**3GPP TSG-RAN WG2 Meeting #119 electronic Draft-R2-2208922**

**E-Meeting, 17 – 29 August, 2022**

**Agenda item: 8.10.3**

**Source: Xiaomi**

**Title: Summary of [AT119-e][652][IDC] TDM solution (Xiaomi)**

**Document for:**  **Discussion**

# 1. Introduction

This paper is to trigger the following email discussion of IDC TDM solutions:

* [AT119-e][652][IDC] TDM solution (Xiaomi)

      Scope: based on companies’ contributions submitted in 8.10.3

      A) Identify the use cases or scenarios (e.g. WLAN, BT multimedia, BT voice) for the TDM solution

               B) TDM solutions for identified use cases/scenarios

      Intended outcome: Report to Wednesday session in R2-2208922

      Deadline: Wednesday 2022-08-24 00:30 AM UTC.

## 1.1 Contacts

Contact person for each participating company:

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# 2. Discussion

The objective related to the IDC TDM solution is quoted as follows:

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| This WI expects to address interference between 3GPP (including various MR-DC architectures, i.e. NR-DC and EN-DC) and non-3GPP RAT (e.g. WiFi).* Introduction of TDM solution (e.g. indication of UE preferred TDM pattern for UL/DL). (RAN2, RAN4).Note: The TDM solution is considered complementary to the FDM solution.

Note: LTE IDC solution should be considered as the baseline for the solutions developed in this WI. |

## 2.1 Scenarios and use cases

According to the 3GPP TR 36.816, the TDM solutions are designed to resolve the IDC issues in various usage scenarios. Since the Rel-18 IDC WID already states that “LTE IDC solution should be considered as the baseline for the solutions developed in this WI”, we consider that the following LTE TDM solutions (or the Rel-18 NR TDM solutions taking the following LTE TDM solutions as baseline) could be applied for the use cases as described in the 3GPP TR 36.816.

* Solution 1: TDM assistance information (i.e. UE reporting of its preferred TDM parttern via *TDM-AssistanceInfo-r11*)
	+ Solution 1.1: DRX based solution (i.e. UE reporting of its preferred DRX configuration via *drx-AssistanceInfo-r11*)
	+ Solution 1.2: HARQ process reservation based solution (i.e. UE reporting of its preferred UL/DL subframe pattern via *idc-SubframePatternList-r11*)
* Solution 2: Network controlled UE autonomous denial (i.e. UE autonomous denial based on the configuration of *autonomousDenialParameters-r11*)

The corresponding usage scenarios for each solution are also quoted from 3GPP TR 36.816, as given blow.

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| 3GPP TR 36.816: Usage scenario for TDM solutions in generalSCO, eSCO, A2DP and ACL protocols are assumed to be supported by in-device BT radio when analyzing the TDM solutions for LTE-BT coexistence. Beacon, power saving and DCF protocols are assumed to be supported by in-device WiFi radio when analyzing the TDM solutions for LTE-WiFi coexistence. |
| 3GPP TR 36.816: Usage scenario for Solution 1.1DRX solution could be used also for shorter interference patters. E.g. with BT voice, it is possible to configure DRX cycle to 10 ms or 5 ms and then achieve a desired gap pattern with appropriate setting on drx-OnDurationTimer, drx-InactivityTimer, drx-retransmissionTimer and DRX offset. In some cases, drx-retransmissionTimer of 0 ms needs to be introduced to avoid the UE to be DRX Active in the subframes that are reserved for ISM traffic.  |
| 3GPP TR 36.816: Usage scenario for Solution 1.2In this solution, e.g. a number of LTE HARQ processes or subframes are reserved for LTE operation, and the remaining subframes are used to accommodate ISM/GNSS traffic.The information that UE provides should allow the network to ensure at least a pair of clean BT Tx/Rx instances in each BT interval, and as much as possible capacity to LTE. |
| 3GPP TR 36.816: Usage scenario for Solution 2UE can autonomously deny LTE resources due to some critical short-term events of ISM side, e.g. some events during BT/WiFi connection-setup or other important signalling.During stable situation of ISM operation, some LTE resources can be denied by UE autonomously to protect ISM data packets, so e.g. the BT eSCO connection or WiFi connection with PS-Poll can be maintained. |

[8] considers “WLAN beacon and BT eSCO as target use cases to assess TDM solutions”. [6] asks “whether to support coexistence use case with Bluetooth voice”. From the rapporteur’s understanding, RAN2 can firstly discuss/confirm whether the TDM solution use cases as described in 36.816 should also be considered in Rel-18 IDC solutions.

#### Question 1: Do you agree that the use cases as described in 36.816 for LTE TDM solutions are considered for developing the Rel-18 IDC TDM solution?

The examples for the TDM uses cases in 36.816 are listed as follows:

* BT voice [6]
* WLAN beacon [8]
* BT eSCO [8]

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| **Company** | **Answer** **(**Yes or No**)** | **Comments** |
| Xiaomi | Yes | Since the Rel-18 IDC WID is targeting at reusing the LTE TDM solutions as baseline, we think that the use cases as described in 36.816 for LTE TDM solutions should also be considered for NR. It is quite obvious that the services/signalling via the BT or WLAN wiil not change when the UE is using LTE or NR. |
| Samsung  | Yes  |  |
| ZTE | Yes |  |
| Lenovo | Yes |  |
| Apple | Yes |  |
| vivo | Yes |  |
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[9] considers that the TDM soluton should be able to resolve the IDC issues of the adjacent channel interference and the intermodulation distortion (IMD) interference. The corresponding scenarios from [9] are listed as follows:

* Scenario 1: Adjacent channel interference between NR and non-3GPP that includes the following sub scenarios
	+ Scenario 1-1: Adjacent channel interference between NR Stand Alone (SA) or MN of NR-DC and non-3GPP
	+ Scenario 1-2: Adjacent channel interference between SN (NR) of MR-DC and non-3GPP
* Scenario 2: Intermodulation Distortion (IMD) interference from simultaneous Tx in MR-DC to non-3GPP that includes the following sub scenarios
	1. Scenario 2-1: IMD interference from simultaneous Tx in EN-DC to non-3GPP
	2. Scenario 2-2: IMD interference from simultaneous Tx in NR-DC to non-3GPP

From the rapporteur’s understanding, RAN2 can firstly confirm whether the design of the Rel-18 TDM solution should target at resovling the adjacent channel interference issue and the intermodulation distortion interference issue, like the LTE TDM solution as described in 3GPP TR 36.816. The MR-DC impacts can be discussed later when RAN2 has selected the TDM solutions to be specified, as different TDM solutions may cause different specification impacts for different MR-DC architectures.

#### Question 2: Do you agree that the Rel-18 IDC TDM solution(s) targets at resolving the adjacent channel interference issue and the intermodulation distortion interference issue, as LTE?

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| **Company** | **Answer** **(**Yes or No**)** | **Comments** |
| Xiaomi | Yes | It is better to confirm the interference issues to be resolved by the Rel-18 IDC TDM solutions, so that all issues will be resovled properly by TDM solutions.  |
| Samsung  | Yes  |  |
| ZTE | See comments | Our understanding is that the LTE TDM solution is mainly for the adjacent channel interference, only the TDM info on one serving cell (Pcell) was reported. For the IMD, the eNB may deactivate the scell |
| Lenovo | Yes |  |
| Apple | Yes |  |
| vivo | Yes |  |
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## 2.2 TDM solutions using LTE baseline

According to the 3GPP TS 36.331 and the Section 5.2.1.2 and 5.2.2.1 of the 3GPP TR 36.816, the TDM solutions specified for LTE IDC include the followings:

* Solution 1: TDM assistance information (i.e. UE reporting of its preferred TDM parttern via *TDM-AssistanceInfo-r11*)
	+ Solution 1.1: DRX based solution (i.e. UE reporting of its preferred DRX configuration via *drx-AssistanceInfo-r11*)
	+ Solution 1.2: HARQ process reservation based solution (i.e. UE reporting of its preferred UL/DL subframe pattern via *idc-SubframePatternList-r11*)
* Solution 2: Network controlled UE autonomous denial (i.e. UE autonomous denial based on the configuration of *autonomousDenialParameters-r11*)

The rapporteur’s understanding is that RAN2 can firstly confirm what has been stated in the IDC WID, i.e. using the LTE TDM solutions as baseline.

#### Question 3: Do you agree that the LTE TDM solutions are considered as the baseline for developing the Rel-18 IDC TDM solution, as indicated in the WID?

(Rapporteur’s comment: Further downselection from the the LTE TDM solutions can be discussed separately.)

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| **Company** | **Answer** **(**Yes or No**)** | **Comments** |
| Xiaomi | Yes | We think that it is better to confirm the design principle as indicated in the WID, so that companies can have the common understanding while selecting TDM solution(s) for mitigating IDC interference. Other TDM solutions can still be considered when time allows. |
| Samsung  | Partial Yes | The DRX part in LTE can be the baseline The subframe pattern part in LTE is not aligned with NR since NR has a more flexible slot structure so the timer domain pattern should take TDM configuration of NR (e.g., slot) into account. |
| ZTE | Partially Yes | Similar view as Samsung, and maybe MUSIM gap-like scheme can also be considered |
| Lenovo | See comments | The granurality between NR and LTE is difference as Samsung mentioned. The important point is that UE needs to report the time-domain information to network. Then, the network reconfigures TDM to UE. RAN2 needs to evaluate/discuss which one (DRX-like or MUSIM gap-like is better.  |
| Apple | See comments | We can confirm DRX like (or MUSIM gap like) solution as the main motivation is to get an off time duration. For HARQ process reservation based solution, we have a big question mark if it is still needed since NR HARQ pattern is much more flexible.For autonomous denial, we don’t have strong views but RAN4 work would be required on the allowed denial rate. |
| vivo | No  | We prefere use MUSIM gap like method. MUSIM gap has been introduced in R17 it is better to use it. LTE methods are not suitable for NR, like company comments. DRX give more timer maintance, and some power saving signallings like DCP will also impact DRX. DL/UL subframe pattern is needed for LTE due to sync HARQ. Auto deny will give more RAN4 works.   |
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| 3GPP TS 36.331: Solution 1.1 and Solution 1.2 included within the *TDM-AssistanceInfo-r11*1> if there is at least one E-UTRA carrier frequency, for which a measurement object is configured, that is affected by IDC problems:2> include the field *affectedCarrierFreqList* with an entry for each affected E-UTRA carrier frequency for which a measurement object is configured;2> for each E-UTRA carrier frequency included in the field *affectedCarrierFreqList*, include *interferenceDirection* and set it accordingly;2> include Time Domain Multiplexing (TDM) based assistance information, unless *idc-HardwareSharingIndication* is configured and the UE has no Time Doman Multiplexing based assistance information that could be used to resolve the IDC problems:3> if the UE has DRX related assistance information that could be used to resolve the IDC problems:4> include *drx-CycleLength*, *drx-Offset* and *drx-ActiveTime*;3> else (the UE has desired subframe reservation patterns related assistance information that could be used to resolve the IDC problems):4> include *idc-SubframePatternList*;3> use the MCG as timing reference if TDM based assistance information regarding the SCG is included; |

As highlighted above, the *TDM-AssistanceInfo-r11* reported by the UE is complementary to the frequency information included in the IDC report. Namely the *TDM-AssistanceInfo-r11* can only be reported when the *affectedCarrierFreqList* is reported for the adjacent channel interference, and the *TDM-AssistanceInfo-r11* is independent from the UL CA frequencies reported for inter-modulation (i.e. *affectedCarrierFreqCombList* and *affectedCarrierFreqCombInfoListMRDC*).

[4][11] considers that the impacts of BWP switching should be considered for the TDM solution. From the rapporteur’s understanding, this depends on whether/how the FDM solution of IDC is impacted by the BWP switching, as the TDM solution of LTE is currently associated to the reported frequency. The BWP switching issue can be discussed later once the FDM solution is clear.

#### Question 4: Do you agree that the UE reports the TDM assistance information for IDC affected frequency list (i.e. not for the frequency combination list of UL CA), as LTE?

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| **Company** | **Answer** **(**Yes or No**)** | **Comments** |
| Xiaomi | Yes | As indicated in the WID, “the TDM solution is considered complementary to the FDM solution”. This is also aligned with the LTE design principles. On the other hand, since the LTE baseline solution of TDM assistance information is independent from the UL CA frequencies reported for inter-modulation interference, we think that clear motivations need to be provided on designling new TDM assistance information for UL CA. |
| Samsung  | Yes with comments  | TDM information for the affected frequency list can be the baseline. However, this does not preclude the other frequency granularity, which needs the progress for FDM solution. |
| ZTE | No | In the LTE only TDM assistance information on the Pcell was reported. |
| Lenovo | Yes with comments | TDM assistance information for IDC affected frequency list can be considered as baseline. additional information could be futher considered. |
| Apple | Yes |  |
| vivo | Yes |  |
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For Solution 1-1, [1][2][3][4][5][6][7][8][9][11][12] propose to allow the UE to report its desired DRX configuration. The rapporteur’s understanding is that same as LTE, the UE can report its desired DRX pattern (including DRX cycle, DRX starting offset and DRX active time) for affected NR frequency list (i.e. not for the frequency combination list of UL CA).

#### Question 5: Do you agree that the UE can report its preferred DRX pattern (including DRX cycle, DRX starting offset and DRX active time), as LTE?

(Rapporteur’s comment: Whether multiple DRX(s) within or across different cell groups or whether more paramters are needed can be a separate discussion.)

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| **Company** | **Answer** **(**Yes or No**)** | **Comments** |
| Xiaomi | Yes | It seems that the UE reporting of its desired DRX pattern for affected NR frequency list can reuse the LTE DRX solution for IDC. Signaling details on whether to consider the latest NR DRX design (e.g. the milli-second granularity of NR DRX configuration or the multiple DRX(s) within a CG) can be discussed further. |
| Samsung  | Yes  |  |
| ZTE | FFS | We are open to take DRX like or MUSIM like scheme |
| Lenovo | See comments | RAN2 needs to perform fo down-selection of DRX pattern and MUSIM gap-like first. |
| Apple | Yes with comments | For DRX operation, one problem is UE needs to maintain many timers. That is why we feel MUSIM gap is also a good candidate. |
| vivo |  No  | MUSIM like scheme is better.  |
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For Solution 1-2, [1][3][4][6][11] considers that the NR flexible numerology and UL/DL configuration may need to be considered while defining the finer granularity for UL/DL transmission/reception. [8][12] considers that Solution 1-2 is not feasible for NR due to “the large number of possible TDD configurations” and “the flexible HARQ timing in NR”. From the rapporteur’s understanding, Solution 1-2 is to provide more flexibilities for the gNB, so as to have more efficient use on the frequency resources, especially for TDD frequencies. For example, when the interference is DL-only interference to a TDD frequency, using the DRX to stop the UL slot seems over-kill. Same problem can also happen for UL-only interference from a TDD frequency.

#### Question 6: Do you agree that the UE can report its preferred UL and/or DL transmission occasion(s), as LTE?

(Rapporteur’s comment: The details on the UL and/or DL transmission occasion can be discussed further, once the proposal is agreed.)

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| **Company** | **Answer** **(**Yes or No**)** | **Comments** |
| Xiaomi | Yes | We think that the finer granularity on indicating UL and/or DL transmission occasion is important for TDD band, since DRX would stop both UL and DL at the inactive period. The IDC interference could be DL-only or UL-only from time to time.  |
| Samsung  | Yes  | In our understanding, the intention of preferred DL/UL transmission is corresponding to preferred subframe pattern reporting in LTE. For NR case, the DL/UL transmission occasions may have more fine granularity. Thus, when designing the detailed TDM pattern, the preferred DL/UL occasions can take NR slot structure into account. |
| ZTE | No | It would increase RAN4’s work on the related requirement, we don’t think it can be finished in this WID. |
| Lenovo | Yes | It may align with the objective. |
| Apple | No | In LTE IDC, HARQ process reservation based solution was to keep the HARQ process un-interrupted. However in NR, we don’t think the issue is still justified as the HARQ timeline becomes much more flexible.  |
| vivo | No  |  |
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| 3GPP TS 36.331: Solution 2 considered as a TDM solution according to “5.2.2.1 TDM solutions” of 3GPP TR 36.8162> if *autonomousDenialParameters* is included:3> consider itself to be allowed to deny any transmission in a particular UL subframe if during the number of subframes indicated by *autonomousDenialValidity*, preceeding and including this particular subframe, it autonomously denied fewer UL subframes than indicated by *autonomousDenialSubframes*; |

For Solution 2, [1][3][4] considers that the LTE solution can be reused for NR. As quoted above from 3GPP TS 36.331, since LTE autonomous denial is based on the granularity of subframe, NR could also reuse the same granularity of subframe.

#### Question 7: Do you agree that the UE can be configured to autonomously deny the NR UL transmission, as LTE?

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| **Company** | **Answer** **(**Yes or No**)** | **Comments** |
| Xiaomi | Yes | According to 3GPP TR 36.816, the autonomous denial solution seems to be the only TDM solution to deal with the “infrequent short-term events”, e.g. “BT/WiFi connection-setup or other important signalling”. Compared with DRX and UL/DL reservation, the autonomous denial solution is more efficient for aperiodic and even-driven control signalling via WiFi or BT. |
| Samsung  | Yes with comments  | We agree the autonomous denial should be supported in Rel-18. However, the LTE autonomous denial is configured per-UE. With the MR-DC configuration, we may need enhance it in Rel-18. |
| ZTE | No | Same reason as Q6 |
| Lenovo | Yes | The autonomously deny can be controlled by network. |
| Apple | No strong view |  |
| vivo | No  |  |
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## 2.3 Other solutions

According to companies’ contributions submitted to RAN2#119-e meeting, a few other solutions for TDM are also provided as follows:

* Solution A: MUSIM gap-like [2][5][8][10][12]
* Solution B: Hardware sharing indication [1]

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| 38.331: Solution AMUSIM-GapInfo-r17 ::= SEQUENCE { musim-Starting-SFN-AndSubframe-r17 MUSIM-Starting-SFN-AndSubframe-r17 OPTIONAL, -- Cond aperiodic musim-GapLength-r17 ENUMERATED {ms3, ms4, ms6, ms10, ms20} OPTIONAL, -- Need S musim-GapRepetitionAndOffset-r17 CHOICE { ms20-r17 INTEGER (0..19), ms40-r17 INTEGER (0..39), ms80-r17 INTEGER (0..79), ms160-r17 INTEGER (0..159), ms320-r17 INTEGER (0..319), ms640-r17 INTEGER (0..639), ms1280-r17 INTEGER (0..1279), ms2560-r17 INTEGER (0..2559), ms5120-r17 INTEGER (0..5119), ... } OPTIONAL -- Cond periodic} MUSIM-Starting-SFN-AndSubframe-r17 ::= SEQUENCE { starting-SFN-r17 INTEGER (0..1023), startingSubframe-r17 INTEGER (0..9)} |

As quoted above for Solution A, the UE can report its desired gap pattern. [6] states that Solution A should not be considered, as the DRX solution is more flexible and suitable for resolving the IDC intereference issue. From the rapporteur’s understanding, if the gap-based solution is adopted, we would anyway need a new reporting signalling separate from MUSIM, since the TDM assistance information is complementary to the affected frequency reported by the UE. The gNB needs both the IDC frequency information and the time-domain information together in order to resolve the interference issue.

#### Question 8: Do you think think that MUSIM gap-like solution should be included in Rel-18 IDC work?

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| **Company** | **Answer****(Yes or No)**  | **Comments** |
| Xiaomi | No | It seems that if we reuse the LTE TDM solutions, the interference issues including both the adjacent channel interference and the intermodulation distortion interference can be resolve already. The MUSIM gap-like solution seems redundant, as it has the same benefit as the DRX solution, and is less flexible than the DRX solution considering the gap values. |
| Samsung  | No  | It seems that MUSIM gap-like solution does not have additional benefit on top of 1) preferred DRX and 2) preferred DL/UL pattern.  |
| ZTE | FFS | We are open on this issue but slightly prefer to take the MUSIM like scheme |
| Lenovo | Yes | RAN2 needs to evaluate/discuss which one (DRX based and MUSIM based) is more suitable. |
| Apple | Yes | MUSIM gap is simpler with regards to UE implementation. |
| vivo | Yes  | Agree with Apple. |
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Regarding the hardware sharing indication (i.e. the UE reporting of *hardwareSharingProblem-r13*), the rapporteur’s understanding is that the “*hardwareSharingProblem-r13*” is not part of the *TDM-AssistanceInfo* in LTE, and is also not part of the TDM solutions as listed in the IDC 3GPP TR 36.816. If companies want to introduce the hardware sharing indication also for NR, more clarifications (e.g. whether/how to use the legacy indication or a new indication for LTE and NR for MR-DC) are needed.

#### Question 9: Do you think think that Hardware sharing indication should be included in Rel-18 IDC work?

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| **Company** | **Answer****(Yes or No)**  | **Comments** |
| Xiaomi | No | Regarding the hardware sharing indication, it seems that this is not in the scope of the WID. If most companies think this solution should be included, we are also ok to include it, but we may need to update the WID. |
| Samsung  | Maybe? | Hardware sharing support may be considered if majority companies agree to have it in Rel-18. |
| ZTE | No | Agree with Xiaomi |
| Lenovo | No  | Agree with Xiaomi. |
| Apple | See comments | We are fine with xiaomi’s proposal that if companies have interests to include hardware sharing, it can be brought to RAN plenary. |
| vivo | No  |  |
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# 3. Conclusion

TBD

# 4. Reference

1. R2-2207379 TDM Assistance Information for IDC Nokia, Nokia Shanghai Bell discussion Rel-18 NR\_IDC\_Enh-Core
2. R2-2207718 TDM solution for IDC problem Lenovo discussion Rel-18
3. R2-2207805 Candidate TDM solutions for IDC Xiaomi discussion Rel-18 NR\_IDC\_Enh-Core
4. R2-2207845 Discussion on TDM solution for in-device co-existence interference avoidance Samsung discussion Rel-18 NR\_IDC\_Enh-Core
5. R2-2207937 Discussion on TDM solution in IDC Apple discussion Rel-18 NR\_IDC\_Enh-Core
6. R2-2207969 TDM solution for IDC Intel Corporation discussion Rel-18 NR\_IDC\_Enh-Core
7. R2-2208113 TDM Solution for NR IDC Ericsson discussion Rel-18 NR\_IDC\_Enh-Core
8. R2-2208118 TDM Solutions in IDC Qualcomm Incorporated discussion Rel-18
9. R2-2208231 Discussion on TDM solution for NR IDC Huawei, HiSilicon discussion Rel-18 NR\_IDC\_Enh-Core
10. R2-2208397 Discussion on TDM solution for IDC vivo discussion Rel-18 NR\_IDC\_Enh-Core
11. R2-2208525 IDC TDM solution LG Electronics discussion Rel-18
12. R2-2207161 Clarification on the IDC scope ZTE Corporation, Sanechips discussion Rel-18 NR\_IDC\_Enh-Core