**Resource Block:**

In 5G, One NR Resource Block (RB) contains 12 sub-carriers in frequency domain similar to LTE. In LTE resource block bandwidth is fixed to 180 KHz but in NR it is not fixed and depend on sub-carrier spacing.

a block of 14 OFDM symbols (1 slot across time domain) with the corresponding 12 subcarriers for those symbols.

|  |  |
| --- | --- |
| **5G NR Numerology** | **Description** |
| **Frequency Range** | • There are two frequency ranges supported in 5G NR viz. FR1 and FR2. • FR1 supports frequencies below 6 GHz where as FR2 supports frequencies above 6 GHz (i.e. mmwave range). • FR1: Frequency range is from 450 to 6000 MHz • FR2: Frequency range is from 24250 to 52600 MHz Refer complete [5G NR Frequency Bands >>](https://www.rfwireless-world.com/Terminology/5G-NR-Frequency-Bands.html). |
| **eMBB, mMTC, URLLC** | eMBB stands for Enhanced Mobile Broadband, mMTC stands for massive Machine Type Communication and URLLC stands for Ultra Reliability and Low Latency Communication. Refer [eMBB vs mMTC vs URLLC >>](https://www.rfwireless-world.com/Terminology/5G-eMBB-vs-mMTC-vs-URLLC.html). |
| **Frame** | a frame in 5G NR consists of 10 ms duration. |
| **Subframe** | A frame consists of 10 subframes with each having 1ms duration similar to LTE. Each subframe consists of 2μ slots. μ can be any value from 0 to 5. |
| **Slot** | s mentioned normal slot occupies either 14 (normal CP) or 12 (Extended CP) OFDM symbols. It enables slot based scheduling. One slot is the possible scheduling unit and slot aggregation is also allowed. Slot length scales with subcarrier spacing. Slot length = 1 ms/2μ, Where μ can be any value from 0 to 5. |
| **Mini-slot** | Mini-slot occupies 2, 4 or 7 OFDM symbols. It enables non-slot based scheduling. It is minimum scheduling unit used in 5G NR. As mentioned mini-slots can occupy as little as 2 OFDM symbols and are variable in length. They can be positioned asynchronously with respect to the beginning of a standard slot. |
| **Subcarrier spacing (SCS),** | It can be any value from 15/30/60/120/240/480 KHz based on 5G NR numerology parameter, μ which has value 0 to 5. For μ = 0, SCS of 15 KHz is used, for μ = 1, SCS of 30 KHz is used and so on. |
| **Slots per frame and subframe** | • Slots per subframe depends on μ. For μ = 0 to 5, slots/subframe vary from 1/2/4/8/16/32. • There are 10 subframes per frame and hence slots per frame is ten times of slots per subframe as mentioned in the table. |
| **OFDM symbol duration (Ts)** | Ts = 1/SCS, For SCS = 15 KHz, Ts = 1/15x103, Ts = 66.7 µs and so on. |
| **Numerology, μ** | It is the 5G NR parameter which changes SCS and other system parameters, It is denoted as μ and ranges from 0 to 5. |
| **Resource Grid** | • The resource grid which consists of number of subcarriers in frequency axis and number of OFDM symbols in time axis is known as resource grid. • 5G NR supports (Ngrid,x)size,μ X (NSC)RB subcarriers and (Nsymb)subframe,μ OFDM symbols. |
| **Resource Block** | • RB (**Resource Block**) consists of total 12 consecutive subcarriers in frequency domain. • (NSC)RB = 12 • There are more than one RBs in a resource grid. • Resource elements are grouped into PRB (Physical Resource Blocks). Each PRB consists of 12 subcarriers as mentioned. |
| **Resource Element** | • Each element in resource grid for antenna port ("p") and subcarrier spacing configuration ("μ") is known as **Resource Element**. • It is uniquely identified by (k,l)p,μ, where k = index in the frequency domain. l = symbol position in time domain. |
| **Cyclic Prefix type and duration** | There are two types viz. normal and extended. For normal each slot occupies 14 symbols and for extended each slot occupies 12 symbols. Extended CP type is used for SCS of 60 KHz only. |

**5G NR frame Structure**

5G NR Supports two frequency ranges FR1 (Sub 6GHz) and FR2 (millimeter wave range, 24.25 to 52.6 GHz). NR uses flexible subcarrier spacing derived from basic 15 KHz subcarrier spacing used in LTE.

OFDM symbols in a slot can be classified as 'downlink', 'flexible', or 'uplink'.  
• Signaling of slot formats is mentioned in subclause 11.1 of TS 38.213 document. Table below mentions the same.  
• In a slot in a downlink frame, the UE shall assume that downlink transmissions only occur in 'downlink' or 'flexible' symbols.  
• In a slot in an uplink frame, the UE shall only transmit in 'uplink' or 'flexible' symbols.

Resource Grid:

Physical layer resource group which is defined separately for the uplink and downlink. Resource grid is defined for each numerology.

subcarrier spacing, number of OFDM symbols within a radio frame) varies in NR depending on numerology.

* *There is one set of resource grids per transmission direction (uplink or downlink) with the subscript  set to DL and UL for downlink and uplink*
* *There is one resource grid for a given antenna port p , subcarrier spacing configuration u, and transmission direction (downlink or uplink).*

**Massive MIMO:**

The main reason for Massive MIMO for 5G is 'there is no other choice'. It is highly likely that we will use very high frequency (mm Wave) signal in 5G. High frequency mean that the size of single antenna will be very small and the aperture (the area for receiving energy) will be very small. To overcome this small aperture on reciever side at high frequency, we need to use a large number of transmission antenna.

This would be the main reason, but once we adopt the Massive MIMO technology

**Numerology:**

The very simple defination of Numerology based on the usage of the term in 3GPP specification would be 'subcarrier spacing  type'. In LTE, we don't need any specific terminology to indicate the subcarrier spacing since there is only one subcarrier spacing, but in NR there are several different types of subcarrier spacing