**3GPP TSG-RAN WG2 Meeting #110-e R2-200xxxx**

**E-meeting, June 1st – June 12th, 2020**

**Agenda item:**6.7.3.2 (NR\_IIOT-Core)

**Source:** vivo

**Title:** [AT110e][044][IIOT] Scheduling Enhancements

**Document for:** Discussion and Decision

# 1. Introduction

The document is to report the summary of the following email discussion:

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| * [AT110e][044][IIOT] Scheduling Enhancements (vivo)   Scope: Treat R2-2004737, R2-2004677, R2-2005338. Note that the proposal in R2-2004677 was attempted last meeting, failed due to nonsufficient support. Now there seems to be additional supporter so we can check if people has changed their mind (no need to re-do a lot of the discussion)  Wanted Outcome: Agreements  Deadline: June 5 0700 UTC |

This email discussion focuses on the issue on whether to support the CG periodicities of multiple of 2/7 symbols.

# 2. Issues/proposals

## 2.1 CG periodicities of multiple of 2/7 symbols

According to the current NR RRC configuration for the configuration grant, it seems that the CG periodicity can be multiple of 14 symbols. Supporting periodicity (e.g. 4) of multiple of 2/7 symbols may cause cross-slot boundary PUSCH. According to the discussion [5] in the RAN2#109bis-e meeting, RAN2 discussed the following issue:

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| FFS whether to support allowing CG periodicities of multiple of 2/7 symbols as a separate capability with a cross-slot boundary capability as a pre-requisite. |

It seems that not many companies provided their views. 5 companies preferred to support the CG periodicities of multiple of 2/7 symbols as a separate UE capability, and 2 companies considered that this is not needed. As a consequence, RAN2 did not make any conclusion on this FFS issue.

The paper [1] co-sourced by 6 companies proposes to “support CG periodicities of multiple of 2/7 symbols as a separate UE capability”, assuming that “PUSCHs that overlap with the slot boundary are handled according to RAN1 specifications (i.e. no RAN1 impact)”. The benefits/ use cases of supporting such capability in [1] are listed as follows:

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| * Observation 1: RAN1 specifications allow a UE to transmit a PUSCH that overlaps with the slot boundary if it supports and it is configured with “PUSCH repetition Type B” as part of the CG configuration. Otherwise, it does not transmit those PUSCHs that overlap with the slot boundary. * Observation 2: There are numerous use cases defined in TS 22.104 for Rel-16 which require periodicities of multiple of 2/7 symbols. * Observation 3: Covering periodicities of multiple of 2 symbols via multiple CG configurations requires seven separate CG configurations, which is highly inefficient in terms of processing and configuration complexity. * Observation 4: The collisions of SRS with CG occasions can already take place in Rel-15, e.g, for CG periodicity of 2 symbols. |

The papers [2][3][4][6] propose not to support CG periodicities of multiple of 2/7 symbols in Rel-16. The concerns from [2][3][4][6] are listed as follows:

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| * No need to support CG periodicities of multiple of 2/7 symbols for cross-slot boundary feature. [2] * CG periodicities of 2/7 symbols are already supported. [2] * The configuration of CG periodicities of multiple of 2/7 symbols can be implemented by configuring multiple CGs. [2] * TSC traffic is symmetric-like traffic at the most case. Yet, no issue/concern is raised on support SPS periodicities of multiple of 2/7 symbols. [2] * It might be premature to support this feature and further introduce a capability which relies on cross-slot boundary without any formal interaction with RAN1. [3] * The slot level periodicity introduced in Rel-16 already provides significant level of flexibility, so the additional gain is not so big. [4][6] |

**Question 1: Do we need to support extra CG periodicities of multiple of 2/7 symbols?**

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| **Company** | **Answers (Yes/No)** | **Comment** |
| vivo | Probably Yes | It seems that we do have some uses cases in TS 22.104 for Rel-16 which require periodicities of multiple of 2/7 symbols. Configuring multiple configurations of CG with 14 symbols periodicity to support a single traffic would reduce the number of periodical traffics to be supported by the UE. Given that RAN2 agreed to support the maximum 32 CG configurations per MAC entity, reducing the number of periodic traffics to be supported by the UE may not be acceptable for the UE working as a router/switch. |
| Nokia | Yes | As indicated in [1], the following are the reasons to support it:   * There are numerous use cases defined in TS 22.104 for Rel-16 which require periodicities of multiple of 2/7 symbols. * Covering periodicities of multiple of 2 symbols via multiple CG configurations requires seven separate CG configurations, which is highly inefficient in terms of processing and configuration complexity.   At the same time, there are no new issues resulting from the support of this feature and no changes other than those covered by the TP in [1] are needed in neither RAN1 nor RAN2 specifications, since:   * RAN1 specifications already allow for such behaviour **regardless** of whether a UE supports cross-slot boundary feature or not and UE behaviour is specified for both those cases. * The collisions of SRS with CG occasions can already take place in Rel-15, e.g, for CG periodicity of 2 symbols.   Also, as long as this is a capability separate from slot-level periodicities, it can be implemented by the UE vendors based on the real market need. |
| LG | No | Agree with company’s concern above. |
| OPPO | No | As we illustrated in [2], no critical issue is foreseen even if the extra CG periodicities of multiple of 2/7 symbols are not supported. So, at least in Rel-16, the enhancement is not needed. |
| Samsung | No |  |
| Spreadtrum | No |  |
| Intel | No | As discussed in our contribution [6], Rel-15 already supports 2 and 7 symbol periodicities for CG. Rel-16 further introduces slot granularity periodicity of up to 640 ms for CG. Additional support of CG periodicities of multiple of 2/7 symbols does not bring much gain of alignment between TSN periodicity and SPS/CG periodicity. |
| Huawei | No |  |
| CATT | Yes | This added flexibility allows CG configurations matching better with actual TSN traffic periodicities and for more numerologies. |
| MediaTek | No |  |
| SONY | Yes |  |
| Apple | No | Agree with contributions [2][3][4][6] and believe this is not needed in Rel-16 at this time. |
| ZTE | Yes |  |
| DOCOMO | Yes | Agree with Nokia. |
| III | No |  |
| Ericsson | Yes |  |
| Fujitsu | No | We also share views in [2][3][4][6]. |

As no contribution proposes to use the cross-slot boundary capability as a pre-requisite, the rapporteur considers that we can probably decide whether we need an new capability indication for supporting CG periodicities of multiple of 2/7 symbols if RAN2 agreed to support the extra CG periodicities of multiple of 2/7 symbols, and companies can provide comments on whether a pre-requisite condition is needed.

**Question 2: Does the UE independently indicate the support of CG periodicities of multiple of 2/7 symbols?**

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| **Company** | **Answers (Yes/No)** | **Comment** |
| vivo | Yes | It seems that according to the RAN1 specification, the UE not supporting cross-slot boundary PUSCH does not transmit those PUSCHs that overlap with the slot boundary. We are not sure whether there is any other pre-requisites. Considering the IOT test, we consider that a new capability bit is probably needed. |
| Nokia | Yes | As indicated above, the cross-slot boundary feature is not a pre-requisite for CG periodicities of multiple of 2/7 symbols. This should be a separate capability, so that it can be implemented by the UE/network vendors based on the real market need. |
| LG | Yes | Considering that cross-slot boundary capability is introduced to support mini-slot based repetition, if CG periodicities of multiple of 2/7 symbols is introduced, this should be indicated by new capability indications. |
| OPPO | Yes, if RAN2 finally agrees with extra CG periodicity. | The cross-slot boundary feature is not a pre-requisite for CG periodicities of multiple of 2/7 symbols, but CG periodicities of multiple of 2/7 symbols may introduce cross-slot boundary scheduling. Thus, we consider that a new capability bit is needed. |
| Samsung | Yes |  |
| Spreadtrum | Yes | If CG periodicities of multiple of 2/7 symbols is supported, cross-slot boundary scheduling may be needed. Thus, we think this should be a separate capability and a new capability bit is needed. |
| Intel | Yes | If RAN2 agrees to introduce CG periodicity of multiple of 2 and 7 symbols, we think a separate UE capability is needed considering UE implementation efforts. |
| Huawei | Yes | There shall be a new capability signaling bit if RAN2 agrees to support multiples of 2/7 symbol periodicity. |
| CATT | Yes | If the UE does not support cross-slot boundary but supports CG periodicities of multiple of 2/7 symbols, it can be left to network appreciation whether to configure CG configurations that may result in some PUSCHs being dropped by the UE. |
| SONY | Yes |  |
| Apple | Yes | If R2 agrees to introducing CG periodicities of multiple 2/7 symbols support. |
| ZTE | Yes |  |
| DOCOMO | Yes |  |
| III | No |  |
| Ericsson | Yes |  |
| Fujitsu | Yes | Only if RAN2 agrees on CG periodicity of multiple of 2/7 symbols. |

## 2.2 Others

In Rel-16, the CG occasion position is determined by timeReferenceSFN, timeDomainOffset, S, periodicity and N. In the current MAC running CR, it is unclear whether N should be an integer equal to or larger than 0. From the spec perspective, no restriction is defined. As illustrated in the figure below, in reality, the network could choose to configure a timeDomainOffset which points to a position after the RRC message is received. In our opinion, such configuration could be useful, especially under certain situations. For instance, if the network has disappointing estimation result about the radio condition, the network might choose to configure the timeDomainOffset with a relatively large distance from RRC message transmission. If N can be a negative value, the UE burden of computational load of deriving the correct CG position immediately after the reception of the RRC message (corresponding to N=-1 in the figure) could be alleviated. Details can refer to [7].



Thus, it may be good to have a room to clarify/discuss the value of N. As discussed with rapporteur, this issue raised in [7] is not overlapped with email discussion, and can be discussed/clarified here. Companies can provide comments on whether N could be a negative integer.

**Question 3: Whether N can be a negative integer in Type-1 CG determination?**

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| **Company** | **Answers (Yes/No)** | **Comment** |
| OPPO | Yes | As we mentioned above, we think the N can be a negative value. |
| Samsung | No | The problematic scenario OPPO pointed out is for the case that offset parameter is too large to start the first CG occasion with non-negative N. This problematic scenario can be avoided by NW configuration with a sufficiently small value to start from non-negative value.  In the current MAC specification, a condition N>=0 is missing. It would be good to add N>=0 in the formula. |
| CATT | No | We don’t quite understand the issue this proposal aims to solve and agree with Samsung to clarify N>=0. |
| Intel | No | We agree with Samsung and also prefer to add clarification N>=0. |
| III | No | Agree with Samsung’s view |
| DOCOMO | No | We also prefer to clarify N>=0. |
| Fujitsu | No | N >=0 was introduced from Rel-15 (CR was in R2-1811965). Indeed, the text N >=0 was removed because of the outcome of email discussion [Offline 53] in RAN2#108 but the purpose of the removal was just to have alignment with SPS. Terefore, N >=0 still holds. It would be good to add N >=0 in both of formulas for SPS and CG.  However, if companies think that N < 0 need to be allowed, it should be only limited to IIoT capabile UEs and not mandate to all UEs (including Rel-15 UEs). |
| LG | No | We think that the network would allocate CG type 1 resources starting from ReferenceTimeSFN + timeDomainOffset. This means that N=0 is the first available CG type 1 resource and the network may not allocate a CG type 1 resource at N=-1. Thus, We think that N cannot be a negative integer and it is not an issue because this is can be avoided by proper network configuration. |

# 3.Proposals

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# 4.Reference

[1] [R2-2004677](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_110-e\Docs\R2-2004677.zip), Periodicities of multiple of 2 or 7 symbols for CG Nokia, Nokia Shanghai Bell, Ericsson, NTT Docomo, CMCC, CATT, Sony, discussion

[2] [R2-2005338](file:///D:\Documents\3GPP\tsg_ran\WG2\TSGR2_110-e\Docs\R2-2005338.zip), Open issues on scheduling enhancement, OPPO, discussion

[3] R2-2005153, Discussion about remaining issues on scheduling enhancements, Huawei, HiSilicon, discussion

[4] R2-2005651, Remaining UE Capability Issues for IIOT, Samsung, discussion

[5] R2-2004149, CMCC, “Summary of offline discussion-026- Scheduling Enhancements”

[6] R2-2005301, Intel, “Remaining issues in IIoT UE capability”

[7] R2-2005339, OPPO, “Discussion on remaining issues for Type-1 CG”