Pro3GPP TSG-RAN WG3 Meeting #114-e Draft R3-215911

E-meeting, 1– 10 Nov, 2021

**Agenda item: 18.4.3**

**Source: CATT (moderator)**

**Title:**  **CB: # AIRAN3\_Mobility -** **Summary of email discussion**

**Document for: Approval**

# 1 Introduction

**CB: # AIRAN3\_Mobility**

**- Converge on the left issues on the input/output, feedback, solution**

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

**- Capture agreements and open issues**

(CATT - moderator)

Summary of offline disc in [R](file:///D%3A%5CMeetings%5CRAN3%23113%5CCB%5CInbox%5CR3-214222.zip)3-215911

Two phases of this email discussion:

* Phase 1 Deadline: **18:00PM UTC, 5th Nov**.
* Phase 2 Deadline : **8:00AM UTC, 9thNov**, Try to have an agreeable TP in the 2nd phase discussion before online session.

# 2 For the Chairman’s Notes

# 3 Discussion

## 3.1 Use case

In [5130], it is proposed to include AI-based beam training and tracking strategies of millimeter wave communication especially in the high-speed rail scenario into the use case description part for AI based mobility management

**Q4.1-1 Companies are invited to provide views on whether the new use case on AI-based beam training and tracking strategies of millimetre wave communication should be introduced in** AI based mobility management **in RAN3.**

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| **Company** | **Yes/No** | **Comment** |
| InterDigital | No | These topics are better handled in air interface AI studies (upcoming in R18) |
| Huawei | No | We think it should be the common understanding that the current SI should focus on the agreed use cases. |
| Lenovo, Motorola Mobility | No | Similar view as InterDigital and Huawei |
| NEC | No | These look like RAN1 topics. |
| Intel | No | Agree it would be better to study in Rel-18 AI/ML air interface. |
| Samsung | No | Same view as InterDigital and Huawei. |
| Nokia | No | This scenario should not be prioritized in this study. It can be considered later as part of Rel. 18. Beam management (intra-cell mobility) is a different use case from mobility which covers PCell handover or PSCell change. |

In [5666],it is proposed to introduce the following events for **Reduction of the probability of unintended events associated with mobility case:**Successful HO with underlying issue, too early or to late PSCell change, triggering PSCell change to wrong PSCell.

**Q4.1-2 Companies are invited to provide views on whether the above events should be included or not.**

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| **Company** | **Yes/No** | **Comment** |
| InterDigital | Yes | We are ok with adding these  |
| Huawei | Yes | We think these are the main cases that can be significantly promoted by AI. |
| Lenovo, Motorola Mobility | Yes |  |
| Intel | Yes |  |
| Samsung | Not sure | We may focus on single connectivity for this SI. If we have time after single connectivity case, we can study the DC case. So prefer to delay the DC case study. |
| Nokia | Yes | Those events can be included as unintended events to be optimized. However, it would be good to clarify that PSCell change is different from PCell handover.PCell handover refers to the change of Primary Cell by means of handover procedure (baseline handover, conditional handover or DAPS HO).PSCell change can be MN-initiated or SN-initiated and is performed using the PSCell change procedure of Rel. 15 or Conditional PSCell Change (CPC) of Rel. 17. |

## 3.2 Solutions and standard impacts

### 3.2.1 General

In [4816], it is proposed to add a new chapter *Locations for* *AI/ML Model Training and AI/ML Model Inference* and move the listed options for the location of AI/ML Model Training and AI/ML Model Inference into this chapter.

**Q3.2.1-1 Companies are invited to provide their views on the restructure i.e. a dedicated chapter for all possible options on the location of AI/ML Model Training and AI/ML Model Inference.**

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| **Company** | **Support/not support** | **Comment** |
| InterDigital | Support | We need to do this or something like this. Having text in the section 5.3.2 is frowned upon in drafting specifications if there are subsections 5.3.2.1, 5.3.2.2. This is just editorial. A different heading for the new 5.3.2.1 is ok, this is just our suggestion.  |
| Huawei | No strong opinion | The more important is to make things clear, as to the structure, either way could work. What is missing is that we think for offline training, technically it should not be located inside RAN. |
| Lenovo, Motorola Mobility |  | No strong view, current structure looks good too.  |
| Intel |  | We think the current structure is look enough. |
| Samsung | No strong view | No strong view about it. But it is better to keep all three use case in consistence. |
| Nokia | No strong view |  |
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In [5479], it is proposed to introduce the following bullets in general part.

1. For the AI/ML Mobility Use Case, a gNB can train and execute an ML model to determine which UE configuration it can provide to its UEs. Subsequently, a gNB provides its neighbours with network performance predictions that UEs will observe when they are handed over to it.

The main intention of introducing this bullet is copied as below:

*In case the source gNB has multiple possible target gNBs for handover, all satisfying radio conditions, the source may estimate the UE configuration at each candidate target gNB and make a more informed decision on the target node. This could also help to improve CHO preparations to the best possible candidate target cells. This can save unnecessary resource reservations to target gNBs that are not selected finally by the source gNB as well as unnecessary signaling to release the resources through handover cancellation messages.*

1. Capture the different options on locations of *AI/ML Model Training and AI/ML Model Inference for* trajectory prediction.

The different options are as blew:

*Considering the locations of AI/ML Model Training and AI/ML Model Inference for mobility solution, following two options are considered:*

* *The AI/ML Model Training function is deployed in OAM, while the Model Inference function resides within the RAN node*
* *Both the AI/ML Model Training function and the AI/ML Model Inference function reside within the RAN node*

*Furthermore, for CU-DU split scenario, following option is possible:*

* *AI/ML Model Training is located in CU-CP or OAM, and AI/ML Model Inference function is located in CU-CP*
1. The study should consider solutions to obtain data for trajectory prediction of a given UE beyond the next cell change with the following reasons.

*Considering UE could not always support location report and only limited trajectory prediction can be supported in legacy networks by using UE history information from neighbour NG-RAN nodes, it is proposed to enable a NG-RAN node to obtain not only information about the next cell change (handover or cell-reselection), but also UE mobility information over a number of cell changes a UE makes into the future. With this, it can give network an enhanced view of UE trajectory which can be used to improve HO related actions.*

4) Capture the requirements for trajectory prediction as below:

* Restrict the amount of mobility history information only to gNBs that have requested such information
* Allow to obtain information on UEs that camped also in idle mode on cells under the gNB.

The rationale to introduce this bullet is copies as follows:

*One simple way of obtaining trajectory information over a number of cell changes, to be used for the training phase of an ML algorithm at the gNB (gNB-CU), is to mandate each of the gNBs that have served a UE to inform all previous serving gNBs where the UE was connected/camped on about UE mobility information, e.g., visited cell/radio measurements. However, it is likely that only a minority of gNBs will require such training information. Therefore, systematically sending this information would introduce a lot of extensive signaling and would not be preferable. A first requirement for a trajectory prediction solution should therefore be that UE mobility information for training purpose is only sent to gNBs that request such information. A second requirement is to obtain information on UEs that camped in idle mode on cells under the gNB.*

**Q3.2.1-2 Companies are invited to provide their views on the above 4 bullets.**

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| **Company** | **Views** | **Further Comment** |
| Huawei | 1. Not sure the benefits
2. Clarifications needed
3. Clarifications needed

In principle yes but | 1. We think the AI/ML inference output should be able to make a reasonable decision for each UE, since the decision could be per UE basis, and input for each UE is different, not sure what additional considerations needed.
2. We already agreed that training could be located in different place, it seems that this proposal is for trajectory prediction only? And any specific points/issues to be addressed here?
3. In general we agree that trajectory prediction should be useful, which could be used as input for HO decision, but what this proposal means, the trajectory info should include “*a number of cell changes a UE makes into the future*”?

Just try to understand the exact meaning, the first bullet seems to say that gNB should initiate the request for mobility history? And the second bullet requires the mobility history information should support idle? |
| Lenovo, Motorola Mobility | Yes: (2)(3)(4)No: (1) | (1) generating UE configuration based on AI looks a new use case, which is rather general, shall be decoupled from mobility optimization. Regarding the use case itself, it is a bit too early to consider in our view.  |
| Intel | 1) Not sure2) ok3) seems not necessary4) yes for first point, No second point | For 1), RRC configuration of one UE contains many aspects, certain optimization also needs to check with RAN2 whether it’s feasible or not.For 2), we also think continuous model training in NG-RAN for model training in OAM should be supported.For 3), if we understand the proposal correctly, it is proposed to predict not only the next target cell, but also target cell in future? We think it may be not be necessary to generate prediction so long time in advance.For 4), for collecting information from IDLE mode UE, we need to check with RAN2 on the feasibility. |
| Samsung | No to (1)Seems not need to (2) due to already agreedYes to (3)Yes to (4) | (1) It is a little bit confused that how it is benefit for mobility optimization.(2) This one already captured in the TR and we may remove the FFS of UE trajectory prediction in model output.(3) We agree trajectory prediction can help to do mobility optimization decision. For “beyond the next cell”, actually it depends on the granularity of trajectory prediction.(4) Yes. To avoid unnecessary data collection, UE reports the mobility related on based on request. |
| Nokia | Yes to (1), (2), (3), (4) | (1): Current HO procedure could be improved if the source gNB had access to predictions of the UE Configuration that could be provided by a Target gNB before the HO is initiated. For instance, the source node can be informed by the target node about the likelihood a PDU session that is associated with a particular slice is not admitted during the handover preparation. (2), (3) AI/ML Trajectory prediction could be Trained in OAM or in RAN (CU-CP) and inference can be in gNB (CU-CP). For Training an AI/ML Trajectory prediction algorithm UE Mobility History information available at gNB (CU) could be analysed and exploited. Having trajectory prediction information over a number of cell changes (not only one cell change) can improve related HO actions. (4) Even though AI/ML Trajectory prediction over a set of next cells can improve HO, some restrictions should be added to control the amount of exchanged information; not all nodes need to support AI/ML Trajectory prediction. Trajectory both of Connected UEs as well as UEs in Idle/Inactive mode could be recorded.Answering to Huawei’s questions, we have an existing mechanism in place, the mobility history, which we can further study to obtain trajectory information for mobility. We could study how this mechanism can be extended to enable prediction of upcoming cell changes. Depending on algorithm, maybe we need to predict the next 3 cell changes or to monitor a certain UE as it traverses different gNBs. At the same time, we need to put some requirements to limit the amount of information we communicate over the interfaces to only those nodes that need this extended mobility history information. On the idle mode UE information, the second bullet says that when possible the obtained trajectory is not only for connected mode UEs but also for idle mode UEs to maintain the continuity of the trajectory information.  |
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In [5474],there are two proposals regard to the general part：

1. Remove the listed options on the location of Model training and Model Inference for CU/DU split scenario and only clarify that Model Inference can be in the gNB-CU.
2. To improve the mobility decisions at a gNB (gNB-CU), a gNB can request mobility feedback from a neighbouring node. Details of the procedure are FFS.

**Q3.2-3 Companies are invited to provide their views on the above proposals.**

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| **Company** | **Views** | **Further Comment** |
| Huawei | Fine |  |
| Lenovo, Motorola Mobility | 1) see comment2) ok | We can remove 1) if Model Inference in DU is not proposed by any company. We agree that assuming both training and inference in CU could be a start point .  |
| NEC | 1. Not sure
2. Maybe
 | 1. It is better to also consider split architecture.
2. First need to see procedure.
 |
| Intel | Ok with both. |  |
| Samsung | (1) Maybe(2) OK | For (1), prefer to training in OAM or CU, inference in CU. |
| Nokia | (1) Not OK completely(2) OK | (1): We need to capture still the different solutions where Training can be placed in OAM or in the CU since this yields different flow charts. |
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In [5666],it is proposed to capture that offline training is in OAM and online training is in NG-RAN node.Futhurmore,it is proposed to add a note that it is not precluded that offline training could be deployed in the gNB by implementation. **Q3.2.1-4 Companies are invited to provide their views on the above proposals.**

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| **Company** | **Views** | **Further Comment** |
| Huawei | Agree | As the proponent, of course we think we need to make things clearer.  |
| Lenovo, Motorola Mobility |  | It would be beneficial to clarify what is really online training and offline training. Maybe it can be discussed based on exact solution.  |
| NEC |  | Options for Model Training and Model Inference were discussed before and included into draft TP. Not sure proposed text adds new information. |
| Intel | Agree with comment | We also propose to allow continue model training in Ng-RAN based on received model from OAM in R3-215270.How to capture the note can be discussed in phase 2. |
| Samsung | Seems no need | The online and offline training are distinguished by whether to update the model during inference stage by new-collected data. The choice of online/offline training and detailed training algorithm are out of scope. It is reasonable to put offline training in OAM and online training in RAN. But the training in the TR includes both online and offline ones. And the current options in TR can cover both online/offline cases. |
| Nokia | No need | We think that there is a general understanding that offline training is in OAM and online training in the RAN. We are afraid that such clarification would create more confusion. |
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### 3.2.2 AI/ML Model Training in OAM and AI/ML Model Inference in a NG-RAN node

In [5526], it is proposed to introduce a flowchart which clearly describes the interaction between UE and NG-RAN node as well as the interaction between NG-RAN node and OAM. The intention is to make the solution much integrity and stable.

In [5666], there is also proposal to have a flowchart which also include mobility enhancement cases.

**Q3.2.2-1 Companies are invited to provide their views on whether the new introduced flowchart is needed or not. If it is needed, whether the description on each step is agreeable?**

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| **Company** | **Yes/no** | **Further Comment** |
| Huawei | Yes | We think to introduce a flow chart would be better to describe the mechanisms. |
| Lenovo, Motorola Mobility | Yes: [5526]No: [5666] | OK to describe the OAM-RAN solution with a flowchart as in [5526]. We can work on the exact wording in the second round.For RAN-RAN solution, we prefer to add necessary steps/elements on top of the current flowchart.  |
| Intel | Ok with [5526] | The details can be discussed in updated TP in phase 2. |
| Samsung | Prefer [5526] | Prefer to keep the same style as current flowchart in 5.3.2.2 in the TR. |
| Nokia | No because | [5666]: The figure illustrated here is one possibility which is in principle correct, but it is limited to a source receiving predicted load info over the interfaces from the neighbours and calculating predicted serving load. In our view, we should capture a more general mobility procedure that is flexible what information/predictions can be received from the neighbours.[5526]: We haven’t agreed yet on the Model Deployment/Update and Model Performance Feedback arrows so at least these arrows are not agreeable by us. |
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In [5270], it is proposed to add description that *NG-RAN node can also continue model online training based on the received AI/ML model from OAM.*The main reason is as follows*:*

*Mobility optimization has higher requirement to real-time performance. The real environment of each NG-RAN node is very essential to making the most accurate decision for mobility optimization. Hence, supporting continuous/further training at NG-RAN node on top of received AI/ML model from OAM is very important for mobility optimization use case.*

**Q3.2.2-2 Companies are invited to provide their views on whether** *NG-RAN node can also continue model online training based on the received AI/ML model from OAM***.**

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| **Company** | **Yes/no** | **Further Comment** |
| Huawei | Yes | We think that, for online training, this should be a typical way that NG-RAN could perform online training over a trained model received from OAM. |
| Lenovo, Motorola Mobility |  | It would be beneficial to clarify what is really online training and offline training. Maybe it can be discussed based on exact solution.  |
| NEC | Yes | This could be possible |
| Intel | Yes | We are the proponent. |
| Samsung | Yes | It is possible to continue the online training to update the model based on received one from OAM.  |
| Nokia | Yes | It will be many times the case that a gNB receives from OAM a pretrained ML Model that will need to retrain according to its physical environment in an online manner. |
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In [5666],it is proposed to introduce descrption on the impact to Xn interface as below

**Potential standard impacts:**

* **Xn interface impact:**
	+ Delivery of the UE trajectory/mobility/performance prediction from the source NG-RAN node to the target NG-RAN node;
	+ Predicted load info from candidate target NG-RAN node to source NG-RAN node
	+ Performance Feedback of the received UE trajectory/mobility/performance prediction from the target NG-RAN node to the source NG-RAN node.

**Q3.2.2-3 Companies are invited to provide their views on above proposal.**

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| **Company** | **Yes/no** | **Further Comment** |
| InterDigital | No  | We don’t disagree with the points made but this information is or should be included in the input and output data sections  |
| Huawei | Yes | The messages mentioned above are necessary for mobility enhancements. |
| Lenovo, Motorola Mobility | Yes |  |
| Intel | Yes |  |
| Samsung | Yes in general | Yes in general, but just one confusion. It is a little confused about why need to transfer the UE performance prediction and how this exchange can contribute to the mobility optimization. |
| Nokia | Yes |  |

### 3.2.3 AI/ML Model Training and AI/ML Model Inference in NG-RAN node

Currently, in the flowchart, there are 8 steps while only 7 steps in the procedure description, there are several alternatives to fix this part

1. In the procedure text, add description on step 8 and keep the flowchart unchanged[5526][5563][5332]
2. In the flow chart, change the step 8 as handover initiation procedure and also add description on step 8[4816]
3. In the flow chart, add step 9 which is the feedback from NG-RAN node 2 to NG-RAN node 1 and add the description on it[5270][5474]

**Q3.2.3-1 Companies are invited to provide their views on which alternative are preferred**

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| **Company** | **Which alternative are preferred** | **Further Comment** |
| InterDigital | 2 | Step 8 should be described so 1) is an alternative. We made step 8 a box since HO and related include messages to the UE. We are not against adding a step 9 as in 3) |
| Huawei | Slightly prefer 1) |  |
| Lenovo, Motorola Mobility | Maybe 1) and 3) | No strong view as the figure reflects the information flow correctly.  |
| Intel | Ok with 1) and 3) | For 2), it is not clear to us what is the handover initiation and what optimal actions are refereed in the description. |
| Samsung | 1 and 3 | The trajectory prediction to target node and performance feedback of handed over UEs can help to do proper mobility optimization decision. |
| Nokia | 3 | Adding step 9 gives a more complete picture. |
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There are some other proposals on this topic as below:

1) In [5526] and [5563], it is proposed to include UE predicted trajectory in handover request message for NG-RAN node 1 to NG-RAN node 2 for future mobility optimization. The proposal also applied to 3.2.2.

2) In [5332], it is proposed to introduce two steps via which NG-RAN node 1 could obtain input from NG-RAN node 2 for model training and model inference separately.

3) In [4816],it is proposed to introduce Xn procedure to allow NG-RAN node 1 receives asynchronously reports from neighbour NG-RAN node2 for model training.

4) In [4816], it is proposed to clarify that report from UE and other adjacent NG-RAN node could be repeated for several times.

5) In [4816], it is proposed to clarify that the UE measurement report serve as reference data for real-time or near real time mobility optimization.

6) In [5474],it is proposed to introduce a class 1 procedure to allows NG RAN node 1 to subscribe to the Mobility

Feedback Update of the neighbouring NG RAN nodes.

**Q3.2.3-2 Companies are invited to provide their views on above bullet****s**

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| **Company** | **Yes/no** | **Further Comment** |
| InterDigital | Yes for 3,4,5Maybe on 1, 2, 6 | First to clarify 3 – we introduce a message from NG-RAN node 2 because there are inputs from neighbouring NG-RAN nodes. The Xn procedure is not a new one (but could be SHR, RLF report, or other messages.Not necessarily against 1 or 6 but we feel it is not necessary to discuss exactly which messages are to be added or modified. The work item can decide that.For 2 we mostly agree, but it is not clear we need two separate messages from NG-RAN node 2.  |
| Huawei | See comments | Technically most of the proposals are not wrong, but not sure if we should step into such detailed discussion, e.g. a new procedure, how UE predicted trajectory info is exchanged (even, if there is a need to exchange), whether class 1 or class 2 should be used or not; especially for 5) and we don’t understand what real-time or near real time means, we think measurement report from UE could be used for model training and inference as well, what else?  |
| Lenovo, Motorola Mobility | Yes: 2) 3)  | 1) whether to send the predicted trajectory in HO request message can be FFS. 4)5) not sure if there is any spec impact6) procedure used to subscribe feedback can be FFS.  |
| Intel | 1) No2) ok3) ok4) 5) not sure what is the spec impact6) ok |  For 1), we don’t think UE predicted trajectory is the output of mobility use case. |
| Samsung | Yes: 1), 2), 6)Maybe: 3), 4), 5) | For 3), it is a little bit confused about the “asynchronously reports”. Maybe more clarification is required.For 4), it seems reasonable, but relies on the specific reporting procedure. Prefer to discuss it during WI phase.For 5), a little bit confused about “real-time” and “near-real-time”. Maybe more clarification is required. |
| Nokia | 1), :Yes2), 3), 4), 5) 6) : No | 2) We don’t need to separate these steps. It will be up to the receiving node how to interpret the data, and how to use them for Model Training or Model Inference.3) What is the meaning of asynchronous reports and how is that different from what we can support today?4): Not needed. It should be clear that this is just to illustrate the procedure and that more than one reports should be send by neighbouring nodes.5): is not needed in our view.6): We could support that NG RAN node 1 requests from a neighbour NG RAN node Mobility Feedback, but it is unclear to us how a subscription to this information can help. Does subscription mean that this information could be broadcasted to multiple NG-RAN nodes? How can this improve Handover as opposed to a regular XnAP procedure? |
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### 3.2.4 Input data

There are still 5 FFSs on the input data which is required for mobility management and different views are provided in [4816][5270][5332][5479][5526][5528][5563][5699].The input data which is still FFS is as below:

**Input Information from UE:**

* a)FFS UE historical location information from MDT, e.g., Latitude, longitude, altitude, cell ID
* b)FFS predicted traffic

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

* c) Position, resource status, FFS QoS parameters of historical HO-ed UE (e.g., loss rate, delay, etc.)
* d)FFS Information about the performance of handed over Ues

*e)FFS on whether new UE measurements are needed.*

**Q3.2.4-1 Companies are invited to provide their views on whether the above information could be used as input data for mobility management?**

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| **Company** | **Yes/no** | **Further Comment** |
| InterDigital | Yes | For UE historical location from MDT, we moved it to the 3rd bullet since it also includes UE historical information, we kept the FFS in our contribution but are ok with removing the FFS. We also clarified in this UE history bullet clarify it is collected over time, not by a single UE message, to avoid confusion with UE history passed as a group over Xn.  |
| Huawei | In general yes, but | Anyway we think there should be further discussions on each detailed parameter case by case, e.g. it should be useful for some KPI info such as loss rate, delay, throughput, but we may have to confirm one by one during normative phase. And maybe we need to clarify here the difference between QoS parameters of historical HO-ed UEs and performance of HO-ed UEs; For new UE measurement, we think FFS should be kept. |
| Lenovo, Motorola Mobility | Yes: a)No: b)Maybe no: c) d) | b) RAN3 shall avoid tackling solutions which requires UE AI/ML capability, e.g., asking UE to provide predicted traffic.If after every HO event, the target node will provide feedback about UE performance after HO, then the source node automatically knows all the information about historical performance after HO, or? Then there maybe no need to provide extra “performance of HO-ed UEs”  |
| Intel | No to a) | As explained in [5270], regarding to the UE historical location information from MDT, as specified in TS38.331 [3], *LocationInfo* is used to transfer detailed location information available at the UE to correlate measurements and UE position information. It will be reported to the network as measurement results. The exact latitude, longitude, altitude information of the UE are encoded in *locationCoordinate* IE carried in *CommonLocationInfo*. This information cannot be decoded at NG-RAN.  |
| Samsung | Yes except (b) | For (b), UE involvement is still under discussion, So prefer to delay the discussion of UE inference based on the conclusion of UE involvement.For (c) and (d), Yes. The performance of handed over UEs from neighbor nodes can evaluate the impact of the strategy generated from AI/ML model. For example, in reinforcement learning, the performance data can be set as the reward for model training to improve the model efficiency. Apart from that, they can also describe the node status to provide reference for handover decision. One of the mobility optimization objective is to guarantee the QoS performance for the UE during mobility, so QoS parameters should be contained in the performance feedback, such as loss rate, delay, etc., to improve the handover robustness and user experience. |
| Nokia | Input from UE: NoInput from neighbouring RAN nodes: We support resource status  | Input for UE: It is unclear if UE is willing to provide such detailed location information and whether details, on this granularity, would have a considerable improvement in performance. Also, on predicted traffic, it seems to assume that UE can perform AI/ML predictions which is not our current understanding for the scope of the study. Input from neighbouring RAN nodes: We are not sure what this position from the neighbour gNB in the input reflects. On UE measurements we support to keep the FFS.  |

**Some other information proposed to be included as input data is listed below：**

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

* 1)UE mobility statistics parameters, e.g., UE location statistics (duration of the time slot) [5528]
* 2)UE mobility predications, e.g., predicated UE location information in the analytical period[5528]

Information from the neighbor RAN nodes:

* 3)Load prediction[5332]
* 4)UE’s successful DC offloading information in the past and received from neighboring RAN nodes[5528]
* 5)Information about the performance of handed over UEs and offloaded DC Ues[5528]
* 6)Estimated Network Performance (if the neighbour RAN node is a Target gNB)[5479]
* 7)Cost of CHO Handover preparation e.g., reflecting the impact in terms of preparation time [5479]
* 8)UE performance prediction/estimation[5474]
* 9)UE dwelling time per cell[5474]
* 10)RAN visible QoE metrics e.g., buffer level[5474]

Information from UE:

* 11)Near-term UE location information in the future, e.g. future location received from UE’s application layer, future location predicted by AI/ML model at the UE side[5270]
* 12)RAN visible QoE metrics e.g., buffer level[5474]
* 13)Trajectory information[5474]
* 14)UE Mobility history information[5474]
* 15)UE trajectory[5474]
* 16)SON Reports of handovers that are successful handover report,[5474]

Input Information from Local node:

* 17)UE’s CQI, SRS(local node) [5270]
* 18) Remove the bullet UE trajectory prediction output (will be used by the RAN node internally)[5474]

Input Information from LMF:

* 18)Historical UE location information[5270]
* 19)Predicted UE location information[5270]

**Q3.2.4-2 Companies are invited to provide their views on whether the above information could be used as input data for mobility management?**

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| --- | --- | --- |
| **Company** | **Yes/no** | **Further Comment** |
| Huawei | See comments | (1), (2): not needed for now. For RAN related use case, we are not sure what useful info RAN could get from CN;For 3), this was also discussed in LB use case, technically the load prediction info might be also useful for mobility decision；For 4) and 10), not sure if there are any obvious benefits to mobility optimization.OK for 5) 6) 7) 9), we could further discuss the need of them, maybe we could just list one of them as example.For 4), 8) and 10), not sure the benefits to mobility optimization, e.g. RAN visible QoE metrics, they are mainly for resource usage evaluation, what’s the need to predict a UE’s performance, etc.OK for 14) and 16), they are normal SON or MDT related info concerning mobility; for other information listed in (11~16), it seems that RAN could generate them, there are overlaps here, e.g. UE trajectory prediction could be done by RAN.For 17) and 18), we are not sure, does mobility require precise positioning info from LMF, maybe not needed.In general, some of those info might be useful, but not sure we should go one by one, we could start from what might not be needed for the moment, e.g.: we think further discussions are needed on whether there is a need to get information from CN; why RAN visible QoE metric is useful to mobility enhancements; for trajectory prediction, if RAN could do that, why we need from UE? Similar comments to UE performance prediction/estimation. |
| Lenovo, Motorola Mobility | Yes: 3) 10) 12) 16) | 1) 2) 18) 19)have CN impact which may be better to avoid for now.4)5) If after every HO event, the target node will provide feedback about UE performance after HO, then the source node automatically knows all the information about historical performance after HO, or? Then there maybe no need to provide extra “performance of HO-ed UEs”6) need to clarify what is network performance 7) is very AI/ML algorithm dependent8) does it mean neighbour node will predict the UE performance and provide the info to source node before HO execution? Not sure how it can be done. 9) seems more like rewarding/feedback information?11) that requires some application involvement, shall not be considered for now. 13) 14) 15) how is it different from those in Q3.2.4-1?17) HO is normally made based on L3 measurement, we don’t see the need to use L1 measurement for HO decision for now. 18) don’t see why not using the predicted trajectory locally if available.  |
| Intel | Yes to 1) 2) 3) 11) 16) 17) 18) 19) | For RV QoE, it is not clear to us how RV QoE is beneficial to mobility optimization. For information from CN and LMF, we are ok to combine them as the same bullet. |
| Samsung | Yes: 3), 10), 12), 13), 14), 15), 16) | For 1) 2) 18) 19): same view as Lenovo. At this stage, it is better to avoid CN impact.For 4) 5), it is DC related. Prefer to focus on normal case firstly. And if we have time after normal case, we can study DC case then.For 6), it is a little confused about what the network performance is.For 7), it is implementation related.For 8) 9), maybe need more clarification, including how to do and what is the benefit.For 11), whether and how to involve UE are still under discussion. Prefer to delay the discussion about inference in UE.For 13) 14) 15), support them. But it seems they are same as “a)FFS UE historical location information from MDT, e.g., Latitude, longitude, altitude, cell ID” in 4.2.4-1. We may just remove “FFS”.For 17), not clear about the benefit.For 18), the trajectory prediction exchange can help node to do further mobility decision. So it may not be used by node internally. |
| Nokia | Information from the Core/LMF: No Information from Neighbour NG-RAN nodes: 3),4),5), 6)7), 9) :OK8), 10): Not OKInformation from UE11), 12), 13), 15): Not OK14),16: OKInput from Local node: Not OK | 13) and 15): We think that Trajectory information from the network would be a more reliable source of UE location. It would also have less UE impacts8): For a UE to predict its performance we would need to assume that UE is capable of providing AI/ML predictions. To our understanding this is not in the scope of this study. 10,12): Unclear how QoE information can be useful for the mobility use case.11),13),15): We support that UE location/trajectory is calculated by the network and not through UE reporting. In our view, network cannot rely on UE to provide its location information since it may not be willing to do so.Input data from local node: UE’s CQI and SRS could be useful, but we are missing the standardization impacts from those. Trajectory prediction output could help a neighbouring node better prepare its resources for a possible HO. |

### 3.2.5 Output data

One FFS i.e. *FFS* *UE trajectory prediction (Latitude, longitude, altitude of UE over a future period of time)* is left on the output data. Among the contributions which discuss this issue, only one company thinks *UE trajectory prediction* should not be the output data[5270][5474] while the others[5056][5332][5526][5563][5699] [5528]support to keep it as output data.

The main reason not to include *UE trajectory prediction as output data* is as follows:

* Location information reported in measurement report depends on the positioning procedure. The detailed location information (e.g. longitude, latitude, altitude, etc) is transparent to NG-RAN node.
* It is considered UE trajectory prediction is performed and collocated with nodes which can perform legacy positioning calculation and already have UE’s location information, i.e. UE and LMF, which can reduce frequency of exchanging UE history location information and reduce complexity.
* It is not needed to predict the trajectory information at the local node as this can be derived from UE speed and UE position

**The reason to keep** *UE trajectory prediction as output data* is as follows:

* + - Outputting RRC decisions directly based on raw inputs collected throughout the network may not fully utilise the benefit of AI/ML and UE trajectory prediction can be used as input for the mobility decision.
		- Deploying the AI/ML function of UE location prediction at the UE or the LMF has drawbacks comparing to the UE location prediction in NG-RAN node.For example, it is too energy and timing consumption to do it in UE side and LMF is far from Uu interface.
		- It is not necessary to make the geographical location information an input of model inference of geographical location prediction—in a sense the UE geographical location prediction module can be integrated with the UE positioning module.
		- UE trajectory prediction could be transferred to the target NG-RAN node for reference via Handover request. Hence, UE trajectory prediction should also be included as the output data.

**Q3.2.5-1 Companies are invited to provide their views on whether** *UE trajectory prediction* **could be regarded as output data?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/no** | **Further Comment** |
| Huawei | See comments | Maybe the first thing is, trajectory prediction is anyway needed, and it even could be outcome of inference, then technically there are two approaches here, one is that this is just used as an input for traditional HO decision making; the other is that this is used as input for another model training for HO decision. |
| Lenovo, Motorola Mobility | Yes | As explained by the moderator.  |
| Intel | No | The key difference between the two options is not whether handover decision is by AI/ML model or by legacy behavior. The key difference is the location of AI/ML model for UE trajectory prediction. As we explained in the contribution [5270], performing UE trajectory in RAN requires data transfer of UE location information from either UE or LMF to RAN, where RAN originally is transparent to such information. This will introduce a huge signaling impact to the system. |
| Samsung | Yes | As explained by the moderator. |
| Nokia | Yes | Trajectory prediction information can help a neighbouring gNB make better handover decisions. So, we support sending it as part of the Output data. |

**Some other proposals to introduce more output data or to update on the existing output data are listed below：**

* 1)Target PSCell in PSCell addition and change[5332](new)
* 2)Candidate PSCells in CPAC[5332](new)
* 3)UE trajectory prediction (Latitude, longitude, altitude of UE over a future period of time)

Estimated arrival probability in CHO and relevant accuracy and confidence interval[5332]

* 4)Predicted handover target node, candidate cells in CHO, may together with the accuracy and confidence of the predi[5332]
* 5)the predicated target SN node IDs for DC together with the confidence of the predication[5528](new)
* 6)Validity time corresponding to predicted handover cells and predicted candidate cells[5270]
* 7)Estimated arrival probability, priority and handover execution timing of predicted candidate target cellsand relevant confidence interval[5270]
* 8)Estimated arrival probability (particularly for CHO, but is relevant for all HO types) and relevant confidence interval for HO and data forwarding optimization strategies[4816]
* 9)Predicted handover target node in the case of legacy and DAPS HO, list of candidate cells in CHO, together with the confidence of the prediction[4816]
* 10)Traffic predictions for resource allocation purposes in mobility (for CA/DC activation/deactivation and Data Forwarding decisions.) [4816](new)

**Q3.2.5-2 Companies are invited to provide their views on whether the above information could be output data?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/no** | **Further Comment** |
| InterDigital | Yes on 1,2,5Yes on 8Yes on 9Yes on 10 Open to 3, 6 | Bullets 1, 2, and 5 should be combined to handle DC issuesBullet 3 (part) 7 or 8 modify the same text. Estimated arrival probability is relevant for CHO but it applies in general to HO, so we like wording in 8 better but would support adding accuracy to the text as per in the second line of 3.This overlaps with 4, Predicted handover target node applies to all handover times (list of candidates for CHO) |
| Huawei | See comments | Some of them are overlappedOK for 1) 3) 5) 7) 8) 9) 10); 4) should be output of inference, but as commented, we are not sure the benefits of accuracy and confidence, 9) is subset of 4)? Again, we are not sure if we should go through one by one, maybe we could start from some of them, e.g. 1), 9)? |
| Lenovo, Motorola Mobility | Yes: 1)2)3)4)6)Maybe: 8) |  |
| Intel | Ok to 1) 2) 4) 5) 6) 7) 8) 9)  | We see there’s some overlap between 4) 7) 8) and 9). It would be good to merge the proposals following prediction for target HO, prediction for CHO, etc. |
| Samsung | Yes to 3) 4) 6) 7) 8) 9) 10)Yes for 1) 2) 5) but may delay the DC case discussion | For 1) 2) 5), they are DC related. We may focus on normal case firstly. If time allows, we can continue to study DC cases after normal case. |
| Nokia | 1),2), 4), 5), 7), 8),9) :OK3), 6), 10) : Not OK | 3) It is not obvious that UE will be willing to provide its detailed coordinates to the network.4),5),7) 8),9) Ok, but we do not support sending the confidence/accuracy of the prediction. 6): We think that validity time can be indicated by sending a new prediction when the previous measurement is invalid.10) For traffic predictions we prefer to have feedback from RAN2.  |

### 3.2.6 Others

In [5332], it is proposed to introduce a chapter for rewarding information as below:

5.3.2.x Rewarding Information

* The feedback from the target SpCell or the UE whether the mobility decision is good or not (e.g. if mobility is successful)

In [5270],it is proposed to introduce a chapter for feedback as below

5.3.2.5 Feedback

* Throughput, packet delay of the handed-over UE, etc

**Q3.2.6-1 Companies are invited to provide their views on above proposals**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/no** | **Further Comment** |
| Huawei  | Not needed | Rewarding information is part of model training itself, we already agreed to have feedback, not sure what else we need, then maybe there is no need to introduce a new chapter. |
| Lenovo, Motorola Mobility | Yes | Both are fine, the point is to capture some feedback/rewarding information which can be used to update the AI model.  |
| Intel | Ok | We are the proponent. |
| Samsung | No to rewarding informationYes to feedback | The rewarding information is up to model training algorithm design, which is out of RAN3 scope. In details, whether need to and how to define the reward value are implementation-specific. Prefer to define the feedback parameters, and leave reward info to implementation.For the feedback, performance of handed-over UE can be the one to evaluate the action to improve the model training efficiency or to describe the current node status to provide the reference information for model inference. So it is beneficial. |
| Nokia | No | We should consider feedback on a case by case basis. In this isolated way, it is unclear how the feedback or reward can improve AI/ML Mobility. |

# References

|  |  |  |
| --- | --- | --- |
| [R3-214816](file:///D%3A%5C%5C%E4%BC%9A%E8%AE%AE%E7%A1%AC%E7%9B%98%5C%5CTSGR3_114-e%5C%5CDocs%5C%5CR3-214816.zip) | Correction of Mobility Optimization - Solutions and standards impacts (InterDigital ) | Other |
| [R3-215056](file:///D%3A%5C%5C%E4%BC%9A%E8%AE%AE%E7%A1%AC%E7%9B%98%5C%5CTSGR3_114-e%5C%5CDocs%5C%5CR3-215056.zip) | Discussion on Standards Impact on Mobility (CATT) | Discussion |
| [R3-215130](file:///D%3A%5C%5C%E4%BC%9A%E8%AE%AE%E7%A1%AC%E7%9B%98%5C%5CTSGR3_114-e%5C%5CDocs%5C%5CR3-215130.zip) | Further discussion on use case of mobility optimization (Purple Mountain Laboratories) | Discussion |
| [R3-215270](file:///D%3A%5C%5C%E4%BC%9A%E8%AE%AE%E7%A1%AC%E7%9B%98%5C%5CTSGR3_114-e%5C%5CDocs%5C%5CR3-215270.zip) | AI/ML based mobility optimization (Intel Corporation) | Discussion |
| [R3-215332](file:///D%3A%5C%5C%E4%BC%9A%E8%AE%AE%E7%A1%AC%E7%9B%98%5C%5CTSGR3_114-e%5C%5CDocs%5C%5CR3-215332.zip) | Discussion on standard impact to support mobility optimization (Lenovo, Motorola Mobility) | Discussion |
| [R3-215479](file:///D%3A%5C%5C%E4%BC%9A%E8%AE%AE%E7%A1%AC%E7%9B%98%5C%5CTSGR3_114-e%5C%5CDocs%5C%5CR3-215479.zip) | (TP for TR 37.817) Further Discussion on Standard Impacts of AI/ML Mobility Optimization (Nokia, Nokia Shanghai Bell) | Other |
| [R3-215526](file:///D%3A%5C%5C%E4%BC%9A%E8%AE%AE%E7%A1%AC%E7%9B%98%5C%5CTSGR3_114-e%5C%5CDocs%5C%5CR3-215526.zip) | Further discussion on solution to AI-based mobility optimization (ZTE Corporation, China Unicom) | Other |
| [R3-215528](file:///D%3A%5C%5C%E4%BC%9A%E8%AE%AE%E7%A1%AC%E7%9B%98%5C%5CTSGR3_114-e%5C%5CDocs%5C%5CR3-215528.zip) | Input/output information for support of AI/ML enabled Mobility Optimization (LG Electronics) | Discussion |
| [R3-215563](file:///D%3A%5C%5C%E4%BC%9A%E8%AE%AE%E7%A1%AC%E7%9B%98%5C%5CTSGR3_114-e%5C%5CDocs%5C%5CR3-215563.zip) | Discussion on Standard Impact for AI/ML based Mobility Optimization (Samsung, Verizon Wireless) | Discussion |
| [R3-215699](file:///D%3A%5C%5C%E4%BC%9A%E8%AE%AE%E7%A1%AC%E7%9B%98%5C%5CTSGR3_114-e%5C%5CDocs%5C%5CR3-215699.zip) | Remaining issues for AI based Mobility and Energy Saving (CMCC) | Discussion |
| [R3-215666](file:///D%3A%5C%5C%E4%BC%9A%E8%AE%AE%E7%A1%AC%E7%9B%98%5C%5CTSGR3_114-e%5C%5CDocs%5C%5CR3-215666.zip) | (TP to TR 37.817) Remaining issues for AI based mobility enhancements and load balancing (Huawei) | other |
| [R3-215474](file:///D%3A%5C%5C%E4%BC%9A%E8%AE%AE%E7%A1%AC%E7%9B%98%5C%5CTSGR3_114-e%5C%5CDocs%5C%5CR3-215474.zip) | AI/ML Load Balancing and Mobility Optimization use cases (Ericsson) | OtherMove to 18.4.2 |

# 5 Conclusion, Recommendations [if needed]

If needed