

SA WG1

TR [22.891](#): Study on New Services and Markets Technology Enablers (New service study)

TR [22.861](#): FS_SMARTER - massive Internet of Things (Massive IoT)

TR [22.862](#): Feasibility study on new services and markets technology enablers for critical communications; Stage 1 (Critical Communication)

TR [22.863](#): Feasibility study on new services and markets technology enablers for enhanced mobile broadband; Stage 1 (eMBB)

TR [22.864](#): Feasibility study on new services and markets technology enablers for network operation; Stage 1 (Network operation)

TS [22.261](#): Service requirements for next generation new services and markets

SA WG2

TR [23.799](#): Study on Architecture for Next Generation System

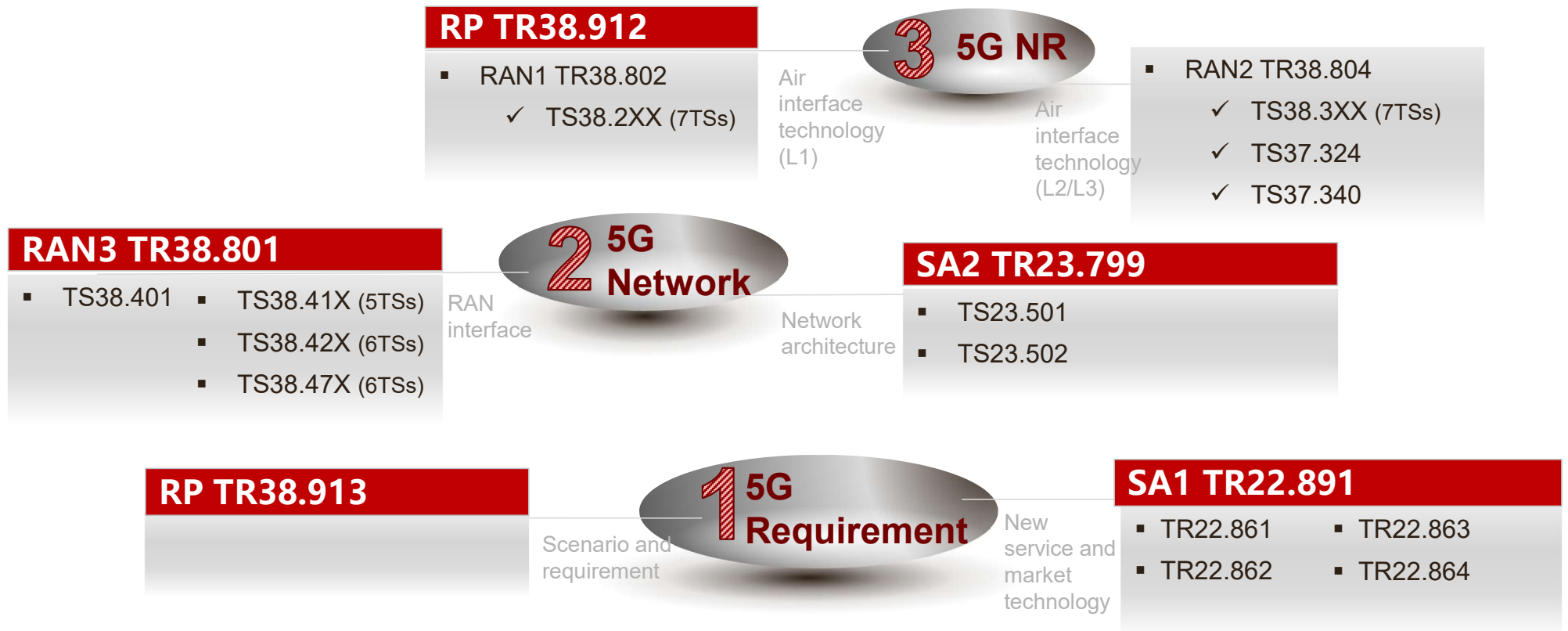
TS [23.501](#): System architecture for the 5G system
TS [23.502](#): Procedure for the 5G system

SA WG3

TR [33.899](#): Study on the security aspects of the next generation system

- **TS: Technical Specification**

Protocol Study Suggestion



Contents



3GPP Protocol Architecture for 5G



5G NR Physical Resource



5G NR Channels and Signals on
18B Application

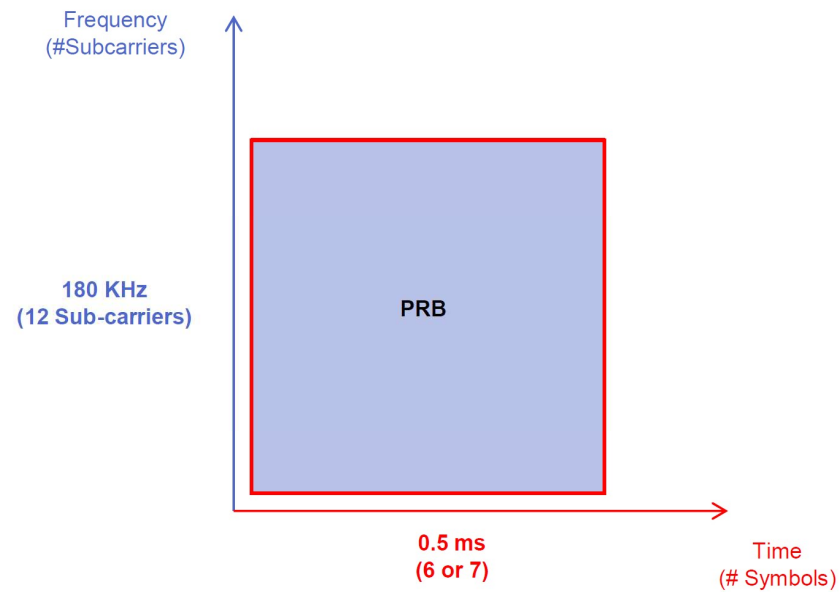
5G NR Physical Resource

1	5G Numerology
2	Time-Domain Resources
3	Frequency-Domain Resources
4	Space-Domain Resources

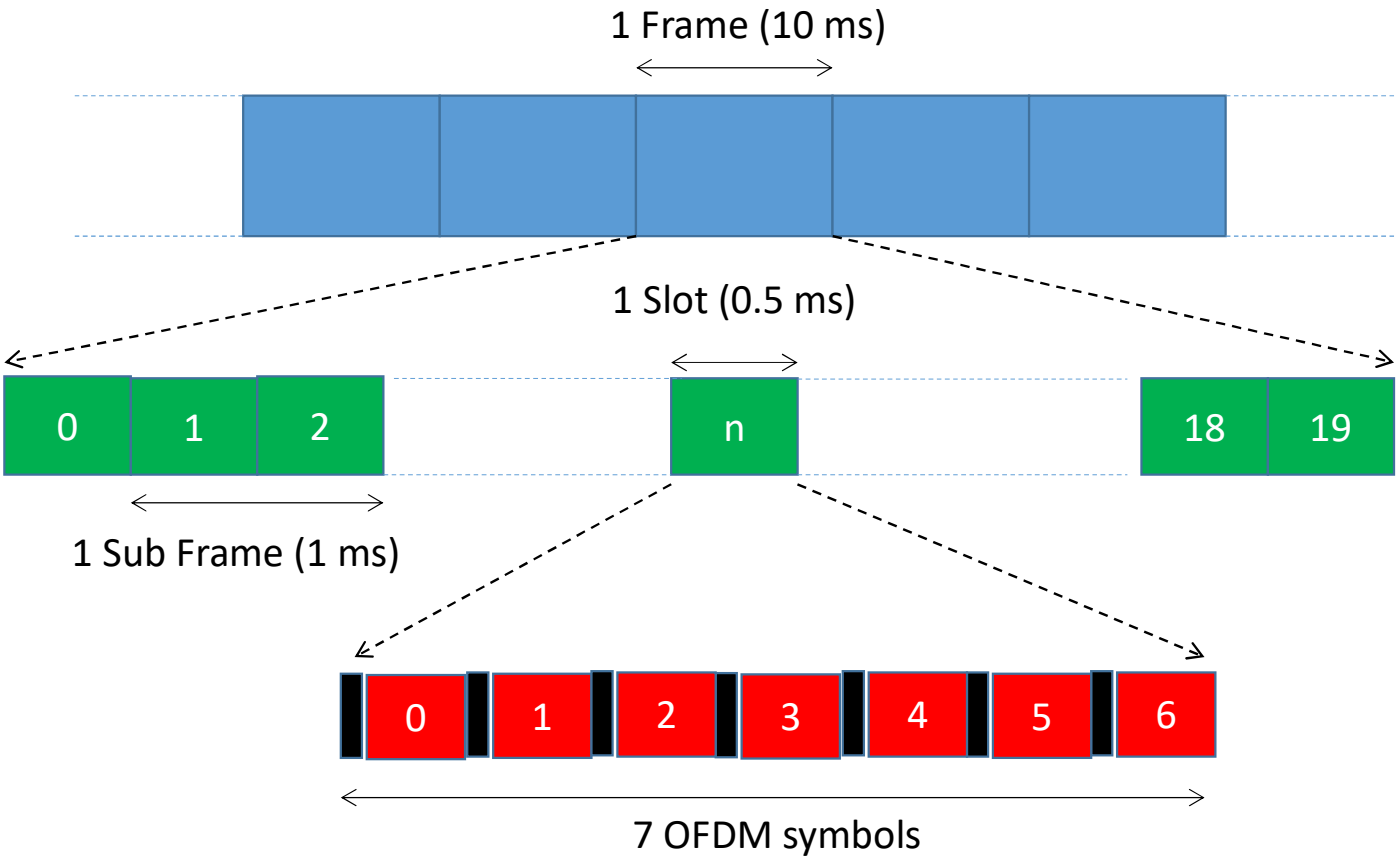
LTE Resource

▪ Physical Resource Block (PRB)

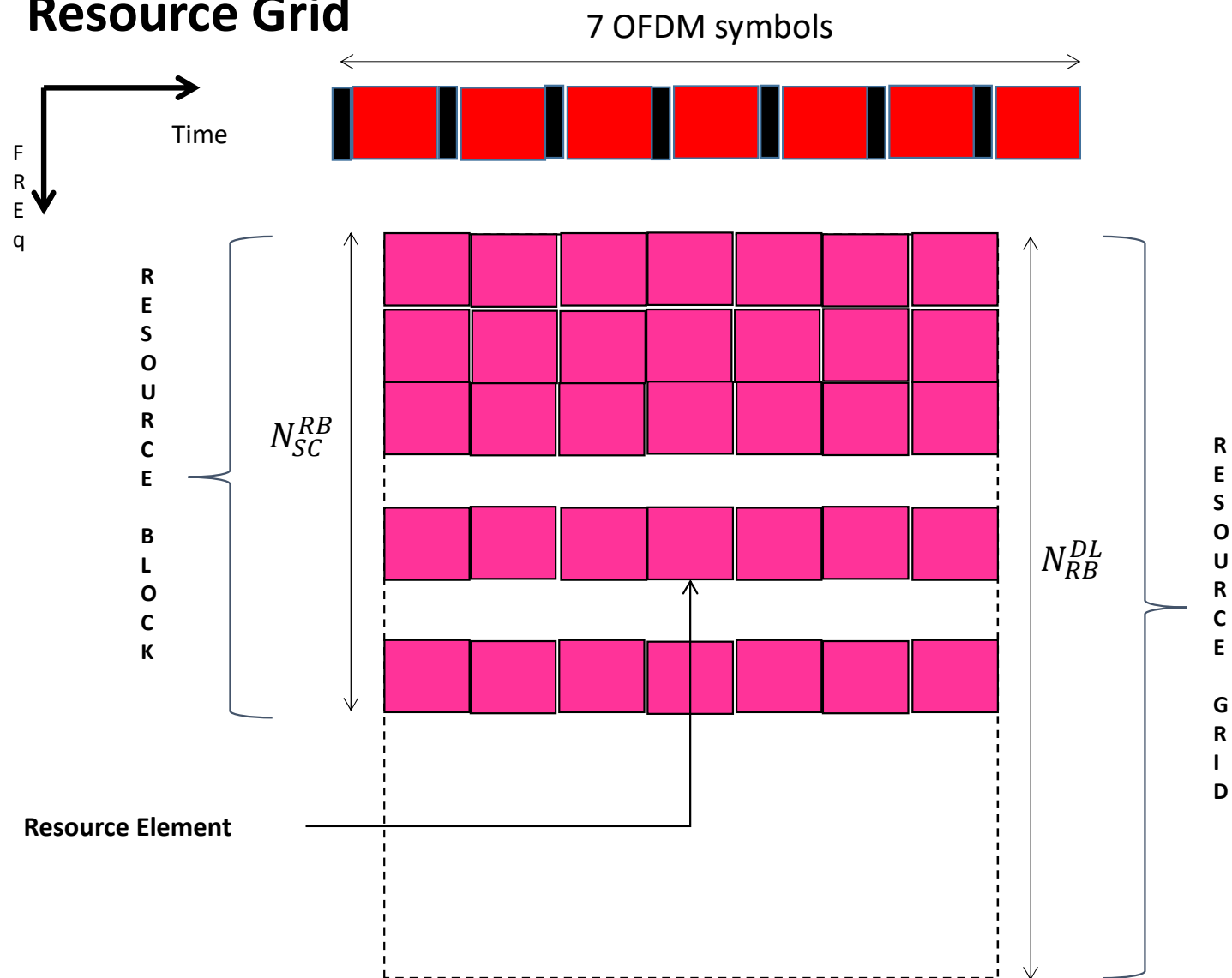
- ✓ The Smallest User Assignment Resource Unit (12 Sub-carriers)



Generic Frame Structure – Type 1

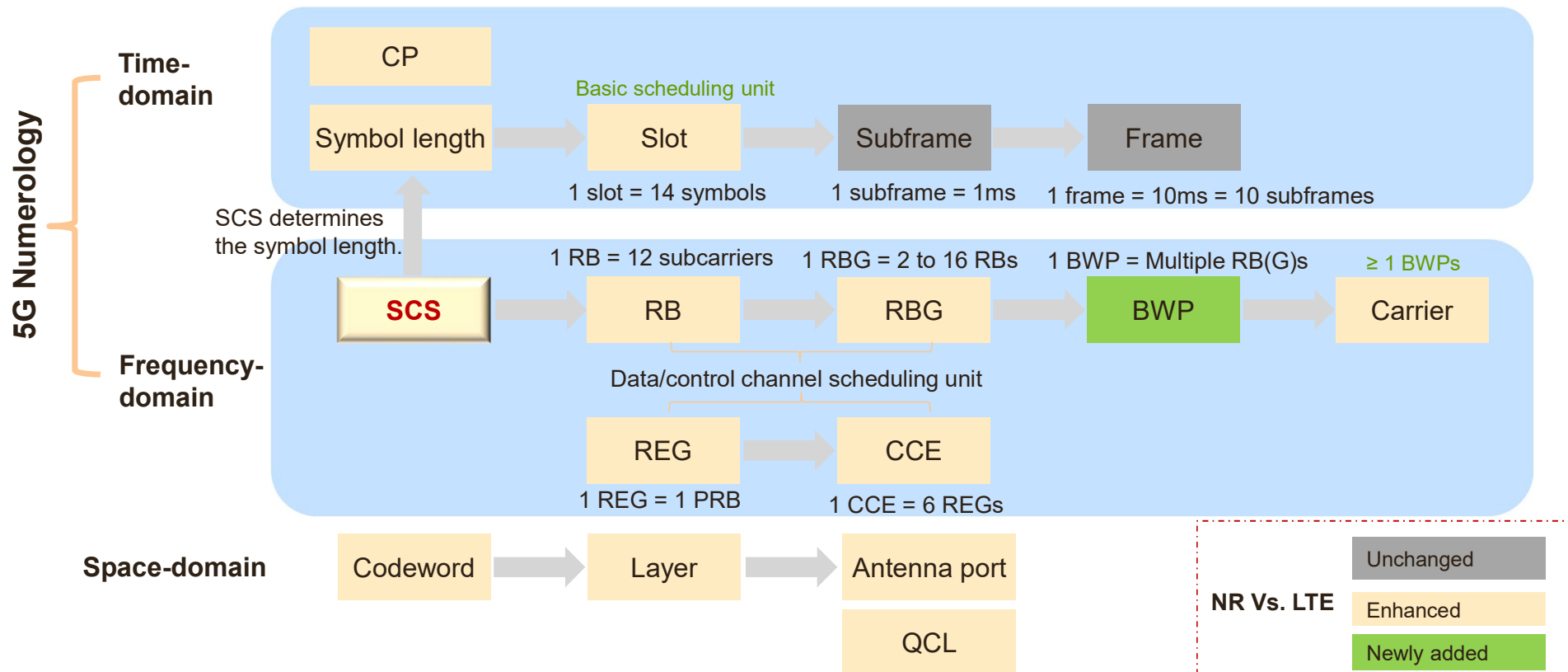


Resource Grid



NR Air Interface Resources Overview

5G Numerology: refers to SubCarrier Spacing (SCS) and related parameters such as the symbol length and CP length of the NR system



SCS(SubCarrier Spacing)

- Numerologies supported by 3GPP Release 15 (TS 38.211)

μ	SCS	CP
0	15 kHz	Normal
1	30 kHz	Normal
2	60 kHz	Normal, extended
3	120 kHz	Normal
4	240 kHz	Normal

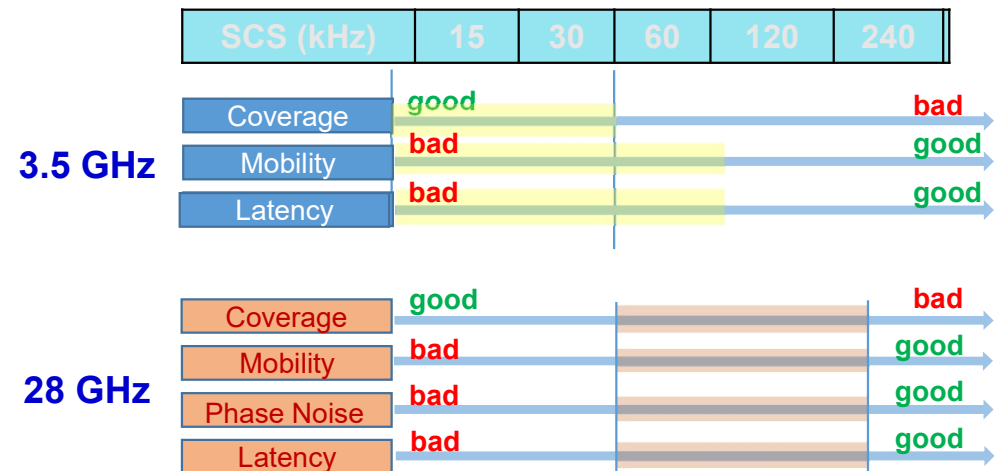
- Application scenarios:

Scalable Numerology		
	Flexibility	Example
Case 1	Different spectrum	Sub-6 GHz, mmWave
Case 2	Multiple services	eMBB, URLLC, mMTC
Case 3	Multiple scenarios	Low/high Speed

- 3GPP TS 38.104 (RAN4) defines SCS for different frequency bands.

- SCS for bands below 1GHz: 15 kHz, 30 kHz
- SCS for bands btw 1GHz and 6GHz: 15 kHz, 30 kHz, 60 kHz
- SCS for band 24GHz to 52.6GHz: 60 kHz, 120 kHz
- In Release 15, 240 kHz for data is not considered.

- Recommended SCS for different frequency bands (eMBB services):



Basic Concepts of Frequency-Domain Resources

- **Resource Grid (RG)**

- Resource group at the physical layer to define bandwidth
- Frequency domain: available RB resources within the transmission bandwidth

- **Resource Element (RE)**

- Smallest unit of physical-layer resources
- Time domain: 1 symbol, frequency domain: 1 subcarrier

- **Resource Block (RB)**

- Basic scheduling unit for data channel
- Frequency domain: 12 contiguous subcarriers

- **Resource Block Group (RBG)**

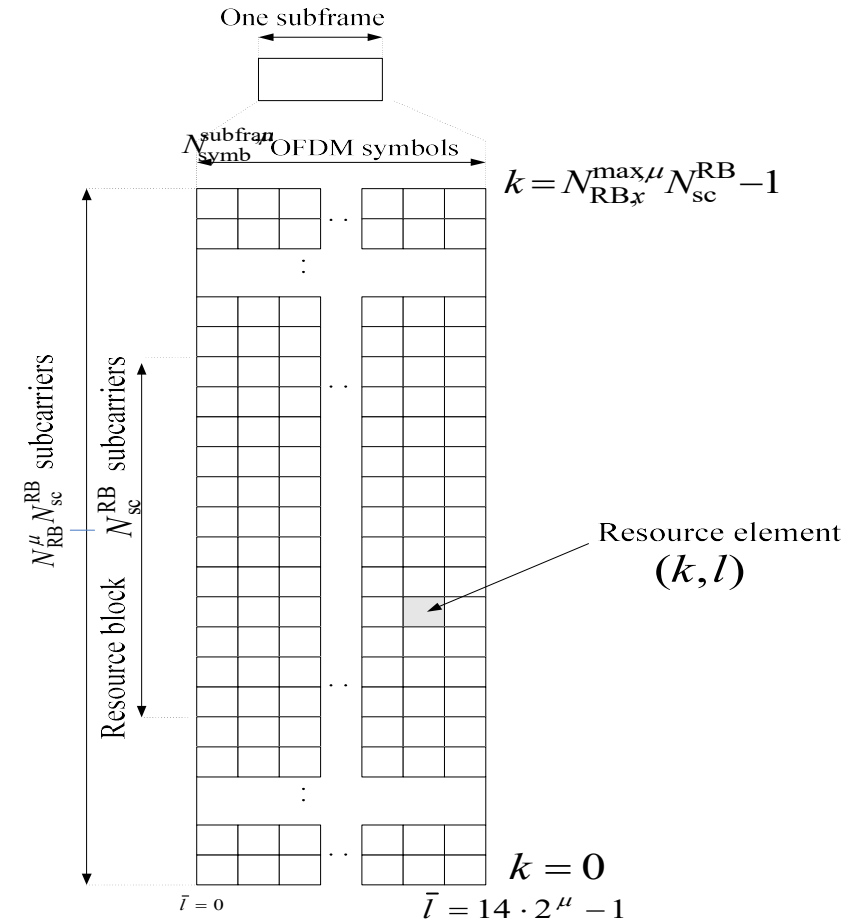
- Basic scheduling unit for data channel, to reduce control channel overheads
- Frequency domain: {2, 4, 8, 16} RBs

- **Resource Element Group (REG)**

- Basic unit involved in control channel resource allocation
- Time domain: 1 symbol, frequency domain: 12 subcarriers (1 PRB)

- **Control Channel Element (CCE)**

- Basic scheduling unit involved in control channel resource allocation
- Frequency domain: 1 CCE = 6 REGs = 6 PRBs
- CCE aggregation level: 1, 2, 4, 8, 16



The Basic Functions of NR Air Interface

- Channel Mapping and Comparison with 4G

