3GPP TSG RAN WG1 #104-e R1-210xxxx

e-Meeting, January 25th – February 5th, 2021

**Agenda item: 8.8.3**

**Title: Feature lead summary on support of Type A PUSCH repetitions for Msg3**

**Source: Moderator (ZTE Corporation)**

**Document for:** **Discussion and Decision**

# Introduction

In RAN#90-e, a new WID on NR coverage enhancements was approved [1]. One objective of the WID is to specify mechanism(s) to support Type A PUSCH repetitions for Msg3.

This contribution provides a summary of proposed Msg3 enhancements in contributions submitted under AI 8.8.3 and AI 8.8.4.

# Summary of Tdocs

## Indication of the number of repetitions for Msg3

### **[H] Issue#1: Indication of the number of repetitions for Msg3 initial transmission**

For Msg3 initial transmission, it can be scheduled by RAR UL grant or fallbackRAR UL grant. Based on companies’ input, the following options are proposed for indication of the number of repetitions for Msg3 initial transmission.

* Option 1: MAC RAR or fallbackRAR
  + Support (18): [2, ZTE], [4, Huawei, HiSilicon], [5, CATT], [6, vivo], [8, Intel], [9, LG], [10, InterDigital], [11, China Telecom], [13, Panasonic], [14, CMCC], [15, ETRI], [16, Xiaomi], [17, Samsung], [18, Apple], [19, Qualcomm], [20, Ericsson], [22, NTT DOCOMO], [28, WILUS], [29, Nokia/NSB]
  + Note, Option 1 includes using the one reserved bit in MAC RAR/fallbackRAR and/or using RAR UL grant for indication.
  + [4, Huawei, HiSilicon], [15, ETRI], [16, Xiaomi] and [20, Ericsson] propose that the size of RAR UL grant used for Msg3 repetition indication shall be unchanged.
  + [6, vivo]: Mechanisms should be defined for UE to determine which RAR UL grant format to parse, if new UL grant format is introduced.
  + [2, ZTE], [10, InterDigital], [15, ETRI], [16, Xiaomi]: The TDRA field of the RAR UL grant indicates the number of repetitions for the initial transmission of msg3.
  + [16, Xiaomi]: Reuse the TPC field in UL grant of RAR to indicate the repetition number of Msg.3 initial transmission.
  + [2, ZTE], [22, NTT DOCOMO]: MAC RAR payload has one reserved bit, it may be possible to reuse the bit for the indication without changing the MAC structure.
* Option 2: DCI format 1\_0 with CRC scrambled by RA-RNTI
  + Support (3): [3, OPPO], [6, vivo], [11, China Telecom], [29, Nokia/NSB]
* Option 3: Implicit method, e.g, implicitly determined by PRACH configuration or information carried by RAR.
  + Support (2): [5, CATT], [ 12, NEC]?
* Option 4: SIB1 only
  + Support (4): [11, China Telecom], [14, CMCC], [17, Samsung], [20, Ericsson]

Regarding fallbackRAR, it is used for scheduling Msg3 in case of switching from 2-step RACH to 4-step RACH, which most possibly happens for cell-edge UEs. The Msg3 scheduled by fallbackRAR is also part of 4-step RACH, and it’s better to include here per FL understanding.

There is a clear majority on Option 1 and most companies supporting other options are also fine with Option 1. In addition, most companies prefer to use RAR UL grant instead of the one reserved bit in MAC RAR/fallbackRAR. Thus, FL suggest to focus on the following proposal.

**Proposal 1: The number of repetitions for Msg3 initial transmission is indicated by RAR UL grant or fallbackRAR UL grant.**

* **The size of RAR UL grant or fallbackRAR UL grant is unchanged.**
* **FFS the bit field for repetition indication.**

### **[H] Issue#2: Indication of the number of repetitions for Msg3 re-transmission**

For Msg3 re-transmission, it is scheduled by DCI format 0\_0 scrambled by TC-RNTI. Based on companies’ input, the following options are raised for indication of the number of repetitions for Msg3 re-transmission.

* Option 1: DCI format 0\_0 with CRC scrambled by TC-RNTI.
  + Support(11): [2, ZTE], [3, OPPO], [8, Intel], [9, LG], [10, InterDigital], [11, China Telecom], [16, Xiaomi], [18, Apple], [19, Qualcomm], [20, Ericsson], [22, NTT DOCOMO], [29, Nokia/NSB]
  + [4, Huawei, HiSilicon]: The size of DCI 0\_0 is strived to be unchanged when the repetition number of Msg3 PUSCH re-transmission is indicated by DCI*.*
  + [2, ZTE], [10, InterDigital][15, ETRI]: The TDRA field of DCI format 0\_0 with CRC scrambled by TC-RNTI indicates the number of repetitions for HARQ retransmission of msg3.
* Option 2: Implicit method. E.g., the repetition factor is implicitly determined by Msg3 initial transmission.
  + [5, CATT], [28, WILUS]

Based on above summary, FL suggests to discuss the following proposal.

**Proposal 2: The number of repetitions for Msg3 re-transmission is indicated by DCI format 0\_0 with CRC scrambled by TC-RNTI.**

* **The size of DCI format 0\_0 with CRC scrambled by TC-RNTI is unchanged.**
* **FFS the bit field for repetition indication.**

### **[M] Issue#3: Candidate values for Msg3 initial/re-transmission repetitions**

In Rel-16, the candidate values for the number of repetitions of PUSCH repetition Type A/B are copied as follows.

|  |
| --- |
| *numberOfRepetitions-r16 ENUMERATED {n1, n2, n3, n4, n7, n8, n12, n16}* |

The maximum number of repetitions would be further increased in Rel-17 as to be discussed in AI 8.8.1.1. For Msg3 repetition, the candidate values including the maximum number of repetitions should be discussed.

This issue is discussed in [3, OPPO], [4, Huawei, HiSilicon], [6, vivo], [7, SoftBank Corp], [ 12, NEC], [18, Apple], [21, Sharp], [29, Nokia/NSB].

* [4, Huawei, HiSilicon], [18, Apple]: The maximal repetition number up to 16 can be considered for Msg3 PUSCH repetition.
* [6, vivo]: The repetition numbers used for PUSCH repetition type A should be adopted as the baseline for the Msg3 repetition design, and the down selection of the repetition numbers should be studied further for the efficient indication.
* [7, SoftBank Corp]: Support at least 2 and 4 repetitions for Type A PUSCH repetitoins for Msg.3
* [12, NEC]: The number of repetition of Msg3 is suggested to be 2, 4, and 8.
* [21, Sharp]: Additional repetition factor on top of ones in Rel-16 should be considered (e.g., 5).
* [29, Nokia]: The identification of the supported number(s) of Msg3 repetitions should be carried out while considering the trade-off between at least increased coverage, increased latency, reduced flexibility and reduced efficiency of UL resource utilization.

Based on above, FL suggest to discuss the following proposal.

**Proposal 3: The repetition factors used for PUSCH repetition type A in Rel-16 is adopted as the baseline for Msg3 repetition design.**

* **FFS potential down selection of the repetition factors or adding new repetition factor(s).**

## Frequency hopping related issues.

### **[H] Issue#4: Support of inter-slot frequency hopping**

In Rel-15/16, only intra-slot FH is supported for Msg3 transmission. Similar to regular PUSCH repetition, support of inter-slot FH for Msg3 repetition should be discussed.

There are totally 10 companies propose to support inter-slot FH for Msg3 repetition, including [2, ZTE], [4, Huawei, HiSilicon], [5, CATT], [13, Panasonic], [16, Xiaomi], [18, Apple] [19, Qualcomm], [20, Ericsson] and [22, NTT DOCOMO], [28, WILUS]. Some observations are summarized as follows.

* [2, ZTE]: Inter-slot FH for Msg3 could achieve frequency diversity gain without increasing the overall DMRS overhead and fragmenting the frequency resource allocation in each slot.
* [4, Huawei, HiSilicon]: The inter-slot frequency schemes discussed for PUSCH enhancements can be reused for Msg3 PUSCH, including inter-slot frequency hopping with inter-slot bundling
* [13, Panasonic]: It was observed that inter-slot frequency hopping can achieve an improvement of 0.5~0.8 dB gain compared to intra-slot frequency hopping.
* [20, Ericsson]: Inter-slot frequency hopping allows channel filtering (averaging) in time domain over a larger duration compared to intra-slot frequency hopping. Initial link level results show 1–2 dB gain from inter-slot hopping over two frequencies compared to repetition without FH.

Based on above, FL suggest to discuss the following proposal.

**Proposal 4: Support inter-slot frequency hopping for repetition of Msg3 initial and re-transmission.**

* **FFS details, e.g., signaling indication and support of inter-slot frequency hopping with inter-slot bundling etc.**

### **[M] Issue#5: Intra-slot frequency hopping for Msg3 repetition**

In Rel-15/16, intra-slot FH is supported for Msg3 transmission without repetition. If repetition is introduced, it needs to discuss whether intra-FH could be still supported, and the FH pattern if supported.

[16, Xiaomi] proposes that only inter-slot frequency hopping is supported for Msg.3 transmission with repetitions. On the other hand, [19, Qualcomm] believe intra-slot FH should be supported, and when intra-slot frequency hopping is configured, the UE assumes the same starting RB and the same frequency offset for Msg3 PUSCH repetitions within a transmission.

FL’s understanding is intra-slot FH is already supported in legacy. It would be natural to also support in Rel-17. In addition, if Msg3 repetition could be dynamically changed, it would be weird to enable or disable intra-slot FH dynamically depending on the number of repetitions. Note, for regular PUSCH, both intra-slot and inter-slot FH are supported. It could be applied to Msg3 as well. Based on above, FL suggests to discuss the following proposal.

**Proposal 5: Support intra-slot frequency hopping for repetition of Msg3 initial and re-transmission.**

* **When intra-slot frequency hopping is configured, the UE assumes the same starting RB and the same frequency offset for Msg3 PUSCH repetitions within a transmission.**

## RV pattern

### **[M] Issue#6: RV pattern for Msg3 repetition**

In NR Rel-15/16, a UE shall use RV0 for Msg3 initial transmission, and use the 2-bit RV bit field in DCI format 0\_0 scrambled by TC-RNTI for RV indication. If Msg3 repetition is enabled, it needs to further determine the RV pattern for repetitions.

In [2, ZTE], [3, OPPO], [5, CATT], [9, LG] and [19, Qualcomm], 5 companies provide views on this issue, where [2, ZTE] and [19, Qualcomm] raise more detailed proposals as follows.

* For RV pattern for repetition of Msg3 initial transmission,
  + [2, ZTE]: FFS whether to use a fixed or dynamically indicated RV for the first repetition of Msg3 initial transmission.
  + [19, Qualcomm]: An RV pattern is fixed in the specification (e.g., 0 2 3 1) for initial Msg3 repetition, the RV associated with the first repetition of the initial Msg3 transmission is the first RV of the RV pattern.
* For RV pattern for repetition of Msg3 re-transmission,
  + [2, ZTE], [19, Qualcomm]: The RV for each repetition of Msg3 re-transmission is based on a fixed RV cycling pattern (e.g., 0 2 3 1) with the RV index for the first repetition indicated by DCI format 0\_0 scrambled by TC-RNTI.

Given there are limited input for detailed solutions for this issue, FL suggests to first discuss the following proposal.

**Proposal 6: Further discuss the determination of RV pattern for Msg3 repetition, including the following aspects.**

* **FFS whether to use a fixed RV pattern, e.g., [0 2 3 1], for the repetition of Msg3 initial and re-transmission.**
* **FFS whether to use a fixed or dynamically indicated RV for the first repetition of Msg3 initial transmission**
* **The RV index for the first repetition of Msg3 re-transmission is indicated by the 2-bit RV bit field in DCI format 0\_0 scrambled by TC-RNTI.**

## Support of enhancements studied for PUSCH in RRC\_CONNECTED state for Msg3 PUSCH initial and re-transmission

According to the WI scope, the following enhancements are included for regular PUSCH enhancements. It needs to discuss whether these enhancements could be applied for Msg3 repetition or not.

|  |
| --- |
| * Specification of PUSCH enhancements [RAN1, RAN4]   + Specify the following mechanisms for enhancements on PUSCH repetition type A [RAN1]     - Increasing the maximum number of repetitions up to a number to be determined during the course of the work.     - The number of repetitions counted on the basis of available UL slots.   + Specify mechanism(s) to support TB processing over multi-slot PUSCH [RAN1]     - TBS determined based on multiple slots and transmitted over multiple slots.   + Specify mechanism(s) to enable joint channel estimation [RAN1, RAN4]     - Mechanism(s) to enable joint channel estimation over multiple PUSCH transmissions, based on the conditions to keep power consistency and phase continuity to be investigated and specified if necessary by RAN4 [RAN1, RAN4]       * Potential optimization of DMRS location/granularity in time domain is not precluded     - Inter-slot frequency hopping with inter-slot bundling to enable joint channel estimation [RAN1] |

Note that, regarding the maximum number of repetitions supported for Msg3 repetition, e.g., whether support increased number of repetitions compared to PUSCH repetition type A in Rel-16, it will be discussed under Issue#3.

### **[M] Issue#7: Support of the number of repetitions counted on the basis of available slots for Msg3 repetition.**

Based on companies’ input, the support of enhanced PUSCH repetition type A regarding the number of repetitions counted on the basis of available slots for Msg3 initial/re-transmission is summarized as follows.

* The number of repetitions is counted on the basis of available UL slots for Msg3 repetition.
  + Support: [2, ZTE], [3, OPPO], [8, Intel], [ 12, NEC], [14, CMCC], [25, CATT]

In addition, it needs to discuss whether the number of repetitions counted on the basis of consecutive UL slots should be also supported.

Based on above, FL suggests to discuss the following proposal.

**Proposal 7: The number of repetitions is counted on the basis of available UL slots for repetition of Msg3 initial and re-transmission.**

* **FFS on support of the number of repetitions counted on the basis of consecutive UL slots.**

### **[M] Issue#8: Support of TB processing over multi-slot PUSCH for Msg3**

Based on companies’ input, the support of TB processing over multi-slot PUSCH for Msg3 initial/re-transmission is summarized as follows.

* Support TB processing over multi-slot PUSCH for Msg3 repetition
  + Support: [3, OPPO],
  + Not support: [2, ZTE]
  + FFS: [25, CATT]

Considering the limited input, FL suggests to first discuss the following proposal.

**Proposal 8: FFS support of TB processing over multi-slot PUSCH for Msg3.**

### **[M] Issue#9: Support of joint channel estimation for Msg3 repetition**

Based on companies’ input, the support of joint channel estimation for Msg3 initial/re-transmission is summarized as follows.

* Support joint channel estimation for Msg3 repetition
  + Support: [2, ZTE], [3, OPPO], [8, Intel] , [9, LG]?, [14, CMCC], [25, CATT]
  + Note that, whether support inter-slot frequency hopping with inter-slot bundling could be further discussed after making decision on Proposal 4 and Proposal 9.

Some companies also provide evaluation results for joint channel estimation for Msg3 with the following observations.

|  |
| --- |
| [8, Intel]: For Msg3 PUSCH with 8 repetitions, ~1.6dB performance gain can be achieved by joint channel estimation and inter-slot frequency hopping with inter-slot bundling, compared to Rel-15 inter-slot frequency hopping without joint channel estimation.  [14, CMCC]: The joint channel estimation could bring additional 1.75dB coverage gain when 2 slot repetitions are considered.  [2, ZTE]: Cross-slot channel estimation among 4 Msg3 repetitions can provide about 1 dB gain. Inter-slot frequency hopping with inter-slot bundling to enable joint channel estimation per bundle can provide additional performance gain for Msg3 repetition. |

In addition, [17, Samsung] and [19, Qualcomm] also raise above issue and propose to further discuss.

Based on above, FL suggests to discuss the following proposal.

**Proposal 9: Support joint channel estimation for repetition of Msg3 initial and re-transmission.**

## Differentiation between CE UEs and legacy UEs

### **[H] Issue#10: Differentiation between CE UEs and legacy UEs**

In NR Rel-15/16, PUSCH repetition is not supported for Msg3. In Rel-17, for coverage enhancement (CE) UEs supporting Msg3 repetition, mechanism is needed to differentiate these Rel-17 CE UEs from legacy UEs during initial access. Then, gNB could identify CE UEs for corresponding signaling indication and link adaptation.

Based on companies’ input, two options are proposed and summarized as follows.

* For differentiation between legacy UEs and Rel-17 CE UEs supporting Msg3 enhancements,
  + Option 1: via PRACH transmission (e.g., via separate initial UL BWP, separate PRACH resource, or PRACH preamble)
    - Support: [2, ZTE], [4, Huawei, HiSilicon], [6, vivo], [8, Intel], [9, LG], [10, InterDigital], [11, China Telecom], [ 12, NEC], [13, Panasonic], [16, Xiaomi], [17, Samsung], [19, Qualcomm], [20, Ericsson], [21, Sharp], [22, NTT DOCOMO]
    - Not support: [5, CATT]
  + Option 2: via Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH)
    - [6, vivo], [17, Samsung], [19, Qualcomm], [20, Ericsson]
    - [26, vivo]: NW may decode MSG.3 PUSCH from multiple UEs, which have transmitted the same preamble on the same RO. It is beneficial to support contention resolution for multiple UEs simultaneously to reduce the access delay of CBRA procedure, if MSG.3 PUSCH repetition is supported.
    - [19, Qualcomm]: The UE indicates the recommended number of repetitions in UCI multiplexing with Msg3 PUSCH.

In [29, Nokia/NSB], it is noted that the cost of specifying any signalling structure meant to be used by CE UEs to inform gNB about their presence and CE capabilities, is non-negligible and shall be carefully assessed by RAN1 and compared to costs and benefits of the blind approach based on oblivious gNB.

It seems majority companies understanding is Msg3 repetition scheduling is decided by gNB, and what UE needs to do is report whether it supports Msg3 repetition or not. However, [6, vivo], [9, LG], [ 12, NEC], [13, Panasonic], [19, Qualcomm] and [21, Sharp] also propose that UE decided/triggered Msg3 repetition can also be considered. Below is a summary of options proposed.

Option 1-1: gNB scheduled Msg3 repetition without UE request.

* + A UE reports support of Msg3 repetition via separate PRACH transmission.
  + For a UE supporting Msg3 repetition, gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.
    - It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.
  + *Pros: Simple solution since what needs UE do is to report the corresponding capability, and the scheduling of Msg3 is all up to gNB, and there is no need bind detection of Msg3 at gNB side.*
  + *Cons: Potential more RACH congestion*

Option 1-2: gNB scheduled Msg3 repetition without UE request.

* + gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.
    - It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.
  + If Msg3 repetition is scheduled, UE transmits Msg3 with or without repetition based on its capability, which will be indicated to gNB by Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH).
  + *Pros: Potential less RACH congestion.*
  + *Cons: It may cause gNB blind detection of Msg3 and may cause resource waste.*

Option 2: UE triggered Msg3 repetition with gNB indicating the number of repetitions

* + A UE can trigger RACH procedure with Msg3 repetition via separate PRACH transmission.
    - Whether a UE would trigger is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.
  + If Msg3 repetition is triggered by UE, gNB decides the number of repetitions X (X>1) for Msg3 (re)-transmission.
  + *Pros: There is no need bind detection of Msg3 at gNB side.*
  + *Cons: Potential more RACH congestion.*

Option 3: UE decided Msg3 repetition.

* + A UE can trigger RACH procedure with Msg3 repetition and decide the number of Msg3 repetitions via separate PRACH transmission.
    - Whether a UE would trigger or how many repetitions to trigger is based on some conditions, e.g., measured SS-RSRP, which may or may not have spec impact.
  + *Pros: There is no need bind detection of Msg3 at gNB side.*
  + *Cons: More RACH congestion. Potential more spec efforts to define the conditions if any.*

For both Option 2 and Option 3, the UE may not trigger RACH procedure with Msg3 PUSCH repetition even the UE has the capability of supporting Msg3 repetition.

Based on the summary of Issue#1, implicitly determination of the number of repetitions for Msg3 initial transmission is not preferred by most of companies since it needs a large portion of PRACH sub-grouping. Therefore, FL suggests to focus on Option 1-1/1-2 and Option 2 above.

**Proposal 10: For triggering and scheduling of Msg3 repetition, down-select one option from the following options.**

**Option 1-1: gNB scheduled Msg3 repetition without UE request.**

* + **A UE reports support of Msg3 repetition via separate PRACH transmission.**
  + **For a UE supporting Msg3 repetition, gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.**
    - **It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.**

**Option 1-2: gNB scheduled Msg3 repetition without UE request.**

* + **gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.**
    - **It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.**
  + **If Msg3 repetition is scheduled, UE transmits Msg3 with or without repetition based on its capability, which will be indicated to gNB by Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH).** 
    - **Note: Bind detection of Msg3 repetition at gNB side is needed.**

**Option 2: UE triggered Msg3 repetition with gNB indicating the number of repetitions**

* + **A UE can trigger RACH procedure with Msg3 repetition via separate PRACH transmission.**
    - **Whether a UE would trigger is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.**
  + **If Msg3 repetition is triggered by UE, gNB decides the number of repetitions X (X>1) for Msg3 (re)-transmission.**

## Start of Contention Resolution timer and PDCCH monitoring for Msg3 repetition

### **[M] Issue#11: Start of Contention Resolution timer and PDCCH monitoring for Msg3 repetition**

In Rel-15/16 RACH procedure, a UE starts the *ra-ContentionResolutionTimer* and restart the *ra-ContentionResolutionTimer* at each HARQ retransmission in the first symbol after the end of the Msg3 transmission. The UE shall monitor PDCCH for Contention Resolution while the *ra-ContentionResolutionTimer* is running. If Msg3 repetition is enabled, then it needs to discuss whether the *ra-ContentionResolutionTimer* can start or re-start after one repetition instead of after all repetitions.

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| --- |
| 5.1.5 Contention Resolution Once Msg3 is transmitted, the MAC entity shall:  1> start the *ra-ContentionResolutionTimer* and restart the *ra-ContentionResolutionTimer* at each HARQ retransmission in the first symbol after the end of the Msg3 transmission;  1> monitor the PDCCH while the *ra-ContentionResolutionTimer* is running regardless of the possible occurrence of a measurement gap;  1> if notification of a reception of a PDCCH transmission of the SpCell is received from lower layers:  ..... |
| *ra-ContentionResolutionTimer ENUMERATED { sf8, sf16, sf24, sf32, sf40, sf48, sf56, sf64}*  ***ra-ContentionResolutionTimer***  The initial value for the contention resolution timer (see TS 38.321 [3], clause 5.1.5). Value *sf8* corresponds to 8 subframes, value *sf16* corresponds to 16 subframes, and so on. |

[6, vivo], [ 12, NEC] and [17, Samsung] propose that the *ra-ContentionResolutionTimer*/PDCCH monitoring can start **before** the end of all repetition of Msg3, e.g., start after the first repetition of Msg3 transmission. The main benefits are summarized as follows:

* It is possible that gNB receives and decodes Msg3 PUSCH successfully and send PDSCH with UE contention resolution before the end of Msg3 repetition. Then, a quicker contention resolution response can be sent, i.e., a lower RACH procedure latency can be achieved.
* A UE could stop Msg3 repetition transmission if an early Contention Resolution is successful. Then, it could save the PUSCH resources by avoiding the unnecessary Msg3 repetition transmission.

An example from [6, vivo] is shown below.



Figure 1. Two candidate mechanism for Contention Resolution

FL understanding is that above advantages are valid and the potential spec impact seems minor. Therefore, FL suggests to discuss the following proposal.

**Proposal 11: Further discuss the following options for the start of Contention Resolution timer and PDCCH monitoring for Msg3 repetition**

* **Option 1: (Re-)start *ra-ContentionResolutionTimer* and PDCCH monitoring in the first symbol after the end of the all repetitions of Msg3 (re-)transmission**
* **Option 2: (Re-)start *ra-ContentionResolutionTimer* and PDCCH monitoring before the end of Msg3 (re-)transmission.**
* **FFS details**

## Other issues

### **[L] Issue#12: Spatial Domain Transmission Relation**

[17, Samsung]: The repetitions for the msg3 PUSCH transmission that is scheduled by RAR use the same beam (spatial setting) as the one for the corresponding PRACH transmission. On the other hand, the UE can select the beam for msg3 re-transmissions.

[27, Samsung]: Support UE to transmit multiple PRACH preambles over a RO bundle, with same or different spatial settings, prior to a RAR reception. Support use of CSI-RS measurements for a UE to select one or more spatial settings for PRACH transmissions. FL’s understanding is these proposals are out of WI scope.

[19, Qualcomm]: Consider one of the following options on spatial domain transmission relation for Msg3 PUSCH transmission:

* Option 1: The UE transmits the Msg3 PUSCH repetitions within a transmission (initial transmission or re-transmission) using the same spatial domain transmission relation.
* Option 2: The UE may transmit the Msg3 PUSCH repetitions within a transmission (initial transmission or re-transmission) using the different spatial domain transmission relations.

Based on the limited input, FL suggests to discuss the following questions first.

**Q-1 for Issue 12: Do you think the repetitions for Msg3 initial transmission should use the same beam (spatial setting) as the one for the corresponding PRACH transmission?**

**Q-2 for Issue 12: Do you think the beam for repetitions for Msg3 re-transmission can be up to UE implementation?**

**Q-3 for Issue 12: Do you think the UE could use different beams for different repetitions for Msg3 initial and re-transmission?**

### **[L] Issue#13: Support of qam64-LowSE MCS**

In [18, Apple]. it raises that qam64-LowSE MCS table provides more lower coding rate entries, it’s beneficial for small data transmission, such as the Msg3 56bit payload size. Therefore, it proposes that qam64-LowSE MCS table is considered for Msg3 PUSCH coverage enhancement.

Based on the limited input, FL suggests to discuss the following questions first.

**Q-1 for Issue 13: Do you think the qam64-LowSE MCS table can be supported for Msg3 repetition?**

### **[L] Issue#14: RedCap related issues**

In [2, ZTE] and [23, ZTE], it observes that Msg3 repetition based enhancements studied for CE UEs can all be applied for RedCap UEs, and no additional RedCap-specific enhancement is needed. In addition, no differentiation between Rel-17 CE UEs and Redcap UEs before Msg3 transmission can be considered.

* If differentiation between Rel-17 CE UEs and Redcap UEs before Msg3 transmission is needed. More separate PRACH configurations are required. This would need more specification efforts and may cause PRACH congestion. Since gNB may not know how many CE UEs and RedCap UEs are in the cell, using separate PRACH configurations may also potentially cause lower resource efficiency.
* In addition, the maximum initial BWP configured for CE UEs should not be larger than 20 MHz during initial access. Because the maximum supported UE bandwidth during initial access for RedCap UEs is 20 MHz, and gNB has to meet this requirement if it doesn’t know whether the accessing UE is a CE UE or RedCap UE. In our view, the physical channels during initial access basically requires very a few number of RBs and would not exceed 20MHz BW. In addition, the frequency selective fading within 20MHz is diverse enough to achieve sufficient diversity gain.

In [16, Xiaomi], it proposes that PRACH resource partition can be considered to indicate the coverage status for both normal UEs and reduced capability UEs. How to avoid too much PRACH resource fragment needs further study.

Though coverage recovery for RedCap UE will be further discussed in the next RAN meeting, it is also good to collect companies initial views on related aspects. Thus, FL suggests to discuss the following questions.

**Q-1 for Issue 14: Do you think Msg3 repetition based enhancements studied for Rel-17 CE UEs can all be applied for RedCap UEs, and no additional RedCap-specific enhancement is needed?**

**Q-2 for Issue 14: Do you think is there a need to differentiate between Rel-17 CE UEs and Redcap UEs before Msg3 transmission?**

# Discussion (1st round)

* 1st check point: Jan 28

Regarding the Issue#01~11, the detailed summary is provided in Section 2. Companies are encouraged to first check the summary above, and then provide your input for these issues below.

Based on the initial round of input, FL suggest to focus on issue#1, issue#2, issue#4 and issue#10.

### **[H] Issue#1: Indication of the number of repetitions for Msg3 initial transmission**

Proposal 1: The number of repetitions for Msg3 initial transmission is indicated by RAR UL grant or fallbackRAR UL grant.

* The size of RAR UL grant or fallbackRAR UL grant is unchanged.
* FFS the bit field for repetition indication.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| China Telecom | Generally support this proposal. Considering that the size of RAR UL grant should not be expanded, some of the current bit filed in RAR grant should then be reused to indicate Msg3 repetition factor. In our view, “PUSCH time resource allocation” field may be reused. |
| CATT | Although we are one of the proponents for explicit indication, there are some drawbacks, e.g. reuse the reserved bits defined in RAN2, re-parse some bit fields which may impact the performance of legacy UE, etc. The pros and cons are not fully discussed yet.  Considering this is the first meeting of the WI, we don’t need to preclude the potential solutions without necessary assessment. We propose to add a FFS point as ‘FFS the implicit mechanism’  Furthermore, the fallback RAR UL grant, it is only used for the two-step RACH, which is already precluded in the SI. It should be removed in the main bullet.  Based on the above comments, we proposed the following modified proposal:  Proposal 1: The number of repetitions for Msg3 initial transmission is indicated by RAR UL grant or fallbackRAR UL grant.   * The size of RAR UL grant or fallbackRAR UL grant is unchanged. * FFS the bit field for repetition indication. * FFS the implicit mechanism |
| NTT DOCOMO | We support unchanging the size of RAR UL grant. However, it is unclear how to indicate the number of repetitions with reserved 1 bit. We should specify how to indicate by RAR UL grant, before deciding that RAR UL grant is the number of repetition. |
| OPPO | Generally we are fine with this proposal, although option2 is our preference. The size of RAR UL grant should not be changed. Some of the current bit field in RAR UL grant can be used to indicate Msg3 repetition number. “Frequency resource allocation” filed can also be considered for the purpose. |
| Xiaomi | The number of repetitions for Msg3 initial transmission indicated by RAR UL grant is a good choice, which can provide an appropriate repetition number for a single UE.  The bit filed can reuse some existing fields, such as TPC, which will neither affect the scheduling, nor change the size of RAR UL grant to enable backward compatibility.  In addition, repetition number can also be merged into TDRA table and indicated by TDRA index in the RAR UL grant, just like the PUSCH repetition number indication mechanism in release 16. |
| Sharp | Support the proposal if TDRA field is used to indicate the number. Explicit information field cannot be added in current MAC RAR without increasing size. |
| WILUS | We support the FL proposal. |
| Intel | We are fine with the proposal 2 in principle. We would like to clarify whether the set of the repetition levels is configured by SIB1 or predefined in the specification. This is the first issue we need to resolve before we can decide the indication in the DCI. |
| Panasonic | We support the FL proposal. |
| Ericsson | The number of repetitions can be indicated in the TDRA list configured by SIB1 given there’s limited bits available in RAR and we should minimize the changes to RAR and DCI. There’s no need to signal number of repetitions in RAR/fallback RAR in this way and this can be used for repetition of retransmission as well. |
| ZTE | Fine with the proposal, and we prefer to use TDRA filed for indication. |
| FL | @ NTT DOCOMO, as other companies commented, it could be indicated by some existing bit field in RAR UL grant, e.g., TDRA field or other bit fields which will be further discussed.  @Intel, For now, I think it is still open, also depending on the discussion in Issue#3 and using which bit field to indicate the repetition factor. For companies preferring to use TDRA filed for indication, the set of candidate repetition factors can be indicated by SIB1 in the TDRA table. For companies supporting to reuse other bit field for indication, the set of candidate repetition factors can be indicated by SIB1 or can be predefined. One FFS point would be added to address your concern, e.g., FFS the set of candidate repetition factors is configured by SIB1 or predefined. |
| vivo | We suggest to also include PDCCH with RA-RNTI in the proposal. Since there are plenty reserved bits in RA-RNTI, and RAR UL grant format can remain unchanged, if reserved bits in RAR-PDCCH is used. For example, the repetition number is configured by SIB, and reserved bits in RAR-PDCCH can be used to trigger MSG3 PUSCH repetition without changing RAR UL grant format.  However, the indication method for MSG.3 repetition also related to the discussion in issue#10, we suggest not to down-select the options listed in section 2.1 before the issue#10 is resolved. |
| InterDigital | We share the same view as Sharp. |
| Nokia/NSB | We think that it is too early to decide that the number of repetitions is to be signalled using RAR and/or DCI. One alternative option is suggested for instance by Ericsson. Others may exist. We think we should acknowledge that there is no conclusive evidence of superiority of one option at this stage. On the other hand, we know that several pros and cons can be found for all options. Our preference is not to agree on only one direction which may not be agreeable to everyone, but rather to exclude directions which are not agreeable to anyone, if any.  Switching the focus to the payload size of UL grant, backward compatibility with Rel-15/Rel-16 operations should be guaranteed. Changes to the payload size of the UL grant may not be desirable, in principle. On the other hand, we wonder why we need to preclude the possibility for this to happen in absolute terms. RAR MAC payload as a whole could be designed to ensure operations are backward compatible, regardless of how Rel-17 UL grants are delivered in it. Surely this could imply a larger spec impact, but it would have the benefit to avoid complicated changes to DCI or to Rel-16 UL grants. Is this really something we should preclude at the very beginning of the WI? |
| Qualcomm | Support in general. However, we think fallback RAR should be FFS. |
| Apple | Support the proposal, also remove the fallbackRAR as Msg2 is not under the scope of this enhancement. |
| Lenovo, Motorola Mobility | We understand the intention of the first sub-bullet is for backward compatibility, and prefer to keep this principle at this stage for the design. With this, we suggest modifying the first sub-bullet as,   * Any modifications of RAR UL grant for indicating Msg3 repetitions shall not impact the legacy UE interpretation of the RAR.   For repetition indication using new TDRA table, we have concern on the flexibility of resource allocation especially if there are multiple repetition candidates, as in issue#3. |
| Huawei, HiSilicon | OK |

Proposal 1-v1:

* For indication of the number of repetitions for Msg3 initial transmission, down-select one option from the options below.
* Option1: RAR UL grant .
  + FFS details, e.g., determination of the candidate repetition factors, the bit field for repetition indication.
  + FFS fallbackRAR UL grant

*[FL note: For Option 1, the repetition factor can be embedded in the TDRA table configured by SIB1, and the TDRA field of the RAR UL grant indicates one row from table . Or a set of candidate repetition factors can be configured by SIB1 or predefined, and RAR UL grant indicates one repetition factor. ]*

* Option2: DCI format 1\_0 with CRC scrambled by RA-RNTI
  + FFS details, e.g., determination of the candidate repetition factors, the bit field for repetition indication.
* Any modifications of RAR UL grant or DCI format 1\_0 with CRC scrambled by RA-RNTI for indicating Msg3 repetitions shall not impact the legacy UE interpretation of the RAR or DCI format 1\_0 with CRC scrambled by RA-RNTI respectively.

Please comment if you have any concerns:

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| **Company** | **Comments** |
| Samsung | Sorry for the late reply.  Regarding the question of indication of repetition number, the first question to ask is whether there is a need to have very flexible repetition number design or even several levels of CE in current R17 CE? From current reasoning, there is not much discussion on the necessity. In our view, there could be just one separation of UEs, UE needs msg3 repetition and the UE doesn’t need.  Then from UE detection perspective, the PRACH reception is only source that gNB could use to decide the msg3 repetition number if the various/flexible number of repetition is supported, however, PRACH reception is basically energy detection, and it’s interference level and estimated SNR level (which used for msg3 PUSCH detection and decoding) may not be that reliable.  More importantly, we still need to discuss whether UE initiates or gNB initiates the msg3 repetitions, directly jump to the explicit solution for repetition indication with knowing the pre-condition is premature. After all, this majority view might be just because using RAR UL grant is an easy way to think, but remember, in rel15, the repetition number for type A PUSCH repetition is configured by RRC, and in rel16, due to the design for type B PUSCH repetition, the TDRA table is extended with addition of repetition number indication, which is not motivated by optimizing type A repetition.  Thus for now, we would like to keep this decision open (for either RAR or SIB1). |
| Ericsson | Option 1 and configure the repetition factors in a TDRA list in SIB1 similar to type A PUSCH repetition in R16. We do not see a need to introduce explicit repetition factor indication in RAR/DCI which was not even used for a normal PUSCH in DCI. Table based solution together with the row index indication in DCI/RAR is enough to avoid any changes in DCI or RAR. |
| Sharp | Option 1 with indication in TDRA field where TDRA table is configured in SIB1. |
| Intel | We are open the discuss different options and down-select in the future meeting. However, it is not clear to us how Option 2 would work. Does that mean repetition factor indication in the DCI would apply for Msg3 for all the scheduled UEs? It would be good to clarify the motivation.  For option 1, suggest to remove “FFS details~~, e.g., determination of the candidate repetition factors, the bit field for repetition indication~~”. The option mentioned by Ericsson can be also candidate solution |
| CATT | We are generally fine with the proposal. As we mentioned before, each solution has pros and cons, which needs to be carefully studied.  Regarding to the wording, we don’t think the e.g. part is needed as the ‘FFS details’ is sufficient. Secondly, we do think fallbackRAR UL grant is needed. We propose the following modification:   * For indication of the number of repetitions for Msg3 initial transmission, down-select one option from the options below. * O ption1: RAR UL grant .   + FFS details~~, e.g., determination of the candidate repetition factors, the bit field for repetition indication.~~   + ~~FFS fallbackRAR UL grant~~ * O ption2: DCI format 1\_0 with CRC scrambled by RA-RNTI   + FFS details~~, e.g., determination of the candidate repetition factors, the bit field for repetition indication.~~ * Any modifications of RAR UL grant or DCI format 1\_0 with CRC scrambled by RA-RNTI for indicating Msg3 repetitions shall not impact the legacy UE interpretation of the RAR or DCI format 1\_0 with CRC scrambled by RA-RNTI respectively. |
| Huawei, HiSilicon | Option 2 is not preferred. For the last bullet, please add back explicit sentence “the size of RAR UL grant is unchanged” for both options, which are the common understanding for both options. |
| vivo | Fine with the proposal, and further down select till issue#10 is resolved. |
| ETRI | We agree with the proposal 1-v1. |
| CMCC | Option 1 is preferred. The TDRA like the repetition indication could be considered as a starting point. |
| FL | A clear majority companies support Option 1, with many of them prefer to use TDRA bit field in UL RAR grant for repetition with repetition factors in a TDRA table configured by SIB1.  3 companies (vivo, OPPO, Nokia/NSB) support Option2. While, it is commented that it may imply that the repetition factor indicated by the DCI would apply for Msg3 for all the scheduled UEs, which may have different coverage conditions.  One company suggests to delete the detailed examples in FFS.  One company suggests to add one option for repetition indication by SIB1 only. If a fixed repetition factor is indicated, early termination of Msg3 repetition as discussed in section 2.6 can be considered to reduce resource waste.  One company prefer to keep the sentence “the size of RAR UL grant is unchanged” for both options. While it seems not acceptable for some companies which prefer to use a more generic terms (the last bullet) at this early stage.  Based on above, a further updated proposal is provided as follows. The intention is not to down-select any of the options for now. Further discussion on the pros and cons can be carried out when down-selection.  Proposal 1-v2:   * For indication of the number of repetitions for Msg3 initial transmission, down-select one option from the options below. * Option1: RAR UL grant.   + FFS details~~, e.g., determination of the candidate repetition factors, the bit field for repetition indication~~.   + FFS fallbackRAR UL grant   *[FL note: For Option 1, the repetition factor can be embedded in the TDRA table configured by SIB1, and the TDRA field of the RAR UL grant indicates one row from table . Or a set of candidate repetition factors can be configured by SIB1 or predefined, and RAR UL grant indicates one repetition factor. ]*   * Option2: DCI format 1\_0 with CRC scrambled by RA-RNTI   + FFS details~~, e.g., determination of the candidate repetition factors, the bit field for repetition indication~~. * Option3: SIB1 only * Any modifications of RAR UL grant or DCI format 1\_0 with CRC scrambled by RA-RNTI for indicating Msg3 repetitions shall not impact the legacy UE interpretation of the RAR or DCI format 1\_0 with CRC scrambled by RA-RNTI respectively. |

### **[H] Issue#2: Indication of the number of repetitions for Msg3 re-transmission**

Proposal 2: The number of repetitions for Msg3 re-transmission is indicated by DCI format 0\_0 with CRC scrambled by TC-RNTI.

* The size of DCI format 0\_0 with CRC scrambled by TC-RNTI is unchanged.
* FFS the bit field for repetition indication.

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| **Company** | **Comments** |
| China Telecom | Support this proposal. Bit field “Time domain resource assignment” can be used for repetition indication. |
| CATT | We don’t support the proposal.  The fundamental question is why we need to change the repetition number of a re-transmission. For a CE UE, the network should try to guarantee the performance of initial transmission, i.e. the repetition number of initial transmission should be suitable or even conservative. Even the initial transmission fails, gNB can achieve the link adaptation by FH, FDRA, TDRA, MCS and so on. Furthermore, the combination of initial transmission and re-transmission can further improve the coverage performance. From this perspective, transmit the Msg3 PUSCH re-transmission with the same repetition number as initial transmission is sufficient.  If the repetition number for Msg3 re-transmission is indicated by DCI format 0\_0, additional standard efforts are needed but the necessity is not justified. |
| NTT DOCOMO | We are fine with the FL’s proposal |
| OPPO | Support this proposal. How to indicate via DCI format 0\_0 can be further studied. |
| Xiaomi | Agree, since DCI format 0\_0 could provide more flexibility so that the network could adjust the number of repetitions for the retransmission based on the reception situation of the initial transmission. While for the detailed indication design, similar to the consideration in the indication in the initial transmission case, the TPC field can be reused as well. |
| Sharp | Retransmission should follow the mechanism specified for msg3 initial transmission. |
| WILUS | We support the FL proposal. |
| Intel | We are fine with the proposal 2 in principle. We would like to clarify whether the set of the repetition levels is configured by SIB1 or predefined in the specification. This is the first issue we need to resolve before we can decide the indication in the DCI. |
| Panasonic | We support the FL proposal. |
| Ericsson | The number of repetitions for retransmission can be either the same as initial transmission or determined by the repetition number signalled in the TDRA list to avoid changes in DCI. |
| ZTE | Support the proposal. |
| FL | @Intel, similar response as Proposal 1. An FFS would be added, e.g., FFS the set of candidate repetition factors is configured by SIB1 or predefined. |
| vivo | We support this proposal.  ‘HARQ process number’ and ‘NDI’ are reserved fields in DCI 0-0 with TC-RNTI, and can be reused to indicate the number of repetitions. |
| InterDigital | We support the FL’s proposal. |
| Nokia/NSB | Agree with Ericsson. |
| Qualcomm | For FFS, we suggest the following update:   * FFS the bit field for repetition indication e.g., repurpose field(s) in the DCI for repetition indication. |
| Apple | Support the FL’s proposal (and no need to keep the same number of repetition as the initial transmission…) |
| Lenovo, Motorola Mobility | We prefer either same repetition level as in the initial transmission or the repetition number is indicated without changing the DCI size. |
| Huawei, HiSilicon | OK. |

Proposal 2-v1:

* For indication of the number of repetitions for Msg3 re-transmission, down-select one option from the options below.
* Option1: DCI format 0\_0 with CRC scrambled by TC-RNTI.
  + FFS details, e.g., determination of the candidate repetition factors, the bit field for repetition indication.
  + Any modifications of DCI format 0\_0 with CRC scrambled by TC-RNTI for indicating Msg3 repetitions shall not impact the legacy UE interpretation of the DCI format 0\_0 with CRC scrambled by TC-RNTI.

*[FL note: For Option 1, the repetition factor can be embedded in the TDRA table configured by SIB1, and the TDRA field of DCI format 0\_0 with CRC scrambled by TC-RNTI indicates one row from table . Or a set of candidate repetition factors can be configured by SIB1 or predefined, and DCI format 0\_0 with CRC scrambled by TC-RNTI indicates one repetition factor. ]*

* Option2: Implicitly determined by Msg3 initial transmission.

Please comment if you have any concerns:

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| **Company** | **Comments** |
| Samsung | Whether indication repetition number or enable/disable msg3 repetition in msg3 retransmission can be further discussed. Other important fundamental issues have not been solved. See our comments in Issue #10. |
| Ericsson | Similar comment to “Proposal 1-v1”, no specific handling is needed for repetition in msg3 retransmission. A unified solution for repetitions in both msg3 initial transmission and retransmission is preferred.  Table based solution together with the row index indication in DCI is enough to avoid any changes in DCI or RAR. |
| Sharp | Option 1. After initial msg3 transmission, the gNB should have flexibility for indication of the repetition number of msg3 retransmission to fit into available time resource at the time of the retransmission. |
| Intel | We are generally fine with the proposal. Similar to the Proposal 1, suggest to remove “FFS details, e.g., ~~determination of the candidate repetition factors, the bit field for repetition indication~~” |
| CATT | Similar view as Intel, we are fine with the proposal except the ‘e.g.’ part. @ Ericsson, is your concern already addressed by option 2? Implicitly determined by Msg3 initial transmission means there is no specific handling for msg3 retransmission, right? |
| Huawei, HiSilicon | OK. |
| vivo | Fine with the proposal. And option 1 is preferred |
| ETRI | We agree with the proposal 2-v1. |
| CMCC | Option 1 is preferred. gNB could increase the repetition number if needed during the retransmission. This could reduce the retransmission number and shorten the latency. |
| FL | Majority companies support Option 1.  6 companies (CATT, Sharp, Ericsson, Apple and Lenovo, Motorola Mobility) support Option 2, with some of them also fine with Option 1.  Two companies want to modify or delete the FFS.  As a result, the proposal is updated as follows.  Proposal 2-v2:   * For indication of the number of repetitions for Msg3 re-transmission, down-select one option from the options below. * Option1: DCI format 0\_0 with CRC scrambled by TC-RNTI.   + FFS details~~, e.g., determination of the candidate repetition factors, the bit field for repetition indication~~.   + Any modifications of DCI format 0\_0 with CRC scrambled by TC-RNTI for indicating Msg3 repetitions shall not impact the legacy UE interpretation of the DCI format 0\_0 with CRC scrambled by TC-RNTI.   *[FL note: For Option 1, the repetition factor can be embedded in the TDRA table configured by SIB1, and the TDRA field of DCI format 0\_0 with CRC scrambled by TC-RNTI indicates one row from table . Or a set of candidate repetition factors can be configured by SIB1 or predefined, and DCI format 0\_0 with CRC scrambled by TC-RNTI indicates one repetition factor. ]*   * O ption2: Implicitly determined by Msg3 initial transmission. |

### **[M] Issue#3: Candidate values for Msg3 initial/re-transmission repetitions**

Proposal 3: The repetition factors used for PUSCH repetition type A in Rel-16 is adopted as the baseline for Msg3 repetition design.

* FFS potential down selection of the repetition factors or adding new repetition factor(s).

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| **Company** | **Comments** |
| China Telecom | Support this proposal. We think that the total number of repetition factors should be no larger than 4 (no larger than 4 kinds of repetition factors). |
| CATT | We are fine with the proposal. Maybe ‘baseline’ should be replaced by ‘starting point’? |
| OPPO | We are fine with the proposal. |
| Xiaomi | Redcap UE with 3 dB loss need more repetition numbers than normal UE, which should be taken into consideration for repetition factor determination if redcap UEs and normal UEs have the same coverage target. |
| Sharp | Support the proposal. At least values [1, 2, 3, 4, 7, 8, 12, 16] included in *numberOfRepetitions-r16* should be supported. |
| Intel | It would be good to first decide other discussion points, e.g., whether Msg3 repetition can be based on available UL slots. If this is agreed, our understanding is that the number of repetitions can be smaller compared to the values for PUSCH repetition type A. |
| Panasonic | We are fine with the FL proposal. |
| Ericsson | Fine. |
| ZTE | Fine with the proposal. |
| vivo | Support this proposal. |
| Nokia/NSB | According to our evaluations, as reported in our Tdoc (not listed in the References), diminishing returns could be observed for a number of actual repetitions larger than 8. Latency would also come into play in this case, and not just for CE UEs but also for legacy UEs which would share the same UL resource (both RRC\_inactive and RRC\_connected UEs). This can be particularly relevant in FR1 deployments. In this sense, we would like to ensure that the formulation of the proposal leaves the possibility to re-evaluate and re-discuss the max number of msg3 repetitions supported in Rel-17. We suggest modifying Proposal 3 as follows:  *Proposal 3: Supported values for the Msg3 repetition factors in Rel-17 will be chosen from the set of repetition factors used for PUSCH repetition type A in Rel-16.*  *FFS how many repetition factors used for PUSCH repetition type A in Rel-16 are supported values for the Msg3 repetition factors in Rel-17.* |
| Qualcomm | OK with the proposal. We think at the end, the set of repetition factors for Msg3 should be a subset of the repetition factors used for PUSCH repetition type A in Rel-17. |
| Apple | We can discuss more on the set of number of repetitions that can be defined for Msg3. We don’t see it has to start with number of rep same as Rel-16 regular Type-A PUSCH. |
| Samsung | We need to discuss first whether single value or multiple values is necessary, which is related to our previous comments that whether or how many CE levels are necessary. |
| Huawei, HiSilicon | OK. |
| ETRI | We agree with the proposal. |
| CMCC | According to the evaluation during the SI phase, Msg 3 coverage is much better than PUSCH. Then the repetition number should not be too large. Rel-16 repetition numbers could be a good starting point. And as mentioned by Nokia, the latency and further resource occupation which may delay the transmission or RACH procedure of legacy or other UEs should be considered. |
| FL | Although majority companies support the proposal, it seems not urgent issue to conclude for now. We can come back to this issue after we have a clear picture on Issue 1/2/10. |

### **[H] Issue#4: Support of inter-slot frequency hopping**

Proposal 4: Support inter-slot frequency hopping for repetition of Msg3 initial and re-transmission.

* FFS details, e.g., signaling indication and support of inter-slot frequency hopping with inter-slot bundling etc.

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| **Company** | **Comments** |
| China Telecom | Support this proposal. |
| CATT | Support. |
| NTT DOCOMO | We are fine with the FL’s proposal |
| OPPO | Support |
| Xiaomi | Comparing with intra-slot frequency hopping, Inter-slot frequency hopping could achieve better channel estimation performance due to more RS can be utilized. Furthermore, in poor channel conditions, the overall performance is more susceptible to the channel estimation performance. Thus, in our opinion, only support inter-slot is sufficient for Msg.3 transmission with repetitions. |
| Sharp | Support FL proposal. |
| WILUS | We support the FL proposal. Both intra-slot and inter-slot frequency hopping can be supported, and it’s up to gNB configuration. |
| Intel | We are fine with the proposal. |
| Panasonic | We support the FL proposal. |
| Ericsson | Fine. |
| ZTE | Support the proposal. |
| vivo | Fine with the main bullet.  For the sub bullet, we don’t think inter-slot frequency hopping with inter-slot bundling is necessary in initial access stage, which is up to UE capability. NW can configure the DMRS bundling for PUSCH transmission after RRC connected. Hence, we suggest to remove the FFS bullet. |
| Nokia/NSB | Support. |
| Qualcomm | Inter-slot bundling should be discussed separately since it may require separate UE capability in addition to the capability of supporting Msg3 PUSCH repetition. Hence, we suggest to update the proposal 4 as follows:  Proposal 4: Support inter-slot frequency hopping for repetition of Msg3 initial and re-transmission.  FFS details, e.g., signaling indication ~~and support of inter-slot frequency hopping with inter-slot bundling etc.~~ |
| Apple | Support the FL proposal |
| Lenovo, Motorola Mobility | Fine |
| Samsung | OK with the proposal. Only the condition should be the repetition for msg3 is enabled. |
| Huawei, HiSilicon | OK. |

Proposal 4-v1: Support inter-slot frequency hopping for repetition of Msg3 initial and re-transmission.

* FFS details, e.g., signaling indication ~~and support of inter-slot frequency hopping with inter-slot bundling etc~~.

Please comment if you have any concerns:

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| **Company** | **Comments** |
| Samsung | Fine with the proposal. |
| Ericsson | Fine. |
| Intel | We suggest to add the support of inter-slot frequency hopping with inter-slot bundling. If it is okay to other companies, we can update it to “whether/how to support inter-slot frequency hopping with inter-slot bundling” |
| CATT | Support |
| Huawei, HiSilicon | Fine. |
| vivo | Support this proposal. |
| ETRI | Agree with the proposal 4-v1. |
| CMCC | Support the proposal. It is natural to introduce the inter slot frequency hopping since the repetitions is introduced.  Further details could be FFS. Our initial thinking is that the signalling of Rel-16 should be reused as much as possible, since there is not much room/filed for further indications of the on/off of the inter-slot hopping. More views are welcome. |
| FL | All companies are fine with the proposal, with one company prefers to delete inter-slot frequency hopping with inter-slot bundling while one company wants to add it. It seems Intel’s suggestion is good enough for each side.  Thus, proposal is updated as follows.  Proposal 4-v2: Support inter-slot frequency hopping for repetition of Msg3 initial and re-transmission.   * FFS details, e.g., signaling indication and whether/how to support inter-slot frequency hopping with inter-slot bundling” etc. |

### **[M] Issue#5: Intra-slot frequency hopping for Msg3 repetition**

Proposal 5: Support intra-slot frequency hopping for repetition of Msg3 initial and re-transmission.

* When intra-slot frequency hopping is configured, the UE assumes the same starting RB and the same frequency offset for Msg3 PUSCH repetitions within a transmission.

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| **Company** | **Comments** |
| China Telecom | Support this proposal. |
| CATT | Support |
| OPPO | Support |
| Xiaomi | Disagree. As our analysis in issue#4, only support inter-slot frequency hopping is sufficient for Msg.3 repetition. |
| Sharp | Support FL proposal. |
| WILUS | We support the FL proposal. Both intra-slot and inter-slot frequency hopping can be supported, and it’s up to gNB configuration. |
| Intel | We are fine with the proposal. We would like to clarify that similar to Rel-15, intra-slot and inter-slot can not be configured at the same time. |
| Panasonic | We are fine with the FL proposal. |
| Ericsson | Intra-slot hopping and repetition doesn’t have to be supported at the same time in our view. |
| ZTE | Support the proposal |
| vivo | Support this proposal |
| Nokia/NSB | Agree with Intel. We prefer this to be stated explicitly in the proposal, i.e., “intra-slot and inter-slot cannot be configured at the same time”. |
| Qualcomm | Support the proposal |
| Apple | Do not support. The wording is problematic, repetition with intra-slot FH should not be supported (as mentioned by Intel) |
| Lenovo, Motorola Mobility | Fine |
| Samsung | Fine with the proposal |
| Huawei, HiSilicon | We have the similar view as Intel that intra-slot and inter-slot cannot be configured at the same time. |
| ETRI | Agree with the proposal 5. |
| FL | Majority companies support the proposal. 3 companies mentioned that intra-slot and inter-slot cannot be configured at the same time. One company has concern on intra-slot FH.  The proposal is updated as follows. FL suggests to further discuss this issue after we conclude on Issue#4.  Proposal 5-v1: Support intra-slot frequency hopping for repetition of Msg3 initial and re-transmission.   * When intra-slot frequency hopping is configured, the UE assumes the same starting RB and the same frequency offset for Msg3 PUSCH repetitions within a transmission. * Intra-slot and inter-slot cannot be configured at the same time. One company has concern on intra-slot FH. |

### **[M] Issue#6: RV pattern for Msg3 repetition**

Proposal 6: Further discuss the determination of RV pattern for Msg3 repetition, including the following aspects.

* FFS whether to use a fixed RV pattern, e.g., [0 2 3 1], for the repetition of Msg3 initial and re-transmission.
* FFS whether to use a fixed or dynamically indicated RV for the first repetition of Msg3 initial transmission
* The RV index for the first repetition of Msg3 re-transmission is indicated by the 2-bit RV bit field in DCI format 0\_0 scrambled by TC-RNTI.

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| **Company** | **Comments** |
| China Telecom | For initial transmission of Msg3, we think a fixed RV pattern is enough. Otherwise, additional signalling may be needed.  For re-transmission of Msg3, the RV bit field in DCI can be used to indicate the RV pattern. |
| CATT | Fine with the proposal. |
| OPPO | Fine with the proposal. For the repetition of Msg3 initial transmission, dynamically indicated RV for the first repetition of Msg3 initial transmission is proposed. It is consistent with the RV indication mechanism for the repetition of Msg3 re-transmission. |
| Xiaomi | For the repetition of Msg3 initial transmission, the fixed RV pattern [0 2 3 1] with the fixed RV “0” for the first repetition should be supported, and we can’t see any benefits in dynamically indicating RV for the first repetition.  For the repetition of Msg3 re-transmission, the fixed RV pattern [0 2 3 1] with a dynamically indicated RV for the first repetition should be supported, just as the RV determination mechanism for type A PUSCH repetition in release 16. |
| Sharp | We are fine to discuss further. |
| WILUS | We support the FL proposal. Fixed RV pattern and fixed indication for the first repetition can be considered for Msg3 initial transmission. For the Msg3 retransmission, RV pattern and indication for the first repetition can follow same behaviour of Rel-15/16. |
| Intel | We suggest to put the last sub-bullet as FFS too. |
| Panasonic | We are fine with the FL proposal. |
| Ericsson | Start with RV0 for initial transmission scheduled by RAR, and the start RV is the one indicated in DCI0-0 for retransmissions scheduled by DCI 0-0.  The RV pattern determination for Msg3 PUSCH repetition can be the same as PUSCH repetition Type A, i.e. use the Table 6.1.2.1-2 in 38.214 V16.4.0. |
| ZTE | We are fine to use a fixed RV pattern for Msg3 initial and re-transmission. |
| vivo | Fine with the proposal. |
| Nokia/NSB | Fine to discuss further. Initial preference aligned with China Telecom’s comment. |
| Qualcomm | Support the proposal |
| Apple | Support the FL’s proposal |
| Lenovo, Motorola Mobility | Fine |
| Samsung | Fine to FFS. |
| Huawei, HiSilicon | OK. |
| ETRI | Agree with the proposal 6. |
| FL | FL will make a more concrete proposal for further discussion. |

### **[M] Issue#7: Support of the number of repetitions counted on the basis of available slots for Msg3 repetition.**

Proposal 7: The number of repetitions is counted on the basis of available UL slots for repetition of Msg3 initial and re-transmission.

* FFS on support of the number of repetitions counted on the basis of consecutive UL slots.

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| **Company** | **Comments** |
| China Telecom | Support this proposal. |
| CATT | Although we are supportive to apply the type A repetition enhancement for normal PUSCH to Msg3 PUSCH, it may be better to defer this discussion waiting for outcome of PUSCH discussion. Additional standard efforts for Msg3 PUSCH are not expected. |
| OPPO | Fine with the proposal. The definition of available UL slots can follow the discussion on PUSCH repetition agenda item. |
| Sharp | Since repetition has not been supported for msg3, supporting repetition up to 16 with counting based on continuous slots would be enough for coverage compensation. |
| WILUS | Available slots should be counted based on *TDD-UL-DL-ConfigCommon* since UE cannot be configured with dedicated signalling before RRC connection. |
| Intel | We are fine with the proposal. |
| Panasonic | We are fine with the FL proposal. |
| Ericsson | Msg3 PUSCH repetition Type A should be the similar to Type A PUSCH repetition in R16 in our view, other optimizations are out of the scope of the work item. |
| ZTE | Support the proposal. |
| vivo | Support the proposal. |
| Nokia/NSB | It is probably too early to discuss this aspect. We are not sure we can state RAN1 properly assessed which of Rel-16 or (unstable yet) Rel-17 Type A PUSCH behaviour is the most suited for msg3. Given the importance of this aspect we propose to wait for discussion in 8.8.1.1 to be more stable. |
| Qualcomm | Should be discussed later when enhancement to counting for PUSCH repetition type A is clear. If the enhancement is complex, it may need a separate UE capability. |
| Apple | Share similar view with Nokia/NSB. Better to have more progress on pros and cons of this topic as 8.8.1.1 moves forward. |
| Huawei, HiSilicon | The issue can be discussed later after more progress on PUSCH repetition AI 8.8.1.1. |
| ETRI | Agree with the proposal 7. |
| FL | Though majority company support the proposal, it also commented by several companies that it can be discussed later after the discussion in 8.8.1.1 is more stable.  FL suggests to first focus on other fundamental issues to support Msg3 repetition. |

### **[M] Issue#8: Support of TB processing over multi-slot PUSCH for Msg3**

Proposal 8: FFS support of TB processing over multi-slot PUSCH for Msg3.

Companies are encouraged to indicate whether do you support TB processing over multi-slot PUSCH for Msg3.

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| **Company** | **Comments** |
| China Telecom | We don’t support this proposal. On one hand, it is out of the scope of current Msg3 enhancement discussion. On the other hand, it is really complex for Msg3 transmission considering TB processing. |
| CATT | OK |
| OPPO | Fine with the proposal. |
| Xiaomi | To achieve better coverage, TB processing over multi-slot combining with type A PSUCH repetition for msg3 could be considered. |
| Sharp | Supporting repetition up to 16 would be enough for coverage compensation. |
| WILUS | We don’t support. We are discussing about the Type A PUSCH repetitions for Msg3. |
| Intel | We do not support TB processing over multi-slot PUSCH for Msg3 |
| Panasonic | It can be discussed after progress on TB processing over multi-slot PUSCH in agenda item 8.8.1.2. |
| Ericsson | Msg3 PUSCH repetition Type A should be the similar to Type A PUSCH repetition in R16 in our view. UE capability on maintaining phase coherency cannot be known for Msg3. |
| ZTE | We don’t support TB processing over multiple slots for Msg3. |
| vivo | We do not support this proposal, it may need UE capability, which may not applicable for idle state transmission. |
| Nokia/NSB | This seems out of scope and unnecessary. We are not sure we should keep this proposal. |
| Qualcomm | We think repetition with RV cycling is enough for Msg3. We don’t see any need to also include TB processing over multi-slot PUSCH. |
| Apple | We do not support this proposal, not justified for Msg3 |
| Huawei, HiSilicon | No. The benefits for TB processing over multiple slots need to be further clarified. The proposal seems not providing any value yet. |
| ETRI | We do not see enough justification of multi-slot TB processing. |
| FL | Similarly, FL suggests to first focus on other fundamental issues to support Msg3 repetition. |

### **[M] Issue#9: Support of joint channel estimation for Msg3 repetition**

Proposal 9: Support joint channel estimation for repetition of Msg3 initial and re-transmission.

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| **Company** | **Comments** |
| China Telecom | Support this proposal. |
| CATT | Support. |
| OPPO | Support |
| Xiaomi | Agree. |
| Sharp | Supporting repetition up to 16 would be enough for coverage compensation. |
| WILUS | We support the FL proposal. |
| Intel | We are fine with the proposal. |
| Panasonic | Although we are supportive the FL proposal, it can be discussed after progress on joint channel estimation in agenda item 8.8.1.2. |
| Ericsson | Msg3 PUSCH repetition Type A should be the similar to Type A PUSCH repetition in R16 in our view. UE capability on maintaining phase coherency cannot be known for Msg3. |
| ZTE | Support. Based on our simulation, we observe the performance gain similar as regular PUSCH. |
| vivo | We do not support this proposal.  Agree with Ericsson that DMRS bundling need UE capability, which may not applicable for transmission in idle state. |
| Nokia/NSB | Very early to discuss this. Definitely not an urgent decision to take. We could discuss about this later during the WI, after substantial progress in 8.8.1.3. |
| Qualcomm | We do not support the proposal. Joint channel estimation should be a separate UE capability due to phase continuity maintenance. |
| Apple | We do not support the proposal, while for regular PUSCH it is still pending… |
| Samsung | To clarify, if this is supported, msg3 repetitions cannot change beams in either analog or digital. |
| Huawei, HiSilicon | Too early to decide it. Especially it is not preferred to introduce too many UE capabilities for initial access when joint channel estimation may not be mandatory feature for a Rel-17 UE capable of Msg3 repetition. |
| ETRI | We tend to agree with Ericsson and Nokia and Huawei. |
| CMCC | Support the proposal. From our simulation during the SI phase, the joint channel estimation among the repetitions could improve the coverage. |
| FL | Similarly, FL suggests to first focus on other fundamental issues to support Msg3 repetition. |

### **[H] Issue#10: Differentiation between CE UEs and legacy UEs**

Proposal 10: For triggering and scheduling of Msg3 repetition, down-select one option from the following options.

Option 1-1: gNB scheduled Msg3 repetition without UE request.

* + A UE reports support of Msg3 repetition via separate PRACH transmission.
  + For a UE supporting Msg3 repetition, gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.
    - It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.

Option 1-2: gNB scheduled Msg3 repetition without UE request.

* + gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.
    - It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.
  + If Msg3 repetition is scheduled, UE transmits Msg3 with or without repetition based on its capability, which will be indicated to gNB by Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH).
    - Note: Bind detection of Msg3 repetition at gNB side is needed.

Option 2: UE triggered Msg3 repetition with gNB indicating the number of repetitions

* + A UE can trigger RACH procedure with Msg3 repetition via separate PRACH transmission.
    - Whether a UE would trigger is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.
  + If Msg3 repetition is triggered by UE, gNB decides the number of repetitions X (X>1) for Msg3 (re)-transmission.

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| **Company** | Comments |
| China Telecom | We think it is better to divided this proposal into several part, and discuss them separately.  For example:  **Praposal a**: For differentiation between legacy Ues and Rel-17 CE Ues supporting Msg3 enhancements,  Option 1: via PRACH transmission (e.g., via separate initial UL BWP, separate PRACH resource, or PRACH preamble)  Option 2: via Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH)  **Proposal b**: Considering Msg.3 repetition, it is up to:  Option 1: gNB scheduling without UE request.  Option 2: UE triggering.  We think it will be clearer in this way. In our view, we prefer to differentiate between legacy Ues and Rel-17 CE Ues via PRACH transmission. If the differentiation work is done via Msg3 transmission, it means initial Msg3 cannot be transmitted with repetition, or else gNB should configure repetition resource for each initial Msg3 transmission, resulting in resource waste.  About the triggering of Msg3 repetition, we think it should be up to gNB scheduling, including: gNB decide whether to trigger Msg3 repetitoin and gNB decide the number of repetition factor. |
| CATT | For option 1-2, I am confused why gNB need to blind detect the Msg3 PUSCH? In the first sub-bullet, gNB already decide whether schedule Msg3 repetition or not via some mechanisms, e.g. based on the detection of PRACH transmission. If gNB already make a decision, why blind detection is still needed?  FL: Assuming gNB schedule Msg3 with repetition, if a UE doesn’t support Msg3 repetition, the UE will transmit Msg3 without repetition. However, gNB doesn’t know whether the UE supports or not. Therefore, gNB has to blind detect Msg3 w/ or w/o repetition based on the first repetition. Based on the detection of DMRS or multiplexed UCI (as proposed by some companies), gNB will know whether this UE supports repetition or not then.  [CATT] It seems the CE UE identification mechanism in your mind is depending on msg3 itself (DMRS or the UCI multiplexed on it). If so, we don’t need the following two sub-bullets for option 1-2, right?   * + gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions. * It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.   Actually, I am confused for the other options as well. No matter we call the solutions listed above, UE always need to let gNB know whether Msg3 PUSCH repetition is possible or not. Correspondingly, gNB needs to identify whether the UE supports Msg3 PUSCH repetition.  FL: Yes. For Option 1-1 and Option 2, UE will use PRACH to let gNB know whether Msg3 repetition is supported or not. For Option 1-2, UE will use Msg3 transmission to let gNB know.  The same procedure is applied for achieving the same understanding between gNB and UE across option 1-1, option 1-2 and option 2. Furthermore, what is the difference between ‘A UE reports support of Msg3 repetition via separate PRACH transmission’ and ‘A UE can trigger RACH procedure with Msg3 repetition via separate PRACH transmission’?  FL: As I summarized in section 2.5, for Option 2, the UE may not trigger RACH procedure with Msg3 PUSCH repetition even the UE has the capability of supporting Msg3 repetition, depending on whether the UE thinks repetition is needed at that time. Thus, the decision is at UE side on whether to trigger repetition or not for Option 2. On the other hand, whether to enable or disable repetition is decided by gNB for Option 1-1 and Option 1-2.  [CATT] I see. Then may be some explanation is needed for better understanding, e.g. option two needs to configure multiple RACH transmission for CE UE in order to give a chance for CE UE to trigger Msg3 repetition or not. No matter which option is adopted in the above options, gNB always needs to identify the CE UE at the first step, right?  Actually my understanding is that option1 already realize the functionality of option 2. For example, there are two sets of RACH configuration(no matter RACH resource, preamble index, RO sub-set) for a CE UE. CE UE can decide which set is used for preamble transmission. If CE UE uses the legacy resources, gNB will not indicate a Msg3 repetition. Otherwise, gNB can indicate a Msg3 repetition. To this regard, option 1-1 and option 2 is actually the same. |
| NTT DOCOMO | We are fine with the FL’s proposal |
| OPPO | In our view, for the initial access of UE, the coverage can be evaluated by UE through measurement. It is difficult for gNB to determine whether Msg3 transmission of a UE should be repeated, and the repletion number. Option 1-1 and 1-2 require gNB to have the knowledge of UE coverage, then gNB can determine the repetition of Msg3 transmission. Option 2 seems more reasonable, but more spec impacts can be foreseen. |
| Xiaomi | Option 1-1, option 1-2 and option 3 all work well. |
| Sharp | Option 1-2 is not preferred. At least whether UE has a capability of msg3 repetition or not should be indicated before msg3 scheduling. Otherwise, network cannot properly schedule mag3 repetition. |
| Intel | The formulation of the options is not clear to us. Option 1-1 seems to us that it is still some form of UE request. Whether to follow UE request is up to gNB implementation and decision. We do not need to mention “without UE request” in the main bullet.  FL: For Option 1-1, a UE only needs to report whether it has capability to support Msg3 repetition or not, i.e., for differentiation between enhanced UE and legacy UE. If the UE reports to support, it’s up to gNB to whether schedule repetition or not. For Option 2, if UE requests Msg3 repetition, it means it supports Msg3 repetition and also would ask gNB to schedule Msg3 with repetition (X>1). Hope this clarifies.  Further, we would like to clarify that separate PRACH transmission means separate RACH occasions or separate preamble in case of shared Ros.  FL: As summarized in section 2.5, it includes PRACH transmission via separate initial UL BWP, separate PRACH resource, or PRACH preamble. I will further update the proposal to make it clear. |
| Panasonic | We think Option 1-1 and Option 2 are desirable. In Rel.13 eMTC, for each PRACH coverage enhancement level, the set of numbers of repetitions for Msg.3 PUSCH transmission are determined such that  - The values indicated for CE Mode A are used for initial Msg.3 transmission corresponding to PRACH CE levels 0 and 1  - The values indicated for CE Mode B are used for initial Msg.3 transmission corresponding to PRACH CE levels 2 and 3.  As similar mechanism is necessary for Rel.17 coverage enhancement, PRACH occasion / preamble should be differentiated based on the number of Msg.3 PUSCH repetition. |
| Ericsson | Option 1-1, considering the resource overhead and implementation complexity are higher in other options. |
| ZTE | Fine with the proposal. Our preference is Option 1. Note that, UE should select a PRACH for transmission with its associating SSB RSRP higher than the configured threshold. Thus, gNB could well know the coverage performance of UE based on the detection of PRACH itself and its associated SSB. |
| vivo | In our understanding, a UE reports support of Msg3 repetition via separate PRACH transmission can be regarded as a ‘UE request’. The difference between option 2 and option 1-1 seems to be whether UE need to meet some pre-conditions for UE to request msg.3 repetition. Hence, we suggest to merge the conditions to for UE to trigger/request MSG.3 repetition under option 1-1. The Rel-15/16 RACH procedure w/o MSG.3 repetition can still be used for Rel-17 UEs with good channel condition. If no pre-conditions are required for UE to initiate a PRACH procedure with MSG.3 repetition, RACH procedure with MSG.3 repetition may be triggered excessively.  For option 1-1, NW can distinguish legacy UE and Rel-17 CE UEs, and schedule MSG.3 with prior information, while it may also lead to excessive fragmentation on PRACH resources. PRACH capacity for legacy UEs is reduced, since some of the RACH resources reserved for Rel-17 CE UEs. The impact to legacy UEs should be considered.  For option 1-2, NW need to schedule MAG.3 PUSCH repetition without prior information, and gNB may need to blind decode MSG.3 PUSCH w/ and w/o repetition. While RACH capacity for legacy UE is not impacted.  Besides, MSG. 3 repetition triggered only in MSG.3 retransmission stage can also be considered.  Hence, we suggest to keep both option 1-1 and option 1-2 in current stage. And we suggest to revise the proposals as follows  Option 1-1: gNB scheduled Msg3 repetition ~~without~~ with UE request.   * + A UE reports support of Msg3 repetition via separate PRACH transmission.   + UE request could be based on some pre-conditions, e.g., the measured SS-RSRP is lower than certain RSRP threshold.   + For a UE supporting Msg3 repetition, gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.     - It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.     - Besides, the MSG.3 repetition can be triggered only in retransmission stage.   Option 1-2: gNB scheduled Msg3 repetition without UE request.   * + gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.     - It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.     - Besides, the MSG.3 repetition can be triggered only in retransmission stage.   + If Msg3 repetition is scheduled, UE transmits Msg3 with or without repetition based on its capability, which will be indicated to gNB by Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH).     - Note: Bind detection of Msg3 repetition at gNB side is needed. |
| Nokia/NSB | During SI a long discussion was carried out on the impact that PRACH enhancements would have had on system performance in terms of latency, collision probability and so on. On the other hand, therein the modification to how resources for msg1 were configured was targeting an actual coverage increase of msg1 itself. In other words, a trade-off about msg1 could be identified, and meaningful discussions could be had. RAN1 decided that the possible latency and collision probability increase was not worth it.  Now, it is hard for us to understand why the assessment should be different in this case, where the actual modifications to how msg1 would be transmitted would not affect msg1 itself, but rather a possible msg3 transmission which may not even happen in practice (assuming that CE UEs are not present in the cell, for instance, and if they are present they are not experiencing coverage shortage and so on). In other words, we would be considering the following scenario: the likely scarce UL resource (please note that we always consider DL-heavy slot structures for both FR1 and FR2, so number of U slots is very limited) which is to be used by RRC\_inactive/RRC\_connected legacy/CE UEs (i.e., all UEs) will have to be fragmented and reduced for each category of UEs, assuming some of those UEs will support msg3 repetitions and that the same UEs will also need to repeat msg3. This does not seem very intuitive and deserves a much more accurate analysis in our opinion. There is a non-negligible risk that this could hinder performance quite significantly, especially at FR2. Are we sure, for instance, that allowing msg3 repetitions only for msg3 re-transmissions will cause more latency than having a “UE request” of any type during PRACH? From our perspective, this not clear at all at this stage.  We are at a very early stage of the WI and we should strive to make sure we do not build a feature whose effectiveness is reduced by poor design. We strongly recommend keeping discussing about pros and cons of each options in detail.  Finally, we share the same opinion as CATT on the “blind detection”. We would like to further discuss about this aspect, to ensure that detection would actually be blind in this case (it may or may not, depending on how the feature is designed). |
| Qualcomm | We think that at this stage it is better to discuss the high-level of each option. Details can be discussed later, when an option is down selected. Therefore, at this stage, we propose the following simplified proposal (details to be discussed later):  Proposal 10: For triggering and scheduling of Msg3 repetition, down-select one option from the following options.   * Option 1: gNB scheduled Msg3 repetition without UE request. * Option 2: UE triggered Msg3 repetition with gNB indicating the number of repetitions |
| Apple | We don’t see the benefit of gNB scheduling Msg3 repetition without UE request. Anyway at this stage, maybe a bit soon to go to down selection |
| Lenovo, Motorola Mobility | We prefer option 1-1 |
| Samsung | First, the CATT version on the proposal might be indeed clearer rather than mix this two aspects together.  Second, regarding the msg1 or msg3 based method, the msg1 RACH resource has taken too many responsibility, imaging 64 preambles for random access (let’s even ignore the on demand SI may take some preambles out already), if 4 SSBs in one RO, 16 preambles per SSB. Then for this 16 preambles, we need consider the partition for group A and group B, CFRA/CBRA, 2step and 4step RACH, not even consider other fancy features to further consuming PRACH resource. So from our point of view, it might be very easy to think using the PRACH for partitioning, but the reality is not that perfect. Then for msg3 based, yes, gNB needs to do some blind detection, but how much will it cost for different DMRS check, it's the multiplexing capacity that gNB has to have anyway. In the EDT (early data transmission) design, gNB even needs to blindly detect the possible TBS (and resource) that UE might use for msg3 transmission. Compared to that, checking DMRS is trivial.  Thus, we prefer discuss the msg3 design step by step, whether gnb or UE initiate? Whether multiple CE level is needed? Then following details. |
| Huawei, HiSilicon | Option 1-1 is prefered. For option 1-2, the complexity of gNB blindly detecting Msg3 repetition would increase and more analysis about the complexity is needed. . |

Proposal 10-v1:

For triggering and scheduling of Msg3 repetition, down-select one option from the following options.

Option 1-1: gNB scheduled Msg3 repetition ~~without UE request.~~

* + A UE reports support of Msg3 repetition via separate PRACH transmission (e.g., via separate initial UL BWP, separate PRACH resource, or PRACH preamble).
  + For a UE supporting Msg3 repetition, gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.
    - *It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.*
    - *FFS he MSG.3 repetition can be triggered only in retransmission stage.*

Option 1-2: gNB scheduled Msg3 repetition ~~without UE request~~.

* + gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.
    - *It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.*
    - *FFS he MSG.3 repetition can be triggered only in retransmission stage.*
  + If Msg3 repetition is scheduled, UE transmits Msg3 with or without repetition based on its capability, which will be indicated to gNB by Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH).
    - *Note: Bind detection of Msg3 repetition at gNB side is needed.*

Option 2: UE triggered Msg3 repetition with gNB indicating the number of repetitions

* + A UE can trigger RACH procedure with Msg3 repetition via separate PRACH transmission (e.g., via separate initial UL BWP, separate PRACH resource, or PRACH preamble).
    - *Whether a UE would trigger is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.*
  + If Msg3 repetition is triggered by UE, gNB decides the number of repetitions X (X>1) for Msg3 (re)-transmission.

*[FL note: the italic texts above could be potentially removed if companies prefer not to go to details at this stage]*

Please comment if you have any concerns:

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| **Company** | **Comments** |
| Samsung | This might be critical issues to be discussed in this meeting. Direct make the down selection is quite pre-mature.  First, the CATT original version on the proposal might be indeed clearer rather than mix this two aspects together. It seems the options here listed are already ruling out the msg3 based separation (which we think it’s still UE triggered but with msg3 indication)  Second, regarding the msg1 or msg3 based method, the msg1 RACH resource has taken too many responsibility, imaging 64 preambles for random access (let’s even ignore the on demand SI may take some preambles out already), if 4 SSBs in one RO, 16 preambles per SSB. Then for this 16 preambles, we need consider the partition for group A and group B, CFRA/CBRA, 2step and 4step RACH, not even consider other fancy features to further consuming PRACH resource. So from our point of view, it might be very easy to think using the PRACH for partitioning, but the reality is not that perfect. Then for msg3 based, yes, gNB needs to do some blind detection, but how much will it cost for different DMRS check, it's the multiplexing capacity that gNB has to have anyway. In the EDT (early data transmission) design, gNB even needs to blindly detect the possible TBS (and resource) that UE might use for msg3 transmission. Compared to that, checking DMRS is trivial.  Thus, we prefer discuss the msg3 design step by step, whether gnb or UE initiate? Whether multiple CE level is needed? Then following details. |
| Ericsson | The proposal basically looks fine.  However, we do not see a need to introduce a new initial UL BWP for PRACH transmission only for Msg3 repetition, we’re not doing enhancement of PRACH design (assuming the purpose may be to allow more PRACH occasions FDMed?). So “via separate initial UL BWP” can be deleted or all examples in the proposal can be deleted at this stage.  Furthermore, “*FFS he MSG.3 repetition can be triggered only in retransmission stage*.” can be deleted. And, if needed, such proposal could be discussed in a separate proposal on whether msg3 repetition is supported only for initial transmission or only for retransmission or both. At least we are assuming msg3 repetition is supposed to be supported for both initial- and re-transmission, otherwise why do we spend time on issue 1. |
| Sharp | Agree with Ericsson that “via separate initial UL BWP” should be removed. Even when the initial UL BWP is configured separately, when the network configures PRACH resources for legacy UE and CE UE in the same resource, anyway separate PRACH resource or preamble is required. In addition, doubling the number of information bits for the initial UL BWP configuration only for msg3 repetition wouldn’t be justified. Initial BWP configuration includes various information regarding PUCCH, PUSCH and PRACH. |
| Intel | It may be good to consider a simplified proposal without much details. The suggestion from CTC or QC in the first round of the discussion could be a good starting point.  Also agree with Ericsson and Sharp that “via separate initial UL BWP” should be removed |
| China Telecom | For the revised proposal, our preference is option 1-1. If everyone is fine with this, then we are all happy, and substantial progress can be made. However, companies may have different concerns, and these options are too specific and detailed. It may difficult to achieve an agreement under current conditions. Thus, we think it is better to discuss step by step, and hope some agreements can be achieved. |
| CATT | We share the similar view with Samsung, the version from CTC is cleared.  As we commented before and the reply to FL, we think there are commonality for option 1-1, 1-2 and 2. For example, all the options need separate RACH transmission in order to identify CE UE. Actually my understanding is that option1 already realize the functionality of option 2. For example, there are two sets of RACH configuration(no matter RACH resource, preamble index, RO sub-set) for a CE UE. CE UE can decide which set is used for preamble transmission. If CE UE uses the legacy resources, gNB will not indicate a Msg3 repetition. Otherwise, gNB can indicate a Msg3 repetition. To this regard, option 1-1 and option 2 is actually the same.  We prefer discuss this issue step by step. CTC version may be a better starting point. |
| Huawei, HiSilicon | We prefer Option 1-1. Similar view as Ericsson, “via separate initial UL BWP” can be deleted. Additionally,“FFS the MSG.3 repetition can be triggered only in retransmission stage.” Can be deleted because it looks like a gNB scheduling restriction and is not necessary at this stage. |
| vivo | We are fine to keep different options, w/ or w/o MSG1 indication, in current stage.  Based on the answer to CATT by FL, it seems that if UE supports MSG.3 PUSCH repetition, UE has to use separate PRACH transmission for MSG 1 to report UE capability, and the PRACH configuration for legacy UEs (w/o MSG3 repetition) can not be used for UE, which support MSG.3 repetition, to initiate a RACH attempt?  In our understanding, the PRACH configuration for legacy UEs can still be used by CE UEs capable of MSG3 repetition if the channel condition is good. And gNB does not need to know UE capability if UE triggers the legacy RACH procedure w/o MSG.3 repetition. NW can be aware of the UE capability of R17 CE UE when UE initiate the RACH procedure with MSG.3 repetition due to poor channel condition. Even if UE meets the pre-conditions to trigger MSG3 repetition, it is still up to gNB to schedule Msg3 repetition or not, and the number of repetitions if scheduled.  And we agree with Ericsson that sperate initial UL BWP should be removed.  Hence, we suggest to merge option 2 to option 1-1, as we commented in last round.  Option 1-1: gNB scheduled Msg3 repetition ~~without UE request.~~   * + A UE reports support of Msg3 repetition via separate PRACH transmission (e.g., ~~via separate initial UL BWP,~~ separate PRACH resource, or PRACH preamble).     - *Whether a UE would trigger is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.*   + For a UE supporting Msg3 repetition, gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.     - *It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.*     - *FFS the MSG.3 repetition can be triggered only in retransmission stage.*   Option 1-2: gNB scheduled Msg3 repetition ~~without UE request~~.   * + gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.     - *It’s up to gNB implementation for decision, e.g., based on the detection of PRACH transmission.*     - *FFS the MSG.3 repetition can be triggered only in retransmission stage.*   + If Msg3 repetition is scheduled, UE transmits Msg3 with or without repetition based on its capability, which will be indicated to gNB by Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH).     - *Note: Bind detection of Msg3 repetition at gNB side is needed.*   ~~Option 2: UE triggered Msg3 repetition with gNB indicating the number of repetitions~~   * + ~~A UE can trigger RACH procedure with Msg3 repetition via separate PRACH transmission (e.g., via separate initial UL BWP, separate PRACH resource, or PRACH preamble).~~     - *~~Whether a UE would trigger is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.~~*   + ~~If Msg3 repetition is triggered by UE, gNB decides the number of repetitions X (X>1) for Msg3 (re)-transmission.~~   Besides, there are two motivations to consider MSG3 repetition only in retransmission stage. For option 1-1(provided by FL and based on our understanding), UE may indicate capability of supporting MSG3 repetition through MSG1 even if UE is in good channel condition. However, gNB may not sure whether UE actually need MSG3 repetition considering channel condition, triggering MSG.3 only in retransmission stage can avoid over reservation of the resources for MSG.3 repetition in initial transmission stage. For option 1-2, gNB may need to blind decode MSG3 w/ or w/o repetition, and reserve some resources for potential MSG.3 repetition, since gNB has no priori information through MSG1. Triggering MSG.3 repetition only in retransmission stage may minimize the impact of these shortcomings. Anyway, it depends on the detailed design of the solution, we do not have strong view in current stage. |
| ETRI | We are fine with all options, though we prefer no FFS in option 1-x. |
| CMCC | Option 1-1 is preferred. And actually we also think option 1-1 and option 2 is the same procedure.  For the option 1-2, the blind detection of UE capability is not an efficient operation. As the gNB will open the detection window without any priori information whether there will be Msg 3 repetition coming. If the gNB assumes a larg e repetition number for theMsg 3 without repetition, a large delay will be induced. And gNB even further combine the Msg 3 without repetition with the noise received in the following repetition occasions, the detection performance would be even worse. This is not fair for the legacy UEs.  For the “via separate initial UL BWP”, we think it is a good way to differentiate the legacy UE and the CE UE. Since it is raised as an example, we do not see much necessary to remove it. At least, for the other two examples, separated resource or preambles, those could be remained to provide further information of “separate PRACH transmission”.  For the italic texts under the 2nd bullet of option 1-1, we think it may not be a good example due to that PRACH could ramp up the power to increase the detection possibilities. We are open to discuss further mechanisms from UE side to facilitate gNB making a good decision of repetition numbers. |
| FL | FL intention was to first figure out the proposed options with combing the differentiation mechanism and triggering mechanism. This could give us a whole picture of the fundamental mechanism to support Msg3 repetition. On the other quite some companies prefer to discuss step by step, without mixing up differentiation and triggering.  Given we anyway we need to discus how to bundle the two aspects together, FL suggests the following:   * Discuss two high-level proposals separately for UE differentiation and Msg3 repetition triggering. Companies can provide views on whether agree with the principle. * Discuss the possible combination options of UE differentiation and Msg3 repetition triggering. Companies are encouraged to indicate the positions for the options listed below. If no option aligns with your proposal, please do not change the given options unless you think it doesn’t work. Instead, provide your detailed mechanism with a new option. Companies are also encouraged to provide the pros and cons of the options, though we may not down-select one at this round of discussion.   **Proposal 10a**: For differentiation between legacy UEs and Rel-17 CE UEs supporting Msg3 enhancements, select one option from the two options below.   * Option 1: via separate PRACH occasion or separate PRACH preamble * Option 2: via Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH)   **Proposal 10b**: For Msg3 repetition triggering, select one option from the two options below.   * Option 1: gNB scheduled Msg3 repetition without UE request. * Option 2: UE triggered Msg3 repetition with gNB indicating the number of repetitions.   Option 1-1: For gNB scheduled Msg3 repetition without UE request,   * + A UE reports support of Msg3 repetition via separate PRACH transmission (e.g., separate PRACH resource, or PRACH preamble).   + For a UE supporting Msg3 repetition, gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.   + FFS details if any.   *[FL note: If UE supports MSG.3 PUSCH repetition, UE has to use separate PRACH transmission for MSG 1 to report UE capability, and the PRACH configuration for legacy UEs (w/o MSG3 repetition) can not be used for UE, which support MSG.3 repetition.]*  *A UE reports its capability/incapability for Msg3 repetition. If supported, it’s up to gNB decision to schedule Msg3 repetition or not. In other words, the enabling of Msg3 repetition is not triggered/decided by UE]*  Option 2-1: For UE triggered Msg3 repetition with gNB indicating the number of repetitions,   * + A UE can trigger RACH procedure with Msg3 repetition via separate PRACH transmission (e.g., separate PRACH resource, or PRACH preamble).     - *Whether a UE would trigger is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.*   + If Msg3 repetition is triggered by UE, gNB decides the number of repetitions for Msg3 (re)-transmission.   + FFS details if any.   *[FL note: If UE supports MSG.3 PUSCH repetition, UE can use PRACH configuration for legacy UEs or separate PRACH transmission for triggering Msg3 repetition. If UE uses legacy PRACH configuration, gNB cannot schedule Msg3 repetition. If UE uses separate PRACH transmission for triggering, gNB can decide the number of repetitions for Msg3, which could be one or more than one repetitions.]*  Option 2-2: For UE triggered Msg3 repetition with gNB indicating the number of repetitions,   * + gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.   + If Msg3 repetition is scheduled, UE transmits Msg3 with or without repetition. If UE transmits Msg3 repetition, the number of repetition follows the indication of gNB and UE uses separate Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH).     - *Whether a UE would trigger is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.*   + FFS details if any.   *[FL note: Before Msg3 transmission, gNB doesn’t know whether a UE supports Msg3 repetition or not. Even in such case, gNB may decide to schedule Msg3 repetition. If Msg3 repetition is scheduled, UE may or may not use separate Msg3 transmission. gNB can blindly detect the first repetition to identify whether Msg3 repetition is triggered by UE. Whether Msg3 repetition would be actually triggered is decided by UE.]* |

### **[M] Issue#11: Start of Contention Resolution timer and PDCCH monitoring for Msg3 repetition**

Proposal 11: Further discuss the following options for the start of Contention Resolution timer and PDCCH monitoring for Msg3 repetition

* Option 1: (Re-)start *ra-ContentionResolutionTimer* and PDCCH monitoring in the first symbol after the end of the all repetitions of Msg3 (re-)transmission
* Option 2: (Re-)start *ra-ContentionResolutionTimer* and PDCCH monitoring before the end of Msg3 (re-)transmission.
* FFS details

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| **Company** | **Comments** |
| China Telecom | We support Option 2. It may be beneficial for improving the UL resource utilization. |
| CATT | Support. |
| OPPO | Support. We are fine with both option 1 and 2. |
| Xiaomi | Option 2 should be supported. Following the method given by option 2, the early termination of msg3 repetition could be achieved, which will reduce the power consumption and save the PUSCH resources by avoiding the unnecessary Msg3 repetition transmission. Besides, it can also minimize the delay of RACH procedure. |
| Sharp | We are fine with either. |
| Intel | We are not sure whether the above options are needed. The current spec is clear and we do not need to change that. Note that the benefit of early termination of repetition was not considered as part of study for NR coverage enhancement and we do not think we need to further consider this for Msg3 PUSCH repetition. |
| Panasonic | We are fine with FL proposal. |
| Ericsson | RAN2 guidance on this may be needed before we discuss any options. |
| ZTE | We are fine with Option 2 which could reduce the latency and also avoid unnecessary repetitions. |
| vivo | Support Option 2. |
| Nokia/NSB | Agree with Ericsson. |
| Qualcomm | Agree with Ericsson and Nokia. |
| Apple | Support the proposal with both options under FFS |
| Samsung | This two aspects may not need to be combined.  (re)start of msg3 contention resolution timer can still be based on msg3 transmission (rather than each repetitions); because this timer is intended to react to the detection results and msg4, so restart for each repetition is not reasonable.  The PDCCH monitoring can start from the end of first repetition |
| Huawei, HiSilicon | Agree with Ericsson, Nokia, Qualcomm. |
| ETRI | Agree with the proposal 11. |
| FL | FL suggests to first focus on other fundamental issues to support Msg3 repetition. |

### **Other issues**

Regarding Issue#12~14, there are limited input, and it seems no urgent to discuss for now. Thus, FL would like to de-prioritize these issues. However, interested companies are also encouraged to provide your view below, if any, based on the listed questions. If the proposals above could somehow progress fast, FL proposals would be made correspondingly.

* Q-1 for Issue 12: Do you think the repetitions for Msg3 initial transmission should use the same beam (spatial setting) as the one for the corresponding PRACH transmission?
* Q-2 for Issue 12: Do you think the beam for repetitions for Msg3 re-transmission can be up to UE implementation?
* Q-3 for Issue 12: Do you think the UE could use different beams for different repetitions for Msg3 initial and re-transmission?
* Q-1 for Issue 13: Do you think the qam64-LowSE MCS table can be supported for Msg3 repetition?
* Q-1 for Issue 14: Do you think Msg3 repetition based enhancements studied for Rel-17 CE UEs can all be applied for RedCap UEs, and no additional RedCap-specific enhancement is needed?
* Q-2 for Issue 14: Do you think is there a need to differentiate between Rel-17 CE UEs and Redcap UEs before Msg3 transmission?

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| **Company** | **Comments** |
| Xiaomi | Q-3 for Issue 12, Q-1 for Issue 13: Yes.  Q-1 for Issue 14: Msg3 repetition based enhancements studied for Rel-17 CE UEs can be applied for Redcap UE with adjustment in the several aspects:   * Repetition number. Comparing with normal UEs, Redcap UEs in the same channel condition have 3 dB loss due to form factor limitation, so the redcap UE needs more repetition numbers if it has the same coverage target with normal UE. * Frequency hopping for msg3 repetition. If redcap UEs and normal UEs share the same initial UL BWP, redcap UE may hop over its system bandwidth if it use the same RB offset or start RB determination with normal UE.   Q-2 for Issue 14: Since redcap UEs have a limited bandwidth and may require more repetition numbers, gNB needs to differentiate between normal UEs and redcap UEs before resource allocation of msg3. |
| vivo | Q-1 for Issue 12:  Follow the same behaviour as that for MSG3 PUSCH without repetition. The same beam can be used by UE implementation.  Q-2 and Q-3 for Issue 12:  If UE have determined a better SSB and UE may use a different beam for MSG.3 retransmission. But, it seems that gNB may not aware of which beam UE selected for MSG.3 retransmission and use the same spatial Rx filter to receive MSG.3 reTx as that for initial transmission. Hence, the benefit of select a different beam for MSG.3 repetition is not clear. Similarly, the benefit to use different beam for different repetition is also not clear.  Q-1 for Issue 13:  No, supporting qam64-LowSE MCS table is optional UE capability in Rel-16, and not applicable for UE in initial access stage.  Q-1 for Issue 14:  We think this issue should be discussed in Redcap AI.  Q-2 for Issue 14:  We think this issue should be discussed in Redcap AI. |
| Samsung | For the beam issue, one additional aspect is whether different beams can be used in the multiple repetitions in one msg3 transmission. |

# Discussion (2nd round)

* 2nd check point: Feb 2

### **[H] Issue#10: Differentiation between CE UEs and legacy UEs**

FL intention was to first figure out the proposed options with combing the differentiation mechanism and triggering mechanism. This could give us a whole picture of the fundamental mechanism to support Msg3 repetition. On the other quite some companies prefer to discuss step by step, without mixing up differentiation and triggering.

Given we anyway we need to discus how to bundle the two aspects together, FL suggests the following:

* Discuss two high-level proposals separately for UE differentiation and Msg3 repetition triggering. Companies can provide views on whether agree with the principle.
* Meanwhile, discuss the possible combination options of UE differentiation and Msg3 repetition triggering. Companies are encouraged to indicate the positions for the options listed below. If no option aligns with your proposal, please do not change the given options unless you think it doesn’t work. Instead, provide your detailed mechanism with a new option. Companies are also encouraged to provide the pros and cons of the options, though we may not down-select one at this round of discussion.

**Proposal 10a**: For differentiation between legacy UEs and Rel-17 CE UEs supporting Msg3 enhancements, select one option from the two options below.

* Option 1: via separate PRACH occasion or separate PRACH preamble.
* Option 2: via Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH).

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| **Company** | **Comments** |
| Nokia/NSB | Option 2. From our perspective, PRACH resources should be preserved as much as possible, if any usage of such resource is not targeting msg1 coverage. Indeed, assuming they can be configured as a signed blank check by gNB, in case anyone needed them, does not seem the wisest course of action. Conversely, striving to design a msg3-based solution which could preserve PRACH resources, at the expense of arguably minor PUSCH resource wastage is more attractive. Let’s remember that the share of CE UEs which will be coverage shortage during access is not expected to be large (definitely not in FR1, for instance). Now, if additional PUSCH resources are configured for those cases, gNB always knows what could happen, and where to look, so many msg3-based solutions become possible without big efforts (the “blind” part of the process can be minimized). We think this road should at least be considered further, and PRACH implications were not downplayed. Let us remember how big of a discussion we had during the SI about them, and there we were discussing about increasing the coverage of msg1, not creating structures for signalling which may not even be used by gNB… |
| CATT | Option1.  If CE UE is differentiated by Msg3 PUSCH, gNB cannot know whether the UE is a CE UE before it detects Msg3 PUSCH. Consequently, there are two issues:   1. gNB has to detect the Msg3 PUSCH with two different assumptions, i.e. with or without repetition. No matter what share of CE UEs in the system, gNB has to blind detect every Msg3 PUSCH. It will increase the complexity of gNB implementation. 2. As gNB cannot know whether the Msg3 PUSCH is repeated or not, it has to schedule a normal PUSCH transmission assuming Msg3 PUSCH is transmitted with repetition. It will introduce significant scheduling restriction for the advanced network, which is not expected.   We have some sympathy with Nokia that the preamble should be reserved as possible as possible. If the preamble index is used to differentiate legacy UE and CE UE, the PRACH capacity would be decreased significantly. The performance of msg1 transmission may also be jeopardized as mentioned by Nokia. Hence we don’t support CE UE identification via preamble.  Separate PRACH occasions could address the concern from preamble mechanism from our understanding. The separate PRACH occasions can be totally backward compatible. The separate PRACH occasions can be achieved by separate PRACH configuration index or reuse the remaining RO which cannot be used for the Rel-15/16 UEs. The first one will introduce more RACH configurations which put more restriction on PUSCH scheduling especially considering that RACH configuration has already been used for 4-step RACH and 2-step RACH differentiation. The later one may introduce additional latency for CE UE. Both of these two solutions can guarantee the full usage of preamble. We are open for the details of option 1. |
| Sharp | We support Option 1.  DMRS sequence check by gNB would cause additional performance loss. UCI multiplexing based solution also impacts the performance since an amount of resource needs to be allocated to the UCI. Further, the UCI multiplexing based solution requires gNB blind detection since gNB will not know whether UCI is multiplexed on the PUSCH or not.  Further, when gNB doesn’t know whether msg3 is transmitted in a single slot or repetition, even when the actual transmission by UE is a single slot, gNB needs to reserve all uplink resources for the repetition. |
| Intel | We support Option 1.  Suggest to update the Option 1 as follows, to differentiate the case between shared ROs and separate ROs.   * “Option 1: via separate PRACH occasion or separate PRACH preamble in case of shared PRACH occasions.”   For option 2, we share similar view as Sharp that using different DMRS configurations/sequences may lead to performance issues and receiver complexity. This highly depends on the DMRS detection performance and overall blind decoding performance. Assuming limited number of PRBs allocated for DMRS and relatively low cod rate for Msg3 PUSCH, intuitively DMRS detection performance would dominate the overall decoding performance. This issue is even more pronounced when multiple number of repetitions can be used from UE to transmit Msg3 PUSCH repetition. In this case, gNB may need to perform multiple hypothesis testing, which would substantially increase complexity.  For UCI multiplexing on Msg3 PUSCH, given that gNB does not know which UE uses repetition for Msg3 PUSCH transmission, blind decoding is needed for UCI decoding first and then gNB can perform Msg3 PUSCH decoding.  Further, as mentioned by Sharp, given that gNB does not know whether UE supports Msg3 PUSCH repetition, the gNB has to reserve Msg3 PUSCH repetitions to all the scheduled UEs, which certainly results in wasted resources. |
| China Telecom | We support Option 1.  For option 2, we share the similar view as CATT. If the differentiation work is via Msg.3 transmission, then gNB will have trouble in initial Msg.3 transmission resource allocation. Thus, we think the differentiation work should be done during Msg.1 transmission.  Considering whether to use separate PRACH occasion or PRACH preamble, we prefer to use PRACH occasion since current preamble is already divided into several groups for different usages or for SSB index indication. |
| Panasonic | We support Option 1.  On Option 2, we share similar view with Sharp and Intel that using different DMRS configurations may cause performance loss and receiver complexity increase. UCI multiplexing on Msg.3 PUSCH need blind detection and it also increase the receiver complexity. |
| vivo | We do not support proposal 10a as an independent proposal. But we are fine to consider proposal 10a as an option together with proposal 10b.  Proposal 10a may follow the logic/procedure in option 1-1 provided below, and we don’t think option 1-1 described in Proposal 10b is an optimized solution.  Mandate Rel-17 UE to transmit a different set of preambles as legacy UEs (based on the FL note for option 1-1), will lead to more PRACH preambles/resources allocated for Rel-17 UEs and further limit the RACH capacity for the legacy UEs. Ultimately, the purpose is to enhance MSG.3 PUSCH coverage rather than indicate capability for coverage enhancements. Option 2-1 aligns with our understanding better.  We are fine to keep it as an option. And, we also suggest to include the option 2 describe above, as follows.  **Proposal 10a**: For differentiation between legacy UEs and Rel-17 CE UEs or between RACH procedure with and without MSG.3 repetition, down select in the following options:   * Option 1: Differentiation between **legacy UEs and Rel-17 CE UEs** supporting Msg3 enhancements, select one option from the two options below. * Option 1a: via separate PRACH occasion or separate PRACH preamble * ***Note: If UE supports MSG.3 PUSCH repetition, UE has to use separate PRACH transmission for MSG 1 to report UE capability, and the PRACH configuration for legacy UEs (w/o MSG3 repetition) can not be used for UE, which support MSG.3 repetition. (FL Note for option 1-1)*** * Option 1b: via Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH) * Option 2: Differentiation between **RACH procedure with MSG3 repetition and MSG3 without repetition** * Option 2a: via separate PRACH occasion or separate PRACH preamble *(option 2-1 in proposal 10b)* * ***Note: Rel-17 UE can also use preambles/resources for legacy UEs, for example, when UE is not at cell edge.*** * Option 2b: via Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH)   Option 2 for Msg3 repetition procedure can also minimize the impacts and keep backward compatible with Rel-15/16 RACH procedure. If we cannot get consensus in a short time, we prefer to also include Option 2 as an possible options. |
| Samsung | Option 2.  We share the comments by Nokia.  In addition, for option 1, one reminder that the SDT(small data transmission) feature is “also” and already agreed to utilize the RACH resource partitioning for different UEs, which makes the RACH resource pool is even more crowd. This is exactly the concerning for msg1 based partition, it may looks like a valid solution. But the practical feasibility or how well it can perform is quite questionable.  Regarding the concerning of option2, mostly on the “blindly” detection part, which first, it’s not a new things in RAN1 for gNB, as we mentioned, for msg3 based EDT, the TBS and related T/F resource needs gNB to “blindly” detect; for normal PUSCH or msgA PUSCH, gNB is already able to detect different DMRS resource/port. Why suddenly using DMRS resource to differentiate UE becomes a complexity intolerable method? |

**Proposal 10b**: For Msg3 repetition triggering, select one option from the two options below.

* Option 1: gNB scheduled Msg3 repetition without UE request.
* Option 2: UE triggered Msg3 repetition with gNB indicating the number of repetitions.

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| **Company** | **Comments** |
| Nokia/NSB | Option 1. UL measurements are the only reliable measurements in this case, to take any informed decision about the need for msg3 repetition or not. Any inference UE may have based on DL measurements can only be imperfect, even more in case of paired spectrum. |
| CATT | Option 1. Agree with Nokia’s assessment. Even in the case of reciprocity is perfect, gNB may still determine the actual Msg3 PUSCH repetition based on more aspects, e.g. the latency, the UL traffic, the impacts to the other UE, etc. |
| Sharp | We slightly prefer Option 2. Option 1 may be fine to us. |
| Intel | Option 1. For NR coverage enhancement, it is expected number of repetitions for Msg3 PUSCH may not be large. Further using PRACH resources to differentiate number of repetitions may not be needed. |
| China Telecom | We support option 1. |
| Panasonic | We think both options can be considered. In our view, the required number of Msg.3 coverage enhancement level could be different among UEs. Therefore, to have flexibility for the indication of the number of repetitions would be necessary. In order to gNB to indicate the proper repetition number, Msg.3 coverage enhancement level could be identified by PRACH occasion / preamble similar to Rel.13 eMTC. This is the merit to differentiate the number of Msg.3 repetitions based on the detected power or load conditions. |
| vivo | Not support as an independent proposal. Fine to consider Proposal 10b as an option together with Proposal 10a. |
| Samsung | Both option can be considered, slightly prefer option 2.  Option 1 will require gNB to decide based PRACH reception, which we have commented a lot on why it is not reliable to determine the exact repetition number because of the difference between msg1 detection and msg3 detection and decoding. However, if gNB decides whether a msg3 repetition (rather than the exact repetition number) is needed based on the reception energy, it will be related gNB implementation and its feasibility could be discussed.  Option 2 will rely on UE to do the DL measurement, in quite a lot of the features, the DL measurements are used to decide the channel quality (or coverage level) related judgement, for example, 2step RACH vs 4 Step RACH. However, there might be some gap between DL channel and UL channel, so the DL measurement to decide the UL coverage might not be perfect. But compared to option 1, we slightly prefer option 2. |

Option 1-1: For gNB scheduled Msg3 repetition without UE request,

* + A UE reports support of Msg3 repetition via separate PRACH transmission (e.g., separate PRACH resource, or PRACH preamble).
  + For a UE supporting Msg3 repetition, gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.
  + FFS details if any.

*[FL note: If UE supports MSG.3 PUSCH repetition, UE has to use separate PRACH transmission for MSG 1 to report UE capability, and the PRACH configuration for legacy UEs (w/o MSG3 repetition) cannot be used for UE which support MSG.3 repetition.]*

*[A UE reports its capability/incapability for Msg3 repetition. If supported, it’s up to gNB decision to schedule Msg3 repetition or not. In other words, the enabling of Msg3 repetition is not triggered/decided by UE]*

Option 2-1: For UE triggered Msg3 repetition with gNB indicating the number of repetitions,

* + A UE can trigger RACH procedure with Msg3 repetition via separate PRACH transmission (e.g., separate PRACH resource, or PRACH preamble).
    - *Whether a UE would trigger is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.*
  + If Msg3 repetition is triggered by UE, gNB decides the number of repetitions for Msg3 (re)-transmission.
  + FFS details if any.

*[FL note: If UE supports MSG.3 PUSCH repetition, UE can use PRACH configuration for legacy UEs or separate PRACH transmission for triggering Msg3 repetition. If UE uses legacy PRACH configuration, gNB cannot schedule Msg3 repetition. If UE uses separate PRACH transmission for triggering, gNB can decide the number of repetitions for Msg3, which could be one or more than one repetitions.]*

Option 2-2: For UE triggered Msg3 repetition with gNB indicating the number of repetitions,

* + gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions.
  + If Msg3 repetition is scheduled, UE transmits Msg3 with or without repetition. If UE transmits Msg3 repetition, the number of repetition follows the indication of gNB and UE uses separate Msg3 transmission (e.g., via separate DMRS configuration or UCI multiplexing with Msg3 PUSCH).
    - *Whether a UE would trigger is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.*
  + FFS details if any.

*[FL note: Before Msg3 transmission, gNB doesn’t know whether a UE supports Msg3 repetition or not. Even in such case, gNB may decide to schedule Msg3 repetition. If Msg3 repetition is scheduled, UE may or may not use separate Msg3 transmission. gNB can blindly detect the first repetition to identify whether Msg3 repetition is triggered by UE. Whether Msg3 repetition would be actually triggered is decided by UE.]*

Companies are encouraged to indicate the positions for the options listed above. **If no option aligns with your proposal, please do not change the given options unless you think it doesn’t work. Instead, provide your detailed mechanism with a new option.** Companies are also encouraged to provide the pros and cons of the options, though we may not down-select one at this round of discussion.

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| **Company** | **Comments** |
| Nokia/NSB | Option 1-1. We would like to clarify the part related to the configuration of the number of repetitions by gNB, i.e., “*For a UE supporting Msg3 repetition, gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB decides the number of repetitions*”. Does this include SIB1-based solutions as per Proposal 1-v4? |
| CATT | Option 1-2.  To our understanding, the only difference between option 1-1 and option 1-2 is whether the PRACH configuration for legacy UEs can be used for CE UEs. UE can of course determine which RO is used based on the RSRP measurement, which is UE implementation. I don’t see the necessity to preclude a CE UE using the PRACH configuration for legacy UEs.  For option 2-2, as we commented on proposal-10a, it will increase the complexity at gNB side and introduce additional scheduling restriction, which is not preferred. For FL notes, i.e. ‘*If Msg3 repetition is scheduled, UE may or may not use separate Msg3 transmission.*’ , it seems UE doesn’t follow gNB’s indication. We don’t think it is a reasonable behaviour which is not aligned with the logic of the current specification everywhere. |
| Sharp | We slightly prefer Option 2-1. Option 1-1 may be fine to us. We don’t prefer Option 2-2 with the same reason as the comment for proposal 10a |
| Intel | Option 1-1.  As commented previously, Option 1-1 is still based on UE request of whether or not support Msg3 PUSCH repetition.  It is not clear to us how Option 2 would work. “If Msg3 repetition is scheduled, UE transmits Msg3 with or without repetition.” Does this mean UE does not need to follow the scheduling information from gNB. |
| China Telecom | We prefer Option 1-1.  But we have one question here on the FL note “*the PRACH configuration for legacy UEs (w/o MSG3 repetition) cannot be used for UE which support MSG.3 repetition*”. Does this mean, the legacy PRACH configuration table (Table 6.3.3.2-2 in 38.211) cannot be used for CE UEs? If so, it seems huge work needs to be done to define a new table. |
| Panasonic | We think Option 1 and Option 2-1 could be considered. |
| vivo | For option 1-1, we provided our views in comments for proposal 10a, that differentiate legacy UE and R17 CE UE is not necessary.  Option 2-1 is aligned with our understanding for a UE triggered RACH procedure with Msg3 repetition.  In our opinion, for MSG3 repetition w/o MSG.1 differentiation, Rel-17 UE should always follow the gNB scheduling information to transmit MSG.3 repetition, and legacy UEs consider the information for repetition as invalid information, gNB need to blind detect MSG.3 w/ or w/o MSG.3 repetition. It is regarded as ‘gNB scheduled Msg3 repetition **without UE request**’ rather than ‘UE triggered MSG3 repetition’, since UE always follows the instructions from gNB with different interpretations for legacy UEs and new UEs. We do not prefer option 2-2, due to UE does not always follow gNB scheduling in current proposal. Hence, we suggest to also include the following option for ‘gNB scheduled Msg3 repetition **without UE request**’.  **Option 1-2:** For gNB scheduled Msg3 repetition **without UE request,**   * + gNB decides whether to schedule Msg3 repetition or not. If scheduled, gNB (dynamically/semi-statistically) decides the number of repetitions.     - For UE does not support MSG3 repetition, UE transmit MSG.3 without repetition     - For UE does support MSG3 repetition, UE transmit MSG.3 with repetition as indicated by gNB   + gNB blind decodes MSG.3 with two different assumptions, w/ and w/o repetition.   + FFS details if any.   *[Note: Different MSG3 parameter(s) can be considered for MSG3 with PUSCH repetitions, to facilitate gNB to distinguish MSG3 transmission w/ and w/o repetition]* |
| Samsung | Both option 2-2 and option 1-2 can be considered, option 2-2 is the first preference. (It seems the option 1-2 is left out in the part of material, not sure if it’s by accident or meaning option 1-2 is ruled out?)  Our views on the related issue are detailed commented in above comments. So not repeated here.  I think one difference between option 1-2 and 2-2 is that, whether UE has to transmit msg3 repetition when it is capable of doing it and gNB schedules (It is not quite comfortable to use “schedule” here because in some solution, it’s just gNB triggers or allows UE to do msg3 repetition) it to do msg3 repetition. Option 1-2 seems mandate UE to do so and option 2-2 will further allow gNB to choose, I don't think either of the option will require gNB to do things differently, i.e., gNB will check DMRS twice in both options. It only matters to whether give UE the freedom to do it or not. Because UE can have the very latest measurement of DL, so UE is the one holding the latest information of the channel quality, so that we think it should give the UE the decision power on whether actually initiate msg3 repetition transmission. |

# Proposals for email approval

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| Issue#1 | * A clear majority companies support Option 1, with many of them prefer to use TDRA bit field in UL RAR grant for repetition with repetition factors in a TDRA table configured by SIB1. * 3 companies (vivo, OPPO, Nokia/NSB) support Option2. While, it is commented that it may imply that the repetition factor indicated by the DCI would apply for Msg3 for all the scheduled UEs, which may have different coverage conditions. * One company suggests to delete the detailed examples in FFS. * One company suggests to add one option for repetition indication by SIB1 only. If a fixed repetition factor is indicated, early termination of Msg3 repetition as discussed in section 2.6 can be considered to reduce resource waste. * **One company preferred to keep the sentence “the size of RAR UL grant is unchanged” for both options. While it seems not acceptable for some companies which prefer to use a more generic terms (the last bullet) at this early stage.** * **Concerns were raised for fallbackRAR and Option 3, all addressed now.**   The updated FL proposal is given as follows. The intention is not to down-select any of the options for now. Further discussion on the pros and cons can be carried out when down-selection.  Proposal 1-v4:   * For indication of the number of repetitions for Msg3 initial transmission, down-select one option from the options below. * Option1: ~~RAR~~UL grant scheduling Msg3. * FFS details. * FFS fallbackRAR UL grant. * Note: Optimization specific for fallbackRAR UL grant in 2-step RACH is not considered in Rel-17 CovEnh WI, if supported. * Option2: DCI format 1\_0 with CRC scrambled by RA-RNTI * FFS details. * Option3: SIB1 only * Any modifications of RAR UL grant or DCI format 1\_0 with CRC scrambled by RA-RNTI for indicating Msg3 repetitions shall not impact the legacy UE interpretation of the RAR or DCI format 1\_0 with CRC scrambled by RA-RNTI respectively. |
| Issue#2 | * Majority companies support Option 1. * 5 companies (CATT, Ericsson, Apple and Lenovo, Motorola Mobility) support Option 2, with some of them also fine with Option 1. * Two companies want to modify or delete the FFS. * **Some editorial changes were made on option 2.**   As a result, the proposal is updated as follows.  Proposal 2-v3:   * For indication of the number of repetitions for Msg3 re-transmission, down-select one option from the options below. * Option1: DCI format 0\_0 with CRC scrambled by TC-RNTI. * FFS details. * Any modifications of DCI format 0\_0 with CRC scrambled by TC-RNTI for indicating Msg3 repetitions shall not impact the legacy UE interpretation of the DCI format 0\_0 with CRC scrambled by TC-RNTI. * Option2: ~~Implicitly~~Can be determined based on the repetition number ~~configured~~for ~~by~~ Msg3 initial transmission |
| Issue#4 | All companies are fine with the proposal**. The example of inter-slot FH with inter-slot bundling was deleted since one company has strong preference.**  Thus, proposal is updated as follows.  Proposal 4-v3:  Support inter-slot frequency hopping for repetition of Msg3 initial and re-transmission.   * FFS details, e.g., signaling indication ~~and whether/how to support inter-slot frequency hopping with inter-slot bundling”~~etc. |

# Reference

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2. R1-2100099 Discussion on support of Type A PUSCH repetitions for Msg3 ZTE
3. R1-2100176 Type A PUSCH repetitions for Msg3 coverage OPPO
4. R1-2100197 Msg3 repetition for coverage enhancement Huawei, HiSilicon
5. R1-2100401 Discussion on Type A PUSCH repetitions for Msg3 CATT
6. R1-2100461 Discussion on Type A PUSCH repetitions for Msg3 vivo
7. R1-2100490 Target of PUSCH Msg.3 coverage enhancements SoftBank Corp.
8. R1-2100669 On Msg3 PUSCH repetition Intel Corporation
9. R1-2100716 Discussion on coverage enhancement for Msg3 PUSCH LG Electronics
10. R1-2100748 Type A PUSCH repetitions for Msg3 InterDigital, Inc.
11. R1-2100919 Discussion on type A PUSCH repetitions for Msg3 China Telecom
12. R1-2100944 Discussion on PUSCH repetitions for Msg3 NEC
13. R1-2101022 Discussion on Type A PUSCH repetitions for Msg.3 Panasonic Corporation
14. R1-2101059 Discussion on type A PUSCH repetitions for Msg3 CMCC
15. R1-2101082 PUSCH coverage enhancement ETRI
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17. R1-2101225 Type A PUSCH repetitions for Msg3 Samsung
18. R1-2101399 Discussion on msg3 PUSCH repetition Apple
19. R1-2101481 Type A PUSCH repetition for Msg3 Qualcomm Incorporated
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21. R1-2101549 Type A PUSCH repetitions for Msg3 Sharp
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28. R1-2101683 Discussion on Type A PUSCH repetitions for Msg3 WILUS Inc.
29. R1-2101714 Approaches and solutions for Type A PUSCH repetitions for Msg3 Nokia, Nokia Shanghai Bell