3GPP TSG-RAN WG3 #117bis-e R3-225917

E-meeting, 10 – 18 October 2022

Agenda Item: 12.2.2.1

Source: Nokia (moderator)

Title: Summary of email Discussion on CB: # AIRAN2\_XnImpact

Document for: Discussion and Approval

# Introduction

**CB: # AIRAN2\_XnImpact**

**- Whether to define the new procedures for AI/ML input, AI/ML output, and AI/ML feedback information respectively. Coverage on design of the new procedure for AI/ML related information?**

**- How to transfer UE related information via UE associated procedure or non- UE associated procedure, via new procedure or existing procedure?**

**- Whether the AI/ML capability is needed, and its definition?**

**- Definition of predicted resource status, UE performance, energy efficiency metrics, et.?**

**- Discuss the start time, duration, end time for AI/ML related information, validity time, accuracy**

**- Capture agreements and open issues**

**- Provide TPs on stage2/3 if agreeable**

(Nok - moderator)

Summary of offline disc [R3-225917](file:///C:\Users\pantelid\Documents\workspace\3GPP\FTP\tsg_ran3\RAN3%20117bis-e\Inbox\Drafts\CB%20%23%20AIRAN2_XnImpact\Inbox\R3-225917.zip)

This email discussion will comprise two phases:

* Phase 1 Deadline: Thursday October 13th, 10pm UTC
* Phase 2 Deadline: Monday October 17th, 8am UTC

In the second phase, we will try to obtain TPs

# For the Chairman’s Notes

The following is proposed to be captured in Chairman’s notes:

**Procedures for AI/ML related information**

**Proposal 1: Introduce a new Class 1 procedure for initiating the reporting of AI/ML Related Information (e.g., predicted information) and a Class 2 procedure for Data Reporting of AI/ML Related Information (e.g., predicted information).**

**It is FFS what is the exact name of the procedure.**

**Proposal 2: Reporting options for the new procedure used for AI/ML Related Information to be evaluated on a case-by-case basis. Possible reporting options are one-time and periodic reporting.**

**Event-based reporting and how to determine an event are FFS.**

**Proposal 3: The new procedure is non-UE associated procedure. If needed, the procedure can be used to capture UE-associated information.**

**Proposal 4: The response message of the new procedure for AI/ML Related Information indicates if the requested measurement (e.g., prediction) can be provided.**

**It is FFS whether a node subscribing to a prediction includes timing information in order to indicate for which time a prediction is requested.**

**The need and methods to interpret prediction accuracy at a receiving node is FFS.**

**UE Performance for Feedback**

**Proposal 5: Support the following UE performance information to be sent for feedback purposes: Average Packet Delay, Average UE Throughput DL, Average UE Throughput UL, Average Packet Error Rate.**

**Other UE performance for feedback purposes is FFS.**

**Proposal 6: Predicted Resource Status Information reported in the new procedure for AI/ML Related Information can be predicted radio resources, predicted number of UEs, and predicted number of RRC Connections.**

**FFS if also Predicted TNL Capacity Indicator, Predicted Composite Available Capacity Group and Predicted Slice Available Capacity are reported.**

**Energy Efficiency**

**The feasibility, interpretability and encoding of the two EE metrics (detailed EE metric, and abstract metric) is FFS.**

**It is FFS how to transfer current Energy Efficiency metric**

**It is FFS whether EE metric is per node or per cell and how per cell EE metric can be calculated.**

**RAN3 to discuss the scenarios where predicted energy efficiency is exchanged are depending on the need to take an EE decision.**

**Validity Time**

**Proposal 7: How to indicate validity time (e.g., implicitly with a new prediction when the previous prediction becomes invalid, explicitly with every prediction in the AI/ML output or by the subscription to the prediction) shall be discussed on a case by case basis.**

**Cell-based UE Trajectory prediction**

**Proposal 8: Cell-based UE Trajectory prediction has the same structure as UE History Information IE.**

**The input needed to train cell-based UE Trajectory prediction, e.g., UE Mobility History IE, UE History Information IE, etc. is FFS**

**Proposal 9: Cell-based UE Trajectory prediction is provided as a list of cells into the future, each of which is indicated together with an expected time of stay into the cell.**

**Feedback Information**

**Proposal 10: WA:  It is up to implementation for how long to maintain the UE context after a HO, to enable association of UE Performance Feedback to the UE context**

# Discussion

## Procedures for AI/ML related information

In the last meeting we agreed that a new procedure is needed for AI/ML related information:

*Define a new procedure over Xn which can be used for AI/ML related information, e.g., predicted information.*

*The new procedure for reporting of AI/ML related information, e.g., predicted information, should be based in a requested way, like resource status report procedure.*

Some companies propose to design the new procedure as a Class-1 procedure, initiating the predicted information reporting and with the predicted information response/failure to indicate successful/failure operation and a Class-2 procedure where the actual reporting takes place (e.g., [5509],[5516], [5779], [5702], [5588]). A lot of different names have been discussed for this procedure, but the actual name depends on the outcome of the discussion on AIRAN1\_General\_Stage2.

**Q1: Do companies agree that the new procedure for reporting AI/ML Related Information (e.g., predicted information) (with name FFS) shall contain a Class 1 procedure, for Reporting Initiation (with tentative name Prediction Data Reporting Initiation) and a Class 2 procedure for Data Reporting (with tentative name Prediction Data Reporting)?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree /Disagree** | **Comments, if any** |
| Lenovo | Agree |  |
| Nokia | Agree | The exact names of the procedures shall be discussed after we agree how many procedures are needed for AI/ML Related Information. |
| Samsung | Agree | Prefer to apply the same manner as resource status reporting. The name and details can be discussed later. |
| Ericsson | Agree to the procedure structure, not agree on the fact the procedure is for predicted information only | As explained in our papers, e.g R3-225509, we support a procedure that is agnostic to the type of information if carries.  The NG-RAN node requesting the information knows the purpose of such information, i.e. whether this is used as input to an AI process, or as feedback, or purely as assistance information to take other actions. There is therefore no reason to make the procedure data type specific, i.e. to limit it to prediction data. Fragmentation of AI/ML data signalling over many procedures unnecessarily complicates the AI/ML design.  The node requesting AI/ML data may require that data samples of different measurements are received at the same time. With a single procedure this is possible. With different procedures data samples of different measurements may be subject to different delays. Hence, timing among data samples may become unsynchronised, which has negative effects on e.g. inference and feedback. As an example, the requesting node may need as inputs for its Model Inference function the current energy efficiency and the predicted resource status information of a neighbour node/cells. This is needed to a) understand the level of energy consumption at the neighbour node (so to decide whether to offload traffic or to avoid it due to already high energy consumption levels) and b) to understand what the level of load of the neighbour node will be (so to decide whether to offload traffic or to avoid it due to foreseen high load levels). It is clear that if we split predicted and actual metrics, input data may also end up being splitted.  Therefore, the procedure can include different types of AI/ML data, so to “package” AI/ML information into one procedure, associated to a specific functionality.  For this we suggest a more generic name, namely: - AI-ML Assistance Data Reporting Initiation  - AI-ML Assistance Data Reporting |
| InterDigital | Agree to the procedure structure, not agree on the fact the procedure is for predicted information only | Agree with Ericsson |
| Deutsche Telekom | Agree | Details on AI/ML related information to be carried via that procedure are still to be defined. |
| CATT | Agree (excluding the message name) |  |
| Qualcomm | Agree | In the last meeting we agreed that the new AI/ML procedure should be similar to Resource Status Reporting procedure. Hence this aligns with the earlier agreement. |
| Huawei | Agree | We think this is similar as the RESOURCE STATUS REQUEST/RESPONSE/UPDATING procedure.  Besides, we also share similar view as E/// that this new procedure should be use case agnostic and for all AI/ML related info (if any) but not only for prediction info. |
| CMCC | Agree | Agree with Ericsson |
| LGE | Agree to the procedure structure, not agree on the fact the procedure is for predicted information only | We agree with Ericsson. |
| ZTE | Agree | Share same view as QC. The new procedures for AI/ML related information should resemble with Resource Status Reporting procedure and Resource Status Initiation procedure. |

**Moderator’s summary**

**All companies who commented to Q1 confirmed the agreement from the previous meeting that the new procedure used for AI/ML related information should be based in a requested way. In addition, they agree that this comprises a Class 1 procedure and a Class 2 procedure. Some companies have concerns on whether the procedures shall be used only for predicted information. Moderator also agrees that we shall not limit this procedure only for predictions at this stage and that usage of this procedure to convey predictions is just an example, based on earlier meeting agreement and pending outcome of the discussion in CB: # AIRAN1\_General\_Stage2.**

**Moderator’s Proposal: Introduce a new Class 1 procedure for initiating the reporting of AI/ML Related Information (e.g., predicted information) and a Class 2 procedure for Data Reporting of AI/ML Related Information (e.g., predicted information). The name of the procedure is FFS.**

The reporting of this new procedure can imitate Resource Status Procedure and therefore companies propose that reporting can also be at once ([5483], [5587]) or be periodic ([5483], [5587], [5702]). In [5587] an issue is brought up, namely that periodic reporting may be more suitable for initial training of an ML Model where more regular and a sufficient amount of data is needed. However, periodic reporting may provide unnecessary measurements when the only intention is to monitor events or updates in model inference, in which case event-based reporting could be introduced to capture changes or updates in the reported predictions. Event-based reporting could also detect when a prediction becomes invalid so that the next prediction is reported.

**Q2: Companies are invited to provide their views on whether the new procedure for reporting of AI/ML Related Information shall support reporting at a) once, b) periodic reporting and c) event-based reporting.**

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| --- | --- | --- |
| **Company** | **Type of reporting to be supported (a) once, b) periodic, c) event-based). Indicate preference on a), b), c)** | **Comments, if any** |
| Lenovo | a) b), FFS c) | One time or periodic reporting similar as legacy resource status report procedure. The benefit of event based reporting is a bit unclear to us at the moment, but we are open to discuss. |
| Nokia | a), b) and c) | We think that all types of reporting are needed. A) and b) follow existing Resource Status procedure. Regarding c) it could provide flexibility in the reporting beyond the (pre)defined period. This could also be useful to allow a reporting node to provide a new Model Inference(prediction) when the previous prediction becomes invalid, something that is not currently supported with the periodic framework. Furthermore, it could help to decrease the amount of predictions being reported when those predictions are only meant to monitor or describe a certain event (e.g., some predicted overload scenario). |
| Samsung | a), b)  partly agree c), see comments | One-time and periodic reporting are required.  For event-triggered, fine for predicted overload scenario. In existing procedure, DU and CUUP can send the warning indicator to CU/CUUP when overload happens by GNB-DU STATUS INDICATION, GNB-CU-UP STATUS INDICATION. The same principle can be applied to the predicted resource status. When predicted load status is high, nodes can send the predicted overload indication to peer node. And the way to design the signalling can refer to the existing status indication procedure.  But it is not clear about reporting when a prediction becomes invalid. Actually, the validity time for one model is a static value. For example, a model can predict the resource status in the future 5min. This “future 5 min” will not change, as it is highly related to the data for training.  In summary, it is fine for event-triggered reporting of the predicted overload situation. And the signalling can refer to the existing status indication procedure. |
| Ericsson | a), b) | a) and b) are for the time being the measurement types needed to support AI/ML. We do not exclude that a framework where a) and b) is supported could also include some form of event based measurements. For example, if UE feedback information is requested then such UE performance measurement could be reported when a UE hands over for AI/ML reasons to a cell of the reporting node. After the UE handed over, the reporting could be done according to the periodicity established in the AI/ML Data Reporting procedure, e.g. every 500ms. The reporting can be done for a time window when the UE context is still available at the source, e.g. for a given configured time or until signalling of UE context Release. As it can be seen, event based reporting can be implicitly supported by a procedure reporting periodically.  Nevertheless, we do not need a procedure where events are defined and event based reporting is explicitly triggered. Periodic metrics reporting allows the receiving node to understand the events that are occurring at the reporting node. |
| InterDigital | a), b)  ffs for c) | Clear we need a and b, the use case for c is not as clear but we are willing to discuss. |
| AT&T | 1. b) and c) | For c) the use case we have in mind is similar to Nokia, where an update can be provided in a proactive manner if due to an unexpected event like a large traffic fluctuation or change in a target UE’s context in between reports can be accounted for to ensure the model remains as accurate as possible. |
| Deutsche Telekom | a), b), c) | We see all reporting types as feasible (see comments from Nokia and InterDigital on possible use cases for c). |
| CATT | All acceptable but should be decided case by case | We are generally open on this topic, but we do not think we need to such an abstract thing now.  Maybe we can agree a way forward that, these 3 types of reporting are considered as candidates for each metric. |
| Qualcomm | 1. b) and c) | We think different use cases may need different triggers to report the data. Hence from spec pov, flexibility should be provided to enable all the 3 ways of reporting. |
| Huawei | See comments | We are open to discuss, for a), we think it is up to receiving node’s implementation; for b) it is existing mechanism in resource status indication procedure.  Maybe we could take b) as base line, if no periodicity is indicated, it is up to receiving node’s implementation whether to respond immediately or not; we are open to discuss c), we need to see the justification of c), i.e. what kind of event, why such event is needed… |
| CMCC | a), b), FFS c) | In current use cases, for predicted resource status report procedure, one time or periodic reporting should be supported; For predicted Energy Efficiency report procedure, periodic reporting should be supported; For predicted UE trajectory report procedure, suggest to cover it in current HO message, it should be one time.  For further use cases, FFS c). |
| LGE | a), b), and c) | a) and b) are the method provided by the existing Resource Status Reporting procedure and are necessary.  For c), we have a similar view as Nokia. |
| ZTE | a) and b) | a), b) is the reporting mechanisms as similar as the resource status procedure.  Regarding c), event-based reporting seems to resolve the invalid reporting issues but the scenarios should be clarified. We think there are two scenarios to such event. One is that source NG-RAN node cannot provide the predicted information, so it can send the failure procedure. And the other is that source NG-RAN node identify the accuracy of predicted information is not good, but how it can identify needs to be clarified first. |

**Moderator’s summary**

**On this question 13 companies agree to use periodic reporting, 12 companies agree to use one-time reporting and 7 companies agree to event-based reporting. 4 companies think that event-based reporting could be FFS and some would like to understand more how to characterize this event. Given that we haven’t yet identified the content of this procedure moderator proposes the following:**

**Moderator’s Proposal: Reporting options for the new procedure used for AI/ML Related Information to be evaluated on a case-by-case basis. Possible reporting options are one-time and periodic reporting. Event-based reporting and how to determine an event is FFS.**

Another FFS from the previous meeting is the following:

*FFS on whether UE associated procedure is needed.*

Some companies propose that the new procedure for AI/ML information is non-UE associated, e.g., [5509], [5516] [5734], [5779], [5888].

**Q3: Companies are invited to provide their views on whether the new AI/ML procedure shall be non-UE associated or also UE-associated.**

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| **Company** | **UE-associated, non UE-associated** | **Comments, if any** |
| Lenovo | Non UE-associated | We agreed with the non-UE associated procedure last meeting. Which can be used to carry UE related measurement as well. Since the network energy saving, load balancing, mobility optimization may impact multiple UEs, we don’t see strong need of UE associated procedure. |
| Nokia | Non UE-associated | The basic mechanism of the procedure for AI/ML information is non UE-associated as agreed. If there is UE-associated information to be exchanged e.g., for feedback purposes, this could be signalled by e.g., using the XnAP UE IDs when such exist (but this may not be always the case). In any case, we don’t see the need to introduce a new separate UE-associated procedure at this stage. |
| Samsung | Case by case | Actually, it depends on the data type.  The UE trajectory prediction is benefit for mobility optimization, and based on discussion, several companies prefer to carry it in handover procedure. For the resource status or energy efficiency, non UE-associated procedure is fine. |
| Ericsson | Non UE-Associated | We agree with Lenovo and Nokia that a non UE associated procedure can serve the purpose of signalling both UE associated and non UE associated information, as it has been specified for the Xn: Access and Mobility Indication procedure. By keeping a single procedure for both UE associated and non UE associated information we enable the AI/ML functionality to gather all AI/ML data via a single procedure, which simplifies the AI/ML design and makes it more efficient. In fact, the node requesting AI/ML information (UE and non UE associated) may require that data samples of different measurements are received at the same time. With a single procedure this is possible. With different procedures data samples of different measurements may be subject to different delays. Hence, timing among data samples may become unsynchronised, which has negative effects on e.g. inference and feedback.  We therefore promote a non-UE associated procedure able to carry also UE associated information. |
| InterDigital | Non UE-Associated | Agree with Lenovo, Nokia and Ericsson |
| Deutsche Telekom | Non UE-Associated | We share the views of other companies on the benefits of such procedure. |
| CATT | Non UE-Associated | Although we doubt that we will end up with introducing UE-associated ones when digging into details IEs, now we can introduce only non-UE-associated ones. Copying messages isn’t a hard work. |
| Qualcomm | Non UE associated | Share the views of other companies |
| Huawei | Non-UE associated | Our understanding, the FFS here is whether to introduce another new UE associated procedure, we think it is not needed. |
| CMCC | Both Non UE-associated and UE-associated | For predicated UE trajectory information, it should be U-associated because it is per UE specific. The others should be Non UE-associated. |
| LGE | Non UE-associated | We agree with Lenovo, Nokia, and Ericsson. |
| ZTE | Non UE-associated | Share same views with other companies. |

**Moderator’s summary**

**11 companies think that the new procedure to transfer the new AI/ML Related Information shall be non-UE associated and 2 think that it depends on the information to be transferred. Based on moderator’s understanding UE associated information can be transferred through non UE-associated signaling.**

**Moderator’s Proposal: The new procedure is non-UE associated procedure. If needed, the procedure can be used to capture UE-associated information.**

Some companies propose that the response message, like in the case of Resource Status Procedure, confirms whether the node can do the requested prediction, e.g., [5702].

**Q4: Companies are invited to provide their views on whether the response message of the new procedure confirms whether a node can perform the requestedmeasurement.**

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| **Company** | **Agree / Disagree** | **Comments, if any** |
| Lenovo | Agree |  |
| Nokia | Agree in general but | It would be useful to also clarify what is the scope of the requested prediction. Does a node request specific Model Inference from a neighbouring node e.g., predicted CAC or does it request general predicted resource status and it is up to the receiving node to determine which predictions (e.g., predicted CAC, predicted slice available capacity, predicted radio status, etc.) it can provide? In the first case, the response message may indeed include whether the node can perform the requested prediction. In the second case, the response message may include which (subset) of predicted resource status information is supported. |
| Samsung | Agree | It follows the same way as resource status response. The requested node can determine which prediction it can perform. So it can give the information of which requested prediction can be reported, e.g. subset of requested predicted resource information. |
| Ericsson | Agree, but the scope of the discussion should not be limited to predictions | The procedure works in the same way as Resource Status Reporting Initiation. The granularity of the request is that of individual measurements, i.e. each requested measurement needs to be explicitly requested. The response message may confirm which measurements can be reported and which are failed to be reported. If no measurement can be reported, a failure message is signalled. |
| InterDigital | Agree but… | Similar view as Ericsson |
| Deutsche Telekom | Agree but … | We also share Ericsson’s view that the content should not only be predictions, but the procedure may also other data. Details tbd. |
| CATT | Agree but… | Similar view as Ericsson |
| Qualcomm | Agree but | We think it should be similar to the Resource Status Reporting procedure. The Response message shall confirm if the requested measurements can be provided or not |
| Huawei | See comments | Not sure the intention of this question, in our understanding, this new non-UE associated procedure should include normal response message or failure message, this should be understood whether to confirm the requested prediction or not, just as what existing Resource Status Reporting procedure does today. |
| CMCC | Agree | Similar to Resource Status Reporting procedure. |
| LGE | Agree but… | We share a similar view as Ericsson. |
| ZTE | Agree | Similar to Resource Status Reporting procedure. |

**Moderator’s summary**

**All companies agree that the response message of the new procedure for AI/ML Related information can indicate if the requested measurement can be provided, similarly to the Resource Status Procedure. If the requested measurement is a prediction, then it can indicate if the node can provide the requested prediction.**

**Moderator’s Proposal: The response message of the new procedure for AI/ML Related Information indicates if the requested measurement (e.g., prediction) can be provided.**

Some companies propose to consider timing information regarding when a prediction is requested since predicted information without knowing when the prediction will be calculated cannot be used at the receiving node, especially when this information is used as an input to another ML Model. Different timing options have been discussed: a start time and end time of a prediction ([5376]), time instant in future ([5483], [5588]), time duration ([5758]).

**Q5: Companies are invited to provide their views on whether timing indication shall be included when node subscribes to a prediction. If so, companies are invited to further provide their views on how this is exactly indicated, namely as a a) start time and end time, b) time instant, or c) time duration.**

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| --- | --- | --- |
| **Company** | **Yes / No** | **If yes, how shall timing information be indicated, through a) start time and end time, b) time instant, or c) time duration.** |
| Lenovo | Yes | Relevant to Q13. We are open to the exact format of the time information, it can be either a time window as a) or c) implies, or a time instant b). |
| Nokia | Yes | We think that timing information is important input to an ML Model. Requesting a prediction from a neighbour without any timing indication is not very useful in the sense that it also affects whether a node can provide the prediction or not. It also leads to different inference outputs (e.g., predicted load in the evening is expected to be less than predicted load on rush hours).  Since it is input information to the model, we should allow all possibilities to indicate timing.  a), b) seem ok though some further time instant indication may be needed for subsequent predictions.  c) is lacking the start time since a duration cannot reflect the beginning of a prediction unless the meaning is that starting time is immediately when the request is received. |
| Samsung | Yes | Prefer a) and b). As the prediction is for a future time, we need to know when the future time is start and end. It gives the clear information. |
| Ericsson | No. Prediction time duration is equal to the reporting period | We believe that a prediction is valid from the time it has been received till the time it is updated. For this reason we believe that the measurement reporting period can function as the validity time of the prediction. There is little benefit of stating a start time or an end time or an explicit duration if the measurement is reported periodically and therefore renewed periodically. |
| InterDigital | No | Actually, some of this is tied to the need for an event triggered prediction question 2 from above. Outside of a event use case (not yet proven), if you are subscribing to a prediction to enhance your models/algorithms you need to have a value at all times, thus the value is used starting when received until it is replaced. For predictions that are tied to events (examples from the TR – Estimated arrival probability in CHO and relevant confidence interval, handover execution timing, predicted resource reservation time window for CHO) these if needed in the target gNB would be a part of the actual handover preparation. |
| AT&T | Yes | We would be ok with b) only or b) + c) depending on the type of information. One issue with a) is that it may be indefinite or indeterminate, while c) can explicitly capture that option as one of the indicated values (e.g. duration = NA, null, Inf, etc.). |
| Deutsche Telekom | Yes | We share Nokia’s views on the 3 types. In case of periodic prediction there is a simplification possible as raised by Ericsson. |
| CATT | Case by case | Ericsson’s comment is valid for some case, so we should not hurry into making any decision now.  Just like Q2, maybe we can agree a way forward that, these 3 types of timing indication are considered as candidates for each metric. |
| Qualcomm | Yes | Share the same view as Nokia |
| Huawei | Maybe not | On one hand, we could include periodicity time in the request message; on the other hand, the prediction should be valid until the next time when it is updated. |
| CMCC | Yes | We suggest each prediction information should include the validity time. |
| LGE | No | We share the same view as Ericsson. |
| ZTE | Yes | The request message should indicate the reporting time duration. Start time, duration and end time are also fine.  If one NG-RAN node requests predicted information from other NG-RAN nodes at time T, the requested reporting time could be {T, T+t}. If one NG-RAN node requests historical information from other NG-RAN nodes at time T, the requested reporting time could be {T-t1, T-t2}. |

**Moderator’s summary**

**Regarding whether to indicate timing information for when a prediction is requested when a node subscribes to a prediction 9 companies agree and 4 companies disagree on including timing information. Moderator thinks that this question can be revisited later when the details of the procedure have matured.**

**Moderator’s Proposal: RAN3 to further discuss whether a node subscribing to a prediction includes timing information to indicate for which time a prediction is requested.**

Some companies also bring up the issue of accuracy and discuss that a node receiving a prediction shall be able to understand the prediction accuracy (e.g., [5483], [5485]). In [5483] two possible options are provided to address understanding of prediction accuracy at the receiving node:

a)Neighbour NG-RAN node sends the prediction information together with accuracy information

**b) Neighbour NG-RAN node sends actual measurement corresponding to the prediction in a later phase.**

**Q6: Do companies think that a node receiving a prediction shall be able to understand the prediction accuracy?**

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| --- | --- | --- |
| **Company** | **Yes / No** | **Comments, if any** |
| Lenovo | Yes | We believe it is beneficial for the requesting NG-RAN node to understand if the prediction information, that it has received, is accurate or how accurate is it. Such that the requesting NG-RAN node could make use of the prediction result in different ways and may stop requesting the prediction information if the prediction accuracy is unacceptable. We are open to further discuss the solution, a) or b) listed can work with pros and cons. |
| Nokia | Yes | It is important for a node that receives predictions to have an understanding of “how good” these predictions are. A “bad” prediction could be more harmful than no prediction. However, we wonder if this should also be part of the request for predictions towards a neighbour, namely whether a node requesting a prediction shall also indicate a confidence that the reported prediction must meet. So the node providing the predicted information shall not report predictions not meeting the confidence. In that sense, all the predictions that a node receives must meet at least the minimum indicated confidence. |
| Samsung | Yes | As the AI/ML model can not achieve 100% accuracy, when the node get the prediction results, it needs to know how this value is accurate. And then the node can set the different strategy to use this predicted information. If low-accuracy, the node may just take it as a reference information. If high-accuracy, the node may take it into the decision setting mechanism.  For a), there is delay for the node to get the results and the accuracy info. So there may exists the case that the node already use the predicted information for decision, but later it finds the prediction accuracy is very low. The decision is already applied, and it may lead to the poor performance. It is not the objective of optimization via AI/ML function.  For b), it is clear and can give the direct info for the node who receives the prediction info. This node can do the related action based on the prediction info and corresponding accuracy. |
| Ericsson | We find the question a bit misleading. A node can “derive” the accuracy of a prediction from measured data | Providing a prediction accuracy together with a prediction is not trivial. For example, if a prediction is carried out on the basis of input data for which the model was not sufficiently trained, the prediction accuracy the model can derive is in itself inaccurate.  Hence it is not reliable for a receiving node to act upon the accuracy received from the inferring node, as such parameter can itself be inaccurate.  Therefore, the best way to derive the accuracy of a prediction is to compare the prediction with its corresponding measured values. This is possible in our framework because virtually all prediction information identified and received by an NG-RAN node also have a counterpart piece of information received at the same node and consisting of measured values. For example, a node receiving predicted resource status information can also receive the actual value of the resource status information.  It is true that there will be a process of “learning” what the accuracy of a prediction is, but this process is very short if we think that measurements will be reported with periodicity of hundreds of milliseconds or seconds. Hence an NG-RAN node can quickly learn in a matter of seconds the accuracy of the predictions from neighbour nodes and decide whether to use them or not. |
| InterDigital | Possibly | This is highly dependant on whether there are cases where inference is done based on different amounts of information, thus the gNB making the inference could know that one prediction was made on less information than another and thus less accurate. However, we do agree with one point Ericsson makes that even if the accuracy is sent the receiving node will need to verify the accuracy over time to be able to give it the proper weight in its inferences. |
| AT&T | Yes | While it is expected the accuracy will improve with time compared to the actual measurements, depending on the time scales involved and whether the information is more system or per-UE related, there is still a benefit in informing the gNB whether the inference is based on an “very” accurate estimate, or may be “limited” (e.g. due to limited time of the UE in the system, etc.) |
| Deutsche Telekom | Yes | We agree with Ericsson that also the accuracy info itself may be inaccurate in certain extreme cases, but in normal operation this information is useful for following decision processes. |
| Qualcomm | FFS | An AI/ML training server always tries to achieve 100% accuracy in prediction. However, that is not always possible due to the input data and the feedback. Based on the feedback if the node knows that prediction was incorrect, it will try and correct its model training and inference. We think it is not logical for a node to send prediction and say that it is 50% accurate, which is not so very useful to the receiver.  However, we are open to discuss on this topic further. |
| Huawei | Maybe not | Our understanding is, what this accuracy should be used by the receiving node? It is difficult to specify receiving node’s behaviour according to different accuracy level, which is not a clear indication. |
| CMCC | Yes | The sending and receiving node should have the same kind of accuracy understanding on the information transferred. Then it can use the prediction information do better strategy. |
| ZTE | FFS | We think only the NG-RAN node which performs the model inference should know the accuracy to evaluate the model performance. The actual measurement as feedback information should be transferred between NG-RAN nodes. |

**Moderator’s summary**

**On this question, 6 companies think that a node receiving a prediction shall be able to understand the prediction accuracy, 2 companies are against and 3 companies think that this could be FFS topic. Since companies think that accuracy information can be useful for prediction making, moderator thinks that this topic can be further discussed.**

**Moderator’s Proposal: RAN3 to further discuss the need and methods to interpret prediction accuracy at a receiving node.**

## UE Performance Information

UE performance has been discussed by several companies as part of feedback information (e.g., in [5514], [5516]). Several ways to evaluate UE performance have been proposed:

1. UE energy consumption
2. Average Packet Delay
3. Average UE Throughput DL
4. Average UE Throughput UL
5. Average Packet Error Rate
6. UE performance in terms of RVQoE
7. Handover interruption time (or other reporting of disruption at handover time) (from 5858)

**Q7. Companies are invited to provide their views on which of the above listed UE performance are useful for Feedback purposes for different use cases.**

|  |  |  |
| --- | --- | --- |
| **Company** | **UE performance/ Use Case** | **Comments, if any** |
| Lenovo | b) c) d) e) | b) c) d) e) are basic ones and can be taken as start point. The necessity of a) and f) are a bit unclear to us. The energy consumption is not easy to collect? And requires RAN2 involvement. RVQoE of a UE requires specific QoE configuration and may require SA involvement. |
| Nokia | b), c), d), e) | We think that b), c) d) e) could be possibly sent as part of feedback information. However, we are not sure if we really need to capture feedback per single UE performance or whether UE performance should be captured based on a number of UEs that received the same inference action for example.  Regarding a), this would be up to RAN2 to define. Regarding f) it is unclear how soon the impacts of RVQoE in terms of buffer increase can become available so that this information can be used. |
| Samsung | b), c), d), e), f) | It is fine for b), c), d), e), f).  Some services need to consider the user experience, so we are fine for take the RVQoE value as the feedback for node to evaluate the AI/ML related decision.  For a), UE EC related to many factors, which can not reflect the feedback directly. And it seems that objectives of ES/LB/MRO are not taking UE EC involved. |
| Ericsson | a), b), c), d), e), f) | For a) we believe it is very important to know what the energy efficiency at the UE is in order to take good energy efficiency decisions at RAN level. It would not be effective nor acceptable for an operator that an action to improve energy efficiency at network level results on a total drainage of UE batteries. Ultimately, UE battery drainage leads to the UE not been able to access network services, which is the main point of running a wireless network.  In terms of what RAN3 can do for a), RAN3 can (as done usually in SON work), send an LS to RAN2 and inform RAN2 that RAN3 is considering UE energy efficiency reporting as a useful information for AI/ML. RAN2 can then discuss whether enabling such reporting is feasible.  With respect to f), we believe that RV QoE is perhaps the most important feedback factor because it provides insights directly on the service quality. As an example, packet throughput for a UE may be reduced, but the user may still experience a good service quality. Hence an evaluation of UE performance based on packet throughput alone may be misleading.  While if service quality decreases, RVQoE will certainly decrease. Hence, RVQoE provides a more reliable UE performance metric  In reply to Nokia, we would like to point out that the minimum RVQoE reporting is of 120ms, hence fast enough to make RVQoE information available already after UE feedback is requested. |
| InterDigital | h)  b), c), d) e) (or just basic QoS fulfilment indication)  a) and f) open | Our proposal for indication like interruption time was missed for the summary – particularly in the energy savings and load balancing use cases, these handovers are sub-optimal for the Ues so this should be feedback in some way  For b)->e) since these are feedback directly on 5QI and other QoS parameters, wouldn’t just an indication that QoS is being fulfilled be enough. We could see that throughput in a bursty application could be misleading depending when the bursts align with the handover.  Would be ok with a) and f) no strong opinion one way or the other. |
| AT&T | a), b), c), d), e), f) | We agree with Ericsson that although a) and f) may involve other WGs than RAN3 they are very relevant for evaluating the practical performance impact of a given approach. In fact, part of the training likely involves building a model relating b), c), d, e), and g) to a) and f) which are closer to the ultimate “user experience” metrics at the end of the day vs. pure network KPIs. |
| Deutsche Telekom | b) – e) ok  a)/f) need further clarification | b) – e) are parameters that are certainly set as basic ones.  We are not against a)/f), but we see the need for further clarification on details (UE energy consumption only related to modem? Measurement interval, …). |
| Qualcomm | b) c) d) e) f) | a) We are not clear on why UE’s energy consumption is needed for AI/ML training in Network. We don’t see the relevance of UE’s energy consumption in Network based AI/ML. |
| Huawei | b), c), d), e): UL/DL throughput, packet delay, packet loss/error rate | For mobility enhancement, there might be also UE level performance, but we think this was already supported in current mechanism. |
| CMCC | b, c, d, e, f | FFS for f on the RVQoE definition. |
| LGE | b) c) d) e) f) | For a), we need to check RAN2’s view on whether the UE can report its energy consumption-related information to the gNB first. If yes, then RAN3 can discuss this information. |
| ZTE | B,C,D,E | We can go forward with BCDE first. RVQoE is also being discussed in other Agenda item, and we should not discuss it in AI/ML RAN for now. |

**Moderator’s summary**

**On this question there was consensus to support the following UE performance information to be sent for feedback purposes: Average Packet Delay, Average UE Throughput DL, Average UE Throughput UL, Average Packet Error Rate. Other UE performance is FFS.**

**Moderator’s Proposal: Support the following UE performance information to be sent for feedback purposes: Average Packet Delay, Average UE Throughput DL, Average UE Throughput UL, Average Packet Error Rate. Other UE performance is FFS.**

## Predicted Resource Status Definition

Various companies supported that Predicted Resource Status Information follows the granularity of existing resource status procedure (see e.g., [5376],[5483], [5514], [5516]). Some company also supported to consider predicted resource status over NR-U channel list ( [5483]). [5726] proposes to consider at least predicted per-cell CAC. Those are captured in the tabular below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| IE/Group Name | Presence | Range | IE type and reference | Semantics description | Criticality | Assigned Criticality |
| **Predicted Resource status information** |  |  |  |  | – |  |
| >Predicted Radio Resource Status | O |  | 9.2.2.50 | Predicted value of the Radio Resource Status IE |  |  |
| >Predicted TNL Capacity Indicator | O |  | 9.2.2.49 | Predicted value of the TNL Capacity Indicator IE |  |  |
| >Predicted Composite Available Capacity Group | O |  | 9.2.2.51 | Predicted value of the Composite Available Capacity Group IE |  |  |
| >Predicted Slice Available Capacity | O |  | 9.2.2.55 | Predicted value of the Slice Available Capacity IE |  |  |
| >Predicted Number of Active UEs | O |  | 9.2.2.62 | Predicted value of the Number of Active Ues IE |  |  |
| >Predicted RRC Connections | O |  | 9.2.2.56 | Predicted value of the RRC Connections IE |  |  |

**Q8. Do companies agree with the entries of the tabular above? Is it agreeable that it is used in the reporting procedure of AI/ML related predicted information?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments, if any** |
| Lenovo | Yes with comment | Theoretically speaking, any resource status in the above list can be predicted. In our view, Composite Available Capacity is one of the most basic criteria that reflecting the resource status, thus shall be at least included. |
| Nokia | Agree | We think that all the above predictions could be optionally supported by a node. |
| Samsung | OK | Support above for the prediction. |
| Ericsson | Agree | All of the above can be used in a predicted format |
| InterDigital | Agree |  |
| AT&T | Agree |  |
| Deutsche Telekom | Agree |  |
| Qualcomm | Agree |  |
| Huawei | See comments | We are open to discuss, but for prediction, we are not sure if we should provide for all these quantities, maybe we could start from simple factors, e.g. radio resources, no. of active UEs or no. of RRC connections… |
| CMCC | Agree |  |
| LGE | Agree |  |
| ZTE | Agree |  |

**Moderator’s summary**

**12 companies responded to this question. 11 companies supported that all of the existing resource status information can be predicted. One company suggested to start by introducing first the more simple ones, e.g., radio resources, number of UEs, number of RRC Connections. To achieve consensus moderator suggests to include in the reporting predictions of radio resources, number of UEs, and number of RRC Connections and keep as FFS the Predicted TNL Capacity Indicator, Predicted Composite Available Capacity Group and Predicted Slice Available Capacity.**

**Moderator’s Proposal: Predicted Resource Status Information reported in the new AI/ML related procedure can be predicted radio resources, predicted number of UEs, and predicted number of RRC Connections. It is FFS if also Predicted TNL Capacity Indicator, Predicted Composite Available Capacity Group and Predicted Slice Available Capacity are reported.**

## Energy Efficiency metrics and Exchange

A lot of the discussions on energy efficiency focus on how to capture the EE metric. Some companies propose to consider a detailed Energy Efficiency metric, calculated based on DV over EC e.g., [5702], [5726], [5760], [5777], [5813], [5879]. Some other companies propose to reflect EE metric in an abstract way by using a quantitative encoding (e.g., through a number in 0 to 100) (see e.g., [5514], [5584]).

**Q9. Companies are invited to provide their views on the exact definition of the EE metric, namely shall it be a) a detailed metric based on DV over EC, or b) an abstract metric based on a qualitative encoding?**

|  |  |  |
| --- | --- | --- |
| **Company** | **What is the EE metric definition, a) or b) ?** | **Comments, if any** |
| Lenovo |  | No strong view. Intention of a) is ok, but not sure how to encode a) in the spec. b) could work tough. |
| Nokia | b) | We think that it is almost impossible to (accurately) calculate a detailed Energy Efficiency metric, especially in certain scenarios, e.g., when it comes to cloud-based platforms. In addition, a detailed metric based on DV over EC could be interpretable at the OAM where additional information is available to interpret the energy consumption, e.g., where population density and geographical conditions are known. But such information cannot be assumed to be available at a neighbouring node.  Allowing a node to interpret the EE metric could be done through OAM configuration. For example, OAM could configure the maximum EE value (to enable a NG-RAN node to map the maximum energy Efficiency to the maximum value of the interval). Upon configuration of the maximum value, a NG-RAN node can utilize the maximum value to map its internal EE to different values of the EE metric using a linear scale. |
| Samsung | a) | For b), it may can not provide the information for node to do global optimization. The way to do the evaluation is different for different nodes. Although the same value for the scores, the actual EEs are not same from multiple nodes. The node who receives the score of EE from neighbour nodes, can not evaluate the overall EE and whether the ES decision lead to the global optimization. |
| Ericsson | b) | We share the views from Nokia.  We would like to add the following drawbacks on a)   * It is impossible to calculate the exact energy per bit if the hardware involved in the delivery of such bit is shared by multiple processes. * The purpose of an energy efficiency metric is that of understanding how energy consumption is changing due to different AI/ML actions. Defining energy efficiency as DV/EC does not allow this because e.g. if the energy consumption and the data volume increase at the same time, their ratio remains the same. Hence it is not always possible to deduce that a node is consuming more (or less) energy   The formulation in b) allows to always deduce how the energy efficiency is changing at a node, i.e. if its energy consumption is increasing or decreasing. As Nokia says, configuration of minimum and maximum may be carried out via the OAM. |
| Deutsche Telekom | a) | We agree that an EE metric based on DV over EC is not easy to calculate (dependent on HW/SW implementation), but a simple abstract metric based on a qualitative encoding is not applicable for optimization processes across nodes and therefore useless. |
| CATT | a) but | For a), The EE in its quotient form cannot and should not be delivered. It is neither feasible nor useful.  However, DV and EC can be delivered, especially EC. DV can be used to distinguish whether a rise of EC is caused by a rise in DV and thus does not mean the action is wrong (this is only a principle, the actual algorithm is much more complex and robust).  For b), an abstract percentage doesn’t work. The purpose of energy saving is to lower the total EC, which is the sum of many per-cell or per-node Ecs.  One cannot get the total EC from abstract percentage, i.e. it does not make sense to add up many percentages. |
| Qualcomm | a) but.. | With b) the issue is the way to compute the EE metric is not standardised. Different systems may compute EE metric and provide values in a linear scale of 0 – 100. How to comprehend a value 50 (for example) at the receiver is unknown.  a) We also agree that computation of DV over EC is not easy. Especially EC is system dependent and different systems can calculate EC in different ways.  Hence our recommendation is to start with DV over EC, but we think computation of EC should be enhanced by involving SA5. |
| Huawei | b) is preferred | We think a percentage or index should be enough to reflect the EE, and the existing definition in SA5 is already there, for details, it could be left to implementation. |
| CMCC | a | a is enough.  For the Data Volume (DV): we can use the definition in TS28.552 as a base line. It should include DL Cell PDCP SDU Data Volume Measurements and UL Cell PDCP SDU Data Volume Measurements. DL Cell PDCP SDU Data Volume Measurements provide the Data Volume (amount of PDCP SDU bits) in the downlink delivered to PDCP layer. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI) and per S-NSSAI. UL Cell PDCP SDU Data Volume Measurements provide the Data Volume (amount of PDCP SDU bits) in the uplink delivered from PDCP layer to higher layers. The measurement is calculated per PLMN ID and per QoS level (mapped 5QI) and per S-NSSAI.  For Energy Consumption (EC): we can use the Power, Energy and Environmental (PEE) measurements defined in TS28.552 as a base line. The EC should include PNF Minimum, Average and Maximum Power Consumption for a given cell. |
| ZTE | a | Prefer to reuse the definition in TS28.552. The qualitative encoding is not applicable, and it is hard to calculate the abstract metric. In addition, if we need to define a new kind of EE metric, SA5 should be informed and coordinated. |

**Moderator’s summary**

**6 companies support to reflect EE metric through a detailed metric based on DV over DC while 3 companies think that an abstract quantitative metric is better. 1 company does not have a strong view (though seems to challenge feasibility of detailed metric). Even though there was no consensus on this topic, some issues were brought up by the companies, namely issues on encoding, feasibility and interpretability of the detailed metric by a neighbour, as well as issues of applicability of the abstract metric for optimization processes across nodes.**

**Moderator’s Proposal: RAN3 to continue discussion on the feasibility, interpretability and encoding of the two EE metrics (detailed EE metric, and abstract metric).**

In the last meeting we made the following agreement:

*Current Energy Efficiency metric can be exchanged between RAN nodes for the energy saving use case.*

A question that remains unanswered is in which procedure the current Energy Efficiency metric shall be transmitted. Some companies support to extend Resource Status procedure to carry Current Energy Efficiency metric (e.g., [5399],[5702], [5777]). Some other companies support to define a new procedure to capture Energy Efficiency information (e.g., [5484], [5584]) while a company proposes to introduce current Energy Efficiency in the new AI/ML procedure (e.g., [5514]).

**Q10. Companies are invited to provide their view on which procedure shall carry the current Energy Efficiency metric, namely whether we shall a) extend Resource Status procedure, b) define a new procedure or c) use the new AI/ML procedure used to carry e.g., predictions.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Companies are invited to choose among the a)-c) options above** | **Comments, if any** |
| Lenovo | b) preferred, a) acceptable | Prediction information is quite AI/ML specific. Other information, no matter of training information or feedback information, is essentially measurement information. In our view, there is no need to restrict the measurement information is used for AI/ML operation only.  From specification point of view, to have a neat design and not mess up with legacy procedure (e.g., it’s a bit difficult to link the name of “Resource Status Reporting” to energy efficiency or UE performance), another new procedure is preferred. |
| Nokia | b) | We think that it is best to define a new procedure to transfer current Energy Efficiency information. Energy Efficiency is not really “resource status” related information, so we don’t think that we should extend Resource Status procedure to include it. Having a new procedure could be useful for other information related to EE that could be standardized in the future (e.g., after the ongoing EE SI). |
| Samsung | a) | EE is the efficiency for energy utilization, so it can be regarded as a kind of resource status. Prefer to embed it into the resource status reporting. There is no need to design new procedure. |
| Ericsson | c) | In R3-225509 2 companies propose to follow the approach in c). We reiterate that in our view the new procedure used for AI/ML information signalling should be data type agnostic. This is to allow all information needed by an AI/ML process to be available at the same time at a requesting node. The requesting node is aware of how the information received will be used, this is up to implementation.  As an example, the requesting node may need as inputs for its Model Inference function the current energy efficiency and the predicted resource status information of a neighbour node/cells. This is needed to a) understand the level of energy consumption at the neighbour node (so to decide whether to offload traffic or to avoid it due to already high energy consumption levels) and b) to understand what the level of load of the neighbour node will be (so to decide whether to offload traffic or to avoid it due to foreseen high load levels).  Why should then the energy Efficiency metric be signalled in a different procedure than the predicted resource status information?  Signalling the two information separately may prevent the Model Inference function to correctly run inference because only a subset of inputs is available at any given time.  We therefore propose to send the Energy Efficiency metric as part of the new procedure for AI/ML. |
| Deutsche Telekom | c) preferred | As EE metrics do not fit well with current Resource Status reporting, a new procedure is preferred, but as the new AI/ML procedure may be extended beyond prediction data, also EE information could be incorporated. Therefore, c) is preferred against b). |
| CATT | c) | c) is more flexible. |
| Qualcomm | a) | The Resource status procedure already contains Energy related parameters for NR-U. Hence in the similar way we prefer to extend the Resource status reporting procedure to carry **current** EE metric. |
| Huawei | a) and/or c) | Since EE is a newly introduced info, this could be included in the new AI/ML procedure as part of requested info, together with predicted EE information; but we think it should not be precluded that the actual EE info might also be transferred over existing message, e.g. in a). |
| CMCC | c) | No strong view. |

**Moderator’s summary**

**On this question 4 companies support to extend Resource Status procedure to carry current Energy Efficiency metric, 2 companies support to define a new procedure, and 5 companies support to use the new AI/ML procedure.**

**Moderator’s Proposal: RAN3 to further discuss how to transfer current Energy Efficiency metric.**

Another relevant question is how to collect current Energy Efficiency information and whether it shall be collected on a per node or per cell granularity.

**Q11. Companies are invited to provide their views on whether current Energy Efficiency metric shall be collected on a per cell or a per NG-RAN node granularity.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Per node or per cell granularity?** | **Comments, if any** |
| Lenovo | Per cell | Energy efficiency of an NG-RAN node would depend on all cells belonging to it, it doesn’t make much sense to relate the energy efficiency of target NG-RAN node to a cell activation/deactivation decision at the source NG-RAN node. |
| Nokia | Per cell | We think that it is best to collect this information per cell since the allowed AI/ML EE actions considered are cell-based actions. |
| Samsung | Per cell | As ES decision is for one cell, the cell-granularity is more valuable to give the information for ES decision setting. |
| Ericsson | Per node | Multiple cells are served by the same gNB-DU infrastructure. For example, the same power amplifier may serve multiple cells. Multiple cells for multiple gNB-DUs are served by the same gNB-CU-CP and gNB-CU-UP infrastructure.  Can the proponents of a per cell metric explain how is it possible to derive the energy consumption per cell, when multiple cells share the same infrastructure and processes?  Surely a calculation of energy consumption is more feasible at node level as one can assume that a node may use a dedicated set of resources.  EE actions can still be performed on a per cell basis, even if energy efficiency can be defined per node. Namely, a per cell EE action can be guided by whether the node level energy efficiency is positively or negatively affected by the action. |
| Deutsche Telekom | Per cell, but | Having the EE info on cell level granularity is certainly preferable with respect to intended decision processes, but the exact computation of per cell values needs further discussion. |
| Qualcomm | Per Node but open for per cell | Agree with E/// reasoning. Since the HW and SW resources are shared between multiple cells of a node, it is tough to compute EC at cell level. Hence we think calculation of EE at node level is more feasible.  However we are open to discuss further on the cell level EE metric. |
| Huawei | See comments | In our understanding, cell level should be a base line, but node level (sum of cell level) could also be considered as optional info. |
| CMCC | Per cell | Based on current use case requirement, cell level energy efficiency collected is better to help make decision on cell activation/deactivation. |
| ZTE | Cell-level | Cell-level metrics should be base line and as a start point. |

**Moderator’s summary**

**On the question whether energy-efficiency metric is per node or per cell, 6 companies support that it is per cell, 2 companies support it is per node and 2 companies are open to both options. A question brought up is how to calculate the EE metric per cell.**

**Moderator’s Proposal: RAN3 to further discuss whether EE metric is per node or per cell and how per cell EE metric can be calculated.**

Finally, shall predicted Energy Efficiency metric be exchanged between neighbours? If so, which procedure shall be used for that?

**Q12. Companies are invited to provide their views on whether predicted Energy Efficiency metric shall be exchanged between neighbours and if so in which procedure?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Exchange predicted Energy Efficiency metric (yes/no).** | **If yes, in which procedure shall this information be sent?** |
| Lenovo |  | No strong view. If yes, it shall be carried in the agreed new procedure carrying prediction information. |
| Nokia | Yes but under a clarification | Could be useful to introduce a procedure through which a network node can predict the impact of its own actions (e.g., cell switch off) in terms of the EE metric at a neighbour node. In this way, it can determine for the networks best interest whether to take the action or not (e.g., whether to switch off a cell or not). For instance it can evaluate the predicted energy efficiency change at a neighbour (coverage cell) for an additional load to be offloaded by a capacity cell when this is switched off and compare it to its own savings in EE by the switch off.  However, we do not see the need to introduce periodic reporting to provide predicted energy efficiency information. |
| Samsung | Yes | Predicted energy efficiency from neighbour nodes can assist ES decision setting. The target cell selection for offloading is part of ES decision. If the predicted energy efficiency is low, the node may not transfer the low to such cell to realize the global energy saving. |
| Ericsson | Yes, if used as part of a negotiation before taking EE actions | We see the use of the predicted energy efficiency metric beneficial in cases where a node that wants to take an EE action communicates to a peer node its predicted EE corresponding to the action to be taken. The peer node can return its own predicted EE corresponding to the same action. This enables awareness of the energy efficiency levels at both nodes in case an EE action is taken.    In the picture above, if x-y returns a positive value, NG-RAN 1 can go ahead and turn off Cell 1.  We do not see the need of a predicted EE metric if such pre-action negotiation is not carried out.  If the predicted EE metric is introduced, we propose to signal it as part of the new AI/ML procedure to support exchange of AI/ML information. |
| Deutsche Telekom | Yes | EE predictions are seen as useful for energy saving related decisions (see examples given by Nokia, Samsung, and Ericsson).  Usage of the new AI/ML procedure for EE predictions is preferred. |
| Qualcomm | FFS | The usage of Predicted EE needs to be clarified further. It is not clear on how the predicted EE value can be interpreted at the receiver. |
| Huawei | Yes, | As indicated in our paper, this should be exchanged in the agreed new non-UE associated procedure |
| CMCC | Yes | Use the new defined prediction procedure through Xn interface. |
| ZTE | Yes | It can be exchanged via the non-UE associated procedure for AI/ML predicted information. |

**Moderator’s summary**

**All companies seem to support exchanging of predicted energy efficiency metric. Some companies suggest that this should be done only for identified scenarios where this would be beneficial.**

**Moderator’s Proposal: RAN3 to discuss the scenarios where predicted energy efficiency is exchanged are depending on the need to take an EE decision.**

## Validity Time

Even though the concept of validity time has been discussed since the SI phase, still there hasn’t been a common understanding among the companies related to how is the validity time defined. In this meeting, validity time has been defined as the time in future that prediction is calculated ([5483]) or the time duration in the future ([5758]) or the time in the future that prediction is valid [5781]. So the essence behind validity time is that it gives the time instant or the time duration during which a prediction is valid.

The question we would like to address here is whether validity time shall be sent together with “periodic” predictions.

Validity time for periodic prediction reporting can be indicated:

1. Implicitly with a new prediction when the previous prediction becomes invalid -no standards impacts from this solution ([5812], [5846])
2. Explicitly with every prediction in the AI/ML output – this solution has standards impacts ([5399], [5702], [5760])
3. By the subscription to the prediction, e.g., a node requests a prediction of 1 minute ([5513])

**Q13: Companies are invited to discuss whether validity time needs to be signaled explicitly or implicitly or whether it is indicated in the subscription procedure.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Do companies agree that validity time can be indicated by the options a)-c) above?** | **If so, which one is the preferred option?** |
| Lenovo | Yes | c)? We agree the first prediction request message can indicate a validity time. But we don’t fully agree with the following proposal made in [5513].  **Validity time for predicted resource status information need not be explicitly signaled since it can be derived from the reporting period of accepted requests.**  For periodic prediction reporting, the validity time can be indicated in the following way, e.g.:   * Assuming the prediction request message is sent at time point T0 * A time information T implying the first prediction report should be about the predicted resource status at T0+T mins * Periodicity value P implying the prediction report shall be sent every P mins, each time carries the predicted resource status at T0+P\*N+T mins. |
| Nokia | a),c) | In our view, options a) and c) seem reasonable, though option a) will need a higher reporting flexibility:  a)In order to enable this option, the new prediction can be sent when the previous prediction becomes invalid. This can be done with current reporting mechanism (assuming that we allow some flexibility in the reporting); Current reporting mechanism allows only for a fixed periodicity during the reporting which means that even if a node detects that a prediction is invalid, it cannot send the new prediction earlier than the period.  c)A node can subscribe to model inference output that meets certain characteristics, e.g., the node subscribes to predictions from a neighbour that are valid for 1 minute. The node providing the predictions reports the predictions with a certain periodicity (e.g., every 2 minutes) but the node receiving the predictions knows that the validity of a prediction (according to the model it has subscribed) is only 1 minute.  Regarding b), this is possible but unnecessary. We never had this discussion earlier but it would be reasonable to assume that a single model is being executed during the reporting (unless the node deploys a new model if the previous becomes invalid). Therefore, all the requested inference outputs shall originate from the same model and shall therefore have the same validity time. |
| Samsung | b) c) | Prediction information is a data valid for a future time or time interval. It is beneficial to explicitly provide validity time of prediction information. The node receives a prediction information in the future X min to Y min, and node can take this foreseen information for its decision setting to avoid local overload, ES ping-pong, etc. For a), the prediction information may not valid at the receiving time, but valid for a future time. E.g., a node receives the predicted info at time a, but it is valid in time a+b to time a+b+c. In such case, the validity time can not be known by receiving a new one. |
| Ericsson | c), possibly a) | We believe that a node requesting periodic reporting of predicted information assumes that the predictions are valid for the duration of the reporting period. A reporting node may reject the request if the predictions cannot be valid for the reporting period duration.  Alternatively, we share Nokia´s views that the reporting procedure could be made flexible and a node may report a new predicted information sample if the prediction becomes invalid. However, this approach should ensure that the reporting node does not end up in excessively frequent reporting |
| InterDigital | c), a) | c should be the default, Support for a) if/when predictions are changed outside of the periodic time. |
| AT&T | b) and c) | There may be tradeoff between the overhead of the information exchange and the accuracy of model and its predictions. As a result, explicit information about the achievable (and desired) time window is the best approach in our view. |
| Deutsche Telekom | a) b) c) | In principle, all 3 variants are feasible and depend on the underlying use case/scenario for which the prediction value is created. A) is certainly the simplest one, but many not fit to all scenarios that may be considered. |
| Qualcomm | a) and c) | The validity of the predicted data varies with use case the predicted data itself. Hence our first preference if to allow more flexibility in signalling by providing validity time with the predicted output explicitly – option a)  If that is not acceptable for the companies, then we prefer c) where in subscription the validity time is mentioned.  We do not prefer b) as for different use cases and predicted data the validity time may vary. Hence it is not possible to define implicit validity for all kinds of predicted data prior. |
| Huawei | a) | In our understanding, the request message could indicate the periodicity of reporting/updating, the prediction itself may also include some timing info (details are FFS). |
| CMCC | b) | Explicitly with every prediction in the AI/ML output – this solution has standards impacts. As we need to define new procedures for prediction information, the validity time should be explicitly added in the IE. |
| LGE | a) and c) | a) is okay because this solution can be performed as the current reporting mechanism and has no specification impact. For c), the request node is able to indicate the validity time for the predicted information which it uses to the reporting node.  For b), if c) is applied, b) may be unnecessary because the validity time for the predicted information can be derived from the accepted requests. |
| ZTE | a) | Actually, we suggest the request message could indicate the validity time (e.g., start time and duration) in 5879 and 5880. |

**Moderator’s summary**

**On how to capture validity time for periodic prediction reporting, the following was supported by the companies:**

**9 companies supported to implicitly indicate validity time with a new prediction when the previous prediction becomes invalid, 5 companies supported that it can be explicitly indicated with every prediction in the AI/ML output and 8 companies think that it could be done with subscription to the prediction, e.g., a node requests a prediction of 1 minute. Some companies think that a combination of options may lead to the actual solution of validity time. Some companies proposed that the actual selection on how to indicate validity time may depend on the use case.**

**Moderator’s proposal: How to indicate validity time (implicitly with a new prediction when the previous prediction becomes invalid, explicitly with every prediction in the AI/ML output or by the subscription to the prediction) shall be discussed on a case by case basis.**

## UE Trajectory Prediction

In the last meeting, it was agreed to transfer cell-based UE Trajectory information to neighbour NG-RAN nodes. During this meeting, a number of companies supported to use UE history information for as an input for UE Trajectory prediction (e.g., [5399], [5509], [5811], [5846]).

**Q14 Do companies agree that UE history information will be the basis of training an AI/ML Model for cell-based UE Trajectory prediction?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments, if any** |
| Lenovo | Yes |  |
| Nokia | Agree |  |
| Samsung | OK |  |
| Ericsson | Agree with the fact that the UE trajectory prediction can follow the same structure as the UE history information | Do we really care what information a training function uses to derive a model that can predict trajectories? Shouldn´t the question rather be if the trajectory prediction can be based on the UE history information structure?  Suring the study phase we agreed that Model Training functions are implementation specific, so we should not agree here of what is the exact input a training function uses to train a UE trajectory prediction model.  We agree that the UE Trajectory prediction should have cell level granularity and it should be based on the UE history information structure. |
| InterDigital | Agree…. | Agree with Ericsson |
| Deutsche Telekom | Agree but … | As Ericsson stated, UE trajectory prediction could be based on UHI, but there may be also other input data that could be incorporated, i.e., UHI is only one possible element. |
| CATT | OK |  |
| Qualcomm | Agree | UHI may not be the only parameter for UE trajectory prediction. But UHI is definitely one of the parameters. The UE mobility history IE in RRC UE Information Response can also be used and there could be other input parameters as well.  Also agree with E/// |
| Huawei | Agree | We share similar view as E/// that UE Trajectory prediction should have cell level granularity and it should be based on the UE history information structure. |
| CMCC | Yes | Of course, local UE history information should be the basis of UE trajectory prediction. |
| LGE | Agree |  |
| ZTE | Agree | UHI can be the baseline of the cell-based UE Trajectory prediction. |

**Moderator’s summary**

**All companies agree that UE history information will be the basis of cell-based UE Trajectory prediction in the sense that the two will have the same structure. Some companies think that Training a model for cell-based UE Trajectory prediction may need other input as well e.g., UE Mobility History IE or other information.**

**Moderator’s Proposal: Cell-based UE Trajectory prediction has the same structure as UE History Information IE. RAN3 to further discuss what input is needed to train cell-based UE Trajectory prediction, e.g., UE Mobility History IE, UE History Information IE, etc.**

Another open point with respect to UE Trajectory prediction is to identify the exact representation of UE Trajectory Prediction. Some companies support that it may be given as a list of predicted cells (e.g., [5511], [5585], [5727], [5760]), a list of predicted beams (e.g., [5727], [5758], [5812], [5870]), or a list of predicted detailed location information (e.g., [5758], [5814], [5879]). Some companies propose that in addition the (expected) time when a UE has stayed at a given “hop” shall also be indicated (e.g., [5760], [5585]).

**Q15: Companies are invited to provide their views on whether cell-based UE Trajectory prediction is provided as a list of cells into the future, each of which is indicated together with an expected time of expected stay into the cell. Are any other granularities of UE Trajectory Prediction acceptable? (e.g., beam-based, location-based).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Are any other granularities of UE Trajectory Prediction acceptable? (E.g., beam-based, location-based, etc.)** |
| Lenovo | Agree | We don’t see strong motivation to support other granularities. Regarding beam based, it’s unclear to us how to get the beam information in other RAN node, especially considering beam deployment may change dynamically. |
| Nokia | Agree | We think that both cell information and an expected time of stay in the cell would be useful information for predicted cell-based UE Trajectory prediction.  Regarding other granularities, we don’t think that those are needed for the current AI/ML use cases we consider and allowed Model Outputs, which are cell-based. So, in our view cell-based granularity seems to be the needed granularity for predicted UE Trajectory. |
| Samsung | Yes | For other granularity, prefer to study the location-based after cell-based. As cell is not so finer, the prediction results may not so accurate. E.g. two UEs in the same underground from same start station to the same end station, so the trajectory in cell level for both two Ues are same, such as cell A, cell B, cell C. But after they get out from underground station, one comes to cell D, and the other goes to cell E. With the input of cell A/B/C, the model inference may be cell D or cell E. In such case, cell-based prediction may be not so accurate.  Node can get UE location information from MDT report. Location-based prediction can be discussed later after the cell-based prediction. |
| Ericsson | Agree | This level of granularity is sufficient and perhaps it is the only feasible option we have. An NG-RAN node may not even be aware of the existence of cells or beams where the UE may end up in the future, hence increasing the granularity may only bring to more uncertainty in the predictions. |
| InterDigital | Agree |  |
| AT&T | Agree + beam-based | Many of the scenarios where mobility is most challenging involve higher bands where beam-based operation is critical. It is certainly already possible for Ues to report beam-level measurements of neighbor cells, so we think that the reporting framework should be flexible to support beam-index based predictions as well. If companies have concerns about the feasibility, asking RAN2 about this could be an option. |
| Deutsche Telekom | Agree | Beam-based granularity sounds interesting, but the benefits of that granularity against a possibly higher inaccuracy of the prediction result have to be evaluated first. |
| CATT | Agree + beam-level | The next cell a UE is predicted to move into can be provided with beam-level predictions. |
| Qualcomm | Agree | We think Cell based UE trajectory prediction is a good starting point. Prediction on how long a UE is expected to stay in a cell is the next level of prediction and this can be taken up once the next hop cell prediction is defined.  Also other granularities of prediction like beam level or geolocation can be discussed later. |
| Huawei | See comments | We think cell-based UE Trajectory prediction together with an expected time of expected stay into the cell, should be enough; there is no need to consider other granularities for the moment, in order to be simple, since the HO target is anyway cell basis. |
| CMCC | Agree | Not only cell-level, but also the beam-level UE trajectory prediction will be helpful. |
| LGE | Agree | Regarding any other granularities of UE Trajectory prediction, we don’t think that these granularities are necessary to be considered. For beam-based UE Trajectory prediction, it is unclear what benefit will be gained by beam-based prediction. |
| ZTE | Agree | We go forward with cell-granularity UE trajectory first. And for location-based trajectory, it is beneficial for RAN node to perform mobility optimization. Finer granularity can give much more accurate reference to NG-RAN node. Support to study location-based trajectory after cell-based trajectory. |

**Moderator’s summary**

**13 companies agree that the cell-based UE Trajectory prediction is provided as a list of cells into the future, each of which is indicated together with an expected time of stay into the cell. Some companies supported to also have beam-based prediction but there was no consensus by companies on the benefits or feasibility of beam-based prediction.**

**Moderator’s Proposal: Cell-based UE Trajectory prediction is provided as a list of cells into the future, each of which is indicated together with an expected time of stay into the cell.**

## Feedback Information

During the last meeting we made the following agreement related to sending UE performance as part of feedback information for each of the use cases:

* *UE performance (e.g, UL/DL throughput, packet delay, packet loss)*

In [5586] it is discussed that UE performance of handed over UEs needs to be calculated over a period of time to allow the average performance of throughput, delay, packet loss, etc. to converge. However, by that time the UE context at the source regarding the Ues for which feedback is requested is likely released. This is because UE context is typically more short-lived compared to the time needed for UE performance measurements to be calculated at a node. In the absence of an active UE context the source node cannot anymore correlate the received feedback information to the corresponding action that led to a certain UE performance.

Two methods were proposed for maintaining an active UE context in this meeting, i.e.,

a) Introduce a new UE context, surviving longer than handover so that UE performance information can be associated with the AI/ML action taken at the source NG-RAN node. [5586]

b) Maintain context after HO procedures are finished in an implementation specific way. [5846]

**Q16: Companies are invited to provide their views on how a UE can be identified for feedback purposes when UE context is released. Do companies think that either of the options a) or b) are agreeable?**

|  |  |  |
| --- | --- | --- |
| **Company** | **How to identify a UE when UE context is released** | **Comments, if any** |
| Lenovo | a) | The full UE context includes all the AS configurations related to the UE. It doesn’t make much sense to store all the AS configuration related to the UE after HO success. On the other hand, some UE context relevant to the AI/ML based NW operation can be stored, e.g., some kind of ID (related to a UE or a AI/ML based NW operation event), predicted UE status. |
| Nokia | a) | Regarding b) we don’t think it is a good idea to prolong the release of UE context after a Handover is completed, for the same reasons mentioned by Lenovo. But we do see the need to have a context to identify a UE until the UE performance information at the target is calculated and reported back to the source node. |
| Samsung | b) | If the target node does not feedback the performance or feedbacks it after a long time, the source node can not release the context, which leads to the high storage burden for source node. As the feedback information is to evaluate the decision, it is fine to leave it to implementation. The node can maintain or release based on its situation or requirements. If the node intends to evaluate the decision, it can maintain the context. And if the maintaining time is so long, the node can release it. So we prefer to leave this issue to implementation. |
| Ericsson | b) | This is the same discussion we had for SON MRO, where it would be good to have a UE context at source at the time an RLF Report is received.  We have agreed for SON that it is up to configuration and implementation for how long the source maintains the UE context. The same can be done for the UE Performance reporting.  Namely, after a UE is handed over to a target NG-RAN node, and if the NG-RAN node has been configured to report the performance of Ues handed over for AI/ML reasons, the target NG-RAN node will start reporting the UE performance to the source. This can be done for a configured amount of time. Alternatively, the target may report until the UE context release is issued, which marks the point when the UE context at source is removed.  Note that collecting the UE performance for e.g. one second after the HO is already sufficient as it informs the source of the performance of the UE *while the UE is in the radio conditions expected by the source* (i.e. close to cell edge) |
| InterDigital | b) |  |
| Deutsche Telekom | b) | In principle, the option a) can be covered by b) without the need to specify a new context model. Based on implementation a node can store only those parts of the UE context relevant for the AI/ML procedure. |
| CATT | b) | No need to specify what part of UE context should be deleted and what should be kept. |
| Qualcomm | Leave it to implementation | If a source node is expecting feedback, then its upto the source node to retain the context in a minimalistic way or the full context. From standards pov, we can provision requesting of feedback by source and providing feedback response with the same UE identifier which can be recognised in both source and receiver.  Validity of how long the context can be retained should be left to the implementation. |
| Huawei | b) | We think there is no need to introduce new UE context, since the source side could decide whether to keep the current UE context for a while or not by itself, if source node decides to delete/release the current contexts, which means that any possible further incoming info associated with this UE is not that useful anymore… |
| CMCC | a) | Agree with Lenovo. A new UE context won’t impact the current procedure. |
| LGE | b) |  |
| ZTE | Leave it to implementation | In addition, the new procedure for AI/ML feedback information is needed. |

**Moderator’s summary:**

**3 companies supported to introduce a new UE context, surviving longer than handover so that UE performance information can be associated with the AI/ML action taken at the source NG-RAN node and 9 companies supported to maintain context after a HO in an implementation specific way. There was no consensus on this topic.**

**Moderator’s Proposal:**

**WA:  It is up to implementation for how long to maintain the UE context after a HO, to enable association of UE Performance Feedback to the UE context**

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|  |  |
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# Conclusion, Recommendations [if needed]

If needed.