5G Frame Structure

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Simulation-Based Design of 5G Wireless Standards

Agenda for today

- Will finish discussing 5G numerology
- Will discussion 5G time/frequency frame structure
  - Section 7.1 to 7.4 of 5G NR book by EricD

5G NR numerology (1)

Subcarrier Spacing (kHz)	Useful Symbol Time, T_u (μs)	Cyclic Prefix, T_{CP} (μs)
15	66.7	4.7
30	33.3	2.3
60	16.7	1.2
120	8.33	0.59
240	4.17	0.29

- Scalable subcarrier spacing $= 2^{\mu} \cdot 15$ kHz
- NR supports a wide range of deployment scenarios
  - from large cells with sub-1 GHz carrier frequency up to mm-wave deployments with wide bandwidths
- A single numerology for all these scenarios is not efficient or even possible

5G NR numerology (2)

Subcarrier Spacing (kHz)	Useful Symbol Time, T_u (μs)	Cyclic Prefix, T_{CP} (μs)
15	66.7	4.7
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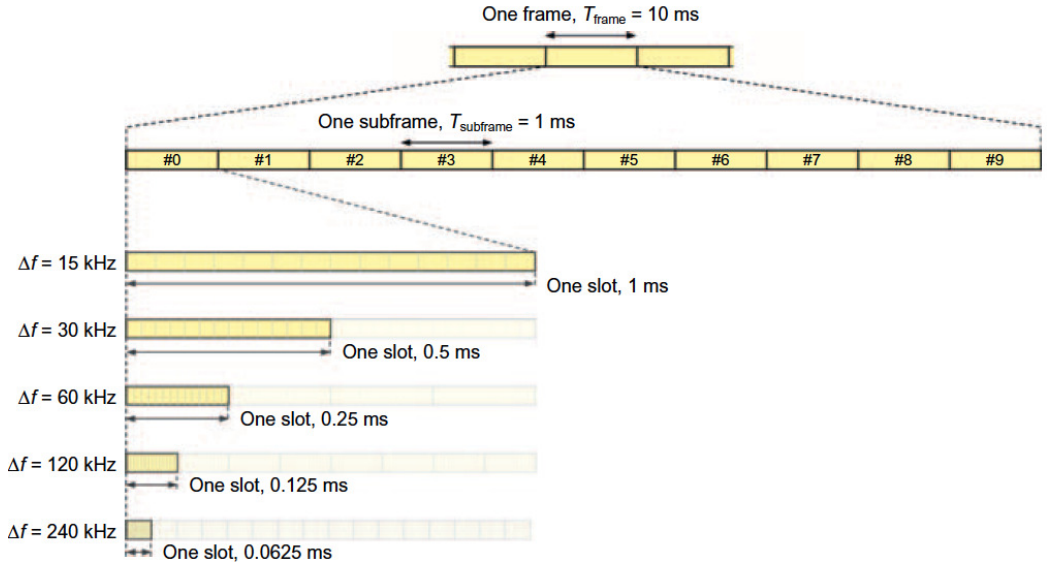
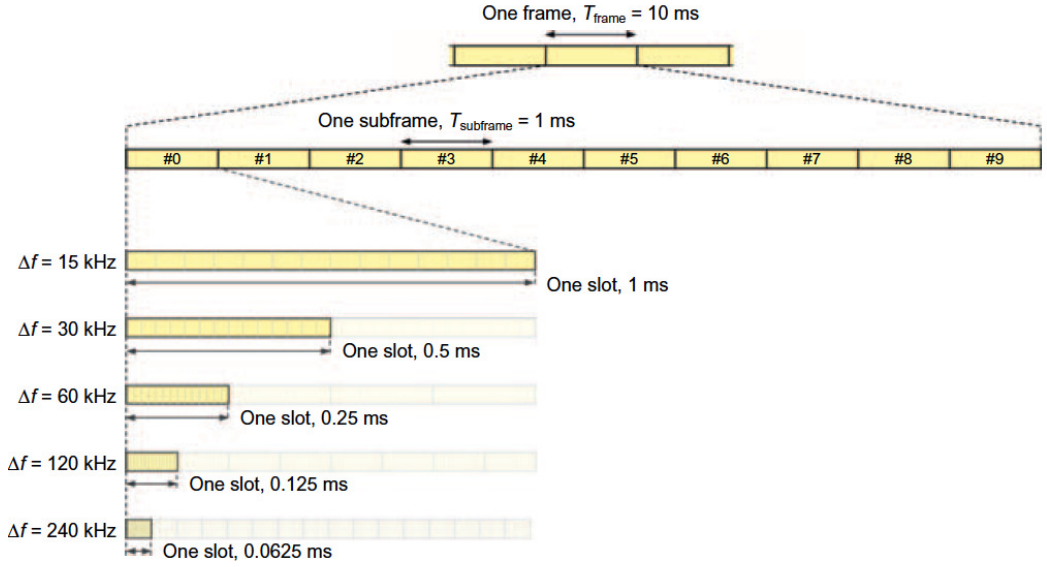
- For FR1, cell sizes can be relatively large and a couple of microseconds of cyclic prefix is necessary
  - to handle the delay spread expected in these type of deployments
  - subcarrier spacing of 15 - 30 kHz, is needed
- FR2 requires higher subcarrier spacings due to higher phase noise
- FR2 cell sizes will be smaller due to hostile channel
- FR2 consequently requires higher subcarrier spacing and a shorter cyclic prefix

Time domain structure (1)



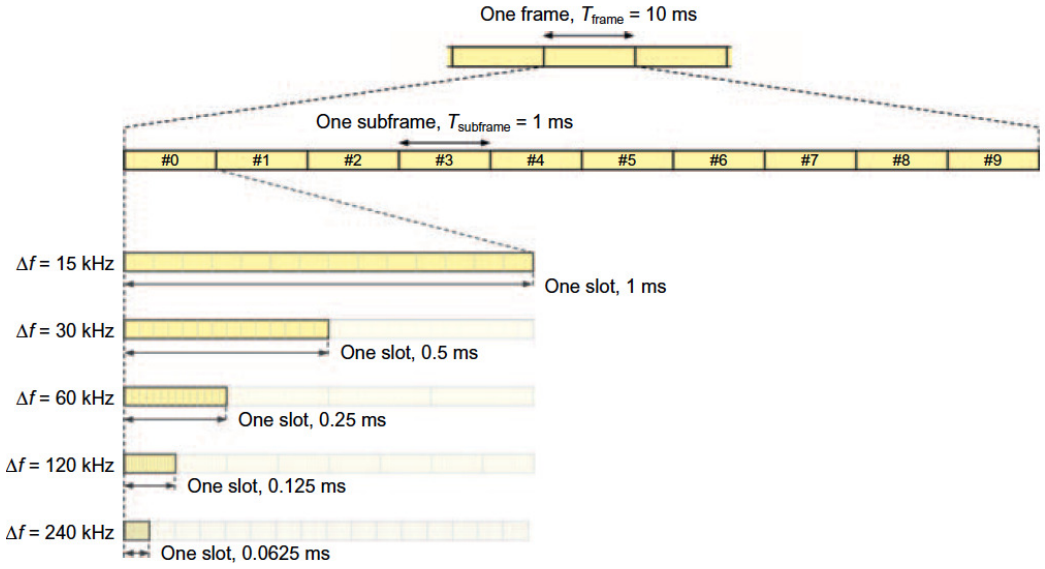
- NR transmissions are organized into frames of length 10 ms,
- Each subframe divided into 10 equal-sized subframes of length 1 ms

Time domain structure (2)



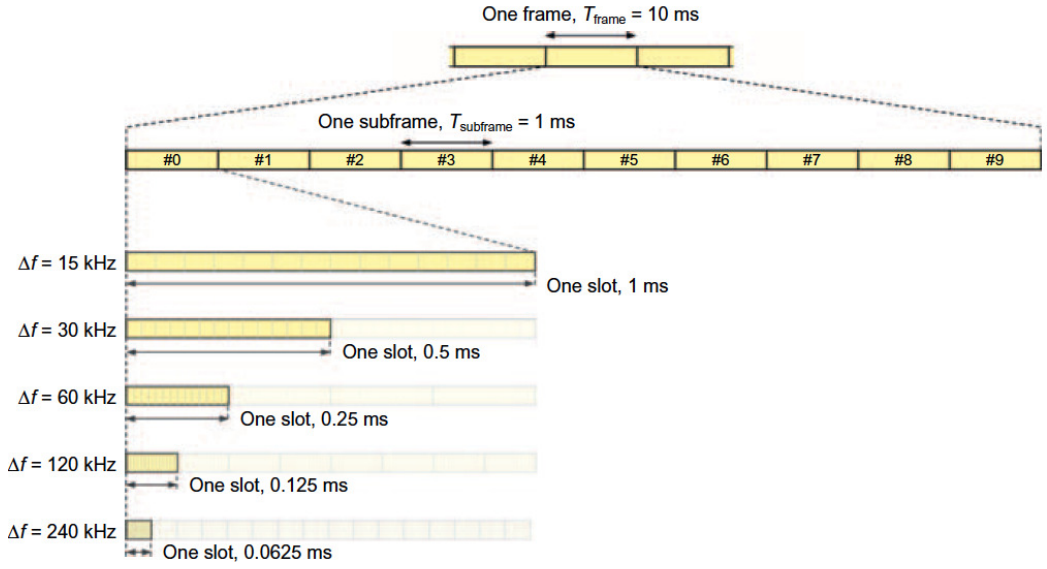
- A subframe is divided into slots consisting of 14 OFDM symbols each
  - Duration of a slot in milliseconds depends on the numerology
  - Slot is the typical dynamic scheduling unit
- Subframe in NR serves as a numerology-independent time reference

Time domain structure (3)



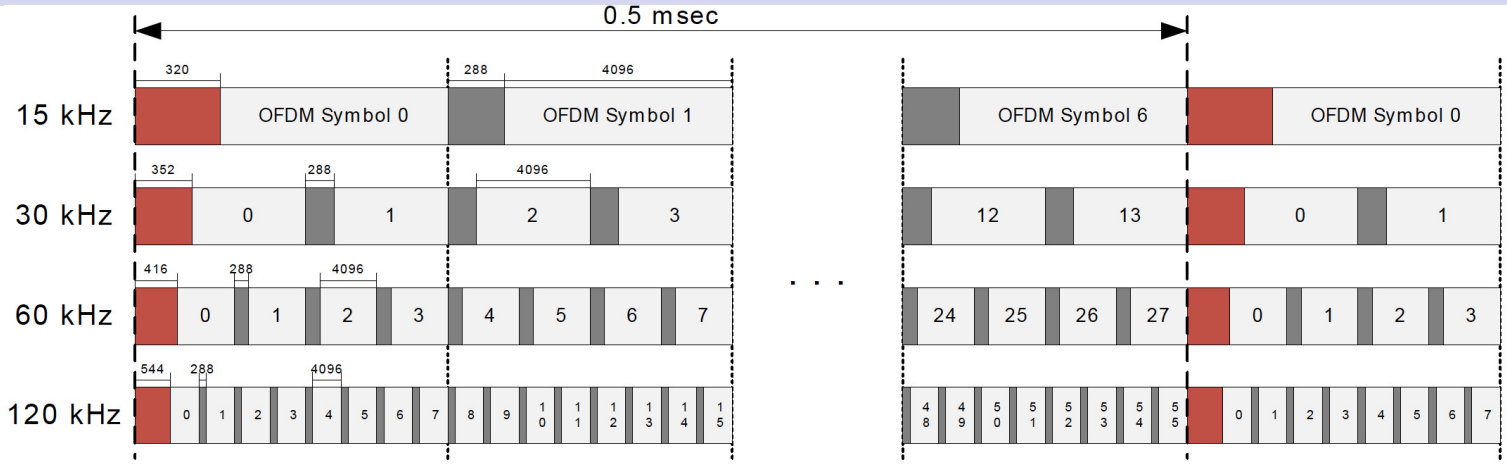
- A slot = 14 OFDM symbols – a higher subcarrier spacing leads to a shorter slot duration
- Can be used to support lower-latency transmission,
  - Cyclic prefix shrinks with increase in subcarrier spacing – not a feasible approach in all deployments

Time domain structure (4)



- Increase the cyclic prefix – increased overhead
- Reducing slot duration is a less efficient way of providing low latency
- Subcarrier spacing is primarily selected according to deployment scenario e.g., carrier frequency

Time domain structure in detail



- Recall for 100 MHz system: i) (I)FFT size $N = 4096$ ii) Number of CP samples: 288
- Total number of samples in 14 symbols: $14 \cdot (288 + 4096) = 61376$
- Recall sampling rate for 100 MHz system: 122.88 MHz. Samples generated in 0.5 msec=61440
- Extra samples $61440 - 61376 = 64$. 64 samples are added to CP of first symbol in each slot