

# TDD Structure

Radha Krishna Ganti

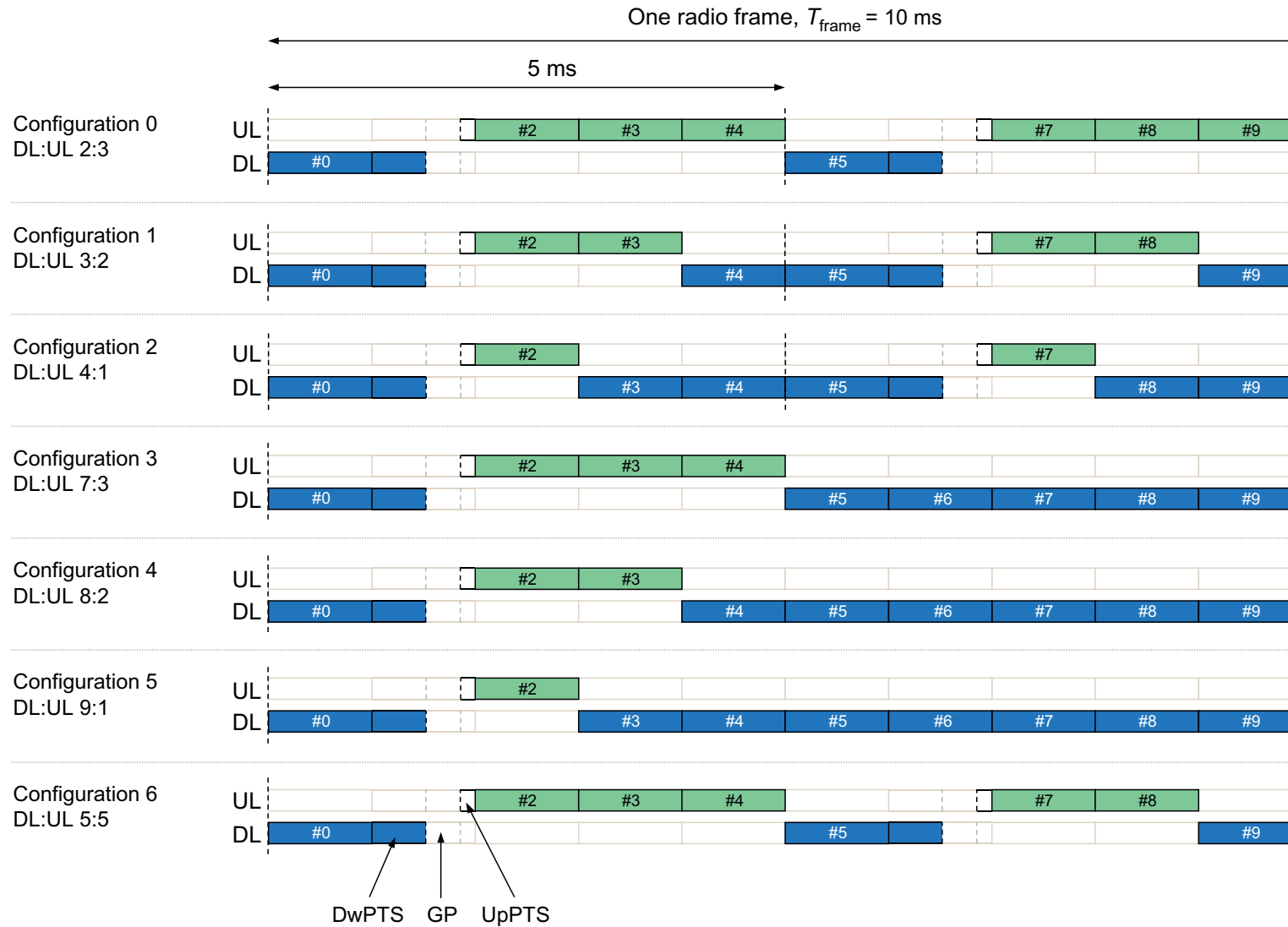
# References

- R1-1721702 “Offline discussion on GC-PDCCH carrying SFI “
- R1-1719172 “Offline discussion on GC-PDCCH carrying SFI”
- 38.213

# TDD Structure

- NR provides a lot of flexibility for TDD
- Control at the level of OFDM symbols
  - DCI and RRC control
- Many more options than LTE

# In LTE

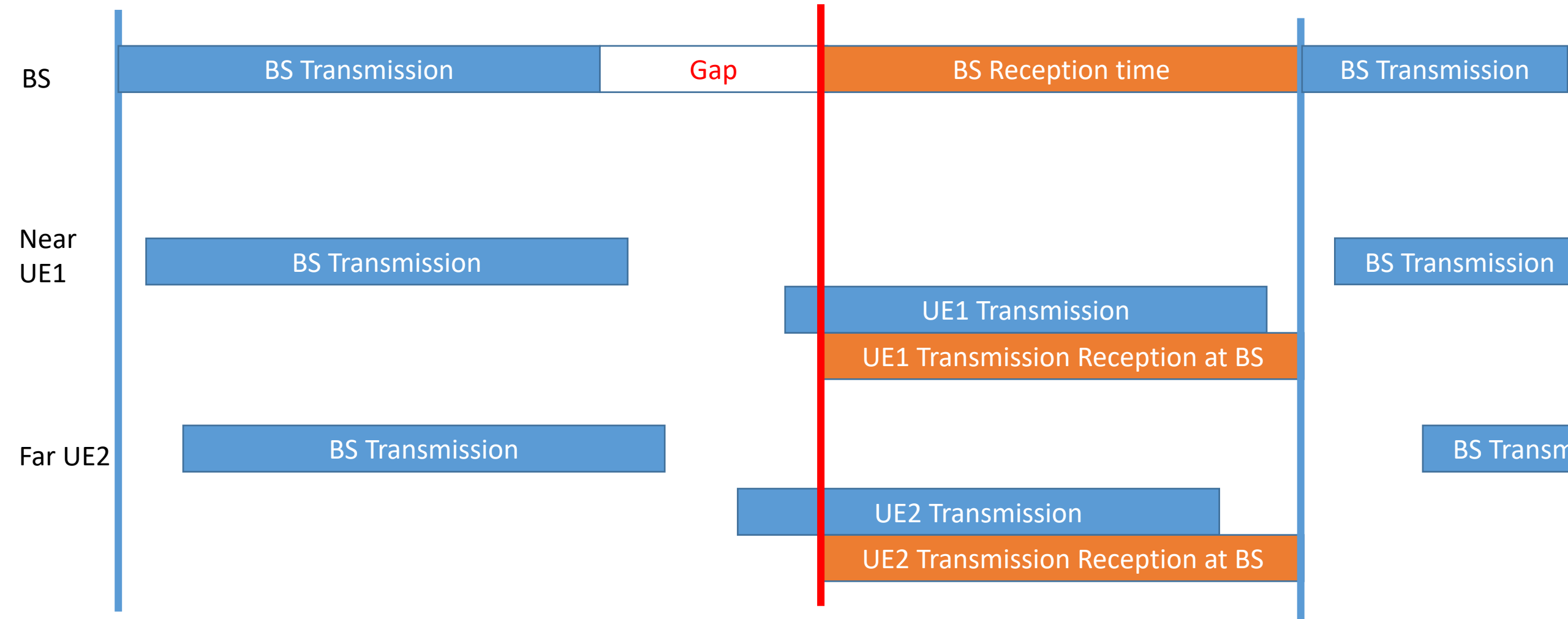


- DL to UL happens in a special subframe (1ms) and the DL to UL has a guard period.
- Only possible TDD configurations

**FIGURE 9.11**

Different downlink/uplink configurations in the case of TDD. Copyright © T Madras, 2019

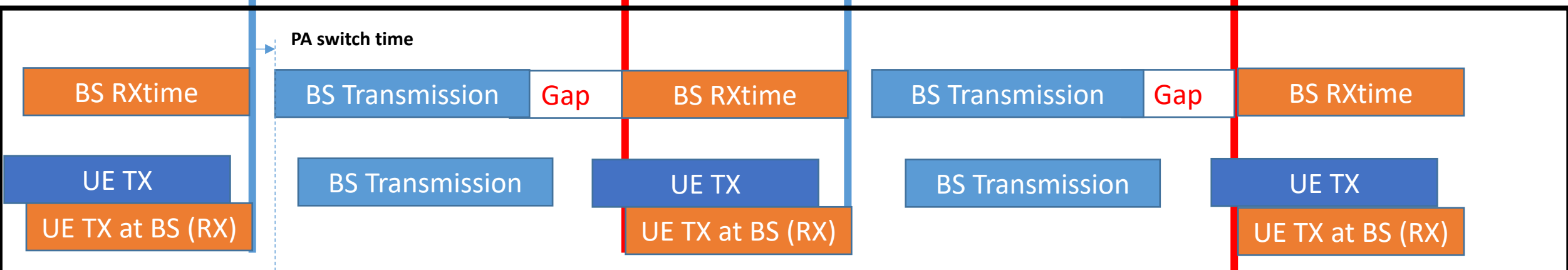
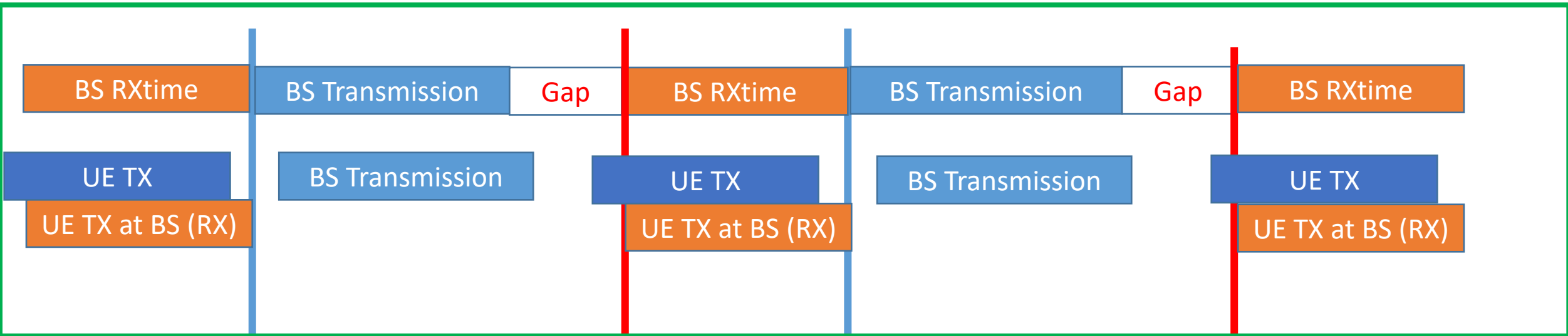
# Timing advance



- The gap between BS TX and BS RX is required to accommodate the UE timing advance
- The gap should be at least the round-trip delay

# Timing advance

Ideal with only compensation for timing advance



Compensation for timing advance and PA switch on (The switching time can be absorbed in the transition slot (GAP) if it is low). The switching time must be indicated to the UE (as offset)

# RRC Configuration of TDD

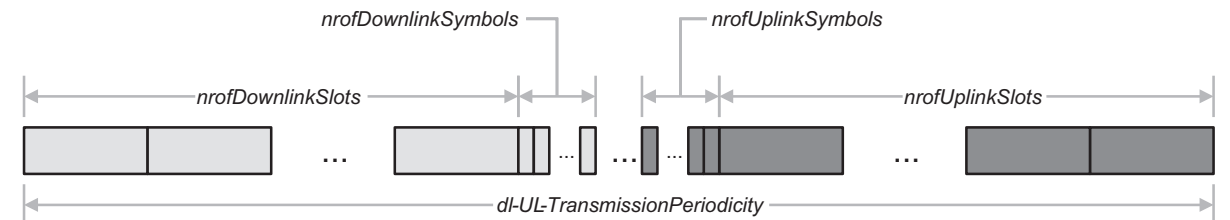
- SIB1  $\rightarrow$  ServingCellConfigCommon  $\rightarrow$  TDD-UL-DL-ConfigurationCommon

```
TDD-UL-DL-ConfigCommon ::=
    SEQUENCE {
        referenceSubcarrierSpacing SubcarrierSpacing,
        pattern1 TDD-UL-DL-Pattern,
        pattern2 TDD-UL-DL-Pattern
    }
```

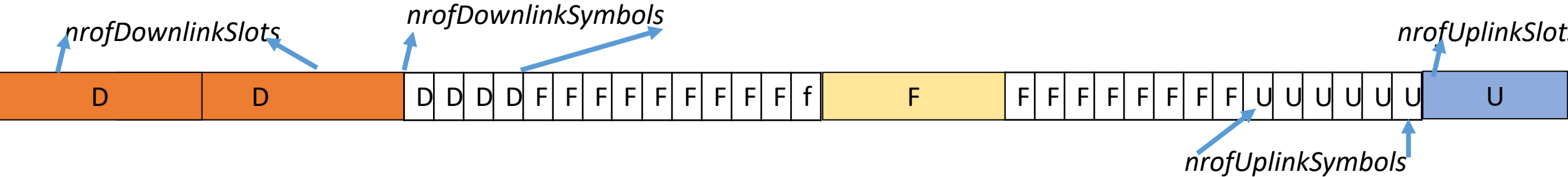
```
TDD-UL-DL-Pattern ::=
    SEQUENCE {
        dl-UL-TransmissionPeriodicity ENUMERATED {ms0p5, ms0p625, ms1, ms1p25, ms2, ms2p5, ms5, ms10},
        nrofDownlinkSlots INTEGER (0..maxNrofSlots),
        nrofDownlinkSymbols INTEGER (0..maxNrofSymbols-1),
        nrofUplinkSlots INTEGER (0..maxNrofSlots),
        nrofUplinkSymbols INTEGER (0..maxNrofSymbols-1),
        ...
        [[
            dl-UL-TransmissionPeriodicity-v1530 ENUMERATED {ms3, ms4}
        ]]
    }
```

1. From the  $S$  slots, a first  $d_{\text{slots}}$  slots include only downlink symbols
2. a last  $u_{\text{slots}}$  slots include only uplink symbols.
3. The  $d_{\text{sym}}$  symbols after the first  $d_{\text{slots}}$  slots are downlink symbols.
4. The  $u_{\text{sym}}$  symbols before the last  $u_{\text{slots}}$  slots are uplink symbols.
5. The remaining  $(S - d - u) N^{\text{slot}}_{\text{symbol}} - d - u$  are flexible symbols.

- a slot configuration period of  $P$  msec by *dl-UL-TransmissionPeriodicity*
- a number of slots  $d_{\text{slots}}$  with only downlink symbols by *nrofDownlinkSlots*
- a number of downlink symbols  $d_{\text{sym}}$  by *nrofDownlinkSymbols*
- a number of slots  $u_{\text{slots}}$  with only uplink symbols by *nrofUplinkSlots*
- a number of uplink symbols  $u_{\text{sym}}$  by *nrofUplinkSymbols*



# TDD-UL-DL-ConfigurationCommon





- Pattern2 (if defined) provides the structure for the next set of slots.
  - If *TDD-UL-DL-ConfigurationCommon* provides both *pattern1* and *pattern2*, the UE sets the slot format per slot over a first number of slots as indicated by *pattern1* and the UE sets the slot format per slot over a second number of slots as indicated by *pattern2*.
- The first symbol every  $20/P$  periods is a first symbol in an even frame
  - The sum of the two pattern periods must divide 20ms.

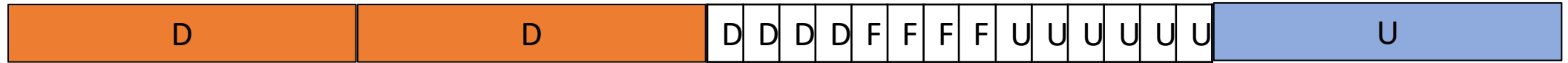
# *TDD-UL-DL-ConfigDedicated* (Once session is setup after RRC setup)

- If *TDD-UL-DL-ConfigDedicated* is configured
  - the parameter *TDD-UL-DL-ConfigDedicated* overrides only flexible symbols per slot over the number of slots as provided by *TDD-UL-DL-ConfigurationCommon*
- *Overrides only the flexible symbols*
  - *UE (or group) specific*
- *CellGroupConfig* → *SpCellConfig* → *ServingCellConfig* → *TDD-UL-DL-ConfigDedicated*

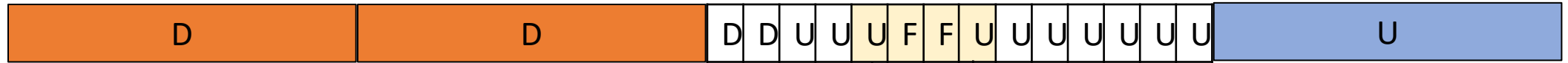
```
TDD-UL-DL-ConfigDedicated ::= SEQUENCE {
    slotSpecificConfigurationsToAddModList SEQUENCE (SIZE (1..maxNrofSlots)) OF TDD-UL-DL-SlotConfig
    slotSpecificConfigurationsToReleaseList SEQUENCE (SIZE (1..maxNrofSlots)) OF TDD-UL-DL-SlotIndex
    ...
}

TDD-UL-DL-SlotConfig ::= SEQUENCE {
    slotIndex TDD-UL-DL-SlotIndex,
    symbols CHOICE {
        allDownlink NULL,
        allUplink NULL,
        explicit SEQUENCE {
            nrofDownlinkSymbols INTEGER (1..maxNrofSymbols-1)
            nrofUplinkSymbols INTEGER (1..maxNrofSymbols-1)
        }
    }
}
```

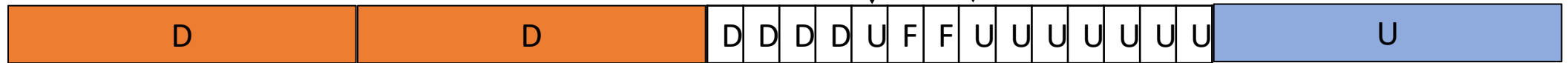
*TDD-UL-DL-ConfigurationCommon*



*TDD-UL-DL-ConfigDedicated*



Final



# Overriding factors

- For a set of symbols of a slot that are indicated to a UE as flexible by *TDD-UL-DL-ConfigurationCommon*, or *TDD-UL-DL-ConfigDedicated*,
  - Not expected to transmit
  - Not expected to receive
- Higher layer parameters configure receive for symbols in a slot
  - If UE does not detect DCI (0-1,0-0,1-0,1-1) that says transmit
    - Then UE receives
  - Else
    - UE does not receive
- Higher layer parameters configure transmit for symbols in a slot
  - UE detects DCI (0-1,0-0,1-0,1-1) that says receive in a subset of the above symbols
    - UE does not cancel the transmission for the symbols smaller than the **PUSCH preparation time**  $T_{proc,2}$
    - the UE cancels the PUCCH, or PUSCH, or PRACH transmission in remaining symbols from the set of symbols and cancels the SRS transmission in remaining symbols from the subset of symbols
  - So, if there is a conflict between DCI and RRC for some symbols, then the UE neither receives nor transmits (except for few symbols in the PUSCH preparation time)
  - So only flexible symbols can be overwritten by DCI

# UE determination of SLOT format (with DCI format 2-0)

```
SlotFormatIndicator ::= SEQUENCE {
    sfi-RNTI RNTI-Value,
    dci-PayloadSize INTEGER (1..maxSFI-DCI-PayloadSize),
    slotFormatCombToAddModList SEQUENCE (SIZE(1..maxNrofAggregatedCellsPerCellGroup)) OF SlotFormatCombinationsPerCell
    slotFormatCombToReleaseList SEQUENCE (SIZE(1..maxNrofAggregatedCellsPerCellGroup)) OF ServCellIndex
    ...
}
```

```
SlotFormatCombinationsPerCell ::= SEQUENCE {
    servingCellId ServCellIndex,
    subcarrierSpacing SubcarrierSpacing,
    subcarrierSpacing2 SubcarrierSpacing
    slotFormatCombinations SEQUENCE (SIZE (1..maxNrofSlotFormatCombinationsPerSet)) OF SlotFormatCombination
    positionInDCI INTEGER (0..maxSFI-DCI-PayloadSize-1)
    ...
}
```

```
SlotFormatCombination ::= SEQUENCE {
    slotFormatCombinationId SlotFormatCombinationId,
    slotFormats SEQUENCE (SIZE (1..maxNrofSlotFormatsPerCombination)) OF INTEGER (0..255)
}
```

```
SlotFormatCombinationId ::= INTEGER (0..maxNrofSlotFormatCombinationsPerSet-1)
```

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	F	F	F	F	F	F	F	F	F	F	F	F	F	F
3	D	D	D	D	D	D	D	D	D	D	D	D	D	F
4	D	D	D	D	D	D	D	D	D	D	D	D	D	F
5	D	D	D	D	D	D	D	D	D	D	D	F	F	F
6	D	D	D	D	D	D	D	D	D	D	F	F	F	F
7	D	D	D	D	D	D	D	D	D	F	F	F	F	F
8	F	F	F	F	F	F	F	F	F	F	F	F	F	U
9	F	F	F	F	F	F	F	F	F	F	F	F	F	U
10	F	U	U	U	U	U	U	U	U	U	U	U	U	U
11	F	F	U	U	U	U	U	U	U	U	U	U	U	U
12	F	F	F	U	U	U	U	U	U	U	U	U	U	U
13	F	F	F	F	U	U	U	U	U	U	U	U	U	U
14	F	F	F	F	F	U	U	U	U	U	U	U	U	U
15	F	F	F	F	F	F	U	U	U	U	U	U	U	U
16	D	F	F	F	F	F	F	F	F	F	F	F	F	F
17	D	D	F	F	F	F	F	F	F	F	F	F	F	F
18	D	D	D	F	F	F	F	F	F	F	F	F	F	F
19	D	F	F	F	F	F	F	F	F	F	F	F	F	U
20	D	D	F	F	F	F	F	F	F	F	F	F	F	U
21	D	D	D	F	F	F	F	F	F	F	F	F	F	U
22	D	F	F	F	F	F	F	F	F	F	F	F	U	U
23	D	D	F	F	F	F	F	F	F	F	F	F	U	U
24	D	D	D	F	F	F	F	F	F	F	F	F	U	U
25	D	F	F	F	F	F	F	F	F	F	F	U	U	U
26	D	D	F	F	F	F	F	F	F	F	F	U	U	U
27	D	D	D	F	F	F	F	F	F	F	F	U	U	U
28	D	D	D	D	D	D	D	D	D	D	D	D	F	U
29	D	D	D	D	D	D	D	D	D	D	D	D	F	U
30	D	D	D	D	D	D	D	D	D	D	D	F	F	U
31	D	D	D	D	D	D	D	D	D	D	D	F	U	U
32	D	D	D	D	D	D	D	D	D	D	F	F	U	U
33	D	D	D	D	D	D	D	D	D	F	F	F	U	U
34	D	F	U	U	U	U	U	U	U	U	U	U	U	U
35	D	D	F	U	U	U	U	U	U	U	U	U	U	U
36	D	D	D	F	U	U	U	U	U	U	U	U	U	U
37	D	F	F	U	U	U	U	U	U	U	U	U	U	U
38	D	D	F	F	U	U	U	U	U	U	U	U	U	U
39	D	D	D	F	F	U	U	U	U	U	U	U	U	U
40	D	F	F	F	U	U	U	U	U	U	U	U	U	U
41	D	D	F	F	F	U	U	U	U	U	U	U	U	U
42	D	D	D	F	F	F	U	U	U	U	U	U	U	U
43	D	D	D	D	D	D	D	D	D	F	F	F	F	U
44	D	D	D	D	D	D	F	F	F	F	F	F	U	U
45	D	D	D	D	D	D	F	F	U	U	U	U	U	U
46	D	D	D	D	D	F	U	D	D	D	D	D	F	U
47	D	D	F	U	U	U	U	D	D	F	U	U	U	U
48	D	F	U	U	U	U	U	D	F	U	U	U	U	U
49	D	D	D	D	F	F	U	D	D	D	D	F	F	U
50	D	D	F	F	U	U	U	D	D	F	F	U	U	U
51	D	F	F	U	U	U	U	D	F	F	U	U	U	U
52	D	F	F	F	F	F	U	D	F	F	F	F	F	U
53	D	D	F	F	F	F	U	D	D	F	F	F	F	U
54	F	F	F	F	F	F	F	D	D	D	D	D	D	D
55	D	D	F	F	F	U	U	U	D	D	D	D	D	D

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Reserved

UE determines the slot format for the slot based on *TDD-UL-DL-ConfigurationCommon* or *TDD-*

- There should not be any conflict between RRC and DCI\_2\_0
  - For a set of symbols of a slot that are indicated as downlink/uplink by *TDD-UL-DL-ConfigurationCommon*, or *TDD-UL-DL-ConfigDedicated*, the UE does not expect to detect a DCI format 2\_0 with an SFI-index field value indicating the set of symbols of the slot as uplink/downlink, respectively, or as flexible.