**3GPP TSG-RAN WG3 Meeting #113electronic R3-214223**

**Online, 16th – 26th Aug 2021**

**Agenda Item: 18.4.3**

**Source: CMCC (moderator)**

**Title: Summary of CB: # AIRAN5\_MobilitySolution**

**Document for: Discussion and Decision**

# 1 Introduction

**CB: # AIRAN5\_MoblitySolution**

**- Discuss the solution, input/output, standard impacts on the Load Balancing**

**- Merging any agreement parts; provide TP if agreeable**

**- Capture agreements and open issues**

(CMCC - moderator)

Summary of offline disc in [R3-214223](file:///C%3A%5CUsers%5Czhangxy%5CDownloads%5CInbox%5CR3-214223.zip)

The deadline for the first phase of the email discussion is Friday 6 pm UTC.

# 2 For the Chairman’s Notes

**To be added after email discussion.**

# 3 Discussion

In last RAN3 #112e meeting, RAN3 agreed the use case description of mobility, and it was further agreed that: Mobility aspects of SON that can be enhanced by the use of AI/ML include

* Reduction of the probability of unintended events
* UE Location/Mobility/Performance prediction
* Traffic Steering

The first round of the CB will be structed as follows:

* Solutions and AI/ML functionality location
* Inputs required for UE trajectory prediction
* Outputs generated from AI-based mobility prediction model
* Feedback/ Rewarding information
* New events

## 3.1 Solutions and AI/ML functionality location

In contribution 3715, AI/ML based mobility optimization is classified into two types:

* Type 1 AI/ML-assisted mobility optimization: Handover strategy is generated by conventional method based on the predicted trajectory information, where the predicted trajectory information is generated by AI/ML model.
* Type 2 AI/ML-generated mobility optimization: Handover strategy is generated by AI/ML model based on the UE and node information.

**Q1: Companies are invited to provide views on whether to classify the solutions into AI/ML-assisted mobility optimization and AI/ML-generated mobility optimization?**

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| **Company** | **Yes/No** | **Reasons/Comments/Suggestions** |
| Nokia | No | We don’t see the need why we need to classify the mobility solution in these two types. This is just algorithm-specific. |
| vivo | No | Type2 includes type1 as the trajectory prediction is the key issue of the AI based HO. If the model inference resides on RAN node, then no need to extract it unless the procedure or message exchange are different.In this case, we suppose the AI based HO can be classified into AI based HO decision and AI based admission control. |
| InterDigital | No | No Need |
| Huawei | Either way could work | We think this is just different implementation, for either way, in general we think the standard impacts should be similar. For example, we think the input for inference should be similar, then the output of inference could be prediction for further decision or just handover decision, which should be up to implementation. Maybe we need to discuss if there any different spec impacts between the two, e.g. on Xn. |
| Ericsson | No | We do not understand why this distinction is needed. In our functional framework we have clear behaviours and roles for different functions. We are studying solutions where an Actor function takes actions based on a received Model Inference function output. We do not specify whether these actions are based only on the Model Inference output, or on the output plus other elements such as historical data, etc. Namely the Actor “may” take the Model Inference output into account to perform its actions and it is up to the Actor implementation to decide how to ultimately take the action. Hence, the classification seems not to be of relevance for the work RAN3 is carrying out.  |
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Several options are proposed regarding where the AI/ML functionality may be placed:

1. Both the training function and the inference function are deployed in LMF (3471)
2. Both the training function and the inference function are deployed in OAM (3542)
3. The training function is deployed in OAM, while the inference function resides within the RAN node (3542, 3724, 3759, 4113, 4130)
4. Both the training function and the inference function reside within the RAN node (3542, 3759)

**Q2: Companies are invited to provide views on which of the above options they prefer:**

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| **Company** | **Option 1-4** | **Reasons/Comments/Suggestions** |
| Nokia | 2,3,4 | In our view option 1) should not be in the scope of this SI. The rest of the options are acceptable options for the study with different pros and cons each. |
| vivo | 3 | Option3 is preferred. For option1 and 2, the latency will be unacceptable for HO if the model inference locates in CN or OAM. For option 4, numerous message exchange between RAN nodes is essential as one single RAN node cannot acquire enough information for model training.  |
| InterDigital  | 2,3,4 | Agree with Nokia |
| Huawei | Prefer 3 | Firstly, we suppose that the training is offline training. Then as commented in the CB on frame work, we think offline training should be in OAM which requires large amount data storage and huge compute resource, which actually makes it impossible for offline training in gNB. For inference, anyway the output of inference should be immediately sent to actor for taking action, so it is better to place inference close to actor which is resided within RAN node.  |
| Ericson | 3, 4 | Solution 1) and 2) are out of scope of the SI. That can be deduced from the SID (RP-201629), stating that the objective is:“Study high level principles for RAN intelligence enabled by AI”With this we are not saying that these solutions are not appropriate, but they are not the subject of this SISolution 3) is perhaps the solution range we should give highest priority. Namely, the RAN is given a trained model and we would study procedures to support inference at the RANSolution 4) is perhaps the second highest priority type of solution, where training and inference occurs at the RAN |
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Furthermore, for CU-DU split scenario, following alternatives are proposed:

1. CU is the suitable node for AI model to reside in terms of mobility optimization (3715, 3895, 3780)
2. ML training is located in CU-CP or OAM, and ML inference function is located in CU-CP (3724)
3. The AI/ML component can be located in the gNB-DU, in case of beam-based AI/ML mobility solutions (3895)

**Q3: Companies are invited to provide views on which of the above options they prefer for CU-DU split:**

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| **Company** | **Option 1-3** | **Reasons/Comments/Suggestions** |
| Nokia | 1,2,3 | All the options can be considered for the study |
| vivo | 1,2 | We agree with option3 but we think it is deprioritized. |
| InterDigital | 1,2,3 | All options should be considered |
| Huawei | Offline training in OAM, on top of that, inference is located in CU-CP.  | As commented above, offline training in OAM. Then for CU/CU-CP vs. DU, since CU/CU-CP could have more information than what DU could get, so inference located in CU/CU-CP is more natural choice.  |
| Ericsson | 1, 2. 3 needs further clarifications | For 3) we shoudl first understand what mobility actions are being tackled. Inter-beam intra-cell movements are not classified as mobility. Yet, these seem to be the only “mobility events” a gNB-DU would be able to control… |
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## 3.2 Input data

Following information is proposed to be the input data for mobility prediction in many papers (3648, 3724, 3759)

* UE historical location information, e.g. Latitude, longitude, altitude
* UE moving direction
* UE velocity
* Radio measurements related to serving cell and neighbouring cells associated with UE location information, e.g., RSRP, RSRQ.
* UE historical serving cells and their locations
* UE trajectory prediction output, local load prediction output, load prediction output from the neighbor node, legacy information collected from UE and the neighbor nodes (for mobility decision)

**Q4: Companies are invited to provide views on whether agree on above input data for AI-based mobility?**

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| **Company** | **Yes/No** | **Reasons/Comments/Suggestions** |
| Nokia | a) UE historical location information, e.g. Latitude, longitude, altitude -> yesb)UE moving direction -> yesc)UE velocity -> yesd)Radio measurements related to serving cell and neighbouring cells associated with UE location information, e.g., RSRP, RSRQ. -> yese)UE historical serving cells and their locations ->yesf)UE trajectory prediction output, local load prediction output, load prediction output from the neighbor node, legacy information collected from UE and the neighbor nodes (for mobility decision) ->yes |   |
| vivo | Yes for all. |  |
| InterDigital  | Yes for all |  |
| Huawei | Not sure if we should agree all such stuff right now, or we just make general guidance/agreements during SI phase? | In general, we think UE trajectory info, location info and radio measurements should be useful as input for model training. What we are not sure is the UE trajectory prediction output, is this provided by UE, and also by AI/ML inside UE? If so, will this add additional burden over UE, e.g. resource/power. We think network could also perform trajectory prediction and might be more powerful… |
| Ericsson | Yes | All inputs are suitable to be taken into account for a discussion on solutions  |
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Furthermore, it is proposed to discuss the input data from different component (3297, 3648, 3715, 3787):

**Long-term information from NWDAF**

**Input Information from CN** (the input can be based on the information from AI based CN function):

* UE mobility statistics parameters, e.g., UE location statistics (duration of the time slot)
* UE mobility predications, e.g., predicated UE location information in the analytical period

**Input Information from UE:**

* Current and past location statistical information, e.g. GPS, GNSS, cell and UE’s staying duration information
* UE may also have the training model on its locations, thus UE can report the predicated location to RAN
* trajectory, moving velocity, measurement report

**Input Information from the neighbor RAN nodes:**

* UE’s successful handover information in the past and received from neighboring RAN nodes
* UE’s successful DC offloading information in the past and received from neighboring RAN nodes
* UE’s history information from neighbor
* position, resource status, QoS parameters of historical HO-ed UE (e.g. loss rate, delay, etc.)
* After successful handover, UE QoE reports for handed over user
* During DC, UE QoE reports for data handled by the SN
* Predicted load
* Resource status and utilization prediction/estimation
* SON Reports of handovers that are successful, too-early, too-late, or handover to wrong (sub-optimal) cell

**Q5: Companies are invited to provide views on whether agree on above input data from different component?**

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| **Company** | **Yes/No** | **Reasons/Comments/Suggestions** |
| Nokia | **Input Information from CN** ->No**Input Information from UE** -Current and past location statistical information, e.g. GPS, GNSS, cell and UE’s staying duration information -> No -UE may also have the training model on its locations, thus UE can report the predicated location to RAN->No-trajectory, moving velocity, measurement report -> Yes**Input Information from the neighbor RAN nodes:** -UE’s successful handover information in the past and received from neighboring RAN nodes -> YesUE’s successful DC offloading information in the past and received from neighboring RAN nodes -> No for nowUE’s history information from neighbor ->Yesposition, resource status, QoS parameters of historical HO-ed UE (e.g. loss rate, delay, etc.) -> YesAfter successful handover, UE QoE reports for handed over user -> Yes During DC, UE QoE reports for data handled by the SN -> No for nowPredicted load -> YesResource status and utilization prediction/estimation -> YesSON Reports of handovers that are successful, too-early, too-late, or handover to wrong (sub-optimal) cell -> Yes | In our view, core network input should not be in the scope of the SI.When it comes to input from UE, we do not support that UE provides current and past location statistical information since this would require a different processing capability at the UE. Also, we do not support that UE reports its predicted location to RAN since AI/ML at the UE is not in the scope of the SI.Regarding information from the neighbour RAN nodes, we do not understand the meaning of “UE’s successful DC offloading information”. We need some more explanation before agreeing to it. It is also unclear whose resource status and position are reported. We also do not support to exchange QoE Reports since QoE WI is still not completed. |
| vivo | **Long-term information from NWDAF ->No****Input Information from CN** ->No**Input Information from UE** -Current and past location statistical information, e.g. GPS, GNSS, cell and UE’s staying duration information -> Yes -UE may also have the training model on its locations, thus UE can report the predicated location to RAN->No-trajectory, moving velocity, measurement report -> Yes**Input Information from the neighbor RAN nodes:** -UE’s successful handover information in the past and received from neighboring RAN nodes -> YesUE’s successful DC offloading information in the past and received from neighboring RAN nodes -> No for nowUE’s history information from neighbor ->Yesposition, resource status, QoS parameters of historical HO-ed UE (e.g. loss rate, delay, etc.) -> YesAfter successful handover, UE QoE reports for handed over user -> Yes During DC, UE QoE reports for data handled by the SN -> No for nowPredicted load -> YesResource status and utilization prediction/estimation -> YesSON Reports of handovers that are successful, too-early, too-late, or handover to wrong (sub-optimal) cell -> Yes | Agree with Nokia that the core network input is in the scope.The UE may provide the location related information if available.The UE is not expected to have AI related functionality in this SI.The prediction of QoS, QoE and resource status can be useful for HO decision. |
| InterDigital | **Long-term information from NWDAF ->No****Input Information from CN** ->No**Input Information from UE** Current and past location statistical information (yes with Caveats) UE may also have the training model on its locations, thus UE can report the predicated location to RAN - no trajectory, moving velocity, measurement report - yes**Input Information from the neighbor RAN nodes:** Yes for all (with caveats)  | Agree with Nokia, Vivo that NWDAF and CN are not in the scope of the study though ultimately in the future they will be involved. For UE inputIf we are talking about past location information that was sent by the UE to the network in the past (baseline already) then potentially yes, but it is no if we are thinking about a “location history” report from the UE. As of now UE is not expected to have AI related functionality in this SI, though I think for some functions like this it should be considered for the work itemFor QoE reports since they are a R17 creation, making a firm decision on them is probably too early, but they will be available and known by the WID and probably should be considered there. So perhaps the QoE reports could be FFS out of the study.  |
| Huawei | Clarifications needed | If we are talking input to offline training, as already commented, offline training is located in OAM, and all the information could be available at OAM, so we don’t understand why the input should be from NWDAF or CN?  |
| Ericsson | **Long-term information from NWDAF ->No****Input Information from CN ->No****Input Information from UE -> Yes****Input Information from the neighbor RAN nodes -> Yes** | For Input Information from the neighbor RAN nodes we believe that the most important information is the UE performance at the target node after mobility or DC configuration is completed. Such information may include QoE measurements (as listed by the moderator) but it may also include e.g. throughput, delay, packet losses and other QoS parameters relative to the UE bearers served by the target RAN node.Predicted load information from neighbour node would be also available from the Load Balancing use case and are useful in this use case too. |
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## 3.3 Output data

Following information is proposed to be the output data (3648, 3715, 3724, 3759, 3787, 4130):

* UE trajectory prediction (Latitude, longitude, altitude of UE over a future period of time)
* the predicated UE’s location with the confidence of the predication
* predicted moving coordination
* estimated arrival probability in CHO and relevant confidence interval, Estimated arrival probability in CPAC and relevant confidence interval
* predicted handover strategy
	+ predicted handover decision: handover or not handover
	+ predicted DC activation decision
	+ predicted handover target node, candidate cells in CHO, target PSCell in PSCell addition and change, candidate PSCells in CPAC; may together with the confidence of the predication
	+ predicted handover source node
	+ predicted handover time
	+ predicted data forwarding strategy
	+ HO admission

**Q6: Companies are invited to provide views on whether agree on above output data for AI-based mobility?**

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| **Company** | **Yes/No** | **Reasons/Comments/Suggestions** |
| Nokia | UE trajectory prediction (Latitude, longitude, altitude of UE over a future period of time) -> Yesthe predicted UE’s location with the confidence of the predication ->Nopredicted moving coordination->Noestimated arrival probability in CHO and relevant confidence interval, Estimated arrival probability in CPAC and relevant confidence interval ->Yespredicted handover strategy ->No | Regarding predicted UE location, in our view this is not needed if we support UE trajectory prediction. Location can be deduced through the trajectory.Regarding predicted moving coordination it is not clear what this means.The predicted handover strategy is algorithm dependent and we don’t think is necessary to be provided with the Output data.  |
| vivo | * UE trajectory prediction (Latitude, longitude, altitude of UE over a future period of time) -> Yes
* the predicated UE’s location with the confidence of the predication -> Not for sure, For the predication with low confidence, the HO should fall back to the legacy mechanism.
* predicted moving coordination -> proponent need to clarify the definition.
* estimated arrival probability in CHO and relevant confidence interval, Estimated arrival probability in CPAC and relevant confidence interval -> yes for the CHO no for the CPAC
* predicted handover strategy
	+ predicted handover decision: handover or not handover -> yes
	+ predicted DC activation decision ->no for now
	+ predicted handover target node, candidate cells in CHO, target PSCell in PSCell addition and change, candidate PSCells in CPAC; may together with the confidence of the predication ->yes for predicted handover target node, candidate cells in CHO, no for others
	+ predicted handover source node -> no, source node is the existing serving node
	+ predicted handover time -> no, the gNB can control the time to send out the RRCReconfiguration.
	+ predicted data forwarding strategy ->no, up to implementation
	+ HO admission -> yes, in this case, no need to exchange the load prediction of target cell.
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| InterDigital | UE trajectory prediction -> Yesthe predicated UE’s location with the confidence of the predication -> seems redundant with trajectorypredicted moving coordination -> proponent need to clarify the definition.estimated arrival probability in CHO and relevant confidence interval, Estimated arrival probability in CPAC and relevant confidence interval -> Yespredicted handover strategy -> no predicted DC activation decision ->possible predicted handover target node, candidate cells in CHO, target PSCell in PSCell addition and change, candidate PSCells in CPAC; may together with the confidence of the predication ->yes predicted handover source node -> no, predicted handover time -> for CHO yespredicted data forwarding strategy ->noHO admission -> not clear | Predicted handover strategy and predicted data forwarding strategy, are algorithm, the real thing here is predicted target, candidate cells in CHO etc. is the real output that is actually the handover strategy and predicted handover time is the real output for a data forwarding strategy |
| Huawei | Not sure  | As commented, we think the output of inference could be trajectory prediction, HO decision/HO strategy etc., i.e. such general descriptions as solution for SI conclusion, and we could also add some supplements such as predicted moving direction, suggested HO target, etc., but we are not sure if we should go one by one, e.g. we are not sure about predicted handover source node, predicted handover time, predicted handover source node…Maybe there is no need to go into such detailed discussions on specific parameter. |
| Ericsson | * UE trajectory prediction (Latitude, longitude, altitude of UE over a future period of time) ->NO
* the predicated UE’s location with the confidence of the predication ->NO
* predicted moving coordination ->NO
* estimated arrival probability in CHO and relevant confidence interval, Estimated arrival probability in CPAC and relevant confidence interval ->needs further discussions
* predicted handover strategy
	+ predicted handover decision: handover or not handover ->Yes
	+ predicted DC activation decision ->Yes
	+ predicted handover target node, candidate cells in CHO, target PSCell in PSCell addition and change, candidate PSCells in CPAC; may together with the confidence of the predication ->Yes
	+ predicted handover source node ->No
	+ predicted handover time ->needs discussions
	+ predicted data forwarding strategy ->No
	+ HO admission ->No
 | Clarification: we believe that the UE related information listed as possible outputs are the inputs to an AI model. The output is a decision on mobility. |
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## 3.4 Feedback/Rewarding information

Both UE side and network side information are discussed for feedback/rewarding information:

UE side measurements (3724, 3780):

* whether the mobility decision is good or not
* Trajectory information (e.g. speed, position, etc.)
* Assistance Information on Traffic
* Quality of experience e.g., buffer level
* Successful HO measurements
* Radio link failure information

Network side measurements (3724,3780, 4230)

* whether the mobility decision is good or not (e.g. if HO is successful)
* Traffic steering configuration used for the UE e.g., multi-connectivity and carrier aggregation
* Load information
* DL/UL throughput
* DL/UL latency
* Cell dwelling time
* HO failure, too late HO, too early HO, HO to wrong cell

**Q7: Companies are invited to provide views on whether agree on above feedback/rewarding information for AI-based mobility?**

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| **Company** | **Yes/No** | **Reasons/Comments/Suggestions** |
| Nokia | **UE side measurements** whether the mobility decision is good or not -> YesTrajectory information (e.g. speed, position, etc.) -> YesAssistance Information on Traffic ->NoQuality of experience e.g., buffer level -> NoSuccessful HO measurements ->YesRadio link failure information ->Yes**Network side measurements** whether the mobility decision is good or not (e.g. if HO is successful)->YesTraffic steering configuration used for the UE e.g., multi-connectivity and carrier aggregation -> NoLoad information -> YesDL/UL throughput -> YesDL/UL latency ->YesCell dwelling time -> MaybeHO failure, too late HO, too early HO, HO to wrong cell ->Yes | In general, we support existing UE measurements but not to introduce new ones, especially ones with high UE impacts. Regarding the network side measurements, it is unclear how network can use traffic steering configuration on a per a UE basis. Regarding Cell dwelling time, we would need to understand more how it can benefit the network. |
| vivo | **UE side measurements** whether the mobility decision is good or not -> YesTrajectory information (e.g. speed, position, etc.) -> YesAssistance Information on Traffic ->Yes if it means the QoS Quality of experience e.g., buffer level -> YesSuccessful HO measurements ->YesRadio link failure information ->Yes**Network side measurements** whether the mobility decision is good or not (e.g. if HO is successful)->YesTraffic steering configuration used for the UE e.g., multi-connectivity and carrier aggregation -> NoLoad information -> YesDL/UL throughput -> YesDL/UL latency ->YesCell dwelling time -> YesHO failure, too late HO, too early HO, HO to wrong cell ->Yes |  |
| InterDigital | **UE side measurements** whether the mobility decision is good or not -> YesTrajectory information (e.g. speed, position, etc.) -> YesAssistance Information on Traffic ->not clear Quality of experience e.g., buffer level -> maybeSuccessful HO measurements ->YesRadio link failure information ->Yes**Network side measurements** whether the mobility decision is good or not (e.g. if HO is successful)->YesTraffic steering configuration used for the UE e.g., multi-connectivity and carrier aggregation -> maybeLoad information -> YesDL/UL throughput -> YesDL/UL latency ->YesCell dwelling time -> MaybeHO failure, too late HO, too early HO, HO to wrong cell ->Yes | Not clear whether traffic steering configuration, and cell dwelling time are beneficial.  |
| Huawei | Not sure | In general, we think feedback/rewarding information could be discussed and introduced, but for what kind of feedback/rewarding information, we could give some general guidance and discuss concrete parameters in detail during normative phase, e.g. the reliability of the received predication of the UE Location/Mobility/Performance from the source node, or the actual UE Location/Mobility/Performance if different from the predicted. |
| Ericsson | In general all feedback information are potentially good | We should keep the list of feedback as FFS and drill down in the solution details to confirm which information is really needed.  |
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## 3.5 New events

It is proposed in 4081 to include following events as unintended events for mobility:

* Successful Handover: During a successful handover, there is underlying issue.
* Too late PSCell change: an SCG failure occurs after the UE has stayed for a long period of time in the PSCell; a suitable different PSCell is found based on the measurements reported from the UE.
* Too early PSCell change: an SCG failure occurs shortly after a successful PSCell change from a source PSCell to a target PSCell or a PSCell change failure occurs during the PSCell change procedure; source PSCell is still the suitable PSCell based on the measurements reported from the UE.
* Triggering PSCell change to wrong PSCell: an SCG failure occurs shortly after a successful PSCell change from a source PSCell to a target PSCell or a PSCell change failure occurs during the PSCell change procedure; a suitable PSCell different with source PSCell or target PSCell is found based on the measurements reported from the UE.

**Q8: Companies are invited to provide views on whether to include above events as unintended events for mobility?**

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| **Company** | **Yes/No** | **Reasons/Comments/Suggestions** |
| Nokia | No | It would make sense to first focus on single connectivity handover scenarios before we look into DC scenarios. |
| vivo | No for now | The single connectivity HO issue should be addressed at first, the DC issue can be considered if time permits |
| InterDigital | No for now | I think that these should be considered for R18 SON work item, not this AI study.  |
| Huawei | Yes | Since the related SON reports have been introduced in Rel-16 or being discussed and introduced in Rel-17. This will not bring additional data collection for the AI/ML assisted optimization taking into consideration the new unintended events. |
| Ericsson | Not high priority | All the events listed are relevant information that could work as “feedback”. However:- We should probably not consider them now and first agree to the basic aspect of the solution- All of the information listed is already signalled (or it will be signalled e.g. as part of MRO for SN change) between source and target and between MN and SN |
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# 4 Conclusion, Recommendations

To be edited, if needed**.**

# 5 Reference

1. R3-213297 Proposed TP to TR 37.817 on Mobility Optimization solutions and standard impacts (NEC)
2. R3-213471 AI/ML based mobility optimization (Intel Corporation)
3. R3-213542 On where to deploy the UE location prediction entity (CATT)
4. R3-213648 Support of AI/ML enabled Mobility Optimization for NG-RAN and EN-DC (LG Electronics)
5. R3-213715 Discussion on Standard Impact for RAN Intelligence (Mobility Optimization) (Samsung)
6. R3-213724 Discussion on standard impact to support mobility optimization (Lenovo, Motorola Mobility)
7. R3-213759 Solution to AI based UE Trajectory Prediction (ZTE Corporation, China Unicom, CMCC)
8. R3-213787 Standardization impacts of Mobility Optimization Use Case for AI (InterDigital)
9. R3-214081 Further discussions on spec impacts of moblity enhancements (Huawei)
10. R3-214113 (TP to TR 37.817) Solutions for AI-based mobility optimization (CMCC)
11. R3-214130 Discussion on AI based mobility optimization (vivo)
12. R3-213780 AI/ML based mobility optimization: Mobility performance feedback after HO (Ericsson)
13. R3-213895 Standards Impacts for the AI/ML Mobility Use Case (Nokia, Nokia Shanghai Bell)