3GPP TSG-RAN WG2 #120 Tdoc R2-22xxxxx

Electronic meeting, 2022-08-17 - 2022-08-29

Agenda Item: x.x.x.x

Source: Ericsson

Title: Report from [Post119-e][650][IDC] Comparison of FDM solutions (Ericsson)

Document for: Discussion, Decision

# 1 Introduction

This is the report from the following email discussion.

* [Post119-e][650][IDC] Comparison of FDM solutions (Ericsson)

      Scope: Analyse the details of FDM candidate solutions raised in R2-2208951, and compare solutions , e.g. applied scenarios (e.g. serving, non-serving, different MR-DC architecture), complexity (e.g. Unified for all scenarios or not), etc;

Intended outcome: Report to RAN2#120

Deadline:  Nov 3rd (Rapporteur may introduce intermediate deadlines, but no deadline during an inactive period, and no deadline in the period from Submisssion deadline to EOM of R2-119bis).

Please provide input by **31st October 23:59 UTC** to give time to compile the report.

Please take note of the guidance provided by the Chair:

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| Extra Long email discussions after R2-119-e, for R2-120, Deadline: Nov 3rd  Outcome tdocs for long email discussions shall be submitted to RAN2 120-e (Nov meeting). Please request tdoc numbers as for any other input tdoc to next meeting, i.e. by 3GU.  NOTE that these discussions shall consider the duration of R2 119bis-e to be an inactive period (in addition to the general 3GPP inactive periods). |

In RAN2-119e the following was agreed:

Agreements:

1 The Adjacent channel interference between NR Stand Alone (SA) or MN of NR-DC and non-3GPP should be considered for the FDM enhancement in Rel.18.

2 The Adjacent channel interference between SN (NR) of MR-DC and non-3GPP should be considered for the FDM enhancement in Rel.18.

3 NE-DC is not considered; We will work on NR freq as SA NR case.

4 We will not consider the enhancements on E-UTRA freq for EN-DC scenario.

FFS, on signalling details;

Agreements:

1 The IMD interference from simultaneous Tx in EN-DC to non-3GPP should be considered for the FDM enhancement in Rel.18.

2 The IMD interference from simultaneous Tx in NR-DC to non-3GPP should be considered for the FDM enhancement in Rel.18.

Note: the solution (on freq granularity) for adjacent can be reused for IMD, we will not invent new solution on freq granularity for IMD. FFS on signalling details.

Agreements:

1 Granular indications of the affected NR frequency reported for IDC issue needs to consider both serving and non-serving frequency as in the legacy FDM solution.

# 2 Contact information

Respondents to the email discussion are kindly asked to fill in the following table.

|  |  |  |
| --- | --- | --- |
| Company | Name | Email Address |
| Nokia | Jarkko Koskela | [jarkko.t.koskela@outlook.com](mailto:jarkko.t.koskela@outlook.com) |
| Xiaomi | Yumin Wu | [wuyumin@xiaomi.com](mailto:wuyumin@xiaomi.com) |
| OPPO | ShiCong/Xinlei Yu | shicong@oppo.com  yuxinlei@oppo.com |
| Qualcomm | Sherif ElAzzouni | selazzou@qti.qualcomm.com |
| ZTE | Wenting Li | Li.wenting@zte.com.cn |
| Apple | Yuqin Chen | yuqin\_chen@apple.com |
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# 3 Background

Current NR IDC FDM solution allows the network to configure a set of candidate frequencies of the granularity of ARFCNs:

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| OtherConfig-v1610 ::= SEQUENCE {  idc-AssistanceConfig-r16 SetupRelease {IDC-AssistanceConfig-r16} OPTIONAL, -- Need M  ...  }  IDC-AssistanceConfig-r16 ::= SEQUENCE {  candidateServingFreqListNR-r16 CandidateServingFreqListNR-r16 OPTIONAL, -- Need R  ...  }  CandidateServingFreqListNR-r16 ::= SEQUENCE (SIZE (1..maxFreqIDC-r16)) OF ARFCN-ValueNR |

If the UE experiences (or will experience) IDC issues that the UE cannot solve by itself on any of those candidate ARFCNs, the UE sends an IDC indication:

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| 1> if configured to provide IDC assistance information:  2> if the UE did not transmit a *UEAssistanceInformation* message with *idc-Assistance* since it was configured to provide IDC assistance information:  3> if on one or more frequencies included in *candidateServingFreqListNR*, the UE is experiencing IDC problems that it cannot solve by itself; or  3> if on one or more supported UL CA combination comprising of carrier frequencies included in *candidateServingFreqListNR*, the UE is experiencing IDC problems that it cannot solve by itself:  4> initiate transmission of the *UEAssistanceInformation* message in accordance with 5.7.4.3 to provide IDC assistance information;  2> else if the current IDC assistance information is different from the one indicated in the last transmission of the *UEAssistanceInformation* message:  3> initiate transmission of the *UEAssistanceInformation* message in accordance with 5.7.4.3 to provide IDC assistance information;  NOTE 1: The term "IDC problems" refers to interference issues applicable across several subframes/slots where not necessarily all the subframes/slots are affected.  NOTE 2: For the frequencies on which a serving cell or serving cells is configured that is activated, IDC problems consist of interference issues that the UE cannot solve by itself, during either active data exchange or upcoming data activity which is expected in up to a few hundred milliseconds. For frequencies on which a SCell or SCells is configured that is deactivated, reporting IDC problems indicates an anticipation that the activation of the SCell or SCells would result in interference issues that the UE would not be able to solve by itself. For a non-serving frequency, reporting IDC problems indicates an anticipation that if the non-serving frequency or frequencies became a serving frequency or serving frequencies then this would result in interference issues that the UE would not be able to solve by itself. |

In this WI, RAN2 should increase the granularity from ARFCNs to something more granular. And the purpose of this discussion is to analyse and compare the candidate solution that were identified at RAN2#119. Such analysis should be done considering the applicable scenarios and should at least be in terms of complexity.

Solutions still in on the table (from [R2-2208951](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2208951.zip)):

**Option 1**: Central frequency + Bandwidth of the actual affected frequency range (3/14 for both serving and non serving frequency, 2/14 non serving frequency) [5], [6], [9], [11].

**Option 2**: Starting frequency + Ending frequency of the actual affected frequency range (2/14 for both serving frequency and non-serving frequency) [5], [6].

**Option 2a**: starting frequency + Bandwidth of the actual affected frequency range (1/14 for both serving frequency and non-serving frequency) [6].

**Option 3**: BWP-based reporting using BWP ID (5/14 serving frequency only , 2/14 for both serving and non serving frequency) [1], [6], [7], [10], [12], [13].

**Option 4**: BWP-based reporting using BWP ID + PRB index (2/14 for serving frequency) [6]. [7], [9].

**Option 5**: Measurement object ID [5] (1/14 – For LTE frequency only)

**Option 6**: Resource Block Group (RBG) based reporting (1/14 for both serving frequency and non-serving frequency) [8].

# 4 Discussion

Some companies discussed in their papers whether the enhancement should work also for non-serving frequencies (i.e. frequency resources which the UE is currently not using). First, the rapporteur suggests getting a common understanding whether the enhanced FDM-granularity should work both on serving and non-serving frequencies.

**Q1: Is it a requirement that RAN2 must define solution(s) for both serving and non-serving frequencies?**

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| **Company** | **Yes/No** | **Comments** |
| Nokia | Yes | Solution should work for non-serving frequencies naturally. We do not see any issue allowing finer granularity for non-serving cells as well. |
| Xiaomi | Yes | We think that a non-serving frequency could be later-on configured as serving frequency, or vice-versa. If the UE can use the enhanced FDM-granularity for the non-serving frequency, the UE does not need to send extra frequency indications when the affected frequency is changed between non-serving frequency and serving frequency. This can save some signalling overheads. |
| OPPO | No | We don’t prefer to further enhance non-serving, i.e., the legacy ARFCN based approach works well. |
| Qualcomm | No | There is no technical reason to start off the discussion with a condition that would restrict our design for serving cell (for example wrt to BWP reporting). Obviously, most of the time the gNB would be trying to solve the issue for the serving cell, that is why we enhance frequency granularity to begin with, to allow the serving cell extra visibility to solve the IDC problem without resorting to HO, so it is counter-intuitive to condition the measurement of the serving cell to being applicable to the non-serving cell and indeed is not a common method to approach measurements.  For the non-serving cell, we have not seen a good technical case yet to enhance the granularity beyond the existing carrier level. |
| ZTE | No | We share the similar view as Qualcomm and OPPO  For the non-serving cell, the network can avoid handover to the affected non-serving frequency based on the legacy ARFCN reporting, thus we don’t see strong motivation to do granularity enhancement for the non-serving cell.  For the serving frequency, with BWP/PRB based reporting, the network can avoid unnecessary handover, e.g. the network can solve the IDC issue by BWP switching. |
| Apple | See comments | We think non-serving frequencies should be supported and there is no necessity to pursue the same solution for both serving cell and non-serving cells.  The detailed reporting for non-serving frequency can be FFS. |
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Some solutions proposed in RAN2#119 had one type of indication for serving frequencies and another type of indication for non-serving frequencies. The rapporteur assumes that having different indications for serving and non-serving frequencies come with at least some added complexity, and it needs to be understood if that added complexity is justified by additional benefits. The rapporteur invites companies to indicate if there would be any benefits or needs of such an approach and explain those benefits/needs.

**Q2: Is there any technical benefit or need of having different FDM indications for serving vs. non-serving frequencies? If so, what?**

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| **Company** | **Yes/No** | **Comments** |
| Nokia | No | We do not currently see strong motivation to have different solutions. In fact we see motivation to have similar as it simplifies our standardization load and as we very well know we have extremely limited time for this WI. |
| Xiaomi |  | We have no strong view on whether to use different FDM indications for serving frequency and non-serving frequency. One may consider that the UE can reuse the BWP-ID and/or PRB index for the serving frequency, which can save some signalling overheads, compared with the FDM indication for the non-serving frequency. |
| OPPO | Yes | The finer granularity, more overhead to report, to avoid frequent IDC indication reporting, we could only consider the enhancement of finer granularity for serving frequencies, and keep legacy for non-serving frequencies. Thus different FDM indications are expected. |
| Qualcomm | Yes | BWP granularity is an important solution with wide support in the contribution phase. We think having BWP is critical since one easy L1 fix for an IDC issue is to simply change BWP for the serving cell to steer the UE Tx/Rx away from the IDC issue. Aside from BWP granularity, we need another level of PRB granularity/frequency granularity if the suspected victim/aggressor system has small BW (e.g. Bluetooth) and the NW does not intend to change the BWP.  Non-serving cell does not naturally lend itself to BWP reporting, thus, the two options would be existing carrier granularity and frequency/PRB granularity. We don’t see good reasoning right now to ask the non-serving cell to report things on the PRB level let-alone that this indeed is increased complexity, thus, we would like to point out that an enhanced granularity for a non-serving cell is not exactly critical. |
| ZTE | Yes | Share the same view as OPPO and Qualcomm. The key issue is whether to support BWP reporting, for that the BWP reporting can only be supported for the serving frequency.  For the serving cell, we think the BWP reporting is a quite signaling saving and efficient way, for that the network can determine whether and how to do BWP switch easily. |
| Apple | Yes | We think BWP based reporting is straightforward for serving cell as also mentioned by other companies above.  For non-serving cell, we need different solution other than BWP based reporting. |
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Option 5 is “Measurement object ID” and is described in [5]. The proponent of this solution clarified that this solution is for LTE frequencies only. In the LTE IDC solution the UE indicates IDC problems to the network by referring to the measurement object IDs:

InDeviceCoexIndication-r11-IEs ::= SEQUENCE {

affectedCarrierFreqList-r11 AffectedCarrierFreqList-r11 OPTIONAL,

tdm-AssistanceInfo-r11 TDM-AssistanceInfo-r11 OPTIONAL,

lateNonCriticalExtension OCTET STRING OPTIONAL,

nonCriticalExtension InDeviceCoexIndication-v11d0-IEs OPTIONAL

}

AffectedCarrierFreqList-r11 ::= SEQUENCE (SIZE (1..maxFreqIDC-r11)) OF AffectedCarrierFreq-r11

AffectedCarrierFreq-r11 ::= SEQUENCE {

carrierFreq-r11 MeasObjectId,

interferenceDirection-r11 ENUMERATED {eutra, other, both, spare}

}

The rapporteur’s understanding of the proposed Option 5 is not that it is an alternative to Option 1/2/2a/3/4/6, but rather a proposal to stick to the current way of indicating problematic frequencies in LTE, i.e. to still use measurement object IDs.

**Q3: Do you agree to that, for LTE, problematic frequencies are indicated by indicating measurement object IDs?**

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| **Company** | **Yes/No** | **Comments** |
| Nokia | Yes | In our understanding WI is focusing on indicating problems on NR frequencies. We should not affect existing signaling. |
| Xiaomi | Yes | Agree with Nokia. We think that the LTE frequency granularity (i.e. LTE measurement object) is sufficient for LTE problematic frequencies. |
| OPPO | Yes | Don’t intend to affect LTE |
| Qualcomm | Yes | Agree with rapporteur point of view to not change LTE, also, this is covered by the agreement “We will not consider the enhancements on E-UTRA freq for EN-DC scenario.” From last meeting |
| ZTE | Yes |  |
| Apple | Yes |  |
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Option 1, 2 and 2a are in the rapporteur’s point of view the same, with the difference of how the final stage-3 ASN.1 signalling would be defined. For the sake of this analysis, the rapporteur suggests treating them as one group of solutions.

**Q4: What are technical benefits and drawbacks of a solution where the UE indicates a frequency region (e.g. like 1/2/2a):**

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| **Company** | **Benefits** | **Drawbacks** |
| Nokia | It is possible to indicate “frequency range” of affected part of requency. This is logical and easy to understand. | Granularity of the solutions seems limited but definitely better than existing signaling. |
| Xiaomi | Applicable for both serving and non-serving frequency.  Applicable for EN-DC and NR-DC.  For Option 1, the field (i.e. *candidateServingFreqListNR*) for the IDC configuration provided by the gNB can be reused, as *candidateServingFreqListNR* is to indicate “the center frequency around which UE is requested to report IDC issues”. | No critical drawbacks are observed. The granularity of the solution depends on the bandwidth granularity to be specified, which can be discussed further.  Slightly more signalling overheads, as the ARFCN-ValueNR is expected to be used for the gNB configuration and the UE reporting signaling. |
| OPPO | * These solutions could apply to both serving and non-serving frequency; * Can provide finer granularity; | * Much more signalling overhead if the affected frequencies are discrete; Even for a single range of frequency, it brings more overhead compared with BWP ID; * It’s not clear how to signal the start frequency, end frequency, and also the bandwidth. |
| Qualcomm | High granularity indication that allows the gNB to pinpoint the PRBs causing IDC issues. Very useful if the BW where the IDC problem is caused is small since it allows the NW to just avoid the problematic PRBs without the need for more invasive solution.  Note that we understand this reporting to be configured only with a frequency reporting granularity but not with specific frequencies to measure, as the NW should not need to guess where the IDC problem occurs by doing a sweep, | High granularity may cause high overhead and/or excessive reporting. For example, for band N50 the IDC issue may occur in several frequencies so the reporting overhead ca get quite large.  If we adopt the view of some companies that specific frequencies are configured for reporting; The IDC may not exactly align with those frequencies which can cause misalignment between UE and gNB and cause the gNB to change frequency to a worse frequency from PRB point of view. |
| ZTE | Can provide finer granularity; | 1. Much more signaling overhead 2. For the serving cell, network still need to determine which BWP/BWP combination are valid from the PRB info, which also increases the network side processing complexity especially for the IMD case. |
| Apple | Finer granularity of problematic resources | More signaling overhead |
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Option 3 is:

**Option 3**: BWP-based reporting using BWP ID (5/14 serving frequency only , 2/14 for both serving and non serving frequency) [1], [6], [7], [10], [12], [13].

**Q5: What are technical benefits and drawbacks of solution 3:**

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| **Company** | **Benefits** | **Drawbacks** |
| Nokia | Maybe smaller signaling from UE to NW (but more signaling from NW to UE) | UE needs to be configured with multiple BWPs and somehow also for non-serving cells – in fact it was not clear how this solution would work for non-serving cells? And if this is based on NW indicating candidate BWPs why would we consider such a solution if UE could indicate actual impacted parts of frequency directly without needing NW to add some additional information which parts of frequency it is interested in? Likely only reason would be possibly reduced signaling from UE to NW?  This seems to be very limited in granularity i.e. UEs would not have any means to indicated precisely what are affected parts |
| Xiaomi | Less signalling overheads compared with Option 1/2/2a | It is not clear how this Option is applicable for EN-DC or NR-DC, as the LTE/NR MN is not able to know the affected SCG BWP.  It is not clear how this Option is applicable for non-serving frequency, as the non-serving has no BWP configuration.  The granularity of reporting BWP depending on the bandwidth of each BWP configuration may not be sufficient when the BWP bandwidth is large. |
| OPPO | * If we only consider enhancement for serving frequency, it doesn’t need more signalling from NW to UE, and UE just needs to report the BWP ID. | * It is not straightforward for non-serving frequency or non-serving cells. But whether this drawback exists depends on whether we need enhancement on granularity for these scenarios really. * Less granularity? |
| Qualcomm | Changing BWP happens via L1, so both the reporting and the solution overhead are very low compared to option 1/2/2a which makes it a more realistic option for adoption.  Offers an intermediate flexibility of reporting between the whole band and the individual PRB extremes.  We do not consider coarse granularity a con since having this as an option with the previous option 1&2 can cover all the flexibilities that the NW may choose to configure.  Simple configuration since there are at most 4 BWPs configured for the UE, so the UE need to just ask the UE to report on the BWP granularity | For a large BWP where IDC only occurs in a portion of frequencies, an IDC problem reported might not clarify that the IDC issue does not affect the whole BWP.  Not applicable for non-serving cell |
| ZTE | 1. Solution is simple 2. Less signaling overhead 3. Simple processing at network side | Not applicable for non-serving cell (if enhancement to the non-serving frequency is supported) |
| Apple | Reporting BWP ID is simple with low signaling overhead. | In our view, BWP based reporting is only applicable to serving cells.  The granularity of problematic resources is coarser than PRB based reporting. |
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Option 4 is:

**Option 4**: BWP-based reporting using BWP ID + PRB index (2/14 for serving frequency) [6]. [7], [9].

**Q6: What are technical benefits and drawbacks of solution 4:**

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| **Company** | **Benefits** | **Drawbacks** |
| Nokia | Granularity of PRB indication is likely about maximum we can get | Same as for option 3 but not having limitation for granularity |
| Xiaomi | Less signalling overheads compared with Option 1/2/2a.  Better granularity compared with Option 3 | It is not clear how this Option is applicable for EN-DC or NR-DC, as the LTE/NR MN is not able to know the affected SCG BWP.  It is not clear how this Option is applicable for non-serving frequency, as the non-serving has no BWP configuration. |
| OPPO |  | * PRB level reporting may lead to frequent IDC indication reporting due to the change of IDC status. * Increased signalling overhead |
| Qualcomm | Same as option 1/2/2a but with even better signalling and more compact reporting. | Same as option1/2/2a without the large overhead part.  Not applicable to non-serving cell |
| ZTE | Can provide more detail info for each BWP | More signaling overheads |
| Apple | Finest granularity of problematic resources. | Larger signaling overhead than BWP ID only reporting. |
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Option 6 is:

**Option 6**: Resource Block Group (RBG) based reporting (1/14 for both serving frequency and non-serving frequency) [8].

**Q7: What are technical benefits and drawbacks of solution 6:**

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| **Company** | **Benefits** | **Drawbacks** |
| Nokia | Granularity seems very good in this solution | Likely bit more signaling needed but we do not expects this to be an issue |
| Xiaomi | Less signalling overheads compared with Option 1/2/2a.  Less signalling overheads compared with Option 4  Better granularity compared with Option 3 | It is not clear how this Option is applicable for EN-DC or NR-DC, as the LTE/NR MN is not able to know the affected SCG BWP.  It is not clear how this Option is applicable for non-serving frequency, as the non-serving has no BWP configuration.  It is unclear how/whether to differentiate the frequency indication between “resource allocation type 0” and “resource allocation type 1” |
| OPPO | Finer granularity | It may lead to frequent IDC indication reporting due to the change of IDC status. |
| Qualcomm | Same as option 1/2/2a | Depends on the resource allocation type. Also less straightforward than the other high granularity options  Not applicable for non-serving frequency |
| ZTE | Similar to option 1/2/2a | Not applicable for non-serving frequency |
| Apple | Similar to option 1/2/2a | Not applicable for non-serving frequency |
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If companies have any other relevant comments, please fill them in here:

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| **Company** | **Comment** |
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# 3 Conclusion

In the previous sections we made the following observations:

[Observation 1 An Observation with automatic numbering. Assign this type by pressing Alt-O. A list of all Observations can be found in the Conclusion section.](#_Toc509923396)

Based on the discussion in the previous sections we propose the following:

[Proposal 1 A Proposal with automatic numbering. Assign this type by pressing Alt-P. A list of all Proposals can be found in the Conclusion section.](#_Toc509923397)

# 4. References

1. [R2-2207162](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2207162.zip) Consideration on the FDM enhancement ZTE Corporation, Sanechips
2. [R2-2207469](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2207469.zip) Discussion on FDM solution enhancements for IDC OPPO
3. [R2-2207539](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2207539.zip) Discussion on FDM solution enhancements Sharp
4. [R2-2207556](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2207556.zip) Assistance information for FDM Nokia, Nokia Shanghai Bell
5. [R2-2207804](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2207804.zip) Discussion on the IDC FDM solutions Xiaomi
6. [R2-2207844](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2207844.zip) Discussion on FDM solution for in-device co-existence interference avoidance Samsung
7. [R2-2207936](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2207936.zip) Discussion on FDM solution in IDC Apple
8. [R2-2207968](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2207968.zip) Enhanced FDM solution for IDC Intel Corporation
9. [R2-2208116](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2208116.zip) FDM Solutions in IDC Qualcomm Incorporated
10. [R2-2208135](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2208135.zip) FDM solution for IDC Ericsson
11. [R2-2208230](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2208230.zip) Discussion on FDM enhancement Huawei, HiSilicon
12. [R2-2208396](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2208396.zip) Discussion on FDM solution for R18 IDC vivo
13. [R2-2208524](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2208524.zip) IDC FDM solution LG Electronics
14. [R2-2207161](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2207161.zip) Clarification on the IDC scope ZTE Corporation, Sanechips

1. [R2-2208951](http://www.3gpp.org/ftp//tsg_ran/WG2_RL2/TSGR2_119-e/Docs//R2-2208951.zip) [AT119-e][651][IDC] FDM solution enhancements (Huawei) Huawei, HiSilicon