

Electronic Meeting, December 12 – 16, 2022

On scope of Rel-18 WI on Expanded and Improved NR Positioning

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SI to WI conversion for Expanded and Improved NR Positioning in Rel-18

- The Rel-18 SI on expanded and improved NR positioning has been recently completed by the RAN WGs.
- At RAN #98e, a new Rel-18 WI on expanded and improved NR positioning is expected to be approved.
- Based on the study, RAN WGs have made recommendations on potential features and enhancements for normative work.
- In this contribution, we present our views on the scope of the Rel-18 WI considering the conclusions from the SI and workload management for the normative work.

Sidelink (SL) Positioning (1/2)

- Normative work to support SL ranging/positioning have been recommended by RAN1 and RAN2.
- Broadly, the work can be categorized under the following areas:
 - Specifying SL Positioning Reference Signals (SL PRS) as a new reference signal for SL (*RAN1-led*)
 - Specifying methods associated with SL ranging/positioning (*RAN1-led*)
 - Specifying resource allocation for SL ranging/positioning (*RAN1-led*)
 - Specifying associated physical layer UE behavior for SL PRS Tx/Rx, e.g., transmit power control, priority handling, etc. (*RAN1-led*)
 - Specifying signalling and UE behavior for support of unicast, groupcast (not including many to one) and broadcast of SL PRS transmissions (*RAN1-led*)
 - Specifying signalling and procedures to facilitate support of SL positioning in all coverage scenarios and for PC5-only and joint PC5-Uu scenarios, including:
 - Protocol and procedures for SL positioning between UEs (SLPP) (*RAN2-led*)
 - Enhancements to LPP and LMF functionalities for supporting SL positioning (*RAN2-led*)
 - Specifying corresponding new core requirements, as well as discuss and identify the impact on the existing RAN4 specification, including RRM measurements and procedures (*RAN4-led*)

Sidelink (SL) Positioning (2/2)

- Considering the rather large workload that is expected to support SL ranging/positioning functionalities in NR specifications, it is necessary to consider some potential prioritization to focus on the most essential parts in this release.
- Towards this the following are recommended:
 - On methods, focus on RTT-type solutions using SL and SL-AoA to enable SL ranging and basic SL positioning capabilities in Rel-18.
 - While SL TDOA has been evaluated and recommended by RAN1, there remain practical challenges due to the dependency on tight synchronization across UEs. On a somewhat related note, RAN1 has also made the following observation based on evaluations:
 - SL absolute positioning performance may be degraded due to uncertainty in the anchor UEs' location coordinates and synchronization error (for SL-TDOA) between anchor UEs.
 - Support of dedicated resource pools for SL PRS transmission may be prioritized in Rel-18.
 - While there are certainly value in supporting SL PRS transmission in resource pools shared with SL communication, specification efforts including identification of solutions to enable shared resource pools can potentially consume significant time and efforts in RAN1.
 - Since dedicated resource pools need to be supported by the specifications in any case, this option may be prioritized and depending on progress at the next RAN meeting, it could be confirmed further whether to also work on support of shared resource pools.

Integrity for RAT-dependent Positioning methods

- Normative work on support of UE-based and LMF-based integrity for RAT-dependent positioning methods has been recommended by RAN2 while RAN1 has provided inputs on identification of error sources and basics of modelling of such error sources.
- In our view, it should be a RAN2-led objective with RAN3 and RAN1 involvement.
 - RAN1 may be expected to provide feedback on further details and parameterization of the error models, as well as address some details on integrity of AoA-based positioning methods.

Low Power High Accuracy Positioning (LPHAP) (1/2)

- For support of LPHAP use-cases as defined in TS 22.104, the following have been recommended by RAN1/RAN2:
 - Extending DRX cycle beyond 10.24s in RRC_INACTIVE state (*recommended by RAN1*)
 - For UL and DL+UL positioning for UEs in RRC_INACTIVE state, specify enhancements to configuration of SRS for positioning to avoid frequent RRC connection for SRS (re)configuration based on SRS positioning validity area (*recommended by RAN1 and RAN2*)
 - Subject to RAN1's study and conclusion on feasibility regarding issues such as interference, timing advance, spatial relation information, pathloss reference and common SRS parameters across multiple cells
 - DL PRS measurements for a UE in RRC_IDLE state (*recommended by RAN2*)
 - Alignment between DRX and PRS configurations (*recommended by RAN2*)
 - Skipping paging reception in RRC_INACTIVE (*recommended by RAN2*)
 - Subject to establishment of need/benefits and feasibility from RAN1's perspective.

Low Power High Accuracy Positioning (LPHAP) (2/2)

- Extending DRX cycle beyond 10.24s in RRC_INACTIVE state (*RAN2-led*)
 - Based on the evaluations conducted by RAN1 on UE battery lifetimes for LPHAP, this enhancement is the most significant contributor to improving UE battery lifetime for LPHAP compared to the other spec-based enhancements.
 - There is currently a very similar objective being pursued as part of Rel-18 WI on eRedCap and it may be reasonable to coordinate the work across these two WIs, e.g., such that Rel-18 WI on eRedCap ensures the specification support (for all UE types) while the values of DRX cycles and associated UE capabilities related to LPHAP may be determined as part of the Rel-18 WI on positioning. Such an approach can limit the workload from this objective to the Rel-18 WI.
- For UL and DL+UL positioning for UEs in RRC_INACTIVE state, specify enhancements to configuration of SRS for positioning to avoid frequent RRC connection for SRS (re)configuration based on SRS positioning validity area (*RAN2-led*)
 - Although there are some further details that RAN1 needs to study and determine for this objective, SRS positioning validity area has been studied and recommended by both RAN1 and RAN2 and it would be appropriate to pursue normative work on this during Rel-18.
- DL PRS measurements for a UE in RRC_IDLE state (*RAN2-led*)
- Alignment between DRX and PRS configurations (*RAN2-led*)
 - The above two objectives may have a limited footprint on RAN2's and overall time budget of the WI and may be considered for specification in Rel-18.
- Skipping paging reception in RRC_INACTIVE (*RAN2-led*)
 - This objective requires further careful study in RAN1 on the benefits and feasibility (there was a single-company result reported on this potential enhancement during the SI).
 - In our view, this objective can be seen as an extreme case of extending DRX cycle and the gains compared to the case of using large values of eDRX cycles need to be established since skipping paging altogether may have additional impacts on overall operations. In this regard, as also observed by RAN2, it is likely to involve work in SA2 as well – “Impacts of skipping paging for UE in RRC_INACTIVE to the core network could be evaluated with SA2 involved in the WI phase”.
 - Considering limited time in RAN1 and RAN2, this objective may be deferred to a future release.

Accuracy Improvement via Bandwidth Aggregation

- During the Rel-18 SI, RAN4 studied and concluded that it is feasible from perspectives of RF and RRM to support bandwidth aggregation of measurements for DL PRS/SRS across multiple intra-band contiguous carriers if the signals over the aggregated resources are transmitted and received (respectively) using a single RF chain (same antenna).
- During Rel-17 RAN1 evaluated this potential feature and accuracy gains were observed under certain scenarios, configurations, and assumptions on modelled impairments as outlined in Clause 8.4 of TR 38.857.
- In our view, BW aggregation is an attractive feature in enabling improved positioning accuracy and should be included in Rel-18.

Accuracy Improvement via NR Carrier Phase Positioning (NR CPP) (1/2)

- During the SI phase, RAN1 evaluated NR CPP methods to improve positioning accuracy.
- Based the study, RAN1 was not able to reach consensus on recommendations for normative work but concluded on the following:
 - “ ... it is feasible to use existing DL PRS and SRS signals to obtain the carrier phase measurements for achieving a horizontal accuracy of up to a few centimeters at least at 50% under certain conditions, including the PRU(s) being located in LOS with TRP(s), and the locations of the PRU(s) and TRPs known with centimeter-level accuracy, in the agreed evaluation assumptions.”
- Additionally, RAN1 made the following conditional recommendations *if NR CPP is agreed for normative work*:
 - Existing DL PRS and UL SRS for positioning purpose are recommended as the reference signals to enable positioning based on NR carrier phase measurements for both UE-based and UE-assisted positioning.
 - New measurements are recommended to be introduced for supporting UE-based and UE-assisted NR carrier phase positioning.
 - Multipath mitigation methods for the carrier phase positioning are recommended to be introduced during normative work.
- Also, potential enhancements may be pursued to address:
 - Impact of initial phases at transmitter and receiver.
 - The issue of integer ambiguity and its resolution.

Accuracy Improvement via NR Carrier Phase Positioning (NR CPP) (2/2)

- In view of the discussions in RAN1 on NR CPP, conclusions from the SI on the feasibility to support NR CPP, and the limited time budget for the WI phase, as one option, the normative work on NR CPP may be limited to:
 - Specifying new measurements and their reporting for NR CPP based on existing DL PRS and UL SRS positioning and deferring other enhancements to a future release.
- In any case, further discussions are needed during RAN #98e to decide whether to include NR CPP in Rel-18.

Positioning for RedCap UEs

- Due to the reduced capabilities compared to eMBB/URLLC NR UEs in terms of maximum bandwidth in DL/UL and numbers of Rx branches, positioning accuracy can be expected to be adversely impacted for RedCap UEs.
 - The evaluations conducted during the SI indicate that the target requirements may not be supported in many cases without further enhancements.
- Based on the study, RAN1 recommended the following for normative work:
 - Support of Frequency Hopping (FH) beyond maximum RedCap UE bandwidth for reception of DL PRS and transmission of UL SRS for positioning (*RAN1-led*).
- Considering that accurate positioning is a key enabler for various RedCap-based solutions for IIoT, public safety, commercial, and V2X use-cases, it is recommended to include this objective in Rel-18.
- The potential impact to UE complexity due to FH needs to be borne in mind. However, it should be also noted that FH/retuning-based operations have been supported by much less capable devices, e.g., Cat M1/M2 UEs (eMTC) since Rel-13 LTE.

Summary

Include the following features as part of Rel-18 WI on Positioning:

- SL ranging/positioning, including SL PRS reference signal design, SL PRS resource allocation, Tx/Rx UE behaviors, protocol and procedures to enable SL positioning.
 - Limited to max bandwidth of 100 MHz in FR1 licensed spectrum
 - On methods, focus on RTT-type solutions using SL and SL-AoA to enable SL ranging and basic SL positioning capabilities in Rel-18.
 - On SL PRS resource allocation, consider prioritization of dedicated resource pools for SL PRS.
- UE-based and LMF-based integrity for RAT-dependent positioning.
- Enhancements for positioning for RedCap UEs.
- Bandwidth aggregation of DL PRS/UL SRS across intra-band contiguous carriers
- Solutions for LPHAP:
 - Extending DRX cycles beyond 10.24 s in RRC_INACTIVE state.
 - Enhancements to avoid frequent RRC connection for SRS (re)configuration based on SRS positioning validity area.
 - Include the following if there may be room:
 - DL PRS measurements for a UE in RRC_IDLE state
 - Alignment between DRX and PRS configurations
- Discuss further to decide whether to include:
 - NR CPP, with the scope limited to support of new measurements and their reporting for NR CPP.

Note: It is expected that RAN4 would need to work to identify new requirements as well as the impact on the existing RAN4 requirements for positioning and other RRM measurements and corresponding procedures for the above objectives.

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