5G UL Channels
“Reference Signal Optimization”

Optimization

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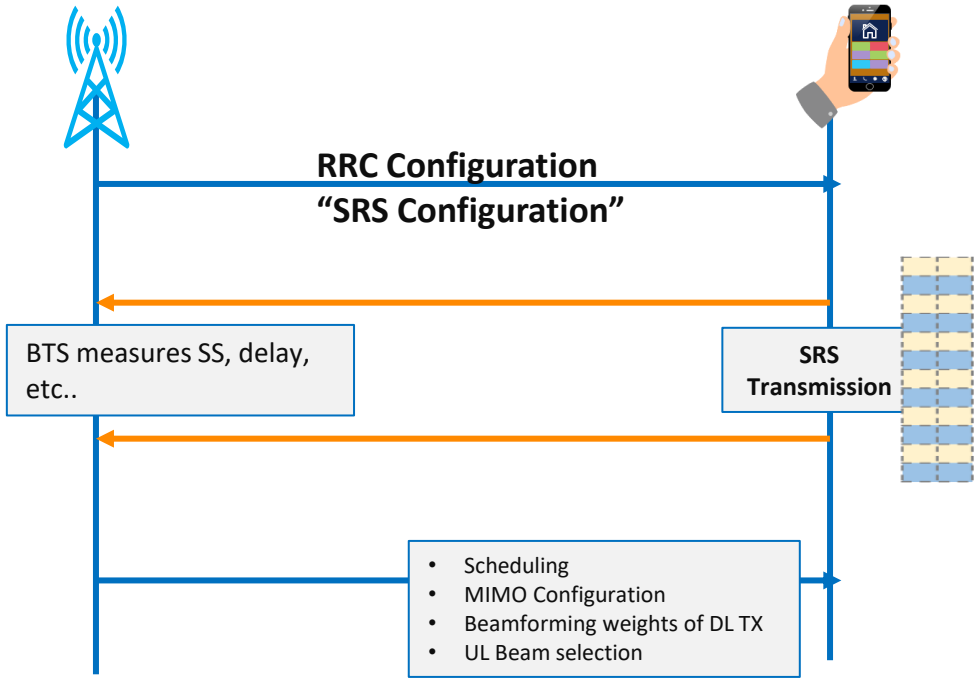
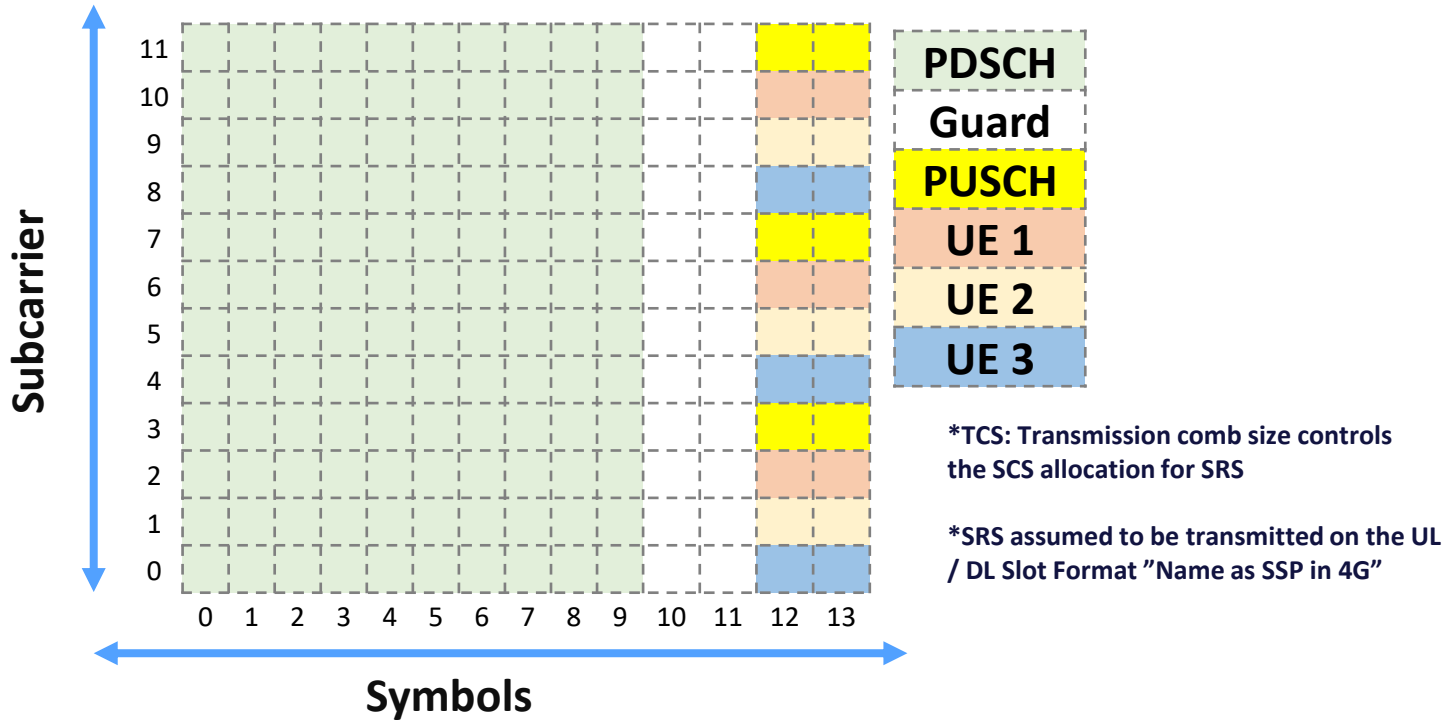
CONTENT

- Why SRS?
- How to check UE SRS support capability
- SRS related Parameter Overview
- SRS Vs. PMI(CSI-RS) weight obtaining procedure

What is the Sounding Reference Signal?

- The UE transmits the Sounding Reference Signal(SRS) according to the instructions provided by the BTS, and is used by the BTS **to measure the UL propagation channel from the SRS**.
- An SRS Transmission can occupy 1, 2, or 4 symbols in the time domain; these symbols can be located at the last 6 symbols of a UL Slot.
- An SRS Transmission can occupy up to 272 RBs in the frequency domain, but an individual **UE does not transmit the SRS on every subcarrier** but select specific SCs based **on transmission comb type.**
- NR SRS are more flexible compared to 4G, for example Lte SRS were occupying one symbol and was using TCS 2 only , while NR occupy up to 4 symbols and is using TCS 2 or 4.





*TCS: Transmission comb size controls the SCS allocation for SRS

*SRS assumed to be transmitted on the UL / DL Slot Format "Name as SSP in 4G"

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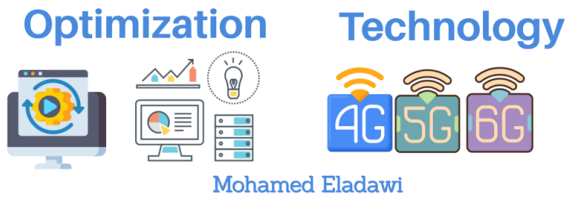
Sounding Reference Signal Function

3GPP SRS UE Capability

SRS 3GPP Parameter Overview

SRS Vs. PMI(CSI-RS) weight obtaining procedure

Sounding Reference Signal Function



- The UE specific measurement can be used for the following:

SRS Function

- **UL Ch aware scheduling and Link adaptation**
  - The Packet scheduler identifies the best set of RBs to allocate
  - BTS measures UL SINR as input for Link adaptation(MCS Adjustment)
- **DL Propagation Ch estimation**
  - UE TX = UE RX → SRS Transmit from each RX Ant, then BTS deduces DL Propagation towards each antenna
  - UE TX < UE RX → UE must support antenna switching
- **Non-codebook transmission**
  - UE Transmits a set of Pre-coded SRS
  - SRS is precoded using a different set of UE-generated weight
  - BTS evaluates SRS Sets and then provides feedback regarding the best weight to be used for PUSCH transmission
- **Codebook Transmission**
  - UE Transmits a set of Non-Pre-coded SRS
  - BTS uses SRS Tx to select PUSCH antenna ports
  - BTS provides feedback to UE in terms of SRI, RI, and TPMI
- **UL Beam management**
  - Used for connections do not benefit from UL/DL correspondence
  - Used to identify both the best UE TX beam and best BTS RX Beam

MIMO-ParametersPerBand	
beamCorrespondenceWithoutUL-BeamSweeping	supported

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Prerequisite For SRS(SRS UE Capability based on 3GPP)

4.2.7.1 BandCombinationList parameters

srs-TxSwitch*, *srs-TxSwitch-v1610

Defines whether UE supports SRS for DL CSI acquisition as defined in clause 6.2.1.2 of TS 38.214 [12]. The capability signalling comprises of the following parameters:

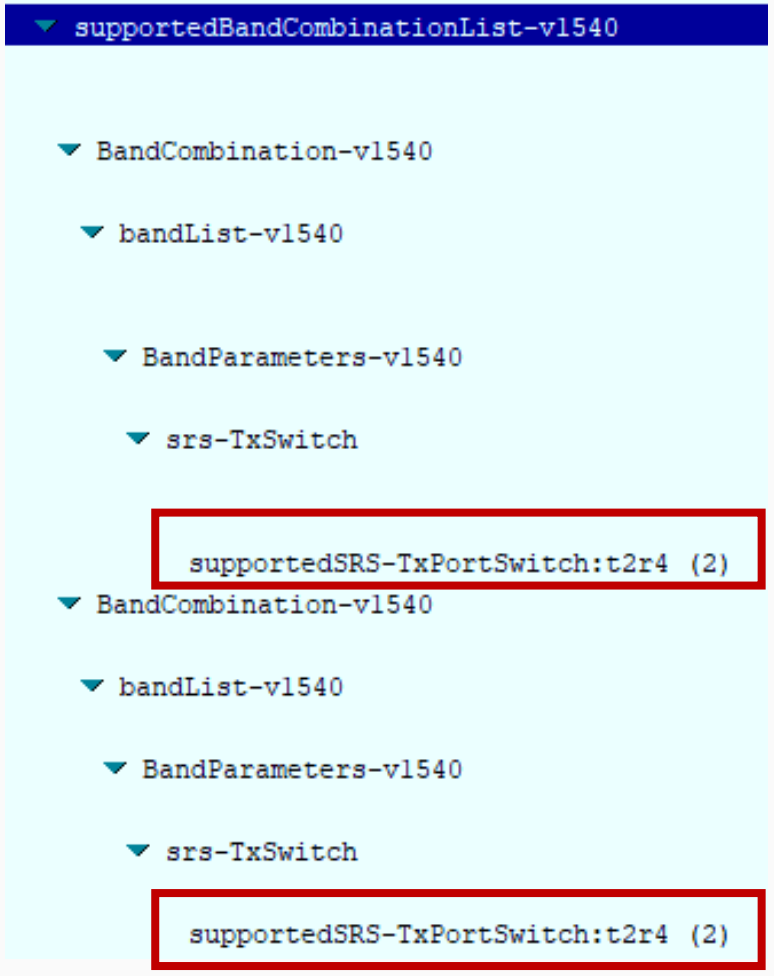
- ***supportedSRS-TxPortSwitch*** **indicates SRS Tx port switching pattern supported by the UE, which is mandatory with capability signalling**. The indicated UE antenna switching capability of 'xTyR' corresponds to a UE, capable of SRS transmission on 'x' antenna ports over total of 'y' antennas, where 'y' corresponds to all or subset of UE receive antennas, where 2T4R is two pairs of antennas. *supportedSRS-TxPortSwitch-v1610*, which is optional to report, indicates downgrading configuration of SRS Tx port switching pattern. If the UE indicates the support of downgrading configuration of SRS Tx port switching pattern using *supportedSRS-TxPortSwitch-v1610*, the UE shall report the values for this as below, based on what is reported in *supportedSRS-TxPortSwitch*.

supportedSRS-TxPortSwitch	***supportedSRS-TxPortSwitch-v1610***
t1r2	*t1r1-t1r2*
t1r4	*t1r1-t1r2-t1r4*
t2r4	*t1r1-t1r2-t2r2-t2r4*
t2r2	*t1r1-t2r2*
t4r4	*t1r1-t2r2-t4r4*
t1r4-t2r4	*t1r1-t1r2-t2r2-t1r4-t2r4*

- ***txSwitchImpactToRx*** indicates the entry number of the first-listed band with UL (see NOTE) in the band combination that affects this DL, which is mandatory with capability signalling;

***3GPP 38306-h40**

UE Capability



Prerequisite For SRS(SRS UE Capability based on 3GPP)

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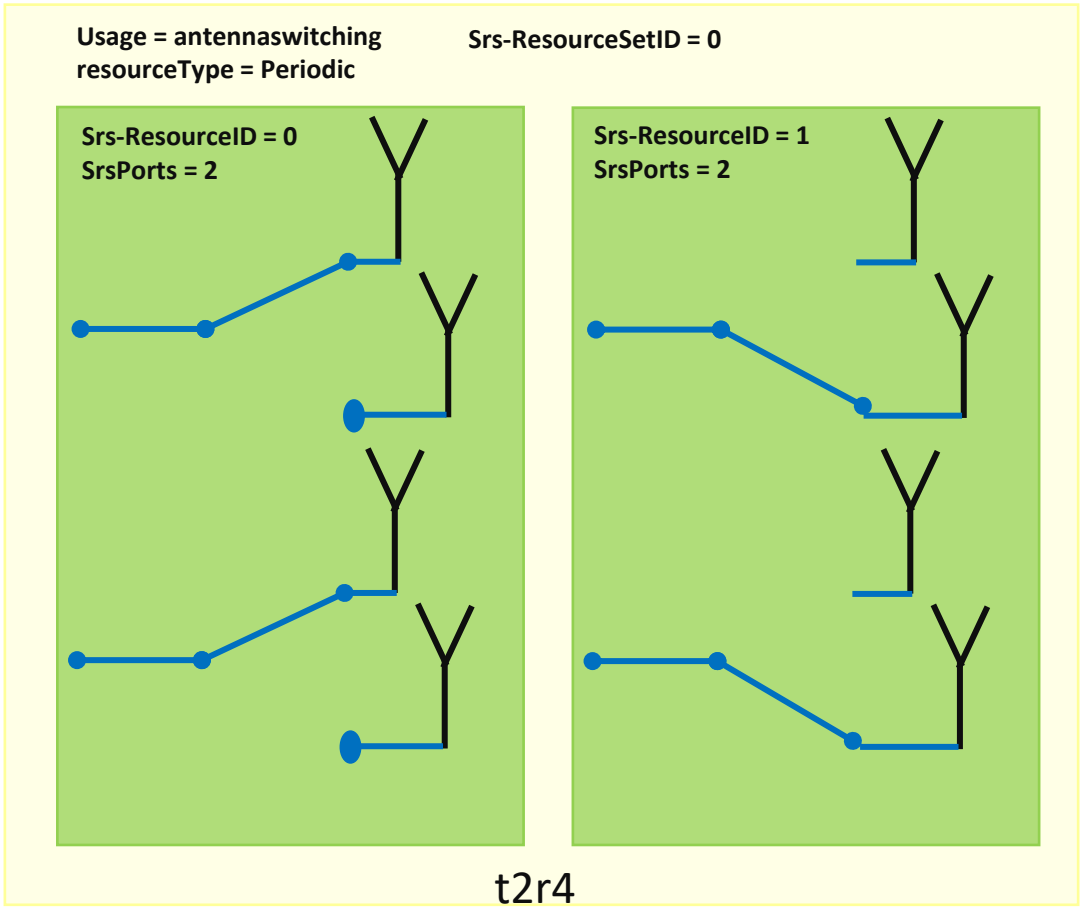
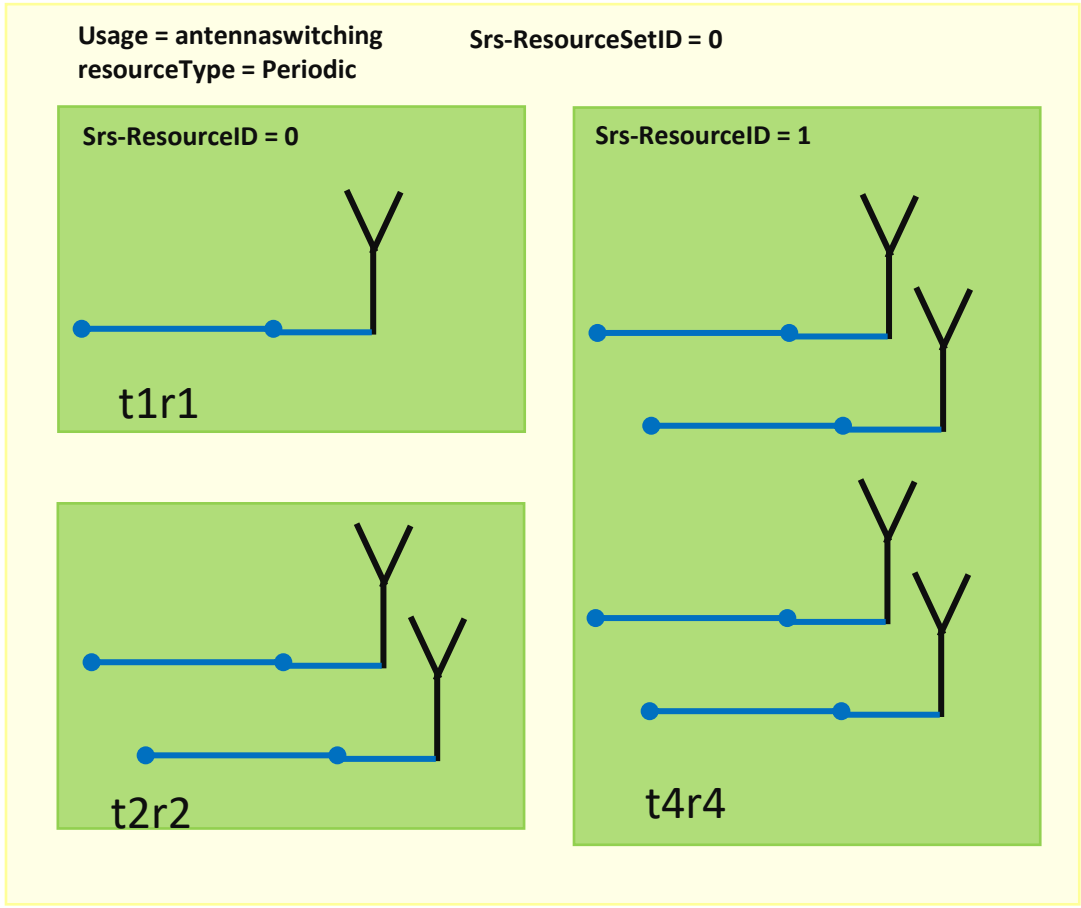
SRS-TXSwitch	
supportedSRS-TXportSwitch	t1r2, t1r4, t2r4, tr-equal

Channel Sounding with antenna switching



*UE receive antenna is more than the transmit paths

Channel Sounding without antenna switching



*UE has an equal number of transmit paths and receive antenna

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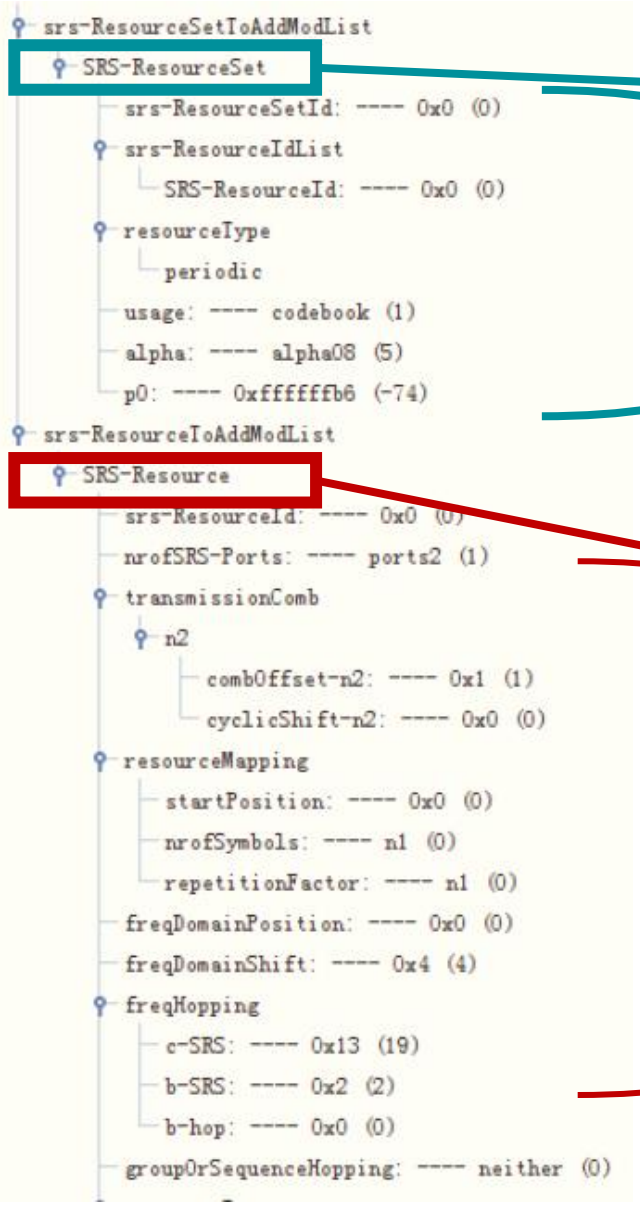
SRS Parameters Description

RRCReconfiguration message



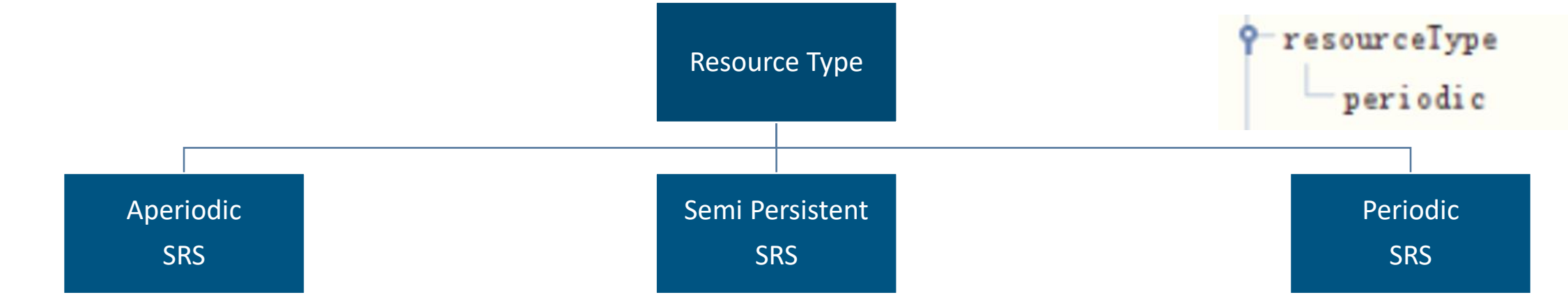
3GPP Parameter name

SRS Resouce Set	
3GPP- ParameterID	Value Range
resourceType	aperiodic semi persistent periodic
usage	beamManagement, codebook, nonCodebook, antennaswitching
alpha	0~1(0.1 step)
p0	"-202 to 24(2 dB step)

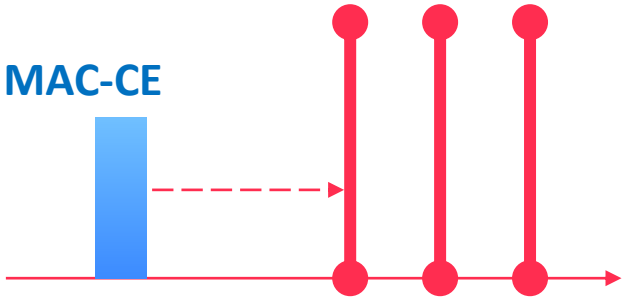
SRS Resouce Set	
3GPP- ParameterID	Value Range
transmissionComb	2,4
resource mapping	startPosition 0 to 5 nrofSymbols 1, 2, 4 reptitionFactor 1, 2, 4
freqHopping	c-SRS(0 to 63) ,b-SRS(0 to 3), b-hop(0 to 3)

SRS Parameters Description: Resource Type

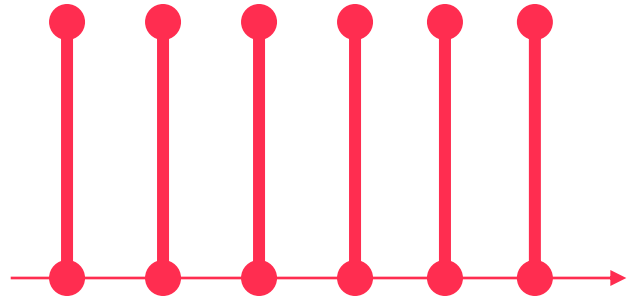
- The SRS Triggering mechanism is configured using the resourceType information element
- **Resource Type parameter has 3 types**



- Triggered using PDCCH DL DCI
- 3 DCI Format can include SRS Request
  - DCI 0_1 for UL RA
  - DCI 1_1 for DL RA
  - DCI 2_3 for SRS TPC



- Triggered using DL MAC CEs which are transmitted on PDSCH



- No Triggering required after configuration
- It do not require an activation instruction after the UE receives the SRS resource set configuration.

SRS Parameters Description: Transmission Comb type

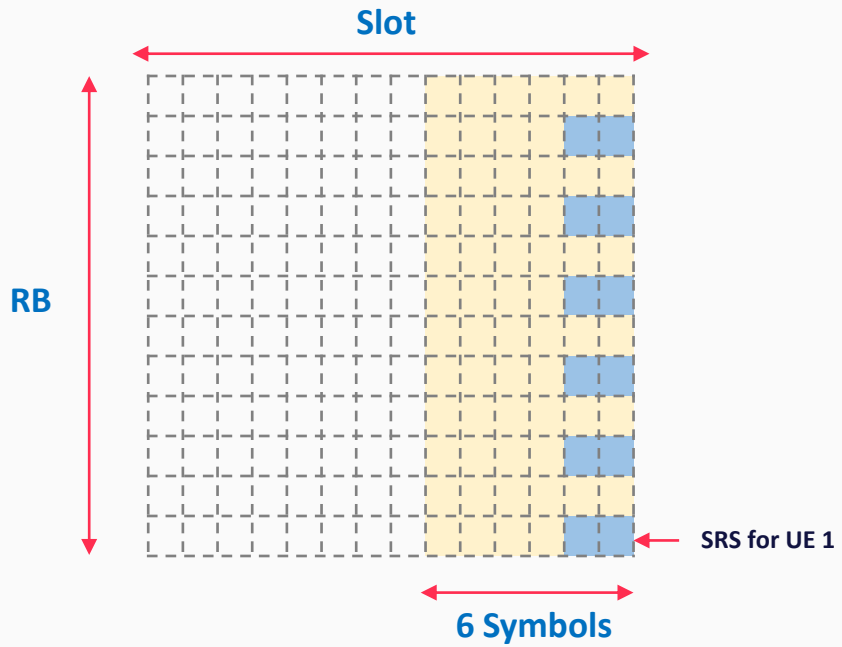
- The UE transmits the Sounding Reference Signal(SRS) according to the instructions provided by the BTS, and is used by the BTS to measure the UL propagation channel from the SRS.

- An SRS Transmission can occupy 1, 2, or 4 symbols in the time domain; these symbols can be located at the last 6 symbols of a UL Slot.

- An SRS Transmission can occupy up to 272 RBs in the frequency domain, but an individual **UE does not transmit the SRS on every subcarrier** but select specific SCs based **on transmission comb type.**

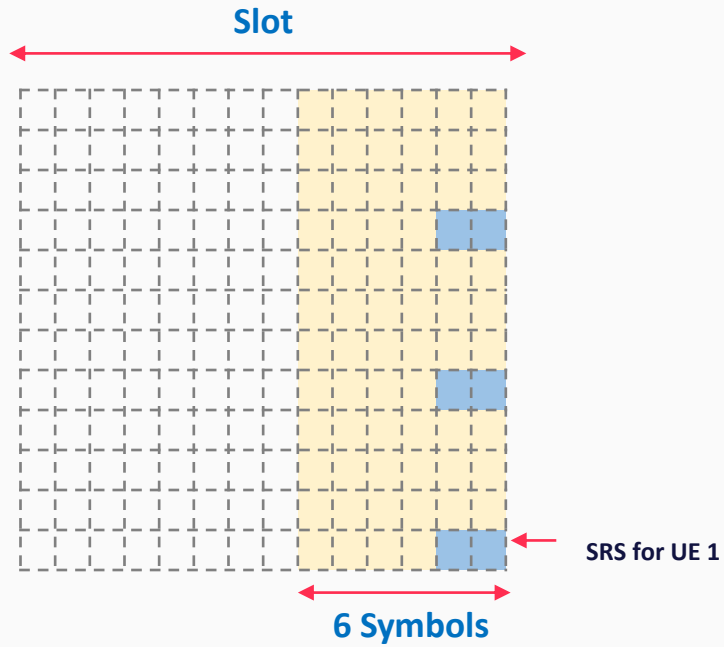
Transmission Comb Size = 2

8 CF is available, so up to 8 UEs can share the same REs



Transmission Comb Size = 4

12 CF is available, so up to 12 UEs can share the same REs

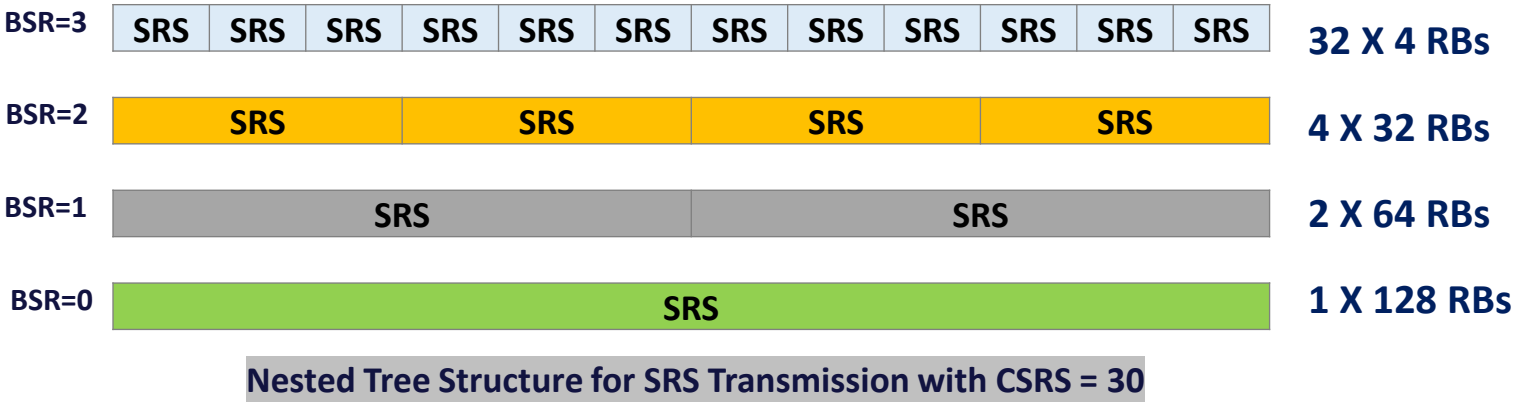


SRS Parameters Description: freqHopping(c-SRS & b-SRS)

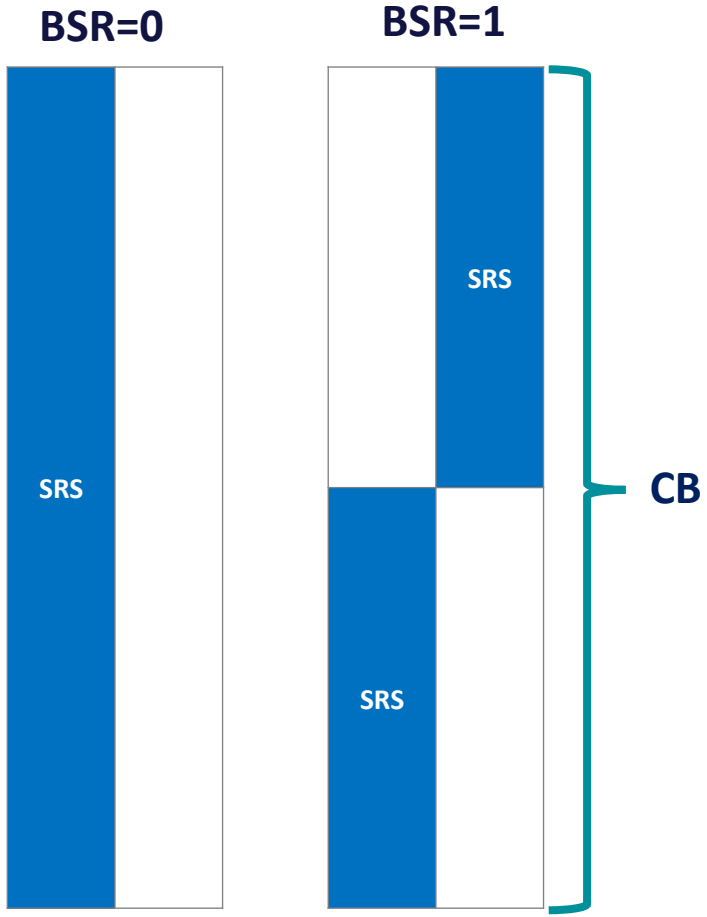
- The UE transmits the Sounding Reference Signal(SRS) according to the instructions provided by the BTS, and is used by the BTS to measure the UL propagation channel from the SRS.

SRS Bandwidth configuration table-3GPP 38211-h40

C_{SRS}	$B_{SRS}=0$		$B_{SRS}=1$		$B_{SRS}=2$		$B_{SRS}=3$	
	$m_{SRS,0}$	N_0	$m_{SRS,1}$	N_1	$m_{SRS,2}$	N_2	$m_{SRS,3}$	N_3
10	36	1	12	3	4	3	4	1
13	48	1	24	2	12	2	4	3
19	72	1	36	**2**	**12**	**3**	4	3
30	128	1	64	2	32	2	4	8



Nested Tree Structure for SRS Transmission with CSRS = 30



*CB: Channel Bandwidth

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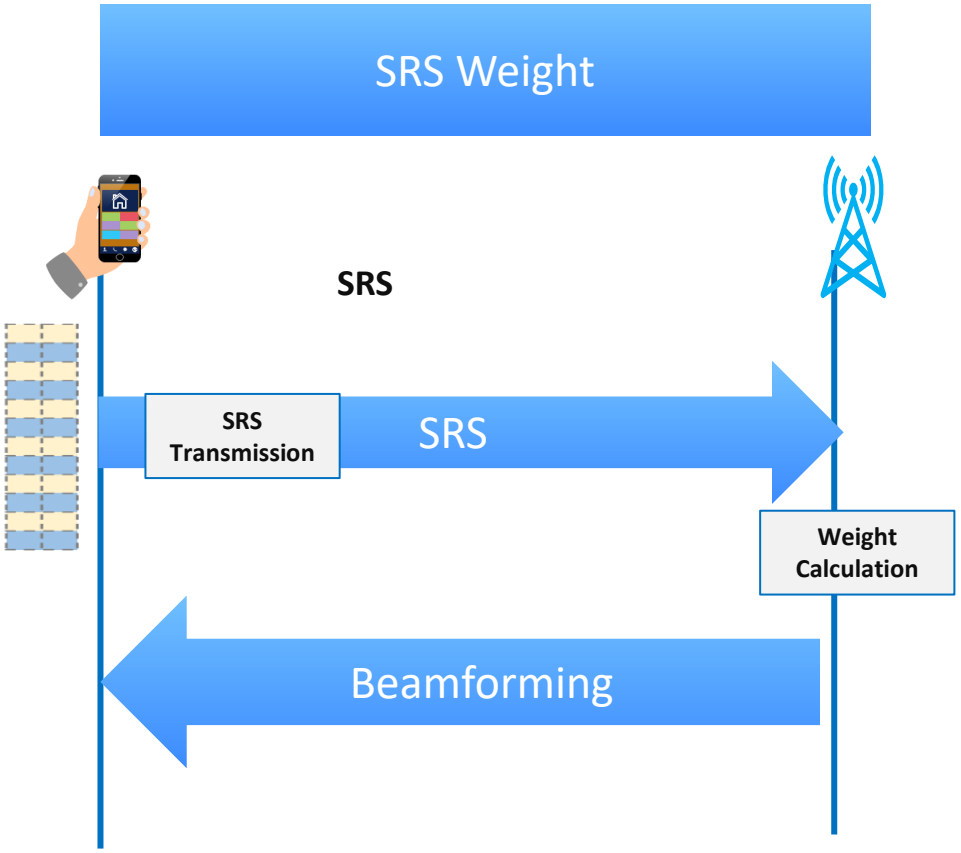
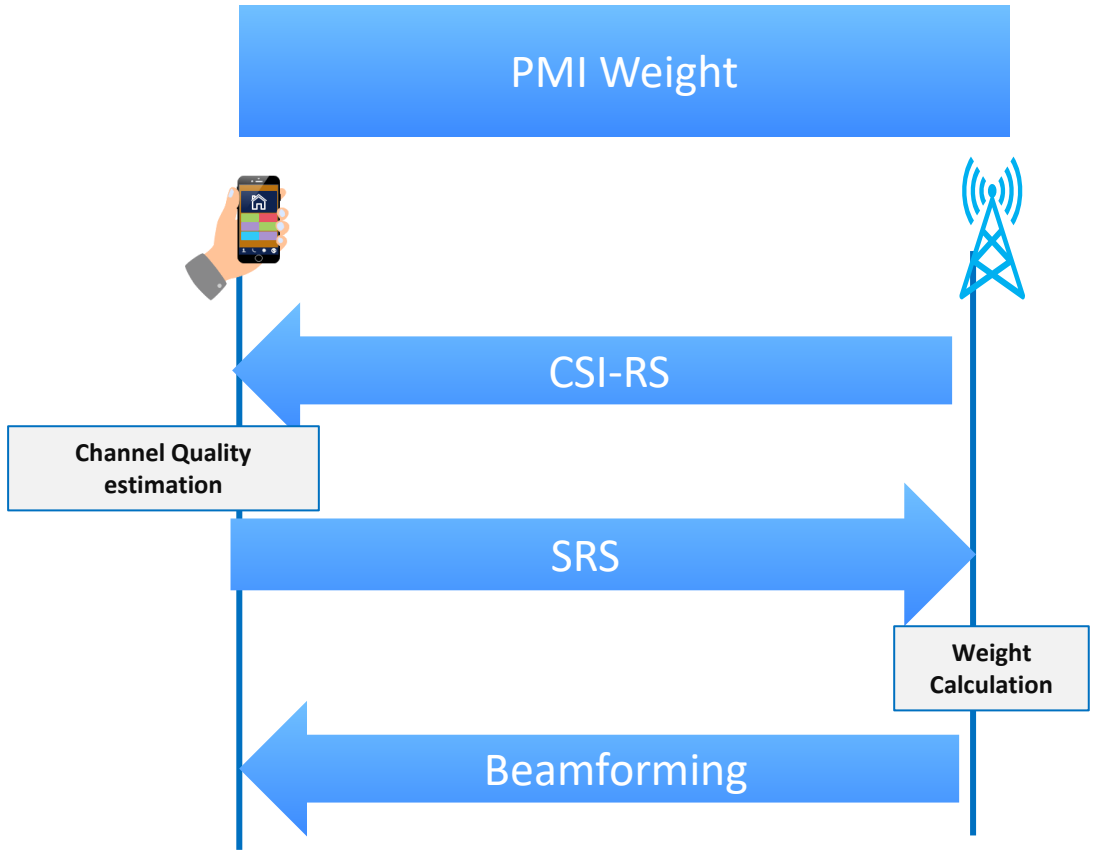
SRS Vs. PMI(CSI-RS) weight obtaining procedure

SRS Vs. PMI(CSI-RS) weight obtaining procedure

- To Adjust the shape and direction of beams, the BTS calculates the weight based on the UE feedback for the DL Channel characteristics





BEAM Selection based on SRS & CSI RS

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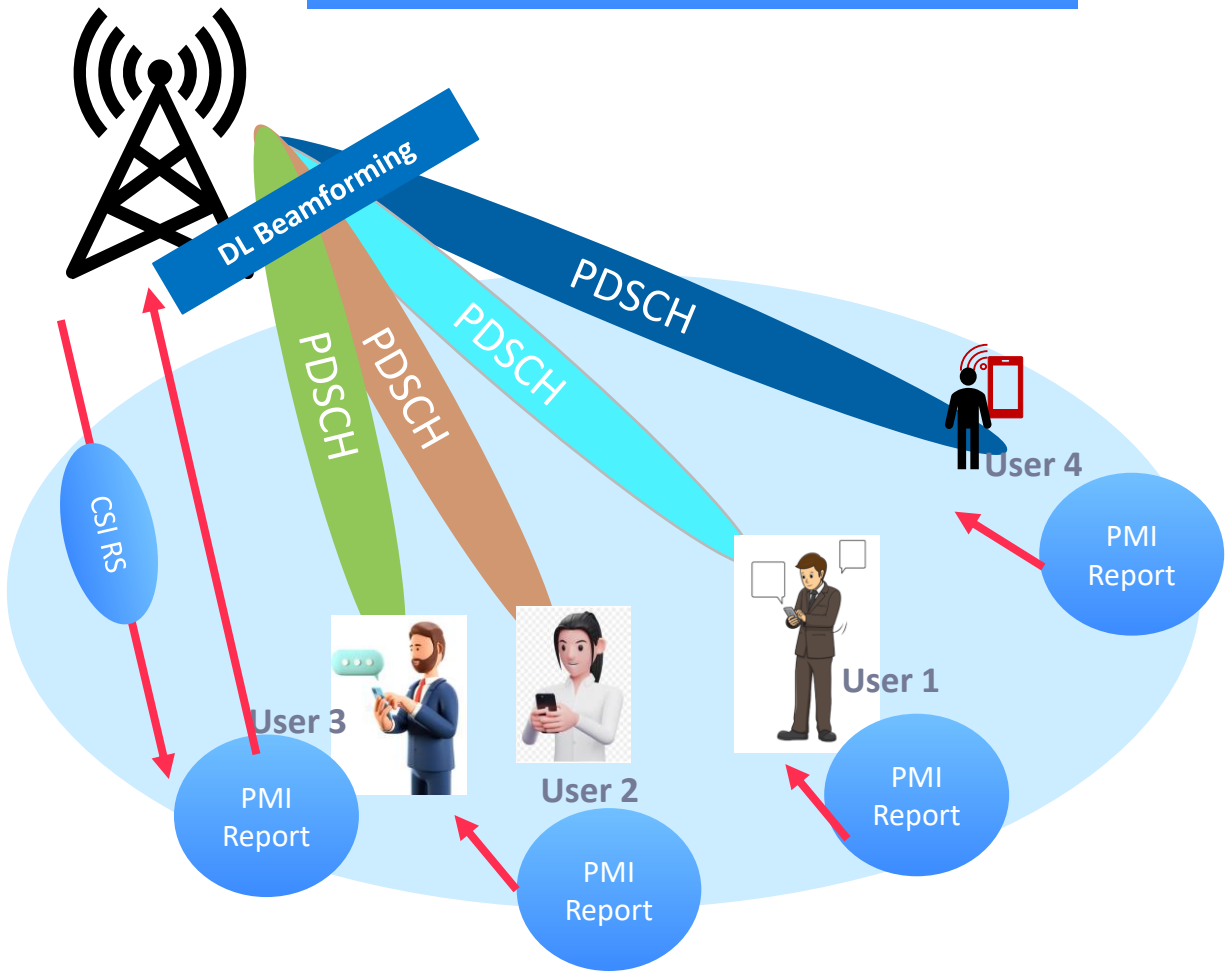
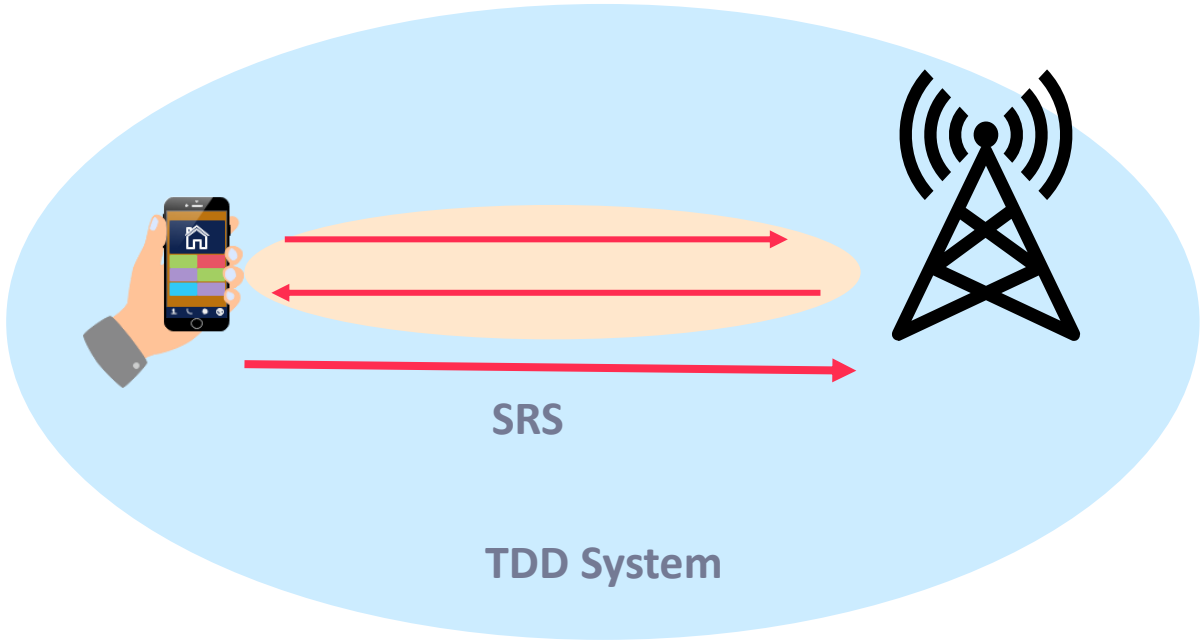
Codebook-based transmission



Reciprocity-based transmission



Same Frequency