First OAI Foundation U.S. Hands-on Workshop

17-19 November 2025

University of Texas at Austin

5G Operational Walkthrough with OAIBOX™ and OpenAirInterface

19/Nov/2025 | 14:00-17:00

Avaya Auditorium

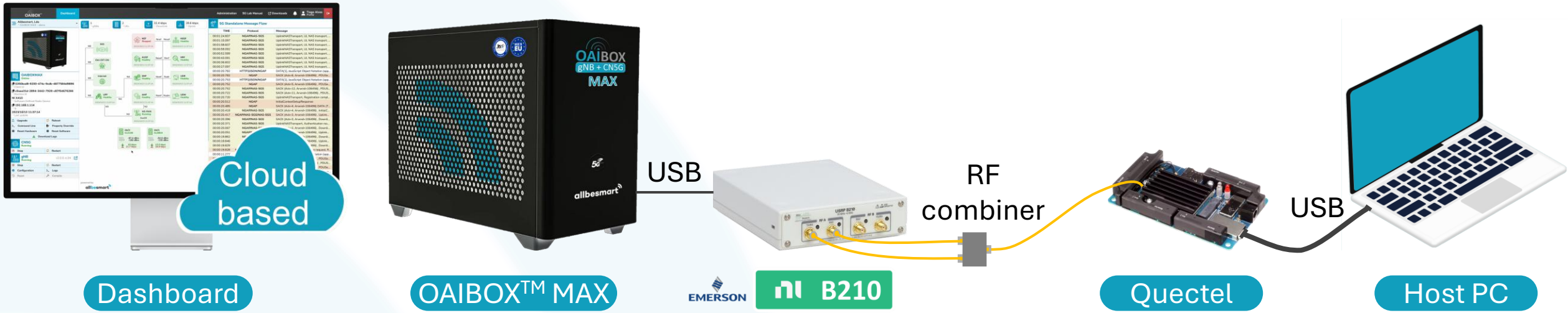
Hugo Marques
Assistant Professor
hugo@ipcb.pt

Luis Pereira
Chief of 5G/6G R&D
lpereira@allbesmart.pt

Paulo Marques
Founder
pmarques@allbesmart.pt

OAIBOXTM: Let's setup a 5G test network with OAIBOXTM

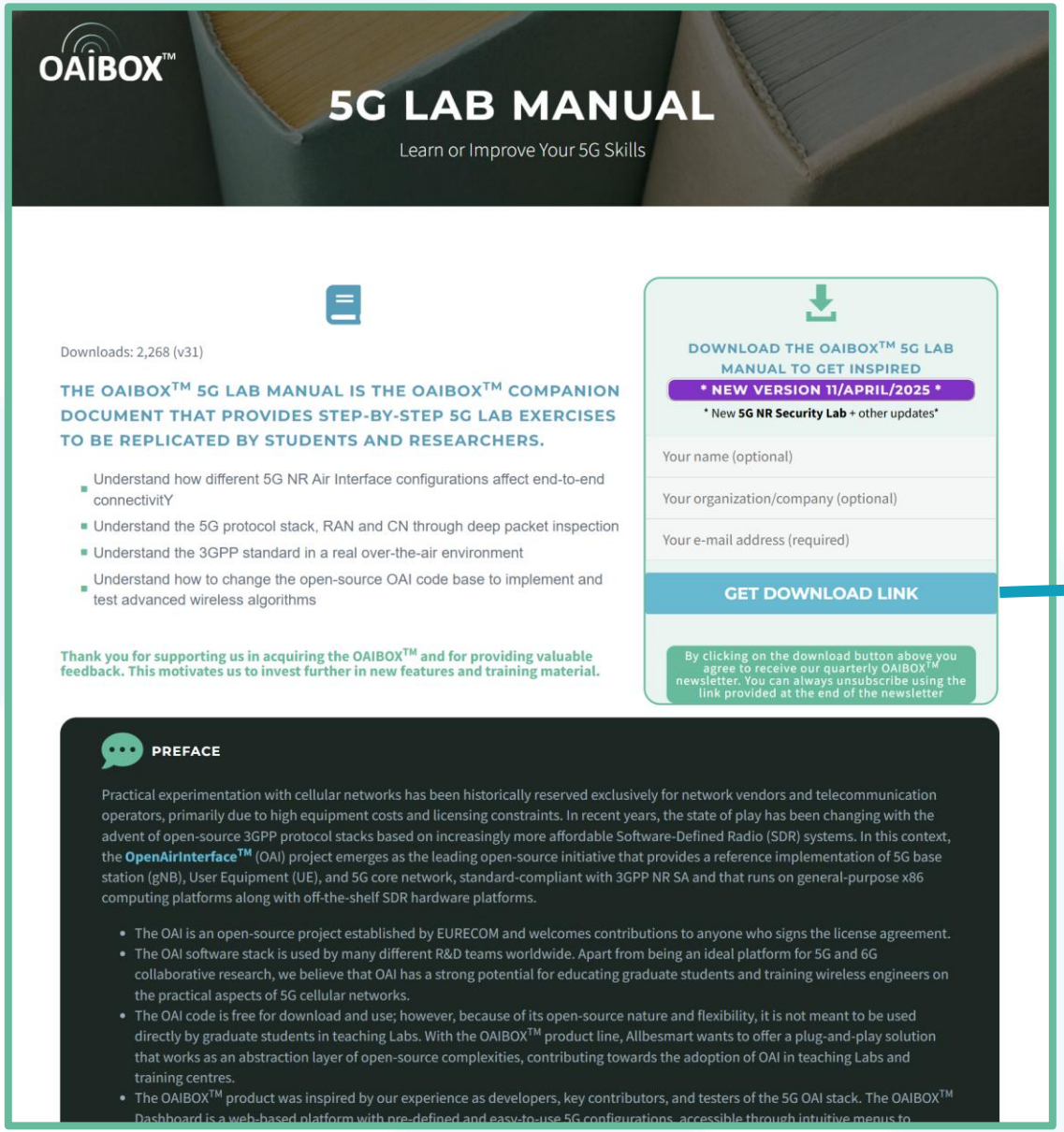
- **Today's setup**

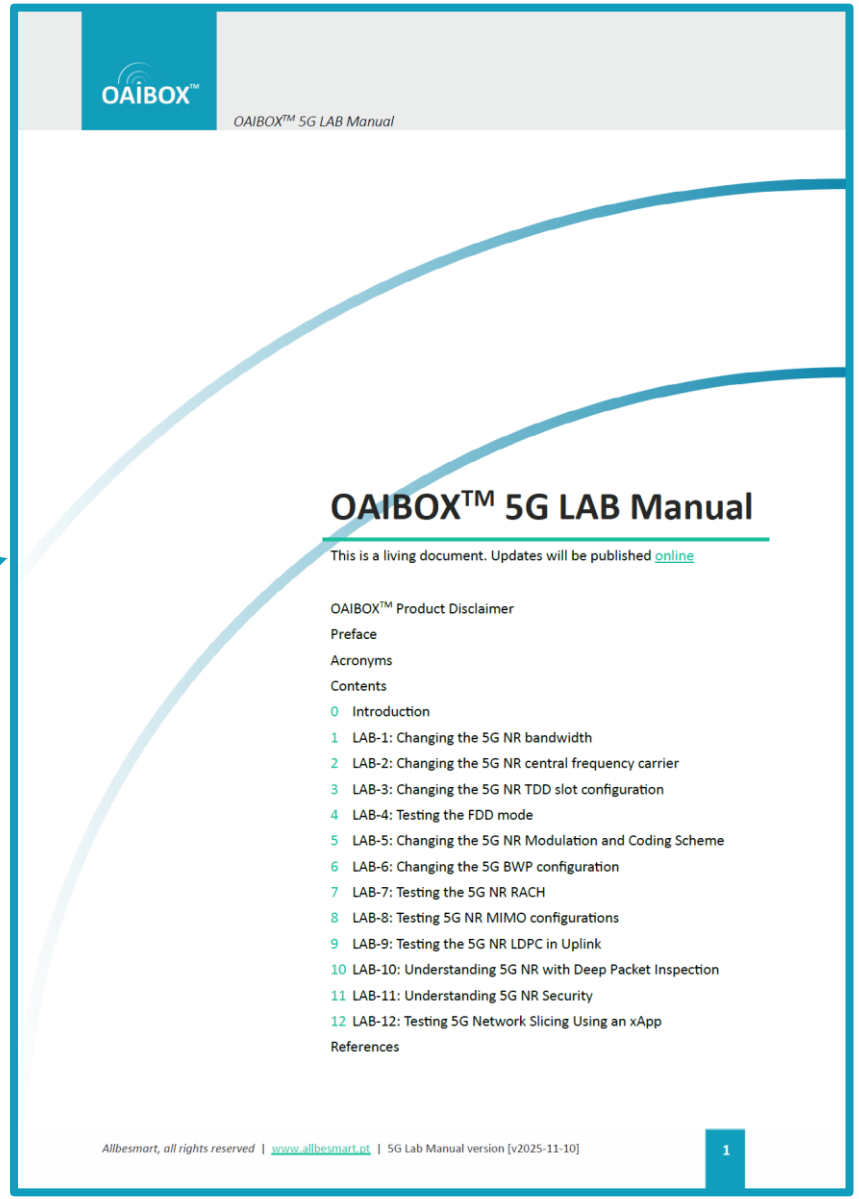


20MHz SISO or MIMO 2x2
40MHz SISO

- OAIBOX™ website: https://oaibox.com
- 5G LAB Manual: https://oaibox.com/5g-lab-manual/

OAIBOX™: The 5G Lab Manual

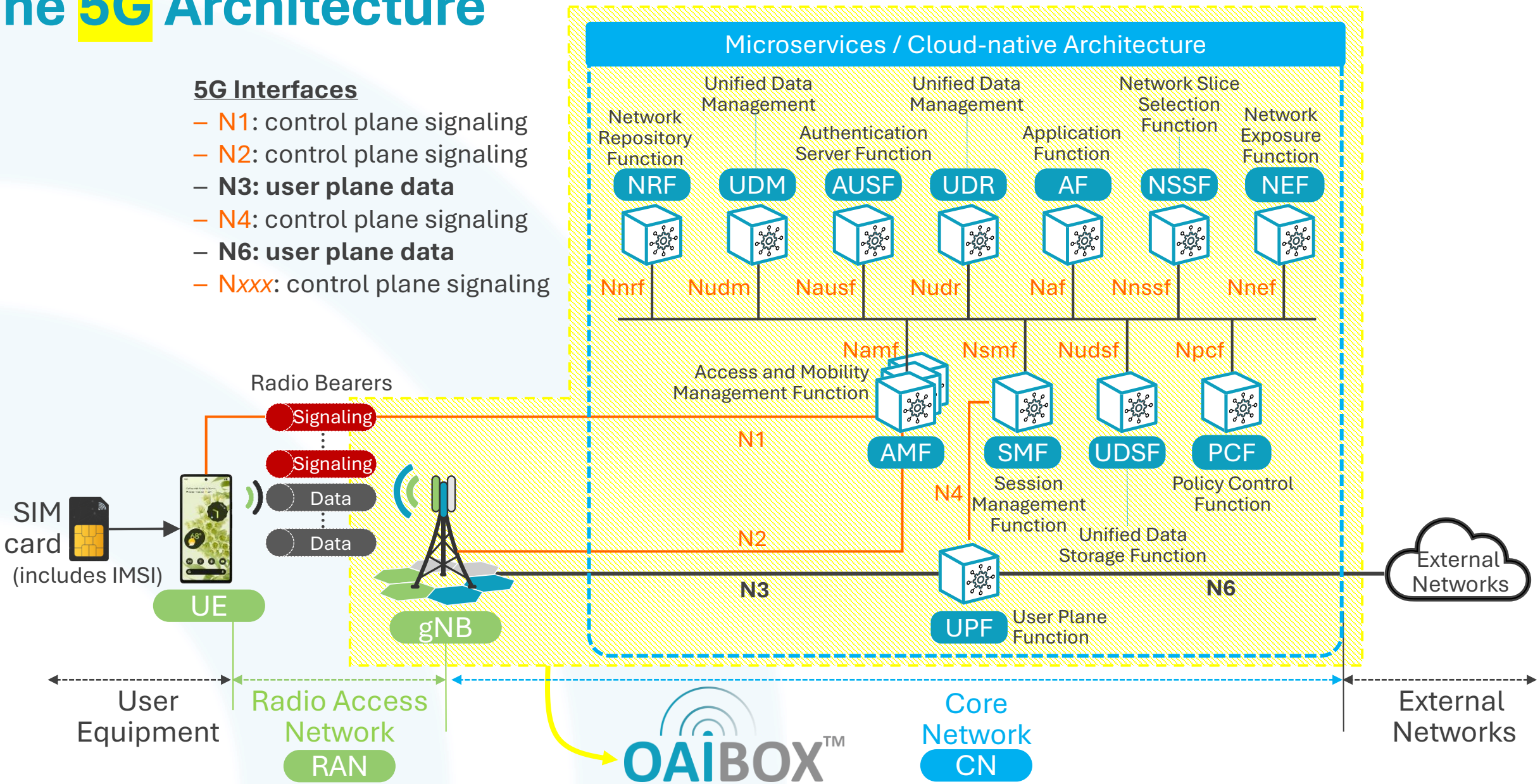




The 5G Architecture

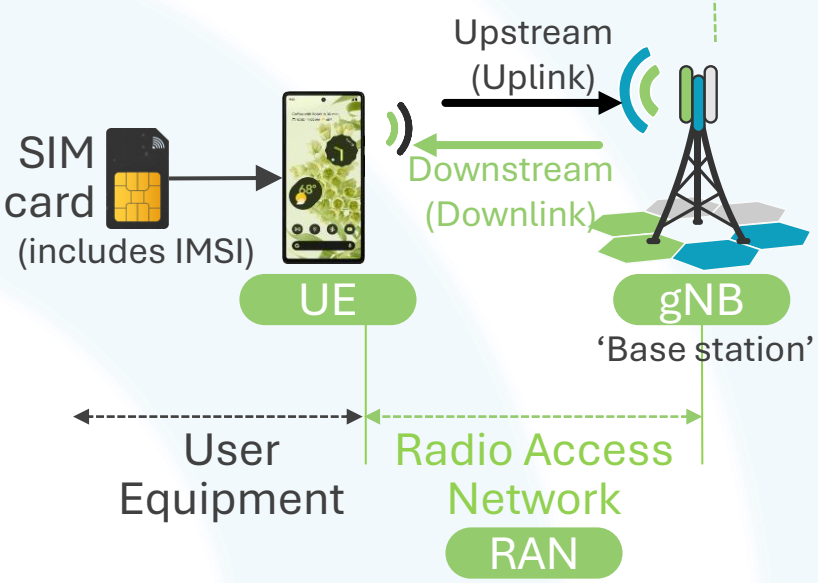
5G Interfaces

- N1: control plane signaling
- N2: control plane signaling
- **N3: user plane data**
- N4: control plane signaling
- **N6: user plane data**
- N*xxx*: control plane signaling



The 4G Radio Access Network (RAN)

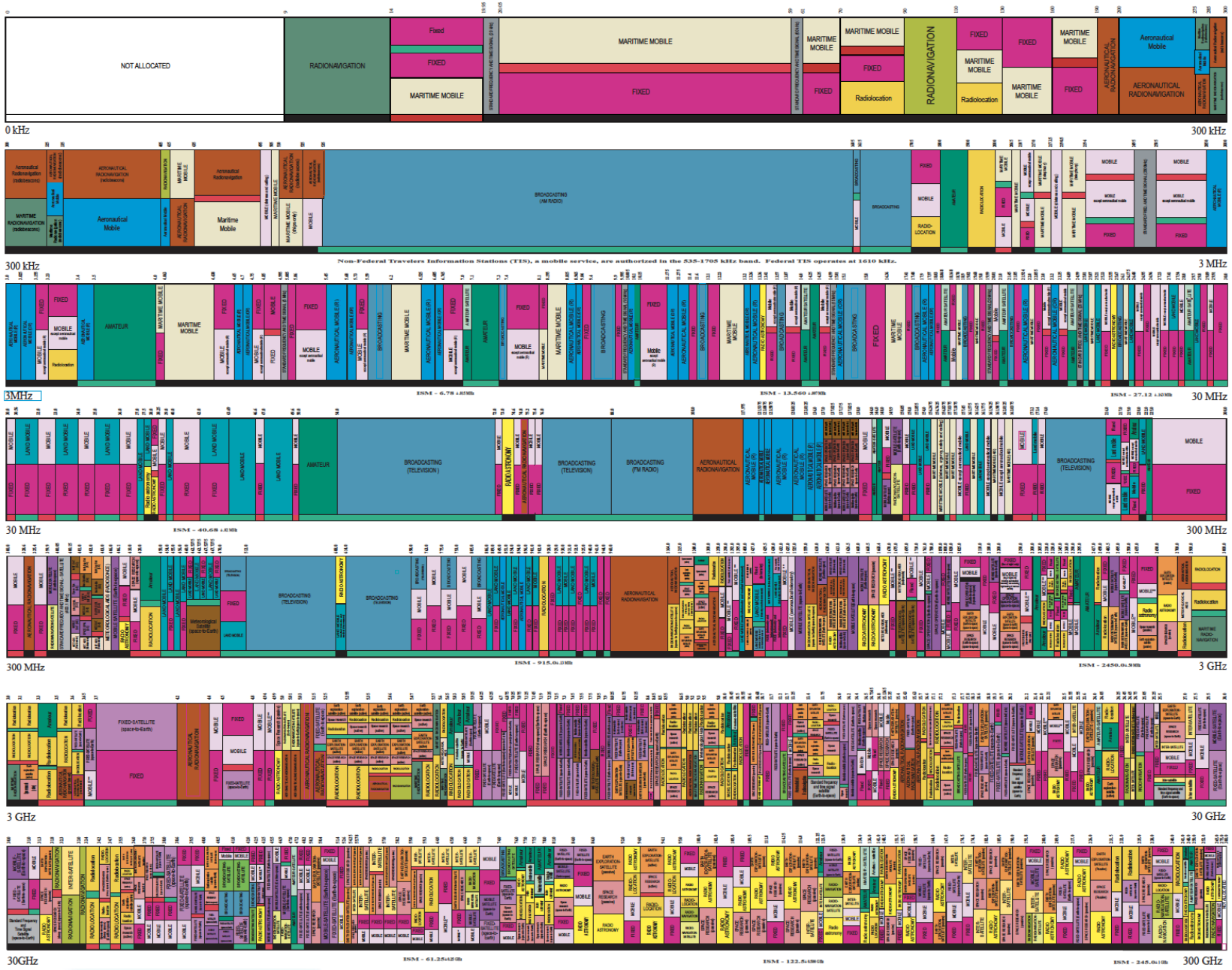
- Located at the *edge* of the network
- Manages wireless radio resources
- Provides coverage to mobile devices (UEs) in its cell
- Coordinates device authentication with other elements
- Coordinates with neighbour base stations to optimize radio use



- Connects UEs to the 'base station'
  - In 5G the 'base station' is called **gNode-B (gNB)**
  - multiple devices connected to each gNB
- Many different possible frequencies bands,
  - multiple channels in each band
  - popular 4G bands: 600, 700, 850, 1500, 1700, 1900, 2100, 2600, 3500 MHz
  - popular TDD 5G bands : 2496–2690MHz (n41), 3300–4200MHz (n77), 3300–3800MHz (n78)
  - popular FDD 5G bands: 703–803MHz (n28), 1800MHz (n3), 2100MHz (n1)
  - separate upstream and downstream channels
- Sharing radio channel among users:
  - OFDM: Orthogonal Frequency Division Multiplexing
    - combination of FDM, TDM

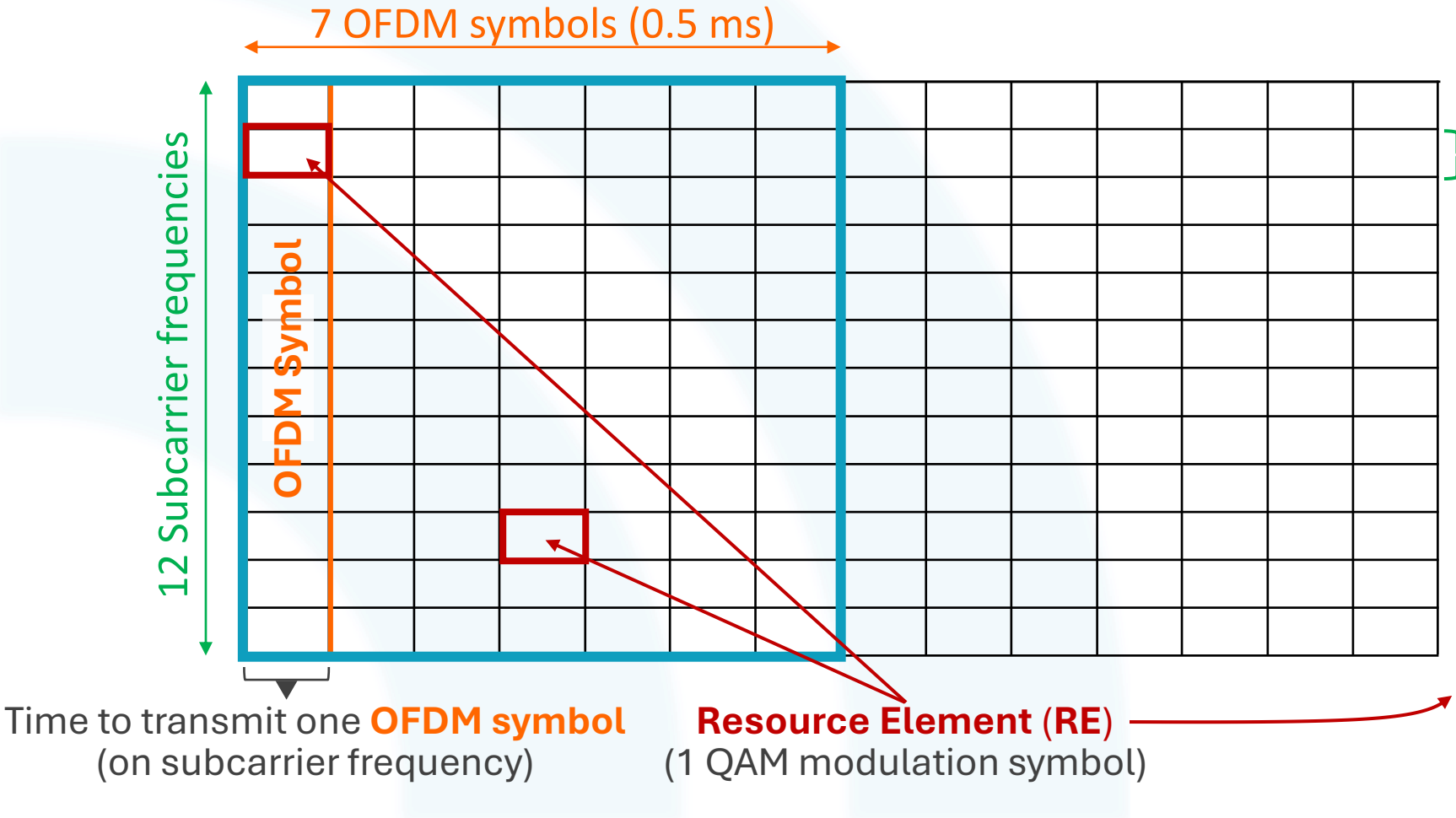
Spectrum allocation

- Figure shows spectrum allocation for USA



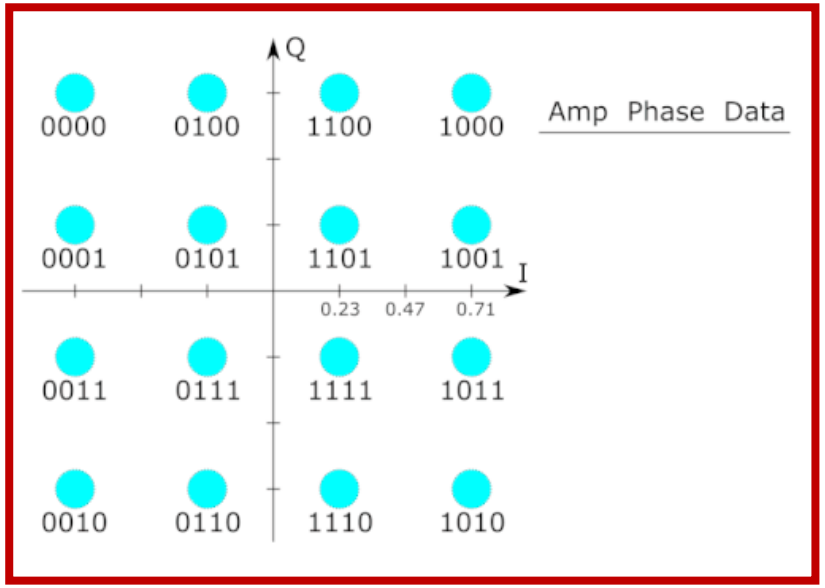
The 4G RAN: OFDM Time Division & Physical Resource Blocks

- 4G Physical Resource Block (**PRB**): block of 7 x 12 = **84** Resource Elements
  - unit of transmission scheduling



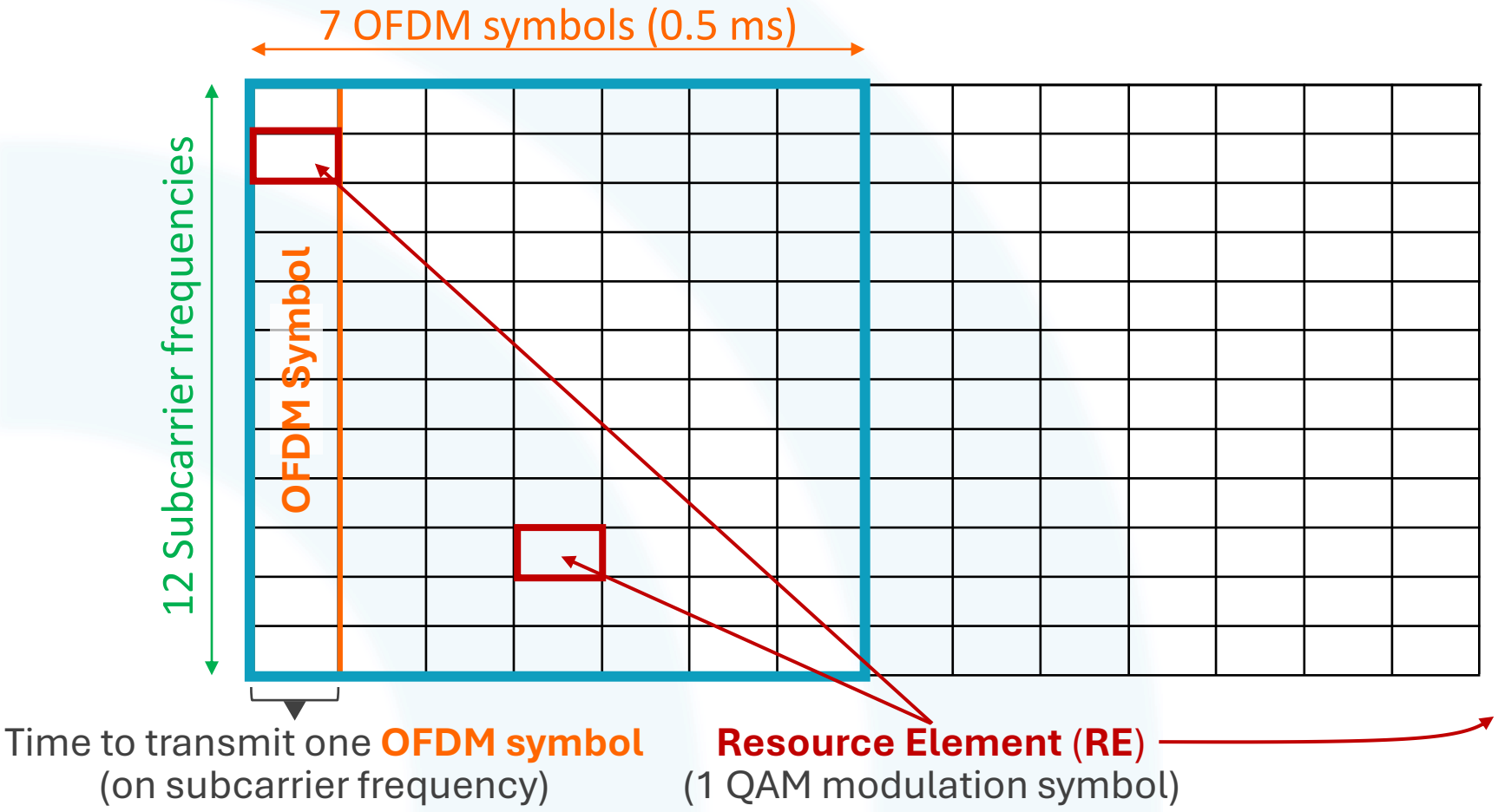
16-QAM

[wikipedia.org | author: GB PW]



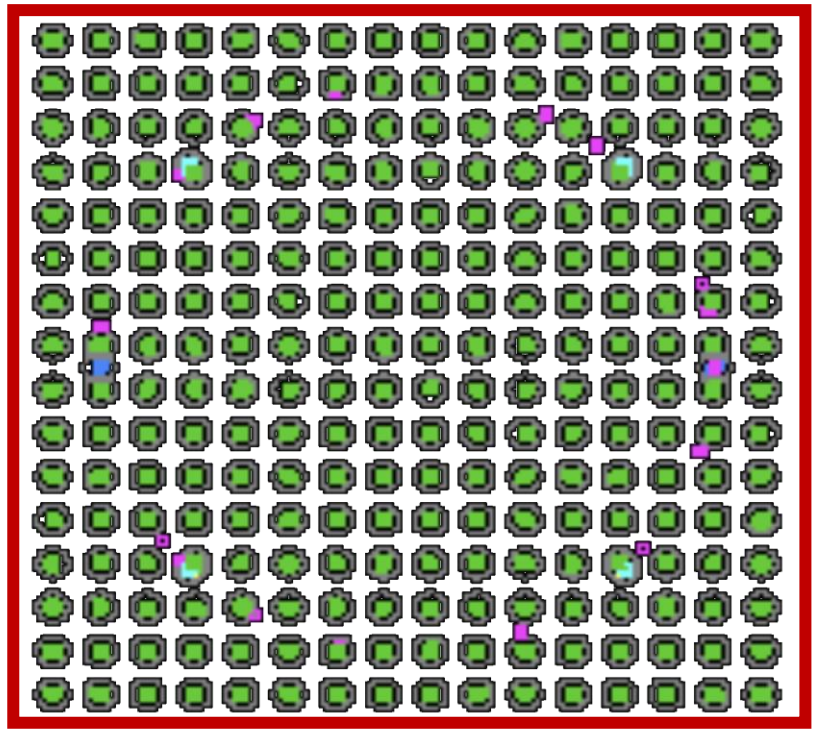
The 4G RAN: OFDM Time Division & Physical Resource Blocks

- 4G Physical Resource Block (**PRB**): block of 7 x 12 = **84** Resource Elements
  - unit of transmission scheduling



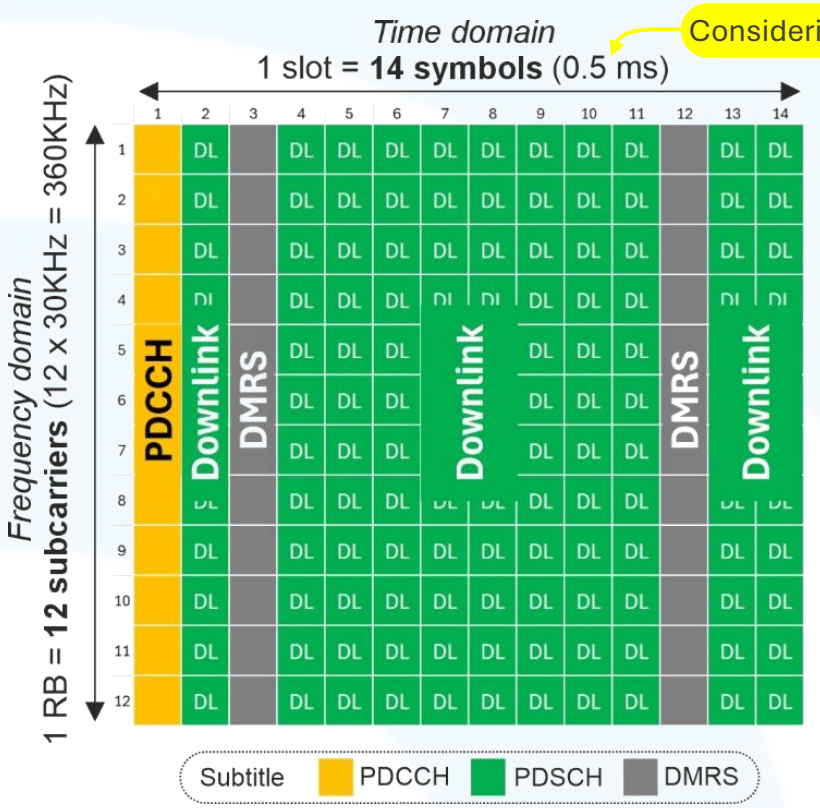
256-QAM

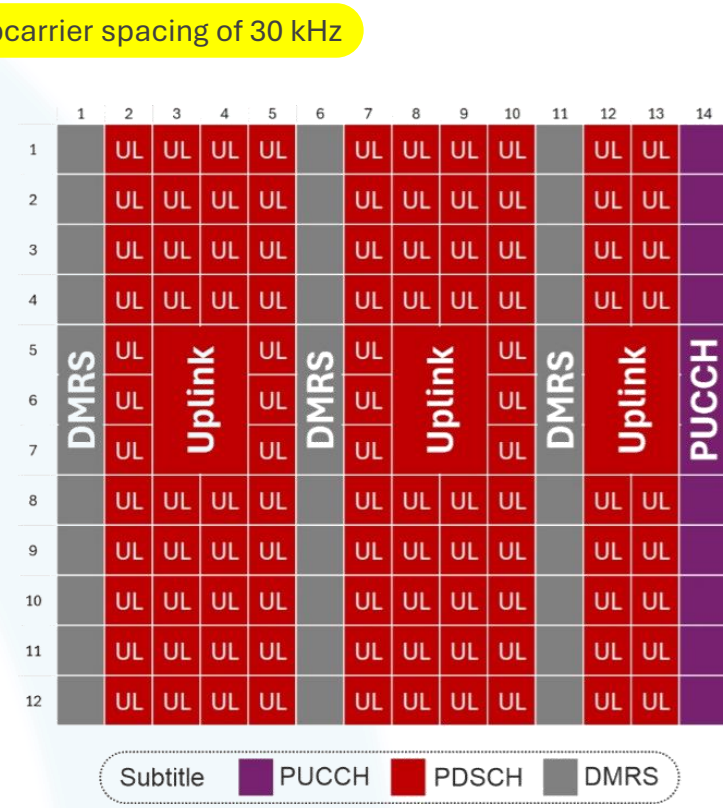
[adapted from Keysight Sowmya Rao, Santosh Pal

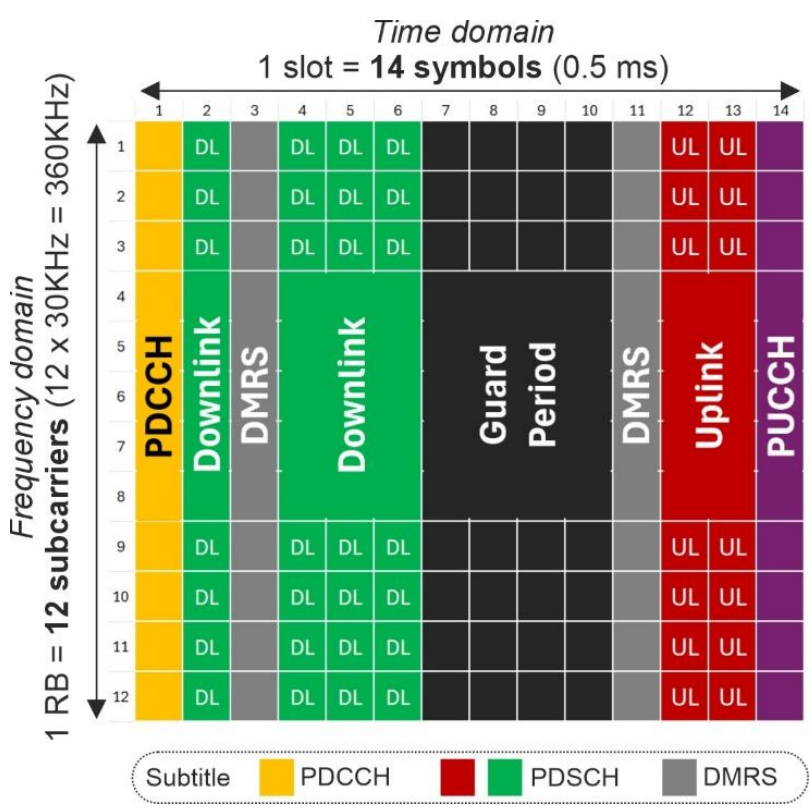


The 5G RAN: OFDM Time Division & Physical Resource Blocks

- 5G Physical Resource Block (**PRB**): block of 14 x 12 = **168** Resource Elements
  - unit of transmission scheduling







DMRS - Demodulation Reference Signal
PDCCH - Physical Downlink Control Channel
PDSCH - Physical Downlink Shared Channel
PUCCH - Physical Uplink Control Channel

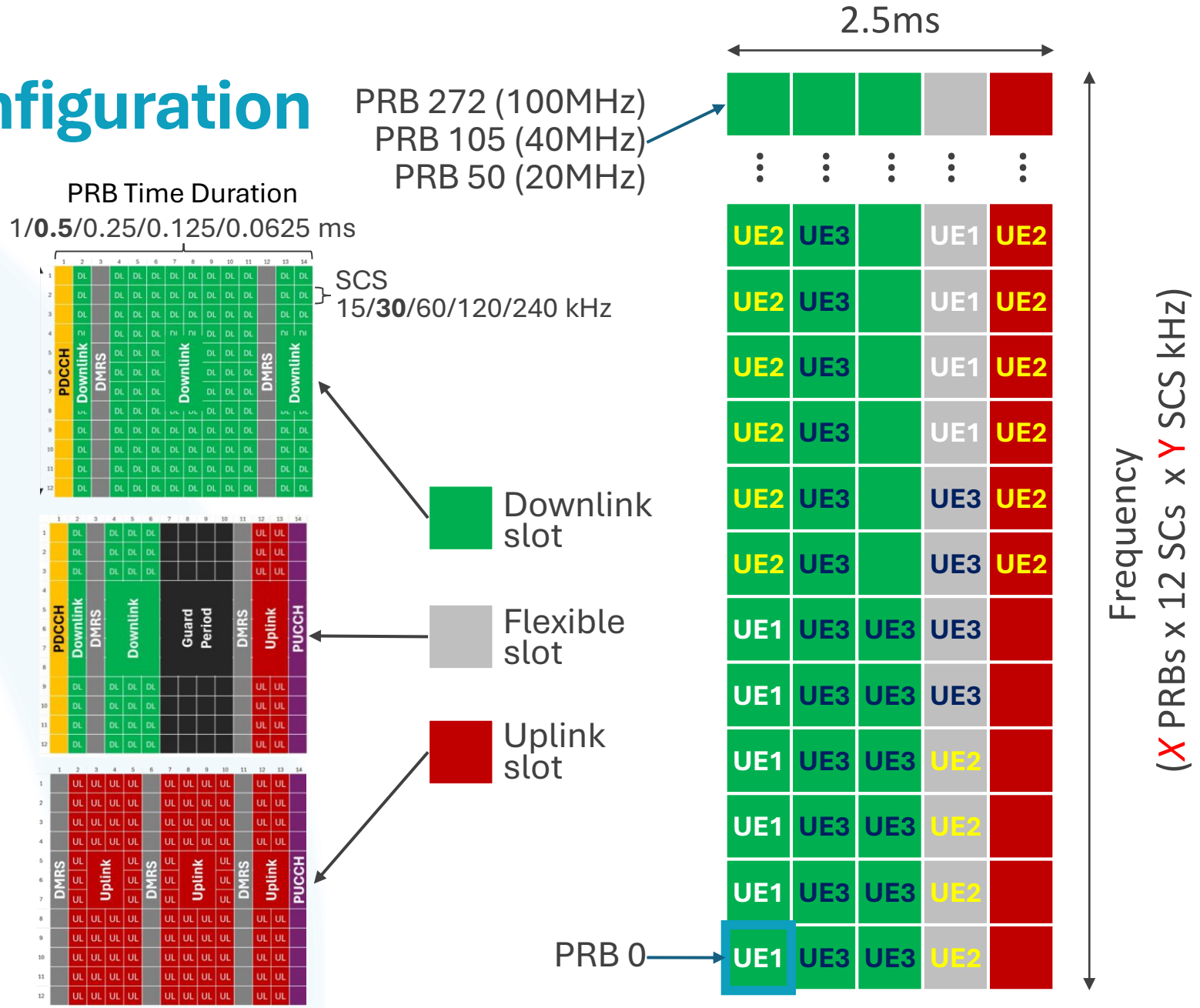
Maximum number of Resource Blocks used for transmission

Bandwidth [MHz]	5	10	15	20	25	30	40	50	60	70	80	90	100
N_{RB}	11	24	38	51	65	78	106	133	162	189	217	245	273

Subcarrier spacing for 5G:
Δf = 15/30/60 kHz (FR1)
Δf = 60/120/240 kHz (FR2)

The 5G RAN: TDD Uplink-Downlink Configuration

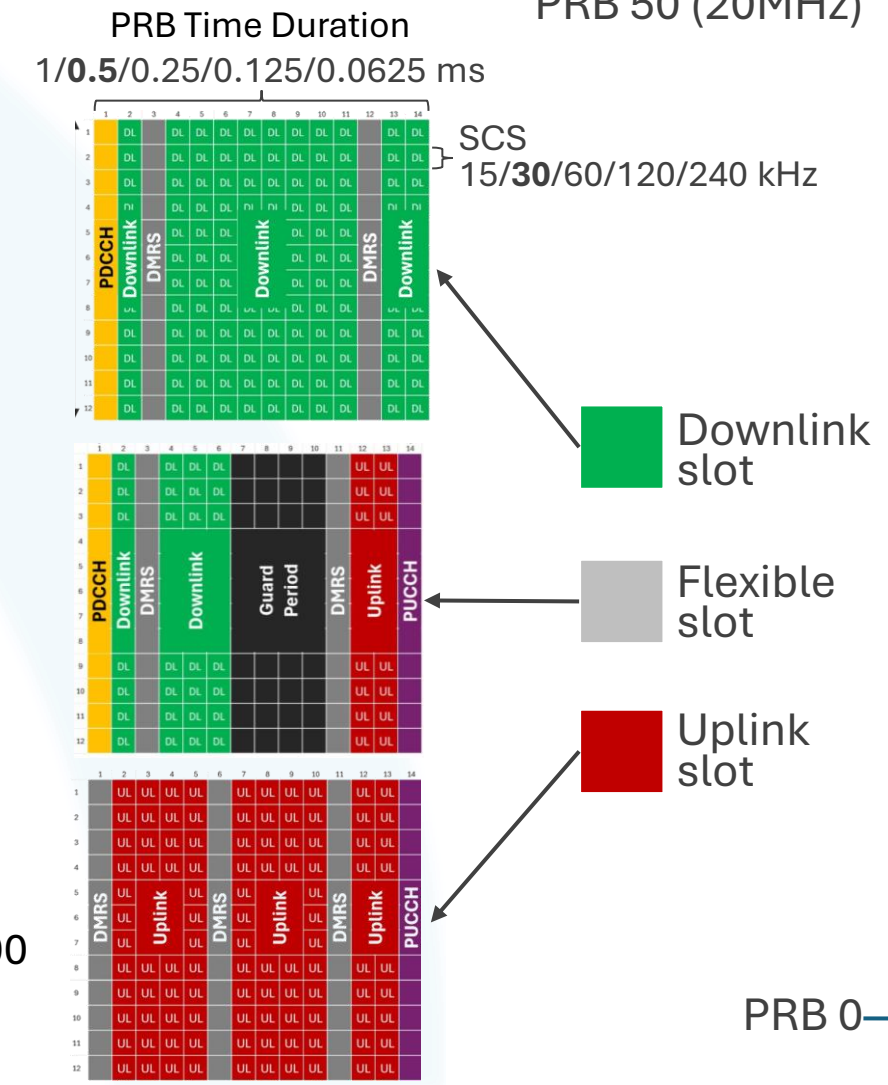
- Example of transmission scheduling (3 UEs)
  - **Note**: some REs / Symbols are unavailable for user data because they are reserved for essential physical signals and control channels
- Figure shows the following TDD slot configuration
  - DDDFU

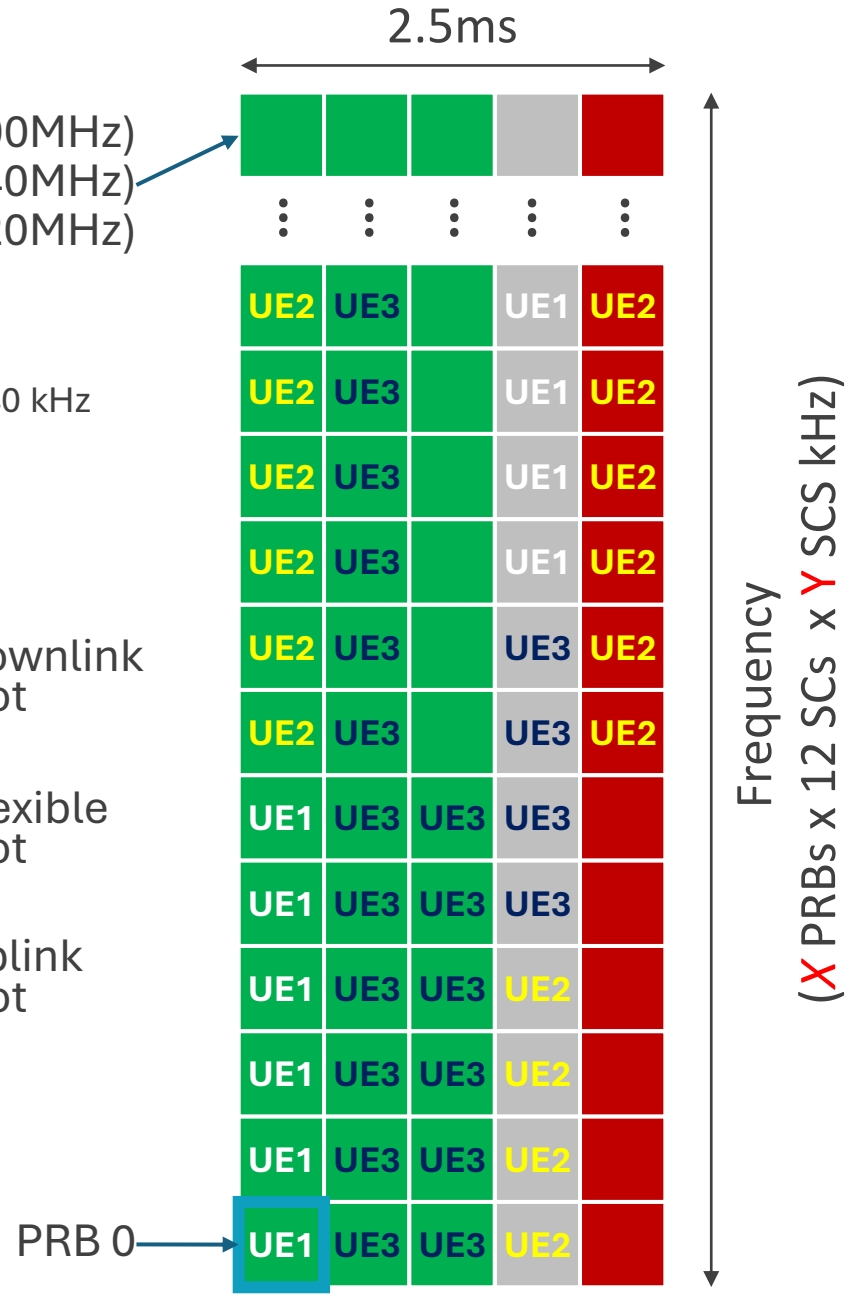


The 5G RAN: TDD Uplink-Downlink Configuration

Downlink calculation for **20MHz**:

- Total REs in one DL PRB:
  - 11 x 12 = 132 REs
- Total REs in one F PRB:
  - 4 x 12 = 48 REs
- Number of PRBs for 20MHz
  - 51 PRBs
- Number of D and F slots per TDD period
  - 3 D slots and 1 F slot
- Total number of REs per TDD period
  - (132 x 3 + 48 x 1) x 51 = 22,644 REs
- Total number of REs per second
  - 22,644 x 1000/2.5 = 9,057,600 REs
- Number of bits per RE (MCS 27)
  - 8 bit with code rate 0.925
- Total DL throughput in bps
  - 9,057,600 x 8 x 0.925 = 67,026,240.00
  - ~67 Mbps

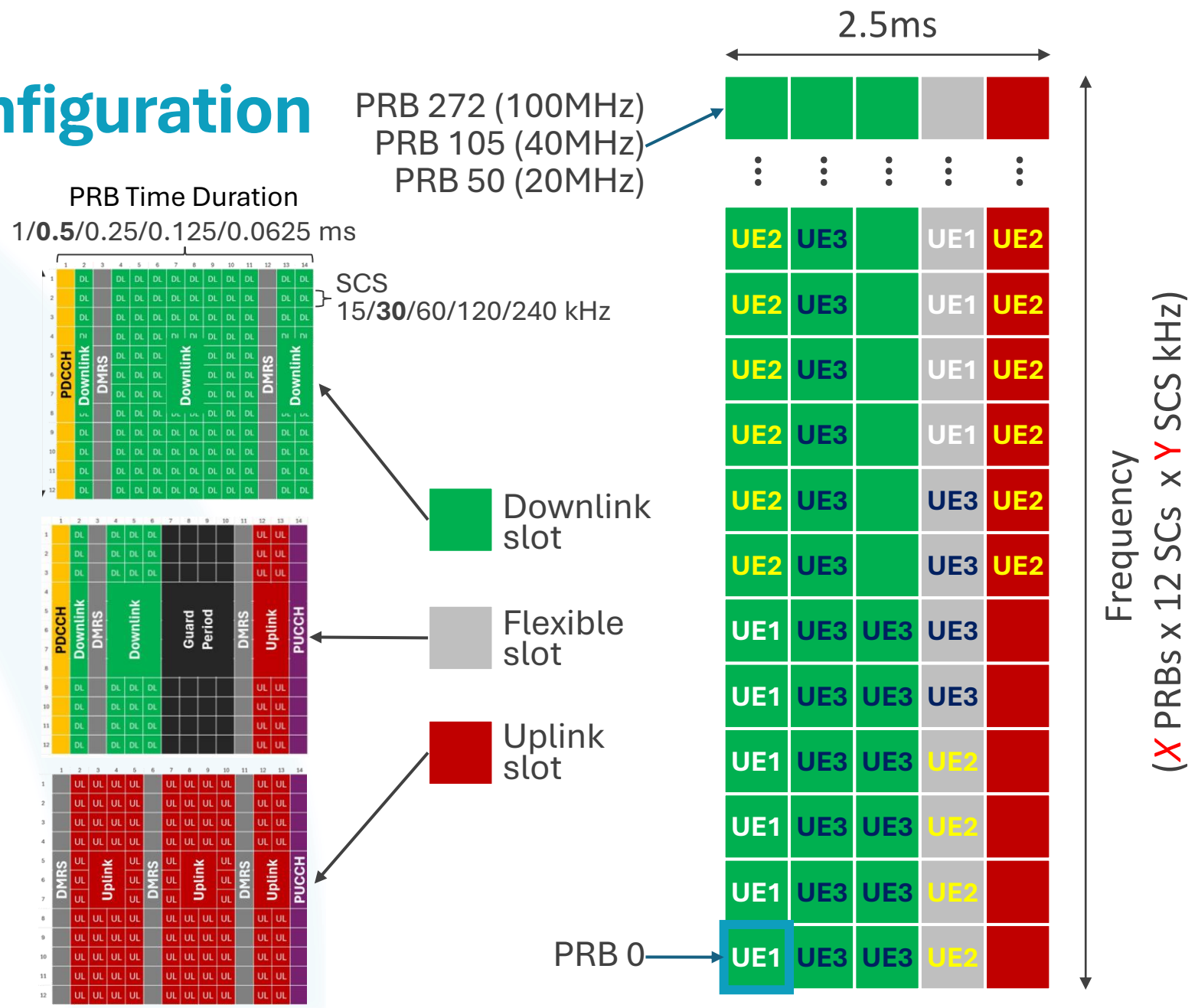




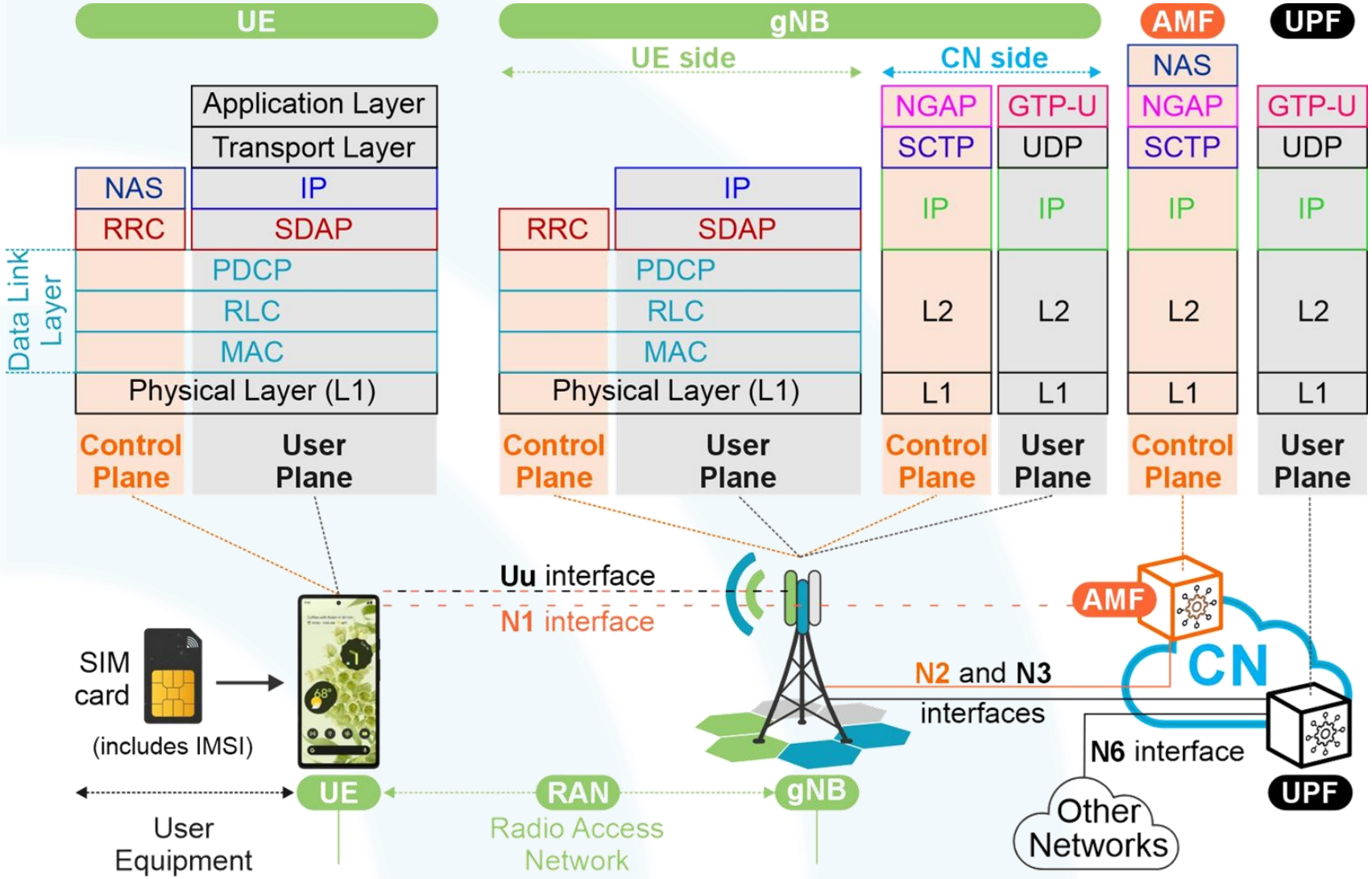
The 5G RAN: TDD Uplink-Downlink Configuration

Downlink calculation for **40MHz**:

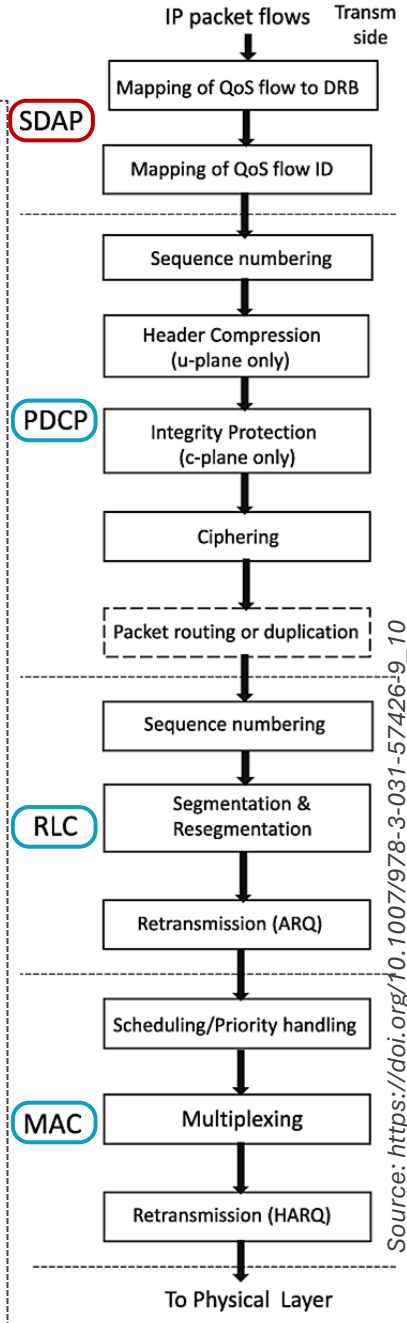
- Total REs in one DL PRB:
  - 11 x 12 = 132 REs
- Total REs in one F PRB:
  - 4 x 12 = 48 REs
- Number of PRBs for 20MHz
  - 106 PRBs
- Number of D and F slots per TDD period
  - 3 D slots and 1 F slot
- Total number of REs per TDD period
  - (132 x 3 + 48 x 1) x 106 = 47,064 REs
- Total number of REs per second
  - 47,064 x 1000/2.5 = 18,825,600 REs
- Number of bits per RE (MCS 27)
  - 8 bit with code rate 0.925
- Total DL throughput in bps
  - 18,825,600 x 8 x 0.925 = 139,309,440
  - 139 Mbps



The 5G Protocol Stack



- NAS: Non-Access Stratum
- NGAP: Next Generation Application Protocol
- GTP-U: GPRS Tunneling Protocol
- SCTP: Stream Control Transmission Protocol
- IP: Internet Protocol
- SDAP: Service Data Adaptation Protocol.
- RRC: Radio Resource Control
- PDCP: Packet Data Convergence Protocol
- RLC: Radio Link Control
- MAC: Medium Access Control



Source: https://doi.org/10.1007/978-3-031-57426-9_10