**3GPP TSG-RAN WG2 Meeting #128 R2-24xxxxx**

**Orlando, USA, Nov. 18th – 22th, 2024**

Agenda Item: 8.3.5

Source: OPPO

Title: Draft summary of [AT128][017][AI mob]Simulation assumptions (OPPO)

Document for: Discussion, Decision

# Introduction

The draft covers following offline discussion:

1, Generalization issue i.e. the simulation combination of UE speed

2, Open simulation assumptions for measurement event and RLF prediction and SLS.

# Discussion

## Generalization issue

During online discussion RAN2 agreed:

|  |
| --- |
| **Agreements** 1. Reuse the evaluation methodology in TR38.843 for generalization study, i.e., the generalization performance is evaluated with the following cases,
* *Baseline:* The AI/ML model is trained using the dataset with Configuration #B and tested using the dataset with Configuration #B.
* *Generalization Case #1 (GC#1):* The AI/ML model is trained using the dataset with Configuration #A but tested using the dataset with Configuration #B.
* *Generalization Case #2 (GC#2):* The AI/ML model is trained using mixed datasets with both configurations and tested using the dataset with Configuration #B.

2 Companies can choose which case they compare with and should report it with simulation results. 3 Generalization issues on RRM measurement prediction are prioritized. 4 Start the study with generalization issue with RRM measurement prediction in temporal domain. Companies can chose to study frequency domain prediction cases and report what they have simulated.  |

* Study generalization over UE speeds
* The simulation assumption of FR1 temporal domain case B is reused for generalization study with 3 UE speeds i.e. 30Km/h, 60Km/h and 90Km/h. FFS on combinations
* The simulation assumption of FR2 temporal domain case A is reused for generalization study with 3 UE speeds i.e. 60Km/h, 90Km/h and 120Km/h. FFS on combinations

In order to understand better, the following table list all the simulation combinations for 1 baseline UE speed i.e. 30km/h for FR1 temporal domain case B:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Training @Dataset: 30km/h | Training @Dataset: 60km/h | Training @Dataset: 90km/h | Inference @30km/h | Inference @60km/h | Inference @90km/h |
| Baseline | Yes  |  |  | Yes  |  |  |
| GC#1 | Yes  |  |  |  | Yes |  |
| GC#1 | Yes |  |  |  |  | Yes |
| GC#2 | Yes | Yes | Yes | Yes |  |  |
| GC#2 | Yes | Yes | Yes |  | Yes |  |
| GC#2 | Yes | Yes | Yes |  |  | Yes |

Table 2.1-1 simulation combinations

If the UE speed in baseline is changed to e.g. 60km/h, then more training and more inference are needed. Here is the statistics:

|  |  |  |
| --- | --- | --- |
| Number of Baseline UE speed | Number of models to be trained | Number of inferences |
| 1 | 2 | 6 |
| 2 | 3 | 9 |
| 3 | 4 | 12 |

**Question 1: Do you share rapporteur’s understanding of the simulation combination?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/no | Comments |
| Ericsson | Yes |  |
| Huawei | Yes | But if we change the baseline to 60 km/h, then the number of combinations does not increase. It only increases if we add more speeds for baseline. |
| vivo | Yes |  |
| Samsung | Yes |  |
| Qualcomm | Mostly agree. Please see comments | We were wondering, for Baseline, whether we can consider the Training dataset to be from 60kmph. The errors upon generalization can be lower compared to the case when the Baseline is 30kmph, since 60kmph is intermediate between 30kmph and 90kmph. |
| Mediatek | Yes with comments | For GC#2, should we also consider the dataset ratio for different speeds? The ratio of datasets with different speeds may vary across different scenarios. Should we use datasets of different speeds evenly, adjust the proportion for certain speeds, or leave it to company implementation?Rapporteur: let’s assume the ratio is equal among dataset. In this case it means 1/3. |
| Xiaomi | Yes |  |
| ZTE | Yes |  |
| Nokia | Yes | It would maybe be more realistic to consider 60, 90 and 120 for FR1 and 30, 60, 90 for FR2 (since cells are smaller in FR2)  |

If company think there is too much simulation combinations, one potential way is to set less UE speed e.g. only one UE speed as baseline.

**Question 2: Do you agree one potential way to limit the simulation combination is to limit the number of UE speed as baseline? If yes, please indicate whether 1 UE speed is sufficient. If no, please provide your opinion in detail.**

|  |  |  |
| --- | --- | --- |
| Company | Yes/no | Comments |
| Ericsson | Yes | We could consider the lowest and the highest speed as input and for inference. |
| Huawei | Yes | Our preference is to focus on GC#2 as it corresponds better to real life scenario. |
| vivo | Yes |  |
| Samsung | Yes | 1 UE speed (30km/h) is enough.Also agree with HW that we can focus on GC#2 considering the real situation. |
| Qualcomm | Yes, 1 UE speed is sufficient as Baseline |  |
| Mediatek | Yes |  |
| Xiaomi | Yes |  |
| ZTE | Yes |  |
| Nokia | Yes |  |

Recommendation 1: Between GC#1 and GC#2, RAN2 focus on GC#2

Recommendation 2 To agree following simulation combination for FR1 generalization study:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Training @Dataset: 30km/h | Training @Dataset: 60km/h | Training @Dataset: 90km/h | Inference @30km/h | Inference @60km/h | Inference @90km/h |
| Baseline | Yes  |  |  | Yes  |  |  |
| GC#1 | Yes |  |  |  | Yes | Yes |
| GC#2 | Yes | Yes | Yes | Yes |  |  |
| Baseline |  | Yes |  |  | Yes |  |
| GC#1 |  | Yes |  |  | Yes | Yes |
| GC#2 | Yes | Yes | Yes |  | Yes |  |
| Baseline |  |  | Yes |  |  | Yes  |
| GC#1 |  |  | Yes |  |  | Yes |
| GC#2 | Yes | Yes | Yes |  |  | Yes |

Recommendation 2a: To agree following simulation combination for FR2 generalization study :

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Training @Dataset: 60km/h | Training @Dataset: 90km/h | Training @Dataset: 120km/h | Inference @60km/h | Inference @90km/h | Inference @120km/h |
| Baseline | Yes  |  |  | Yes  |  |  |
| GC#1 | Yes |  |  |  | Yes | Yes |
| GC#2 | Yes | Yes | Yes | Yes |  |  |
| Baseline |  | Yes |  |  | Yes |  |
| GC#1 |  | Yes |  |  | Yes | Yes |
| GC#2 | Yes | Yes | Yes |  | Yes |  |
| Baseline |  |  | Yes |  |  | Yes  |
| GC#1 |  |  | Yes |  |  | Yes |
| GC#2 | Yes | Yes | Yes |  |  | Yes |

## Measurement event prediction (part 1)

After post email discussion [1], here is part of proposal 9 by removing direct prediction specific parameters. In addition, in current TR the set of UE speed is 60/90/120 km/h for 2nd study goal, we need respect that and hence 30km/h is removed from 3rd column. The main discussion point is baseline value in 2nd column. Note the removed parameters related to direct prediction will be discussed as part 2 in section 2.5.

**Proposal 1: To agree the baseline value for the listed parameters for intra-frequency temporal domain case A and open for more values for some of the parameters as indicated in the table below:**

|  |  |  |
| --- | --- | --- |
| Parameters | baseline value | Note |
| A3 event offset (db) | 2 |  |
| TTT (ms) | 320 | Open for one shorter value |
| UE speed (km/h) | 90 | Open for ~~30 ,~~ 60 and 120km/h |
| OW length (ms) | N/A | Up to implementation |
| PW length (ms) | 400 | Open for more values |
| Max ETD (ms, note1) | 80 | Open for more values |
| ~~Event occurrence Window Length (ms, note 2)~~ | ~~N/A~~ | ~~Up to conclusion under question 2~~ |
| ~~Probability threshold (%, note 2)~~ | ~~80%~~ | ~~Open for more values~~  |

*Note1: parameters for indirect prediction*

Table 2.2-1 Parameters for measurement event prediction of temporal domain case A

**Question 2: Do you agree with the content listed in the table 2.2-1?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No? | Comments |
| Ericsson | Yes |  |
| Huawei | Yes |  |
| Samsung | Yes |  |
| Qualcomm | Mostly agree. Please see comments | **A3 event offset (dB):** 3dB (for higher RRM RSRP MAE values)  |
| Mediatek | Yes |  |
| Xiaomi | Yes with commewnts | **Shorter PW is preferred, since the prediction accuracy is expected to be higher in shorter PW**  |
| ZTE | Yes |  |
| Nokia | Yes |  |

Recommendation 3: To agree following values:

|  |  |  |
| --- | --- | --- |
| Parameters | baseline value | Note |
| A3 event offset (db) | 2 | Open for 3db |
| TTT (ms) | 320 | Open for one shorter value |
| UE speed (km/h) | 90 | Open for 60 and 120km/h |
| OW length (ms, note1) | N/A | Up to implementation |
| PW length (ms, note1) | 400 | Open for more values |
| Max ETD (ms, note1) | 80 | Open for more values |

*Note1: parameters for indirect prediction only*

For temporal domain case B, here is proposal 10 in [1]:

**Proposal 3: To agree the baseline value for the listed parameter for intra-frequency temporal domain case B and open for more values for some of the parameters as indicated in the table below:**

|  |  |  |
| --- | --- | --- |
| Parameters | baseline value | Note |
| A3 event offset (db) | 2 |  |
| TTT (ms) | 320 | Open for one shorter value |
| UE speed (km/h) | 30 | Open for 60 and 90km/h |
| OW length (ms) | N/A | Up to implementation |
| PW length (ms) | N/A | Up to implementation |
| Max ETD (ms, note1) | 40 | Open for more values |
| MRRT | 50% | Open for more values |

Table 2.2-2 Parameters for measurement event prediction of temporal domain case B

In table 2.2-2, one more parameter i.e. MRRT is added in the same table by combining proposal 11 as below:

Proposal 11: For intra-frequency temporal domain case B, RAN2 is invited to discuss whether MRRT=50% could be baseline value

**Question 4: Do you agree with the content listed in the table 2.1-2?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No? | Comments |
| Ericsson | Yes |  |
| Huawei | Yes, but… | For PW we also could agree on one baseline value (e.g. 400 ms) and allow for more. |
| vivo | Yes with comments | Add another factor on the skipping pattern, i.e., example 2 as baseline and open for example 1. |
| Samsung | Yes with comment | PW length is up to MRRT. We understand that 50% MRRT means PW length (= 1 SSB period = 40msec for FR1). |
| Qualcomm | Mostly agree. Please see comments | **A3 event offset (dB):** 3dB (for higher RRM RSRP MAE values)  |
| Mediatek | Yes |  |
| Xiaomi | Yes |  |
| ZTE | Yes |  |
| Nokia | Yes |  |

Recommendation 4: To agree following values:

|  |  |  |
| --- | --- | --- |
| Parameters | baseline value | Note |
| A3 event offset (db) | 2 | Open for 3db |
| TTT (ms) | 320 | Open for one shorter value |
| UE speed (km/h) | 30 | Open for 60 and 90km/h |
| OW length (ms,note1) | N/A | Up to implementation |
| PW length (ms,note1) | 200 | Open for more values |
| Max ETD (ms, note1) | 80 | Open for more values |
| MRRT | 50% | Open for more values |

*Note1: parameters for indirect prediction only*

Another issue for temporal domain case B is the filtering options for input L3 RSRP of the model. There are 3 options listed in the proposal 12 as below:

**Proposal 12: For intra-frequency temporal domain case B company can report following filtering options for input L3 RSRP measurement in sub-use case 2:**

**Filtering option 1: L3 filtering is based on its L1 filtered result and the immediate last skipped measurement result;**

**Filtering option 2: L3 filtering is based on its L1 filtered result i.e. no L3 filtering if the immediate last result is skipped;**

**Filtering option 3: L3 filtering is based on the L1 filtered result and last actual measurement result i.e. the skipped result(s) in between is ignored.**

**For indirect prediction, the skipped result refers to predicted L3 RSRP measurement result previously by the RRM measurement prediction model**

**For direct prediction, the skipped result refers to skipped L1 measurement result**

It could be difficult to reach consensus about the options. But it will be helpful to understand preference from company so that RAN2 can know which option is preferred by the majority company.

**Question 5: Which option are your favourite option?**

|  |  |  |
| --- | --- | --- |
| Company | Option 1/2/3 | Comments |
| Ericsson | Option 1 |  |
| Huawei | Option 3 | We have agreed to use L3 measurements as the output, so option 2 is not preferred. Option 1 will result in error propagation, so this leaves us with option 3. |
| vivo | Option 1 | Option 1 may cause prediction error accumulation in sub-use case 2, but OK for sub-use case2 1 and 3 as the input is L1 RSRP.  |
| Samsung | Option 3 | For option 1, the output from the previous prediction would be used as part of input for the following prediction. I.e., the predicted value at T2 is used to calculate the L3 filtered value at T3 that is input data for the prediction at T4. In this case, the prediction error would be propagated/accumulated over time. The option 2 means no L3 filtering in practice. |
| Qualcomm | It should be left up to companies to choose |  |
| Mediatek | Option 3 | Option 2 is unreasonable without L3 filtering. Option 1 may accumulate prediction errors, as it updates the L3 filter measurement with the prediction result. In contrast, Option 3 does not have these potential errors. |
| Xiaomi | Can be reported by companies | But we would like to clarify only option 1 is aligned with the L3 filtering definition of current spec. option 2/3 is new filtering methods. |
| ZTE | Option 3Option 2 is also ok | With option 1, the prediction error will be accumulated; option 2 and Option 3 don’t have the problem of prediction error accumulation since all results are from actual measurement.Besides, from the simulation perspective, option 1 requires more work, since the predicted results will be used for the input. |
| Nokia | Option 3 |  |

Recommendation 5: Company can report option 1, open 2, option 3.

Recommendation 5a: to capture the 3 options into TR

## RLF prediction (part 1)

Here is the parameter for RLF prediction by combining proposal 18 and proposal 23 in [1] by removing direct prediction specific parameters. Note the removed parameters related to direct prediction will be discussed as part 2 in section 2.5. In addition, for indirect prediction OW length and PW length should be also assumed.

**Proposal 18: To agree on following parameter for RLF prediction:**

|  |  |
| --- | --- |
| Parameter | Value |
| Qin threshold | -6db |
| Qout threshold | -8db |
| Sample rate (TIndication\_interval) | 20ms(FR2)/40ms(FR1)  |
| Qin evaluation period | 100ms |
| Qout evaluation period | 200ms |
| T310 | 1000ms |
| N310 | 1 |
| N311 | 1 |
| Max ETD (ms, note1) | 20ms(FR2)/40ms(FR1) |
| ~~Event occurrence Window Length (ms, note 2)~~ | ~~Under discussion in question 13~~ |
| ~~Probability threshold (%, note 2)~~ | ~~80%~~ |
| The number of beams for FR1 fixed beam pattern | 1 |
| The number of beams for FR2 fixed beam pattern | ~~4~~ |
| PW length (ms) | 400 |
| OW length (ms) | Up to implementation |

Table 2.3-1 Parameters for RLF prediction

**Question 6: Do you agree with the content listed in the table 2.3-1?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/No? | Comments |
| KDDI | No. See comments | We suggest to consider blockage in a channel model to ensure realistic performance evaluation of RLF prediction. We see some companies want to consider blockage. Considering the workload, option1 can be chosen.**Proposal: RAN2 to choose from the following options in order to collect more RLF event.****Option1. Blockage in a channel model is allowed to consider and how to model the blockage can be up to companies.****Option2. Parameters related to blockage in a channel model are added below.**Considering the workload, Model A can be selected (clause 7.6.4 of TR 38.901). For Blockage model A of RLF prediction, unify required parameters of Blockage model A, or determine the rules for describing parameters.* + - The number of blocker *K* (the standard number is *K* = 4).
		- Scenarios for deciding non-self-blocking regions parameters given in Table 7.6.4.1-2 of TS 38.901.
		- Scenarios for deciding spatial correlation distance given in Table 7.6.4.1-4 of TS 38.901.
		- Whether the blocker has movement speed *v.*
		- Are there any other missing configurable parameters?
 |
| Ericsson | Partly | We think ETD can be 80 ms, the prediction needs to be very precise otherwise. |
| Huawei | Yes | We could agree on one ETD value, but it might be worth checking more of them (up to companies) as it will give us an idea of what performance we get for each “accuracy”. Blockage will make things complicated and we already agreed not to do HO, so we can force some RLFs anyway. |
| vivo | Question on the PW length  | The current T310 is 1000ms and the PW length is 400ms. But we think the PW length should be equal/ larger than T310. |
| Samsung | Question on the number of fixed beam pattern in FR2. | We have a question about the number of fixed beam in FR2. First, we would like to clarify that SINR measurement is based on SSB (not CSI-RS) in our simulation. Then, from our understanding, when the UE measures the SINR of a certain SSB from the serving cell, other neighbor cells also transmit SSB with one beam. Thus, we think the number of beams for fixed beam pattern for neighbor cell should be also 1 in FR2. Can’t understand how neighboring cell can transmit SSB with four different beams simultaneously. |
| Qualcomm | Ok, except for the number of beams for FR2 fixed beam pattern | It is not clear what it means to have a fixed number of beams for FR2 fixed beam pattern.  |
| Mediatek | Question for clarification | “The number of beams for FR1 fixed beam pattern”“The number of beams for FR2 fixed beam pattern”This seems to be a newly added parameters of RLF, and it is not exactly aligned with the simulation in 38.744. Is it Tx beam number of neighbouring cells to fix the interference beam? |
| Xiaomi | Yes |  |
| ZTE | See comments | **For sample rate in FR1:**We suggest to reuse the sample rate in TR 36.839 (i.e. 10ms) or use 20ms (typical SSB period in FR1). **For sample rate in FR2:** We agree to use 20ms, but we need to clarify which UE Rx beam is used to detect RLM-RS since in FR2 there are multiple Rx beams. Our suggestion is to use best UE Rx beam to detect RLM-RS.**For the number of beams for FR1/FR2 fixed beam pattern:**Also unclear for the meaning of ‘the number of beams for fixed beam pattern’  |
| Nokia | Yes | We think T310 time can be a bit shorter, e.g., 500ms. |

Recommendation 6: To agree following values. Value with yellow color need be discussed:

|  |  |
| --- | --- |
| Parameter | Value |
| Qin threshold | -6db |
| Qout threshold | -8db |
| Sample rate (TIndication\_interval) | 20ms (FR2)/40ms(FR1)  |
| Qin evaluation period | 100ms |
| Qout evaluation period | 200ms |
| T310 | 1000ms |
| N310 | 1 |
| N311 | 1 |
| Max ETD (ms, note1) | 80ms |
| PW length (ms,note1) | 400 |
| OW length (ms, note1) | Up to implementation |

*Note1: parameters for indirect prediction only*

Revert the agreement on the fixed beam pattern :Zonda

One open issue about the fixed beam pattern: can we assume the transmission pattern is synchronized across cells?

Option 1: yes, then the two parameters “the number of beams for FR1/FR2 fixed beam pattern” is not needed

Option 2: no, then we need align these two parameters

Recommendation 6a: The beam transmission pattern is synchronized across the site/cells i.e., at any give time the transmitted beam index is the same across the site/cells.

## System level simulation (part 1)

The issue left for SLS is the handover model for both temporal domain case A and case B. To facilitate the discussion, this section focuses on case that measurement event is predicted indirectly so that the predicted time instance i.e., t1 in the context is clear.

For temporal domain case B, if the last measurement results to derive the measurement event is actual measurement, then there is the time to report the measurement result i.e. t0 and the time of event occurrence i.e. t1 is the same, then there is no ambiguity about handover model because legacy handover model can be adopted. But if the last measurement result is predicted one, then t1>t0. In this case there are two options:

 

 Figure 2.4-1 Option 1 for case B Figure 2.4-2 Option 2 for case B

**Option 1:** UE report measurement report @t0 as illustrated in Figure 2.3-1 when it is predicted. Network start handover preparation once the measurement report is received. Since t1>t0, handover command could be received @ max(HO prep, t1-t0)

**Option 2:** UE delay to t1 to report measurement result as if the predicted measurement event occurs there. Network starts the preparation after receiving the measurement report. And handover command will be received after handover preparation.

|  |  |  |
| --- | --- | --- |
| Case B | Pro | Con |
| Option 1 | (partial) handover preparation time can be saved so that HO CMD can be received early | Mixed the study between case A and case B |
| Option 2 | The evaluation is purely for 1st study goal i.e. decouple from case A | the benefit of the model is wasted |

Table 2.4-1 analysis between 2 options

**Question 7: Which option of handover model for temporal domain case B do you prefer?**

|  |  |  |
| --- | --- | --- |
| Company | Option 1/2 | Comments |
| Ericsson | Out of these options, option 1 | No benefits of predictions with option 2. We could also leave it to company implementation. |
| Huawei | Option 1 | There is no need to wait for the actual measurement in case the prediction already indicates that the event will be met.  |
| vivo | Option 1 with modification | The handover is sent at max(t0+HO Pre, t1-TTT) |
| Samsung | Option 2 | Now we think that there can be two features related to temporal domain prediction.1. Report of predicted future event is to improve HO KPI by far future prediction 2. Measurement skipping at UE-side is to reduce UE’s measurement overhead by near future prediction In Case B scenario, we understand the first and second feature can be used together. However, we don’t think both features should be always used/configured together. We don’t need to combine these two features for different goals as one feature. Considering that Case B is for the 1st goal, only the second feature for measurement skipping can be assumed in Case B to evaluate the impact of measurement skipping on HO KPI correctly.  |
| Qualcomm | Please see comments | Our understanding of the options is that in Option 1, the UE sends a report when it predicts that the measurement event occurs without waiting to send at the time when the event occurs, which is Option 2. In that case, our preference is Option 1, because otherwise the benefits of prediction are wasted. There should be some accuracy requirements that the predictions must meet so that the network can rely upon the prediction report and act, i.e., initiate HO preparation.  |
| Mediatek | Option 2 | We can follow the legacy HO mechanism and assumes that there is no network behavior change on HO decision. Option 1 implies that the timing information of the event will be provided by the UE to the network, allowing the network to determine when to transmit the HO command, such as t1-t0. However, this changes the current network behaviour for HO decisions and complicates network implementation. Option 1 is a combination of temporal domain prediction case B+event prediction. For the SLS for case B, the most fundamental question to answer is to what extent the reduction can be achieved without degrading system performance. If we combine the enhancement of event prediction, the performance degradation due to measurement reduction may be compensated by the event prediction. |
| Xiaomi | Option 2 | If we mixed the two goals, it may be difficult to make conclusion on the performance improvement/degradation. We prefer to focus on single goal. If time allows, we can further study the mixed goals in future. |
| ZTE | Option 1 |  |
| Nokia | Option 1 | Slightly prefer option1 so that handover preparation time can be reduced. The main difference between option1 and 2 relies on if TTT is skipped. For option1, we understand that TTT is skipped, while for option2, UE will wait until TTT expired then sends measurement report. |

Rapporteur comment: the intention of evaluation is to under the performance for 1st study goal better

Recommendation 7: For measurement event prediction for temporal domain case B, goes for option 2:

**Option 2:** UE delay to t1 to report measurement result as if the predicted measurement event occurs there. Network starts the preparation after receiving the measurement report. And handover command will be received after handover preparation.

As for handover model for temporal domain case A, there are two options in the summarized proposal 25:

Proposal 25: As for simulation base on temporal domain case A, RAN2 conclude one of the two options to decide exactly when to transmit handover command:

**Option 1:** if there is an actual measurement event occurring (@ t2) before the predicted measurement event (@t1), then network will transmit handover command based on actual measurement event ,or otherwise on predicted measurement event(@t1).

**Option 2:** network transmit handover command purely based on actual measurement event regardless whether an actual measurement result(@t2) is earlier or later than predicted measurement event((@t1))

Another option is proposed in [3] as following:

Proposal 1(**Option 3**): For AI mobility, HO preparation starts when an event is predicted to happen (i.e., t0), and HO command is sent when A3 entering conditions are met based on actual/real measurement and an event is predicted to be met for the duration of TTT. Using the timing from the figures: HO command is sent at t3, where t3=t0+max(HO prep time, t1-t0-TTT), provided that entering conditions of the event are met based on real/actual measurement at t3.

 

 Figure 2.4-3 Figure 2.4-4



 Figure 2.4-5 Figure 2.4-6

|  |  |  |  |
| --- | --- | --- | --- |
| Case  | Option 1 | Option 2 | Option 3 |
| Case 1: Actual event is earlier than predicted event | Figure 2.3-4 @ t2 | Figure 2.3-4 @ t2 | Figure 2.3-6 @ t1-TTT |
| Case 2: actual event is later than predicted event | Figure 2.3-3 @ t1 | Figure 2.3-5 @ t2 | Figure 2.3-6 @ t1-TTT |

Table 2.4-2 when HO CMD is received

For all 3 options, if HO preparation can’t be completed before the time supposing to receive HO CMD, then HO CMD is delayed until HO preparation is finished.

**Question 8: Which option of handover model for temporal domain case A do you prefer?**

|  |  |  |
| --- | --- | --- |
| Company | Option 1/2/3 | Comments |
| Ericsson | Out of these options, option 1 | Regarding option 3, the formula should not contain TTT, since it is already taken into account when the event prediction is triggered (at t1). The event prediction is triggered when the cell quality is predicted to be higher than a certain threshold for the TTT time. So, the predicted event is triggered (at t1) TTT ms in advance. |
| Huawei | Option 3 | It seems there may be different interpretations of whether TTT is considered or not. Last meeting it was clarified online that event prediction time indicates the time after TTT has passed. Our point with option 3 is that we should analyze the maximum gains we can get from the predictions, i.e. saving HO preparation time and TTT (under the condition that the entering conditions of the event are met and the prediction indicates they will keep on being met until TTT expiry). |
| vivo | Option 3 | The table 2.4-2 is not aligned with the description for option3? The HO CMD is t3=t0+max(HO prep time, t1-t0-TTT) |
| Samsung | Option 2 | First, AI-based prediction should be additional feature that can be used on top of existing HO framework. Thus, HO based on actual measurement event should be baseline. Also, we think HO command without actual MR (based only on prediction) is risky. If UE’s moving speed or direction change after the prediction, when NW make HO command at the predicted timing, UE would not be able to perform HO successfully. Given that prediction accuracy can not be guaranteed in real field, we prefer to be conservative on HO decision and support option 2.For option 3, we can avoid the risk of early HO a little bit more than option 1 by sending predicted MR after A3 entering condition is first met. However, in that case, we understand there should be two different prediction report from UE (One at t0 for early HO preparation and another one at t1-TTT for early HO command), which seems inefficient and has not been discussed until now. |
| Qualcomm | Please see comments | If network receives an event prediction report, the network need not wait for an actual measurement report before transmitting the HO command to the UE, assuming that the event prediction report is transmitted by the UE if accuracy requirements are met, as mentioned in our response to Q7.  |
| Mediatek | Neither of the optionsOption 3 is acceptable purely for simulation purpose. | First, the network behaviour should follow the current legacy behaviour, where the network sends the HO command immediately upon receiving the MR from the UE, regardless of whether the MR is triggered by prediction or actual measurement.Second, as the event prediction is UE-side model, when to send the MR will be decided by the UE, who takes the TTT into account when sending the MR. Taking the following figure as example: The UE starts the prediction when the entering condition is met, and the prediction is to verify that whether the entering condition can be fulfilled in TTT. If it is the case, the UE can send MR immediately.  |
| Xiaomi | Option 2 | The predicted result may be incorrect. In option 1, the incorrect prediction would result in too early handover, which further causes additional HOF. However, in option 2, no additional HOF would be caused by AI, since HO is always triggered by real measurement. The AI would definitely bring gain from reducing HO delay point of view.  |
| ZTE | Option 1 |  |
| Nokia | Option 2 | Agree with Samsung.  |

Rapporteur comment: the key issue is how much we can trust the predicted measurement event. Option 2 takes least risk but maybe also least performance. Option3 takes more risk but maybe also most performance. And option 1 is in the middle. For the sake of study purpose, it is commended:

Recommendation 8: For measurement event prediction for temporal domain case A, company focus on option 2 or option 3.

**Option 2:** network transmit handover command purely based on actual measurement event regardless whether an actual measurement result(@t2) is earlier or later than predicted measurement event((@t1))

**Option 3**: For AI mobility, HO preparation starts when an event is predicted to happen (i.e., t0), and HO command is sent when A3 entering conditions are met based on actual/real measurement and an event is predicted to be met for the duration of TTT.

Recommendation 8a: Handover Preparation time is 40ms and handover execution time: 40ms

## Direct prediction

### Common issue

The common issue for both measurement event prediction and RLF prediction is how to interpret the time window where a measurement event/RLF can be predicted. Rapporteur put two interpretations on the table for temporal domain case A:



Figure 2.5.1-1 Interpretation 1 of time window



Figure 2.5.1-2 Interpretation 2 of time window

In the summary of post email [1] some company propose there could be multiple time windows in the prediction window. Rapporteur think it is not aligned with the agreement in RAN2#127 bis meeting as following:

For direct measurement event prediction, the model output is the probability of event occurrence within a time window



Figure 2.5.1-3 intermediate time windows

But it seems gives a way to achieve interpretation 1 by the model. It can be assumed that model can predict several time windows in future, among which there are different probability. Then there must be a time window with highest probability and hence this time window should be chosen if the probabilty is higher than preconfigured threshold. However, if a model can only predict one time window in future, then interpretation 2 is feasible.

**Question 9: Which interpretation of time window for direct prediction do you prefer?**

|  |  |  |
| --- | --- | --- |
| Company | Interpretation 1/2 | Comments |
| Ericsson | Interpretation 1 |  |
| Huawei | 1 | As commented previously in the e-mail discussion, with interpretation 2 the window where the event can actually happen is too wide and it is not clear how this can be useful. Direct prediction should be on par with indirect method where the event is supposed to be predicted correctly in case it falls within a short time window from the real event occurrence which corresponds to interpretation 1. |
| vivo |  | An simple approach is the RLF prediction is performed upon T310 and the prediction result is whether the T310 will expires. |
| Qualcomm | Interpretation 2 |  |
| Mediatek | Interpretation 2 with comment | With interpretation 2, the blue time window can align with the PW, and the output should be a probability vector of multiple time instance [10%, 10%, 90%, 20%] within the PW. If the probability of certain time instance is higher than preconfigured threshold, then the time window similar with ETD can be used to derive the KPIs (i.e., F1 score). |
| Xiaomi | Interpretation 2 |  |
| Nokia | Interpretation 2 |  |

Recommendation 9: The time window for direct prediction goes for interpretation 2



Regardless which interpretation is chosen, we still need figure the length of the time window for both measurement event prediction and RLF prediction. To align with indirect prediction, it could be equal to the parameter max ETD for interpretation 1 and equal to length of PW for interpretation 2.

Here is recommended value for time window length and probability threshold:

|  |  |  |
| --- | --- | --- |
|  | Measurement event prediction | RLF prediction |
| Time window length (Interpretation 1) | 80ms | 20ms |
| Time window length (Interpretation 2) | 400ms | 400ms |
| Probability threshold | 80% | 80% |

Table 2.5.1-1

**Question 10: Do you agree with the parameters in table 2.5.1-1?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/no | Comments |
| Ericsson | Partly | We think ETD can be the same for RLF prediction as for event prediction, i.e. 80 ms. |
| Huawei | Yes, but… | For interpretation 1 we also need to agree the distance between t0 and t1 which should be aligned with the PW length we agree for indirect prediction. |
| vivo |  | For interpretation 2, why the window is shorter than the T310?For interpretation 1, the gap between t0 and t1 is also needed? |
| Samsung | no | Probability threshold can be up to company. Each company can use their own probability threshold to optimize the F1 score. For fair comparison with indirect method, the length of time window used to determine True/False positive in direct approach should be equal to 2\*maxETD.  |
| Qualcomm | Yes for Interpretation 1.No for Interpretation 2. | Regarding Interpretation 2, we are confused since prediction window has been used only in the context of RRM measurement prediction, and hence for Indirect Event prediction. It is not clear what prediction window means for Direct Event prediction.  |
| Mediatek | Yes with probability threshold. | The “Time window length (Interpretation 2)” is the PW, can left to company implementation. The time window length should be difference from max ETD. They should be independent. |
| Nokia | No | Agree with Samsung on the probability threshold.  |

Recommendation 10: For direct prediction, following values are agreed and company can report probability threshold for corresponding case:

|  |  |  |
| --- | --- | --- |
|  | Measurement event prediction | RLF prediction |
| Time window length (Interpretation 2) | PW length as indirect case(FR1:200ms; FR2:400ms) | PW length as indirect caseFR1/FR2: 400ms |

### System level simulation (part 2)

For the handover model option 1 and option 3, it matters when the predicted measurement event occurs i.e., t1. For both interpretation 1 and 2. For direct prediction, a straight way is that t1 is in the middle of the time window. If option 2 is approved, then this issue is not valid any more.

**Question 11: Do you agree predicted measurement event occurs in the middle of the time window for the sake of handover modelling?**

|  |  |  |
| --- | --- | --- |
| Company | Yes/no | Comments |
| Ericsson | Yes |  |
| Huawei | Not sure | Do we really need to consider direct prediction for SLS? The modelling seems quite unclear. |
| vivo |  | Agree with HW to focus on the indirect prediction for SLS. |
| Samsung | no | Since it is unclear when the event is predicted to occur in Direct approach, we are not sure whether the option 1 & 3 can work with Direct approach. |
| Mediatek | No | With interpretation 2, the output can be a probability vector of multiple time instances [10%, 10%, 90%, 20%] within the PW. With this approach the issue is not exist anymore, the maximum probability time point can be used to determine the time point when an event occurs. |

Recommendation 11: for SLS, RAN2 focus on indirect prediction methodology

# Conclusion

Following recommendations are concluded during offline and hence are proposed to be agreed by RAN2:

**Recommendation 1:** Between GC#1 and GC#2, RAN2 focus on GC#2

**Recommendation 2:** To agree following simulation combination for FR1 generalization study:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Training @Dataset: 30km/h | Training @Dataset: 60km/h | Training @Dataset: 90km/h | Inference @30km/h | Inference @60km/h | Inference @90km/h |
| Baseline | Yes  |  |  | Yes  |  |  |
| GC#1 | Yes |  |  |  | Yes | Yes |
| GC#2 | Yes | Yes | Yes | Yes |  |  |
| Baseline |  | Yes |  |  | Yes |  |
| GC#1 |  | Yes |  |  | Yes | Yes |
| GC#2 | Yes | Yes | Yes |  | Yes |  |
| Baseline |  |  | Yes |  |  | Yes  |
| GC#1 |  |  | Yes |  |  | Yes |
| GC#2 | Yes | Yes | Yes |  |  | Yes |

**Recommendation 2a:** To agree following simulation combination for FR2 generalization study:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Training @Dataset: 60km/h | Training @Dataset: 90km/h | Training @Dataset: 120km/h | Inference @60km/h | Inference @90km/h | Inference @120km/h |
| Baseline | Yes  |  |  | Yes  |  |  |
| GC#1 | Yes |  |  |  | Yes | Yes |
| GC#2 | Yes | Yes | Yes | Yes |  |  |
| Baseline |  | Yes |  |  | Yes |  |
| GC#1 |  | Yes |  |  | Yes | Yes |
| GC#2 | Yes | Yes | Yes |  | Yes |  |
| Baseline |  |  | Yes |  |  | Yes  |
| GC#1 |  |  | Yes |  |  | Yes |
| GC#2 | Yes | Yes | Yes |  |  | Yes |

**Recommendation 3:** To agree following values:

|  |  |  |
| --- | --- | --- |
| Parameters | baseline value | Note |
| A3 event offset (db) | 2 | Open for 3db |
| TTT (ms) | 320 | Open for one shorter value |
| UE speed (km/h) | 90 | Open for 60 and 120km/h |
| OW length (ms, note1) | N/A | Up to implementation |
| PW length (ms, note1) | 400 | Open for more values |
| Max ETD (ms, note1) | 80 | Open for more values |

*Note1: parameters for indirect prediction only*

**Recommendation 4:** To agree following values:

|  |  |  |
| --- | --- | --- |
| Parameters | baseline value | Note |
| A3 event offset (db) | 2 | Open for 3db |
| TTT (ms) | 320 | Open for one shorter value |
| UE speed (km/h) | 30 | Open for 60 and 90km/h |
| OW length (ms,note1) | N/A | Up to implementation |
| PW length (ms,note1) | 200 | Open for more values |
| Max ETD (ms, note1) | 80 | Open for more values |
| MRRT | 50% | Open for more values |

*Note1: parameters for indirect prediction only*

**Recommendation 5:** Company can report option 1, open 2, option 3.

**Recommendation 5a:** to capture the 3 options into TR

**Recommendation 6**: To agree following values. Value with yellow color need be discussed:

|  |  |
| --- | --- |
| Parameter | Value |
| Qin threshold | -6db |
| Qout threshold | -8db |
| Sample rate (TIndication\_interval) | 20ms (FR2)/40ms(FR1)  |
| Qin evaluation period | 100ms |
| Qout evaluation period | 200ms |
| T310 | 1000ms |
| N310 | 1 |
| N311 | 1 |
| Max ETD (ms, note1) | 80ms |
| PW length (ms,note1) | 400 |
| OW length (ms, note1) | Up to implementation |

**Recommendation 6a**: The beam transmission pattern is synchronized across the site/cells i.e., at any given time the transmitted beam index is the same across the site/cells.

**Recommendation 7:** For measurement event prediction for temporal domain case B, goes for option 2:

**Option 2:** UE delay to t1 to report measurement result as if the predicted measurement event occurs there. Network starts the preparation after receiving the measurement report. And handover command will be received after handover preparation.



**Recommendation 8:** For measurement event prediction for temporal domain case A, company focus on option 2 or option 3.

**Option 2:** network transmit handover command purely based on actual measurement event regardless whether an actual measurement result(@t2) is earlier or later than predicted measurement event((@t1))

 

**Option 3**: For AI mobility, HO preparation starts when an event is predicted to happen (i.e., t0), and HO command is sent when A3 entering conditions are met based on actual/real measurement and an event is predicted to be met for the duration of TTT.



**Recommendation 8a:** Handover Preparation time is 40ms and handover execution time: 40ms

**Recommendation 9:** The time window for direct prediction goes for interpretation 2



**Recommendation 10:** For direct prediction, following values are agreed and company can report probability threshold for corresponding case:

|  |  |  |
| --- | --- | --- |
|  | Measurement event prediction | RLF prediction |
| Time window length (Interpretation 2) | PW length as indirect case(FR1:200ms; FR2:400ms) | PW length as indirect caseFR1/FR2: 400ms |

**Recommendation 11:** for SLS, RAN2 focus on indirect prediction methodology

Additional note from rapporteur:

Following agreement need be reverted by **Recommendation 6a**::

7 the interference comes from fixed beam pattern of neighbor cells

Following [CB] can be removed by **Recommendation 8a:** :

7 The handover preparation time and execution time are x and y ms for both FR1 and FR2 (X and Y are the same for FR1 and FR2, CB the exact value]

Following [CB] can be removed by **Recommendation 7:**

8 [CB]As for simulation based on temporal domain case B, agree following approach:

 If a predicted A3 event at t1 is reported at t0 (t0<=t1) then HO command is transmitted at t3, where t3=t0+max(HO prep time, t1-t0). [CB – discuss time when handover command is transmitted]

Following proposal can be agreed by **Recommendation 9:** :

5 [CB] To agree following definition for true event prediction, false event detection and missed event detection for direct measurement event prediction

Counter n3’ (true event prediction): it increases by 1 when a real event occurs within the occurrence window of predicted event whose possibility is higher than a predefined threshold

Counter n1’ (false event detection): it increases by 1 when no real event occurs within the occurrence window of predicted event whose possibility is higher than a predefined threshold

Counter n2’ (missed event detection): it increases by 1 when a real event occurs, but it doesn’t fall in the occurrence window of any predicted event whose possibility is higher than a predefined threshold

# Reference

[1] Email discussion ([POST127bis][022][AI mobility] Simulation Assumption of measurement event/RLF prediction and SLS (OPPO)

[2] R2-2410800 Discussion on generalization aspects and simulation assumption ZTE Corporation

[3] R2-2410540 Discussion on simulation assumptions and generalization Huawei, HiSilicon discussion

[4] R2-2409867 Simulation assumptions on event/RLF/SLS and model generalization Xiaomi discussion