**3GPP TSG-RAN2 Meeting #109-eR2-20XXXXX**

**24 February – 6 March 2020**

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| *CR-Form-v12.0* |
| **CHANGE REQUEST** |
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|  | **38.321** | **CR** | **0698** | **rev** | **1** | **Current version:** | **15.8.0** |  |
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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network | **X** | Core Network |  |

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| ***Title:***  | Introduction of NR IIOT |
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| ***Source to WG:*** | Samsung |
| ***Source to TSG:*** | R2 |
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|  |  |
| ***Work item code:*** | NR\_IIOT-Core |  | ***Date:*** | 2020-03-06 |
|  |  |  |  |  |
| ***Category:*** | **B** |  | ***Release:*** | Rel-16 |
|  | *Use one of the following categories:****F*** *(correction)****A*** *(mirror corresponding to a change in an earlier release)****B*** *(addition of feature),* ***C*** *(functional modification of feature)****D*** *(editorial modification)*Detailed explanations of the above categories canbe found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)Rel-12 (Release 12)**Rel-13 (Release 13)Rel-14 (Release 14)Rel-15 (Release 15)Rel-16 (Release 16)* |
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| ***Reason for change:*** | MAC specification should capture agreements of NR IIOT WI, including- In Rel-16, SPS periodicity is configured in the unit of slot.- A new prioritization rule based on logical channel priority and data availability was agreed for both SR-Data prioritization and Data(CG)-Data(CG or DG) conflicts. A new rule for determining the prioritiy of each uplink grant shoud be also introduced.- As multiple SPS/CG configurations were introduced, the offset of HARQ process was agreed.- UE autonomous retransmission using subsequent CG resource with the same HARQ process is introduced for a MAC PDU which was deprioritized but already generated was agreed.- New LCP restrictions, *allowedCG-List* and *allowedPHY-PriorityIndex*, were agreed.- Any integer multiple of slot of CG periodicity was agreed. Current formulas on CG occasion are applicable only for devisior or 10240ms.- Multiple Entry Configured Grant Confirmation MAC CE was agreed to support muliple active CG configurations. It was agreed to include only bitmap field which indicates confirmation status of each configured grant.- Priority order of Multiple Entry CG confirmation MAC CE is needed for multiplexing.- A new MAC CE of single byte format indicating RLC entities which are used for PDCP duplication was agreed. The corresponding UE behavior upon reception of this MAC CE should be specified.- In addtion to the new MAC CE, RRC can indicates which RLC entities are used for PDCP duplication. - For the new Configured Grant Confirmation MAC CE and the new Duplication Activation/Deactivation MAC CE, each MAC CE uses a new LCID value. |
|  |  |
| ***Summary of change:*** | Agreements in IIOT WI were captured:- In 4.4, priority handling between overlapping resources of one UE is added as a MAC function.- In 5.3.1, a new formula on HARQ process ID for DL SPS where periodicity of slot and *harq-procID-offset* are used is added.- In 5.4.1, a new configuration *lch-basedPrioritization* indicating to use Rel-16 prioritization based on logical channel priority is introduced.- In 5.4.1, a new formula on HARQ process ID for UL CG where *harq-procID-offset* is used is introduced.- In 5.4.1, priority value determination for a uplink grant based on logical channel priority and data availability is specified.- In 5.4.1, prioritization rule for a resource conflict based on priority of an uplink grant and LCH priority which triggered the SR is specified. This rule is applicable for both SR-Data prioritization and Data (CG)-Data (CG or DG) prioritization.- In 5.4.2.1, deprioritization is speficied: A MAC PDU is not obtained if the corresponding grant is deprioritized and the MAC PDU has not been already obtained.- In 5.4.2.1, UE autonomous retransmission using the same HARQ process is specified: if it was deprioritized in the previous configured grant, the MAC PDU is considered as it has been obtained.- In 5.4.3.1.1 and 5.4.3.1.2, new LCP restrictions, i.e. *allowedCG-List* and *allowedPHY-PriorityIndex* are introduced.- In 5.4.3.1.3, priority order of the new confirmation MAC CE, Multiple Entry Configured Grant Confirmation MAC CE is specified.- In 5.4.4, prioritization rule for a resource conflict for SR-Data prioritization is specified.- In 5.8.1, the description to support the multiple active SPS configurations in the same BWP and *harq-procID-offset* is introduced.- In 5.8.2, the description to support the multiple active configured grant configurations in the same BWP and *harq-procID-offset* is introduced. - In 5.8.2, formulas on CG occasion are updated to consider sequantiall Nth uplink grant. For type 1 configured grant, *timeReferenceSFN* to indicate the offset of the reception of CG configuration is introduced. - In 5.10, UE behavior upon reception of Duplication RLC Activation/Deactivation MAC CE is specified.- In 6.1.3.X, Multiple Entry Configured Grant Confirmation MAC CE format is introduced. - In 6.1.3.Y, Duplication RLC Activation/Deactivation MAC CE is introduced.- In 6.2.1, one downlink LCID value is reserved for Duplication RLC Activation/Deactivation MAC CE.- In 6.2.1, one uplink LCID value is reserved for Multiple Entry Configured Grant Confirmation MAC CE.  |
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| ***Consequences if not approved:*** | New MAC functions for IIOT are not supported. |
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| ***Clauses affected:*** | 4.4, 5.3.1, 5.4.1, 5.4.2.1, 5.4.3.1.1, 5.4.3.1.2, 5.4.3.1.3, 5.4.4, 5.8.1, 5.8.2, 5.10, 6.1.3.X, 6.1.3.Y, 6.2.1 |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** |  | **X** |  Other core specifications  | TS/TR ... CR ...  |
| ***affected:*** |  | **X** |  Test specifications | TS/TR ... CR ...  |
| ***(show related CRs)*** |  | **X** |  O&M Specifications | TS/TR ... CR ...  |
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| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

Start of changes

4.4 Functions

The MAC sublayer supports the following functions:

- mapping between logical channels and transport channels;

- multiplexing of MAC SDUs from one or different logical channels onto transport blocks (TB) to be delivered to the physical layer on transport channels;

- demultiplexing of MAC SDUs to one or different logical channels from transport blocks (TB) delivered from the physical layer on transport channels;

- scheduling information reporting;

- error correction through HARQ;

- logical channel prioritisation;

- priority handling between overlapping resources of one UE.

The relevance of MAC functions for uplink and downlink is indicated in Table 4.4-1.

**Table 4.4-1: The link direction association of MAC functions.**

|  |  |  |
| --- | --- | --- |
| **MAC function** | **Downlink** | **Uplink** |
| Mapping between logical channels and transport channels | X | X |
| Multiplexing |  | X |
| Demultiplexing | X |  |
| Scheduling information reporting |  | X |
| Error correction through HARQ | X | X |
| Logical Channel prioritisation |  | X |

Next change

5.3 DL-SCH data transfer

5.3.1 DL Assignment reception

Downlink assignments received on the PDCCH both indicate that there is a transmission on a DL-SCH for a particular MAC entity and provide the relevant HARQ information.

When the MAC entity has a C-RNTI, Temporary C-RNTI, or CS-RNTI, the MAC entity shall for each PDCCH occasion during which it monitors PDCCH and for each Serving Cell:

1> if a downlink assignment for this PDCCH occasion and this Serving Cell has been received on the PDCCH for the MAC entity's C-RNTI, or Temporary C‑RNTI:

2> if this is the first downlink assignment for this Temporary C-RNTI:

3> consider the NDI to have been toggled.

2> if the downlink assignment is for the MAC entity's C-RNTI, and if the previous downlink assignment indicated to the HARQ entity of the same HARQ process was either a downlink assignment received for the MAC entity's CS-RNTI or a configured downlink assignment:

3> consider the NDI to have been toggled regardless of the value of the NDI.

2> indicate the presence of a downlink assignment and deliver the associated HARQ information to the HARQ entity.

1> else if a downlink assignment for this PDCCH occasion has been received for this Serving Cell on the PDCCH for the MAC entity's CS-RNTI:

2> if the NDI in the received HARQ information is 1:

3> consider the NDI for the corresponding HARQ process not to have been toggled;

3> indicate the presence of a downlink assignment for this Serving Cell and deliver the associated HARQ information to the HARQ entity.

2> if the NDI in the received HARQ information is 0:

3> if PDCCH contents indicate SPS deactivation:

4> clear the configured downlink assignment for this Serving Cell (if any);

4> if the *timeAlignmentTimer*, associated with the TAG containing the Serving Cell on which the HARQ feedback is to be transmitted, is running:

5> indicate a positive acknowledgement for the SPS deactivation to the physical layer.

3> else if PDCCH content indicates SPS activation:

4> store the downlink assignment for this Serving Cell and the associated HARQ information as configured downlink assignment;

4> initialise or re-initialise the configured downlink assignment for this Serving Cell to start in the associated PDSCH duration and to recur according to rules in clause 5.8.1;

For each Serving Cell and each configured downlink assignment, if configured and activated, the MAC entity shall:

1> if the PDSCH duration of the configured downlink assignment does not overlap with the PDSCH duration of a downlink assignment received on the PDCCH for this Serving Cell:

2> instruct the physical layer to receive, in this PDSCH duration, transport block on the DL-SCH according to the configured downlink assignment and to deliver it to the HARQ entity;

2> set the HARQ Process ID to the HARQ Process ID associated with this PDSCH duration;

2> consider the NDI bit for the corresponding HARQ process to have been toggled;

2> indicate the presence of a configured downlink assignment and deliver the stored HARQ information to the HARQ entity.

For configured downlink assignments without *harq-procID-offset*, the HARQ Process ID associated with the slot where the DL transmission starts is derived from the following equation:

HARQ Process ID = [floor (CURRENT\_slot × 10 / (*numberOfSlotsPerFrame* × *periodicity*))] modulo *nrofHARQ-Processes*

where CURRENT\_slot = [(SFN × *numberOfSlotsPerFrame*) + slot number in the frame] and *numberOfSlotsPerFrame* refers to the number of consecutive slots per frame as specified in TS 38.211 [8].

For configured downlink assignments with *harq-procID-offset*, the HARQ Process ID associated with the slot where the DL transmission starts is derived from the following equation:

HARQ Process ID = [floor (CURRENT\_slot / *periodicity*)] modulo *nrofHARQ-Processes* + *harq-procID-offset*where CURRENT\_slot = [(SFN × *numberOfSlotsPerFrame*) + slot number in the frame] and *numberOfSlotsPerFrame* refers to the number of consecutive slots per frame as specified in TS 38.211 [8].

When the MAC entity needs to read BCCH, the MAC entity may, based on the scheduling information from RRC:

1> if a downlink assignment for this PDCCH occasion has been received on the PDCCH for the SI-RNTI;

2> indicate a downlink assignment and redundancy version for the dedicated broadcast HARQ process to the HARQ entity.

Next change

5.4 UL-SCH data transfer

5.4.1 UL Grant reception

Uplink grant is either received dynamically on the PDCCH, in a Random Access Response, or configured semi-persistently by RRC. The MAC entity shall have an uplink grant to transmit on the UL-SCH. To perform the requested transmissions, the MAC layer receives HARQ information from lower layers. An uplink grant addressed to CS-RNTI with NDI = 0 is considered as a configured uplink grant. An uplink grant addressed to CS-RNTI with NDI = 1 is considered as a dynamic uplink grant.

If the MAC entity has a C-RNTI, a Temporary C-RNTI, or CS-RNTI, the MAC entity shall for each PDCCH occasion and for each Serving Cell belonging to a TAG that has a running *timeAlignmentTimer* and for each grant received for this PDCCH occasion:

1> if an uplink grant for this Serving Cell has been received on the PDCCH for the MAC entity's C-RNTI or Temporary C-RNTI; or

1> if an uplink grant has been received in a Random Access Response:

2> if the uplink grant is for MAC entity's C-RNTI and if the previous uplink grant delivered to the HARQ entity for the same HARQ process was either an uplink grant received for the MAC entity's CS-RNTI or a configured uplink grant:

3> consider the NDI to have been toggled for the corresponding HARQ process regardless of the value of the NDI.

2> if the uplink grant is for MAC entity's C-RNTI, and the identified HARQ process is configured for a configured uplink grant:

3> start or restart the *configuredGrantTimer* for the correponding HARQ process, if configured.

2> deliver the uplink grant and the associated HARQ information to the HARQ entity.

1> else if an uplink grant for this PDCCH occasion has been received for this Serving Cell on the PDCCH for the MAC entity's CS-RNTI:

2> if the NDI in the received HARQ information is 1:

3> consider the NDI for the corresponding HARQ process not to have been toggled;

3> start or restart the *configuredGrantTimer* for the corresponding HARQ process, if configured;

3> deliver the uplink grant and the associated HARQ information to the HARQ entity.

2> else if the NDI in the received HARQ information is 0:

3> if PDCCH contents indicate configured grant Type 2 deactivation:

4> trigger configured uplink grant confirmation.

3> else if PDCCH contents indicate configured grant Type 2 activation:

4> trigger configured uplink grant confirmation;

4> store the uplink grant for this Serving Cell and the associated HARQ information as configured uplink grant;

4> initialise or re-initialise the configured uplink grant for this Serving Cell to start in the associated PUSCH duration and to recur according to rules in clause 5.8.2;

4> stop the *configuredGrantTimer* for the corresponding HARQ process, if running;

For each Serving Cell and each configured uplink grant, if configured and activated, the MAC entity shall:

1> if the MAC entity is configured with *lch-basedPrioritization*; or

1> if the PUSCH duration of the configured uplink grant does not overlap with the PUSCH duration of an uplink grant received on the PDCCH or in a Random Access Response for this Serving Cell:

2> set the HARQ Process ID to the HARQ Process ID associated with this PUSCH duration;

2> if the *configuredGrantTimer* for the corresponding HARQ process is not running:

3> consider the NDI bit for the corresponding HARQ process to have been toggled;

3> deliver the configured uplink grant and the associated HARQ information to the HARQ entity.

For configured uplink grants without *harq-procID-offset*, the HARQ Process ID associated with the first symbol of a UL transmission is derived from the following equation:

HARQ Process ID = [floor(CURRENT\_symbol/*periodicity*)] modulo *nrofHARQ-Processes*

where CURRENT\_symbol = (SFN × *numberOfSlotsPerFrame* × *numberOfSymbolsPerSlot* + slot number in the frame × *numberOfSymbolsPerSlot* + symbol number in the slot), and *numberOfSlotsPerFrame* and *numberOfSymbolsPerSlot* refer to the number of consecutive slots per frame and the number of consecutive symbols per slot, respectively as specified in TS 38.211 [8].

For configured uplink grants with *harq-procID-offset*, the HARQ Process ID associated with the first symbol of a UL transmission is derived from the following equation:

HARQ Process ID = [floor(CURRENT\_symbol / *periodicity*)] modulo *nrofHARQ-Processes* + *harq-procID-offset.*

NOTE 1: CURRENT\_symbol refers to the symbol index of the first transmission occasion of a repetition bundle that takes place.

NOTE 2: A HARQ process is configured for a configured uplink grant where *harq-procID-offset* is not configured, if the configured uplink grant is activated and the associated HARQ process ID is less than *nrofHARQ-Processes*. A HARQ process is configured for a configured uplink grant where *harq-procID-offset* is configured, if the configured uplink grant is activated and the associated HARQ process ID is greater than or equal to *harq-procID-offset* and less than sum of *harq-procID-offset* and *nrofHARQ-Processes* for the configured grant configuration.

NOTE 3: If the MAC entity receives both a grant in a Random Access Response and an overlapping grant for its C-RNTI or CS-RNTI, requiring concurrent transmissions on the SpCell, the MAC entity may choose to continue with either the grant for its RA-RNTI or the grant for its C-RNTI or CS-RNTI.

For the MAC entity configured with *lch-basedPrioritization,* priority of an uplink grant is determined by the highest priority among priorities of the logical channels with data available that are multiplexed or can be multiplexed in the MAC PDU, according to the mapping restrictions as described in clause 5.4.3.1.2.

When the MAC entity is configured, with *lch-basedPrioritization* for each uplink grant, which is not already a deprioritized uplink grant:

1> if this uplink grant is addressed to CS-RNTI with NDI = 1 or C-RNTI:

2> if there is no overlapping PUSCH duration of a configured uplink grant, in the same BWP, whose priority is higher than the priority of the uplink grant; and

2> if there is no overlapping PUCCH resource with an SR transmission where the priority of the logical channel that triggered the SR is higher than the priority of the uplink grant:

3> this uplink grant is a prioritized uplink grant;

3> the other overlapping uplink grant(s), if any, is a deprioritized uplink grant.

1> else if this uplink grant is a configured uplink grant:

2> if there is no overlapping PUSCH duration of another configured uplink grant, in the same BWP, whose priority is higher than the priority of the uplink grant; and

2> if there is no overlapping PUSCH duration of an uplink grant addressed to CS-RNTI with NDI = 1 or C-RNTI, in the same BWP, whose priority is higher than or equal to the priority of the uplink grant; and

2> if there is no overlapping PUCCH resource with an SR transmission where the priority of the logical channel that triggered the SR is higher than the priority of the uplink grant:

3> this uplink grant is a prioritized uplink grant;

3> the other overlapping uplink grant(s), if any, is a deprioritized uplink grant.

NOTE: If there is overlapping PUSCH duration of at least two configured uplink grants whose priorities are equal, the prioritized uplink grant is determined by UE implementation.

5.4.2 HARQ operation

5.4.2.1 HARQ Entity

The MAC entity includes a HARQ entity for each Serving Cell with configured uplink (including the case when it is configured with *supplementaryUplink*), which maintains a number of parallel HARQ processes.

The number of parallel UL HARQ processes per HARQ entity is specified in TS 38.214 [7].

Each HARQ process supports one TB.

Each HARQ process is associated with a HARQ process identifier. For UL transmission with UL grant in RA Response, HARQ process identifier 0 is used.

When the MAC entity is configured with *pusch-AggregationFactor* > 1, the parameter *pusch-AggregationFactor* provides the number of transmissions of a TB within a bundle of the dynamic grant. After the initial transmission, *pusch-AggregationFactor* – 1 HARQ retransmissions follow within a bundle. When the MAC entity is configured with *repK* > 1, the parameter *repK* provides the number of transmissions of a TB within a bundle of the configured uplink grant. After the initial transmission, HARQ retransmissions follow within a bundle. For both dynamic grant and configured uplink grant, bundling operation relies on the HARQ entity for invoking the same HARQ process for each transmission that is part of the same bundle. Within a bundle, HARQ retransmissions are triggered without waiting for feedback from previous transmission according to *pusch-AggregationFactor* for a dynamic grant and *repK* for a configured uplink grant, respectively. Each transmission within a bundle is a separate uplink grant after the initial uplink grant within a bundle is delivered to the HARQ entity.

For each transmission within a bundle of the dynamic grant, the sequence of redundancy versions is determined according to clause 6.1.2.1 of TS 38.214 [7]. For each transmission within a bundle of the configured uplink grant, the sequence of redundancy versions is determined according to clause 6.1.2.3 of TS 38.214 [7].

For each uplink grant, the HARQ entity shall:

1> identify the HARQ process associated with this grant, and for each identified HARQ process:

2> if the received grant was not addressed to a Temporary C-RNTI on PDCCH, and the NDI provided in the associated HARQ information has been toggled compared to the value in the previous transmission of this TB of this HARQ process; or

2> if the uplink grant was received on PDCCH for the C-RNTI and the HARQ buffer of the identified process is empty; or

2> if the uplink grant was received in a Random Access Response; or

2> if the uplink grant was received on PDCCH for the C-RNTI in *ra-ResponseWindow* and this PDCCH successfully completed the Random Access procedure initiated for beam failure recovery; or

2> if the uplink grant is part of a bundle of the configured uplink grant, and may be used for initial transmission according to clause 6.1.2.3 of TS 38.214 [7], and if no MAC PDU has been obtained for this bundle:

3> if there is a MAC PDU in the Msg3 buffer and the uplink grant was received in a Random Access Response; or:

3> if there is a MAC PDU in the Msg3 buffer and the uplink grant was received on PDCCH for the C-RNTI in *ra-ResponseWindow* and this PDCCH successfully completed the Random Access procedure initiated for beam failure recovery:

4> obtain the MAC PDU to transmit from the Msg3 buffer.

4> if the uplink grant size does not match with size of the obtained MAC PDU; and

4> if the Random Access procedure was successfully completed upon receiving the uplink grant:

5> indicate to the Multiplexing and assembly entity to include MAC subPDU(s) carrying MAC SDU from the obtained MAC PDU in the subsequent uplink transmission;

5> obtain the MAC PDU to transmit from the Multiplexing and assembly entity.

3> elseif this uplink grant is a configured grant which is a prioritized uplink grant; and

3> if the configured grant is configured with *autonomousReTx*; and

3> if the previous configured uplink grant for this HARQ process was de-prioritized; and

3> if a MAC PDU had already been obtained for this HARQ process; and

3> if a transmission of the obtained MAC PDU has not been performed:

4> consider the MAC PDU has been obtained.

3> else if the MAC entity is not configured with *lch-basedPrioritization*; or

3> if this uplink grant is a prioritized uplink grant:

4> obtain the MAC PDU to transmit from the Multiplexing and assembly entity, if any;

3> if a MAC PDU to transmit has been obtained:

4> deliver the MAC PDU and the uplink grant and the HARQ information of the TB to the identified HARQ process;

4> instruct the identified HARQ process to trigger a new transmission;

4> if the uplink grant is a configured uplink grant; or

4> if the uplink grant is addressed to C-RNTI, and the identified HARQ process is configured for a configured uplink grant:

5> start or restart the *configuredGrantTimer*, if configured, for the corresponding HARQ process when the transmission is performed.

3> else:

4> flush the HARQ buffer of the identified HARQ process.

2> else (i.e. retransmission):

3> if the uplink grant received on PDCCH was addressed to CS-RNTI and if the HARQ buffer of the identified process is empty; or

3> if the uplink grant is part of a bundle and if no MAC PDU has been obtained for this bundle; or

3> if the uplink grant is part of a bundle of the configured uplink grant, and the PUSCH duration of the uplink grant overlaps with a PUSCH duration of another uplink grant received on the PDCCH or in a Random Access Response for this Serving Cell; or

3> if the MAC entity is configured with *lch-basedPrioritization* and this uplink grant is not a prioritized uplink grant:

4> ignore the uplink grant.

3> else:

4> deliver the uplink grant and the HARQ information (redundancy version) of the TB to the identified HARQ process;

4> instruct the identified HARQ process to trigger a retransmission;

4> if the uplink grant is addressed to CS-RNTI; or

4> if the uplink grant is addressed to C-RNTI, and the identified HARQ process is configured for a configured uplink grant:

5> start or restart the *configuredGrantTimer*, if configured, for the corresponding HARQ process when the transmission is performed.

When determining if NDI has been toggled compared to the value in the previous transmission the MAC entity shall ignore NDI received in all uplink grants on PDCCH for its Temporary C-RNTI.

NOTE: When the configured grant configured with *autonomousReTx* is de-prioritized, it is up to the UE implementation to determine the processing time restriction determining whether the very next CG resource with same HARQ process can be used, or the following one.

5.4.2.2 HARQ process

Each HARQ process is associated with a HARQ buffer.

New transmissions are performed on the resource and with the MCS indicated on either PDCCH, Random Access Response, or RRC. Retransmissions are performed on the resource and, if provided, with the MCS indicated on PDCCH, or on the same resource and with the same MCS as was used for last made transmission attempt within a bundle.

If the HARQ entity requests a new transmission for a TB, the HARQ process shall:

1> store the MAC PDU in the associated HARQ buffer;

1> store the uplink grant received from the HARQ entity;

1> generate a transmission as described below.

If the HARQ entity requests a retransmission for a TB, the HARQ process shall:

1> store the uplink grant received from the HARQ entity;

1> generate a transmission as described below.

To generate a transmission for a TB, the HARQ process shall:

1> if the MAC PDU was obtained from the Msg3 buffer; or

1> if there is no measurement gap at the time of the transmission and, in case of retransmission, the retransmission does not collide with a transmission for a MAC PDU obtained from the Msg3 buffer:

2> instruct the physical layer to generate a transmission according to the stored uplink grant.

5.4.3 Multiplexing and assembly

5.4.3.1 Logical Channel Prioritization

5.4.3.1.1 General

The Logical Channel Prioritization (LCP) procedure is applied whenever a new transmission is performed.

RRC controls the scheduling of uplink data by signalling for each logical channel per MAC entity:

- *priority* where an increasing priority value indicates a lower priority level;

- *prioritisedBitRate* which sets the Prioritized Bit Rate (PBR);

- *bucketSizeDuration* which sets the Bucket Size Duration (BSD).

RRC additionally controls the LCP procedure by configuring mapping restrictions for each logical channel:

- *allowedSCS-List* which sets the allowed Subcarrier Spacing(s) for transmission;

- *maxPUSCH-Duration* which sets the maximum PUSCH duration allowed for transmission;

- *configuredGrantType1Allowed* which sets whether a configured grant Type 1 can be used for transmission;

- *allowedServingCells* which sets the allowed cell(s) for transmission;

- *allowedCG-List* which sets the allowed configured grant(s) for transmission;

- *allowedPHY-PriorityIndex* which sets the allowed PHY priority index(es) of a dynamic grant for transmission.

The following UE variable is used for the Logical channel prioritization procedure:

- *Bj* which is maintained for each logical channel *j*.

The MAC entity shall initialize *Bj* of the logical channel to zero when the logical channel is established.

For each logical channel *j*, the MAC entity shall:

1> increment *Bj* by the product PBR × T before every instance of the LCP procedure, where T is the time elapsed since *Bj* was last incremented;

1> if the value of *Bj* is greater than the bucket size (i.e. PBR × BSD):

2> set *Bj* to the bucket size.

NOTE: The exact moment(s) when the UE updates *Bj* between LCP procedures is up to UE implementation, as long as *Bj* is up to date at the time when a grant is processed by LCP.

5.4.3.1.2 Selection of logical channels

The MAC entity shall, when a new transmission is performed:

1> select the logical channels for each UL grant that satisfy all the following conditions:

2> the set of allowed Subcarrier Spacing index values in *allowedSCS-List*, if configured, includes the Subcarrier Spacing index associated to the UL grant; and

2> *maxPUSCH-Duration*, if configured, is larger than or equal to the PUSCH transmission duration associated to the UL grant; and

2> *configuredGrantType1Allowed*, if configured, is set to *true* in case the UL grant is a Configured Grant Type 1; and

2> *allowedServingCells*, if configured, includes the Cell information associated to the UL grant. Does not apply to logical channels associated with a DRB configured with PDCP duplication within the same MAC entity (i.e. CA duplication) for which PDCP duplication is deactivated; and

2> *allowedCG-List*, if configured, includes the configured grant index associated to the UL grant; and

2> *allowedPHY-PriorityIndex*, if configured, includes the priority index (as specified in clause 9 of TS 38.213 [6]) associated to the dynamic UL grant.

NOTE: The Subcarrier Spacing index, PUSCH transmission duration, Cell information and priority index are included in Uplink transmission information received from lower layers for the corresponding scheduled uplink transmission.

5.4.3.1.3 Allocation of resources

The MAC entity shall, when a new transmission is performed:

1> allocate resources to the logical channels as follows:

2> logical channels selected in clause 5.4.3.1.2 for the UL grant with *Bj* > 0 are allocated resources in a decreasing priority order. If the PBR of a logical channel is set to *infinity*, the MAC entity shall allocate resources for all the data that is available for transmission on the logical channel before meeting the PBR of the lower priority logical channel(s);

2> decrement *Bj* by the total size of MAC SDUs served to logical channel *j* above;

2> if any resources remain, all the logical channels selected in clause 5.4.3.1.2 are served in a strict decreasing priority order (regardless of the value of *Bj*) until either the data for that logical channel or the UL grant is exhausted, whichever comes first. Logical channels configured with equal priority should be served equally.

NOTE: The value of *Bj* can be negative.

If the MAC entity is requested to simultaneously transmit multiple MAC PDUs, or if the MAC entity receives the multiple UL grants within one or more coinciding PDCCH occasions (i.e. on different Serving Cells), it is up to UE implementation in which order the grants are processed.

The UE shall also follow the rules below during the scheduling procedures above:

- the UE should not segment an RLC SDU (or partially transmitted SDU or retransmitted RLC PDU) if the whole SDU (or partially transmitted SDU or retransmitted RLC PDU) fits into the remaining resources of the associated MAC entity;

- if the UE segments an RLC SDU from the logical channel, it shall maximize the size of the segment to fill the grant of the associated MAC entity as much as possible;

- the UE should maximise the transmission of data;

- if the MAC entity is given a UL grant size that is equal to or larger than 8 bytes while having data available and allowed (according to clause 5.4.3.1) for transmission, the MAC entity shall not transmit only padding BSR and/or padding.

The MAC entity shall not generate a MAC PDU for the HARQ entity if the following conditions are satisfied:

- the MAC entity is configured with *skipUplinkTxDynamic* with value *true* and the grant indicated to the HARQ entity was addressed to a C-RNTI, or the grant indicated to the HARQ entity is a configured uplink grant; and

- there is no aperiodic CSI requested for this PUSCH transmission as specified in TS 38.212 [9]; and

- the MAC PDU includes zero MAC SDUs; and

- the MAC PDU includes only the periodic BSR and there is no data available for any LCG, or the MAC PDU includes only the padding BSR.

Logical channels shall be prioritised in accordance with the following order (highest priority listed first):

- C-RNTI MAC CE or data from UL-CCCH;

- Configured Grant Confirmation MAC CE or Multiple Entry Configured Grant Confirmation MAC CE;

- MAC CE for BSR, with exception of BSR included for padding;

- Single Entry PHR MAC CE or Multiple Entry PHR MAC CE;

- data from any Logical Channel, except data from UL-CCCH;

- MAC CE for Recommended bit rate query;

- MAC CE for BSR included for padding.

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5.4.3.2 Multiplexing of MAC Control Elements and MAC SDUs

The MAC entity shall multiplex MAC CEs and MAC SDUs in a MAC PDU according to clauses 5.4.3.1 and 6.1.2.

5.4.4 Scheduling Request

The Scheduling Request (SR) is used for requesting UL-SCH resources for new transmission.

The MAC entity may be configured with zero, one, or more SR configurations. An SR configuration consists of a set of PUCCH resources for SR across different BWPs and cells. For a logical channel, at most one PUCCH resource for SR is configured per BWP.

Each SR configuration corresponds to one or more logical channels. Each logical channel may be mapped to zero or one SR configuration, which is configured by RRC. The SR configuration of the logical channel that triggered the BSR (clause 5.4.5) (if such a configuration exists) is considered as corresponding SR configuration for the triggered SR.

RRC configures the following parameters for the scheduling request procedure:

- *sr-ProhibitTimer* (per SR configuration);

- *sr-TransMax* (per SR configuration).

The following UE variables are used for the scheduling request procedure:

- *SR\_COUNTER* (per SR configuration).

If an SR is triggered and there are no other SRs pending corresponding to the same SR configuration, the MAC entity shall set the *SR\_COUNTER* of the corresponding SR configuration to 0.

When an SR is triggered, it shall be considered as pending until it is cancelled. All pending SR(s) triggered prior to the MAC PDU assembly shall be cancelled and each respective *sr-ProhibitTimer* shall be stopped when the MAC PDU is transmitted and this PDU includes a Long or Short BSR MAC CE which contains buffer status up to (and including) the last event that triggered a BSR (see clause 5.4.5) prior to the MAC PDU assembly. All pending SR(s) shall be cancelled and each respective *sr-ProhibitTimer* shall be stopped when the UL grant(s) can accommodate all pending data available for transmission.

Only PUCCH resources on a BWP which is active at the time of SR transmission occasion are considered valid.

As long as at least one SR is pending, the MAC entity shall for each pending SR:

1> if the MAC entity has no valid PUCCH resource configured for the pending SR:

2> initiate a Random Access procedure (see clause 5.1) on the SpCell and cancel the pending SR.

1> else, for the SR configuration corresponding to the pending SR:

2> when the MAC entity has an SR transmission occasion on the valid PUCCH resource for SR configured; and

2> if *sr-ProhibitTimer* is not running at the time of the SR transmission occasion; and

2> if the PUCCH resource for the SR transmission occasion does not overlap with a measurement gap:

3> if the PUCCH resource for the SR transmission occasion does not overlap with a UL-SCH resource; or

3> if the MAC entity is configured with *lch-basedPrioritization*, and the PUCCH resource for the SR transmission occasion overlaps with any UL-SCH resource(s), and the priority of the logical channel that triggered SR is higher than the priority of the uplink grant(s) for any UL-SCH resource(s) where the priority of the uplink grant is determined as specified in clause 5.4.1:

4> the other overlapping uplink grant(s), if any, is a deprioritized uplink grant;

4> if SR\_COUNTER < sr-TransMax:

5> increment *SR\_COUNTER* by 1;

5> instruct the physical layer to signal the SR on one valid PUCCH resource for SR;

5> start the *sr-ProhibitTimer*.

4> else:

5> notify RRC to release PUCCH for all Serving Cells;

5> notify RRC to release SRS for all Serving Cells;

5> clear any configured downlink assignments and uplink grants;

5> clear any PUSCH resources for semi-persistent CSI reporting;

5> initiate a Random Access procedure (see clause 5.1) on the SpCell and cancel all pending SRs.

NOTE 1: The selection of which valid PUCCH resource for SR to signal SR on when the MAC entity has more than one overlapping valid PUCCH resource for the SR transmission occasion is left to UE implementation.

NOTE 2: If more than one individual SR triggers an instruction from the MAC entity to the PHY layer to signal the SR on the same valid PUCCH resource, the SR\_COUNTER for the relevant SR configuration is incremented only once.

The MAC entity may stop, if any, ongoing Random Access procedure due to a pending SR which has no valid PUCCH resources configured, which was initiated by MAC entity prior to the MAC PDU assembly. Such a Random Access procedure may be stopped when the MAC PDU is transmitted using a UL grant other than a UL grant provided by Random Access Response, and this PDU includes a BSR MAC CE which contains buffer status up to (and including) the last event that triggered a BSR (see clause 5.4.5) prior to the MAC PDU assembly, or when the UL grant(s) can accommodate all pending data available for transmission.

Next change

5.8 Transmission and reception without dynamic scheduling

5.8.1 Downlink

Semi-Persistent Scheduling (SPS) is configured by RRC per Serving Cell and per BWP. Multiple assignments can be active simultaneously in the same BWP. Activation and deactivation of the DL SPS are independent among the Serving Cells.

For the DL SPS, a DL assignment is provided by PDCCH, and stored or cleared based on L1 signalling indicating SPS activation or deactivation.

RRC configures the following parameters when the SPS is configured:

- *cs-RNTI*: CS-RNTI for activation, deactivation, and retransmission;

- *nrofHARQ-Processes*: the number of configured HARQ processes for SPS;

- *harq-procID-offset*: Offset of HARQ process for SPS;

- *periodicity*: periodicity of configured downlink assignment for SPS.

When the SPS is released by upper layers, all the corresponding configurations shall be released.

After a downlink assignment is configured for SPS, the MAC entity shall consider sequentially that the Nth downlink assignment occurs in the slot for which:

(*numberOfSlotsPerFrame* × SFN + slot number in the frame) =
[(*numberOfSlotsPerFrame* × SFNstart time + slotstart time) + N × *periodicity* × *numberOfSlotsPerFrame* / 10] modulo (1024 × *numberOfSlotsPerFrame*)

where SFNstart time and slotstart time are the SFN and slot, respectively, of the first transmission of PDSCH where the configured downlink assignment was (re-)initialised.

5.8.2 Uplink

There are two types of transmission without dynamic grant:

- configured grant Type 1 where an uplink grant is provided by RRC, and stored as configured uplink grant;

- configured grant Type 2 where an uplink grant is provided by PDCCH, and stored or cleared as configured uplink grant based on L1 signalling indicating configured uplink grant activation or deactivation.

Type 1 and Type 2 are configured by RRC per Serving Cell and per BWP. Multiple configurations can be active simultaneously in the same BWP. For Type 2, activation and deactivation are independent among the Serving Cells. For the same BWP, the MAC entity can be configured with both Type 1 and Type 2.

RRC configures the following parameters when the configured grant Type 1 is configured:

- *cs-RNTI*: CS-RNTI for retransmission;

- *periodicity*: periodicity of the configured grant Type 1;

- *timeDomainOffset*: Offset of a resource with respect to SFN = *timeReferenceSFN* in time domain;

- *timeDomainAllocation*: Allocation of configured uplink grant in time domain which contains *startSymbolAndLength* (i.e. *SLIV* in TS 38.214 [7]);

- *nrofHARQ-Processes*: the number of HARQ processes for configured grant;

- *harq-procID-offset*: Offset of HARQ process for configured grant.

- *timeReferenceSFN*: Offset of SFN immediately preceding the reception of the configured grant configuration.

RRC configures the following parameters when the configured grant Type 2 is configured:

- *cs-RNTI*: CS-RNTI for activation, deactivation, and retransmission;

- *periodicity*: periodicity of the configured grant Type 2;

- *nrofHARQ-Processes*: the number of HARQ processes for configured grant.

- *harq-procID-offset*: Offset of HARQ process for configured grant.

Upon configuration of a configured grant Type 1 for a Serving Cell by upper layers, the MAC entity shall:

1> store the uplink grant provided by upper layers as a configured uplink grant for the indicated Serving Cell;

1> initialise or re-initialise the configured uplink grant to start in the symbol according to *timeDomainOffset* and *S* (derived from *SLIV* as specified in TS 38.214 [7]), and to reoccur with *periodicity*.

After an uplink grant is configured for a configured grant Type 1, the MAC entity shall consider sequentially that the Nth uplink grant occurs in the symbol for which:

[(SFN × *numberOfSlotsPerFrame* × *numberOfSymbolsPerSlot*) + (slot number in the frame × *numberOfSymbolsPerSlot*) + symbol number in the slot] =
[(*timeReferenceSFN* × *numberOfSlotsPerFrame* × *numberOfSymbolsPerSlot + timeDomainOffset* × *numberOfSymbolsPerSlot* + *S* + N × *periodicity*) modulo (1024 × *numberOfSlotsPerFrame* × *numberOfSymbolsPerSlot*).

After an uplink grant is configured for a configured grant Type 2, the MAC entity shall consider sequentially that the Nth uplink grant occurs in the symbol for which:

[(SFN × *numberOfSlotsPerFrame* × *numberOfSymbolsPerSlot*) + (slot number in the frame × *numberOfSymbolsPerSlot*) + symbol number in the slot] =
[(SFNstart time × *numberOfSlotsPerFrame* × *numberOfSymbolsPerSlot* + slotstart time × *numberOfSymbolsPerSlot* + symbolstart time) + N × *periodicity*] modulo (1024 × *numberOfSlotsPerFrame* × *numberOfSymbolsPerSlot*).

where SFNstart time, slotstart time, and symbolstart time are the SFN, slot, and symbol, respectively, of the first transmission opportunity of PUSCH where the configured uplink grant was (re-)initialised.

When the configured uplink grant is released by upper layers, all the corresponding configurations shall be released and all corresponding uplink grants shall be cleared.

The MAC entity shall:

1> if at least one configured uplink grant confirmation has been triggered and not cancelled; and

1> if the MAC entity has UL resources allocated for new transmission:

2> if the MAC entity is configured with *configuredGrantConfigList*:

3> instruct the Multiplexing and Assembly procedure to generate a Multiple Entry Configured Grant Confirmation MAC CE as defined in clause 6.1.3.X, even if configured grant confirmation was triggered several times.

2> else:

3> instruct the Multiplexing and Assembly procedure to generate a Configured Grant Confirmation MAC CE as defined in clause 6.1.3.7.

2> cancel the triggered configured uplink grant confirmation.

For a configured grant Type 2, the MAC entity shall clear the configured uplink grant(s) immediately after first transmission of Configured Grant Confirmation MAC CE or Multiple Entry Configured Grant Confirmation MAC CE which confirms the configured uplink grant deactivation.

Retransmissions except for repetition of configured uplink grants use uplink grants addressed to CS-RNTI.

Next change

5.10 Activation/Deactivation of PDCP duplication

If one or more DRBs are configured with PDCP duplication, the network may activate and deactivate the PDCP duplication over all or a subset of associated RLC entities for the configured DRB(s).

The PDCP duplication for the configured DRB(s) is activated and deactivated by:

- receiving the Duplication Activation/Deactivation MAC CE described in clause 6.1.3.11;

- receiving the Duplication RLC Activation/Deactivation MAC CE described in clause 6.1.3.Y;

- indication by RRC.

The PDCP duplication over all or a subset of associated RLC entities for the configured DRB(s) is activated and deactivated by:

- receiving the Duplication RLC Activation/Deactivation MAC CE described in clause 6.1.3.Y;

- indication by RRC.

The MAC entity shall for each DRB configured with PDCP duplication:

1> if a Duplication Activation/Deactivation MAC CE is received activating the PDCP duplication of the DRB:

2> indicate the activation of PDCP duplication of the DRB to upper layers.

1> if a Duplication Activation/Deactivation MAC CE is received deactivating the PDCP duplication of the DRB:

2> indicate the deactivation of PDCP duplication of the DRB to upper layers.

1> if a Duplication RLC Activation/Deactivation MAC CE is received activating PDCP duplication over associated RLC entities of a DRB configured with PDCP duplication:

2> indicate the activation of PDCP duplication over the indicated secondary RLC entity(ies) of the DRB to upper layers.

1> if a Duplication RLC Activation/Deactivation MAC CE is received deactivating PDCP duplication over associated RLC entities of a DRB configured with PDCP duplication:

2> indicate the deactivation of PDCP duplication over the indicated secondary RLC entity(ies) of the DRB to upper layers.

Next change

#### 6.1.3.X Multiple Entry Configured Grant Confirmation MAC CE

The Multiple Entry Configured Grant Confirmation MAC CE is identified by a MAC subheader with LCID as specified in Table 6.2.1-2. It has a fixed size and consists of a four octets containing 32 CG-fields. The Multiple Entry Configured Grant Confirmation MAC CE is defined as follows (Figure 6.1.3.X-1).

* CGi: This field indicates whether PDCCH indicating activation or deactivation of configured uplink grant with *ConfiguredGrantConfigIndexMAC* i has been received. The CGi field is set to 1 to indicate that PDCCH indicating activation or deactivation of type 2 configured uplink grant with *ConfiguredGrantConfigIndexMAC* i has been received. The CGi field is set to 0 to indicate that PDCCH indicating activation or deactivation of type 2 configured uplink grant with *ConfiguredGrantConfigIndexMAC* i has not been received.



Figure 6.1.3.X-1: Multiple Entry Configured Grant Confirmation MAC CE

#### 6.1.3.Y Duplication RLC Activation/Deactivation MAC CE

The Duplication RLC Activation/Deactivation MAC CE is identified by a MAC subheader with LCID as specified in Table 6.2.1-1. It has a fixed size and consists of a single octet defined as follows (Figure 6.1.3.Y-1).

* DRB ID: This field indicates the identity of DRB for which the MAC CE applies. The length of the field is 5 bits;
* RLCi: This field indicates the activation/deactivation status of PDCP duplication over the RLC entity i where i is ascending order of logical channel ID of secondary RLC entities in the order of MCG and SCG, for the DRB. The RLCi field is set to 1 to indicate that the PDCP duplication for the RLC entity i shall be activated. The RLCi field is set to 0 to indicate that the PDCP duplication over the RLC entity i shall be deactivated.



Figure 6.1.3.Y-1: Duplication RLC Activation/Deactivation MAC CE

Next change

6.2 Formats and parameters

6.2.1 MAC subheader for DL-SCH and UL-SCH

The MAC subheader consists of the following fields:

- LCID: The Logical Channel ID field identifies the logical channel instance of the corresponding MAC SDU or the type of the corresponding MAC CE or padding as described in Tables 6.2.1-1 and 6.2.1-2 for the DL-SCH and UL-SCH respectively. There is one LCID field per MAC subheader. The LCID field size is 6 bits;

- L: The Length field indicates the length of the corresponding MAC SDU or variable-sized MAC CE in bytes. There is one L field per MAC subheader except for subheaders corresponding to fixed-sized MAC CEs, padding, and MAC SDUs containing UL CCCH. The size of the L field is indicated by the F field;

- F: The Format field indicates the size of the Length field. There is one F field per MAC subheader except for subheaders corresponding to fixed-sized MAC CEs, padding, and MAC SDUs containing UL CCCH. The size of the F field is 1 bit. The value 0 indicates 8 bits of the Length field. The value 1 indicates 16 bits of the Length field;

- R: Reserved bit, set to 0.

The MAC subheader is octet aligned.

**Table 6.2.1-1 Values of LCID for DL-SCH**

|  |  |
| --- | --- |
| **Index** | **LCID values** |
| 0 | CCCH |
| 1–32 | Identity of the logical channel |
| 33-45 | Reserved |
| 46 | Duplication RLC Activation/Deactivation |
| 47 | Recommended bit rate |
| 48 | SP ZP CSI-RS Resource Set Activation/Deactivation |
| 49 | PUCCH spatial relation Activation/Deactivation |
| 50 | SP SRS Activation/Deactivation  |
| 51 | SP CSI reporting on PUCCH Activation/Deactivation |
| 52 | TCI State Indication for UE-specific PDCCH |
| 53 | TCI States Activation/Deactivation for UE-specific PDSCH |
| 54 | Aperiodic CSI Trigger State Subselection |
| 55 | SP CSI-RS/CSI-IM Resource Set Activation/Deactivation |
| 56 | Duplication Activation/Deactivation |
| 57 | SCell Activation/Deactivation (four octets) |
| 58 | SCell Activation/Deactivation (one octet) |
| 59 | Long DRX Command |
| 60 | DRX Command |
| 61 | Timing Advance Command |
| 62 | UE Contention Resolution Identity |
| 63 | Padding |

**Table 6.2.1-2 Values of LCID for UL-SCH**

|  |  |
| --- | --- |
| **Index** | **LCID values** |
| 0 | CCCH of size 64 bits (referred to as "CCCH1" in TS 38.331 [5]) |
| 1–32 | Identity of the logical channel |
| 33–50 | Reserved |
| 51 | Multiple Entry Configured Grant Confirmation |
| 52 | CCCH of size 48 bits (referred to as "CCCH" in TS 38.331 [5]) |
| 53 | Recommended bit rate query |
| 54 | Multiple Entry PHR (four octets Ci) |
| 55 | Configured Grant Confirmation |
| 56 | Multiple Entry PHR (one octet Ci) |
| 57 | Single Entry PHR |
| 58 | C-RNTI |
| 59 | Short Truncated BSR |
| 60 | Long Truncated BSR |
| 61 | Short BSR |
| 62 | Long BSR |
| 63 | Padding |

End of changes

# Annex <Z> (informative; to be removed later): RAN2 Agreements in IIOT WI

Gray: no impacts to MAC specification

Yellow: no need to change. It is related to MAC, but current texts already capture the agreement.

# Z.1 RAN2#105bis

**Accurate reference timing**

* Confirm that we use LTE rel-15 SIB and RRC unicast based methods for reference time delivery
* The reference time information shall correspond to a reference SFN, explicitly indicated in unicast signalling, FFS if inferred from the transmission of the SIB for SIB signalling.
* R2 assumes the UE shall use the end of the reference SFN value as the precise point in time to which the reference time corresponds.
* FFS whether the reference SFN refers to time in the future, past or whether this need to mandated one way or another
* R2 assumes that some propagation delay compensation may be needed for distance > 200m.
* FFS what would be the method, e.g. based on current TA, and whether this can be left for UE implementation or something need to be specified.

**Scheduling enhancements**

* RAN2 think that knowledge of survival time is beneficial to gNB. FFS whether there would be any impact to AS specifications to make use of this, and such discussions would have lower priority, as it is not explicitly a WI objective. There are also concerns that QoS framework may be impacted due to survival time being provided explicitly
* R2 assumes that the maximum number of active SPS configurations for a given BWP of a serving cell in the specification is 8 or 16 (FFS).
* R2 assumes short SPS/CG periodicities and/or multiple SPS/CG configurations and/or combination thereof could be used to mitigate the periodicity misalignment between the TSN periodicity and CG/SPS periodicity. Other solutions not precluded, e.g. to address resource consumption.
* Will support “short” SPS periodicities, at least down to 0.5ms
* Ask R1 on feasibility, and additionally the feasibility to go down to even lower values, e.g. 2 symb.
* R2 assumes that activation/deactivation is done by DCI.
* RAN1 should address activation/deactivation DCIs related with configured grant Type 2 and SPS in the case of multiple configurations
* When multiple UL CG or DL SPS configurations is configured, an offset for each configuration is needed for the calculation of the HARQ process ID

**Ethernet header compression**

* We develop Ethernet header compression 100% in 3GPP TS (not by extending ROHC)

# Z.2 RAN2#106

**Accurate reference timing**

* SFN boundary at or immediately after the ending boundary of the SI-window in which SIB is transmitted is always used as a reference in case the time reference information is provided by broadcast signalling (as in LTE)
* The UE considers the frame indicated by the referenceSFN nearest to the frame where the time information is received, which can be either in the past or in future, in case the time reference information is provided by unicast signalling
* Signalling to support 10ns granularity.
* R2 assumes that either SIB9 or a new SIB is used for reference time information broadcast delivery, depending on R3 discussion outcome.
* “00:00:00 on Gregorian calendar date 6 January, 1980 (start of GPS time)” as the origin of the time reference information, at least for the baseline case where time info type is not present or used (as in LTE).
* The field used for reference time information delivery is excluded from estimation of changes in system information.
* Specify uncertainty parameter in the reference time information in NR, encoding FFS
* We will have the clock type field, similar to LTE. R2 considers that this have no relation to ongoing discussions in SA2 on TSC

**Ethernet header compression**

* Ethernet Header Compression (EHC) is configured per DRB, separately for UL and DL.
* Use context ID concept such that compressor and decompressor associates a context ID with Ethernet header contents.
* Compression is done with following principle:
	+ For Ethernet flow resulting in creation of new context, compressor transmits at least one packet with full header and context id (to establish context in decompressor).
	+ After above, compressor starts transmits compressed packets. FFS if multiple transmissions and/or feedback is needed.
* EHC header format is designed to include following mandatory fields: Context ID, Indication of header format (i.e. full header and compressed header), FFS other field, e.g. profile ID

**Intra-UE prioritization and multiplexing**

* For de-prioritized PUSCH on dynamic grant, the UE should store the de-prioritized MAC PDU in the HARQ buffer, to allow gNB to schedule re-transmission using the same HARQ process.
* For de-prioritized PUSCH on configured grants, a) the UE could store the de-prioritized MAC PDU in the HARQ buffer, to allow gNB to schedule re-transmission. b) FFS if the UE could transmit it using the subsequent radio resources e.g. associated with the same HARQ process
* The above agreements are at least applicable for cases when MAC has already generated the de-prioritized MAC PDU

**PDCP duplication enhancement**

* Intention is that Copies are sent on different legs
* Dynamic Network control of DRB duplication is by MAC CE
* By the MAC CE, Network to control which of the configured RLC entities that is/are active
* Support the case that no of copies = no of active RLC entities

# Z.3 RAN2#107

**Intra-UE prioritization and multiplexing**

* R2 will de-prioritize work on intra-UE prioritization until R1 has made more progress.
* same prioritization solution for CG vs CG conflict and CG vs DG conflict
* Extend LCP restrictions by allowing restrictive mapping between an LCH and certain CG configurations.
* LCP restriction enhancements for DG to take into account reliability is needed, details FFS.
* no need to define UE processing time in MAC
* The same UE prioritization behaviour should be applied for resource conflicts between new transmissions or a new transmission and a retransmission.
* RAN2 assumes that MAC PDU recovery method in grant prioritization could be reused for PUSCH vs SR conflict.
* The case of highest priorities of two conflicting grants are equal is handled according to the following: for CG DG conflict, DG is prioritized, other cases FFS to what extent to specify.
* For The case when no PDU has been generated at all yet, and there is two grants where one will be de-prioritized (and there is data available for both grants). One PDU is generated
* If PUCCH resource for an SR’s transmission occasion overlaps a UL-SCH resource, SR’s transmission is allowed based on a comparison of priority of the LCH that triggered the SR and a priority value for the UL-SCH resource, if the priority of the LCH that triggered the SR is “high” (FFS). Priority value of the UL-SCH resource is FFS
* If an SR was triggered before MAC PDU assembly and PUCCH resource for the SR’s transmission occasion conflicts with UL-SCH resource of the MAC PDU, and the UL-SCH transmission is deprioritized, a MAC PDU will not be generated. (conflict = they cannot both be transmitted)
* When a PUSCH transmission is deprioritized, desired PHY behaviour is for RAN1 to decide

**PDCP duplication enhancements**

* The number of copies generated is equal to the number of active RLC entities, i.e. one copy per leg/RLC entity, and active/inactive state is determined by MAC CE.
* The network provides in RRC only one LCH cell restriction configuration per LCH, like in Rel-15. Changes to LCH cell restriction configuration is only possible via RRC.
* At PDCP duplication, application of the configured cell restrictions are not dynamically changed upon activation or deactivation of PDCP duplication beyond Rel-15. (FFS the case of CA duplication)
* The MAC CE signaling structure is either:
	+ a. Per DRB signaling with the activation status of the associated RLC entities, or
	+ b. All DRBs with the activation status of the associated RLC entities for each DRB
* A new LCID is used for the Rel-16 MAC CE controlling PDCP duplication.

# Z.4 RAN2#107bis

**Accurate reference timing**

* SIB9 is used for accurate reference timing delivery by broadcast.
* DLInformationTransfer message is used for serving cell’s accurate reference timing delivery by unicast.
* R2 assumes there will be no particular functionality to ensure accurate timing distribution at the moment of handover in Rel-16
* The uncertainty of reference time info is unspecified, if the uncertainty field is absent.
* We send an LS: RAN2 asks SA2 to provide information on whether and how the need for reference time information can be determined for any given connected UE
* FFS if The referenceSFN field indicates the time at the ending boundary of the SFN indicated by referenceSFN of PCell.

**Scheduling enhancements**

* R2 assumes to support 8 as the maximum number of simultaneously activated SPS configurations per BWP per serving cell.
* Introduce SPS/CG index to identify each SPS/CG among multiple SPS/CG configurations, i.e., as in Rel-15 LTE.
* The association between “state” (used in the joint release DCI) and the CG configuration(s) for type-2 CG is configured via RRC message.
* Each CG configuration is always configured independently, as in Rel-15 LTE.
* The association between “state” (used in the joint release DCI) and the SPS configuration(s) is configured via RRC message, if RAN1 working assumption for joint release for multiple SPS configuration is confirmed.
* Each SPS configuration is always configured independently, as in Rel-15 LTE.
* Support simultaneous Type 1 & 2 CG configurations in a BWP.
* CG periodicities of any integer-multiple of one slot (FFS if we go even lower, e.g. 2 symb, 7 symb) below a maximum value should be supported. FFS on the maximum value of integer N.
* SPS periodicities of any integer-multiple of one slot below a maximum value should be supported in Rel-16. FFS on the maximum value of integer N.
* R2 assumes that HARQ offset parameter is explicitly configured by the network for each CG/SPS configuration.
* For CG, HARQ Process ID = [floor(CURRENT\_symbol/periodicity)] modulo nrofHARQ-Processes + harq-procID-offset.
* FFS (for checking) if For SPS, HARQ Process ID = [floor(CURRENT\_slot/periodicity)] modulo nrofHARQ-Processes + harq-ProcID-offset, Where CURRENT\_slot = [(SFN × numberOfSlotsPerFrame) + slot number in the frame].
* Introduce a new confirmation MAC CE format in Rel-16, which reflects the confirmation of multiple configured grant configurations
* A single LCH can be map to multiple CG configurations.
* Multiple LCHs can be map to a single CG configuration.
* R2 think it would be useful to introduce a new LCP restriction in the following way: The DCI that is scheduling PUSCH may include a specific indication. LCH configuration in RRC contains information on whether the LCH can utilize grant with this indication or not. R2 intends that this mechanism can be used to differentiate grants for traffic that requires high reliability.

**Ethernet header compression**

* The EHC function is in PDCP
* The EHC header is located after the SDAP header, and it is ciphered
* The EHC can removes the following fields: SOURCE/DESTINATION ADDRESS, TYPE, and EHC do not support multiple formats
* FFS: Pad removal
* For context establishment the compressor send the full header and the context ID via PDCP data PDU
* ROHC and EHC are independent, e.g. from specification point of view they could both be configured for a DRB.
* FFS if for context establishment the explicit feedback is sent via PDCP control PDU.
* For context establishment the de-compressor sends an explicit feedback to the compressor after the establishment of the context, i.e. when a full header packet is received with a context id.
* For context establishment the explicit feedback includes the “Context ID”.
* When the compressor receives the feedback it is confident that the context is successfully established, and from this time compressed header packets can be transmitted.

**Intra-UE prioritization and multiplexing**

* We don’t do the solution where the UE indicate explicitly to the network that there is data for a deprioritized PDU
* There is support to have “UE autonomous retransmission in a CG resource”. Allow checking of complexity to next meeting.

**PDCP duplication enhancements**

* The mechanism of primary path defined for Rel-15 PDCP duplication should be retained for Rel-16 (FFS if allowed to deactivate a primary path ie to not send data PDU).

# Z.5 RAN2#108

**Accurate reference timing**

* The following is FFS (Ericsson and LG have concerns):
	+ R2 assume that UE may perform propagation delay compensation.
	+ We don’t specify how the UE perform propagation delay compensation.
	+ For unicast and broadcast, the network can indicate to the UE to not do delay compensation.
* The reference cell of the time at the ending boundary of the SFN indicated by referenceSFN can be PCell
* We use linear encoding
* The uncertainty value of reference time info is the uncertainty field value multiplied by 25 ns
* The number of bits to encode uncertainty field is 15 and the maximum value of uncertainty field is 2^15 -1, i.e., the maximum uncertainty value of reference time info is 0.8096 millisecond
* The smallest uncertainty field value is zero

**Scheduling enhancement**

* For CG/SPS periodicity determination, support the maximum values of N as specified already, depending on SCS, i.e. N= 640 for 15kHz, 1280 for 30kHz, 2560 for 60kHz and 5120 for 120kHz.
* In addition to specific CG-LCH mapping It should be possible to configure that all CGs are allowed, and none of the CGs are allowed
* Multiple CG activation/deactivation confirmation MAC CE contains only a bitmap of CG configurations using CG ID unique per MAC entity and configured by RRC in addition to CG ID introduced by RAN1.
* Multiple CG activation/deactivation confirmation MAC CE uses new LCID value.
* In MAC specifications, correct formulas for CG occasion determination so that they consider N sequentially, as for SPS.
* HARQ process ID determination with multiple SPS configurations is based on the following formula: HARQ Process ID = [floor(CURRENT\_slot/periodicity)] modulo nrofHARQ-Processes + harq-ProcID-offset, Where CURRENT\_slot = [(SFN × numberOfSlotsPerFrame) + slot number in the frame]
* In Rel-16, SPS periodicities in RRC are expressed in number of slots.
* We don’t introduce additional mechanism to align CG/SPS to TSC traffic pattern period

**Ethernet header compression**

* There is support in R2 to have Ethernet Padding Removal for IIOT
* The following tentative agreements are postponed, we send an LS to SA1, but we will decide next meeting regardless if get a reply in time or not
* RAN2 confirm the feedback mechanism already agreed in the last meeting and apply this to both AM DRB and UM DRB.
* The EHC algorithm is not allowed to be configured for a uni-directional link.
* Q-TAGs can be removed in EHC, considering all sub-fields, assuming this is static (i.e. no dynamic indications in EHC)

**Intra-UE prioritization and multiplexing**

* The TPs can work, as baseline (maybe some details to fix)
* UE autonomously transmits the de-prioritized PDU as a new transmission in a CG resource from the same CG configuration (FFS different CG configuration)
* The new CG uses the same HARQ process as the deprioritized CG.
* The Aut (re-) transmission feature is optional
* The case when the next CG resource cannot be used for a retransmission because of UE processing time limitation can occur (no consensus on whether this is a corner case or a mainstream case). Leave the timeline restriction to UE implementation (we don’t specify a new number, can specify something).
* UE shall not perform autonomous transmission of the PDU if network has scheduled a retransmission grant for the PDU. FFS whether we specify some time restriction
* RRC configures a LCH with one or more allowed L1-priority level values (e.g. in a allowedPriorityLevels list) in LogicalChannelConfig (as in the current LCH restrictions), applied at least for mapping to DG, FFS for CG
* For CGCG conflicts, and CGDG conflicts, the priority value of an uplink grant (UL-SCH resource) is the highest priority of the LCHs that is multiplexed or can be multiplexed in MAC PDU, taking into account LCH restrictions and data availability.
* If PUCCH resource for an SR’s transmission occasion overlaps a UL-SCH resource, SR’s transmission is allowed (prioritized) based on a comparison of priority of the LCH that triggered the SR and a priority value for the UL-SCH resource (where the priority value is determined as in previous agreement), if the priority of the LCH that triggered the SR is higher.
* For CG-CG conflict with equal priority, prioritization is up to UE implementation.
* For SR-Data conflict with equal priority, UL-SCH (i.e. data) is prioritized.

**PDCP duplication enhancement**

* Network coordination is beneficial for PDCP duplication in the uplink in NR-DC/CA architectures.
* The primary path should not be de-activated for data PDUs.
* For PDCP duplication controlling MAC CE format, per DRB signaling with the activation status of the associated RLC entities should be adopted in Rel-16.
* The initial state for each leg can be configured by RRC
* When multiple RLC entities are configured for the DRB, and PDCP duplication is deactivated (less than 2 RLC entities activated for duplication), fallback to Split bearer operation is supported in Dual Connectivity (2 RLC entities belonging to different cell groups).
* For fallback to split bearer operation, a pointer to the secondary RLC entity is introduced in RRC to identify which of the multiple configured RLC entities shall be used.
* One PDCP entity has one primary path.
* R16 MAC CE for both leg selection and on/off
* R15 MAC CE on/off (for R16 configurations) is FFS

# Z.5 RAN2#109-e

**Accurate reference timing**

* Capture for the reference time information in 38.331 that “The indicated time is referenced at the network, i.e., without compensating for RF propagation delay.”
* In Rel-16, propagation delay compensation may be done by UE implementation.
* Do not capture propagation delay compensation aspect in stage-2 specifications.
* No EN-DC specific enhancements are pursued for accurate reference time objective of Rel-16 IIOT WI.
* Do not make any specifications changes to indicate which of the received reference time information takes precedence in case the UE receives reference time via both unicast and broadcast signalling.
* It is FFS if UE in RRC Connected can request SIB9 using on-demand SI request (by reusing OSI mechanism defined for RRC Connected UEs, with assumption of no additional work is needed in IIOT WI).
* **FFS whether data vs. data and SR vs. data prioritization can be configured separately.**
* **Both 1-byte header and 2-bytes header is supported and the choice depends on RRC configuration (of DRB). For one DRB the header size is fixed.**

**Scheduling enhancement**

* Confirm LCH configured with allowedCG-List is allowed to be mapped to dynamic grant
* LCH configured with allowedPHY-PriorityIndex is allowed to be mapped to dynamic grant without any priority indication only in case the configuration allows it to be mapped on low priority grant.
* allowedPHY-PriorityIndex restriction applies only to dynamic grants.
* If configuredGrantConfigList-r16 is configured in the MAC entity, the multiple entry configured grant confirmation MAC CE is always used.
* As in legacy, the multiple entry configured grant confirmation MAC CE is generated if 1) the MAC entity has UL resources allocated for new transmission; 2) there is at least one triggered but not cancelled confirmation.
* Confirm that Multiple Entry Configured Grant Confirmation MAC CE has the same priority as Confirmation Grant Confirmation MAC CE.
* For Type-1 CG, after receiving the configuration, UE should first identify the lowest N value corresponding to the nearest available CG occasion, then, N is incremented after each CG occasion starting from the N identifiedin the first step.
* Introduce timeReferenceSFN in RRC CG type 1 configuration.
* Align the terminology and use name “phy-PriorityIndex” in TS 38.300, TS 38.321, TS 38.331 to indicate the priority of the grant/SR-source agreed by RAN1
* Maximum 32 CG configurations per MAC entity.
* MAC CE for CG configuration has a fixed size of 4 bytes.
* Confirm that multiple entry configured confirmation MAC CE only confirms configured grant type 2 configurations and other entries can be ignored.
* Multiple entry confirmation MAC CE confirms the reception of (re)-activation/de-activation DCI.
* Two CGs of any type, one activated in UL and another activated in SUL, are not time-overlapping by the control of the network. This can be captured in the stage-2 spec.

**Ethernet Header Compression**

* Each different PCP/DE value combination in a flow across all Q Tags (single or multiple) is associated with a separate context ID.
* The ROHC header is located after EHC header (illustrated below).
* When a DRB is configured with RoHC and EHC, the sender/compressor behaviour for a non-IP Ethernet packet shall be to bypass ROHC and deliver that packet from EHC compressor to lower layers.
* When a DRB is configured with RoHC and EHC, the receiver/decompressor behaviour for a packet that has non-IP Ethertype (after EHC decompression) is to bypass RoHC and deliver the packet directly to higher layers.
* For SDAP Control PDU, the EHC header is not generated.
* 1-bit Indication in EHC header is used for header format differentiation.
* CID overwriting mechanism is supported.
* Use a NOTE to specify CID overwriting mechanism in the specification.
* The compressor can use an “all zeros” context ID to indicate that no context is to be established, when transmitting uncompressed packets.
* EHC feedback is transmitted via PDCP Control PDU.
* No need to specify how the compressor to determine that a context establishment procedure was unsuccessful.
* Configuration of a parameters (e.g. drb-ContinueEHC) indicates whether or not EHC is reset at PDCP re-establishment.
* EHC context continue function can be indicated separately for UL and DL, through configuration of parameters, e.g. ul-drb-ContinueEHC and dl-drb-ContinueEHC.
* The processing order of the EHC and ROHC is up to UE implementation.
* Only the feedback based mechanism is supported for EHC context establishment.
* No enhancement needed on the compressor side. The compressor keeps sending full header packets till the first feedback is received and start to transmit the compressed header packets.
* No special mechanism is needed on the decompressor side to control the number of feedbacks.
* If the Ethernet frame header contains a LENGTH field, the header can be sent compressed or uncompressed, no special handling
* EHC header only contains Context ID field, format indication bit, and reserved bit(s) if needed. The number of reserved bit(s) are FFS

**Intra-UE prioritization and multiplexing**

* UE autonomous transmission uses the same HARQ process and the same CG configuration. No change to the current running CR.
* A PDU from a de-prioritized DG scheduled for a re-transmission of a de-prioritized CG cannot be autonomously transmitted using the subsequent CG with same HARQ process. No change to the current running CR.
* autonomousReTx is only configurable per configured grant configuration.
* No limit (timer or counter) is specified in Rel-16 on the number of times a MAC PDU is consecutively de-prioritized. No specification changes are required.
* No optimization of the configuredGrantTimer procedure is foreseen to reduce the delay to the next available CG for autonomous transmission.
* No new condition on whether at least some DM-RS symbols associated with the de-prioritized PUSCH have been transmitted is added to trigger/no trigger an autonomous transmission.
* No optimization is foreseen to address the issue of a PDCCH scheduling a dynamic retransmission of the deprioritized TB received before the PUSCH used for the autonomous transmission whereas the PUSCH corresponding to the PDCCH occurs after the PUSCH resource for the autonomous transmission
* The issue of a type-2 CG configuration change between the de-prioritized CG and the new CG resource for autonomous transmission preventing the de-prioritized PDU to fit the new CG resource will be addressed.
* A HARQ process cannot be shared between different CGs.
* The issue of a running configuredGrantTimer when the HARQ buffer of the corresponding HARQ process is empty is not addressed.
* The issue of a LCH mapping restrictions mismatch when rescheduling a dropped CG with new transmission DG (as opposed to re-transmission DG) is not addressed.
* Postpone the discussion on the solution addressing autonomous transmission when type-2 CG’s configuration changes to the next meeting.
* RAN2 confirms to introduce lch-basedPrioritization (configuration parameter of intra-UE prioritization based on LCH priority) in MAC running CR.
* RAN2 confirms that UE can perform autonomous transmission of the de-prioritized configured uplink grant by the prioritized SR transmission.
* An uplink grant addressed to CS-RNTI with NDI=1 (retransmission of CG) is a dynamic grant in prioritization.
* An uplink grant addressed to CS-RNTI with NDI=0 ((re-)activation of type 2 CG) is a configured grant in prioritization.
* RAN2 confirms the current MAC running CR already captures that CG with configuredGrantTimer running is not considered in prioritization.
* An uplink grant is not de-prioritized by other de-prioritized SR or uplink grant. TP in Phase-2 discussion is a baseline.
* Retransmission grants are not reused for new transmissions in Rel-16. No specification changes are required.
* When the CG is de-prioritized, it is up to the UE implementation to determine the processing time restriction determining whether the very next CG resource with same HARQ process can be used, or the/a following one, for an autonomous transmission
* Observation, acc to current R2 agreements: In case that two MAC PDUs with the same L1 priority (i.e. high-high or low-low) are delivered by MAC, the second PDU has priority from RAN2 perspective (based on LCH priority).

**PDCP duplication enhancement**

* Rel-16 PDCP duplication is applied to SRBs.
* For SRBs, all secondary RLC entities are activated when configured.
* MAC CE based activation/deactivation of PDCP duplication is not supported for SRBs.
* When a secondary RLC entity is deactivated (but PDCP duplication is still activated), the UE shall discard duplicated PDCP PDUs in the deactivated secondaryRLC entity.
* If Rel-16 MAC CE indicates all secondary RLC entities are deactivated for a DRB, the UE shall deactivate PDCP duplication for the DRB. FFS whether and howthis has TS impact.
* DRBdup ID in Rel-16 MAC CE is set to 5bits full DRB ID.
* FFS if and how Rel-15 MAC CE is used for Rel-16 Duplication