**3GPP TSG-RAN WG2 #130 R2-2504778**

**St.Julians, Malta, May 19th – 23rd, 2025**

Agenda Item: 8.9.3

Source: MediaTek

Title: Report of [AT130][301][R19 IoT NTN] CB-msg4 design – Second round

Document for: Discussion

# 1 Introduction

This is the phase 2 report of below offline discussion:

* [AT130][301][R19 IoT NTN] CB-msg4 design (Mediatek)

 Scope: discuss open issues MAC-12, MAC-13, MAC-14

 Intended outcome: summary of the offline discussion

 Offline time: Monday 2025-05-19 afternoon coffee break in BO3

 Deadline for offline discussion summary: Tuesday 2025-05-20 11:00

 Scope: discuss remaining two proposals for CB-msg4 design marked CB Friday

 Intended outcome: summary of the offline discussion

 Deadline for companies’ feedback: Thursday 2025-05-22 20:00

 Deadline for offline discussion summary (in R2-2504778): Friday 2025-05-23 08:00

# 2 Current agreements

RAN2 had made the following agreements related to CB-Msg4 structure before RAN2#130.

RAN2 Agreements

Contention resolution identity

- The UE stops the PDCCH monitoring window(s) once it receives a CB-msg4 containing a matching Contention Resolution Identity (FFS if there is no RRC message together with the CB-msg4)

Multiplexing

- RAN2 confirms the working assumption that one CB-Msg4 can target multiple UEs simultaneously. FFS how the multiplexing is organized.

C-RNTI

- The C-RNTI is included in CB-Msg4 if the UE is expected to receive additional RRC messages or data from the network after CB-Msg4 (FFS how to include the C-RNTI)

Timing alignment information

- The timing alignment information (FFS reusing TAC MAC-CE) can be included in the CB-Msg4

Backoff information

- Backoff information could be included in CB-Msg4.

In this meeting, RAN2 has below agreements related to CB-Msg4 structure.

Agreements:

3. Multiple contention resolution IDs could be included in CB-MSG4, the information related to multiple UEs can be multiplexed in the MAC PDU.

4. The number of Msg3 replies in one Msg4 can be left to eNB implementation. Expect no SPEC impact.

5. The HARQ feedback resource information can be included in the CB-Msg4 together with contention resolution ID which identity the specific UE. RAN2 could revisit this proposal if RAN1 has some concern.

6. Whether to send the HARQ feedback for CB-Msg4 can be controlled by NW. UE does not send HARQ NACK.

8. Reuse the existing format of HARQ ACK allocation signalling in the DCI. There is 2-bit HARQ ACK resource for eMTC and 4-bit HARQ ACK resource for NB-IoT. Reuse the meaning of DCI field in R1 SPEC. Send LS to RAN1 for information on all RAN2 decisions related to HARQ feedback

9. Introduce a new MAC PDU for CB-Msg4 including new types of MAC sub-header and a new type of MAC payload

10. The MAC PDU for CB-Msg4 consists of sub-header(s) followed by MAC payload and optional padding if needed.

11. Introduce a new CB BI MAC sub-header in CB-MSg4 for backoff parameter. There is 4 bits BI for backoff indication.

12. Introduce a new CB-Msg3 Response (CBR) MAC sub-header in CB-Msg4. It has 1bit E for sub-header/payload indication, 2 bits T for sub-header type, 1bit T2 for HARQ ACK resource present, 1 bit T3 for TAC present, 1 bit T4 for C-RNTI present and 2bit R for reservation.

Agreements – part 2:

5. The TAC is optionally used in the CB-Msg3 response.

6. RAN2 assumes that NTA=0 for initial CB-msg3 transmission. Include this in the LS to RAN1 and RAN4

7. RAN2 assumes the length of the TAC field is 6 bits (we can revisit this if there is major R1 impact on TA calculation)

# 3 Discussion

We discuss below two proposals in this offline.

Proposal 12: (MAC-13) Introduce a new CB Data MAC sub-header in CB-MSg4 for MAC SDU for logical channel data. It has 1 bit E for sub-header/payload indication, 2 bits T for sub-header type, 5 bits LCID, 8 bits L for MAC SDU length.

* CB Friday

Additional proposal from R2-2504528 (MTK) which was not included in offline 301:

Proposal 13c: (MAC-13) New CB-Msg3 Response (CBR). It has 48 bits contention resolution ID, 2 bits HARQ ACK resource offset for eMTC, 4 bits HARQ-ACK resource for NB-IoT, 6 bits TAC, 16 bits C-RNTI.

* CB Friday

Based on the agreement below, the rapporteur proposes to have the PDU format in Figure 1.

Agreements:

9. Introduce a new MAC PDU for CB-Msg4 including new types of MAC sub-header and a new type of MAC payload

10. The MAC PDU for CB-Msg4 consists of sub-header(s) followed by MAC payload and optional padding if needed.



Figure 1 MAC PDU format of CB-Msg4

Based on the agreement below, the rapporteur proposes to have the BI MAC sub-header structure in Figure 2.

Agreements:

11. Introduce a new CB BI MAC sub-header in CB-MSg4 for backoff parameter. There is 4 bits BI for backoff indication.



Figure 2 CB BI MAC sub-header

Agreements:

12. Introduce a new CB-Msg3 Response (CBR) MAC sub-header in CB-Msg4. It has 1bit E for sub-header/payload indication, 2 bits T for sub-header type, 1bit T2 for HARQ ACK resource present, 1 bit T3 for TAC present, 1 bit T4 for C-RNTI present and 2bit R for reservation.



Figure 3 CBR MAC sub-header

**Proposal 1:** **(MAC-13) Introduce a new CB Data MAC sub-header in CB-MSg4 for MAC SDU for logical channel data. It has 1 bit E for sub-header/payload indication, 2 bits T for sub-header type, 5 bits LCID, 8 bits L for MAC SDU length. There is one L field per CB Data sub-header except for the last sub-header.**



Figure 4a (Original) CB Data MAC sub-header



Figure 4b (Mobified) CB Data MAC sub-header

Q1: Do companies agree the P1?

**Summary**

FFS

**Proposal 2: (MAC-13) introduce a new CB-Msg3 Response (CBR) with variable length. It has 48-bit contention resolution ID, optional HARQ ACK, optional TAC, optional 16-bit C-RNTI.**



Figure 5 CBR for NB-IoT

Q2: Do companies agree the P2?

**Summary**

FFS

# 4 Conclusion

# Appendix – TP for CB-MSG4

6.1.2 MAC PDU (DL-SCH and UL-SCH except transparent MAC and Random Access Response, MCH, CB-MSG4)

A MAC PDU consists of a MAC header, zero or more MAC Service Data Units (MAC SDU), zero, or more MAC control elements, and optionally padding; as described in Figure 6.1.2-3.

Both the MAC header and the MAC SDUs are of variable sizes.

A MAC PDU header consists of one or more MAC PDU subheaders; each subheader corresponds to either a MAC SDU, a MAC control element or padding.

A MAC PDU subheader consists of the header fields R/F2/E/LCID/(R/R/eLCID)/(F)/(L). The L field is present in the MAC PDU subheader except for the last subheader in the MAC PDU and fixed sized MAC control elements. The last subheader in the MAC PDU and subheaders for fixed sized MAC control elements consist of the header fields R/F2/E/LCID/(R/R/eLCID). A MAC PDU subheader corresponding to padding consists of the four header fields R/F2/E/LCID.

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**Figure 6.1.2-1: R/F2/E/LCID/(R/R/eLCID)/F/L MAC subheader with 7-bits and 15-bits L field**

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**Figure 6.1.2-1a: R/F2/E/LCID/(R/R/eLCID)/L MAC subheader with 16-bits L field**

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**Figure 6.1.2-2: R/F2/E/LCID/(R/R/eLCID) MAC subheader**

MAC PDU subheaders have the same order as the corresponding MAC SDUs, MAC control elements and padding.

MAC control elements are always placed before any MAC SDU.

Padding occurs at the end of the MAC PDU, except when single-byte or two-byte padding is required. Padding may have any value and the MAC entity shall ignore it. When padding is performed at the end of the MAC PDU, zero or more padding bytes are allowed.

When single-byte or two-byte padding is required, one or two MAC PDU subheaders corresponding to padding are placed at the beginning of the MAC PDU before any other MAC PDU subheader.

A maximum of one MAC PDU can be transmitted per TB per MAC entity. A maximum of one MCH MAC PDU can be transmitted per TTI.

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**Figure 6.1.2-3: Example of MAC PDU consisting of MAC header, MAC control elements, MAC SDUs and padding**

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6.1.5 MAC PDU (Random Access Response)

A MAC PDU consists of a MAC header and zero or more MAC Random Access Responses (MAC RAR) and optionally padding as described in figure 6.1.5-4.

The MAC header is of variable size.

A MAC PDU header consists of one or more MAC PDU subheaders; each subheader corresponding to a MAC RAR except for the Backoff Indicator subheader. If included, the Backoff Indicator subheader is only included once and is the first subheader included within the MAC PDU header.

A MAC PDU subheader consists of the three header fields E/T/RAPID (as described in figure 6.1.5-1) but for the Backoff Indicator subheader which consists of the five header field E/T/R/R/BI (as described in figure 6.1.5-2).

A MAC RAR consists of the following fields R/Timing Advance Command/UL Grant/(R/ER)/Temporary C-RNTI (as described in figures 6.1.5-3, 6.1.5-3a, 6.1.5-3b and 6.1.5-3c). For BL UEs and UEs in enhanced coverage in enhanced coverage level 2 or 3 (see clause 6.2 in TS 36.213 [2]) the MAC RAR in figure 6.1.5-3a is used, for NB-IoT UEs (see clause 16.3.3 in TS 36.213 [2]) the MAC RAR in figure 6.1.5-3b is used, except for NB-IoT UEs using preamble format 2, the MAC RAR in figure 6.1.5-3c is used. Otherwise the MAC RAR in figure 6.1.5-3 is used.

Padding may occur after the last MAC RAR. Presence and length of padding is implicit based on TB size, size of MAC header and number of RARs.

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**Figure 6.1.5-1: E/T/RAPID MAC subheader**

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**Figure 6.1.5-2: E/T/R/R/BI MAC subheader**

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**Figure 6.1.5-3: MAC RAR**

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**Figure 6.1.5-3a: MAC RAR for PRACH enhanced coverage level 2 or 3**

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**Figure 6.1.5-3b: MAC RAR for NB-IoT UEs**

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**Figure 6.1.5-3c: MAC RAR for NB-IoT UEs using PRACH preamble format 2**

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**Figure 6.1.5-4: Example of MAC PDU consisting of a MAC header and MAC RARs**

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6.1.x MAC PDU (CB-Msg4)

A MAC PDU consists of a MAC header, one or more MAC CB-Msg3-EDT Responses (MAC CBR), zero or more optionally MAC SDUs, and optionally padding as described in figure 6.1.x-5. The MAC SDU is associated with the UE indicated by the MAC CBR that precedes it.

The MAC header is of variable size.

A MAC PDU header consists of one or more MAC PDU subheaders; each subheader except for the CB Backoff Indicator subheader corresponding to a MAC CBR, MAC SDU, or padding. If included, the CB Backoff Indicator subheader is only included once and is the first subheader included within the MAC PDU header.

The CB Backoff Indicator subheader consists of the four header field E/T/R/BI (as described in figure 6.1.x-1).

A CBR subheader consists of the seven header fields E/T/R/R/T2/T3/T4 (as described in figure 6.1.x-2).

A MAC PDU subheader consists of the header fields R/T/LCID/(L). The L field is present in the MAC PDU subheader except for the last subheader in the MAC PDU. (as described in figure 6.1.x-3). A MAC PDU subheader corresponding to padding consists of the four header fields E/T/LCID.

For BL UEs and UEs in enhanced coverage, a MAC CBR consists of the following fields UE Contention Resolution Identity/(Timing Advance Command)/(HARQ ACK resource)/(C-RNTI) (as described in figures 6.1.x-4). For NB-IoT UEs, a MAC CBR consists of the following fields UE Contention Resolution Identity/(R)/(HARQ ACK resource) /(R)/(Timing Advance Command)/(C-RNTI) (as described in figures 6.1.x-5).

Padding occurs at the end of the MAC PDU, except when single-byte or two-byte padding is required. Padding may have any value and the MAC entity shall ignore it. When padding is performed at the end of the MAC PDU, zero or more padding bytes are allowed.

When single-byte or two-byte padding is required, one or two MAC PDU subheaders corresponding to padding are placed at the beginning of the MAC PDU before any other MAC PDU subheader.

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**Figure 6.1.x-1: E/T/R/BI MAC subheader**

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**Figure 6.1.x-2: E/T/R/R/T2/T3/T4 MAC subheader**

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**Or**

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**Figure 6.1.x-3:E/T/LCID/(L) MAC subheader**

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**Figure 6.1.x-4: MAC CBR for BL UEs and UEs in enhanced coverage**

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**Figure 6.1.x-5: MAC CBR for NB-IoT UEs**

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**Figure 6.1.x-6: Example of MAC PDU consisting of a MAC header, MAC CBRs, MAC SDUs and padding**

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6.2.x MAC header for CB-MSG4

The MAC header is of variable size and consists of the following fields:

- E: The Extension field is a flag indicating if more fields are present in the MAC header or not. The E field is set to "1" to indicate at least another subheader follows. The subsequent subheader can be E/T/R/BI MAC subheader, E/T/R/R/T2/T3/T4 MAC subheader or E/T/LCID/(L) MAC subheader. The E field is set to "0" to indicate that either a MAC CBR, a MAC SDU or padding starts at the next byte;

- T: The Type field is a flag indicating the type of the MAC subheader. The T field is set to "00" to indicate the presence of a Backoff Indicator field in the subheader (BI). The T field is set to "01" to indicate the presence of T2 in the subheader. The T field is set to "10" to indicate the presence of a Logical Channel ID field (LCID) in the subheader. The Type field is 2bits;

- T2: The Type2 field is a flag indicating the presence of the HARQ ACK resource field in the corresponding MAC CRB. For NB-IoT, it aslo inidcate the presence of the 4-bit R fields preceding the HARQ ACK resource field in the same MAC CRB;

- T3: The Type3 field is a flag indicating the presence of the Timing Advance Command field in the corresponding MAC CRB. For NB-IoT, it aslo inidcate the presence of the 2-bit R fields preceding the Timing Advance Command field in the same MAC CRB;

- T4: The Type4 field is a flag indicating the presence of the C-RNTI field in the corresponding MAC CRB;

- R: Reserved bit, set to "0";

- BI: The Backoff Indicator field identifies the overload condition in the cell. The size of the BI field is 4 bits;

- LCID: The Logical Channel ID field identifies the logical channel instance of the corresponding MAC SDU or padding as described in tables 6.2.1-1 for the DL-SCH. There is one LCID field for each MAC SDU, or padding included in the MAC PDU. In addition to that, one or two additional LCID fields are included in the MAC PDU, when single-byte or two-byte padding is required but cannot be achieved by padding at the end of the MAC PDU. The LCID field size is 5 bits.

The MAC header and subheaders are octet aligned.

6.2.y MAC payload for CB-MSG4

The MAC CBR is of fixed size and consists of the following fields:

- UE Contention Resolution Identity: This field contains the first 48 bits of the uplink CCCH SDU;

- R: Reserved bit, set to "0";

- HARQ ACK resource: This field indicate the resource used for HARQ ACK resource. For BL UEs and UEs in enhanced coverage, the length of this field is 2 bit (see HARQ-ACK resource offset in clause 5.3.3.1.13 of TS 36.212). For NB-IoT, the length of this field is 4 bit (see HARQ-ACK resource in clause 6.4.3.2 of TS 36.212);

- Timing Advance Command: The Timing Advance Command field indicates the index value *TA* (0, 1, 2… 63) used to control the amount of timing adjustment that the MAC entity has to apply (see clause 4.2.3 of TS 36.213 [2]). The size of the Timing Advance Command field is 6 bits;

- C-RNTI: This field contains the C-RNTI of the MAC entity. The length of the field is 16 bits.