**3GPP TSG RAN WG1 #100bis-e R1-20xxxxx**

**e-Meeting, 20th – 30th April, 2020**

**Agenda item:** 6.2.5

**Source:** Moderators (AT&T, NTT DOCOMO, INC.)

**Title:** Summary on email discussion [100b-e-LTE-UEFeatures-Remaining]

**Document for:** Discussion and Decision

1. Introduction

This contribution summarizes the following email discussion in AI 6.2.5 regarding Rel-16 LTE UE features.

[100e-b-LTE-UEFeatures-Remaining] Email discussion/approval of remaining issues (especially the one identified as low priority items in FL’s summaries) starting no earlier than 4/30 till next meeting – Hiroki (DCM)/Ralf (ATT)

Companies are encouraged to check further updates for UE features list based on R1-2003071 shown below and provide feedback if any. Please note that the target of this email discussion is to improve the quality of the UE features list by reflecting agreeable updates rather than solving any controversial discussion point. If there is any controversial discussion point, it should be discussed in the next RAN1 meeting.

1. LTE\_eMTC5

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the eNB to know if the feature is supported | Need for the UE to know if the feature is supported (only for V2X WI, where the PC5-RRC capability signalling is delivered between the UEs) | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Capability interpretation for mixture of FDD/TDD | Note | Mandatory/Optional |
| 1. LTE\_eMTC5 | 1-1 | Group WUS without group resource alternation | 1. Group WUS without group resource alternation | Rel-15 MWUS | Yes | N/A | The UE will be paged with Rel-15 MWUS or without MWUS instead of Group WUS. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-2 | Group WUS with group resource alternation | 1. Group WUS with group resource alternation | 1-1 | Yes | N/A | If UE does not support group resource alternation and the eNB enables group resource alternation, UE falls back to Rel-15 MWUS when Rel-15 MWUS is configured or no MWUS when Rel-15 MWUS is not configured. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-3 | PUR for full-PRB in CEmodeA | 1. PUR for full-PRB in CEmodeA | CEmodeA | Yes | N/A | UL data transmission will use EDT or connected mode instead of PUR in CEmodeA. | Per UE | Yes | N/A | RAN2 has agreed that PUR with UP and CP solutions have separate indications, but this is not captured in this RAN1 UE feature list. | Optional with capability signalling |
| 1-3a | Combination of PUR for full-PRB in CEmodeA with max UL TBS 2984 bits | 1. Combination of PUR for full-PRB in CEmodeA with max UL TBS 2984 bits | 1-3,and *ce-PUSCH-NB-MaxTBS* | Yes | N/A | PUR transmission will not use the larger UL TBS. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-4 | PUR for full-PRB in CEmodeB | 1. PUR for full-PRB in CEmodeB2. Potential UE-specific cyclic shift for DMRS | 1-3,and CEmodeB | Yes | N/A | UL data transmission will use EDT or connected mode instead of PUR in CEmodeB. | Per UE | Yes | N/A | RAN2 has agreed that PUR with UP and CP solutions have separate indications, but this is not captured in this RAN1 UE feature list. | Optional with capability signalling |
| 1-5 | PUR for sub-PRB in CEmodeA | 1. PUR for sub-PRB in CEmodeA | 1-3,and UL sub-PRB | Yes | N/A | PUR will not use sub-PRB allocation in CEmodeA. | Per UE | Yes | N/A | RAN2 has agreed that PUR with UP and CP solutions have separate indications, but this is not captured in this RAN1 UE feature list. | Optional with capability signalling |
| 1-6 | PUR for sub-PRB in CEmodeB | 1. PUR for sub-PRB in CEmodeB | 1-4,and UL sub-PRB | Yes | N/A | PUR will not use sub-PRB allocation in CEmodeB. | Per UE | Yes | N/A | RAN2 has agreed that PUR with UP and CP solutions have separate indications, but this is not captured in this RAN1 UE feature list. | Optional with capability signalling |
| 1-7 | PUR serving cell RSRP TA validation | 1. Serving cell RSRP for TA validation for PUR | 1-3 | Yes | N/A | PUR will not use serving cell RSRP for TA validation. | Per UE | Yes | N/A | TA validation mechanisms based on ‘Serving cell changes’ and ‘TA timer for idle mode’ (and ‘TA always valid’) are mandatory for PUR UEs. | Optional with capability signalling |
| 1-8 | PUR frequency hopping | 1. Frequency hopping for PUR | 1-3 | Yes | N/A | PUR will not use frequency hopping. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-9 | PUR L1 ACK | 1. L1 ACK for PUR | 1-3 | Yes | N/A | PUR will not use L1 ACK. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-10 | Multi-TB unicast for DL in CEmodeA | 1. Multi-TB unicast scheduling for DL in CEmodeA | CEmodeA | Yes | N/A | Each DCI will schedule a single TB instead of multiple TBs in DL in CEmodeA. | Per UE | Yes | N/A | Following legacy capabilities are reused to support combinations.o Rel-14 feature for 2984 bits max UL TBS in 1.4 MHz in CE mode Ao Rel-14 feature for new numbers of repetitions for PUSCH in CE mode Ao Rel-14 feature for modulation restrictions for PDSCH/PUSCH in CE mode Ao Rel-15 features for flexible starting PRB for PDSCH/PUSCH in CE mode A/B | Optional with capability signalling |
| 1-11 | Multi-TB unicast for DL in CEmodeB | 1. Multi-TB unicast scheduling for DL in CEmodeB | CEmodeB | Yes | N/A | Each DCI will schedule a single TB instead of multiple TBs in DL in CEmodeB. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-12 | Multi-TB unicast for UL in CEmodeA | 1. Multi-TB unicast scheduling for UL in CEmodeA | CEmodeA | Yes | N/A | Each DCI will schedule a single TB instead of multiple TBs in UL in CEmodeA. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-13 | Multi-TB unicast for UL in CEmodeB | 1. Multi-TB unicast scheduling for UL in CEmodeB | CEmodeB | Yes | N/A | Each DCI will schedule a single TB instead of multiple TBs in UL in CEmodeB. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-14 | Multi-TB unicast TB interleaving | 1. TB interleaving for multi-TB unicast scheduling | 1-10 or 1-11 or 1-12 or 1-13 | Yes | N/A | Multi-TB unicast will not use TB interleaving. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-15 | Multi-TB unicast HARQ bundling | 1. DL HARQ bundling for multi-TB unicast scheduling | 1-10 | Yes | N/A | Multi-TB unicast will not use HARQ bundling. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-16 | Multi-TB unicast UL sub-PRB | 1. UL sub-PRB allocation for multi-TB unicast scheduling | 1-12 or 1-13,and UL sub-PRB | Yes | N/A | Multi-TB unicast will not use UL sub-PRB. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-17 | Multi-TB unicast UL early termination | 1. UL early termination for multi-TB unicast scheduling | 1-12 and 1-25,or 1-13 and 1-26 | Yes | N/A | Multi-TB unicast will not use UL early termination. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-18 | Multi-TB unicast DL 64QAM | 1. DL 64QAM for multi-TB unicast scheduling | 1-10,and DL 64QAM | Yes | N/A | Multi-TB unicast will not use DL 64QAM. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-19 | Multi-TB unicast frequency hopping | 1. Frequency hopping for multi-TB unicast scheduling | 1-10 or 1-11 or 1-12 or 1-13 | Yes | N/A | Multi-TB unicast will not use frequency hopping. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-21 | Multi-TB SC-MTCH in CEmodeA | 1. Multi-TB SC-MTCH scheduling in CEmodeA2. Potential scheduling gaps for multi-TB SC-MTCH scheduling in CEmodeA | CEmodeA,and SC-PTM | Up to RAN2 | N/A | UE will not be able to receive SC-PTM transmissions using multi-TB scheduling in CEmodeA. | Per UE | Yes | N/A | The basic multicast (SC-PTM) functionality was introduced for LTE-M/NB-IoT in Rel-14 without capability signaling. | Up to RAN2 |
| 1-22 | Multi-TB SC-MTCH in CEmodeB | 1. Multi-TB SC-MTCH scheduling in CEmodeB2. Potential scheduling gaps for multi-TB SC-MTCH scheduling in CEmodeB | CEmodeB,and SC-PTM | Up to RAN2 | N/A | UE will not be able to receive SC-PTM transmissions using multi-TB scheduling in CEmodeB. | Per UE | Yes | N/A | The basic multicast (SC-PTM) functionality was introduced for LTE-M/NB-IoT in Rel-14 without capability signaling. | Up to RAN2 |
| 1-23 | Subframe level resource reservation for DL in CEmodeA | 1. Subframe-level time-domain resource reservation in DL in CEmodeA2. RBG-level frequency-domain resource reservation in DL in CEmodeA | CEmodeA | Yes | N/A | Whole DL subframe(s) may need to be configured as invalid in order to avoid NR collision. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-23a | Slot/symbol level resource reservation for DL in CEmodeA | 1. Slot/symbol-level time-domain resource reservation in DL in CEmodeA2. RBG-level frequency-domain resource reservation in DL in CEmodeA | 1-23 | Yes | N/A | Whole DL PRB pair(s) may need to be configured as invalid in order to avoid NR collision. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-24 | Subframe level resource reservation for DL in CEmodeB | 1. Subframe-level time-domain resource reservation in DL in CEmodeB2. RBG-level frequency-domain resource reservation in DL in CEmodeB | CEmodeB | Yes | N/A | Whole DL subframe(s) may need to be configured as invalid in order to avoid NR collision. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-24a | Slot/symbol level resource reservation for DL in CEmodeB | 1. Slot/symbol-level time-domain resource reservation in DL in CEmodeB2. RBG-level frequency-domain resource reservation in DL in CEmodeB | 1-24 | Yes | N/A | Whole DL PRB pair(s) may need to be configured as invalid in order to avoid NR collision. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-25 | Subframe level resource reservation for UL in CEmodeA | 1. Subframe-level time-domain resource reservation in UL in CEmodeA | CEmodeA | Yes | N/A | Whole UL subframe(s) may need to be configured as invalid in order to avoid NR collision. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-25a | Slot/symbol-level resource reservation for UL in CEmodeA | 1. Slot/symbol-level time-domain resource reservation in UL in CEmodeA | 1-25 | Yes | N/A | Whole UL PRB pair(s) may need to be configured as invalid in order to avoid NR collision. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-26 | Subframe level resource reservation for UL in CEmodeB | 1. Subframe-level time-domain resource reservation in UL in CEmodeB | CEmodeB | Yes | N/A | Whole UL subframe(s) may need to be configured as invalid in order to avoid NR collision. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-26a | Slot/symbol-level resource reservation for UL in CEmodeB | 1. Slot/symbol-level time-domain resource reservation in UL in CEmodeB | 1-26 | Yes | N/A | Whole UL PRB pair(s) may need to be configured as invalid in order to avoid NR collision. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-27 | Subcarrier puncturing for DL in CEmodeA | 1. Subcarrier puncturing for DL in CEmodeA | CEmodeA | Yes | N/A | The UE will suffer a slight DL performance degradation if eNB punctures anyway. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-28 | Subcarrier puncturing for DL in CEmodeB | 1. Subcarrier puncturing for DL in CEmodeB | CEmodeB | Yes | N/A | The UE will suffer a slight DL performance degradation if eNB punctures anyway. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-29 | DL quality report in Msg3 in Idle | 1. Using 2 bits in Msg3 in Idle2. Using 4 bits in Msg3 in Idle | CEmodeA | Up to RAN2 | N/A | The eNB will have to rely on other information, e.g. CSI reports if available. | Per UE | Yes | N/A | It is up to RAN2 whether to have separate capabilities for CE mode A and B. | Up to RAN2 |
| 1-30 | DL quality report in Connected | 1. DL quality report using 4 bits in Connected | CEmodeA | Up to RAN2 | N/A | The eNB will have to rely on other information, e.g. CSI reports if available.  | Per UE | Yes | N/A | It is up to RAN2 whether to have separate capabilities for CE mode A and B. | Up to RAN2 |
| 1-31 | MPDCCH performance improvement with precoder cycling in CEmodeA | 1. MPDCCH performance improvement with precoder cycling in CEmodeA | CEmodeA | Yes | N/A | MPDCCH demodulation will rely on DMRS only (not CRS) in CEmodeA. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-32 | MPDCCH performance improvement with precoder cycling in CEmodeB | 1. MPDCCH performance improvement with precoder cycling in CEmodeB | CEmodeB | Yes | N/A | MPDCCH demodulation will rely on DMRS only (not CRS) in CEmodeB. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-33 | MPDCCH performance improvement with CSI-based mapping | 1. MPDCCH performance improvement with CSI-based mapping | 1-31 | Yes | N/A | MPDCCH performance improvement does not use CSI-based mapping. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-34 | MPDCCH performance improvement with reciprocity-based candidates in TDD | 1. MPDCCH performance improvement with reciprocity-based candidates in TDD | 1-31 or 1-32 | Yes | N/A | MPDCCH performance improvement does not use reciprocity-based candidates in TDD. | Per UE | TDD only | N/A |  | Optional with capability signalling |
| 1-35 | CSI-RS-based feedback for non-BL UE | 1. CSI-RS-based feedback for non-BL UE in CEmodeA | CEmodeA | Yes | N/A | CSI feedback will be based on CRS. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-35a | Codebook subset restriction for CSI-RS-based feedback for non-BL UE in CEmodeA | 1. Codebook subset restriction for CSI-RS-based feedback for non-BL UE in CEmodeA | 1-35 | Yes | N/A | CSI feedback will be based CSI-RS without codebook subset restriction (or on CRS). | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-36 | ETWS/CMAS indication in connected mode for non-BL UE in CEmodeA | 1. ETWS/CMAS indication in connected mode for non-BL UE in CEmodeA | CEmodeA | Yes | N/A | UE will need to be released to idle mode before it can receive the ETWS/CMAS indication. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-37 | ETWS/CMAS indication in connected mode for non-BL UE in CEmodeB | 1. ETWS/CMAS indication in connected mode for non-BL UE in CEmodeB | CEmodeB | Yes | N/A | UE will need to be released to idle mode before it can receive the ETWS/CMAS indication. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-38 | LTE control region use for MPDCCH in CEmodeA | 1. LTE control region use for MPDCCH in CEmodeA | CEmodeA | Yes | N/A | MPDCCH reception will rely only on symbols transmitted in the LTE data region. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-39 | LTE control region use for MPDCCH in CEmodeB | 1. LTE control region use for MPDCCH in CEmodeB | CEmodeB | Yes | N/A | MPDCCH reception will rely only on symbols transmitted in the LTE data region. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-40 | LTE control region use for PDSCH in CEmodeA | 1. LTE control region use for PDSCH in CEmodeA | CEmodeA | Yes | N/A | PDSCH reception will rely only on symbols transmitted in the LTE data region. | Per UE | Yes | N/A |  | Optional with capability signalling |
| 1-41 | LTE control region use for PDSCH in CEmodeB | 1. LTE control region use for PDSCH in CEmodeB | CEmodeB | Yes | N/A | PDSCH reception will rely only on symbols transmitted in the LTE data region. | Per UE | Yes | N/A |  | Optional with capability signalling |
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| Company | Comment |
| Qualcomm | For 1-34, probably we need to discuss whether it can apply to CE mode B (in CE mode B there is no SRS).For 1-35, I guess this also requires TM9 to be supported.For 1-17, we are not sure of the dependency with 1-25/26.Editorial:- In 1-3, RPB->PRB (changed in text directly)- It would be good to align the description of resource reservation between eMTC and NB-IoT. |
| Ericsson | For 1-35, the prerequisite can be \*replaced\* with “*tm9-CE-ModeA-r13*”.Perhaps we can insert FFSs for the other comments from Qualcomm if it is desired to wrap up this email discussion quickly and resolve them in the May RAN1 e-meeting. |
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1. NB\_IOTenh3

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the eNB to know if the feature is supported | Need for the UE to know if the feature is supported (only for V2X WI, where the PC5-RRC capability signalling is delivered between the UEs) | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Capability interpretation for mixture of FDD/TDD | Note | Mandatory/Optional |
| 2. NB\_IOTenh3 | 2-1 | UE-group wake-up signal (Group WUS) with a wake-up time before the first associated PO (without group resource alternation) | 1. UE-group wake-up signal (Group WUS) with a wake-up time before the first associated PO (without group resource alternation)
 | Rel-15 NWUS | Yes | N/A | The network cannot wake-up a group of users with one wake-up signal | Per UE | FDD only | N/A |  | Optional with capability signalling |
| 2-2 | UE-group WUS with a wake-up time before the first associated PO (with group resource alternation) | 1. UE-group WUS with a wake-up time before the first associated PO (with group resource alternation)
 | 2-1 | Yes | N/A | The network cannot wake-up a group of users with one wake-up signal | Per UE | FDD only | N/A | If UE does not support group resource alternation and the eNB enables group resource alternation, UE falls back to Rel-15 NWUS when Rel-15 NWUS is configured or no NWUS when Rel-15 NWUS is not configured. | Optional with capability signalling |
| 2-3 | Transmission in preconfigured UL resources (PUR) (with potential UE-specific cyclic shift for DMRS) | 1. Transmission in preconfigured UL resources (PUR) (with potential UE-specific cyclic shift for DMRS)
 |  | Yes | N/A | UE cannot transmit without an UL grant | Per UE | FDD only | N/A | RAN2 has agreed that PUR with UP and CP solutions have separate indications, but this is not captured in this RAN1 UE feature list. | Optional with capability signalling |
| 2-4 | PUR with serving cell RSRP for TA validation | 1. PUR with serving cell RSRP for TA validation
 | 2-3 | Yes | N/A | PUR will not use serving cell RSRP for TA validation | Per UE | FDD only | N/A | RAN2 has agreed that PUR with UP and CP solutions have separate indications, but this is not captured in this RAN1 UE feature list.TA validation mechanisms based on ‘Serving cell changes’, ‘TA timer for idle mode’ and ‘TA always valid’ are mandatory for PUR UEs | Optional with capability signalling |
| 2-5 | PUR with L1 ACK | 1. PUR with L1 ACK
 | 2-3 | Yes | N/A | PUR will not use L1 ACK | Per UE | FDD only | N/A | RAN2 has agreed that PUR with UP and CP solutions have separate indications, but this is not captured in this RAN1 UE feature list. | Optional with capability signalling |
| 2-6 | Multi-TB scheduling for unicast in DL with a single DCI(Interleaved transmission) | 1. Multi-TB scheduling for unicast in DL with a single DCI (Interleaved transmission)
 | Two HARQ processes | Yes | N/A | The network cannot schedule transmission of multiple TBs in DL with a single DCI (interleaved transmission) | Per UE | FDD only | N/A |  | Optional with capability signalling |
| 2-7 | Multi-TB scheduling for unicast in DL with a single DCI (Non-interleaved transmission)  | 1. Multi-TB scheduling for unicast in DL with a single DCI (Non-interleaved transmission)
 | Two HARQ processes | Yes | N/A | The network cannot schedule transmission of multiple TBs in DL with a single DCI (non-interleaved transmission) | Per UE | FDD only | N/A |  | Optional with capability signalling |
| 2-8 | Multi-TB scheduling for unicast in UL with a single DCI (Interleaved transmission) | 1. Multi-TB scheduling for unicast in UL with a single DCI (Interleaved transmission)
 | Two HARQ processes | Yes | N/A | The network cannot schedule transmission of multiple TBs in UL with a single DCI (interleaved transmission) | Per UE | FDD only | N/A |  | Optional with capability signalling |
| 2-9 | Multi-TB scheduling for unicast in UL with a single DCI(Non-interleaved transmission) | 1. Multi-TB scheduling for unicast in UL with a single DCI(Non-interleaved transmission)
 | Two HARQ processes | Yes | N/A | The network cannot schedule transmission of multiple TBs in UL with a single DCI (non-interleaved transmission) | Per UE | FDD only | N/A |  | Optional with capability signalling |
| 2-10 | Multi-TB scheduling for unicast in DL in a single DCI (HARQ bundling for HARQ-ACK feedback to interleaved transmission) | 1. Multi-TB scheduling for unicast in DL in a single DCI (HARQ bundling for HARQ-ACK feedback to interleaved transmission)
 | 2-6 | Yes | N/A | The network cannot schedule transmission of multiple TBs in DL with a single DCI (HARQ bundling for HARQ-ACK feedback to interleaved transmission) | Per UE | FDD only | N/A |  | Optional with capability signalling |
| 2-11 | Multi-TB scheduling for SC-MTCH | 1. Scheduling of multiple transport blocks for SC-MTCH in a single DCI2. Scheduling of multiple transport blocks for SC-MTCH in a single DCI with scheduling gaps | SC-PTM | No | N/A | The network cannot schedule transmission of multiple TBs with a single DCI | Per UE | FDD only | N/A | The basic multicast (SC-PTM) functionality was introduced for LTE-M/NB-IoT in Rel-14 without capability signaling. |  Up to RAN2 |
| 2-12 | DL resource reservation with subframe-level granularity of NB-IoT non-anchor carriers. | 1. DL resource reservation with subframe-level granularity of NB-IoT non-anchor carriers.
 |  | Yes | N/A | NB-IoT transmission may collide with NR transmission | Per UE | Yes | N/A |  | Optional with capability signalling |
| 2-12a | DL resource reservation with slot-level and symbol-level granularity of NB-IoT non-anchor carriers. | 1. DL resource reservation with slot-level and symbol-level granularity of NB-IoT non-anchor carriers.
 | 2-12 | Yes | N/A | NB-IoT transmission may collide with NR transmission | Per UE | Yes | N/A |  | Optional with capability signalling |
| 2-13 | UL resource reservation with subframe-level granularity of NB-IoT non-anchor carriers. | 1. UL resource reservation with subframe-level granularity of NB-IoT non-anchor carriers.
 |  | Yes | N/A | NB-IoT transmission may collide with NR transmission | Per UE | Yes | N/A |  | Optional with capability signalling |
| 2-13a | UL resource reservation with slot-level and symbol(s)-level granularity of NB-IoT non-anchor carriers. | 1. UL resource reservation with slot-level and symbol(s)-level granularity of NB-IoT non-anchor carriers.
 | 2-13 | Yes | N/A | NB-IoT transmission may collide with NR transmission | Per UE | Yes | N/A |  | Optional with capability signalling |
| 2-14 | Quality report in Msg3 for non-anchor access | 1. Quality report in Msg3 for non-anchor access in IDLE mode | Non-anchor carrier for paging/RACH, non-anchor carrier for unicast | No | N/A | The network cannot receive the quality report for non-anchor carriers in IDLE mode | Per-UE | FDD only | N/A |  | Optional without capability signalling |
| 2-15 | Quality report in connected mode | 1. Quality report in connected mode other than Msg3 for anchor and non-anchor carriers |  | Yes | N/A | The network cannot receive the quality report other than in Msg3 | Per-UE | FDD only | N/A |  | Optional with capability signalling |
| 2-16 | NRS on a non-anchor carrier for paging | 1. Presence of NRS on a set of subframes on a non-anchor carrier when no paging NPDCCH is transmitted | Paging non-anchor carrier | No | N/A | UE does not know whether NRS is transmitted on a non-anchor carrier when paging is not present | Per UE | FDD only | N/A |  | Optional without capability signalling |
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| Company | Comment |
| Qualcomm | Editorial:- The description of PUR 2-3 (consequence if not supported) is probably better described in eMTC.For 2-14, the prerequisite should be only “non-anchor carrier for RACH” (capability *multiCarrier-NPRACH-r14*) |
| Ericsson | For 2-14, the prerequisite can be \*replaced\* with “*multiCarrier-NPRACH-r14*”. |
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1. LTE DL MIMO efficiency enhancements

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the eNB to know if the feature is supported | Need for the UE to know if the feature is supported (only for V2X WI, where the PC5-RRC capability signalling is delivered between the UEs) | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Capability interpretation for mixture of FDD/TDD | Note | Mandatory/Optional |
| 3.LTE DL MIMO efficiency enhancements | 3-1 | Additional SRS symbols within normal UL subframes without frequency hopping | 1. Support of additional 1~13 SRS symbols within normal UL subframes with repetitions, | SRS | Yes | N/A | Network cannot utilize additional SRS symbols within normal UL subframes | Per UE | TDD only | N/A | FFS: How to capture the limitation that a UE may support additional SRS in cells with PUSCH, but not in PUSCH-less SCells. This may be realized by additional capability signaling (including new FG), or change the “additional SRS” (3-1) to per BoBC | Optional with capability signalling |
| 3-1A | Additional SRS symbols within normal UL subframes with frequency hopping | with frequency hopping | 3-1 | Yes | N/A | Network cannot utilize frequency hopping for additional SRS symbols within normal UL subframes | Per UE + Per BoBC  | N/A | N/A | The UE may report a single capability (per UE) that applies to all band combinations in which the BoBC capability is not present (similar to nonPrecoded-r13 or beamformed-r13)Note: It is RAN1’s understanding that any further UE capability related details for indication of the gap for frequency hopping, if any, are within the purview of RAN4 | Optional with capability signalling |
| 3-1B | Additional SRS symbols within normal UL subframes with antenna switching | With antenna switching | 3-1 | Yes | N/A | Network cannot utilize antenna switching for additional SRS symbols within normal UL subframes | Per UE + Per BoBC | N/A | N/A | UE reports one or more of {1T2R, 1T4R, 2T4R\_2pairs, 2T4R\_3pairs} The UE may report a single capability (per UE) that indicates that the capability for additional SRS with antenna switching is the same as the capability for legacy SRS with antenna switching (given by BandParameters-v1530 and BandParameters-v1380) that applies to all band combinations in which the BoBC capability is not present.  Note: It is RAN1’s understanding that any further UE capability related details for indication of the gap for antenna switching, if any, are within the purview of RAN4 | Optional with capability signalling |
| 3-2 | Virtual cell Id | 1. Support of virtual cell ID for legacy (Rel-15 and earlier releases) SRS. | SRS | Yes | N/A | Network cannot utilize the virtual cell ID for SRS | Per UE | TDD only | N/A | N/A | Optional with capability signalling |
| 3-2A | Virtual cell Id | 1. Support of virtual cell ID for additional SRS symbol(s) within normal UL subframes. | SRS | Yes | N/A | Network cannot utilize the virtual cell ID for SRS | Per UE | TDD only | N/A | N/A | Optional with capability signalling |
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| Company | Comment |
| Qualcomm | Just a minor comment: there is no “SRS” feature group, probably this dependency can be removed. |
| Ericsson | Minor comment: ‘N/A’ in the Notes column of both 3-2 and 3-2A can be removed. |
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1. LTE\_TERR\_BCAST

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the eNB to know if the feature is supported | Need for the UE to know if the feature is supported (only for V2X WI, where the PC5-RRC capability signalling is delivered between the UEs) | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Capability interpretation for mixture of FDD/TDD | Note | Mandatory/Optional |
| 4. LTE\_TERR\_BCAST | 4-1 | 2.5kHz PMCH | 1. Support of 2.5kHz SCS for PMCH | Support of fembmsMixedCell or fembmsDedicatedCell | Yes | N/A | UE cannot receive services transmitted with 2.5kHz numerology | Per band | No | N/A | Need to add capability for support, plus scaling factor, like mbms-ScalingFactor1dot25. The values for the scaling factor are {2, 4, 6, 8} | Optional with capability signalling |
| 4-2 | 0.370kHz PMCH with T\_d = 2 | 1. Support of 0.370kHz SCS for PMCH with stagger length of 2 slots | Support of fembmsMixedCell or fembmsDedicatedCell | Yes | N/A | UE cannot receive services transmitted with 0.370kHz numerology and reference signal with stagger length of 2 slots | Per band | No | N/A | Need to add capability for support, plus scaling factor, like mbms-ScalingFactor1dot25. The values for the scaling factor are {12, 16, 20, 24} (the scaling factor is common for T\_d=2 and T\_d=4) | Optional with capability signalling |
| 4-3 | 0.370kHz PMCH with T\_d = 4 | 1. Support of 0.370kHz SCS for PMCH with stagger length of 4 slots | Support of fembmsMixedCell or fembmsDedicatedCell | Yes | N/A | UE cannot receive services transmitted with 0.370kHz numerology and reference signal with stagger length of 4 slots | Per band | No | N/A | Need to add capability for support, plus scaling factor, like mbms-ScalingFactor1dot25. The values for the scaling factor are {12, 16, 20, 24} (the scaling factor is common for T\_d=2 and T\_d=4) | Optional with capability signalling |
| 4-4 | PDCCH AL16 | 1. Support of PDCCH AL16 for CAS in MBMS-dedicated cell.
 | Support of fembmsDedicatedCell | No | N/A | Reduced coverage for PDCCH | Per UE | No | N/A |  | Optional without capability signalling |
| 4-5 | CFI indication in MIB-MBMS | 1. Support of semi-static CFI indication in MIB
 | Support of fembmsDedicatedCell | No | N/A | Reduced coverage for PDCCH due to PCFICH | Per UE | No | N/A |  | Optional without capability signalling |
| 4-6 | PBCH repetition  | 1. Support of PBCH repetition in CAS
 | Support of fembmsDedicatedCell | No | N/A | Reduced coverage for PBCH | Per UE | No | N/A |  | Optional without capability signalling |
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1. [5G\_V2X\_NRSL]

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| **Features** | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | **Need for the eNB to know if the feature is supported** | **Need for the UE to know if the feature is supported (only for V2X WI, where the PC5-RRC capability signalling is delivered between the UEs)** | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | **Need of FDD/TDD differentiation** | **Capability interpretation for mixture of FDD/TDD** | **Note** | **Mandatory/Optional** |
| 5. [5G\_V2X\_NRSL] | 5-1 | Receiving NR sidelink configured by LTE Uu | 1) UE can receive NR PSCCH/PSSCH. Up to [A] sidelink HARQ processes are supported.2) UE can receive [X] PSCCH in a slot.3) UE can decode [Y] RBs per slot (FFS: counting both PSCCH and PSSCH).4) UE supports reception based on the normal 64QAM MCS table [and 256QAM MCS table in FR1].5) UE supports PT-RS reception in FR2.FFS: 6) The UE can receive [Z] total number of soft channel bits in a slot.[7) minimum two receive antennas]8) UE can receive using the subcarrier spacing [and CP length] [defined for a given band in R15 in RAN4] [as configured for NR UL]FFS: 9) CP length10) Supports 14-symbol SL slot with [all/some] DMRS patterns corresponding to {#PSSCH symbols, #DMRS symbols} = {12, 4}, {9, 3} for slots w/wo PFSCH[11) UE can receive PSSCH with 256QAM in NR sidelink]12) UE can receive using 30 kHz subcarrier spacing in FR1, FFS FR2 | None | Yes | No |  | Per band | N.A. | N.A. | FFS: This is the basic FG for sidelink in licensed spectrum where eNB is operating on or managing that spectrum and optional FG otherwiseFFS: details for component (10) Note: Component 12 is required in a band indicated with only the PC5 interface in 38.101-1 Table 5.2E-1Component-2 candidate value set: {value1, value2, …}FFS: whether to report different value for each SCS indicated in component-8Component-3 candidate value set: {value1, value2, …}FFS: whether to report different value for each SCS indicated in component-8FFS: Component-6 candidate value set: {value1, value2, …}[Component-8 candidate value set in FR1:{{15 kHz}, {30 kHz}, {60 kHz}, {15, 30 kHz}, {30, 60 kHz}, {15, 60 kHz}, {15, 30, 60 kHz}}Component-8 candidate value set in FR2:{{60 kHz}, {120 kHz}, {60, 120 kHz}}][Component-12 candidate value set in FR1:{{15 kHz}, {30 kHz}, {60 kHz}, {15, 30 kHz}, {30, 60 kHz}, {15, 60 kHz}, {15, 30, 60 kHz}}Component-8 candidate value set in FR2:{{60 kHz}, {120 kHz}, {60, 120 kHz}}]Candidate values for A are {value1, value2 …} | Optional with capability signallingFFS: For UE supports NR sidelink in licensed spectrum where eNB is defined, UE must indicate this FG is supported. |
| 5-2 | Transmitting NR sidelink mode 1 scheduled by LTE Uu | 1) UE can transmit PSCCH/PSSCH using configured grant type 1 in NR sidelink mode 1 scheduled by LTE Uu. Up to [8] configured grants can be configured for a UE. Up to [C] sidelink processes are supported.2) UE supports transmission based on the normal 64QAM MCS table.3) UE supports PT-RS transmission in FR2.4) UE can transmit using the subcarrier spacing it reports.6) UE can transmit using the subcarrier spacing [and CP length] it reports.FFS: 7) CP length 8) Supports 14-symbol SL slot with [all/some] DMRS patterns corresponding to {#PSSCH symbols, #DMRS symbols} = {12, 4}, {9, 3} for slots w/wo PFSCH[9) Support downlink pathloss based open loop power control] | None | Yes | No |  | Per band | N.A. | N.A. | Note: Random selection in the exceptional pool is supported.FFS: This is the basic FG for sidelink in licensed spectrum where eNB is operating on or managing that spectrum and optional FG otherwiseComponent-6 candidate value set in FR1:{{15 kHz}, {30 kHz}, {60 kHz}, {15, 30 kHz}, {30, 60 kHz}, {15, 60 kHz}, {15, 30, 60 kHz}}Component-6 candidate value set in FR2:{{60 kHz}, {120 kHz}, {60, 120 kHz}}FFS: whether to mandate an SCS. | Optional with capability signallingFFS: For UE supports NR sidelink in licensed spectrum where eNB is defined, UE must indicate this FG is supported.Candidate values for C are {value1, value2 …} |
| 5-3 | Transmitting NR sidelink mode 2 configured by LTE Uu | 1) UE can transmit PSCCH/PSSCH using NR sidelink mode 2 configured by LTE Uu. Up to [B] sidelink processes are supported.2) UE supports transmission based on the normal 64QAM MCS table.3) UE supports PT-RS transmission in FR2.[4) UE can perform sensing and resource allocation operations.][5) UE supports rank 1 PSSCH transmissions.]6) UE can transmit using the subcarrier spacing [and CP length] it reports for FG 5-1.FFS: 7) CP length8) Supports 14-symbol SL slot with [all/some] DMRS patterns corresponding to {#PSSCH symbols, #DMRS symbols} = {12, 4}, {9, 3} for slots w/wo PFSCH9) default SCS with pre-configuration: 30 kHz with normal CP: [operator managed] same as Rel. 15 NR Uu10) UE can transmit using 30 kHz [and normal CP] subcarrier spacing in FR1, FFS FR2[11) DL pathloss based open loop power control when mode 2 is configured by NR Uu] | 5-1 | FFS | No |  | Per band | N.A. | N.A. | Note: Random selection in the exceptional pool is supported.FFS: This is the basic FG for sidelink in licensed spectrum where eNB is operating on or managing that spectrum and optional FG otherwise[Note: Component 5 is not required to be supported in a band indicated with only the PC5 interface in 38.101-1 Table 5.2E-1]Note: Component 6 is not required to be supported in a band indicated with only the PC5 interface in 38.101-1 Table 5.2E-1Note: Component 10 is required in a band indicated with only the PC5 interface in 38.101-1 Table 5.2E-1FFS: all details for component (11) | Optional with capability signallingFFS: For UE supports NR sidelink in licensed spectrum where eNB is defined, UE must indicate this FG is supported.Candidate values for B are {value1, value2 …} |
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| 5-5 | Sidelink congestion control | 1) UE can report CBR measurement to eNB [when operating in Mode 1] [and mode 2] (FFS: delete component 1) 2) UE can adjust its radio parameters based on CBR measurement and CRlimit.3) UE can process CBR and CR within the time it indicates | 5-1 and at least one of 5-2 and 5-3 | Yes | FFS |  | Per band | N.A. | N.A. | FFS: This is the basic FG for sidelink in licensed spectrum where eNB is operating on or managing that spectrum and optional FG otherwiseFFS: details of components (1)Component-3 candidate value set{Congestion process time 1, Congestion process time 2} whereCongestion process time 1: 2, 2, 4, 8 slots for 15, 30, 60, 120 kHz subcarrier spacing.Congestion process time 2: 2, 4, 8, 16 slots for 15, 30, 60, 120 kHz subcarrier spacing | Optional with capability signalling |
| 5-6 | Short-term time-scale TDM for in-device coexistence | 1) Support prioritization between LTE sidelink transmission/reception and NR sidelink transmission/reception | At least one of 5-1, 5-2, 5-3 | No | No |  | Per band | N.A. | N.A. | FFS whether a set of candicate values need to be defined for the time required for the inter-RAT conflict resolution | Optional with capability signalling |
| 5-7 | 256QAM sidelink transmission | 1) UE can transmit PSSCH with 256QAM in NR sidelink | At least one of 5-2, 5-3 | Yes | Yes | UE supports QPSK, 16QAM, and 64 QAM for transmission only. | Per band | N.A. | N.A. |  | Optional with capability signalling |
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| 5-9 | Low-spectral efficiency 64QAM MCS table | 1) UE can transmit or receive PSSCH with low-spectral efficiency 64QAM MCS table | At least one of 5-1, 5-2, 5-3 | Yes | Yes | UE supports normal 64QAM MCS table and 256QAM MCS table only. | Per band | N.A. | N.A. |  | Optional with capability signalling |
| 5-10 | eNB type synchronization source for NR sidelink | 1) UE can transmit or receive NR sidelink based on the synchronization to an eNB.2) UE additionally supports eNB, GNSS and SyncRef UE as the synchronization reference according to the synchronization procedure with sl-SyncPriority set to gnbEnb.3) If UE supports 5-4, UE additionally supports eNB, GNSS and SyncRef UE as the synchronization reference according to the synchronization procedure with sl-SyncPriority set to GNSS and sl-NbAsSync set to true. | At least one of 5-1, 5-2, 5-3 | Yes | No |  | Per band | N.A. | N.A. |  | Optional with capability signalling |
|  | 5-11 | Simultaneous transmission of uplink and sidelink | 1) UE supports simultaneous transmission of LTE uplink and NR sidelink (on different carriers) in all bands for which the UE indicated simultaneous sidelink and uplink support in a band combination. | At least one of 15-2 and 15-3 | Yes | No |  | Per band combination | N.A. | N.A. |  | Optional with capability signalling |
|  | 5-12 | Support of SL slot less than 14 consecutive symbols | 1) UE additionally supports transmission/reception of SL slot configured with 7, 8, 9, 10, 11, 12, 13 consecutive symbols [and the corresponding DMRS patterns it reports.]2) [UE supports [some/all] applicable DMRS patterns for the number of consecutive Sl symbols it reports] | At least one of 5-1, 5-2, 5-3 | Yes | No | UE supports SL only in a SL slot configured with 14 consecutive symbols. | Per band | N.A. | N.A. | FFS: This is the basic FG for sidelink in licensed spectrum where eNB is operating on or managing that spectrum and optional FG otherwiseThe component-1 candidate value set can be DRMS patterns corresponding to {#PSSCH symbols, #DMRS symbols} = {{12,2},{12,1}, {11,4},{11,3},{11,2}, {10,4},{10,3},{10,2}, {9,2},{8,3},{8,2},{7,2},{6,2}, {5,2}} | Optional with capability signalling |
|  | 5-13 | [Support of multiple synchronization references] | [1) UE can support sidelink reception using up to A synchronization references in a carrier/BWP] | At least one of 15-1, 15-2, 15-3 | Yes | No | UE supports only a single synchronization reference in a carrier/BWP. | Per band | N.A. | N.A. | Component-1 candidate value set: {1, 2, 3, 4}Note: RAN1 is still discussing whether this FG is needed | Optional with capability signalling |
|  | 5-14 | Support of rank 2 transmission | 1) UE additionally supports rank 2 PSSCH transmission | [At least one of 5-2 and 5-3] | FFS | FFS | UE supports rank 1 PSSCH transmission only. | Per band |  N.A. |  N.A. | This FG is a WA | Optional with capability signalling |
|  | 5-15 | Support of rank 2 reception | 1) UE additionally supports rank 2 PSSCH reception | [5-1] | FFS | FFS | UE supports rank 1 PSSCH reception only. | Per band |  N.A. |  N.A. | This FG is a WA. FFS: This is the basic FG for sidelink in licensed spectrum where eNB is operating on or managing that spectrum and optional FG otherwise | [Optional with capability signalling]  |
|  | 5-16 | Support of open loop SL power control and RSRP report | 1) Support sidelink pathloss based open loop power control and RSRP report in case of unicast2) [downlink pathloss based OLPC] | FFS | FFS | Yes |  | Per band |  N.A. |  N.A. | Working assumption: This FG is a basic UE FG [at least] for UEs supporting mode 1FFS: all details for component (2) FFS: whether this is a basic FG also for UEs not supporting mode 1 | Optional with capability signalling |

Note that above table is updated based on current version of NR V2X UE features list in R1-2003073. Changes are summarized below.

Common: Changed the basic FG related text to "FFS: This is the basic FG for sidelink in licensed spectrum where eNB is operating on or managing that spectrum and optional FG otherwise." This is based on the understanding that the LTE FG list of NR SL is necessary only when NR sidelink is controlled via LTE Uu and therefore NR sidelink without network control (i.e., based on pre-configuration) will be handled in NR FG list.

5-1: Copied 15-1. Deleted the pre-configuration related text

5-2: Copied 15-2. Deleted the text related to dynamic scheduling and sidelink HARQ-ACK reporting

5-3: Copied 15-3 and changed Component 9 to "[operator managed] same as Rel. 15 NR Uu"

5-4: Deleted as 15-4 is the basic feature for Rel-16 NR sidelink UEs, i.e., eNB already knows that Rel-16 NR SL capable UE supports it.

5-5: Copied 15-5 and changed gNB to eNB in Component 1

5-6: Copied 15-6

5-7: No change (same as 15-10)

5-7a: Deleted in accordance with NR feature list

5-8: Deleted as 15-11 is the basic feature for Rel-16 NR sidelink UEs

5-9: No change (same as 15-12)

5-10: Deleted "If UE supports 5-4" in Component 2 and 3

5-11: No change (same as 15-16)

5-12: Copied 15-22

5-13: Copied 15-24

5-14, 5-15, 5-16: Newly added based on 15-18, 15-19, 15-23. They may need to be reported to eNB depending on further discussion in NR UE feature list.

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1. Wideband PRG size

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the eNB to know if the feature is supported | Need for the UE to know if the feature is supported (only for V2X WI, where the PC5-RRC capability signalling is delivered between the UEs) | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Capability interpretation for mixture of FDD/TDD | Note | Mandatory/Optional |
| 6. Wideband PRG size | 6-1 | Wideband PRG size for TM9/10 in subframe operation | 1. Support the precoding granularity of TM9/10 as the scheduled resource blocks in the frequency domain for subframe PDSCH. | At least one of transmission mode 9, transmission mode 10 | Yes | N/A | In decoding of subframe PDSCH, UE cannot utilize a precoding granularity of scheduled RBs in frequency domain.  | Per UE | No | N/A |  | Optional with capability signalling |
| 6-2 | Wideband PRG size for TM9/10 in subslot operation | 1. Support the precoding granularity of TM9/10 as the scheduled resource blocks in the frequency domain for subslot SPDSCH. | At least one of transmission mode 9, transmission mode 10;Subslot operation | Yes | N/A | In decoding of subslot PDSCH, UE cannot utilize a precoding granularity of scheduled RBs in frequency domain. | Per UE | No | N/A |  | Optional with capability signalling |
| 6-3 | Wideband PRG size for TM9/10 in slot operation | 1. Support the precoding granularity of TM9/10 as the scheduled resource blocks in the frequency domain for slot SPDSCH. | At least one of transmission mode 9, transmission mode 10;slot operation | Yes | N/A | In decoding of slot PDSCH, UE cannot utilize a precoding granularity of scheduled RBs in frequency domain. | Per UE | No | N/A |  | Optional with capability signalling |

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