3GPP TSG RAN Meeting #79
Chennai, India, March 19 – 22, 2018
Agenda Item:9.5

R1-180377

Views on NR UE capabilities

Huawei, HiSilicon

NR UE Rel-15 Capabilities (1/2)

- Setting mandatory/optional property for Rel-15 NR UE features shall
  - ensure the NR performance
  - avoid ecosystem fragmentation
  - sufficiently consider IoT availability
  - ensure NR commercial timeline

- Proposals:
  - RAN shall start discussing mandatory/optional property of Rel-15 NR UE features in RAN#79 and complete the decision by RAN#80
  - RAN WGs shall continue to discuss and identify any potential forward compatibility issues
  - RAN WGs shall jointly discuss the UE capability types further and finalize the UE capability ASN.1

NR UE Rel-15 Capabilities (2/2)

Huawei proposes mandatory support for at least these features in addition to the basic functions (RP-180377)

1. 60 kHz SCS in bands between 1 and 6 GHz [0-9]
   - Forward compatibility issue
2. CSI-RS based RRM/RLM [1-5/5a/7/8]
   - Better performance than SS based measurement due to wider BW and applicability of narrow beams
3. 4 layer PDSCH reception at the UE [2-2] for FR1 , 2 layer PUSCH transmission at the UE [2-3] for FR1
   - Distinguished performance enhancements vs. 1T2R
4. Both type I DMRS and type II DMRS [2-10/7/8/17/18/18a],
   - Type II DMRS enhances capacity largely by supporting up to 12 layer MU-MIMO. Type I can only support up to 8 layers)
5. A subset (shown in page 10) of Type II feedback schemes [2-41/42/43]

Type II vs Type I feedback		
	Cell average gain	Cell edge gain
4T2R	~18%	~27%
32T2R	~35%	~49%

6. SRS antenna switching [2-55], and SRS carrier-based switching for CA capable UEs [2-56]
   - Proven DL performance enhancements of SRS switching in LTE to compensate the channel information loss due to less antennas in UL than DL, and less activated carriers in UL than DL)
7. Grant-free type I [5-13/14]
   - Large savings of L1 control signaling overhead
8. All LTE-NR coexistence features if UE reports support NR in any band that can be used for LTE [6-15/16/17/18, 5-28]
   - Resolving UL coverage issue, PUCCH feedback timing not limited by UL-DL configurations in NR carrier any more; smooth refarming of LTE to NR

- Besides the above proposed mandatory features, keep the capability for 256QAM for FR2 in Rel-15
  - It is feasible for CPE type UE
  - It provides system benefit in small cell and WTTx scenarios

Mandatory: SUL and UL sharing [6-15/16/17/18/19]

7.5 kHz raster shift, mandatory without capability signaling for LTE re-farmed paired bands and SUL bands [6-15]

- Support LTE/NR UL in-band co-existence, NB-IoT inband operation in NR bands

RACH, PUSCH, PUCCH, SRS in a band combination including SUL, mandatory without capability signaling for UEs supporting SUL [6-16]

- Basic SUL operation

Supplemental uplink with different numerology [6-17]

- Likely deployment of 30kHz in NR band and 15kHz in SUL band, from the currently agreed SUL band combinations

Supplemental uplink with dynamic switch [6-18]

- Significant throughput benefit to allow PUSCH transmitted (via TDM) on both NR and SUL carriers

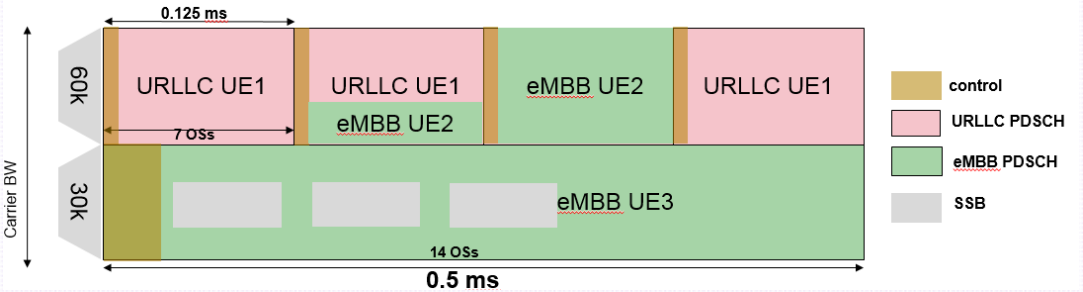
Simultaneous Tx of SRS and PUSCH/PUCCH/SRS on SUL and non-SUL [6-19]

- Optional with UE capability signaling

Mandatory: 60kHz [0-9]

Benefits of 60KHz

- For URLLC
  - › 60kHz numerology can allow for relaxed hardware processing to meet 0.5ms URLLC latency than 30 kHz numerology
  - › 60kHz can provide better performance (2-3dB) than 30kHz with the same mini-slot length



- For eMBB
  - › Better (3-5dB) link performance for high speed scenario
  - › Better (12-16%) user throughput gain for low to medium traffic load
  - › 60kHz agreed as mandatory for mm-wave, it is straight forward to support 60kHz for those UE which support mm-wave
- URLLC coexistence with eMBB
  - › In a carrier, URLLC traffic can be flexibly scheduled in 60kHz BW part
    - » 60kHz numerology provides more flexible scheduling opportunity for URLLC
    - » 60kHz BW part does not contain SSB, hence, resource allocation is less constrained
  - › Regular/Large eMBB traffic can be scheduled in 30kHz or 15kHz BW part with slot-level TTI
  - › For dynamic resource sharing, eMBB traffic can be opportunistically scheduled in 60kHz BW part

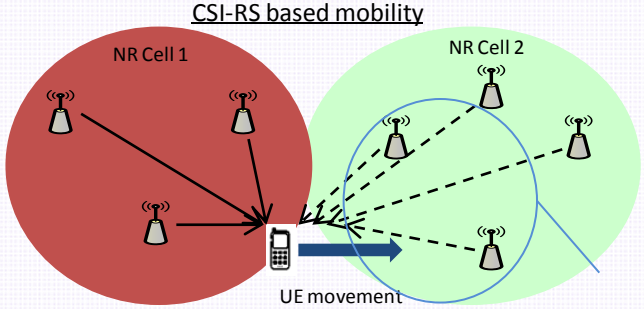
Forward compatibility issues:

- If NR does not support 60kHz SCS, forward compatibility issues would occur for URLLC, eMBB, URLLC and eMBB coexistence

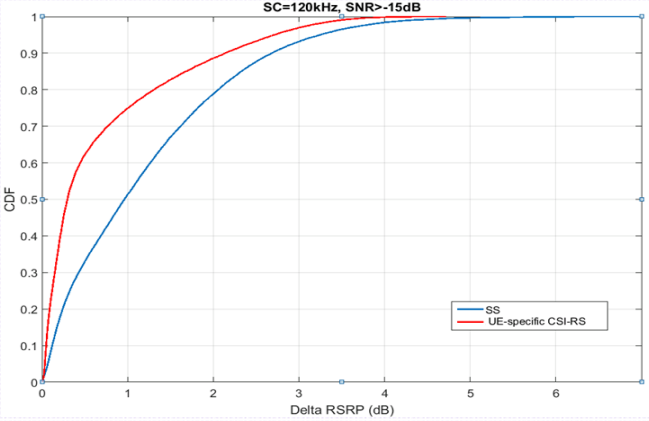
*Reference: R1-1801783

Mandatory: CSI-RS based RRM/RLM [1-5/5a/7/8]

- CSI-RS for RRM and RLM is essential for good system performance
  - Per UE CSI-RS can be configured in wider bandwidth and on a per need basis providing improved RSRP and RSRQ accuracy.
  - Provide an accurate RLM(hypothetical PDCCH BLER) i.e. CSI-RS can be sent in narrower beam compared to SS-RS for RLM.
  - Efficient for NR deployment supporting multi-TRPs per cell when SSB beams from different TRPs are transmitted on the same resources. Target cell can establish the right TRP(s) based on the CSI-RS association with RACH preamble.
  - Allow networks to configure SS Blocks burst set periodicity up to 160ms for power efficient network operations.
  - CSI-RS based RRM/RLM are needed in Scells without SSB for efficient secondary carrier activation/deactivation, e.g. in non-contiguous intra cell CA.



After hand-over, network can immediately establish UE-specific TRP(s) for data communication



CSI-RS can be configured in wider bandwidth "as needed", providing improved RSRP accuracy.

R1-1802081, Discussion on CSI-RS based RRM/RLM as a mandatory feature in Rel-15

Mandatory: DMRS configuration type 2 [2-10/7/8/17/18/18a]

	DMRS configuration Type 1	DMRS configuration type 2
Main Features	• Max 8 orthogonal ports for MU • Max 4/8 ports for DL SU • Comb 2 + 2 CS + (TD-OCC)	• Max 12 orthogonal ports for MU • Max 6/8 ports for DL SU • 2-FD-OCC across adjacent REs + (TD-OCC)
Throughput	Lower throughput performance • Smaller number of ports	Higher throughput performance • Larger number of ports • 15%~20% mean UPT gain for 4Rx UE and 17%~29% mean UPT gain for 8Rx UE
Estimation Performance	Poor performance due to de-spreading loss: • Performance loss compared to type 2 DMRS for large subcarrier spacing scenarios • Performance loss compared to type 2 DMRS for frequency-selective scenarios	Robust performance with higher de-spreading gain: • Benefit to large subcarrier spacing scenarios • Benefit to frequency-selective scenarios • ~1dB SINR gain @60KHz SCS or 1000ns delay spread
Reception Complexity	Higher channel estimation complexity • Limits PRB bundling size	Lower channel estimation complexity • Can support larger bundling size

Mandatory: Type 2 Codebook [2-41/42/43]

- Comparison between type I and type II

Table 1		
Items	NR Type I	NR Type II
Principle of codebook design	beam selection codebook	Beam combination codebook
Feedback overhead	See the table 2	
performance	See the table 3-4	
Supported rank	Rank 1~8	Rank 1~2

Table 2. Overhead comparison				
Payload size for 4 ports				
	Type I		Type II (L=2,W+S,8PSK)	
	WB-reporting	SB-reporting (10 subbands)	WB-reporting	SB-reporting (10 subbands)
Rank 1	5	23(L=1)/42(L=4)	24	135
Rank 2	6	15(L=1)/34(L=4)	44	266
Payload size for 8 ports (wideband)				
	Type I	Type II (L=2, W+S,8PSK)	Type II (L=3, W+S,8PSK)	Type II (L=4, W+S,8PSK)
Rank 1	8	27	39	49
Rank 2	9	47	72	94
Payload size for 8 ports (10 subbands)				
	Type I	Type II (L=2, W+S,8PSK)	Type II (L=3, W+S,8PSK)	Type II (L=4, W+S,8PSK)
Rank 1	26(L=1)/45(L=4)	138	184	268
Rank 2	18(L=1)/37(L=4)	269	362	532

Table 3. Performance of 4T2R					
CSI Type	config	Amp.	Phase	Avg Gain (MB)	Edge Gain (MB)
NR Type I	config1			0.00%	0.00%
	config2			1.51%	4.95%
NR Type II	L=2	Wideband 3bit	QPSK	7.36%	17.56%
		Wideband 3bit + Subband 1bit	QPSK	11.96%	24.36%
		Wideband 3bit	8PSK	12.00%	21.21%
		Wideband 3bit + Subband 1bit	8PSK	17.64%	27.39%

Table 4. Type II vs Type I		
	Cell average gain	Cell edge gain
4T2R	**~18%**	**~27%**
32T2R	**~35%**	**~49%**

Mandatory: Type 2 Codebook [2-41/42/43]

- UE complexity (8T2R, N1=N2=2, O1=O2=4, Rank1 feedback)

	Type I	Type II
WB operation	• Searching the best PMI within all the candidate PMIs by • $H'\begin{bmatrix} b \\ \varphi b \end{bmatrix}$ • N1N2O1O2 candidate b， 4 candidate φ	• Perform SVD decomposition with wideband H to obtain the most significant eigenvector V • Searching the best L (2/3/4) DFT beams within all the beam groups and corresponding candidate DFT beams by • V'b • N1N2O1O2 candidate b • The wideband amplitudes are the amplitude of V'b with the selected L beams
	Complex multiplication in WB: ~**5000**	Complex multiplication in WB: ~**600**
SB operation	• Searching the best PMI within all the candidate PMIs by • $H'\begin{bmatrix} b \\ \varphi b \end{bmatrix}$ • 1/4 candidate b， 4 candidate φ	• Perform SVD decomposition with subband H to obtain the most significant eigenvector V • The subband amplitudes and phases can be obtained by V'b with the selected L beams • V'b • N1N2O1O2 candidate b
	Complex multiplication in SB: ~**300**	Complex multiplication in SB: ~**150**

- *Note: complex multiplication is the most typical criterion to evaluate the UE complexity*

- Taking 10 subbands as an example
  - The total number of complex multiplication with Type I and Type II: 8120 and 2031
  - Compared with Type I, the complexity at UE side for Type II is 25%

Mandatory: Type 2 Codebook [2-41/42/43]

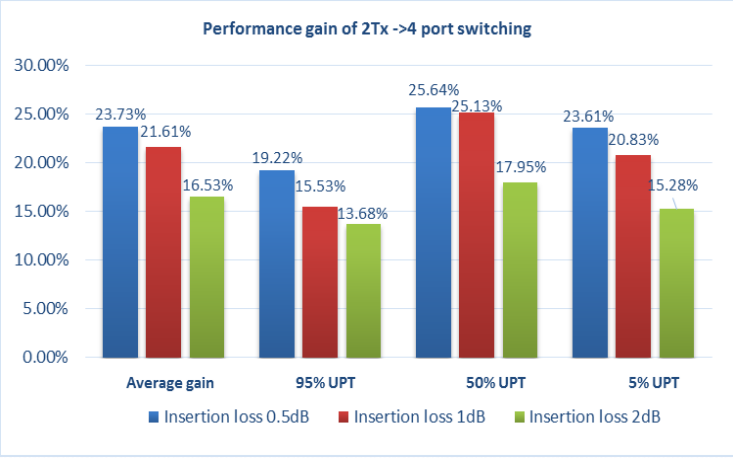
Type II NP- rank1/2					
Paremeters	port number	beam number	subband amplitude	subband phase	View
Value	4	L=2	on/off	QPSK/8PSK	Mandatory
	8	L=2	on/off	QPSK/8PSK	Mandatory
		L=3	on/off	QPSK/8PSK	Mandatory
		L=4	on/off	QPSK/8PSK	Mandatory

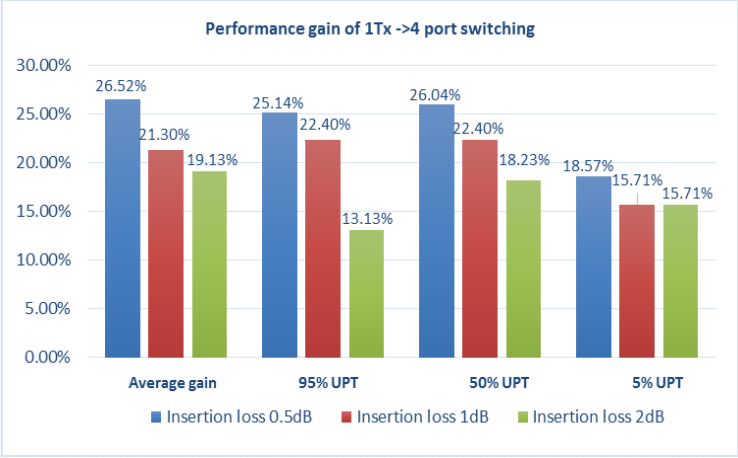
- At least a subset of type II NP codebook (as shown above) is mandatory.

[References] R1-1801809, UE capability of type II codebook, Huawei, HiSilicon, RAN#92

Mandatory: SRS antenna switching [2-55]

- **Support higher rank DL transmission**
  - With 4 Rx at UE side, support up to 4 layers DL transmission.
  - In the TDD case, enable 4 antenna SRS switching (1T→4T or 2T→4T) for obtaining the full rank channel.



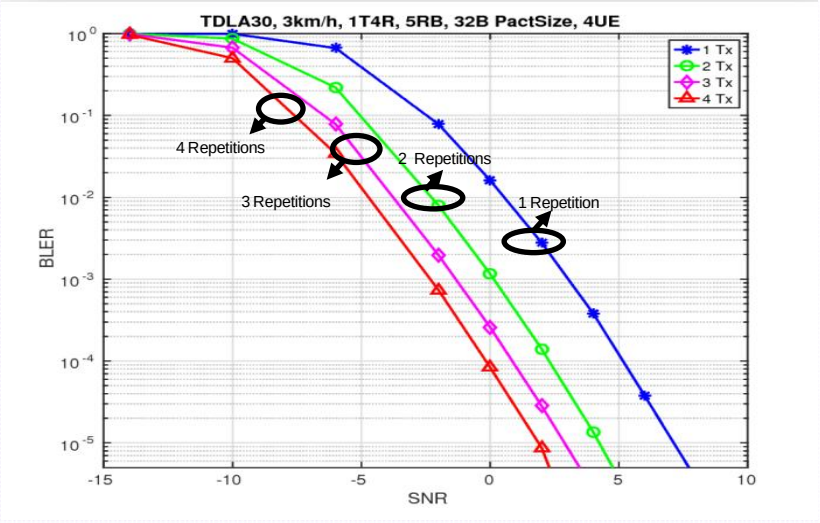


- About 23% mean UPT gain can be observed over 2Tx switching for 2T4R/UE
- About 26% mean UPT gain can be observed over 1Tx switching for 1T4R/UE

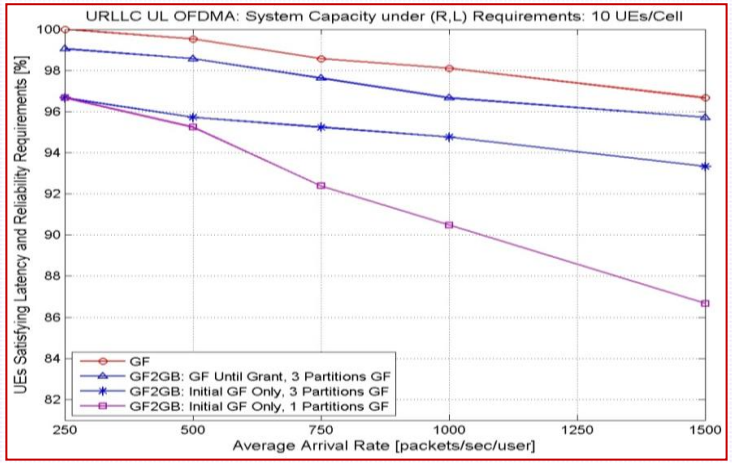
Mandatory: GF Type 1 and repetitions [5-13/14, 5-19] (1/2)

- GF type 1 (all transmission parameters configured by RRC without L1 signaling) is an effective tool to meet the NR latency requirements, for all use cases such as eMBB, URLLC and mMTC
- GF type 1 is also beneficial to URLLC in terms of high reliability and resource utilization
- GF type 1 is also beneficial and forward compatible for mMTC in terms of large energy saving and high resource utilization
- K-repetition within a slot or between slot improves the system coverage and provides higher reliability

Mandatory: GF Type 1 and repetitions [5-13/14, 5-19] (2/2)



Performance improvement by repetition combining



Latency reduction of GF-repetition over GB-Rx

- Proposal: GF Type 1 is mandatory
- Proposal: K repetitions within a slot should be mandatory for GF to ensure low latency with reasonable reliability

Thank you !