Slot Based Scheduling

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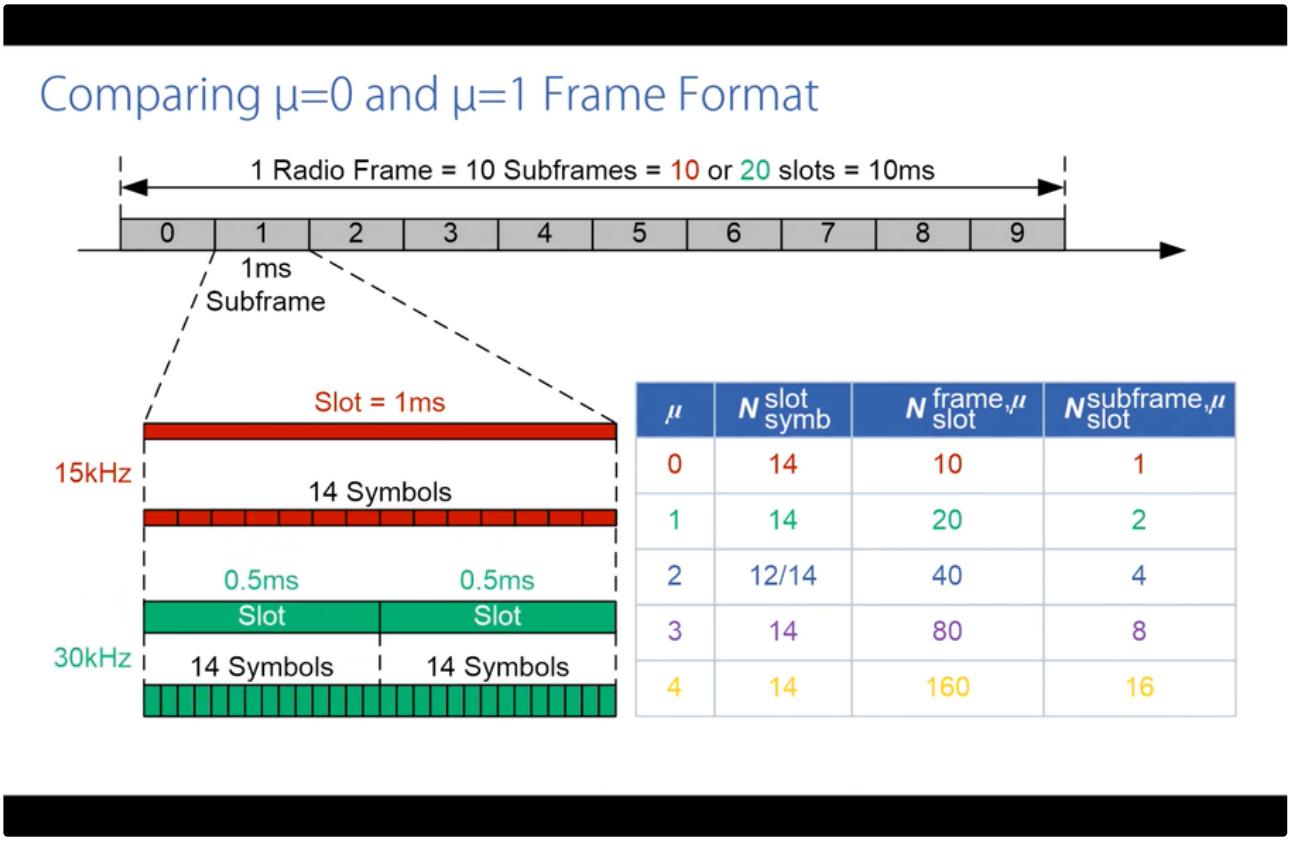
One of the ways that NR enables the three axes of 5G (eMBB, URLLC, mMTC) is by providing greater flexibility in use of radio resources.

In both 4G and 5G

- a radio frame is defined as a 10ms interval, and
- a subframes is defined as one of 10 contiguous 1ms intervals within a radio frame.

In 4G the number of slots in a subframe is always 1, and the number of symbols in a slot is always 14.

In 5G, that combination is just one of 7 options called numerologies. The 7 different numerologies are indexed by the symbol μ in the table below.



μ	N^{slot}_{symb}	$N^{frame,\mu}_{slot}$	$N^{subframe,\mu}_{slot}$
0	14	10	1
1	14	20	2
2	12/14	40	4
3	14	80	8
4	14	160	16

5G numerologies in some pre-release 17 state; release 17 has 7 numerologies and in each the number of symbols per slot is either 7 or 14.

The smallest division of time here, a symbol, is the time for transmission of one OFDM symbol.

That is, there is a double use of the word symbol here; in discussion of modulation schemes the word “symbol' refers to a unit of information, but on this page “symbol” refers to a window of time. I’ll clarify with an example. Referring back to the contents of the Introduction to 5G page on modulation, if a subcarrier frequency of f=700MHz is to send the QAM symbol for 01 (encoded with I=-1 for the 0, and Q=1 for the 1) then it sends a sinusoidal wave proportional to

$$(-1)\cos(2\pi f t) - (1)\sin(2\pi f t)$$

over the time interval for the symbol.

Thus, each subcarrier frequency carries a symbol (like 01) over each time interval called a symbol (like a μ=0 interval of width 1ms/14).

Slot Formats

The UE and gNB agree on a timing for use of a subcarrier frequency as an uplink or downlink channel. The timing options for 14 symbol slots are enumerated by 3GPP specifications, and a few of the options are shown below. In the table, D is for downlink and U is for uplink.

Format	Symbol number in a slot													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	D	D	D	D	D	D	D	D	D	D	D	D	D	D
1	U	U	U	U	U	U	U	U	U	U	U	U	U	U
2	X	X	X	X	X	X	X	X	X	X	X	X	X	X
…	…													
32	D	D	D	D	D	D	D	D	D	D	X	X	U	U
…	…													
61	D	D	X	X	X	X	U	D	D	X	X	X	X	U
62 – 254	Reserved													
255	UE determines the slot format for the slot based on *TDD-UL-DL-ConfigurationCommon*, or *TDD-UL-DL-ConfigDedicated* and, if any, on detected DCI formats													

Source: 3GPP TS 38.213 V15.4.0, Table 11.1.1-1

Duplexing with Slot Formats

Recall that the term “duplexing” refers to sending information both directions, uplink and downlink. By contrast, half-duplex refers to sending information one direction. This subsection shows how the format options in NR facilitate a range of duplexing.

Half Duplex

Format 0 and 1 correspond to using a carrier frequency as a half duplex channel. Format 0 is the time division duplexing option for the half duplex scheme one might call “downlink only”. Format 1 is the time division duplexing option for the half duplex scheme one might call “uplink only”.

FDD

Use of format 0 and format 1 for two different subcarrier frequencies to allow simultaneous uplink and downlink. That simultaneous use is called frequency division duplexing (FDD).

TDD

The other formats are for time division duplex; the slots are broken down into time periods for uplink, downlink or for neither. Some applications are uplink heavy (like uploading a video). Others are downlink heavy (like watching a video.) NR can accommodate a wide variety of these applications using the 62 predefined format options, future format options that 3GPP might specify for option 63 etc, or custom UE defined option 255.

Slot Format Scheduling

Most typically, the signaling about which slot format to use on each subcarrier frequency is transmitted from the gNB to the UE by either

- the dedicated signaling connection in the RRC layer
- the downlink control information (DCI) which has a slot format indicator.

Less typically, as seen in the table above, format 255 specifies that the UE decides tells the gNB the slot format.

Thus, slot format 255 might be a good option for application that require careful control by an application of the uplink-downlink ratio. In particular, future VR applications run over NR will likely need a high level of control over the uplink to downlink data transmission ratio.

Mini-slots

Please help; I can not find a presentation of 5G minislots that does not center around the idea “as you already know about minislots…”