**3GPP TSG-RAN WG2 #127bis *R2-24xxxx***

**Hefei, China, October 14th – 18th, 2024**

Agenda Item: 8.3.1

Source: Mediatek Inc.

Title: Report of [POST127][027][AI Mob] Simulation table (Mediatek)

Document for: Discussion, Decision

# Introduction

This report provides a summary for the following post-meeting email discussion:

* [POST127][027][AI Mob] Simulation table (Mediatek )

 Intended outcome: Agree how to capture simulation results

 Deadline: two weeks

The deadline for providing comments is September 6, 2024, Friday at 7:00 UTC.

Companies providing input to this email discussion are requested to leave contact information below.

|  |  |  |
| --- | --- | --- |
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# Discussion

The study focuses on three use cases: RRM measurement prediction, measurement event prediction, and RLF/HOF prediction pertinent to the PCell change procedure in standalone NR scenario. To systematically organize and evaluate the simulation outcomes across these varied use cases, a straightforward approach is to organize the simulation results into three separate folders, each corresponding to one of these use cases. Within each folder, there are spreadsheets that capture the simulation results for a range of scenarios specific to that particular use case.

**Q1:****Do companies agree** **to organize the spreadsheets into three separate folders, each folder dedicated to one of the three use cases?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comment |
| Mediatek | Yes | Example: |
| OPPO | Yes |  |
| vivo | Yes |  |
| Apple | Yes |  |
| Ericsson | Yes |  |
| Nokia | Yes |  |
| Huawei, HiSilicon | Yes |  |
| ZTE | Yes |  |
| CMCC | Yes |  |

**Summary:** all companies replied yes and agree to to organize the spreadsheets into three separate folders, each folder dedicated to one of the three use cases.

**Proposal 1:** **The spreadsheets are organized into three separate folders, with each folder corresponding to one of the three use cases.**

Given the limited progress and available simulation results for the measurement event prediction and RLF/HOF prediction use cases, we suggest using the RRM prediction use case as a template for the documentation process. We expect that a similar approach to document simulation results will be applied to both the measurement event prediction and RLF/HOF prediction use cases as further progress are achieved. The specific details within the spreadsheets can be tailored and refined according to the requirements and evaluation target of each use case.

**Q2:** **Do companies agree to** **use** **the RRM prediction use case as a template for the documentation process, with the intention that** **the similar documentation approach is applied to the measurement event prediction and RLF/HOF prediction use cases?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comment |
| Mediatek | Yes |  |
| OPPO | Yes |  |
| vivo | Yes |  |
| Apple | Yes |  |
| Ericsson | Yes | We can revise later when simulation results for event predictions and RLF/HOF predictions are available |
| Nokia | Yes |  |
| Huawei, HiSilicon | Yes |  |
| ZTE | Yes |  |
| CMCC | Yes |  |

**Summary:** all companies replied yes and agree use the RRM prediction use case as a template for the documentation process. This documentation approach will also be applied to the measurement event prediction and RLF/HOF prediction use cases. As suggested by Ericsson, the corresponding tables for the event prediction and RLF/HOF prediction use cases can be revised once the simulation results become available.

**Proposal 2:** **The RRM prediction use case is used as a template for the documentation process. This approach will be similarly applied to the measurement event prediction and RLF/HOF prediction use cases, the spreadsheets of which are subject to revision upon availability of the simulation results.**

In the RRM prediction use case, various scenarios have been identified and ranked in terms of priority, similar to those detailed in Table 5.2.1-1 of the TR.

Table 5.2.1-1 prioritization of evaluation scenarios

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| scenario number | Priority  | Evaluation scenario | Target study goal | Methodology |
| 1 | Low | FR1 to FR1 intra-frequency temporal domain case A | 2nd goal | TBD |
| 2 | High | FR1 to FR1 intra-frequency temporal domain case B | 1st goal | Intra-cell |
| 3 | High | FR1 to FR1 inter-frequency (frequency domain) | 1st goal | Inter-cell  |
| 4 | High | FR2 to FR2 intra-frequency temporal domain case A | 2nd goal | Intra-cell |
| 5 | Low | FR2 to FR2 intra-frequency temporal domain case B | 1st goal | TBD |
| 6 | Middle | FR2 to FR2 intra-frequency spatial domain | 1st goal | Intra-cell |

To facilitate easy access and simplify the evaluation process for each use case, individual spreadsheets can be created to document the simulation results, outcomes, and findings for each identified scenario, for instance, scenarios 1 through 6, ensuring consistency with the terminology and descriptions found in the TR. If additional scenarios beyond those initially identified are proposed by companies, new spreadsheets can be incorporated at a later stage to accommodate these supplementary simulations. Furthermore, additional spreadsheets may be needed for generalization performance evaluation.

**Q3:** **Do companies** **agree to** **create individual spreadsheet for each identified scenario for the use case of RRM prediction, e.g., scenarios 1~6 with the understanding that we can add more spreadsheets as required e.g., when other scenarios are identified?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comment |
| Mediatek | Yes | We have provided four example spreadsheets for scenarios considered as high and medium priority. |
| OPPO | Yes |  |
| vivo | Yes |  |
| Apple | OK (also see comments) | File-per-case is fine, alternatively a sheet-per-case (with multiple cases in a single file) would have been fine too.[Rapp] We may consider consolidating them into a single file later on if they exhibit a significant number of commonalities, thereby minimizing duplication, such as in the case of simulation assumptions. |
| Ericsson | Yes |  |
| Nokia | Yes  | Agree with the intention of the question. We will also need to account for the KPIs that we will agree for the mobility optimization goal. [Rapp] Yes, we will incorporate additional KPIs into the spreadsheet once they are agreed upon. |
| Huawei, HiSilicon | Yes |  |
| ZTE | Yes |  |
| CMCC | Yes |  |

**Summary:** All companies are OK to create individual spreadsheet for each identified scenario for the use case of RRM prediction, e.g., scenarios 1~6 with the understanding that we can add more spreadsheets as required e.g., when other scenarios are identified. We will add more KPIs in to the spreadsheet once they are agreed upon. We can consider whether to use a single file to include all scenarios if this approach is more efficient.

**Proposal 3: Individual spreadsheet for each identified scenario for the use case of RRM prediction is created, e.g., scenarios 1~6 with the understanding that we can add more spreadsheets as required e.g., when other scenarios are identified.**

For each spreadsheet, we will create distinct tabs/sheets to document the simulation assumptions, KPIs, simulation results from different companies, key findings, and potentially a comparison of results across companies. Currently, we will ensure that each spreadsheet includes separate tabs for at least the simulation assumptions, evaluated KPIs and definitions, and simulation results from different companies. As the evaluation progresses, we can add new tabs as needed and based on discussions.

**Q4:** **Do companies agree** **to initially set up distinct sheets for capturing the simulation assumptions, evaluated KPIs and definitions, and simulation results from companies, with the understanding that we will add more sheets as needed and** **in accordance with discussions that emerge during the evaluation process?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comment |
| Mediatek | Yes | Please refer to the spreadsheet examples. |
| OPPO | Yes |  |
| vivo | Yes |  |
| Apple | Yes (also see comment) | The “KPIs” sheet is not actually needed, as companies are not expected to provide any inputs in that sheet, right?[Rapp]Companies are not expected to provide any inputs in the sheet. The KPI sheet is to provide the list of evaluated KPIs and the corresponding definitions. The reason to have this sheet is that the evaluated KPIs for different use cases may be different.  |
| Ericsson | Yes |  |
| Nokia | Yes |  |
| Huawei, HiSilicon | Not entirely… | Please note that some simulation assumptions (e.g. spatial consistency option, UE trajectory option, LOSsoft etc.) which are currently listed in “Simulation assumptions” tab, are up to companies to decide. It would be good to gather all the selectable items in one sheet, i.e. move all selectable simulation assumptions to the last sheet, together with “Setting”. This would allow for easier checking of impact of different selections on the results. Here is a depiction of what we mean:[Rapp] I believe it's more convenient to compile all simulation assumptions in a single tab rather than scattering them across various locations. However, your suggestion to consolidate all selectable options in the results sheet is valuable for efficiently assessing the impact of different choices on the outcomes. I will incorporate these selectable simulation assumptions into the results sheet accordingly. This suggestion is related to Q5, and will be reflected in the proposal for Q5.  |
| ZTE | Yes |  |
| CMCC | Yes |  |

**Summary**: Majority of the companies replied yes. Huawei provide a good suggestion to include the selectable simulation assumptions in the result sheet.

**Proposal 4: Distinct sheets are initially set up for capturing the simulation assumptions, evaluated KPIs and definitions, and simulation results from companies, with the understanding that we will add more sheets as needed and in accordance with discussions that emerge during the evaluation process.**

Capturing the simulation assumptions and evaluated KPIs/definitions has not presented significant issues. However, the method for documenting simulation results from different companies within the spreadsheet requires discussion to ensure it is well-organized and scalable. The columns in the simulation results sheet are categorized into four main groups: general information (such as company name and case description), variable settings (including the number of Tx beams, number of Rx beams, UE speed, and temporal domain prediction parameters like observation/prediction window, MRRT, MRRS, etc.), model-related information (covering model inputs and outputs, AI model type, model complexity, computational complexity, training/validation set size, testing set size), and performance metrics for various KPIs (for example, the average L3 cell-level RSRP difference). One example for scenarios 2 (FR1 to FR1 intra-frequency temporal domain case B) is illustrated below for your reference.



**Q5:** **Do companies** **agree to** **categorize** **the columns in the simulation results sheet into four main groups: general information, variable settings, model-related information and performance metrics for various KPIs?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comment |
| Mediatek | Yes | The system performance metrics will be added when agreed. |
| OPPO | Yes |  |
| vivo | Yes with comments | Setting: some parameters are duplicated in ‘Simulation assumption’, i.e., UE speed(km/h), Number of Tx beams, Number of Rx beams, suggest removing UE speed in the ‘Simulation assumption’ sheet and removing Number of Tx beams, Number of Rx beams in the ‘results’ sheet.[Rapp] I believe it is more convenience to compile all simulation assumptions within a single tab on the assumption sheet. Regarding the results, having duplicated items facilitates filtering and enables a simpler evaluation of how varying those parameters influences the outcomes.Performance Metrics: One more column should be added to align with ‘KPIs’ sheet, i.e., Average L1-RSRP difference (dB)(optional).  |
| Apple | Yes | OK with the categories (have comments for the actual columns within those categories) |
| Ericsson | Yes with comment | We suggest to list all the configurable parameters in the “Result” sheet, so it would be possible to filter the simulation results based on these configurable parameters, as well.[Rapp] will do that. |
| Nokia | Yes with comment | Agree with the intention. However, the selection of some of the KPIs would also depend on the algorithm that is used. For instance, FLOPs are fine if we consider neural networks. For other models, they might be more difficult to estimate. [Rapp] I think that’s OK, we can indicate NA if this KPI is not applicable to the AI/ML algorithm. |
| Huawei, HiSilicon | Yes, but… | ...please see our reply for the previous question basically, we have the same proposal as Ericsson).[Rapp] will do that. |
| ZTE | Yes with comments | We agree to categorize the columns in the simulation results sheet into four parts. But for the content of each part, please see our reply to Q8.  |
| CMCC | Yes |  |

**Summary:** All companies replied yes. Ericsson, Huawei suggest to list all the configurable parameters in the result tab. The rapporteure consider it’s a good suggestion and add one colume for the configurable parameters.

**Proposal 5: The columns in the simulation results sheet are categorized into five main groups: general information, variable settings, selectable simulation assumption, model-related information and performance metrics for various KPIs.**

Currently, 3 sub-use cases are considered for cell-level RRM measurement prediction.  The 'case' column takes into account these sub-use cases and, optionally, their combination with other factors. For example, for inter-frequency prediction, this column also distinguishes between predictions from lower to higher frequencies and those from higher to lower frequencies. According to the agreement that ‘*it is up to companies to select the number of cells for input and output (companies should clarify what they are using for cluster-based approach). Cluster-based approach evaluation is optional and lower priority for now.’,* cluster-based approach is reported as part of model input/output.

**Q6:** **Do companies agree that** **the ‘case’ column considers the three sub-use cases at the time being and where applicable, their combination with** **additional factors that may be determined through discussions as the evaluation progresses?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comment |
| Mediatek | Yes |  |
| OPPO | Yes |  |
| vivo | Yes with comments | L3-filtered beam level prediction is agreed at last meeting. Therefore, the sub-use cases for beam-level should also be included.[Rapp] will add it.  |
| Apple | Yes (with comments) | One might argue that the case column actually belongs to the “AI model” column category but ultimately it doesn’t matter that much. Since the “cases” are about model inputs/outputs there is a bit of redundancy between them and the “model input” and “model output” columns. But once again, not a big deal either way.  |
| Ericsson | Yes | We think combinations can be discussed case by case later  |
| Nokia | Yes |  |
| Huawei, HiSilicon | Yes, but… | Perhaps it is worth having a separate column for the RRM sub use-case and for “other factors” (e.g. the exact scenario for inter-frequency predictions). Then model input column could only include additional inputs used for the model (e.g. if the model uses info about UE location, info from multiple cells etc.)[Rapp] Will do that. |
| ZTE | See comments | Agree with Huawei. It’s better to have separate columns for the RRM sub use case and additional factors, which is clearer. [Rapp] Will do that. |
| CMCC | Yes with comments | Have the same view with Huawei and ZTE. It is better to introduce separate columns for RRM sub use-case and other factors(e.g., L1/L3 filtering, skip pattern for temporal domain Case B etc.) |

**Summary**: Maority of the companies replied yes. Huawei and ZTE suggested to add one separate colume to consider ‘other factors’ in combine with RRM sub use-cases. Vivo suggested to consider the sub-use case for beam-level prediction.

**Proposal 6:** **The ‘case’ column considers the three sub-use cases and their combination with additional factors. One colume for additional factors will be introduced. Those factors can be determined through discussions** **as the evaluation progresses.**

While the primary focus of the email discussion is to figure out a proper approach for documenting simulation results and provide a template for companies to use.  While detailing the exact content for the spreadsheets is not critically urgent, we suggest adopting the attached spreadsheets, which address different RRM prediction scenarios, as a starting point. The content of these spreadsheets is flexible and can be adjusted as necessary. We invite companies to provide their input on these spreadsheets, and we are prepared to update them in response to your feedback.

**Q7:****Do companies agree to** **adopt the example spreadsheets provided in the attachment as a starting point, understanding that their content is flexible and can be modified as needed?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comment |
| OPPO | Yes | We agree with Rapp. Some typos can be revised.[case A] [Spatial] In simulation assumption sheet, UE speeds are 60,90,120 km/h according to our agreement.[Case B] In simulation assumption sheet, UE trajectory boundary process does not have option #4 (should be #3). |
|  |  | [Spreadsheet 1][Spreadsheet 2][Spreadsheet 3][Spreadsheet 4] |
| vivo | Yes | [Spreadsheet 1]Frequency Range FR1 @2/4GHz with SCS 15/30KHz: suggest removing 2GHz in Case B;[Rapp]OK.UE Speed "30km/h (baseline), 60km/h (optional), 90km/h (optional), 120km/h (optional): suggest removing 120km/h in Case B;[Rapp] OKBS Antenna Configuration, UE Antenna Configuration: the number should be align with agreements.UE trajectory boundary processing: duplicated row[Rapp] Thanks![Spreadsheet 2]UE Speed "30km/h (baseline), 60km/h (optional), 90km/h (optional), 120km/h (optional): suggest removing 30km/h in Case A;[Rapp] OK.[Spreadsheet 3]UE Speed "30km/h (baseline), 60km/h (optional), 90km/h (optional), 120km/h (optional): suggest removing 60, 90, 120 km/h in inter-frequency;BS Antenna Configuration, UE Antenna Configuration: the number should be aligned with agreements.[Rapp] I understand your suggestion is according to what we agreed for inter-frequency prediction in last meeting. But…if we don’t run the simulation with different speed, how we know whether UE speed has impact or not on the performance. Maybe we can say 30km/s is mandatory. [Spreadsheet 4]UE Speed "30km/h (baseline), 60km/h (optional), 90km/h (optional), 120km/h (optional): suggest removing 120km/h as this case is for measurement reduction.[Rapp] OK |
| Apple | Yes (with comments) | Would be good to have a column for “case A/B”. Also, we don’t need “MRTT” and “prediction window” simultaneously, so we may merge those coumns to “MRTT/prediction window” depending on case A or B.[Rapp] Case A and Case B are in separate spreadsheets, do we need this column?Suggest an additional column for “model details”, e.g. number of hidden layers, etc.[Rapp] will do that.Observation and prediction window belong to “AI model”, not “settings”. |
| Ericsson | Yes |  |
| Nokia | Yes |  |
| Huawei, HiSilicon | Yes | Additionally, we agree it would be useful to add a column with model details as suggested by Apple.[Rapp] will do that. |
| ZTE | See comments | For ‘simulation assumption’ sheet:* The RRM simulation assumptions are not captured in the sheet, e.g. FilterCoefficient, measurement period...

[Rapp] Will add.* Agree with Ericsson and Huawei. Suggest to only list fixed simulation assumptions in the ‘simulation assumption’ sheet. For the comfigurable/selectable simulation assumptions, list them in the ‘Results’ sheet in order to better compare the simulation results among companies.

[Rapp] Will do that.For ‘Results’ sheet:* For ‘setting’ part:
	+ We tend to agree with Apple that observation &prediction window length are part of AI model, however, after checking the table for AI-BM, it seems the “pattern configurations are in the same colour with e.g. UE speed.. so no strong view on whether to move them to “AI model”.

For case B: We have different view as Apple, we think besides MRRT, it’s necessary to list the prediction window and observation window in the ‘results’ sheet to better compare the simulation results.* For ‘performance metric’ part:
	+ Besides RSRP difference between predicted RSRP via AI model and actual RSRP, maybe we can have another column to show the RSRP difference between predicted RSRP via non-AI (i.e. sample and hold) and actual RSRP for case A and case B.

[Rapp] Since non-AI benchmark has not been agreed, I will keep the table as it is. But companies are inspired to compare the results with a reasonable and practical benchmarking, like sample and hold. * + In some cases, the prediction window may have multiple prediction results, our understanding is that companies can still put multiple results in one single table cell. For example, for prediction window=800ms with non-sliding L3 filtering, companies can provide two result values for each line, the first one refers to the predicted results at 400ms, and the second one refers to the predicted results at 800ms. (same as what we did for the 1st round of simulation).
	+ It’s better to show which cell the prediction accuracy is for. For example, some companies may perform prediction on the serving cell; while some companies may perform prediction on the best neighbour cell. Should we have separate columns to show the prediction accuracy for serving cell and best neighbour cell respectively?

[Rapp] According to the agreement* Prediction accuracy metric for RRM measurement cell level prediction is defined as “RSRP difference between predicted L3 cell level measurement result and actual L3 cell level measurement result of **the same cell**” for all RRM sub cases;
* Average RSRP difference is taken as prediction accuracy metric for RRM measurement prediction. Note the RSRP difference values should be an absolute value before they are averaged

One aspect that requires clarification is the definition of 'average.' One method is to calculate the average across all predicted results indiscriminately, without distinguishing whether they are the first, second, or third predictions in a temporal sequence. Alternatively, as you suggested, the average could be computed separately for the first, second, and third predictions across various prediction windows. Now I think the first approach can be considered as the baseline. I am open to consider the second approach, but can we leave it as FFS and clarify it in the next meeting?Additionally, we agree to add a column to show more details. But the content is not limited to model details, companies can report what they think needs to be reported. |
| CMCC | Yes |  |

**Summary**: In response to feedback from various companies, the following updates will be made to the spreadsheets:

1. A new column will be added to the results sheets to list selectable simulation assumptions.
2. An 'other factors' column will be introduced to work alongside the sub-use cases column, providing a detailed description of the scenarios.
3. A sub-use case dedicated to beam-level prediction will be included.
4. A column will be added to detail the specifics of the AI model used.
5. Adjustments to the simulation assumptions will be as follows:
6. Incorporation of assumptions regarding FilterCoefficient and measurement period.
7. Elimination of certain speed options from the simulation assumptions.
8. General editorial revisions.

**Proposal 7: Adopt the example spreadsheets provided in the attachment as a starting point, understanding that their content is flexible and can be modified as the evaluation progresses.**

# Conclusion

**Proposal 1: The spreadsheets are organized into three separate folders, with each folder corresponding to one of the three use cases.**

**Proposal 2: The RRM prediction use case is used as a template for the documentation process. This approach will be similarly applied to the measurement event prediction and RLF/HOF prediction use cases, the spreadsheets of which are subject to revision upon availability of the simulation results.**

**Proposal 3: Individual spreadsheet for each identified scenario for the use case of RRM prediction is created, e.g., scenarios 1~6 with the understanding that we can add more spreadsheets as required e.g., when other scenarios are identified.**

**Proposal 4: Distinct sheets are initially set up for capturing the simulation assumptions, evaluated KPIs and definitions, and simulation results from companies, with the understanding that we will add more sheets as needed and in accordance with discussions that emerge during the evaluation process.**

**Proposal 5: The columns in the simulation results sheet are categorized into five main groups: general information, variable settings, selectable simulation assumption, model-related information and performance metrics for various KPIs.**

**Proposal 6: The ‘case’ column considers the three sub-use cases and their combination with additional factors. One colume for additional factors will be introduced. Those factors can be determined through discussions as the evaluation progresses.**

**Proposal 7: Adopt the example spreadsheets provided in the attachment as a starting point, understanding that their content is flexible and can be modified as the evaluation progresses.**