**3GPP TSG-RAN WG2 Meeting #119-e *draft* R2-2209405**

**Electronic meeting, 17th – 26th Aug,** **2022**

**Agenda item:** 8.2.4

**Source:** CATT

**Title:** [Post119-e][407][POS] LPHAP upper layer enhancements (CATT)

**Document for:** Discussion and Agreement

# 1 Introduction

This is to continue the online discussion on the study of potential LPHAP upper layer enhancements.

* [Post119-e][407][POS] LPHAP upper layer enhancements (CATT)

 Scope: Discuss the potential benefits of the candidate higher layer enhancements submitted to RAN2#119-e:

* Optimised paging and/or RRM measurements
* Enhancements of DL and/or UL positioning methods to use MT-SDT
* Enhance SRS configuration request to reduce signalling overhead (including area validity mechanism)
* Event report enhancements
* DL-PRS configuration optimisations
* Exposure of information to the gNB to support RRC state decisions
* Exposure of information to the gNB and/or LPF to identify UEs benefiting from LPHAP enhancements
* Enhancements to the segmentation mechanism for cooperation with LCS messages
* Support of RAT-dependent positioning in RRC\_IDLE

 Intended outcome: Report to next meeting

 Deadline: Long

Rapporteur would like to have the following schedule for this email discussion to have enough time for preparing the summary report.

* Phase 1: Companies are invited to provide inputs and comments to questions by 2022-09-23rd 22:00 UTC
* Phase 2: Rapporteur will provide draft summary with proposals, companies are invited to provide comments to the summary proposals by 2022-09-29th 10:00 UTC.

The remainder of this document is organized as the following. Section 2 provides Rel-18 SID related to LPHAP. Section 3 contains the questionnaire on potential enhancements which are summarized from the contributions submitted to RAN2#119-e. The purpose is to collect the views and identify the commonalties and differences in order to provide proposals for next meeting, i.e. RAN2#119bis-e.

# 2 Rel-18 SID

According to the SID [1], one objective of the R18 expanded and improved NR positioning is:

|  |
| --- |
| * Improved accuracy, integrity, and power efficiency:
	+ Study the requirements on LPHAP as developed by SA1 and evaluate whether existing RAN functionality can support these power consumption and positioning requirements. Based on the evaluation, and, if found beneficial, study potential enhancements to help address any limitations [RAN2, RAN1]
		- Study is limited to a single representative use case (use case 6 as defined TS 22.104). The choice of selected use case can be reviewed at the start of the study.
		- Study is limited to enhancements to RRC\_INACTIVE and/or RRC\_IDLE state.
 |

The required operation time of the 5G enabled IoT device and duty cycle of the updated position information for use case 6 defined in TS 22.104 [2] is shown as follow.

Table A.7.2-1: Low power high accuracy positioning use cases

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Use Case # | Horizontal accuracy | Corresponding service level (22.261) | Positioning interval/ duty cycle | battery life time/ minimum operation time |
| 1 | 10 m | Service Level 1 | on request | 24 months |
| 2 | 2 m to 3 m | Service Level 2 | < 4 seconds | > 6 months |
| 3 | < 1 m | Service Level 3 | no indication | 1 work shift - 8 hours (up to 3 days, 1 month for inventory purposes) |
| 4 | < 1 m | Service Level 3 | 1 second | 6 - 8 years |
| 5 | < 1 m | Service Level 3 | 5 seconds - 15 minutes | 18 months |
| 6 | < 1 m | Service Level 3 | 15 s to 30 s | 6 - 12 months  |
| 7 | 30 cm | Service Level 5 | 250 ms | 18 months |
| 8 | 30 cm | Service Level 5 | 1 second | 6 - 8 years (no strong limitation in battery size) |
| 9 | 10 m | Service Level 1 | 20 minutes | 12 years (@20mJ/position fix) |

# 3 LPHAP Upper Layer Enhancements

## 3.1 Optimized paging and/or RRM measurements

In contribution R2-2207111, R2-2208454 and R2-2208626, optimized paging and/or RRM measurements are proposed on purpose of extending the UE battery life by reducing the listening and/or measurement time of UE.

Considering the limited application scenario of use case 6, for some IoT terminals, there may be no other communication requirements apart from the positioning service. So it may be possible to relax the monitoring time and measurements according to the time characteristic of positioning service.

1. Relax the paging: R2-2207111, R2-2208626
* After receiving the positioning request of deferred 5GC-MT-LR, during the whole deferred MT-LR period, NW may not page UE due to positioning requirement.



Figure 1. Paging optimize method[9]

1. MICO-like mode to RRC-INACTIVE/IDLE state: R2-2208454, R2-2208626
* UE may stop paging monitoring, cell re-selection, RAU and so on. The UE behavior in Mobile Initiated Connection Only (MICO) mode can be taken as baseline.

**Q1-1: Do you agree to study optimized paging and/or RRM measurements for power saving?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Agree/Disagree** | **Comments** |
| Huawei, HiSilicon | Agree | Paging and RRM measurement would be one of the major power consumers of the UE if the objective is to sustain the UE’s operation for one year without changing the UE’s battery. Thus, we think it needs to be studied.  |
| CATT | Agree | Under the limited use case in Rel-18, the paging is appears according to a certain periodic characteristic. By relaxing the paging with the periodic characteristic, the power consumption can be saved. |
| ZTE | Agree | Reducing the paging and RRM measurement can reduce the power of LPHAP UE which is assumed always in RRC\_INACTIVE/RRC IDLE. |
| OPPO | Agree |  |
| Ericsson | Disagree, however pls See comments | We are positioning WI and not power saving. Not sure if we have the expertise to go deeper into this UE power saving techniques.However, we should reuse the work done by UE power saving WI and we could reuse MICO state which is defined already.We can send LS to SA2 asking if for positioning, we can use the MICO state or if they see any issue per se. |
| vivo |  | OK with the intention to optimize paging and/or RRM measurement for power saving. But we think this work is more related to other items, e.g., enhanced eDRX in RRC\_INACTIVE in redcap\_enh. |
| Xiaomi | Disagree |  We think LPHAP should focus on the positioning procedure to reduce UE power consumption.  |
| Intel | Disagree | It is unrelated to positioning itself. We should avoid to introduce a new device type in positioning WI. It would be good to focus on the optimization on positioning itself.  |
| Lenovo | Agree | Support to study paging optimization considering it is one of most straightforward way to reduce power consumption. |
| Nokia | Agree to study | For the use case where workpieces are tracked, we assume each workpiece is attached with a tag (IoT device) that needs to be positioned periodically. For such special purpose IoT devices, there is opportunity to optimize the paging and measurement taking advantage of the specific function they are expected to perform. we understand the concern from companies that LPHAP enhancements should focus on enhancements to positioning procedures/functions and not procedures/functions outside positioning area. However, so far there aren’t sufficient details on the different enhancements. May be after looking at some more details on the enhancements we can decide whether to pursue these under positioning WID or not. |
| Qualcomm | Agree | Fine to study. |
| Spreadtrumcommunications | Disagree | We should focus on positioning procedure related enhancements to reduce UE power consumption.  |
| Sony | Disagree | But relevant to not send another page for positioning purpose if already Deferred MT-LR has been configured, |
| CMCC | Agree | The intention of studying paging or RRM optimization is to achieve the LCS for RRC\_INACTIVE/RRC\_IDLE UEs as well as gain more power saving to meet the up-to-1-year battery requirement.  |
| InterDigital | Disagree | Same understanding with Xiaomi and Intel. We think the focus of the study should be on positioning specific enhancements for LPHAP rather than optimizations to paging and/or RRM measurements. |

**Summary:**

15 companies participated in the discussion. 8/15 companies agree to study optimization on paging and/or RRM measurements for power saving. 6/15 companies hold an opposing attitude. They think this work is more related to power saving WI, we should focus on the enhancement on positioning procedure itself.

The proposal will be put forward after summarizing Q1-2.

**Q1-2: If you agree to study optimized paging and/or RRM measurements, please provide your views on which of the following solutions do you prefer? You are also welcomed to provide: e.g. performance evaluation of the solutions above, or specify the solutions above in detail.**

**a) Relax the paging;**

**b) MICO-like mode to RRC-INACTIVE/IDLE state;**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Solution(s)** | **Comments** |
| Huawei, HiSilicon | a) or b) | Need to understand the difference btw a) and b)From our first impression, a) and b) seem to be the same that the UE does not need to monitor paging once if it is configured by the network to do so. There seem to be no difference. Besides, we also need to consider how RRM measurement can be relaxed based on the service characteristics of LPHAP |
| CATT | a) | For a): UE reports its capability to the network. With knowing the period characteristic of deferred MT-LR event, the network will stop paging the UE in certain duration, and UE can stop monitoring the POs accordingly. This solution has limited impact on the specification.For b): Define a new mode will bring impact to core network as well and it seems complex impacts on specifications. |
| ZTE | none | For a), we wonder whether it is workable to skip all the paging/POs in the time period. Paging may contain SI change or ETWS (Earthquake and Tsunami Warning System) message which should be received by UE immediately.For b), the new mode involves much core network’s enhancement (registration, activation and cancellation)We think relaxed RRM measurement for LPHAP UE should be further studied, for example, reduce/configure the SSB to match the PRS instance. |
| OPPO |  | We are not sure if the assumption of a): ‘apart from the positioning service, there may be no other communication requirements’ is reasonable or not. Does it means that the UE is only for positioning?  |
| Ericsson | b | But we can check with SA2 if there are issues in using this for positioning.To ZTE: The scenario for LPHAP is only for IIOT/factory. Hope these UEs are not regular mobile phones. |
| vivo  | none | To our understanding, the LPHAP UE still needs to support mobility and receiving data from NW, thus the UE shall perform paging monitoring and RRM measurement.RAN2 may ask SA for clarification on the requirement of LPHAP, if needed, e.g., whether the paging and RRM measurement can be skipped for LPHAP. |
| Xiaomi | none |  |
| Intel | None |  |
| Lenovo | a) | For option a), we support paging relax can be studied as an efficient way for power consumption. But how to relax paging, e.g., the specified time duration for paging relax should be discussed in detail.For option b), since MICO mode is requested by UE during the registration procedure, introduction of MICO-like mode may cause additional spec impact which is out of RAN2 scope. Further, the benefit and necessity of MICO-like mode should be confirmed firstly, then we could consider how to implement it in LPHAP if necessary. From our side, seems the power saving gain for introducing such mode can also be achieved by other solutions, e.g., paging relaxing. We didn't see the need to introduce this mode at least now. |
| Nokia |  | Need to discuss first if there is a special UE type, say LPHAP UE and understand the requirements for such UE. We must confirm if these are really positioning-only UEs or if they have other requirements that may rely on full paging capability like a regular UE. |
| Qualcomm | none | For (a), similar view as ZTE. This appears generally not feasible and/or may have huge CN impacts. The "deferred MT-LR period" may generally not be predictable (dependent on event type). Extended DRX seems sufficient for this purpose.For (b), we wonder why a new "MICO-like mode" is required. I.e., the existing MICO feature seems sufficient, which was introduced to enable UE power saving and to enhance MT reachability.  |
| Spreadtrumcommunications | None |  |
| Sony | None | Not clear about the use case |
| CMCC | a) and b) | RAN1 has listed different power states with different operations. For the MICO-like mode, the main point is that some behaviour in RRC-INACTIVE/IDLE may be stopped or relaxed since they are not relevant to positioning procedures, especially when UEs only requesting LCS. Paging and RRM are both worth to be optimized for LPHAP.To Nokia, as an operator, we have received some demands from our industry customer that for some UEs in the factory, positioning is their main functions or even the only function.  |

**Summary:**

14 companies participated in the discussion.

4/14 companies support option a) relax paging. 3/14 companies support option b) introduce MICO-like mode to RRC-INACTIVE/IDLE state.

Within the 7/14 companies oppose to these two candidate solutions, some companies wonder that if there is UE only for positioning and whether the UE has other requirements rely on full paging and/or RRM measurement like a regular UE. They suggest asking SA2 whether the paging and/or RRM can be relaxed or even skipped for the use case of LPHAP.

**Proposal 1: RAN2 to further study optimization on paging and/or RRM measurements for the 6 - 12 months battery life requirement of LPHAP (8/15) including:**

**1. Discuss if there is requirement of positioning-only UEs in LPHAP.**

**2. Discuss the candidate solutions based on the requirement:**

* **a) Relax paging and/or RRM measurement** **through simple negotiation between UE and network. (4/14)**
* **b) Define a new mode for LPHAP with reference to the MICO mode which is used for CM\_IDLE UE at present. (3/14)**
* **c) Extended DRX or reduce/configure the SSB to match the PRS instance. (1/14)**

## 3.2 Enhance DL and/or UL positioning via MT-SDT

In contribution R2-2207083, R2-2207488, R2-2207584 and R2-2208454, enhance positioning via MT-SDT is proposed on purpose of reducing some restrictions of the positioning procedure.

In Rel-17, only MO-SDT was supported in RRC\_INACTIVE positioning. When there is no MO-SDT is initiated by UE, if NW wants to send DL message to UE, NW will trigger the UE transition to RRC\_CONNECTED. This mechanism restricts some procedures, e.g. semi-persistent SRS activation/deactivation and dedicated PRS configuration.

In Rel-18, the Mobile Terminated-Small Data Transmission (MT-SDT) for NR will be supported [3].

|  |
| --- |
| Specify the support for paging-triggered SDT (MT-SDT) [RAN2, RAN3]* MT-SDT triggering mechanism for UEs in RRC\_INACTIVE, supporting RA-SDT and CG-SDT as the UL response;
* MT-SDT procedure for initial DL data reception and subsequent UL/DL data transmissions in RRC\_INACTIVE.

Note: Data transmission in DL within paging message is not in scope of this WI. |

With supporting MT-SDT, the benefits mentioned in these contributions are summarized as:

* The following restriction for semi-persistent SRS activation/deactivation in RRC\_INACTIVE is removed, so that the can be performed timely;

RAN2#117 Agreements:

Proposal 4 (modified): Support the following options for activation of SP-SRSp transmission in RRC INACTIVE:

- Option a: If there is ongoing SDT, the network can send SRS activation command to the UE in INACTIVE.

- Option b: Send the Activation MAC CE along with the SRSp configuration when gNB releases the UE to RRC\_INACTIVE

Proposal 5 (modified): Support the following for deactivation of SP-SRSp transmission in RRC INACTIVE:

- If gNB chooses to send the SP-SRSp deactivation command to the UE in INACTIVE, gNB can send SP-SRSp deactivation command to the UE if there is ongoing SDT.

- If gNB chooses not to send the SP-SRSp deactivation command to the UE in RRC\_INACTIVE, no additional mechanism is specified (i.e. the gNB can only wait for the TA timer to expire)

* Positioning initiated by MT-LR can be supported. NW can flexibly send LCS/LPP messages including LPP assistance data containing dedicated PRS configurations to the UE, without triggering UE transform to RRC\_CONNECTED state.

**Rapporteur’s comments:**

For the first benefit bullet, the possible power consumption is brought by timely SP-SRSp deactivation to avoid unnecessary SRS transmission. For the second benefit bullet, since service types other than ‘Low Power Periodic and Triggered 5GC-MT-LR Procedures’ has not been confirmed to support in Rel-18 LPHAP, it is not a necessary reason to support MT-SDT.

Considering the starting of study on MT-SDT in Rel-18, and the limited benefits for low power requirement of RRC\_INACTIVE positioning foreseen, “support MT-SDT in Rel-18 positioning” can be treated as low priority in SI.

**Q2-1: Do you agree that “support MT-SDT in Rel-18 positioning” is treated as low priority in SI?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Agree/Disagree** | **Comments** |
| Huawei, HiSilicon | Agree | Agree with the comments from the rapporteur. It needs to be better justified how MT-SDT benefits the objectives of LPHAP |
| CATT | Agree | At least for the service type “Low Power Periodic and Triggered 5GC-MT-LR Procedures”, which is already agreed to be considered, the benefit on power consumption brought by MT-SDT and the signalling consumption should be analysed firstly. Since the mechanism of MT-SDT is still not clear, support MT-SDT can be treated as low priority. |
| ZTE | Agree  | If MT-SDT is supported, MT-LR can also be supported for LPHAP UE. However MT-SDT is just beginning, we can leave it to low priority and follow the move |
| OPPO | Agree | Agree to wait for the further progress of the MT-SDT to evaluate the benefit of it towards the LPHAP |
| Ericsson | Agree | There may still be power consumption to monitor the MAC CE deactivation command. So, it is not for free anyways. So, we agree it can be low prio. |
| vivo | Agree |  |
| Xiaomi | Agree |  |
| Intel | Agree | We see the benefit to optimize positioning based on MT-SDT. But we also agree that it would be good to discuss it once Rel-18 MT-SDT is in good shape. It can save our time.  |
| Lenovo | Agree | We agree with rapporteur’s comment. Firstly, considering Rel-18 MT-SDT is still in progress, the support of MT-SDT in Rel-18 positioning may be considered at least when this mechanism has been fully studied and concluded; Secondly, since MT-LR has not been included in Rel-18 LPHAP yet, the reason for introducing the MT-SDT to support MT-LR service is not valid at least for now. It is also preferable for us to treat “support MT-SDT” as low priority in SI.  |
| Nokia | Agree | Agree to de-prioritize. Removing the limitation of no support for MT-SDT is good to have bidirectional unconditional signalling support using SDT but we can wait for MT-SDT support to be agreed first under the SDT work item before we consider positioning enhancements that rely on MT-SDT. |
| Qualcomm | Agree | More progress on MT-SDT work would be required. There may be no/not much impact to LCS/positioning specifications. |
| Spreadtrumcommunications | Agree |  |
| Sony | Agree | Agree to wait and evaluate the progress in MT-SDT Rel-18 study |
| CMCC | Agree |  |
| InterDigital | Disagree | We think there are benefits in terms of power savings by prolonging the UE to operate in INACTIVE state when supporting UL-based and/or DL-based positioning methods along with MT-SDT. As agreed during the last RAN2 meeting, other procedures besides “Low Power Periodic and Triggered 5GC-MT-LR Procedures” are not excluded from consideration. As such, we do not think MT-SDT should be treated with low priority. |
|  |  |  |

**Summary:**

15 companies participated in the discussion. 14/15 agree that support MT-SDT in Rel-18 positioning is treated as low priority in SI, introduce MT-SDT can be considered when this mechanism is fully studied. 1/14 hold an opposing attitude, they think MT-SDT can bring power saving by prolonging the UE to operate in INACTIVE state, and MT-SDT should not be treated as low priority for other procedures are not excluded now.

According to the opinions of most companies, the proposal is given as “support MT-SDT in Rel-18 positioning is treated as low priority in SI”.

**Proposal 2: RAN2 agree that support of MT-SDT in Rel-18 positioning is treated as low priority in SI. (14/15)**

**Q2-2: If you disagree to treat “support MT-SDT in Rel-18 positioning” as low priority, please provide your views on: e.g. potential benefits analysis of this candidate enhancement, or specify the mechanism in detail.**

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| --- | --- | --- |
| **Company name** | **Solution(s)** | **Comments** |
| InterDigital |  | See comments above to Q2-1 |
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**Summary:**

Merged into the summary under Q2-1.

## 3.3 Enhance SRS configuration

In contribution R2-2207083, R2-2207089, R2-2207111, R2-2207390, R2-2207584, R2-2207703, R2-2207912, R2-2208128, R2-2208454 and R2-2208626, serval potential enhancements on SRS configuration are proposed on purpose of reducing the frequency of SRS configuration.

In Rel-17, the SRS configuration is considered as valid under the following criteria [4]:

* The inactivePosSRS-TimeAlignmentTimer is running;
* RSRP increased/decreased within *inactivePosSRS-RSRP-ChangeThreshold*;
* No cell re-selection happened after receiving the configuration.

Obviously, the above mentioned criteria restrict the validity of a configured SRS in very limited scope.



Figure 2. SRS mobility in RRC\_INACTIVE[13]

In Rel-18, for use case 6, the scenario is mainly in factory or industrial park with the positioning requirement of some IoT equipment. The IoT equipment moving in certain range and relatively fixed route, which may span serval cells. Under the mechanism of Rel-17, the SRS configuration may occurs frequently and bring huge signalling overhead together with corresponding energy consumption. To solve this problem, some companies have proposed serval candidate solutions in RAN2#119e, sort as follow:

1. Validity area mechanism: R2-2207083, R2-2207089, R2-2207111, R2-2207390, R2-2207703, R2-2207912, R2-2208128, R2-2208626
* Support area specific SRS along with valid area, that is the configured SRS can be used if the UE is within the valid area. The valid area can cover serval cells.
* R2-2207390 think SRS configurations are valid within a positioning area will waste resources.
* R2-2208078 worry about the interference problem caused by SRS transmission with cross cell mobility.
1. SRS update mechanism: R2-2207083, R2-2208626
* When the UE leaves the valid area and there is an ongoing deferred MT-LR, UE request an updated SRS configuration via SDT and get the updated SRS configuration without entering RRC\_CONNECTED.
1. Pre-configure multiple SRS: R2-2207111, R2-2207584, R2-2208128
* Multiple SRS configuration, which may belong to one or more cells, can be pre-configured to UE by the serving gNB, e.g., by broadcasting in system information.
* R2-2208078 think if configuration is provided in advance, it may not be accurate as UE spatial relation or RSRP.

**Q3-1: Do you agree to study** **enhancements on SRS configuration?**

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| --- | --- | --- |
| **Company name** | **Agree/Disagree** | **Comments** |
| Huawei, HiSilicon | Agree | WE think uplink positioning in RRC\_INACTIVE for UL in R17 provide a baseline solution for INACTIVE positioning, but still have several limitations that need to be addressed to be better fitted with LPHAP. We also acknowledge the benefits of power saving for UL positioning.  |
| CATT | Agree | Considering the mainly application scenario characteristics of use case 6, the criteria for SRS validity judgment in Rel-17 is not optimal for Rel-18. Some enhancements on SRS validity and configurations can be considered for the purpose of power consumption. |
| ZTE | Agree  |  |
| OPPO | Agree | We think to further save the power consumption, when UE leaves the SRS valid area, the network could instruct UE to continue using the SRS, if the network find the UE configured SRS is orthogonal the set of SRS signals configured in the new area. |
| Ericsson | RAN1 and RAN3 should be consulted | Interference can be major problem; if UE is not properly synchronized and power controlled and carries the UL SRS to another cell; it will cause interference which would drastically impact NW capacity.RAN2 cannot study or progress on this before RAN1 discusses and decides if this is feasible. From RAN2 it is only signaling impact as such which if RAN1 acks can be done during WI.This has also RAN3 impacts; since UE moves; the listening node may have to be reconfigured?  |
| vivo | Agree |  |
| Xiaomi | Agree |  |
| Intel | RAN1 and RAN3 should be consulted | We are open on this area. But we share the same view with Ericsson that it will impact both RAN1 and RAN3, and therefore RAN1/RAN3 should be consulted.  |
| Lenovo  | Agree | SRS configuration for RRC\_INACTIVE UE in Rel-17 can be taken as baseline solution for Rel-18 Positioning. However, the solutions in Rel-17 does not consider the low power requirements in positioning, we suggest enhancing the solutions on SRS configuration by taking low power requirements into consideration. |
| Mani | Agree | Agree to study. Any solution for reduction in frequent SRS configuration or updates has good potential for UE power savings. |
| Qualcomm | Agree | The Rel-17 procedures for configuring UL-SRS in RRC\_INACTIVE seem rather suboptimal.  |
| SpreadtrumCommunications | Agree |  |
| Sony | Wait RAN1 | Wait RAN1 progress |
| CMCC | Agree |  |
| InterDigital | Agree |  |
|  |  |  |

**Summary:**

15 companies participated in the discussion. 12/15 agree to study the enhancements on SRS configuration for power saving. The main reason is the limitations of SRS validity in Rel-17 are not optimal for LPHAP. 3/15 proposed the possible problems on interference and changes of spatial relations caused by UE movement, and they suggest consulting RAN1 and RAN3.

The proposal will be put forward after summarizing Q3-2.

**Q3-2: If you agree to study enhancements on SRS configuration, please provide your views on which of the following solutions do you prefer? You are also welcomed to provide: e.g. performance evaluation of the solutions above, or specify the solutions above in detail.**

**a) Validity area mechanism;**

**b) SRS update mechanism;**

**c) Pre-configure multiple SRS;**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Solution(s)** | **Comments** |
| Huawei, HiSIlicon | a), b), and c) | We think a), b) and c) handles different aspects of positioning area for SRS1. Handles the issue of mobility during the positioning session, i.e., when the cell change happens, the positioning procedure does not get interrupted and the UE does not need to request the SRS configuration again. This saves the UE’s power
2. This handles the case when the UE moves out of the defined positioning area and need updated configuration
3. This handles the issue of how the posArea and SRS configuration is given to the UE.
 |
| CATT | a) and c) | For a):A valid area and a valid time can be defined for the area-based SRS. The valid area of an SRS can be defined as a set of cells which can be recommended by LMF. If UE is still in the valid area, LMF will not trigger gNB to assign SRS configuration after receiving event report. For c): One potential solution is to preconfigure some candidate SRS configurations for UE. When needed, NW only send an index to indicate which one to choose. By this way, UE can reduce the power consumption on receiving the huge SRS configuration. We can further study on c) if a) is agreed.For b): we are not sure how it works smoothly together with different receiving gNBs so far. |
| ZTE | a), c) | Pre-configured SRS for multiple cells can reduce the number of state transition. For example, UE’s last serving gNB configures the association between cell list and SRS configuration index, when UE moves to one cell, UE can automatically adopt the corresponding SRS configuration without transmitting to RRC\_CONNECTED or receiving the indication from NW |
| OPPO | 1. and b)
 | Preconfigure multiple SRS will waste lots of SRS resources. The TRP will also need to monitor lots of SRS configurations that are not used in practise.  |
| vivo | b) | For solution b), If the UE reselects another cell different from the cell in which the SRS configuration is received, the UE shall initial RRC resume to the new cell, and then the new cell can get the Requested SRS Transmission Characteristics from the old cell via UE context retrieve. In this way, the new cell may generate one new SRS configuration to the UE with RRCRelease with suspendconfig and the UE can be kept in the RRC\_INACTIVE state. Note that the Requested SRS Transmission Characteristics in UE context retrieve have been specified in Rel-17 by RAN3. It is a simple way to reuse the mechanism to timely update the SRS configuration.For solutions a) and c), the spec impact is significant, especially on RAN3. If solution a) and c) is preferred from RAN2 perspective, RAN2 shall send LS to RAN3 to confirm the feasibility. Besides, how to maintain the TA upon cell reselection is one key issue for options a) and c). If the UE still needs to update the TA by RACH to the new cell, then the benefit of valid area/ pre-configuration is not significant. |
| Xiaomi | a), b) | For a, it can reduce the signalling procedure to acquire the SRS configuration to reduce UE power consumption. For b, when UE moves out the SRS validity area, the UE can request the SRS configuration from gNB directly.   |
| Intel | A, b, c | We should study the gain/pain from each solutions, e.g. how much power we can save from each solution? How complex it will be for a network to support this, etc.  |
| Lenovo | (a), (b) | For option a): current cell-specific SRS configurations are inconsistent with the low power requirement for LPHAP since a moving UE needs to acquire new SRS configurations frequently across the cells. A validity area (e.g., include multiple cells) can be defined in which the SRS configurations are continued to be kept valid when UE moves within the same positioning area. Signalling overhead can be reduced. Associated procedure to define the area and maintain the configuration in the area should be considered in detail.For option b): if option a) is applied, then option b) should be considered to update the configuration when UE moves out of the area, both UE-initiated and NW-initiated update solution could be studied.For option c): the benefits for low power and accuracy requirements for pre-configuration solutions are not so clear.  |
| Mani | A, B and C |  |
| Qualcomm | a), b), c) | All require further studies |
| Spreadtrumcommunications | A and c | Pre-configured SRS for multiple cells can reduce the number of state transition.  |
| CMCC | a), b), c) | We prefer not to preclude potential enhancements at this stage. |
| InterDigital | (a), (b) and (c) | Share similar understanding with Huawei.  |

**Summary:**

13 companies participated in the discussion. The support for these three candidate solutions is summarized as follow:

12/13 companies support a), they think the valid area mechanism can reduce the signalling overhead and power consumption. However as the comments in Q3-1, considering the possible issue of interference and changes of spatial relations caused by UE movement between cross cells, the feasibility of this mechanism may need to be confirmed by RAN1 and RAN3.

10/13 companies support b), this mechanism can handle the case when UE move out of the defined positioning area, UE can get the updated SRS configuration without entering RRC\_CONNECTED.

9/13 companies support c), they think this mechanism can reduce the number of state transition and reduce the UE power consumption. One company hold an opposing attitude, they think preconfigure multiple SRS will waste the SRS resources and TRP have to monitor lots of SRS. Similar to a), this solution may also cause issues of interference and changes of spatial relations, and may need to be confirmed by RAN1 and RAN3.

**Proposal 3: RAN2 agree to study enhancements on SRS configuration (12/15). Further study the following candidate enhancements on SRS configuration, including the possible interference and changes of spatial relations problems.**

* **a) Validity area mechanism; (12/13)**
* **b) SRS update mechanism; (10/13)**
* **c) Pre-configure multiple SRS; (9/13)**

## 3.4 Enhance DL-PRS configuration

In contribution R2-2207083, R2-2207390, R2-2207584, R2-2207703 and R2-2208078, serval potential enhancements on PRS configuration are proposed on purpose of reducing power consumption of receiving PRS and/or state transition. The candidate solutions are sort as follow:

1. Simplified PRS configuration: R2-2207584
* Reduce the number of PRS resource or reduce the receive power of a single PRS resource in RRC\_INACTIVE/RRC\_IDLE for LPHAP UE, e.g. limit the PRS frequency layer to 1, limit the PRS symbol to 1, or reduce the configured TRP number.
1. PRS is configured close to SSBs: R2-2207584
* If the time offset between a PRS and a SSB is within 6 ms, UE will be in micro sleep and doesn’t consume ramp-up/ramp-down power. One way is to configure PRS close to SSB’s time position to reduce state transition power.



Figure 3. Example of PRS and SSB power consumption when different sleep mode applies [13]

1. Limit PRS reception in a time period: R2-2207584
	* Periodic PRSs come from multiple TRPs and may be distributed in different slots with long interval. One way to reduce the number of state transition is to configure PRS reception only in a limited time period, e.g. PRS reception window, so that the power of receiving PRS can be decreased.



Figure 4. Example of PRS reception window in RRC\_INACTIVE/RRC\_IDLE [13]

1. Configuration alignment between PRS and DRX: R2-2207083, R2-2207111, R2-2207390, R2-2207703, R2-2207830, R2-2208078
	* At present, the (e)DRX information applied by UE and the DL-PRS configured by LMF are independent, which will result in misalignment between PRS reception and the DRX period. Considering aligning DRX and PRS configuration will promote the positioning efficient and reduce some energy consumption. (Similar problem is present for SRS transmission in UL positioning.)



Figure 5. DL-PRS configuration and DRX period [9]

**Q4-1: Do you agree to study** **enhancements on DL-PRS configuration?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Agree/Disagree** | **Comments** |
| Huawei, HiSilicon | OK to study, but see comments | For different options listed above, we think that (a) (b) (c) should be discussed in R1 first. (b) This is up to the gNB’s implementation whether SSB and PRS can be sent close to each other(c) Same as (b)(d) paging configurations, such as paging rate/density, DRX cycle are determined by the service requirements, e.g., delay requirements for the UE’s availability. While the PRS configs are determined by the positioning service requirements. Not sure how they can be aligned if the requirements are different.  |
| CATT | Agree | In RRC\_INACTIVE/RRC\_IDLE state, listing and measuring PRS is one of the main sources of power consumption. Enhancement on DL-PRS needs to be discussed.In case of misalignment between PRS reception and the DRX period, UE needs a longer time to detect sufficient quantity of DL-PRS. More seriously, the UE may not detect any DL-PRS with the result of positioning failure. This issue makes the DL positioning procedure at low efficient and low accuracy, and it also brings some unnecessary energy consumption.  |
| ZTE | Agree  |  |
| OPPO | agree | a) seems a LMF implementation issue, given that the LMF knows that UE pursues a LPHAP service.b) seems a gNB implementation issue.c) seems a LMF co-ordination issue. d) seems needs the LMF and gNB co-ordinationIn our opinion, firstly, we need to study and justify the RAN2 impact brought by these 4 candidate solutions, respectively. If any of them is found to have no impact on Uu, it is better to be raised in RAN3. |
| Ericsson | Agree |  |
| vivo | Agree | Benefits are foreseen if the periodicities of PRS measurement and paging monitoring are close or are multiples of each other. |
| Xiaomi | Agree | The options are benefit for UE power saving, but some options may be implementation method. |
| Intel | OK to study, but see comments | A, b, c are definitely in RAN1 scope. Do not see how can RAN2 to discuss this. For d, RAN1 is also discussing whether to introduce new DRX cycle to fix PRS configuration. It would be good to leave the whole discussion in RAN1.  |
| Lenovo | Agree | From RAN1’ solution, evaluations of baseline Rel-17 RRC\_INACTIVE state positioning with the evaluation assumptions agreed for the study show that the power consumption on deep sleep state accounts for the highest proportion in the total power. The alignment between DRX active time and PRS reception/measurement can make UE fall in deep sleep as much as possible in DRX off time. Therefore, for power saving purpose, RAN2 is suggested to study the DRX impact on positioning, The study aspects may include whether or not the DRX configurations depending on the UE’s RRC state/DRX configuration should be shared with the LMF and any associated procedures. This aspect could be studied with high priority. |
| Nokia | See comments | All enhancements listed here, a, b, c and d, need to be studied and decided in RAN1. These needs to be submitted and directly discussed in RAN1. |
| Qualcomm | Agree | O.K. to study, but we wonder what the specification impacts will be. I.e., most features appear to be deployment options which can already be realized with Rel-16.  |
| Spreadtrum Communications | Ok to study, but see comments | A, b and c are in RAN1 scope. For d, we can further study how to align with DRX and PRS configuration. |
| Sony | Agree |  |
| CMCC | Agree | Ok to study, but wait for RAN1’s conclusion. |
| InterDigital | Agree | On (d), there is potential for power savings by reducing the number of wake up instances during the sleep duration/cycles. As such, we think RAN2 should study the mechanisms for aligning DRX with PRS transmissions. On (a), (b) and (c), we share same understanding with Intel and Nokia to leave the discussion to RAN1.  |

**Summary:**

15 companies participated in the discussion. All companies tend to agree that these enhancements on DL-PRS configuration will help reducing the power consumption. However, there are some divergent views on which group is responsible for these enhancements. 9 companies further participated in the discussion of Q4-2. The comments from Q4-2 are also summarized here.

For a) b) c), 10/15 companies think these enhancements are in scope of RAN1 and should be discussed in RAN1 firstly. Some possible specification impacts are also mentioned without detailed description.

For d), serval companies think the alignment of DRX and PRS transmission may relate to RRC state, signalling interaction between UE, NG-RAN and CN, the specification impact should be further identified and discussed. Some companies mentioned RAN1 is also discussing whether to introduce new DRX cycle to fix PRS configuration, they think it would be good to leave the whole discussion in RAN1.

**Proposal 4: RAN2 will study the candidate enhancements on DL-PRS configuration after there is progress in RAN1.**

* **a) Simplified PRS configuration; (2/15)**
* **b) PRS is configured close to SSBs; (2/15)**
* **c) Limit PRS reception in a time period; (3/15)**
* **d) Configuration alignment between PRS and DRX; (9/15)**

**Q4-2: If you agree to study enhancements on DL-PRS configuration, please provide your views on which of the following solutions do you prefer? You are also welcomed to provide: e.g. performance evaluation of the solutions above, or specify the solutions above in detail.**

**a) Simplified PRS configuration;**

**b) PRS is configured close to SSBs;**

**c) Limit PRS reception in a time period;**

**d) Configuration alignment between PRS and DRX;**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Solution(s)** | **Comments** |
| Huawei, HiSilicon |  | See comments above |
| CATT | d) | a), b) and c) need to be discussed and decided by RAN1.For d):LMF may set/recommend configuration alignment between PRS and DRX according to requirement. By this way, UE can finish the measurement on PRS efficiently with lower power consumption. |
| ZTE | 1. b) c) d)
 | All the enhancements are useful for reducing power for LPHAP UE when performing DL/DL+UL positioning. For c), RAN4 already have the agenda to discuss PRS reception window in RRC\_INACTIVE state.  |
| OPPO |  | See comments above |
| Ericsson | d) | Agree with CATT |
| vivo | c) d) | How to align the PRS measurement and paging monitoring is in SA2 and RAN3 scope. The LMF shall indicate the UE to measure the PRS at a specific period/ time window. |
| Xiaomi | d | Agree with CATT. |
| Lenovo | d) | a), b), c) are within RAN1’ scope and can wait for their conclusion.For d), see comments above. |
| Nokia |  | See our comments for Q4-1. |
| Qualcomm | all | All can be studied. See also comments in our response to Q4-1.Specification changes may be required for parts of (a) (e.g., single symbol PRS), or (d) (alignment between PRS and DRX periodicities). |
| Spreadtrum Communications | d | Agree with CATT |
| CMCC |  | See our comments for Q4-1. |
| InterDigital | d | See comments above |

**Summary:**

Merged into the summary under Q4-1.

## 3.5 Event report enhancements

In contribution R2-2207083 and R2-2208626, potential enhancements on event report are proposed. These two contributions proposed to skip the event report step in DL and UL positioning procedure separately to reduce the power consumption. The candidate solutions are sort as follow:

1. Enhance event report in DL positioning procedure: R2-2207083
* R2-2207083 proposed the mechanism that if the difference between the two successive measurement results/location estimates is less than a certain threshold, UE report an indication or even skip the report to indicate NW the measurement result is almost unchanged.



Figure 6: Low Power Periodic and Triggered 5GC-MT-LR Procedure with SDT (DL-only and RAT-Independent positioning). [5]

1. Enhance event report in UL positioning procedure: R2-2208626
* In Rel-17, whenever an event is triggered in the deferred MT-LR, the UE needs to send event report to the network. Considering the positioning service is generally fixed and pre-determined for LPHAP, there is no need to use event report to trigger UL positioning.



Figure 7: Low Power Periodic and Triggered 5GC-MT-LR Procedure with SDT (UL-only positioning). [5]

**Q5-1: Do you agree to study** **enhancements on event report?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Agree/Disagree** | **Comments** |
| Huawei, HiSilicon | Agree | We think it is beneficial to study the role of event report in UL positioning, and whether it is needed. in the uplink positioning methods, UE does not need to send measurement results to the LMF. While, in order to send event report, the UE would need to support SDT in RRC\_INACTIVE. This would also complicate the UE’s implementation, or increase the UE’s cost for LPHAP |
| CATT | Agree | When the positioning service is fixed and LPHAP is informed in advance, maybe the event report can be omitted to save the effort in UE. |
| ZTE | agree |  |
| OPPO | Neds to be further clarified | Regarding a), currently, motion event is specified in 23.273, as follows: **Motion: An event where the UE moves by more than some predefined straight line distance from a previous location**.We think this event implies using the delta of the location measurement result to evaluate whether or not the UE should send event report towards the UE. Otherwise how to justify if the movement has been more than some predefined straight line distance? Therefore, we wonder what is difference between the proposed method with the motion event that has been already definedWe have similar concern on b). It seems that the Motion Event applies to UL positioning also. Only when the UE moves by more than some predefined straight line distance from a previous location, the UE will trigger the event report. It seems that current spec can already enable UE to report necessary event.  |
| Ericsson | SA2 Study? | Event Report as such is LCS msg; it should be studied by SA2?  |
| vivo | Agree |  |
| Xiaomi | Agree |  |
| Intel | SA2 Study? | Agree with Ericsson that it should be studied by SA2. In addition, A, do not see what can be saved if the UE still needs to send an indication instead of the whole measurement results. B, seems a network implementation; |
| Lenovo | Agree | Reduced signalling overhead in some extent, may benefit LPHAP. |
| Nokia |  | For the agreed use case, periodic positioning is more suited i.e., for tracking of workpieces. So, one could study to see if deferred location procedures can be streamlined for periodic positioning and avoid any overhead from event triggered positioning. However, we agree with others who point out this may be a SA2 area of study. It can be taken up in SA2. |
| Qualcomm | Agree | Fine to study. |
| Spreadtrum Communications | Agree |  |
| CMCC | Agree |  |
| InterDigital | Agree |  |
|  |  |  |

**Summary:**

14 companies participated in the discussion. 10/14 companies agree to study enhancements on event report. 3/14 companies think event report is a LCS message, and the enhancement is in scope of SA2.

The proposal will be put forward after summarizing Q5-2.

**Q5-2: If you agree to study enhancements on event report, please provide your views on which of the following solutions do you prefer? You are also welcomed to provide: e.g. performance evaluation of the solutions above, or specify the solutions above in detail.**

**a) Enhance event report in DL positioning procedure;**

**b) Enhance event report in UL positioning procedure;**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Solution(s)** | **Comments** |
| Huawei, HiSIlicon | b) | We would like to discuss whether the legacy event report is still needed in UL positioning procedure or in order to better enable UL positioning, whether the current event report can be enhanced |
| CATT | b) | For a):The mechanism can be covered by the event type “Motion” which is already defined for deferred location request in 23.273 section 4.1a.5.1.For b):When the event report is omitted, in procedure of UL positioning, UE only needs to send SRS ideally. By this way, the power consumption can be reduced. The conditions when the event report can be omitted need to be study further. |
| ZTE | b | It seems event report in UL positioning in deferred MT-LR can be omitted to save power, and without no functional broken |
| OPPO | B if majority agrees |  |
| vivo | a) b) | For a), In case of motion event reporting, the UE shall be aware of its location estimate, thus only UE-based DL positioning is supported. For UE-assisted DL positioning, the measurement can be further optimized.For b), the event report is used to update the SRS configuration when it turns invalid. But if the SRS configuration is still valid, it is a simple way to reduce power consumption by omitting unnecessary event reports. SA2 shall be involved to confirm the feasibility. |
| Xiaomi | b | For the UL positioning, if the SRS is still valid, there is no need to send event report to acquire the new SRS configuration. |
| Lenovo | a), b) | The difference between event report in DL and UL positioning procedure is that the event report in DL positioning also carry UE measurement report while UL positioning not. For solutions to option a), we think it is also related to the location information reporting optimization. We suggest distinguishing the event report and location information report enhancement to avoid confusion. Regarding to location information reporting enhancement, e.g., do not report duplicate results or indication report only can be studied as a separate issue. While for event report enhancements, we think the study should focus on whether legacy event report for both UL/DL can be omitted/skipped and associated conditions if necessary.  |
| Qualcomm | none | An Event Report is provided by the UE to inform the LMF that the configured event type has occurred (e.g., area, periodic, motion events), or when the maximum reporting interval timer expired (without event). There may also be "One Time Events" or "Multiple Time Events" being configured. Therefore "skipping event reports" seems generally not feasible.  |
| CMCC | b |  |
| InterDigital | (a), (b) | For a), enhancements for deciding whether the measurement reports can be skipped for DL-based UE-assisted positioning can be considered.For b), whether/how UL-based positioning procedure in INACTIVE may be impacted when skipping event report should be discussed.  |
|  |  |  |
|  |  |  |

**Summary:**

10 companies participated in the discussion.

9/10 companies support enhance event report in UL positioning procedure. They think in UL positioning event report is used to update the SRS configuration, if SRS is still valid, there is no need to send event report.

3/10 companies support enhance event report in DL positioning procedure. One company suggest distinguishing the event report and location information report enhancement to avoid confusion.

1/10 company support neither of these two solutions, they think the event report has the function of inform LMF of the occurrence event type, so skipping event reports seems generally not feasible.

Since event report is an LCS message used to inform the LMF, omit the event report may cause some influence to CN. Hence, the rapporteur proposes:

**Proposal 5: RAN2 agree to study enhancements on event report (10/14). Further discuss the use case and the associated conditions when the legacy event report can be omitted/skipped in UL/DL positioning procedure, e.g. the positioning event is periodic and time determined event in deferred MT-LR, and send an LS to SA2 if there is progress.**

## 3.6 Exposure of information to the gNB to support RRC state decisions

In contribution R2-2208128, exposure of information to the gNB to support RRC state decisions is discussed.

The AMF may provide the NG-RAN node with expected UE behavior/activity to assist the NG-RAN node with the RRC\_INACTIVE state transition. In case of UE configured with deferred MT-LR, the UE reporting activity – in particular for periodic events – is rather predictable. The UE reporting activity is determined by the IEs periodicLocation, areaEventReporting, or motionEventReporting, which can be considered by the AMF when determining assistance send to gNB. The NG-RAN node may use this information together with the UE capability for RRC\_INACTIVE positioning and SDT-SRB2 to decide on a suitable RRC state.



Figure 8: Initiation of Deferred MT-LR. [18]

**Rapporteur’s comments:**

This issue seems mainly related to the signalling interaction between NG-RAN and AMF which is out of RAN2’s scope.

**Q6-1: Do you agree to study enhancements on “exposure of information to the gNB to support RRC state decisions”?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Agree/Disagree** | **Comments** |
| Huawei, HiSilicon | Agree | May further discuss whether the assistance is between gNB and AMF or gNB and LMF |
| CATT |  | This issue can be discussed in RAN3. |
| ZTE |  | Agree with CATT. We see no RAN2 impact |
| OPPO |  | Agree with Rapporteur that it is out of RAN2 scope |
| Ericsson | RAN3 Study | Agree with CATT; out of RAN2 scope |
| vivo | Already supported? | Agree with the above. And RAN3 has introduced the UE Reporting Information in Rel-17, which included Reporting Amount and interval. The gNB can take this info into account for UE RRC state transition. |
| Xiaomi |  | It is up to RAN3 and have the same view with vivo that it already supported. |
| Intel |  | This can be combined with 3.7, i.e. the information can be LPHAP identification or capability.  |
| Lenovo |  | Based on the signalling impact of Figure 8, this issue is out of RAN2’ s scope. We also wonder about the benefits of the AMF to recommend a RRC state transition without involving the LMF. |
| Nokia |  | Out of scope of RAN2. |
| Qualcomm | Agree | There may be no RAN2 impacts (other than Stage 2), but this applies to many enhancements being discussed here as well, e.g., MICO/paging enhancements, enhance DL-PRS configuration, Event Report enhancements, etc. We think RAN2 could still discuss/evaluate and inform other WGs on RAN2 findings and potential enhancements should be captured in the TR. RAN2 is still the responsible group for 38.305. |
| Spreadtrum Communications |  | Out of scope of RAN2. |
| CMCC |  | Agree with CATT.  |
|  |  |  |

**Summary:**

13 companies participated in the discussion. 10/13 companies think there is no RAN2 impact and should be studied by RAN3. 3/10 companies prefer to further study the possible impact.

Since most companies hold an opposing attitude and there is no strong supporting reason, the rapporteur suggests closing the discussion.

## 3.7 Exposure of information to the gNB and/or LMF to identify UEs benefiting from LPHAP enhancements

In contribution R2-2207083, R2-2207390 and R2-2207584, exposure information to the gNB and/or LMF to identify UEs benefiting from LPHAP enhancements is proposed.

In case of LPHAP, in order to reduce power consumption, the network may need to relax some configuration. In consequence, it is necessary for the network to know whether the UE is a LPHAP UE. R2-2207584 proposed the following three candidate solutions:

1. RedCap-like solution:
* RedCap UE supports early indication via Msg1/Msg3. After gNB identifies the early indication, gNB send an indication to core network to inform this is a RedCap UE in the initial UE message.
* However they think LPHAP UE can be seen as normal UE during initial access procedure, it is unnecessary to report to NW at that time which may cause negative impact on the system performance of the cell.
1. Direct-to-LMF solution:
* UE capability indicates it is a LPHAP UE, and is directly sent to LMF via LPP message.
1. Direct-to-gNB solution:
* UE capability signaling indicates it is a LPHAP UE, and is directly sent to serving gNB via RRC message.

**Q7-1: Do you agree to study** **enhancements on “Exposure of information to the gNB and/or LMF to identify UEs benefiting from LPHAP enhancements”?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Agree/Disagree** | **Comments** |
| Huawei, HiSilicon | Agree | We are open to discuss a definition of new UE type of LPHAP UE. But, we need to understand why this needs special discussion, if this is about the RRC/LPP/NAS capability. If this is the case, this can be discussed during the WI phaseSA2 is also discussing this issue. See key issue #12 in TR 23700-71 and the solutions for this key issue |
| CATT | Agree | It is necessary for gNB and/or LMF to know if the UE is an LPHAP UE or not in the LPHAP use case. By this way, the NW will enhance the configuration of reference signal and/or perform some other enhancements to reduce the power consumption. |
| ZTE | Agree | The prerequisite of all the power-saving configuration is that NW needs to know the UE is a LPHAP UE requiring low power operation. |
| OPPO | Disagree | Agree with Huawei. Capability related aspects should be discussed in WI stage. |
| Ericsson | Agree |  |
| vivo | Agree | Different from the INACTIVE positioning in Rel-17, the LMF shall be aware of the requirement of LPHAP to optimize the configuration. |
| Xiaomi | Agree |  |
| Intel | Agree | This is the simplest way to let the network handle LPHAP properly. We think b and c are simple solutions.  |
| Lenovo | Agree | We understood that the purpose for exposure the LPHAP information to gNB or LMF is to let network know some enhancements for power saving mentioned by other bullets need to be performed, e.g., relax some configuration or perform alignment between DRX and Positioning if adopted. Therefore, there is some sort of coordination required between NG-RAN and LMF and such LPHAP capability indication is a first step of the process.  |
| Nokia | See comments | If SA2 is also studying this, then leave it to SA2. Don’t do parallel discussions in two WGs. Need for such capability signalling can also be decided during WID phase as Huawei says. |
| Qualcomm | Disagree | This seems "normal" capability exchange and should not require a study. There exists no "LPHAP UE"; there may be UEs supporting certain new Rel-18 features. |
| Spreadtrum Communications | Agree |  |
| CMCC | Agree |  |
| InterDigital | Agree |  |

**Summary:**

14 companies participated in the discussion. All company tend to agree that the network need to know the UE is for LPHAP. However, there are some divergent views on whether to discuss this issue in RAN2 or SA2, in SI stage or WI stage. 14 companies further participated in the discussion of Q7-2. The comments from Q7-2 are also summarized here.

Within the three candidate solutions, 7/14 companies think b) and c) are simply ways to let the network handle LPHAP properly, whether to adopt solution b) or c) or both depends on which enhancements will be adopted finally.

4/14 companies think this seems normal capability exchange which should be discussed in WI stage. 5/14 companies think SA2 is also discussing this topic, so it can be leave to SA2. After checking TR 23700-71, there is only one candidate solution #26 which defines a new UE type in SA2. However all the candidate solutions discussed in RAN2 are related to information between UE and gNB/LMF (solution a,b,c) with the influence on RRC and/or LPP message, which cannot be covered by the discussion in SA2.

**Proposal 6: RAN2 to agree exposure information from UE to gNB and/or LMF, e.g. indication for LPHAP scenario (10/14). Further discuss if the solution e.g. capability as the indication should be discussed in SI or WI.**

**Q7-2: If you agree to study the enhancement in Q7-1, please provide your views on which of the following solutions do you prefer? You are also welcomed to provide: e.g. performance evaluation of the solutions above, or specify the solutions above in detail.**

**a) RedCap-like solution;**

**b) Direct-to-LMF solution;**

**c) Direct-to-gNB solution;**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Solution(s)** | **Comments** |
| Huawei, HiSilicon |  | See the comments above |
| CATT | b) | Whether to adopt solution b) or c) or both depends on which enhancements will be adopted finally. These issue can be studied later, at least when the potential enhancements are determined. |
| ZTE | B or c | Agree with CATT that b and c are both possible and it depends on the solutions.  |
| OPPO |  | See the comments above |
| Ericsson | b |  |
| vivo |  | Depends on the solution in the SA2 comment by HW. Besides, the info can be added to location request from AMF to LMF |
| Xiaomi |  | SA2 already discussed the solutions. So suggest to wait the conclusion from SA2. |
| Intel | B, c | This is the simplest way to let the network handle LPHAP properly. We think b and c are simple solutions.  |
| Lenovo | b), c) | Both b) and c) can be considered, depends on the entity to perform the enhancements. |
| Nokia |  | See our comments to Q7-1. |
| Qualcomm | none | See comments in our response to Question Q7-1. |
| Spreadtrum Communications |  | Suggest to wait for SA2 conclusion. |
| CMCC | b or c | Depend on the adopted enhancement. |
| InterDigital | (b), (c) |  |

**Summary:**

Merged into the summary under Q7-1.

## 3.8 Enhancements to the segmentation mechanism for cooperation with LCS messages

In contribution R2-2208128, enhancements to the segmentation mechanism for cooperation with LCS messages is discussed.

In the case of an LCS Event Report with embedded LPP message and with LPP message segmentation required, the NAS transport container types would be different for the first LCS Event Report with embedded LPP message segment and all the subsequent LPP message segments. It is currently unclear if such a scenario is "allowed" in the specifications and whether an LMF would be able to handle such a case. They proposed a candidate solution:

* Although UE triggered LPP message is currently not defined, considering UE have the Deferred Routing Identifier, the Additional Information IE of the UL NAS Transport message can be used.
* The LMF would realize from the LPP message in the LCS Event Report that more LPP message segments are on the way and would have to wait for all LPP segments before sending the LCS Event Report Acknowledgement, so the UE knows the LMF received all the LPP message segments.



Figure 9: DL and RAT-Independent Event Reporting with LPP message segmentation.[18]

**Q8-1: Do you agree to study “Enhancements to the segmentation mechanism for cooperation with LCS messages”?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Agree/Disagree** | **Comments** |
| Huawei, HiSilicon | Agree, but can be discussed in SA2 | This has been discussed briefly during R17. We think that the main discussion should be done in SA2, but we also think it is beneficial to discuss.  |
| CATT | Agree | We suggest further study the benefit. |
| ZTE | Agree but | Agree with HW that this issue should be done in SA2 |
| OPPO | Agree |  |
| Ericsson | SA2 Study |  |
| vivo |  | Can be contribution driven in SA2 |
| Xiaomi |  | It can be discussed in SA2. |
| Intel | Disagree | Is this really related to LPHAP? This should be discussed in TEI17 if needed. Also agree to let SA2 discuss this first (contribution driven) |
| Lenovo |  | Seems more related with SA2 |
| Mani | Disagree | This is out of scope of RAN2 given that the signalling enhancement involved is between NG-RAN and AMF. |
| Qualcomm | Agree | Similar to our response to Q6-1, there should be no RAN2 impacts (other than Stage 2), but RAN2 could still discuss/evaluate and inform other WGs on RAN2 findings and potential enhancements. SA2 may not be familiar with this issue. On the LPHAP relation, well, if not supported the UE would have to transition to RRC\_CONNECTED state for Event Reporting, which adds to the power consumption and is unnecessary. |
| Spreadtrum Communications | Agree but | Agree with HW that this issue should be done in SA2 |
| CMCC | Agree | Up to SA2. |

**Summary:**

13 companies participated in the discussion. 10/13 companies think this issue is out of RAN2 scope and should be studied by SA2, the rapporteur suggests closing the discussion.

## 3.9 Support of RAT-dependent positioning in RRC\_IDLE

Positioning in RRC\_IDLE state is analyzed and discussed with the following topics.

### 3.9.1 DL positioning

Reference to the outcome of Rel-17 SI on RRC\_IDLE: [6]

|  |
| --- |
| 10.9 DL positioning measurement in RRC\_IDLE stateFrom a physical layer perspective, it is feasible for a UE to perform DL positioning measurement in RRC\_IDLE state.- Note: This does not imply that measurements have to be reported in RRC\_IDLE state.The following procedures are considered as feasible for DL positioning methods in RRC\_IDLE:- Reporting of DL-PRS measurement and/or location estimate performed in RRC\_IDLE when the UE is in RRC\_INACTIVE/RRC\_CONNETED.NOTE: The following procedures are considered to have already been supported and can be reused for positioning in RRC\_IDLE- On-demand SI request in RRC\_IDLE for assistance data delivery by broadcast in RRC\_IDLE*- ProvideAssistanceData* can be sent in RRC\_CONNECTED for DL-PRS configuration used in RRC\_IDLE downlink positioning*- RequestLocationInformation* can be sent in RRC\_CONNECTED for DL-PRS measurement and/or location estimate performed in RRC\_IDLE |

At least we can determine that UE can perform PRS measurement in IDLE mode. What we need to study is whether there is feasible DL positioning procedure in RRC\_IDLE state.

In contribution R2-2207083, R2-2207089, R2-2207111, R2-2207390, R2-2207488, R2-2207703, R2-2207912, R2-2208078, the DL positioning in RRC\_IDLE state is analyzed. Several key issues together with some potential directions are summarized as follow:

1. How to configure assistance date to UE in RRC\_IDLE?
2. Via broadcast signalling: R2-2207390, R2-2207703, R2-2208078
3. Pre-configuration: R2-2207390, R2-2207703
4. How to report the positioning measurement?
5. legacy RACH procedure: R2-2207703, R2-2207488
6. legacy PUR design as baseline: R2-2207703
7. measurement in IDLE and report in CONNECTED: R2-2207083, R2-2207089, R2-2208078, R2-2207912
8. The AS context/security problem in RRC\_IDLE;

**Q9-1: Do you agree to study DL** **positioning in RRC\_IDLE?**

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| --- | --- | --- |
| **Company name** | **Agree/Disagree** | **Comments** |
| Huawei, HiSilicon | Disagree | The study is not quite aligned with the objectives of LPHAP. 1/ The main issue is how to report the measurement results to the network. One option is to transit to the connected mode for reporting, but this is not beneficial for power saving2/ R18 does not support MO-SDT in RRC\_IDLE |
| CATT | Agree | We agree to study DL positioning in RRC\_IDLE state at least for deferred MT-LR service type.  |
| ZTE | Agree |  |
| OPPO | Agree |  |
| Ericsson | Agree |  |
| vivo | Agree |  |
| Xiaomi | Agree |  |
| Intel | Agree | As mentioned by Rapporteur, we need to study whether there is feasible DL positioning procedure in RRC\_IDLE state, esp, whether existing procedure can support a UE to send the measurement performed in IDLE when moves to CONNECTED mode.  |
| Lenovo | Agree | RAN1 has confirmed it is feasible for a UE to perform DL positioning measurement in RRC\_IDLE state. RAN2 is suggested to study DL Positioning in RRC\_IDLE state in R18 SID scope. |
| Nokia | Disagree | If MO-SDT is not supported in RRC\_IDLE and if the only way is to transition to RRC\_CONNECTED to report the measurements, then we agree with Huawei comments. Also, this enhancement seems like a general introduction of positioning in IDLE as opposed to looking at power savings for LPHAP. |
| Qualcomm | Agree | Fine to study. |
| Spreadtrum Communications | Agree | Agree to treat it as low priority. |
| Sony | Agree |  |
| CMCC | Agree |  |
| InterDigital | Agree |  |

**Summary:**

Merged into the summary under Q9-2.

**Q9-2: If you agree to study DL** **positioning in RRC\_IDLE, please provide your views on: e.g. analysis on the related open issues, or specify the potential solutions in detail.**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Solution(s)** | **Comments** |
| CATT |  | For the concern on AS context/security, SA2 should be involved in this feature. |
| ZTE |  | Suggest to study measurement report in RRC\_IDLE  |
| OPPO |  | Study send DL-PRS configuration towards the UE for the RRC\_Idle positioning, bearing in the mind that AS context cannot be maintained in the RRC\_Idle state.  |
| Ericsson |  | One can also reduce power in DL by being able to perform measurement in RRC Idle. RAN1 should define RSTD measurements also for RRC Idle mode. Then AD can be configured as in legacy using:1. Via broadcast signalling:
2. Pre-configuration:

The UE may consume the position itself if UE based then there is no need to report which can also save power. Otherwise UE can transit to connected mode. |
| vivo |  | UE may perform PRS measurement in RRC\_IDLE and feedback measurement report when UE enters RRC\_CONNECTED. |
| Xiaomi |  | UE performs PRS measurement in RRC IDLE and sends measurement after UE transmitting to RRC CONNECTED. |
| Intel | How to report the positioning measurement? | As mentioned in [10], Proposal 2a: RAN2 to discuss whether the positioning in RRC\_IDLE is supported or not based on existing methods, i.e. whether the CN can handle the measurement reports from the UE in RRC\_CONNECTED, while the positioning was performed in RRC\_IDLE for MO-LR, MT-LR and NI-LR.Proposal 2b: RAN2 to send LS to SA2, to check whether the CN can handle the measurement reports from the UE in RRC\_CONNECTED, while the positioning was performed in RRC\_IDLE for MO-LR, MT-LR and NI-LR.  |
| Lenovo |  | The solutions to support positioning in RRC\_IDLE state can take the solutions for positioning in RRC\_INACTIVE state in R17 as baseline in some extent. 1) For positioning assistance delivery, consider reuse the solution that delivered by broadcasting of positioning system information, i.e., PosSIB.2) For positioning measurement report, legacy RACH procedure can be enhanced for PRS measurement reporting. |
| InterDigital |  | We think the focus should be on measurement reporting in IDLE. On this, enhancements to RACH procedure can be considered for carrying measurement reports/location estimates with initial access messages.  |
|  |  |  |
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**Summary:**

15 companies participated in the discussion of Q9-1. 13/15 companies agree to study DL positioning in RRC\_IDLE. 2/15 companies hold an opposing attitude, they think without MO-SDT in RRC\_IDLE, UE has to transit to RRC\_CONNECTED to report measurements, which is not beneficial for power saving.

9 companies further participated in the discussion of Q9-2. Some candidate solutions are proposed on how to configure DL-PRS and how to report the measurement. For how to configure DL-PRS, some companies proposed to pre-configure or broadcast, there seems no further divergence on this issue. However, for the issue of how to report the measurements, there are still some concerns on these candidate solutions, which are summarized as follow:

a) Measurement is performed in IDLE and reported in CONNECTED;

* Whether the mechanism of measurement in IDLE and report in CONNECTED is more beneficial for power saving than legacy mechanism, i.e. RRC\_INACTIVE positioning.
* Whether the CN can handle the measurement reports from the UE in RRC\_CONNECTED, while the positioning was performed in RRC\_IDLE for MO-LR, MT-LR and NI-LR.

b) When measurement is carried with initial access messages;

* Is there AS context/security issue on sending the measurements to LMF?

Summarized from the comments under Q9-1 and Q9-2, the rapporteur proposes:

**Proposal 7: RAN2 agree to study DL positioning in RRC\_IDLE (13/15) including:**

**1. Agree to provide AD for DL positioning in RRC\_IDLE as in legacy using: via a broadcast signaling or pre-configuration.**

**2. Further discuss the two candidate solutions on how to report measurements as below:**

**Alt1: measurement is performed in IDLE and reported in CONNECTED, including the concerns:**

* **Whether the mechanism of measurement in IDLE and report in CONNECTED is more beneficial for power saving than legacy mechanism, i.e. RRC\_INACTIVE positioning.**
* **Whether the CN can handle the measurement reports from the UE in RRC\_CONNECTED, while the positioning was performed in RRC\_IDLE for MO-LR, MT-LR and NI-LR.**

**Alt2: measurement is performed in IDLE and report is carried with initial access messages, including the concern:**

* **Is there AS context/security issue on sending the measurements to LMF?**

### 3.9.2 UL positioning

In contribution R2-2207083, R2-2207089, R2-2207111, R2-2207488 and R2-2207703, the UL positioning in RRC\_IDLE state is analyzed with several key issues summarized as follow:

* Reference signal selection, e.g., SRS or PRACH;
* How to configure reference signal to UE in RRC\_IDLE;
* How to maintain the UL sync in RRC\_IDLE;
* The AS context/security problem in RRC\_IDLE;

**Q9-3: Do you agree to study UL** **positioning in RRC\_IDLE?**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Agree/Disagree** | **Comments** |
| Huawei, HiSIlicon | Disagree | The main issue is that there is no AS security in RRC\_IDLE. But the UE needs AS security in order to perform SRS transmission.  |
| CATT | Agree | We agree to study UL positioning in RRC\_IDLE state at least for deferred MT-LR service type. |
| ZTE | disagree | First issue is whether SRS can be transmitted in RRC\_IDLE. For the solution of PRACH based positioning, it lacks of accuracy due to the time configuration/power. Suggest to treat UL positioning in RRC\_IDLE as low priority |
| OPPO | Agree | Needs to confirm the feasibility of UL transmission with RAN4 at first.  |
| Ericsson | Disagree | Agree with Huawei and ZTE. |
| vivo |  | Can be low priority, further progress based on RAN1 evaluation. |
| Xiaomi |  | Agree to treat it as low priority. |
| Intel |  | We consider RAN1 is the right group on these issues. |
| Lenovo | Agree | Share the same view with CATT, agree to study UL positioning in RRC\_IDLE state at least for deferred MT-LR service type. |
| Nokia | Disagree | This enhancement seems like a general introduction of positioning in IDLE as opposed to looking at power savings for LPHAP |
| Qualcomm | disagree | Similar view as ZTE. We don't think this is feasible and/or needed. The power consumptions come from the UL-SRS transmission and this is the same in all RRC states. |
| Spreadturm Communications | Disagree | Agree with Huawei and ZTE. |
| CMCC | Agree |  |
| InterDigital | Agree |  |

**Summary:**

14 companies participated in the discussion.

5/14 companies agree to study UL positioning in RRC\_IDLE, 4 of them further participated in the discussion of Q9-4 and proposed some open issues which need to be further studied. 6/14 companies hold an opposing attitude. They have some concerns on the feasibility of UL positioning in RRC\_IDLE. 3/14 companies think this topic need to be evaluated by RAN1, and can be treated as low priority.

For UL positioning in RRC\_IDLE, whether supported or not, the issue raised by these companies are mainly focused on the following aspects:

* The beneficial for power saving of support UL positioning in RRC\_IDLE state;
* Whether UE can send SRS in RRC\_IDLE state, considering capability and/or AS security problem;
* The accuracy of PRACH based positioning;

**Proposal 8: RAN2 to further discuss whether to study UL positioning in RRC\_IDLE (5/14) including the following issues:**

* **The beneficial for power saving of support UL positioning in RRC\_IDLE state;**
* **Whether UE can send SRS in RRC\_IDLE state, considering capability and/or AS security problem;**
* **The accuracy of PRACH based positioning;**

**Q9-4: If you agree to study UL** **positioning in RRC\_IDLE, please provide your views on: e.g. analysis on the related open issues, or specify the potential solutions in detail.**

|  |  |  |
| --- | --- | --- |
| **Company name** | **Solution(s)** | **Comments** |
| CATT |  | For the issue of reference signal selection, we wonder whether UE can send SRS in RRC\_IDLE state.For the concern on AS context/security, SA2 should be involved in this feature. |
| OPPO |  | Suggest study how to configure the SRS configuration towards in the RRC\_Idle state, bearing in the mind that AS context cannot be maintained in the RRC\_Idle state. |
| Lenovo |  | For reference signal selection, no problem is identified to transmit the SRS in RRC\_IDLE state from RAN1’s perspective as long as SRS configuration is valid. So RAN2 may need to focus on the issues of SRS configuration, and TA maintenance in RRC\_IDLE state. For AS context/security problem in RRC\_IDLE, we can check with SA3 in time if necessary. |
| InterDigital |  | For addressing the AS context/security issue, we think usage of RACH resources for UL positioning can be considered. Other issues related to contention resolution when using RACH-based positioning can be further studied.  |
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**Summary:**

Merged into the summary under Q9-3.

# 4 Conclusion

Based on company feedback, the following is observed and proposed:

**Proposal 1: RAN2 to further study optimization on paging and/or RRM measurements for the 6 - 12 months battery life requirement of LPHAP (8/15) including:**

**1. Discuss if there is requirement of positioning-only UEs in LPHAP.**

**2. Discuss the candidate solutions based on the requirement:**

* **a) Relax paging and/or RRM measurement** **through simple negotiation between UE and network. (4/14)**
* **b) Define a new mode for LPHAP with reference to the MICO mode which is used for CM\_IDLE UE at present. (3/14)**
* **c) Extended DRX or reduce/configure the SSB to match the PRS instance. (1/14)**

**Proposal 2: RAN2 agree that support of MT-SDT in Rel-18 positioning is treated as low priority in SI. (14/15)**

**Proposal 3: RAN2 agree to study enhancements on SRS configuration (12/15). Further study the following candidate enhancements on SRS configuration, including the possible interference and changes of spatial relations problems.**

* **a) Validity area mechanism; (12/13)**
* **b) SRS update mechanism; (10/13)**
* **c) Pre-configure multiple SRS; (9/13)**

**Proposal 4: RAN2 will study the candidate enhancements on DL-PRS configuration after there is progress in RAN1.**

* **a) Simplified PRS configuration; (2/15)**
* **b) PRS is configured close to SSBs; (2/15)**
* **c) Limit PRS reception in a time period; (3/15)**
* **d) Configuration alignment between PRS and DRX; (9/15)**

**Proposal 5: RAN2 agree to study enhancements on event report (10/14). Further discuss the use case and the associated conditions when the legacy event report can be omitted/skipped in UL/DL positioning procedure, e.g. the positioning event is periodic and time determined event in deferred MT-LR, and send an LS to SA2 if there is progress.**

**Proposal 6: RAN2 to agree exposure information from UE to gNB and/or LMF, e.g. indication for LPHAP scenario (10/14). Further discuss if the solution e.g. capability as the indication should be discussed in SI or WI.**

**Proposal 7: RAN2 agree to study DL positioning in RRC\_IDLE (13/15) including:**

**1. Agree to provide AD for DL positioning in RRC\_IDLE as in legacy using: via a broadcast signaling or pre-configuration.**

**2. Further discuss the two candidate solutions on how to report measurements as below:**

**Alt1: measurement is performed in IDLE and reported in CONNECTED, including the concerns:**

* **Whether the mechanism of measurement in IDLE and report in CONNECTED is more beneficial for power saving than legacy mechanism, i.e. RRC\_INACTIVE positioning.**
* **Whether the CN can handle the measurement reports from the UE in RRC\_CONNECTED, while the positioning was performed in RRC\_IDLE for MO-LR, MT-LR and NI-LR.**

**Alt2: measurement is performed in IDLE and report is carried with initial access messages, including the concern:**

* **Is there AS context/security issue on sending the measurements to LMF?**

**Proposal 8: RAN2 to further discuss whether to study UL positioning in RRC\_IDLE (5/14) including the following issues:**

* **The beneficial for power saving of support UL positioning in RRC\_IDLE state;**
* **Whether UE can send SRS in RRC\_IDLE state, considering capability and/or AS security problem;**
* **The accuracy of PRACH based positioning;**

# 5 References

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2. TS 22.104 Service requirements for cyber-physical control applications in vertical domains.
3. RP-213583 New WI: Mobile Terminated-Small Data Transmission (MT-SDT) for NR.
4. 3GPP TS 38.331 Radio Resource Control (RRC) protocol specification (Release 17).
5. R2-2203949 LS on Positioning in RRC\_INACTIVE State.
6. 3GPP TR 38.857 Study on NR Positioning Enhancements (Release 17).
7. R2-2207083 Discussion on LPHAP vivo discussion Rel-18 FS\_NR\_pos\_enh2
8. R2-2207089 Consideration on LPHAP OPPO discussion Rel-17 FS\_NR\_pos\_enh2
9. R2-2207111 Discussion on LPHAP CATT discussion Rel-18 FS\_NR\_pos\_enh2
10. R2-2207390 Support of LPHAP Intel Corporation discussion Rel-18 FS\_NR\_pos\_enh2
11. R2-2207436 On LPHAP Apple discussion Rel-18 FS\_NR\_pos\_enh2
12. R2-2207488 Discussion on LPHAP InterDigital, Inc. discussion Rel-18 FS\_NR\_pos\_enh2
13. R2-2207584 Discussion on LPHAP ZTE, Sanechips discussion Rel-18 NR\_pos\_enh-Core
14. R2-2207703 Discussion on low power high accuracy positioning Lenovo discussion Rel-18
15. R2-2207830 Considerations on solution for Low Power High Accuracy Positioning Sony discussion Rel-18 FS\_NR\_pos\_enh2
16. R2-2207912 Discussion on LPHA positioning Xiaomi discussion
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18. R2-2208128 Limitations of RRC\_INACTIVE positioning for LPHAP Qualcomm Incorporated discussion
19. R2-2208180 Use case and area of focus for LPHAP study Nokia, Nokia Shanghai Bell discussion Rel-18 FS\_NR\_pos\_enh2
20. R2-2208454 Initial considerations on LPHAP CMCC discussion Rel-18 FS\_NR\_pos\_enh2
21. R2-2208626 Discussion on the LPHAP Huawei, HiSilicon, Deutsche Telekom discussion Rel-18 FS\_NR\_pos\_enh2 R2-2207867

# 6 Participants

|  |  |
| --- | --- |
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