**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:\Users\zhangxy\Downloads\Inbox\R3-214223.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?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Samsung | Yes | This classification is from AI/ML functionality aspect instead of algorithm aspect. For these two types, the AI functionality and corresponding input/output are not same. The classification can help to sort out the standard impact for different AI functionalities. |
| Lenovo, Motorola Mobility | Yes, with comment | Since we are discussing solutions for mobility optimization, it’s of course important to understand what the purpose of the AI model is, meaning the output of the AI model. Type 1 is providing assisting input for a mobility decision. Type 2 is generating the mobility decision.  We will not discuss the exact algorithm, but classifying the solutions into type 1 and 2 sounds reasonable and will facilitate the discussion.  On the other hand, whether we need to explicitly define these 2 types of models or just explain in the solution description whether this solution is to generate a mobility decision or to provide input for a mobility decision, we are open. |
| NEC | Not sure | This classification looks like related to previous discussion on “toolbox use cases.”  We acknowledge that two types of approaches exist, but this is a kind of algorithm dependent.  Further questions in this SoD cover inputs/outputs for both approaches.  It needs to be clarified what is the benefit to have such classification in terms of progress of this SI. |
| KDDI | Reasonable | Classifying the solutions seems to be reasonable for facilitating the discussion. If signalling procedures and spec impact between two types are actually different, this classifying is needed to progress SI. |
| Intel | No | We understand the intention of separating two types of solution in terms of action-based and prediction-based. However, this may be an implementation issue, i.e. using supervised learning, unsupervised learning or reinforcement learning.  Also, from RAN3 point of view, “Model inference” will generate the decision/action of mobility optimization for both AI-assisted and AI-generated, i.e. handover command and configurations. That is the network node with “Model inference” functionality should also generate the handover decision based on AI-assisted information, then pass the decision to Actor. Hence, there’s no need to separate two solutions, RAN3 should just focus on the required input for model inference and output from network node with model inference functionality to Actor. |
| CMCC | Not sure | Currently we don’t see strong intention to do the classification. |
| ZTE | No need | We prefer not to classify the solutions. Type1 is to do mobility prediction, while type2 is to generate the mobility decision directly by ML model. Two kinds of the solution may have similar signalling impact. |
| Deutsche Telekom | No | Not needed as this is already solution specific. |

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:**

|  |  |  |
| --- | --- | --- |
| **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 SI  Solution 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 RAN  Solution 4) is perhaps the second highest priority type of solution, where training and inference occurs at the RAN |
| Samsung | 3 | As training requires high data storage and computation power, while the inference requirements are much lower, to not bring large burden to gNB, training can be placed in OAM and inference in gNB to provide timely prediction or decision. |
| Lenovo, Motorola Mobility | 3, 4 | For 1) 2), may be not much RAN3 impact?  3) and 4) are reasonable. |
| NEC | 2,3,4 | All three deployment options between OAM and NG-RAN node are possible depending on how real-time outputs are needed. |
| KDDI | 3, 4 | Option 1) and 2) are out of scope of RAN. 3) and 4) are baseline for study. |
| Intel | See our comment | We need to discuss what is the decision/output generated from this AI/ML model first. From our understanding, some companies’ contributions proposed that mobility optimization may also generate UE predicted location information as output of mobility optimization use case, which we think is not appropriate. We think it would be good to separate UE trajectory prediction and mobility optimization decision into two parts. From our understanding, both issues require a huge and complex AI/ML model in order to successfully finish training procedure. The AI/ML model is very hard to converge if the problem is so complex.  If AI-based mobility optimization would like to predict handover decision based on UE future location, UE future location can be considered as the input.  Additionally, we would like to clarify that we proposed the UE trajectory prediction (training/inference) is located at LMF or UE, while mobility training/inference is located at RAN, considering the real-time latency for mobility decision. |
| CMCC | 2,3,4 | Agree with Nokia. |
| ZTE | 2,3,4 | For 2), there is no standard impact in RAN3 if Model training and Model inference are both located in the OAM.  Besides, trajectory prediction we proposed is to predict the UE trajectory on the seconds granularity, so if Model training and Model inference are both deployed at OAM, required measurements report from UE or NG-RAN node have to be transferred to OAM for training and inference. However, data transmission over backhaul interface cannot meet the requirement on real time. It’s not a suitable solution to the AI-based trajectory prediction for making mobility decision which needs to be adjusted in real time.  So we prefer ML inference resides in the NG-RAN nodes. |
| Deutsche Telekom | 3 | 1) and 2) not in scope of the SI. 2) is a pure OAM case and can be considered by SA5 in their MDA work.  4) not preferred as initial (offline) ML training should not happen from our perspective in the RAN domain (e.g. due to data storage and processing power required). |

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:**

|  |  |  |
| --- | --- | --- |
| **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 should 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… |
| Samsung | 1,2 | In terms of computation power, data availability and node function, CU or CU-CP is the suitable location for model inference to generate mobility optimization related results. |
| Lenovo, Motorola Mobility | 1,2,3 |  |
| KDDI | 1,2,3 | From HO point of view, option 1 and 2 (CU) can be considered as a baseline, but meanwhile, from beam-based mobility option 3 (DU) can be considered. Firstly, we propose to clarify whether inter-beam intra-cell movements are classified as mobility, as Ericsson pointed out. |
| Intel | 1, 2 | FFS for solution 3) |
| CMCC | 1, 2 | Option 3 needs further clarification |
| ZTE | 1, 2 | To meet the requirement on real time, we prefer that NG-RAN node is responsible for ML inference. CU is better position to do the ML inference, and we don’t preclude that CU can be responsible for the ML training. |
| Deutsche Telekom | 1, 2 | More clarification needed if (1) covers also training in CU. In that respect we share the same view as Huawei.  The application in (3) needs generally more clarification. |

## 3.2 Input data

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

1. UE historical location information, e.g. Latitude, longitude, altitude
2. UE moving direction
3. UE velocity
4. Radio measurements related to serving cell and neighbouring cells associated with UE location information, e.g., RSRP, RSRQ.
5. UE historical serving cells and their locations
6. 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?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Reasons/Comments/Suggestions** |
| Nokia | a) UE historical location information, e.g. Latitude, longitude, altitude -> yes  b)UE moving direction -> yes  c)UE velocity -> yes  d)Radio measurements related to serving cell and neighbouring cells associated with UE location information, e.g., RSRP, RSRQ. -> yes  e)UE historical serving cells and their locations ->yes  f)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 |
| Samsung | It should be defined based on the AI/ML functionality.  **For trajectory prediction:**  **Yes for:**  - UE historical location information, e.g. Latitude, longitude, altitude  - UE moving direction  - UE velocity  - UE historical serving cells and their locations  **For mobility optimization decision generation:**  **Yes for:** ALL above info | The input is different for the AI/ML model with different AI functionality. So the input should be defined based on AI/ML functionality. |
| Lenovo, Motorola Mobility | Yes:   * UE historical location information * Radio measurements * UE historical serving cells and their locations * UE trajectory prediction output, local load prediction output…   Not sure:   * UE moving direction * UE velocity | UE moving direction and velocity can be deduced from the historical location information |
| NEC | Depends on the output | Depending on whether the output is UE location prediction or mobility optimization parameters, different sets of inputs from the mentioned above would be beneficial. |
| KDDI | Yes for:  - UE historical location information - UE historical serving cells and their locations  Not sure for:  - UE moving direction  - UE velocity  Others: No strong opinion | UE historical location information (e.g. Latitude, longitude, altitude) and UE historical serving cells and their locations ; These inputs can be used to detect whether pin-pong HOs occurred precisely.  UE moving direction and velocity seems to be deduced from UE historical location information. |
| Intel | **Yes for**:  -Radio measurements related to serving cell and neighbouring cells associated with UE location information, e.g., RSRP, RSRQ.  -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)  **No for**:  -UE historical location information, e.g. Latitude, longitude, altitude  -UE moving direction  -UE velocity  -UE historical serving cells and their locations | As we replied in Q2, we don’t think UE trajectory prediction should be part of AI-based mobility optimization.  Additionally, we don’t think there will be sufficient UE historical location information can be collected by RAN if UE historical location information proposed by companies are collected by MDT. In MDT report procedure, UE may only report its location information when it’s available. The availability of UE location at UE side also highly depends on whether LCS procedure is enabled at UE or not.  “if the *includeCommonLocationInfo* is configured in the corresponding *reportConfig* for this *measId* and detailed location information that has not been reported **is available**, set the content of *commonLocationInfo* of the *locationInfo* as follows:”  Sufficient input for training is the key factor to ensure the accuracy of AI/ML output. If gNB don’t have sufficient information of UE location information, the mobility decision may not be accurate based on predicted UE location, which will lead to HO failure and introduce more service interruption.  For AI-based mobility solution, we suggest not to consider UE trajectory prediction as part of AI/ML model for AI-based mobility in RAN. |
| CMCC | Yes for all |  |
| ZTE | All is fine for us. | To Lenovo, we agree that UE moving direction and velocity can be deduced from the historical location information. But from our side, the actual UE direction and velocity is much more precise than the information deduced. For example, UE velocity you deduced perhaps is the average velocity. |
| Deutsche Telekom | Yes | We see all given info as useful input for mobility information but there is probably the need for differentiation in a 2nd step to evaluate the benefit of each of those parameters on final output quality. |

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):

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

**Input Information from UE:**

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

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

* f) UE’s successful handover information in the past and received from neighboring RAN nodes
* g) UE’s successful DC offloading information in the past and received from neighboring RAN nodes
* h) UE’s history information from neighbor
* i) position, resource status, QoS parameters of historical HO-ed UE (e.g. loss rate, delay, etc.)
* j) After successful handover, UE QoE reports for handed over user
* k) During DC, UE QoE reports for data handled by the SN
* l) Predicted load
* m) Resource status and utilization prediction/estimation
* n) 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?**

|  |  |  |
| --- | --- | --- |
| **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 -> Yes  UE’s successful DC offloading information in the past and received from neighboring RAN nodes -> No for now  UE’s history information from neighbor ->Yes  position, resource status, QoS parameters of historical HO-ed UE (e.g. loss rate, delay, etc.) -> Yes  After successful handover, UE QoE reports for handed over user -> Yes  During DC, UE QoE reports for data handled by the SN -> No for now  Predicted load -> Yes  Resource status and utilization prediction/estimation -> Yes  SON 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 -> Yes  UE’s successful DC offloading information in the past and received from neighboring RAN nodes -> No for now  UE’s history information from neighbor ->Yes  position, resource status, QoS parameters of historical HO-ed UE (e.g. loss rate, delay, etc.) -> Yes  After successful handover, UE QoE reports for handed over user -> Yes  During DC, UE QoE reports for data handled by the SN -> No for now  Predicted load -> Yes  Resource status and utilization prediction/estimation -> Yes  SON 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 input  If 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 item  For 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. |
| Samsung | **No for:**  **- Long-term information from NWDAF**  **- Input Information from CN**  - UE may also have the training model on its locations  **Others are Yes, but the detailed input needs to be defined based on the AI functionality.** | Same view as Nokia, the input from CN is out of scope.  And the UE to support AI function is also out of scope of this SI. |
| Lenovo, Motorola Mobility | Yes: a) b) c), f), i), j), l), m), n)  Not sure: e) g) h) k)  No: d) | We assume the question is about whether those can be used as input if they are available, rather than whether the CN, UE, neighbour RAN must provide these data.  For d) it assumes UE has AI capability and can provide predicted result, this is something related to UE capability, don’t think we should touch upon it in this release.  For e) it can be deduced from c), maybe e) is not needed.  g) not sure what DC offloading information is.  h) not sure what history information includes  k) does it mean UE QoE reports after switching to a new SN? Similar as j)? |
| NEC | Depends on algorithm | In general we agree that CN (NWDAF), UE, and NG-RAN nodes are sources of valuable information for mobility optimization.  Exact parameters need further detailed discussion. |
| KDDI | **Long-term information from NWDAF** ->No  **Input Information from CN** ->No  **Input Information from UE:**  Yes : c) No : d), e)  **Input Information from the neighbor RAN nodes:**  Yes : f), h), i), j), l), m), n)  Not sure : g), k) | **Long-term information from NWDAF**  **Input Information from CN:**  Same view as Nokia, the input from CN is out of scope.  **Input Information from UE:**  Accurate UE location information is beneficial, but meanwhile, considering cost, processing power and battery consumption, UE’s functions for AI/ML should not be implemented or should be minimized.  **Input Information from the neighbor RAN nodes:**  Regarding Information related DC, necessary is not clear for now. |
| Intel | **Yes:**  - b) d) f) g) j) k) l) m) n)  **No:**  - Long-term information from NWDAF  - a)  **Not clear with motivation:**  - h)  **Need Clarification:**  - c) e) i) | b): for clarification, the predicted UE location may need to request from CN (i.e. LMF or MDA).  c) e): existing MDT procedure can support this information collection from UE, however we are not sure whether gNB can get sufficient information for prediction or not.  i): we are ok with exchanging resource status and QoS parameter of historical HO-ed UE based on existing procedure, but not for position of historical HO-ed UE.  d) UE may have future location information in two ways: 1) based on location prediction model at UE side; 2) future location from application layer (not based on AI/ML). We can conclude in general: UE future location information either by AI/ML model or received from its application layer. |
| CMCC | **Yes:**  c e f g h i j k l m n  **NO:**  Long-term information from NWDAF  Input Information from CN  d) | We also don’t think that UE is expected to have AI related functionality in this SI. |
| ZTE | **Long-term information from NWDAF -> Not for now**  **Input Information from CN -> Not for now**  **Input Information from UE:**   * c) ->Yes * d) ->No * e) ->Yes   **Input Information from the neighbor RAN nodes:**   * f) ->yes * g) ->not sure * h) -> Not sure * i) -> Not sure * j) -> Not sure * k) -> Not sure * l) ->yes * m) ->yes * n) ->yes | The input data from NWDAF and CN could be discussed later, which seems out of SI scope now.  For the information from UE, d) is related to the AI functionality of UE, which also seems out of SI scope now.  We support the load information (included) as inputs from other RAN nodes, so we always support AI-based load prediction could be a tool-box use case. |
| Deutsche Telekom | **Input from CN/NWDAF 🡪 No**  **Input from UE 🡪 No**  **Input from neighbour RAN nodes 🡪 Yes (DC related info FFS)** |  |

## 3.3 Output data

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

* a) UE trajectory prediction (Latitude, longitude, altitude of UE over a future period of time)
* b) the predicated UE’s location with the confidence of the predication
* c) predicted moving coordination
* d) estimated arrival probability in CHO and relevant confidence interval, Estimated arrival probability in CPAC and relevant confidence interval
* e) 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 (for DC case to determine MN change or SN change for a specific UE)
  + 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) -> Yes  the predicted 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 ->Yes  predicted 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. |  |
| InterDigital | UE trajectory prediction -> Yes  the predicated UE’s location with the confidence of the predication -> seems redundant with trajectory  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  predicted 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 yes  predicted data forwarding strategy ->no  HO 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. |
| Samsung | It should be defined based on the AI/ML functionality.  **For trajectory prediction:**  **Yes for:**  - UE trajectory prediction (Latitude, longitude, altitude of UE over a future period of time)  **For HO decision generation:**  **Yes for:**  - 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 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 time  predicted data forwarding strategy | The output is different for the AI/ML model with different AI functionality. So the output should be defined based on AI/ML functionality.  One clarification for “predicted handover source node”: we include this one in our discussion paper. It is for DC case to determine MN change or SN change for a specific UE. |
| Lenovo, Motorola Mobility | Yes: a) b) d)  Not sure: c) e) | a) and d) are easy to understand,  b) shall be ok in principle, especially helpful to understand the UE is moving to which cell  c) and e) does not seem very much needed if we have a) b) d) |
| NEC | Depends on algorithm | If the goal of the algorithm it to predict UE location, then output expressing UE location is needed.  If the goal of the algorithm is mobility optimization, then output influencing HO decisions is needed. |
| Intel | **Yes**:  - d) with comment  - e) with comment  **No**:  a) b) c) | d) a simple way of estimated arrival probability is to set priority to the candidate CHO target cells, which can be used by UE to select the highest priority candidate target cell for handover.  e) the predicted handover time here may also refers to the validity time of predicted HO strategy.  a) b) c) UE location is not predicted as outcome of AI-based mobility optimization. Those information can be predicted by a separate UE location prediction model in either LMF or UE. |
| CMCC | **Yes:** a) d), following part of e)   * + 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 time | Others are not clear now. |
| ZTE | Yes: a), b), c)  e) Not sure. | Fine for the a) UE trajectory prediction and predicted handover target node…, but not sure about b), c). Does a) include the b) and c)? Need more clarification.  For e), we are fine with the predicted handover target node. Others in e) may need much clarification. Besides, we suggest to avoid overlapping these outputs. |
| Deutsche Telekom | Same view as Nokia | The meaning of some parameters (e.g. predicted moving coordination) needs more clarifications.  HO strategy details may be implementation specific. |

## 3.4 Feedback/Rewarding information

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

UE side measurements (3724, 3780):

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

Network side measurements (3724,3780, 4230)

* g) whether the mobility decision is good or not (e.g. if HO is successful)
* h) Traffic steering configuration used for the UE e.g., multi-connectivity and carrier aggregation
* i) Load information
* j) DL/UL throughput
* k) DL/UL latency
* l) Cell dwelling time
* m) 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?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Reasons/Comments/Suggestions** |
| Nokia | **UE side measurements**  whether the mobility decision is good or not -> Yes  Trajectory information (e.g. speed, position, etc.) -> Yes  Assistance Information on Traffic ->No  Quality of experience e.g., buffer level -> No  Successful HO measurements ->Yes  Radio link failure information ->Yes  **Network side measurements**  whether the mobility decision is good or not (e.g. if HO is successful)->Yes  Traffic steering configuration used for the UE e.g., multi-connectivity and carrier aggregation -> No  Load information -> Yes  DL/UL throughput -> Yes  DL/UL latency ->Yes  Cell dwelling time -> Maybe  HO 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 -> Yes  Trajectory information (e.g. speed, position, etc.) -> Yes  Assistance Information on Traffic ->Yes if it means the QoS  Quality of experience e.g., buffer level -> Yes  Successful HO measurements ->Yes  Radio link failure information ->Yes  **Network side measurements**  whether the mobility decision is good or not (e.g. if HO is successful)->Yes  Traffic steering configuration used for the UE e.g., multi-connectivity and carrier aggregation -> No  Load information -> Yes  DL/UL throughput -> Yes  DL/UL latency ->Yes  Cell dwelling time -> Yes  HO failure, too late HO, too early HO, HO to wrong cell ->Yes |  |
| InterDigital | **UE side measurements**  whether the mobility decision is good or not -> Yes  Trajectory information (e.g. speed, position, etc.) -> Yes  Assistance Information on Traffic ->not clear  Quality of experience e.g., buffer level -> maybe  Successful HO measurements ->Yes  Radio link failure information ->Yes  **Network side measurements**  whether the mobility decision is good or not (e.g. if HO is successful)->Yes  Traffic steering configuration used for the UE e.g., multi-connectivity and carrier aggregation -> maybe  Load information -> Yes  DL/UL throughput -> Yes  DL/UL latency ->Yes  Cell dwelling time -> Maybe  HO 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. |
| Samsung | Depends on AI functionality | The reward information depends on the AI functionality. For trajectory prediction, UE trajectory information is needed. For AI to decide HO strategy, the QoS information for HO-ed UE is useful. |
| Lenovo, Motorola Mobility | Yes: a) b) d) e) f) g) m) l)  Not sure: c) h) i) j) k) | c) i) j) k) seem like rewarding information more for traffic load prediction  h) not sure, if it means the neighbour RAN node will share its configuration to the other RAN node |
| Intel | FFS at this stage | We share the same view with E/// that we can keep FFS at this point.  Additionally, as UE is already HO-ed to the target cell, we may need to clarify UE side measurement is reported to the target NG-RAN. The target NG-RAN will further send UE reported information to the source NG-RAN via Xn interface. |
| CMCC | Yes for a), b) d) e) f) g) i) j) k) m) | Others are not clear now |
| ZTE | Not sure, keep FFS | That’s better to introduce the feedback/rewarding information, and specific details included in the feedback/rewarding could be trajectory prediction, QoE, QoS, etc.  Share same view with E/// and intel, we are fine to discuss the details of feedback/rewarding information, but we can keep it FFS.  Feedback/rewarding information may be related to the inputs/outputs, we would suggest to focus on the inputs/outputs details first. |
| Deutsche Telekom | UE side info:  Yes: a) b) e) f)  Not sure: c)  No: d)  NW side measurements:  Yes: g) i) j) k) m)  Not sure: h) l) | The meaning of c) needs clarification. |

## 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?**

|  |  |  |
| --- | --- | --- |
| **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 |
| Samsung | No for now. Can discuss later. | Prefer to discuss these issue after the normal mobility cases. |
| Lenovo, Motorola Mobility | Yes | Agree with Huawei, since they are introduced in R-17 already under SON topic, they can be added to the unintended event list. |
| Intel | Not for now. | We should focus on the baseline solution first. New unintended event should be studied in SON/MDT. |
| CMCC | Not for now. | Agree with vivo, Ericsson, Samsung and Intel. |
| ZTE | Can be discussed later | We prefer to focus on the current case agreed in the mobility optimization, but we can discuss the PScell change later. |
| Deutsche Telekom | Yes, but | Same view as Huawei, but initial focus should be on single connectivity. |

# 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)