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**5G;
NR;
User Equipment (UE) radio access capabilities
(3GPP TS 38.306 version 18.9.0 Release 18)**

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1 Scope

The present document defines the NR UE Radio Access Capability Parameters.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [2] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception Part 1: Range 1 Standalone".
- [3] 3GPP TS 38.101-2: "NR; User Equipment (UE) radio transmission and reception Part 2: Range 2 Standalone".
- [4] 3GPP TS 38.101-3: "NR; User Equipment (UE) radio transmission and reception Part 3: Range 1 and Range 2 Interworking operation with other radios".
- [5] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".
- [6] 3GPP TS 38.211: "NR; Physical channels and modulation".
- [7] 3GPP TS 37.340: "Evolved Universal Terrestrial Radio Access (E-UTRA) and NR Multi-connectivity".
- [8] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification".
- [9] 3GPP TS 38.331: "NR; Radio Resource Control (RRC) protocol specification".
- [10] 3GPP TS 38.212: "NR; Multiplexing and channel coding".
- [11] 3GPP TS 38.213: "NR; Physical layer procedures for control".
- [12] 3GPP TS 38.214: "NR; Physical layer procedures for data".
- [13] 3GPP TS 38.215: "NR; Physical layer measurements".
- [14] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA) radio transmission and reception".
- [15] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access (E-UTRA) User Equipment (UE) radio access capabilities".
- [16] 3GPP TS 38.323: "NR; Packet Data Convergence Protocol (PDCP) specification".
- [17] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA) Radio Resource Control (RRC); Protocol Specification".
- [18] 3GPP TS 38.101-4: "NR; User Equipment (UE) radio transmission and reception Part 4: Performance requirements".
- [19] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures".

- [20] 3GPP TS 25.306: "UE radio access capabilities".
- [21] 3GPP TS 38.304: "User Equipment (UE) procedures in Idle mode and RRC Inactive state".
- [22] 3GPP TS 37.355: "LTE Positioning Protocol (LPP)".
- [23] 3GPP TS 38.340: "NR; Backhaul Adaptation Protocol (BAP) specification".
- [24] 3GPP TR 38.822: "NR; User Equipment (UE) feature list".
- [25] 3GPP TS 37.324: "E-UTRA and NR; Service Data Adaptation Protocol (SDAP) specification"
- [26] 3GPP TS 38.314: "NR; Layer 2 Measurements".
- [27] 3GPP TS 36.133: "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".
- [28] 3GPP TS 38.300: "NR; NR and NG-RAN Overall Description; Stage-2".
- [29] 3GPP TS 26.247: "Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)".
- [30] 3GPP TS 26.114: "IP Multimedia Subsystem (IMS); Multimedia Telephony; Media handling and interaction".
- [31] 3GPP TS 26.118: "Virtual Reality (VR) profiles for streaming applications".
- [32] 3GPP TS 37.213: "Physical layer procedures for shared spectrum channel access".
- [33] 3GPP TS 38.401: "NG-RAN; Architecture description".
- [34] 3GPP TS 38.101-5: "NR; User Equipment (UE) radio transmission and reception; Part 5: Satellite access Radio Frequency (RF) and performance requirements".
- [35] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception".
- [36] 3GPP TS 38.322: "NR; Radio Link Control (RLC) protocol specification".
- [37] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

eRedCap UE: a UE with enhanced reduced capabilities as specified in clause 4.2.22.1.

Fallback band combination: A Uu band combination that would result from another Uu band combination (parent band combination) by releasing at least one SCell or uplink configuration of SCell, or SCG, or SUL. A PC5 band combination that would result from another PC5 band combination (parent band combination) by releasing at least one sidelink carrier. An intra-band non-contiguous band combination is not considered to be a fallback band combination of an intra-band contiguous band combination. A fallback band combination supports the same channel bandwidth(s) for each carrier as its parent band combination(s).

Fallback per band feature set: A feature set per band that has same or lower capabilities than the reported capabilities from the reported feature set per band for a given band.

Fallback per CC feature set: A feature set per CC that has same or lower capabilities than the capabilities of UE (e.g. supported MIMO layers, BW, modulation order) while keeping the numerology the same from the reported feature set per CC for a given carrier per band. The *supportedMinBandwidthDL/supportedMinBandwidthUL* defines the lower bound of the bandwidth supported by the UE.

RedCap UE: The UE with reduced capabilities as specified in clause 4.2.21.1.

SON report(s): A SON report corresponds to one report from UE such as Random Access report, Radio Link Failure report, Connection Establishment Failure report, Mobility History Information report, Successful Handover report, and Successful PSCell change report.

Switching SCell (sSCell): The SCell configured with cross-carrier scheduling to PCell/PSCell.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

MaxDLDataRate:	Maximum DL data rate
MaxDLDataRate_MN:	Maximum DL data rate in the MN
MaxDLDataRate_SN:	Maximum DL data rate in the SN
MaxULDataRate:	Maximum UL data rate
MaxSLtxDataRate:	Maximum SL data rate in transmission
MaxSLrxDataRate:	Maximum SL data rate in reception

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

A-CSI	Aperiodic-CSI
ATG	Air To Ground
BAP	Backhaul Adaptation Protocol
BC	Band Combination
BPS	Body Proximity Sensing
BT	Bluetooth
CCS	Cross Carrier Scheduling
CMR	Channel Measurement Resource
CPAC	Conditional PSCell Addition/Change
DAPS	Dual Active Protocol Stack
DL	Downlink
DSR	Delay Status Report
EHC	Ethernet Header Compression
FS	Feature Set
FSPC	Feature Set Per Component-carrier
GSO	Geosynchronous Orbit
HSDN	High Speed Dedicated Network
IAB-MT	Integrated Access Backhaul Mobile Termination
IDC	In-Device Coexistence
MAC	Medium Access Control
MHI	Mobility History Information
MBS	Multicast/Broadcast Service
MCG	Master Cell Group
MN	Master Node
MO-SDT	Mobile Originated Small Data Transmission
MRB	MBS Radio Bearer
MR-DC	Multi-Radio Dual Connectivity
MSD	Maximum Sensitivity Degradation
MT-SDT	Mobile Terminated Small Data Transmission
mTRP	Multiple TRP
MUSIM	Multi-Universal Subscriber Identity Module
NCJT	Non-Coherent Joint Transmission
NCR	Network Controlled Repeater
NCR-MT	NCR Mobile Termination
NCSG	Network Controlled Small Gap
NES	Network Energy Savings

NGSO	Non-Geosynchronous Orbit
NTN	Non-Terrestrial Network
P-CSI	Periodic CSI
PDCP	Packet Data Convergence Protocol
PSI	PDU Set Importance
QoE	Quality of Experience
RLC	Radio Link Control
RTT	Round Trip Time
SCG	Secondary Cell Group
SDAP	Service Data Adaptation Protocol
SDL	Supplementary Downlink
SN	Secondary Node
sTRP	Serving TRP
SUL	Supplementary Uplink
TN	Terrestrial Network
TRP	Transmit/Receive Point
UDC	Uplink Data Compression
UL	Uplink
VSAT	Very Small Aperture Terminal
WLAN	Wireless Local Area Network
XR	eXtended Reality

4 UE radio access capability parameters

4.1 Supported max data rate

4.1.1 General

The DL, UL and SL max data rate supported by the UE is calculated by band or band combinations supported by the UE. A UE supporting NR (NR SA, MR-DC) shall support the calculated DL and UL max data rate defined in 4.1.2. A UE supporting NR sidelink communication shall support the calculated SL max data rate defined in 4.1.5.

4.1.2 Supported max data rate for DL/UL

For NR, the approximate data rate for a given number of aggregated carriers in a band or band combination is computed as follows.

$$\text{data rate (in Mbps)} = 10^{-6} \cdot \sum_{j=1}^J \left(v_{\text{Layers}}^{(j)} \cdot Q_m^{(j)} \cdot f^{(j)} \cdot R_{\text{max}} \cdot \frac{N_{\text{PRB}}^{\text{BW}(j),\mu} \cdot 12}{T_s^{\mu}} \cdot (1 - OH^{(j)}) \right)$$

wherein

J is the number of aggregated component carriers in a band or band combination

$R_{\text{max}} = 948/1024$

For the j-th CC,

$v_{\text{Layers}}^{(j)}$ is the maximum number of supported layers given by *maxNumberMIMO-LayersPDSCH* for downlink and maximum of *maxNumberMIMO-LayersCB-PUSCH* and *maxNumberMIMO-LayersNonCB-PUSCH* for uplink.

$Q_m^{(j)}$ is the maximum supported modulation order given by *supportedModulationOrderDL* for downlink and *supportedModulationOrderUL* for uplink.

$f^{(j)}$ is the scaling factor given by *scalingFactor* or *scalingFactor-1024QAM-FR1* and can take the values 1, 0.8, 0.75, and 0.4.

μ is the numerology (as defined in TS 38.211 [6])

T_s^μ is the average OFDM symbol duration in a subframe for numerology μ , i.e. $T_s^\mu = \frac{10^{-3}}{14 \cdot 2^\mu}$. Note that normal cyclic prefix is assumed.

$N_{PRB}^{BW(j),\mu}$ is the maximum RB allocation in bandwidth $BW^{(j)}$ with numerology μ , as defined in 5.3 TS 38.101-1 [2], 5.3 TS 38.101-2 [3], and 5.3 TS 38.101-5 [34], where $BW^{(j)}$ is the UE supported maximum bandwidth in the given band or band combination.

$OH^{(j)}$ is the overhead and takes the following values

- 0.14, for frequency range FR1 for DL
- 0.18, for frequency range FR2 for DL
- 0.08, for frequency range FR1 for UL
- 0.10, for frequency range FR2 for UL

NOTE 1: Only one of the UL or SUL carriers (the one with the higher data rate) is counted for a cell operating SUL.

NOTE 2: For UL Tx switching between carriers, only the supported MIMO layer combination across carriers that results in the highest combined data rate is counted for the carriers in the supported maximum UL data rate.

The approximate maximum data rate can be computed as the maximum of the approximate data rates computed using the above formula for each of the supported band or band combinations. For the CCs where UE supports *pdsch-1024QAM-2MIMO-FR1-r17* for the concerned band, data rate shall be derived as maximum what UE would support if using 1024 QAM (when *mcs-Table-r17* or *mcs-TableDCI-1-2-r17* is configured) or 256 QAM.

For single carrier NR SA operation and except for UEs supporting *supportOfRedCap-r18*, the UE shall support a data rate for the carrier that is no smaller than the data rate computed using the above formula, with $J = 1$ CC and component $v_{Layers}^{(j)} \cdot Q_m^{(j)} \cdot f^{(j)}$ is no smaller than 4.

NOTE 3: As an example, the value 4 in the component above can correspond to $v_{Layers}^{(j)} = 1$, $Q_m^{(j)} = 4$ and $f^{(j)} = 1$.

For single carrier NR SA operation and for UEs supporting *supportOfRedCap-r18*, the UE shall support a data rate for the carrier that is the data rate computed using the above formula, with $J = 1$ CC and:

if the UE supports *eRedCapNotReducedBB-BW-r18*:

- component $v_{Layers}^{(j)} \cdot Q_m^{(j)} \cdot f^{(j)}$ is 0.75 if $v_{Layers}^{(j)} = 1$, or;
- component $v_{Layers}^{(j)} \cdot Q_m^{(j)} \cdot f^{(j)}$ is 0.8 if $v_{Layers}^{(j)} = 2$;

else:

- component $v_{Layers}^{(j)} \cdot Q_m^{(j)} \cdot f^{(j)}$ is 3.2, and;;
- $N_{PRB}^{BW(j),\mu}$ is 25 if $\mu = 0$ or, 12 if $\mu = 1$;

For EUTRA in case of MR-DC, the approximate data rate for a given number of aggregated carriers in a band or band combination is computed as follows.

$$\text{Data rate (in Mbps)} = 10^{-3} \cdot \sum_{j=1}^J TBS_j$$

wherein

J is the number of aggregated EUTRA component carriers in MR-DC band combination

TBS_j is the total maximum number of DL-SCH transport block bits received or the total maximum number of UL-SCH transport block bits transmitted, within a 1ms TTI for j-th CC, as derived from TS 36.213 [19] based on the UE supported maximum MIMO layers for the j-th CC, and based on the maximum modulation order for the j-th CC and number of PRBs based on the bandwidth of the j-th CC according to indicated UE capabilities.

The approximate maximum data rate can be computed as the maximum of the approximate data rates computed using the above formula for each of the supported band or band combinations.

For MR-DC, the approximate maximum data rate is computed as the sum of the approximate maximum data rates from NR and EUTRA.

4.1.3 Void

4.1.4 Total layer 2 buffer size for DL/UL

The total layer 2 buffer size is defined as the sum of the number of bytes that the UE is capable of storing in the RLC transmission windows and RLC reception and reassembly windows and also in PDCP reordering windows for all radio bearers.

The required total layer 2 buffer size in MR-DC is the maximum value of the calculated values based on the following equations:

- $MaxULDataRate_MN * RLCRTT_MN + MaxULDataRate_SN * RLCRTT_SN + MaxDLDataRate_SN * RLCRTT_SN + MaxDLDataRate_MN * (RLCRTT_SN + X2/Xn\ delay + Queuing\ in\ SN)$
- $MaxULDataRate_MN * RLCRTT_MN + MaxULDataRate_SN * RLCRTT_SN + MaxDLDataRate_MN * RLCRTT_MN + MaxDLDataRate_SN * (RLCRTT_MN + X2/Xn\ delay + Queuing\ in\ MN)$

Otherwise it is calculated by $MaxDLDataRate * RLC\ RTT + MaxULDataRate * RLC\ RTT$.

NOTE: Additional L2 buffer required for preprocessing of data is not taken into account in above formula.

The required total layer 2 buffer size is determined as the maximum total layer 2 buffer size of all the calculated ones for each band combination and the applicable Feature Set combination in the supported MR-DC or NR band combinations. The RLC RTT for NR cell group corresponds to the smallest SCS numerology supported in the band combination and the applicable Feature Set combination.

wherein

$X2/Xn\ delay + Queuing\ in\ SN = 25ms$ if SCG is NR, and $55ms$ if SCG is EUTRA

$X2/Xn\ delay + Queuing\ in\ MN = 25ms$ if MCG is NR, and $55ms$ if MCG is EUTRA

RLC RTT for EUTRA cell group = $75ms$

RLC RTT for NR cell group is defined in Table 4.1.4-1

Table 4.1.4-1: RLC RTT for NR cell group per SCS

SCS (kHz)	RLC RTT (ms)
15KHz	50
30KHz	40
60KHz	30
120KHz	20
480KHz	20
960KHz	20

4.1.5 Supported max data rate for SL

For NR sidelink, the approximate data rate is computed as follows.

$$\text{data rate (in Mbps)} = 10^{-6} \cdot v_{layers} \cdot Q_m \cdot f \cdot R_{max} \cdot \frac{N_{PRB}^{BW,\mu} \cdot 12}{T_s^\mu} \cdot (1 - OH)$$

wherein

$$R_{\max} = 948/1024,$$

v_{Layers} is the the maximum number of supported layers for sidelink transmission (or reception) given by UE capability on supporting rank 2 PSSCH transmission and *rankTwoReception*,

Q_m is the maximum supported modulation order between 6 or 8 given by *sl-Tx-256QAM* and *sl-Rx-256QAM*,

f is the scaling factor for sidelink transmission and reception given by *scalingFactorTxSidelink* and *scalingFactorRxSidelink* respectively, as specified in TS 36.331 [17] and TS 38.331 [9], and can take the values 1, 0.8, 0.75, and 0.4.

μ is the numerology (as defined in TS 38.211 [6])

T_s^μ is the average OFDM symbol duration in a subframe for numerology μ , i.e. $T_s^\mu = \frac{10^{-3}}{14 \cdot 2^\mu}$. Note that normal cyclic prefix is assumed.

$N_{PRB}^{BW, \mu}$ is the maximum possible RB allocation in bandwidth BW for PSSCH, where BW is the UE supported maximum bandwidth in the given band or band combination,

OH is the overhead and takes the following values

0.217, for frequency range FR1 for SL
0.25, for frequency range FR2 for SL

4.1.6 Total layer 2 buffer size for NR SL

The total layer 2 buffer size for NR sidelink communication is defined as the sum of the number of bytes that the UE is capable of storing in the RLC transmission windows and RLC reception and reassembly windows and also in PDCP reordering windows for all radio bearers for NR sidelink communication.

The required total layer 2 buffer size for NR sidelink communication is the maximum value of the calculated values based on the following equations:

$$MaxSLtxDataRate * RLC\ RTT + MaxSLrxDataRate * RLC\ RTT.$$

NOTE: Additional L2 buffer required for preprocessing of data is not taken into account in above formula.

The required total layer 2 buffer size for NR sidelink communication is determined as the maximum total layer 2 buffer size of all the calculated ones for each band combination and the applicable Feature Set combination in the supported NR sidelink band combinations. The RLC RTT for NR sidelink communication corresponds to the smallest SCS numerology supported in the band combination and the applicable Feature Set combination.

wherein

RLC RTT for NR sidelink communication is defined in Table 4.1.6-1

Table 4.1.6-1: RLC RTT for NR sidelink communication per SCS

SCS (kHz)	RLC RTT (ms)
15KHz	200
30KHz	100
60KHz	50
120KHz	25

4.2 UE Capability Parameters

4.2.1 Introduction

The following clauses define the UE radio access capability parameters. Only parameters for which there is the possibility for UEs to signal different values are considered as UE radio access capability parameters. Therefore, mandatory features without capability parameters that are the same for all UEs are not listed here.

The network needs to respect the signalled UE radio access capability parameters when configuring the UE and when scheduling the UE.

For capabilities that required to be set consistently for all FDD-FR1 bands (i.e. capabilities that are supposed to be per UE), the UE shall also set capability values for all SUL bands with same values for FDD-FR1 bands if SUL band is supported by the UE.

The UE may support different functionalities between FDD and TDD, and/or between FR1 and FR2. The UE shall indicate the UE capabilities as follows. In the table of UE capability parameter in subsequent clauses, "Yes" in the column by "FDD-TDD DIFF" and "FR1-FR2 DIFF" indicates the UE capability field can have a different value for between FDD and TDD or between FR1 and FR2 and "No" indicates if it cannot. "(Incl FR2-2 DIFF)" in the column by "FR1-FR2 DIFF" indicates the UE capability field can have a different value for between FR2-1 and FR2-2. Regarding to the per UE capabilities that are FDD/TDD differentiated (i.e. capabilities indicated as "Yes" in the column by "FDD-TDD DIFF"), the corresponding capabilities indicated by the FDD capability is applied to SUL/SDL if SUL/SDL band is supported by the UE. "FD" in the column indicates to refer the associated field description. "FR1 only" or "FR2 only" in the column indicates the associated feature is only supported in FR1 or FR2 and "TDD only" indicates the associated feature is only supported in TDD and not applicable to SUL/SDL carriers. "N/A" in the column indicates it is not applicable to the feature (e.g. the signalling supports the UE to have different values between FDD and TDD or between FR1 and FR2).

- 1> set all fields of UE-NR/MRDC-Capability except fdd-Add-UE-NR/MRDC/Sidelink-Capabilities, tdd-Add-UE-NR/MRDC/Sidelink-Capabilities, fr1-Add-UE-NR/MRDC-Capabilities and fr2-Add-UE-NR/MRDC-Capabilities, to include the values applicable for all duplex mode(s) and frequency range(s) that the UE supports;
- 1> if UE supports both FDD (or SUL/SDL) and TDD and if (some of) the UE capability fields have a different value for FDD (or SUL/SDL) and TDD:
 - 2> if for FDD (and, if the UE supports SUL/SDL, for SUL/SDL), the UE supports additional functionality compared to what is indicated by the previous fields of UE-NR/MRDC-Capability/SidelinkParameters:
 - 3> include field fdd-Add-UE-NR/MRDC/Sidelink-Capabilities and set it to include fields reflecting the additional functionality applicable for FDD;
 - 2> if for TDD, the UE supports additional functionality compared to what is indicated by the previous fields of UE-NR/MRDC-Capability/SidelinkParameters:
 - 3> include field tdd-Add-UE-NR/MRDC/Sidelink-Capabilities and set it to include fields reflecting the additional functionality applicable for TDD;
- 1> if UE supports both FR1 and FR2 and if (some of) the UE capability fields have a different value for FR1 and FR2:
 - 2> if for FR1, the UE supports additional functionality compared to what is indicated by the previous fields of UE-NR/MRDC-Capability:
 - 3> include field fr1-Add-UE-NR/MRDC-Capabilities and set it to include fields reflecting the additional functionality applicable for FR1;
 - 2> if for FR2, the UE supports additional functionality compared to what is indicated by the previous fields of UE-NR/MRDC-Capability:
 - 3> include field fr2-Add-UE-NR/MRDC-Capabilities and set it to include fields reflecting the additional functionality applicable for FR2;

NOTE 1: The fields which indicate "shall be set to 1" or "shall be set to *supported*" in the following tables means these features are purely mandatory and are assumed they are the same as mandatory without capability signalling.

NOTE 2: For the case where the UE is allowed to support different functionality between FDD and TDD and between FR1 and FR2 according to the specification, the UE capability indication is clarified in Annex B.

NOTE 2a: In this release of the specification, if the UE is allowed to support different functionalities between FDD and TDD, and/or between FR1 and FR2, these functionalities are signalled per band with the text "UE shall set the capability value consistently for all FDD-FR1 bands, all TDD-FR1 bands, all TDD-FR2-1 bands and all TDD-FR2-2 bands respectively".