**3GPP TSG-RAN WG2 Meeting #123bis** **R2-231xxxx**

**Xiamen, China, 11-17 October, 2023**

**Agenda item: 7.5.1**

**Source: Qualcomm Incorporated**

**Title: Open issues in MAC running CR for XR enhancements**

**Document for: Discussion and Decision**

1. Introduction

This document aims to facilitate the discussion on open issues related to MAC CR for XR enhancements, as per the following e-mail discussion:

**[POST123bis][024][XR] 38.321 Running CR (Qualcomm)**

Scope:

- Review running CR

- Identify open issues

- Get inputs for subset of open issues (focus more detailed open issues that would help with CR finalisation.

 Deadline: Nov 1st, 2023

In this discussion, companies may provide their input for (minor) open issues related to stage-3 design details in the MAC running (e.g. MAC CE format design, etc) that have not been officially agreed yet. The intention is to build consensus and prepare for easy agreement at the next RAN2 meeting.

The following are the deadlines for this discussion:

- Company feedback: by 2200 on Oct 30 UTC

- Rapporteur’s summary: by 0900 on Oct 31 UTC

- Final deadline: by 2200 on Nov 1 UTC

2. Contact information

Please provide your contact information in the table below.

|  |  |  |
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3. Input for the open issues

3.1 Enhanced BSR MAC CE

First, let us discuss the format of the Enhanced BSR MAC CE.

One of the key questions in the format design is how to indicate which BSR table an LCG uses. The rapporteur thinks there can be at least two options (as illustrated in Figure 1):

* Option 1. Introduce a new 8-bit bitmap which indicates which BSR table an LCG uses; or
* Option 2. Add one bit indicator coupled with each Buffer Size field.

There may be other design options too. If you think so, please describe your preferred design in the Comments column.



**Figure 1. Options for the format of the Enhanced BSR MAC CE**

**Question 1: Which format for the Enhanced BSR MAC CE do you prefer?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1/2 or other** | **Comments** |
| LGE | Option 1 | It looks simpler. |
| Apple | Option 1  | Also, we prefer to model it as one additional BSR MAC CE format (can be dubbed as e.g. *Enhanced Long BSR*) in 6.1.3.1:6.1.3.1 Buffer Status Report MAC CEsBuffer Status Report (BSR) MAC CEs consist of either:- Short BSR format (fixed size); or- Extended Short BSR format (fixed size); or- Long BSR format (variable size); or- Extended Long BSR format (variable size); or- Short Truncated BSR format (fixed size); or- Extended Short Truncated BSR format (fixed size); or- Long Truncated BSR format (variable size); or- Extended Long Truncated BSR format (variable size); or- Enhanced Long BSR format (variable size); or- Enhanced Long Truncated BSR format (variable size). |
| Huawei, HiSilicon | Option1 |  |
| Samsung | Option 1 |  |
| Nokia | Option 1 |  |
| Futurewei | Neither | There was no agreement to introduce a second new MAC CE that only reports data volume without indicating the remaining time. If the remaining time is not indicated, the data volume being reported is not delay-critical. If the data is not delay-critical, they can be reported using one of the legacy BSR MAC CEs. Non-delay-critical data are transmitted opportunistically, i.e., only after all delay-critical data have been transmitted, at which time it is unlikely that all non-delay-critical data can be transmitted using the leftover resource. And any residual non-delay-critical data can be reported more accurately once they become delay-critical. Hence, a larger quantization error on the non-delay-critical data volume, when reported via a legacy BSR MAC CE, is not that critical. We object introducing the second new MAC CE as it is not justified.If the main motivation for introducing this new BSR MAC CE is to add the dynamic indication of BS table selection, given BSR MAC CEs are dedicated signaling, why this octet of BT bitmap cannot be added to the end of the legacy Long BSR and Long Truncated BSR MAC CEs as a optionally present field, as shown below, where the BT bitmap field is present only if at least one LCG of the UE is configured with dynamic BS table selection. In this way, we can save two eLCIDs (for Long and Truncated Long versions). |
| Fujitsu | Option 1 |  |
| vivo | Option 1 | Option 1 looks neater than Option 2. |
| OPPO | Option 1 |  |
| Qualcomm | Option 1 |  |
| Xiaomi | Option 1 | Option 1 is simpler. Since MAC CE is byte aligned in length, there is no signalling overhead gain from using Option 2. |
| CATT | Option 1 for long BSR, and option 3 for short BSR | Option 1 looks good for long BSR. Moreover, considering XR traffic will likely be conveyed over a single QoS (at least in early deployments) we also propose discussing whether to introduce short BSR MAC CE which has a fixed size and includes one LCG. The format could be:Option 3 (for short BSR) |
| NEC | Other | Option1 is neat then option2.However being inspired with option1, we propose to merge LCGi and BTi filed into one joint 2 bits filed (LCG-BTi), which we call it option 3 here.and the codes of the 2-bit LCG-BTi field are as following:Option 3 has the same overhead (bits) as option 1. However, if option 1 is adopted and one more BS table (3rd table) is introduced in the future, we need to introduce a new MAC CE format. For option 3, we can just reuse the codepoint 11 (which is reserved in this release) to indicate the new BS table (3rd table). |
| Ericsson | Option 1 | This is the simpler alternative now when we have agreed to limit to one new table, i.e. only 1 bit is needed for selection between new table and legacy table. |

**Summary:**

12 out of 14 companies prefer Option 1. Two other companies proposed alternative schemes, which may also work. The rapporteur would suggest that we go with the option that has the majority support and adopt Option 1 as the format for the Enhanced BSR MAC CE.

**Proposal 1. For the Enhanced BSR MAC CE, include a new 8-bit bitmap between the LCG bitmap and buffer size fields to indicate which BSR table an LCG uses. (12/14)**

In legacy, padding BSR includes a truncated version (i.e. long/short Truncated BSR MAC CE), which is used when there are not enough padding bits to accommodate a regular-sized BSR MAC CE. We may or may not need a truncated version of the Enhanced BSR MAC CE. Please share your preference and comments.

**Question 2: Is it necessary to introduce a truncated version of the Enhanced BSR MAC CE?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| LGE | Yes |  |
| Apple | Yes | We think it is possible for the UE to send padding BSR with LCG using the new table. The UE can choose which format (legacy or new) to report according to the number of available padding bits. |
| Huawei, HiSilicon | Yes | Same as legacy. Since padding BSR will be triggered as in legacy, the size of the BSR should be able to fit within the remaining space in the MAC PDU. It might need to be truncated in this case. |
| Samsung | Yes |  |
| Nokia | Could live without | Legacy truncated BSR is anyway needed for the cases when the space is not enough to include the subheader and bitmaps of the Enhanced BSR MAC CE. e.g. when there is only 2 bytes padding (with 1 byte subheader + 1 byte payload), it should be possible to report the LCG using the legacy 5-bit table, even if it is configured with new table and falls within the range. Otherwise, nothing can be reported.Same for 3 or 4 bytes padding, better to use legacy table as well with 1 byte subheader + 2 or 3 bytes payload, since the two bytes bitmap in the enhanced BSR MAC CE does not provide any BS information. If eLCID is used for Enhanced BSR, at least 5 bytes are needed for the 2 byte subheader + 2 byte bitmap + at least one BS.Enhanced BSR could provide finer granularity, but legacy BSR can provide BS for two more LCG, so in that sense, can also live with legacy table only for truncated padding BSR. |
| Futurewei | No | We object introducing the Enhanced BSR MAC CE, let alone the truncated version of it. However, we would be OK to add the BT bitmap field as an optionally present field to the legacy Long and Long Truncated BSR MAC CEs, as illustrated before. |
| Fujitsu | No | We prefer to send the legacy padding BSR only in the padding bits to have lower impact on MAC standard.  |
| vivo | Yes | Padding BSR with new BSR table should also be supported. Otherwise, legacy BSR table has to be used when padding BSR is triggered and there is still 6.5% quantization error. After Enhanced BSR MAC CE is defined, the additional work to introduce truncated version of Enhanced BSR MAC CE is small. |
| OPPO | Yes | We assume that the remaining space can be used to include the data volume info associated with a new table. |
| Qualcomm | - | No strong view. Can go with the majority.  |
| Xiaomi | Yes |  |
| CATT | Yes | Truncated BSR MAC CEs are needed as for legacy. |
| NEC | Maybe No | Truncated BSR MAC CE is used when padding BSR is triggered and the padding bit is not enough to report BS of all LCGs with buffered data. Since the truncated BSR MAC CE in anyway will not give NW the full buffer information in UE, to keep simple, we can leave with truncated version of legacy BSR MAC CE .If truncated version of the enhanced BSR MAC CE is introduced, It should use same enhanced MAC CE format with different LCID  |
| Ericsson | Yes | Should be able to use the new table also in padding BSR and not limit truncated to legacy table, which would create potential mismatch in reporting granularity. Basically this new BSR format should work similarly as legacy. |

**Summary:**

10 out of 14 companies replied have indicated that a truncated version of the Enhanced BSR MAC CE can be introduced. Two company think it is not critically needed, and another two companies preferred not to have it (e.g. to minimize the impact on the MAC spec). Given the majority support, the rapporteur hence would suggest that we can try to go with the following proposal.

**Proposal 2. Introduce Truncated Enhanced BSR MAC CE, which uses the new BSR table. (10/14)**

There are three types of LCID (legacy 6-bit LCID, one octet eLCID, or two-octet eLCID) that the Enhanced BSR MAC CE may use.

**Question 3: which type of LCID do you think the new Enhanced BSR MAC CE should have?**

* **Option 1: legacy 6-bit LCID;**
* **Option 2: one-octet eLCID;**
* **Option 3: two-octet eLCID.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1/2/3** | **Comments** |
| LGE | Option 2 | Similar to other BSR formats |
| Apple  | Option 1/2 |  |
| Huawei, HiSilicon | Option2 | The discussion should only be on Option2/1. Between these two options, we prefer option2. With XR services ongoing, there shouldn’t be coverage issues. |
| Samsung | Option 2 |  |
| Nokia | Option 2 | Overhead should not be too big concern when Enhanced BSR MAC CE is used.  |
| Futurewei | Not Option 1 | We don’t think the proposed Enhanced BSR MAC CE is justified, let alone the use of 6-bit LCID for it.We think it is unnecessary to waste two eLCIDs considering that the BT bitmap field can be added to the end of the legacy Long and Long Truncated BSR MAC CEs as an optionally present field, as illustrated before. |
| Fujitsu | Option 2 |  |
| vivo | Option 2 |  |
| OPPO | Option 2 |  |
| Qualcomm | Option 2 |  |
| Xiaomi | Option 2 | The general guideline is to use one-octet eLCID for MAC CE. |
| CATT | Option 2 | It is expected to be a big MAC CE anyways, so there is little interest in optimizing the header size. |
| NEC | Option2 | 6-bit LCID should not be used unless there is no other choice e.g., for earlier capability indication. Two-octet eLCID is only used for IAB case |
| Ericsson | Option 2 |  |

**Summary:**

All companies except one can support the use of one-octet eLCID for the Enhanced BSR MAC CE. The rapporteur hence would suggest that we go for the following proposal:

**Proposal 3. The Enhanced BSR MAC CE has a one-octet eLCID. (13/14)**

The Enhanced BSR MAC CE needs to be assigned a logical channel priority. The rapporteur does not see any strong reasons for it to have a priority different from that of the legacy BSR MAC CEs. Please indicate if you would agree.

**Question 4: Do you agree that the Enhanced BSR MAC CE should have the same logical channel priority as the legacy BSR MAC CEs (the ones except the padding BSR)?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| LGE | Yes |  |
| Apple | Yes | In our view this is a new BSR format instead of an independent MAC CE, so the priority of which certainly does not change from the legacy BSR (just like we do not differentiate the priority between Long BSR and Short BSR). |
| Huawei, HiSilicon | Yes |  |
| Samsung | Yes | Enhanced BSR should be one of the BSR formats, similar to the cases of long and short BSR. |
| Nokia | Yes |  |
| Futurewei | - | Since the proposed Enhanced BSR MAC CE doesn’t indicate the remaining time, we don’t see any reason why it should have a higher priority. |
| Fujitsu | Yes |  |
| vivo | Yes | As far as our understanding, the UE sends either Enhanced BSR MAC CE or legacy BSR MAC CE (except the padding BSR), but not both. There is no competition for resource competition between Enhanced BSR MAC CE and legacy BSR MAC CE. Hence it is not necessary assign different priority for them.  |
| OPPO | Yes |  |
| Qualcomm | Yes |  |
| Xiaomi | Yes |  |
| CATT | Yes |  |
| NEC  | Yes  |  |
| Ericsson | Yes | It should function in the same way as legacy BSR |

**Summary:**

All companies agree that the Enhanced BSR MAC CE should have the same logical channel priority as the legacy BSR MAC CEs.

**Proposal 4. The Enhanced BSR MAC CE has the same logical channel priority as the legacy BSR MAC CEs. (14/14)**

## 3.2 DSR MAC CE

Based on the agreements so far, the DSR MAC CE should include at least the following fields:

* LCG bitmap, which indicates which LCG has delay information included in the MAC CE;
* remaining time for a reported LCG;
* Amount of data associated with the reported remaining time.

Let us first discuss how to encode the remaining time. Based on proposals submitted so far, there are at least the following two options:

* Option 1: Encode the remaining time field directly through some linear mapping, since the typical delay requirements for UL XR traffic are not stringent (e.g. 50msec). As an example, we may define that the value *r* of the field corresponds to remaining time in the range of 0.5 × (*r*, *r*+1] msec, for r ∈(0, 63]. This mapping covers remaining times from 0 to 64 msec.
* Option 2: One may define a lookup table in the spec, similar to how BSR table is used to encode buffer sizes. This option seems useful only if companies decide to use a non-linear distribution to encode remaining times.

**Question 5: Which option do you prefer to encode the remaining time field in the DSR MAC CE?**

**- Option 1: define in the spec a linear mapping between the values of the field and the values of the remaining time, e.g. the value *r* of the field corresponds to remaining time in the range of 0.5 × (*r*, *r*+1] msec, for r ∈(0, 63];**

**- Option 2: define a lookup table in the spec, similar to how BSR table is used to encode buffer sizes. Distribution and range of this table can be discussed based on companies’ input (please provide details in your comment).**

**- [Ericsson] Option 3: The delay table can be defined by explicit indication of the threshold values.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1/2** | **Comments** |
| LGE | Option 2 | Agree that linear mapping seems enough and there is no need to further optimize the remaining time table, but it looks simpler to define a lookup table for remaining time, rather than making a new equation.In our view, one 4-bit linear table for remaining time is enough for XR traffic, e.g., 1ms to 15ms.  |
| Apple | Option 2 | A look-up table is more straightforward |
| Huawei, HiSilicon | Option1 | If the mapping is linear, no need for a table but a formula should be enough |
| Samsung | Option 2 | Lookup table-based solution looks simpler and more efficient considering real-world implementation for both UE and gNB. |
| Nokia | Option 2 | In the granularity of ms should be enough considering the discard timer is in ms. |
| Futurewei | Option 2 | We also agree with LGE that a 4-bit table is sufficient, e.g., 1, 2, …, 14, 15, >15, or with 2 linear regions, 1, 2, …, 9, 10, 15, 20, 25, 30, 35, >35.  |
| Fujitsu | Option 2 | We prefer a lookup table including the remaining time index and the corresponding range.  |
| vivo | Option 2 | Instead of a fixed table (i.e. Option 1), a configurable look up table could be preferred. the gNB can configure the interested delay ranges that can be reported by the UE.  |
| OPPO | Option 2  | We prefer a lookup table other than a formula/equation. |
| Qualcomm | Option 1 | If the mapping is linear, there is no need for a table. A simple description of the mapping is sufficient. |
| Xiaomi | No strong view |  |
| CATT | Option 1 | With linear mapping, an equation is simpler. |
| NEC | Option 1 | Option 1 is preferred, since exact remaining time value can help gNB make a better scheduling decision.  |
| Ericsson | Option 3 | We should take a step back here and ask ourselves, what is the goal of the new delay reporting feature? The answer is to give the scheduler early and precise timing information so it can do smarter and more efficient scheduling. This is what has been shown in evaluations to be beneficial for XR capacity. And to remind ourselves, in those evaluations the remaining time has been reported early. Thus for the solution to work the threshold should be possible to be set close to PDB values, i.e. if we have PDB value of 30ms it should be possible to set thresholds up to 30ms value. Whatever the solution that is chosen it needs to be able to at least support such configuration.Another important aspect to think of is what happen if there are multiple PDU Sets in the buffer? What time and buffer values should be reported then? If the solution allows for multiple values to be reported this is simple, just report the buffer value for each threshold. However if just one buffer value is to be reported, then there need to be a decision if only the most urgent data is reported (this is a very inferior solution since then the reporting of the later PDU Set will be delayed and must anyway be decided how it will be handled, i.e. that data is reported in a new DSR report which will create even more overhead) or all data is multiplexed into one delay value (also inferior solution since that doesn’t give granularity on the time remaining of the data in the UE buffer). Whatever table solution that is chosen this aspect needs to be considered. This could be practically solved with a table/format solution with 8 thresholds since this give a very simple way of reporting more delay values (as Ericsson has shown in the latest BSR contribution). The overhead with such solution is smaller than to have multiple DSR reports sent.For the table options we lack the option that Ericsson has been proposing on having the thresholds configurable by the network (see Ericsson latest contribution on BSR enhancements). By explicitly specifying the threshold values those can be tailored to the specific traffic and network conditions at hand. This will make it possible to get the highest gains from the DSR solution, since remaining time will be reported when network wants it and can use it, while still keeping possible of a compact reporting format (e.g. only use 8 thresholds).A predefined table will not be suitable for all traffic options unless the table is sufficiently long and it has a high granularity and thus can support many different traffic requirements. A linear mapping formula can work if the range is configurable but will not be as flexible as specifying the thresholds explicitly.So in summary, if configurability is not agreed on the solution that is chosen need to support at least reporting time values up to around PDB values, e.g. up to ~30ms, and still have granularity to give precision in the reported value. |

**Summary:**

8 out of 14 companies prefer Option 2. 4 companies think it is simpler to use a formula/equation instead of a table. 1 company proposes to define a delay table by explicit indication of the threshold values. 1 company does not have strong view. The rapporteur hence would suggest we discuss issue further online:

**Proposal 5. Discuss whether to define a lookup table, a formula or some other methods to encode the remaining time field in the DSR MAC CE. (8 vs 4 vs 1)**

It also needs to be discussed how to signal which BSR table is used to encode the buffer size field. Similar to the discussion on the Enhanced BSR MAC CE, the rapporteur thinks there can be at least two options: either use a bitmap such as the one used in the Enhanced BSR MAC CE or use one bit between the Remaining Time field and the Buffer Size field for the purpose. The formats of these two options are illustrated in Figure 2. Lastly, there is also the option to use only one particular table, e.g. use either only the legacy table or only the new table (if the range of the new BSR table that companies finally agree on is wide enough).



[Futurewei]: although unrelated to Question 6, we think the above two options are not the only options for indicating the LCG(s). Because it is practically impossible to have all 8 LCGs be configured for XR UL traffics (the current models in TR 38.838 at most include 3 traffic streams: video, audio, and pose/control). So, there is room to combine the LCG bitmap with Remaining Time 1 field to save one octet, increasing the chance that a padding DSR can be sent.

**Figure 2. Options for the format of the DSR MAC CE.**

**Question 6: which option do you prefer to indicate which BSR table is used to encode the Buffer Size field in the DSR MAC CE?**

* **Option 1: use a one-octet bitmap for the indication;**
* **Option 2: use a one-bit indicator for each reported LCG;**
* **Option 3: use only a specific BSR table (either only the legacy table or only the new table). Hence no indicator for is needed.**
* **Option 4: other (Please describe details of your preferred design in your comment).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1/2/3/4** | **Comments** |
| LGE | Option 3 | Given that DSR MAC CE only includes the data volume less than the configured delay threshold, the amount of data would not be large, so enhanced BS table is not needed and legacy BS table is enough.However, if it is really needed to reduce the quantization error for DSR MAC CE, Option 1 is preferred.  |
| Apple | Option 3 | Agree with LGE. Also, DSR and the new BS table should be treated as two independent capabilities. We may have the cases where DSR is configured for a UE that does not support new BS Table. Thus, we prefer to keep it simple by not considering the new BS table for DSR in Rel-18. |
| Huawei, HiSilicon | Option2 |  |
| Samsung | Option 2 | Option 2 is more concise than Option 1, i.e., no reserved bit and hence less overhead.  |
| Nokia | Option 3 | Agree with LG/Apple. Option 3 could be enough with the assumption that the data below delay threshold should be rather small and legacy table already provide good enough granularity for lower end, since otherwise the NW would not be able to schedule them on time and the two features of DSR and new BS table can be totally independent. |
| Futurewei | Option 3 | We agree that the BS table should be RRC-configured, instead of dynamically indicated, but for a different reason than LG/Apple/Nokia. We think the most important buffer size levels to cover by the table is from 15 KB (average size of P frames of 720p video) to 125 KB (average size of I frames of 1080p video). To have some safety margin, we think the table should cover at least from 10 (or 5) KB to 200 KB. If designed carefully, the new table should outperform the legacy table within this range most of the time. So, we think the new table will likely bring more gain when used for DSR of a LCG configured for UL AR video than the legacy table. In any case, we think RRC configuration is sufficient and dynamic table indication will likely be useless most of the time but incurring additional signaling overhead all the time.  |
| Fujitsu | Option 3 | Agree with LGE and Apple.  |
| vivo | Option 1 or Option 2 |  |
| OPPO | Option 3 | Agree with LGE, the legacy BS table seems sufficient.  |
| Qualcomm | Option 2 or 3 |  |
| Xiaomi | Option 3 with legacy table |  |
| CATT | Option 1, but more compact | 1. We don't think long remaining time is needed. So 4 bits for the remaining time field are enough (e.g. 64ms range with 4ms granularity).2. Then, we should discuss whether it makes sense to report DSR with 8 LCGs. Considering 1) this is for delay-critical traffic only, and 2) in case a UE serves multiple of those their LCHs could be associated with the same LCG, we think it is overkill to consider 8 LCGs and at most 4 LCGs might be sufficient. And the reshape of option 1 can be discussed, such asLong DSR MAC CE3. As we comment in Q1, the DSR includes only one LCG needs to be considered. And the format can be:Short DSR MAC CE |
| NEC | Option 4(other) | As we mentioned in Q1, we can combine the function of LCG*i* and BT*i* into a 2-bit field. It’s better than option 1 for that if one more BS table is introduced in the future, we don’t need to design a new MAC CE format. |
| Ericsson | Option 4 | It is actually the exact same situation for the DSR as for the Enhanced BSR – same tables should be possible to be used! The data will be similar in size in the Enhanced BSR as in the DSR, this is because there will often be just a single PDU Set in the buffer with XR traffic. Thus a major part of the benefits from using the new BSR table comes from improving the granularity in the range of one PDU Set. Those who argues otherwise should specify what traffic assumptions they are referring to, since at least that is not in line with the assumptions that RAN has used in the evaluations the last couple of years.So it is clear that at least the new table should be used in the DSR. This table will also have increased granularity at the low range, that is implicit from having the exponential distribution and a lower high max value (see answer to question 13).Then if legacy table should be used depends on if there is a need to be able to provide buffer values for higher ranges than the new table will support. This again depends on if there is a need to report for multiple PDU Sets (related to our answer in the previous question), i.e. if all data below the reporting threshold is reported or just a subset of the data. If all data is reported (i.e. all PDU Sets below trigger threshold) then there may be multiple PDU Sets in the reported buffer value. As we explained earlier, reporting for all data below the reporting threshold is useful to have a good solution, reporting only for the most critical PDU Set is an inferior solution.An example of a delay reporting format with maximum 8 thresholds is shown below. With one value reported there will simply be one octet for the buffer value. The P-row indicate which threshold this buffer value belongs to while the T-row indicate what table is used for that P-row. If one then wants to extend to reporting of multiple buffer value/remaining times (e.g. PDU Sets below trigger threshold) it is simple to just add more buffer value octets. This format thus has low overhead and is future proof. However the most important matter to discuss before selecting what format to use is how to handle when there are multiple PDU Sets below the trigger threshold. Figure – Example of the delay reporting format. |

**Summary:**

Out of 14 companies, 8 companies prefer Option 3, 3 companies prefer Option 2, and 2 company can also support Option 1. 3 companies gave additional designs. One of the reasons given by the proponents of Option 3 is that support for DSR and new BSR table should be two separate UE capabilities. The rapporteur thinks that is a good point and should be considered in the proposal. We can leave the final format design FFS, because it depends on the design of the remaining time field too.

**Proposal 6. Dynamic indication of BSR table in the DSR MAC CE is not supported. FFS how UE determines which BSR table to use when reporting, e.g. defined in the spec or configured by RRC. (8/14)**

Next, let us discuss which type of LCID (legacy 6-bit LCID, one octet eLCID, or two-octet eLCID) the DSR MAC CE should have.

**Question 7: which type of LCID do you think the DSR MAC CE should have?**

* **Option 1: legacy 6-bit LCID;**
* **Option 2: one-octet eLCID;**
* **Option 3: two-octet eLCID.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1/2/3** | **Comments** |
| LGE | Option 2 | Similar to BSR MAC CE. |
| Apple | Option 2 |  |
| Huawei, HiSilicon | Option2 | Again, There is no coverage issue |
| Samsung | Option 2 |  |
| Nokia | Option 2 |  |
| Futurewei | Option 1/2 | Option 1 can increase the chance that a padding DSR can be sent. |
| Fujitsu | Option 2 |  |
| vivo | Option 2 |  |
| OPPO | Option 2 |  |
| Qualcomm | Option 2 |  |
| Xiaomi | Option 2 | The general guideline is to use one-octet eLCID for MAC CE. |
| CATT | Option 2 |  |
| NEC | Option2 | 6-bit LCID should not be used unless there is no other choice e.g., for earlier capability indication. Two-octet eLCID is only used for IAB case |
| Ericsson | Option 2 |  |

**Summary:**

All 14 companies agree with Option 2. 1 company also thinks Option 1 can be considered because it would increase the chance of padding DSR (Note: Whether to support padding DSR has not been discussed so far).

**Proposal 7. The DSR MAC CE uses one-octet eLCID. (14/14)**

Please indicate which logical channel priority you think the DSR MAC CE should have. For example, if you think its priority should be below LBT Failure MAC CE but above MAC CE for SL-BSR, then please indicate “LBT failure” in the “Below” column and “SL-BSR” in the “Above” column.

**Question 8: which logical channel priority do you think the DSR MAC CE should have?**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Below** | **Above** | **Comments** |
| LGE | Timing Advance Report | SL-BSR |  |
| Apple | Timing Advance Report | SL-BSR | We are also fine if the DSR has the same priority as SL-BSR or BSR. |
| Huawei, HiSilicon | LBT failure MAC CE |  | Maybe it is beneficial to discuss whether the XR enhanced features can work together with NRU. Our thinking is that except for multi-PUSCH CG enhancement, other higher layer enchancement, like XR awareness, or PDU set discard are transparent to the lower layer transport. Hence, it should be possible to support them bothIf both of them can be supported together, we think LBT failure MAC CE would be more important |
| Samsung | Timing Advance Report | SL-BSR |  |
| Nokia | Timing Advance Report | SL-BSR  |  |
| Futurewei | Timing Advance Report | SL-BSR | Also OK with between LBT failure MAC CE and Timing Advance Report. |
| Fujitsu | Timing Advance Report | SL-BSR |  |
| vivo | MAC CE for SL-BSR (not for padding SL-BSR)  | MAC CE for PHR | We think DSR should be of the same priority as the regular/periodic BSR. |
| OPPO | Timing Advance Report | SL-BSR |  |
| Qualcomm | Timing Advance Report | SL-BSR prioritized |  |
| Xiaomi | Timing Advance Report | SL-BSR |  |
| CATT | Timing Advance Report | SL-BSR |  |
| NEC | Timing Advance Report | SL-BSR | DSR MAC CE is more delay sensitive, so it should have higher priority than BSR MAC CE. Furthermore, in current spec, MAC CE for Timing Advance Report is between MAC CE for LBT failure and SL-BSR, we think DSR MAC CE should below MAC CE for Timing Advance Report rather than LBT failure. |
| Ericsson | Timing Advance Report | SL-BSR |  |

**Summary:**

12 out of 14 companies think the logical channel priority of the DSR MAC CE should be below Timing Advance Report MAC CE and above SL-BSR prioritized (Note: The rapporteur takes the liberty of interpreting the “SL-BSR” in the comments as “SL-BSR prioritized”, because otherwise there is a wide range of priorities to choose from but ). One company thinks it should be below LBT failure, which has higher priority than Timing Advanced Report. Another company thinks it should have the same priority as BSR MAC CE. Given the clear majority, the rapporteur hence would suggest that:

**Proposal 8. The DSR MAC CE has a logical channel priority lower than the Timing Advanced Report and higher than the SL-BSR (prioritized). (12/14)**

## 3.3 PSI-based PDU discard activation/deactivation MAC CE

First, let us discuss which type of LCID (legacy 6-bit LCID, one octet eLCID, or two-octet eLCID) the PSI-Based PDU Discard Activation/Deactivation MAC CE should have.

**Question 9: which type of LCID do you think the PSI-Based PDU Discard Activation/Deactivation** **MAC CE should have?**

* **Option 1: legacy 6-bit LCID;**
* **Option 2: one-octet eLCID;**
* **Option 3: two-octet eLCID.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1/2/3** | **Comments** |
| LGE | Option 2 |  |
| Apple | Option 2 |  |
| Huawei, HiSilicon | Option2 | No coverage issue |
| Samsung | Option 2 |  |
| Nokia | Option 2 |  |
| Futurewei | Option2 |  |
| Fujitsu | Option 2 |  |
| vivo | Option 2 |  |
| OPPO | Option 2 |  |
| Qualcomm | Option 2 |  |
| Xiaomi | Option 2 | The general guideline is to use one-octet eLCID for MAC CE. |
| CATT | Option 1 | Considering it carries no payload, keep it as compact as possible. |
| NEC | Option2 | 6-bit LCID should not be used unless there is no other choice e.g., for earlier capability indication. Two-octet eLCID is only used for IAB case |
| Ericsson | Option 2 |  |

**Summary:**

13 out of 14 companies prefer Option 2, i.e. to use one-octet LCID. 1 company prefers Option 1, because it carriers no payload and hence should be kept as compact as possible.

**Proposal 9. The PSI-Based PDU Discard Activation/Deactivation MAC CE use one-octet eLCID. (13/14)**

When specifying the handling procedures of DL MAC CEs, the MAC spec usually specifies the initial state of a feature upon its configuration and handover. The rapporteur thinks the same needs to be specified for the PSI-Based PDU Discard Activation/Deactivation MAC CE. Moreover, it is reasonable to assume that the PSI-based discard should be initially deactivated upon its configuration and handover.

**Question 10. Do you agree that the PSI-based PDU discard should be initially deactivated upon its configuration and handover?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| LGE | No | Note that it should be PSI-based ‘SDU’ discard.Similar to PDCP duplication, initial state for PSI-based SDU discard should be indicated by RRC. |
| Apple | No | We think it is useful to have some RRC-configured initial state per DRB, to handle the cases where congestion is already present when configured. The new RRC parameter *psi-BasedDiscard* (based on PDCP running CR) itself, if present, can be served as a binary flag for the initial state, so no additional overhead is needed. |
| Huawei, HiSilicon | No | The initial state should be indicated by RRC |
| Samsung | No | Indicated by RRC |
| Nokia | - | PSI-based discard is provisioned to be used in congested links and it should be initially deactivated if no explicit indication. Ok with explicit indication in RRC as well. |
| Futurewei | Yes | If network is congested at the time of configuration, why would the gNB proceed with the configuration, knowing that the QoE will likely suffer and the congestion will be aggravated?  |
| Fujitsu | No strong view | It is reasonable to be initially deactivated upon its configuration and handover. We are also fine that the initial state is indicated via RRC configuration. |
| vivo | Yes | Otherwise, PSI-based discard will be initially activated, which will lead discard in case there is no congestion. It is not the intention for this mechanism.  |
| OPPO | No | The initial status can be indicated by RRC to allow the control of the PSI-based discard upon configuration. |
| Qualcomm | Yes | If network wants to activate congestion based discard right away, network can send activation/deactivation MAC CE together with RRC configuration for the discard.  |
| Xiaomi | Yes | Agree with Nokia that the feature is for congestion, which is rare. So it should be initially deactivated.But we are also OK to follow majority view. |
| CATT | Yes | It is not likely that gNB accepts a new service for a UE when it is congested. So gNB usually configures PSI-based PDU discard before NW congestion. |
| NEC | Yes  |  |
| Ericsson | Yes | PSI based discard is a last resort try. First there will be other means to combat the congestion, e.g. rate adaption. Also agree with Qualcomm that in the exceptional circumstance that network want it activated it can immediately send a activation MAC CE anyway. |

**Summary:**

Out of 14 companies, 7 companies think that the initial state should be deactivated, and 5 companies think the initial state can be RRC configured, 2 companies do not have strong view and are fine with either option. In addition, two companies mentioned explained that Option 2 can be implemented based on Option 1, i.e. network sends the activation MAC CE together with the RRC configuration. The rapporteur thus would suggest to discuss this issue further online at the next meeting:

**Proposal 10. Discuss whether the initial state of the PSI-Based PDU Discard Activation/Deactivation MAC CE is deactivated upon configuration and handover or configured by RRC. (7 vs 5)**

3.4 Modulus operation on non-integer DRX cycles

RAN2 have agreed to introduce non-integer DRX cycles for XR services and keep the modulus operations in the legacy DRX formula for the new DRX cycles. To minimize the mismatch between the start times of DRX on duration and XR traffic with non-integer DRX cycles, it is important that the modulus operation with non-integer divisor does not produce any rounding errors. At RAN2#123bis, it has been agreed that “We will have normative text to avoid rounding errors.”

Different options have been proposed in contributions. For example,

* We may only need to have a line in the normative text stating that “The MAC entity shall ensure no rounding error is generated when performing the modulus operation with drx-NonIntegerShortCycle or drx-NonIntegerLongCycle as the divisor.” The exact method to ensure no rounding error can be left to UE implementation. For example, some programming languages support fractional number data types or symbolic computations, which can represent and process non-integer values exactly without rounding errors. This option requires minimal changes to the legacy DRX formula and yet can avoid inter-operability issues.
* If one wants to have more details in the spec to ensure UEs do implement the modulus operation properly, a mathematical formula for modulus operation with non-integer divisor must be clearly specified instead of leaving it to UE implementation. For example, it is suggested in [1] that modulus (A, B) can be implemented by A – floor (A/B) × B. It is suggested in [2] that the least common multiples method may also be used, i.e. A modulus (B/C) = (A × C/C) modulus (B/C) = [(A × C) modulus B] / C, where both B and C are integers. For example, if frame rate is 60 fps or DRX cycle is 50/3 msec, then B = 50 and C = 3.

**Question 11. Which one of the following options do you prefer to capture the agreement that “We will have normative text to avoid rounding errors.”?**

* **Option 1. Add a line in the normative text after the DRX formula stating that “The MAC entity shall ensure no rounding error is generated when performing the modulus operation with drx-NonIntegerShortCycle or drx-NonIntegerLongCycle as the divisor.” The exact method to implement the modulus operation without rounding error is left to UE implementation.**
* **Option 2. Specify in the normative text that the modulus operation with non-integer DRX cycles shall be implemented by modulus (A, B) = A – floor (A/B)** × **B.**
* **Option 3. Specify in the normative text that the modulus operation with non-integer (ratio between integers) DRX cycles shall be implemented by modulus (A, B/C) = [(A** × **C) modulus B] / C.**
* **Option 4. Please describe your own preferred method in your comment.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1/2/3/4** | **Comments** |
| LGE | Option 1 or Option 3 | No strong view  |
| Apple | Option 1 | We prefer not to impose too many restrictions on UE implementation. |
| Huawei, HiSilicon | Option1 |  |
| Samsung  | Option 1  | This option allows different implementations.  |
| Nokia | Option 3 | Option 1 is not enough as it is not easy to test. Option 2 has issues as explained in our Tdoc R2-2310686. |
| Futurewei | Option 1 |  |
| Fujitsu | Option 4 | As proposed in our contribution [10], we propose:A modulo (B/C) = A – floor(A×C/B)×B/C, which is a **further detailed version of Option 2**. Since we have already defined the fractional number DRX cycle with two integers (B and C), it is preferred to use them in the normative text to guide the UE implementation to avoid the rounding errors. That’s the whole purpose we define the non-integer DRX cycle with two integers. |
| vivo | Option 3 | I assume this is the only way. Regarding option 1, I am still trying to understand how to no rounding error is generated for different UEs. We think same mechanism/results should be guaranteed between different UEs. |
| OPPO | Option 1 | We prefer not to restrict the algorithm used. |
| Qualcomm | Option 1 | We prefer not to impose too many restrictions on UE implementation. As to testing, we do not think 3GPP is able to test which formula UE implements. One can only test whether UE’s implementation produce rounding error or not. |
| Xiaomi | Option 1 |  |
| CATT | Option 1 | 3GPP specifications have always stayed away from specifying implementation details. We can leave it to “XR over NR” books/white papers ☺.  |
| NEC | Option 2 | If possible, we prefer to clearly indicate what UE should do. |
| Ericsson | Option 1 or 3 | Only concern with option 1 is if the text makes it clear what a rounding error is, or if this needs to be better specified. Option 3 could work too as this seems to remove potential error according to our analysis. |

**Summary:**

Out of the 14 companies, 9 companies prefer Option 1, 4 companies prefer Option 3, 1 company prefers Option 2, 1 company prefers Option 4 (which is an enhanced version of Option 2). Given the majority support for Option 1, the rapporteur would suggest we can try to agree to the following:

**Proposal 11. Discuss whether to leave it to UE implementation to ensure no rounding error in the modulus operation or define it based on a specific formula. (9 vs 5)**

## 3.5 Range of the new BSR table

For the maximum buffer size in the new BSR table, a number of options have been proposed in the contributions, which are listed below (the list may not be exclusive):

* It can be determined based on the maximum bit rate and lowest frame rate (e.g. which are specified in the SA4 TR) [3][7];
* It should be based on the maximum PDU size [5];
* It should be the same as the maximum of the legacy BSR table [6].

**Question 12: Please indicate which option you prefer for determining the maximum buffer size for the new BSR table?**

**- Option 1: it can be determined based on the maximum bit rate and lowest frame rate [3][4][7]. (Note: For now, we do not need to emphasize the exact formula for using these two parameters);**

**- Option 2: it can be based on the maximum PDU size [5];**

**- Option 3: it is the same as the maximum buffer size in the legacy BSR table [6];**

**- Option 4: other (please describe your preferred method in your comment).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1/2/3/4** | **Comments** |
| LGE | Option 1 | The exact value could be further updated based on the frame rate for AR UL traffic, depending on the SA4 discussion. |
| Apple | Option 3, but can follow majority | We prefer Option 3 as it minimizes specification efforts, and the new BS table could be used for different types of traffics other than XR, so it is a bit restrictive to specify the BS table with considerations of XR use cases only.  |
| Huawei, HiSilicon | Option1 | Anyway, we have the legacy table to fall back to. The range should cater for the XR services |
| Samsung | Option 3 | Option 1 & 2 only reflect a single QoS flow case, but one LCG can include multiple LCHs, and hence multiple QoS flows. |
| Nokia | Option 1 | We should also consider the PDB and the number of full frames that can be in the buffer at any given time given certain data and frame rates. |
| Futurewei | Option 1 | And, we should use the parameters for UL AR video. Note that reference [3][4][7] have used the parameters for DL VR video in their derivations. Please also consider the BS range as described in **R2-2307762** and **R2-2309594**.  |
| Fujitsu | Option 3 | Agree with Apple.  |
| vivo | Option 1 with comments | It is fine to derive the maximum buffer size based on the maximum bitrate and the lowest frame rate. But how to determine the maximum bit rate and the lowest frame rate should be investigated. For different resolution video, the frame rate range is different according H.264. Maybe we can select a reference video (e.g. 4Kx2K) to determine the maximum buffer size |
| OPPO | Option 3 | Agree with Apple and Samsung. But, we can follow the majority. |
| Qualcomm | Option 1 | For XR traffic, even if it is true that there are multiple flows, the maximum burst size would not be as large as the maximum in the legacy BSR table. So we should choose a smaller value to reduce quantization error.  |
| Xiaomi | Option 1 |  |
| CATT | Option 1 | The new BSR table is designed for the purpose of narrowing down the scope. |
| NEC  |  | Leave this to proponents of one static new BSR |
| Ericsson | Option 1 | Again we need to refer to our simulation results, where we have done extensive testing of various ranges and granularities on BS tables. Check all recent Ericsson contributions on BSR enhancements. The maximum value NEED to be lower than legacy. This cant be stressed enough. That is the single most important lesson to draw from the evaluations. The lower the maximum (Bmax), and the minimum (Bmin), values are set the higher the gains becomes! It is actually beneficial with high granularity all the way down to 0. And with the exponential distribution agreed we will see this higher granularity all the way down to 0 since Bmax is lower than in legacy. Whatever option we select there will never be possible to find a perfect value for Bmax. But it doesn’t matter, the important thing is to select some reasonable low Bmax but high enough so that it covers most of the possible future traffic frame size ranges. With the agreement to use exponential it is not that sensitive what value is selected since every increase doesn’t affect the low range granularity much. However the value shouldn’t be set unnecessarily high. The number floating around earlier of ~780 000 (based on Qualcomm analysis) could work but probably is unnecessary large. Anything higher than that for sure is NOT needed.Some points raised by companies is true, e.g. that there could potentially be more than one PDU Set in the buffer at one time. But we need to analyse what the point is to report for when multiple PDU Sets are there. This essentially means the UE has a low transmission rate and the high buffer values will actually not matter as much for the granularity in scheduling. Basically in those scenarios there will often be possible to update scheduler with new BSRs (when buffer is smaller) before the granularity becomes important (i.e. when transmissions will empty buffer) and padding in the grants will be less occurrent. Thus it is more important to increase the granularity of this new table, with a lower Bmax, than to cover the scenarios where there are multiple PDU Sets in the buffer.Thus setting a Bmax to around the upper limit of what the future expected maximum frame size will be is enough. |

**Summary:**

9 out of 14 companies prefer Option 1, 3 companies prefer Option 3, but 1 of those 3 companies can also go with the majority. 1 company does not appear to be have an opinion. Hence the rapporteur thinks there is a clear majority preferring Option 1 and would suggest we can try to agree to the following:

**Proposal 12. The maximum buffer size in the new BSR table is the determined based on the maximum bit rate and minimum frame rate of UL XR traffic. FFS the exact formula for determining the maximum using those two parameters. (9/13)**

The following is a list of different proposals from the contributions (the list may not be exclusive) for determining the minimum buffer size of the new BSR table:

* Option 1: it can be determined based on the minimum bit rate and highest frame rate (e.g. which are specified in the SA4 TR) [3][4][7];
* Option 2: it should be the code point at which quantization error starts to ramp-up sharply or becomes intolerable [5][6].

**Question 13: Please indicate which option you prefer for determining the minimum buffer size for the new BSR table?**

**- Option 1: it can be determined based on the minimum bit rate and highest frame rate (Note: For now, we do not need to emphasize the exact formula for using these two parameters);**

* **Option 2: it should be the code point at which quantization error starts to ramp-up sharply or becomes intolerable [5][6];**
* **Option 3: other (please describe your preferred method in your comment).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option 1/2/3** | **Comments** |
| LGE | Option 1 |  |
| Apple | Option 2 | In our understanding, we introduce the new BS table because we cannot tolerate the quantization error caused by the legacy BS table. Also, there is no need to tightly couple the new BS table with XR traffics, as the new BS table could be applied for other use cases. |
| Huawei, HiSilicon | Option1 | Same rationale as above |
| Samsung | Option 1 |  |
| Nokia | Option 1 | Option 2 it is unclear to which point the “error starts to ramp-up sharply or becomes intolerable” since we did not define any target quantization error and for exponential the error rate is kind of fixed. |
| Futurewei | Option 1 | And we are open to a longer tail at the lower end so that a more accurate BS level may be reported by a padding DSR. |
| Fujitsu | Option 2 | Agree with Apple.  |
| vivo | Option 1 with comments | There seems no typical minimum data rate for XR. The very low data rate (e.g. 64Kbps) video should not be used to derive the minimum buffer size. It seems better to determine a reasonable reference video case (e.g. 720D) to determine the minimum rata and maximum frame rate. |
| OPPO | Option 1 |  |
| Qualcomm | Option 1 |  |
| Xiaomi | Option 1 |  |
| CATT | Option 2 |  |
| Ericsson | Option 3 | The simple answer is 0. See again answer to question 12. There will be higher granularity down to 0 with the exponential distribution and significantly lower Bmax. Thus setting the Bmin to 0 (or at least close to 0) will give higher XR capacity and there is no reason to not do so.  |

**Summary:**

9 out of 13 companies prefer Option 1, 3 companies prefer Option 2, and 1 company prefers Option 3 (i.e. see Bmin to 0). Given the clear majority of Option 1, the rapporteur would suggest that we can try to agree to the following:

**Proposal 13. The minimum buffer size in the new BSR table is the determined based on the minimum bit rate and highest frame rate of UL XR traffic. FFS the exact formula for determining the minimum using those two parameters. (9/13)**

# 4. Conclusion

Based on the discussions and comments received, the rapporteur would suggest the following proposals for easy agreements:

**Proposal 1. The Enhanced BSR MAC CE includes a new 8-bit bitmap between the LCG bitmap and buffer size fields to indicate which BSR table an LCG uses. (12/14)**

**Proposal 3. The Enhanced BSR MAC CE has a one-octet eLCID. (13/14)**

**Proposal 4. The Enhanced BSR MAC CE has the same logical channel priority as the legacy BSR MAC CEs. (14/14)**

**Proposal 7. The DSR MAC CE uses one-octet eLCID. (14/14)**

**Proposal 8. The DSR MAC CE has a logical channel priority lower than the Timing Advanced Report and higher than the SL-BSR (prioritized). (12/14)**

**Proposal 9. The PSI-Based PDU Discard Activation/Deactivation MAC CE use one-octet eLCID. (13/14)**

And the following proposals for possible agreements:

**Proposal 2. Introduce Truncated Enhanced BSR MAC CE, which uses the new BSR table. (10/14)**

**Proposal 6. Dynamic indication of BSR table in the DSR MAC CE is not supported. FFS how UE determines which BSR table to use when reporting, e.g. define in the spec or configured by RRC. (8/14)**

**Proposal 12. The maximum buffer size in the new BSR table is the determined based on the maximum bit rate and minimum frame rate of UL XR traffic. FFS the exact formula for determining the maximum using those two parameters. (10/14)**

**Proposal 13. The minimum buffer size in the new BSR table is the determined based on the minimum bit rate and highest frame rate of UL XR traffic. FFS the exact formula for determining the minimum using those two parameters. (9/13)**

And the following proposals for further discussion during online:

**Proposal 5. Discuss whether to define a lookup table, a formula or some other methods to encode the remaining time field in the DSR MAC CE. (8 vs 4 vs 1)**

**Proposal 10. Discuss whether the initial state of the PSI-Based PDU Discard Activation/Deactivation MAC CE is deactivated or configured by RRC. (7 vs 5)**

**Proposal 11. Discuss whether to leave it to UE implementation to ensure no rounding error in the modulus operation or define it based on a specific formula. (9 vs 5)**

# 5. Reference

1. R2-2310929, Remaining issues for C-DRX in XR, MediaTek Inc, Oct 2023.
2. R2-2309486, Power saving enhancements for XR, Qualcomm Incorporated, Oct 2023.
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5. R2-2310109, BSR enhancements for XR, ZTE Corporation, Sanechips, Oct 2023.
6. R2-2310331, BSR Enhancements for XR, Apple, Oct 2023.
7. R2-2310687, BSR Enhancements for XR, Nokia, Nokia Shanghai Bell, Oct 2023.
8. R2-2307762, Discussions on new Buffer Status table design for XR, Futurewei.
9. R2-2309594, Detailed Buffer Size table design for XR, Futurewei.
10. R2-2309897, Remaining issues on C-DRX enhancement for XR, Fujitsu, Oct 2023