3GPP TSG-RAN WG2 Meeting #121bis-e R2-230xxxx

Elbonia, 17 – 26 April 2023

**Agenda item: 7.16.2.2**

**Source: Nokia (Rapporteur)**

**Title: Report of [AT121bis-e][024][AIML18] on Data Collection Table (Nokia)**

**WID/SID: FS\_NR\_AIML\_air - Release 18**

**Document for: Discussion and Decision**

# Introduction

This document is the report of the following email discussion:

R2-2302650 AIML data collection Nokia, Nokia Shanghai Bell discussion Rel-18 FS\_NR\_AIML\_air

DISCUSSION P1 P2

- OPPO wonder what is the Inference (output),

- Intel also wonder this, and think training data may be a large data set com to inference. Thnk inference output and input doesn’t need to be split.

- ZTE think use case shall be considered as well.

- CATT support to split input and output as we need to collect for labelling, and we need to add use case info.

- Nokia example: can collect radio measurement e.g. RSRP, which may be used as input, but is not the output of the model.

* Extend the previously endorsed table with 3 columns: Inference, Monitoring and Training, and explain in free text the applicability of the data collection method to the LCM purpose and the use case(s).

Go offline with this (Nokia)

* [AT121bis-e][024][AIML] Data Collection Table (Nokia)

Scope: Extend the previously endorsed table with 3 columns (3 LCM purposes): Inference, Monitoring and Training, and explain in free text the applicability of the data collection method to the LCM purpose and the use case(s).

Intended outcome: Report with agreeable (or almost agreeable) table update

Deadline: CB W2 Wednesday.

**The deadline for comments is Monday, 24 April, 2023 at 23:59 UTC.**

The RAN2#121-bis-e agenda items [1] for AIML Methods related to data collection are captured below.

**7.16.2 AIML methods**

Explore AIML methods that are expected applicable to this SI and their expected or potential architecture (allocation of functionality to entities), Identification of Models, other framework aspects, impact on RAN2. Most of LCM is in RAN2 scope.

Both general aspects and use-cases specific aspects are applicable (for use cases in scope). Aspects of on-line/real-time training are deprioritized at current meeting. Please input to 7.16.2.x

**7.16.2.2 Data Collection**

Expect to continue evaluation, e.g. evaluation of cases / methods wrt different LCM purposes. Determine which tangible issues if any (e.g. performance aspects) should/could be considered for later decisions on data collection.

The purpose of this email discussion is to determine which additional columns and/or details should be captured for the comparison of data collection frameworks, and whether these should be captured in the pre-existing table [2] as agreed during RAN2#121 [3] or if they should be captured in a new table. Additionally, it will be discussed whether details about model inputs consumed by the model for the purpose of inference and monitoring should be discussed separately from details about model outputs that are reported to the network.

# Contact Points

Respondents to the email discussion are kindly asked to fill in the following table.

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

The following proposals from the data collection email discussion [4] were loosely agreed during RAN2#121 [3]. Points for discussion from the loosely agreed proposals are highlighted below. Note that according to the agenda for this meeting [1], that “aspects of on-line/real-time training are deprioritized at current meeting.”

**Proposal 1** RAN2 to simultaneously focus on studying data collection solutions for both NW- and UE-sided AIML models, including assistance signalling and (dataset) reporting from the concerning entity.

**Proposal 3** RAN2 to separately analyse the data collection requirements and solutions for the different LCM purposes. FFS if general frameworks/solutions could be adopted.

The main topic of the email discussion is to determine the appropriate categories, and potential contents for each, for the analysis of data collection frameworks for AIML. During the second online session for AIML during this meeting, the following was agreed.

Extend the previously endorsed table with 3 columns: Inference, Monitoring and Training, and explain in free text the applicability of the data collection method to the LCM purpose and the use case(s).

**Observation 1**: It was agreed to at least extend the previously endorsed table with 3 additional columns: inference, monitoring, and training.

Furthermore, we think the topic of the termination point of each data collection framework should be analysed. To focus the discussion, it is suggested to consider models as one-sided, even if they are part of a two-sided model because for data collection, each side of the model can be uniquely identified by its location (UE or NW) and by the LCM purpose. For example, a two-sided CSI compression model includes a UE-side model that will report inference output toward the gNodeB, and a gNodeB-side model which will collect the UE-side model inference output as an input to its model to perform inference. These models and their sides can be considered separately.

It was also raised by several companies that the legacy reporting frameworks function well for configuring the UE to send measurement reports toward the network, but further study is required for configuring the UE to make measurements for the purpose of model input.

**Observation 2**: When studying the applicability of a legacy data collection framework, the termination point(s) of the framework can be used to map their applicability to a particular sidedness per LCM purpose, e.g., UE-side, gNodeB-side, LMF-side, etc., and inference, monitoring, and offline training.

## Capturing LCM Purpose

Creating a mapping between the legacy data collection frameworks will help determine where there are missing elements in the legacy system and will help determine for which LCM purposes the limitations of the data collection frameworks are impactful or not. To this end, we should first discuss how to best present the analyses we are trying to capture.

**Observation 3**: The purpose of the comparison table [2] is to aid in determining the applicability of each data collection framework for use in LCM for AIML models. As-is, the table describes the frameworks, but does not approach any conclusions on when each framework should or could be used.

**Question 1: Should a table be developed to capture the mapping of LCM purpose to data collection frameworks?**

|  |  |  |
| --- | --- | --- |
| Answers to Question 1 | | |
| Company | Yes/ No | Technical Arguments |
| Nokia, Nokia Shanghai Bell | Yes | The existing table for comparing data collection frameworks is useful to help justify each for a use case or LCM purpose, but it is clear from TDocs in this meeting and the last that we need a way to capture the views. For example, data volume and data type requirements differ for inference, monitoring, and offline training. |
| Huawei, HiSilicon | No | We are confused. RAN2 has agreed to extend the previously endorsed table with 3 columns: Inference, Monitoring and Training. What is the point of creating a new table?  In addition, we suggest to discuss the requirements a bit in RAN2, and our paper R2-2303894 provided some inputs. And more RAN1 inputs will be helpful. |
| Qualcomm | Yes | We believe that the existing table for comparing data collection frameworks is **not** useful to help justify each for a use case or LCM purpose. |
| Apple | No | 1. We agree with Huawei that this discussion is out of scope of this offline discussion:   * [AT121bis-e][024][AIML] Data Collection Table (Nokia)   Scope: Extend the previously endorsed table with 3 columns (3 LCM purposes): Inference, Monitoring and Training, and explain in free text the applicability of the data collection method to the LCM purpose and the use case(s).  Intended outcome: Report with agreeable (or almost agreeable) table update  2. We believe it should be RAN1 to provide a table on requirements of data volume and data type (i.e. the suggested table by Rapporteur). Does the new table intend to propose RAN2 to discuss these requirement by bypassing RAN1? |
| Xiaomi |  | We support to consider applicable LCM procedure for each data collection tool. Because the requirement for inference/monitoring/training are different. It’s better to evaluate the existing tools according to the applicable LCM procedures. But we may not need another table. We prefer to extend the previously endorsed table. |
| Ericsson | Yes, but | It is difficult to capture which are the “missing elements in the legacy system”, without first discussing the requirements of the various LCM functionalities, i.e. model training/inference/monitoring. We are not sure if this question intends to capture these requirements/expectations.  So, as also mentioned by HW, and Apple, we need a table, or some entries in the table (as in the Option 2 in Q2) to capture the requirements/expectations on the data collection frameworks for the various LCM functions, i.e. inference, monitoring and training. |
| Spreadtrum | No | LCM purpose extension should be considered on top of previous agreed data collection table. |
| OPPO | No need to have Q1 | We think Q3 is sufficient. |
| NEC | Yes |  |
| LGE | Yes | Each LCM has different data collection requirements, and based on that, the data collection method can be determined. Therefore, we agree that the LCM purpose is captured to the table. |
| Intel | See comment | We share the sympathy that we need to first understand the requirement of data collection for different LCM purpose, since if we want to map the LCM purpose to the existing table (where each framework has its unique characteristic, e.g. termination, latency, etc), this requirement would be quite helpful to avoid companies having different understanding and debate on whether one should be considered or not.  A small step based on HW’s table could work, but we also need to consider the other aspects in the existing table when map LCM purpose to it, e.g. termination, etc. More information from RAN1 is also expected. |
| Fujitsu | Yes | We do need some kind of summary of the mapping between data collection frameworks and LCM functions so that each framework can be discussed further in more details.  We do not expect too many tables to be appeared in the discussion but it seems that only one table [2] and its simple extension are difficult to capture all details of the LCM mapping so we suggest at least at this stage one new table to be introduced.  We agree with some companies above that more RAN1 input are necessary, but it will not block one new table to be created, it is even more necessary for a new table to include the new contents per use case when RAN1 use case specific details are provided. |
| ZTE | No | One table for data collection is sufficient, no more table is needed.  In our understanding, we can just directly add the 3 columns for each purpose (i.e. model training, model inference, model monitoring), for each block that belongs to both the collection framework and purpose, we can use the free text to describe the applicability to the purpose of each use case. |
| vivo | Yes | We need to have an initial analysis of which data collection framework(s) may be feasible for each specific LCM purpose.  However, agree with OPPO that Q1 is duplicated with Q3. |
| Lenovo | No | Agree with some of the above companies that we should develop on top of the previous table. |
| CATT | Yes | Although the agreement said extend the previously endorsed table, we think to use a new table is clearer to represent the relationship between LCM and data collection frameworks. |
| CMCC |  | We agree with OPPO that Q1 is not needed and Q3 is sufficient. |
| Interdigital | See comment | We agree with what other companies have stated above (that what was agreed in the online session was to extend the data collection table, not create a new one.) However, creating a new table is more useful (in terms of possibility to add more LCM specific information, readability, etc.,) |
| TCL | See comment | It is better for a table to capture the mapping between data collection frameworks and LCM functions, which is useful for analyzing whether the existing data collection frameworks need to be enhanced or not. However, extend the existing table or introduce a new table, both are ok to us.  Similar views with some of above companies’, we think the requirements of each LCM propose should be clarified at first, it needs to wait RAN1 progress. |
| Mediatek | No | We don’t think the discussion on how to present the analysis is important. Whether to extend current table or create a new one can be discussed later when all the key points are identified, and conclusions are made. Generally, we should identify the aspects/criterion to be considered to evaluate the applicability of the data collection method to the LCM purposes, e.g., data collection requirements, the data content and termination point. At the time being, we prefer to stick to current email discuss scope, i.e., extend the previously endorsed table with 3 columns (3 LCM purposes). |

**Summary 1**: TBD

**Proposal: TBD**

The current data collection framework comparison table does not capture the suitability of each data collection framework for the use cases

**Observation 4:** Each of the AIML use cases, beam management, CSI feedback enhancement, and positioning enhancement may have different data collection requirements.

**Question 2: Should the analysis of each of the use cases be captured in separate tables?**

|  |  |  |
| --- | --- | --- |
| Answers to Question 2 | | |
| Company | Yes/ No | Technical Arguments |
| Nokia, Nokia Shanghai Bell | Yes | As in the answer to Q1, many companies have provided use-case specific views that could be captured per use case for each data collection framework. The table could allow us to capture, for example, the strong views that LPP can satisfy requirements for the positioning use case. |
| Huawei, HiSilicon | Yes, but not needed for this meeting | In the previous RAN2 meeting, this was heavily discussed.  On one hand, most of companies are fine to look at requirements on data collection for each use case, which means we will have concrete analysis at some point in time.  On the other hand, it is quite difficult to do that at that time because it depends on RAN1 progress (they may have made some agreements, but still lots of things are under discussions). In other words, we can keep it in mind, but it may not be fesibile for RAN2 to do it in this meeting. |
| Qualcomm | Maybe | We would prefer to do it step-by-step. Initially, we can try to capture per LCM, thereafter we can do per use-case (maybe till then we can have more clarity from RAN1 on use case-specific data collection). |
| Apple | Maybe but not needed for this meeting | We also prefer step by step. |
| Xiaomi | Yes |  |
| Ericsson | Yes but wait | As previously commented, let´s first discuss the expectations of each LCM function, i.e. model training/inference/monitoring. |
| Spreadtrum | not needed for this meeting | Agree with QC. |
| OPPO | Maybe Yes | Though we think it may go a little bit too far to analyse per use case based on the agreements in W1, it may be hard to decouple with per LCM purpose analysis, i.e. per LCM purpose analysis may involve per use case differentiation, so we can try and see how far we can go. |
| NEC | Yes |  |
| LGE | Yes | Since the data required for each use case is different, it is useful to separate tables by use case. |
| Intel |  | Not for this meeting. it might be a little early to conclude for each use case, which highly depends on RAN1 input on what data needs to be collected. |
| Fujitsu | Maybe, probably yes but not now | It depends on many factors such as the granularity of discussion and more RAN1 input, so it may be too early to conclude at this stage, e.g., for some coarse cases, MIMO-related two use cases (CSI/BM) can be discussed in one table, but for some other finer cases, even direct POS and assisted POS need two tables for detailed study. |
| ZTE | Yes | To our understanding, the LCM purpose is use case specific ,the use case is not LCM purpose specific, if we really want to do the things here step by step, we need firstly discuss use case rather than LCM purpose. |
| vivo | Yes | The data collection framework of positioning may be different from that of Beam management and CSI enhancement. |
| Lenovo | Maybe not now | We expect this will be the last step of analysis. Some could be obvious that LPP is only for positioning, but some such as MDT could work for all CSI/BM/Positioning. We prefer to keep things in one table first to have a full picture. |
| CATT | Yes | In the agreement, use case is mentioned to be considered in the table. We think it's better to separate tables according to different use cases. But the detail content of the table we can discuss in the next meeting based on companies’ contributions. |
| CMCC | Not needed for this meeting | We think more RAN1 inputs are needed for use case specific data collection. |
| Interdigital | See comment | Agree in principle, but maybe better first to focus on general aspects of LCM and then we can address specific use case aspects. |
| TCL | Maybe | A new table may more clearly show the mapping between data collection frameworks and use cases; while same to Q1 comments, the requirements of use cases highly depend on RAN1, we needs more RAN1 input. |
| Mediatek | Yes, but not now | We expected that the separate tables will be required for different use cases in the end. We agree with Lenovo that we don’t need to discuss it now. |

Summary 2:

**Proposal: TBD**

From the rapporteur’s point of view, there are two viable options for capturing LCM purpose-specific analyses. The first option (Table 1) is to extend the existing table with new columns for each LCM purpose to be analysed: inference; monitoring; and offline training. The second option (Table 2) is to create a new table, which maps each LCM purpose to be analysed: inference; monitoring; and offline training, to capture specific requirements and feasibility analyses. The characteristics of each data collection framework captured in the original table [2] could be used to formulate inputs to the new table.

The structure for the existing table [2] with new columns (Option 1) is shown below.

Table 1 – Existing Data Collection Framework Comparison Table with Columns Added for LCM Purpose

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Involved Network entity | RRC state to generate data | Max payload size per reporting\* | Contents to be collected | End-to-End report latency\*\* | Report type | Security and Privacy | Inference | Monitoring | Offline Training |
| Framework |  |  |  |  |  |  |  |  |  |  |

The structure of a new table (Option 2) could use the following format originally suggested in [5].

Table 2 – New Table to Map LCM Purposes to Data Collection Frameworks and their Analyses

|  |  |  |  |
| --- | --- | --- | --- |
| LCM purpose | Data collection requirements | Framework | Feasibility analysis |
| Inference |  | L3 Measurements |  |
| Other Frameworks |  |

**Question 3**: Which of the following options is preferred to capture LCM purpose in our comparison of data collection frameworks?

* **Option 1:** Add a new column to discuss the applicability of each data collection framework to the table [2] for each of the identified LCM purposes: inference, monitoring, and (offline) training. (Table 1)
* **Option 2:** Create a new table that maps each of the identified LCM purposes: inference, monitoring, and (offline) training to the data collection frameworks, using the pre-existing table [2] as a reference for filling in the new table to discuss the applicability of each data collection framework. (Table 2)

|  |  |  |
| --- | --- | --- |
| Answers to Question 3 | | |
| Company | Option | Technical Arguments |
| Nokia, Nokia Shanghai Bell | 2 | To add additional columns to the existing data collection frameworks comparison table could make it quite illegible as it gains even more columns. We suggest that the existing table could be used to formulate inputs to the table suggested by option 2. The data collection requirements could discuss topics suggested by companies such as latency or data quantity, and feasibility analysis would compare the requirement to the capabilities of each data collection framework. |
| Huawei, HiSilicon | 1 | Option 1 is sufficient, we do not see a need for option 2. |
| Qualcomm | 2 | Agree with Nokia |
| Apple | Option 1 | Option 1 is what we agreed online. Why challenge agreement in offline discussion? |
| Xiaomi | 1 | For now, it’s difficult for RAN2 to make evaluation, due to lack of requirement in RAN1. So option 1 can be enough. Even if new table is introduced, we assume lots of table would be blank. |
| Ericsson | 2, but | Agree with Nokia, but we would like to highlight the following: Irrespective of whether Table 1 or 2 above is adopted, we should have a column (or a placeholder within the various boxes) to capture any issue with the legacy frameworks when they are applied to a certain LCM purpose and also considering the entity used for the data collection, e.g. gNB or OAM.  For example, in this column, we should capture that the legacy logged MDT may have issues when applied to offline training since that can be used only for IDLE/INACTIVE mode. Or that it is not clear how the MDT would work when the NW-sided model is gNB-centric, etc. |
| Spreadtrum | 1 |  |
| OPPO | Now strong view | Slightly think Option2 is more constructive but pre-existing table [2] should be there for inference also when filing Table 2. |
| NEC | 2 | There may be an issue for the readability of option-1.  Meanwhile it is unclear if we need list all of the framework we discussed so far in this table. |
| LGE | 2 | Existing procedure was analysed through option 1. In the next step, the data collection requirements of each LCM need to be analysed. So, option 2 seems appropriate for discussion. However, specifying one framework and expressing the rest as “other” is not supported. If option 2 is used, I think that all analysed solutions should be written. |
| Intel | Option 1 with comment | We could just extend existing table with the assumption of data collection requirement. The requirement itself for different LCM purpose may not need a separate table. |
| Fujitsu | Option 2 at least for now. | Similar to our Q1 answer, we do not expect too many tables to be created, but currently it seems at least one new table will be more concise, neat and easier for discussion. |
| ZTE | 1 | If we go for option 2, does it mean we reverse the agreement achieved last Monday? |
| vivo | 2 | Capturing the LCM component to the table of data collection framework analysis will make the table tedious, especially when the LCM is per use case.  As some frameworks, e.g., early measurements, may not be suitable for most LCM purposes, we can only capture the feasible frameworks to the table of Option 2 to avoid blank table cells. |
| Lenovo | Option 1 | We in general prefer to keep developing on one table to have full picture, until we have a clear view how to split one table into many.  We have the same impression that what we have discussed online is to develop on top of the existing table. |
| CATT | Option 2 | Moreover, we think the per-use case related analysis can be further extended using this table2. |
| CMCC | 1 | Option 2 is not the intention for this offline discussion. |
| Interdigital | No strong view | Similar comment to Q1. What was agreed to be discussed was option 1. However, option 2 improves readability and will be easier to expand in the future with more details. |
| TCL | No strong view | We are open about these two options. |
| Mediatek | Option 1 | Similar comment to Q1. We can discuss how to formulate the table and make it more readable as the final step, but not now. |

**Summary 3**: TBD

**Proposal**: TBD

It has been noted by several companies [6, 7, 8, 10, 15, 17, 19, 20, 21] that the target of the data collection for each LCM purpose has an impact on whether each legacy data collection framework is suitable. For example, data collection of inputs for inference for a gNodeB-side or LMF-side model might be able to directly reuse measurements reported in RRC measurement reports or LPP location information, while data collection of inputs for inference for a UE-side model might only require the UE to know where particular RSes are being transmitted, but not to directly report those measurements.

**Observation 5: The suitability of each data collection framework might depend on the location of the AIML model (e.g., UE-side, gNodeB-side, LMF-side, etc.).**

**Question 4**: For each LCM purpose: inference; monitoring; and offline training, should model sidedness be considered per data collection framework?

|  |  |  |
| --- | --- | --- |
| Answers to Question 4 | | |
| Company | Yes/No | Technical Arguments |
| Nokia, Nokia Shanghai bell | Yes | Depending on the sidedness of the model (UE-side, NW-side, etc.), some data collection frameworks might not be well suited. For example, L3 RRC measurement reporting could work well for transmitting DL measurements to the gNodeB for a gNodeB-side model, but for a UE-side model that makes use of the same measurements, the reporting of the measurements is not required. |
| Huawei, HiSilicon | Yes, but | In the previous table, the column “Involved Network entity” is listed and the target is to further check the gaps, so we suggest to take model sidedness into considerations.  However, this model sideness discussion is part of architecture discussion (agenda item 7.16.2.1 Architecture General), and it seems more discussions are needed for that. From Huawei point of view, we have some preferences based on our paper, e.g. for CSI/BM, we can focus on UE/gNB (maybe OAM) for data collection, and for Positioning, we can focus on UE/PRU/gNB/LMF (maybe OAM) for data collection. But other companies may have different views, so RAN2 may further discuss it.  So we think the discussion of model sidedness for data collection can be postponed, and we can wait for more progress for architecture discussion. |
| Qualcomm | Yes with comment | Model training of UE-sided models can happen outside the 3GPP systems. Therefore, the data collection requirement for supporting model training outside the 3GPP system should also be considered. |
| Apple | Postpone | Same view as Huawei that we need to wait for more progress on architecture discussion. |
| Xiaomi | Yes |  |
| Ericsson | Yes, but | For sure the “model sidedness” should be considered to evaluate the suitability of a data collection framework. However, it should be also considered the entity performing the function, especially for NW-sided AIML. For example, in case of NW-sided training, the suitability of a certain framework might be different, depending on whether the NW-sided training is OAM-centric, or gNB-centric.  Hence our proposal (similar to Huawei) is to consider, besides the sidedness, also the entity performing the training/monitoring/inference, i.e. UE, gNB, OAM, LMF. |
| Spreadtrum | Postpone | We prefer to postpone the discussion. It is about functionality mapping to entities. For data collection, it can be located at different entities for different LCM purposes.  Also considering all existing data collection frameworks report data from UE to NW, not sure how it is used for UE-side model LCM purposes. |
| OPPO | Yes with modification | We think the original intention here is to clarify the data collection framework may be different if the corresponding LCM purpose, i.e. inference; monitoring; and offline training, takes place in different node, e.g. UE side/gNB side/LMF side/OAM side, there is nothing to do with model sidedness, for instance, even if considering UE side model, model monitoring still can be network side, so prefer to modify the question to the following to remove ambiguity:  **Question 4**: For each LCM purpose: inference; monitoring; and offline training, should where the corresponding LCM purpose takes place be considered per data collection framework? |
| NEC | Yes | The location of the AIML model should be clarified  At the same time, it would be better to also clarify which entity need to collect the data if gNB is not the only assumption. |
| LGE | Yes | Some LCMs conducted on the UE side, e.g., offline model training in UE, are unclear. So, it is questionable whether all model sideness should be considered for now. |
| Intel | Yes with comment | Location of the model is not clear from our understanding, whether it refers to inference or training?  Since we are focusing on data collection, maybe **the termination of collected data** for UE-sided, gNB-sided, LMF-side model would be enough, rather than model location. |
| Fujitsu | Yes, with comments | First, we agree with OPPO/Intel that the model deployment entity and the data collection entity may not be the same, e.g., LMF/gNB may collect data for offline training for a UE-sided model. Second, for certain data collection frameworks, the direction of the data flow are fixed such as UAI. Therefore, basically we need to care more on the DATA FLOW or DATA TERMINATION SIDE rather than AI/ML model side. |
| ZTE | Yes | The functionality mapping of the model training/inference/monitoring is a deterministic factor to evaluate the availability of the data collection framework to each purpose. For example, if the model inference for one use case residing in DU or gNB, it is obvious the LPP is not appropriate to the model inference for such use case. |
| vivo | Yes for inference | In general, we think the termination of the data collection for each LCM component should be considered.  The model sidedness will imply the termination of the data collection for model inference. However, for model training and model monitoring, agree with others that there is no one-to-one mapping between model sidedness and termination of data collection.  Therefore, we prefer to revise it as:  For each LCM purpose: inference; monitoring; and offline training, ~~should~~ the termination of data collection ~~model sidedness~~ be considered per data collection framework |
| Lenovo | Maybe not now | We agree with some of above companies, there is some dependency on the other discussion on functionality mapping. We may discuss it later together with the per use case analysis . |
| CATT | Yes with modification | We agree the intention. But we think this question is a little bit confusion. The data collection framework depends on where the corresponding LCM purpose takes place. Thus, OPPO’s modification is fine for us. |
| CMCC | Postpone | We agree with other companies that the termination of data collection for each LCM purpose should be considered. However, we also think this is about the mapping of functionalities to entities and we can wait for more progress on architecture discussion. |
| Interdigital | Yes, with comments | This has to be considered at some point, as the location of the model and the (network) entity where the training/monitoring is done will have an impact regarding which data collection is suitable. |
| TCL | Yes with comment | We are also confused about ”model sidedness” , it presents the location of model, or location of inference?  And we share same view with some of above companies, for discussing data collection, only clarify termination of the collected data for each LCM purpose seems to be sufficient. |
| Mediatek | Postpone | Agree with HW and Apple |

Although a few companies listed examples of functionality mapping per LCM purpose or per LCM purpose and use case, it is the rapporteur’s view that companies should be given the opportunity to provide inputs in the next meeting.

**Summary 4**: TBD

**Proposal: TBD**

The next question applies to both table options in Q3. To help determine whether each data collection framework will be suitable for each LCM purpose and model location, the LCM purpose columns could be split into two parts: UE-side; and NW-side. Because there are many options, which are not relevant for every use case, for where the NW-side model could reside, the column could be kept general, but the details could discuss specific NW entities.

**Question 5**: Following up on Q4, should each column for LCM purpose be split in two parts: UE-side; and NW-side, where specifics about each relevant NW entity captured in the NW-side column?

|  |  |  |
| --- | --- | --- |
| Answers to Question 5 | | |
| Company | Yes/No | Technical Arguments |
| Nokia, Nokia Shanghai Bell | Yes | We think that the feasibility analysis portion column of the table proposed in option 2 of Q3 could be split into two pieces, or the LCM-specific columns could be split into two pieces to capture UE-side and NW-side aspects of each. An example of the difference in applicability of a data collection framework for gNodeB-side model vs. a UE-side model is provided in our answer to Q4 above. |
| Huawei, HiSilicon | FFS | On one hand, we agree that different sided types may lead to different requirements, which are worth studying. On the other hand, there will be more and more categories to be considered, and this category (UE/NW-side) may correspond to new categories.  So we suggest to just put FFS to Q5, and we may come back it in later meetings. |
| Qualcomm | Yes with modification | Discussion should cover RAN1 agreed classification of training, i.e., UE-side, network-side, and neutral-sid. |
| Apple | FFS | We also suggest to put FFS on Q5. |
| Xiaomi | Yes |  |
| Ericsson | Yes | As per our comment to previous question. |
| Spreadtrum | FFS | Postpone the discussion for now. |
| OPPO | Yes with modification | As clarified in Q4, the differentiation is based on LCM operation location not based on model sidedness issue, better to remove this ambiguity when we structure the Table. |
| NEC | No | That would make the table very complex and then be lack of readability. Why not take a different table for each type of model: gNodeB-side model vs. a UE-side model |
| LGE | Yes | Prefer UE-sided/NW-sided to UE-sided/gNB-sided. This is because it has not been decided which entity should collect data for offline training. |
| Intel | See comment | As we suggestion in Q4, with that approach, we don’t need to further split the table into different columns. |
| Fujitsu | FFS | Similar to our answer for Q4, furthermore we think we can proceed step by step so this point may be postponed for further study. |
| ZTE | Yes with comments | Prefer UE sided/gNB sided/CN sided for each possibility of the LCM sidedness for each use case. |
| vivo | Yes | Agree with Nokia |
| Lenovo | FFS | As commented in Q4. |
| CATT | Yes with modification | Agree with OPPO. |
| CMCC | FFS | We prefer to postpone the discussion for now. |
| Interdigital | Yes, with comments | If we go with separate table option, this could be a good way forward. However, if we are continuing with the old table, this will become highly unreadable. |
| TCL | Yes with comments | OPPO’s view is fine to us. |
| Mediatek | FFS | We prefer to postpone the discussion for now. |

**Summary 5:**

**Proposal: TBD**

For inference, there are two aspects to data collection that need to be considered: collection of data as input to the model; and collection of data that is the output of the model. Figure 1 below uses as an example that the input to the model would be measurements, and the output of the model would be a report. Note that every data collection framework being discussed, except for LPP, is only used to configure the UE to perform certain measurements, process them, and then send a report to the network.

**Observation 6: The data collection frameworks being discussed, except for LPP, are only used to configure the UE to perform certain measurements, process them, and then send a report to the network.**

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Figure 1 - A generic example of flow of data in machine learning (ML) model.

In order to analyse whether the existing data collection frameworks could be suitable, we must be able to identify for which LCM purposes, model sidedness, and use cases the current solutions are deficient. Therefore, it may also be useful to separately analyse data collection for model input and model output, at least for inference and monitoring.

**Observation 7: The legacy data collection frameworks might not be sufficient to support collecting input and/or output for each of the LCM purposes, model sidedness, and use case combinations.**

**Question 6**: Should the analysis of data collection for each model sidedness and use case combination separately consider data collection for the input and output for inference? FFS on how to capture the details.

|  |  |  |
| --- | --- | --- |
| Answers to Question 6 | | |
| Company | Yes/No | Technical Arguments |
| Nokia, Nokia Shanghai Bell | Yes | We think that data collection can be configured by indicating to a UE which physical layer resources are associated with cell-specific or UE-specific reference symbols, without the requirement to report those measurable quantities, and that the report that is generated by the UE could be a different type of content. For example, in the CSI compression use case, the UE might measure CSI-RS whose positions are signalled to the UE by the gNodeB, but report compressed CSI, which doesn’t exist in the legacy system today. |
| Huawei, HiSilicon | No | The question is not clear. What does it mean by “should the anlaysis of XXX combination separately”?  For “data collection for the input and output for inference”, we think the following questions should be considered first:   * what is the input or output for the inference for a specific use case, and is it needed to collect them for some purposes?   If the requirements can be identified, it is natural to study the gaps and possible enhancements. Without looking into the requirements, it is hard to judge whether to definitely consider something. |
| Qualcomm | No  With comment | For UE-side model inference   * The network does not need to define measurements or the input. Only the output of the model should be defined (e.g., periodicity, events, etc.)   For NW-side model inference   * The network can configure the required input to the model (for example, input needed for the model side model). Similarly, UE does not need to know the output. |
| Apple | No | We also think the question is not clear.  On input/output for inference, suggest not to repeat the same discussion which was already concluded in online discussion. From technique perspective, we have similar view as Huawei that the intention to separate input/output is not clear. |
| Xiaomi | No | We understand the requirement for data collection is specific to use case, not to specific model input/output. The model inference procedure is not specified by 3GPP. |
| Ericsson | No | We should just focus on data collection and its applicability to UE-sided and NW-sided. Then it will be natural to conclude on the inputs/outputs of the LCM purpose depending on the sidedness, and also whether inputs/outputs need to be specified. Additionally, it is very likely that the inputs/outputs will come from RAN1, so no need to spend time discussing that at the moment. |
| Spreadtrum | No | Prefer to wait for RAN1 to figure out the details of input and output.  And just from our view, maybe only need to focus on input data collection for one LCM purpose. As for the output, it can be the input for another LCM purpose. |
| OPPO | No | Firstly, it’s not agreed online, secondly, data collection for output is ambiguity, after reading the background given by offline rapporteur, it seems that ‘data collection for output’ means ‘collection of data that is the output of the model’, but the reason to collect data from model output is not clearly given for model inference, how RAN2 can agree this proposal without clear justification. More addition, model inference highly relies on RAN1 guidance/inputs, even if RAN2 agreed to consider data collection for model inference, if the corresponding field is hard to fill, empty value is still acceptable as we still have more meeting in the future for update. |
| NEC | See comments | This discussion may depend on the RAN1 input. |
| LGE | Yes | Sympathy for Nokia's comment. What the input/output of inference will be, we still need more inputs from RAN1. However, considering the cases below, it seems useful to discuss input and output separately. (1) Transfer input data for NW-sided model from UE, (2) Transfer output as UE-sided model from UE |
| Intel | No | We also didn’t fully understand the question. But if the question is asking to split model inference further to input/output, we think it’s not necessary. It is highly rely on what information is collected, e.g. one inference output could be input for another side of the model, then whether it’s input or output? We don’t think such further split will help the analysis of data collection framework for AI/ML. |
| Fujitsu | No | We consider the proposal behind this question conflicts with some previous ones, e.g., data collection with sided consideration. A simple example, an LPP dataflow from UE to LMF can be either output of UE-sided model or input of LMF-sided model, so what is the point to discuss it twice here? Besides, we also support HW’s comments for the ambiguity of this question. |
| ZTE | Output of the model inference is not for now | For model inference, we can just consider the input of the model inference into account, e.g. the UE measurement result for NW sided model inference. Regarding the output of the model inference, to our understanding, it will be forwarded into model monitoring, for now, it is not crystal clear for us what path will be used for the output of the mode inference to be forwarded to the model monitoring, we think the output of the model inference can be postponed. |
| vivo | No | To our understanding, for model inference, the exchange of input is in the scope of data collection, while the exchange of output is not. |
| Lenovo | No | We suggest focusing on the input of inference for the time being.  Actually when we are talking about data discussion for training/inference/etc. we are mostly talking about collecting data that will be used for training/inference/etc. Not sure how this applies to output of inference, do we mean   * Collect data to generate inference output 🡪 this means exactly same as inference input * Collect the generated inference output 🡪 we believe it is a totally separate discussion. |
| CATT | See comments | We think it’s useful to discuss the data collection framework based on the input and output for inference for different use cases. For some use cases, the data collection framework may be different for the input and output for inference.  But it’s not necessary to have separate row/column to analysis the input and output. Explanation in free text is feasible. |
| CMCC | No | we also think the question is not clear. In addition, the requirements on input/output for model inference needs more RAN1 inputs. |
| Interdigital | See comments | The question is not clear. Also, the collection of the input and output data is most likely to be correlated (e.g., for performance monitoring purposes), and as such may not be necessary at this point to start discussing them separately. This could be done as a next step, if necessary. |
| TCL | No | The content and requirements of input/output of model inference depends on RAN1 progress, the discussion is premature. |
| Mediatek | No | We also think we should focus on the input at the time being. |

**Summary 6**: TBD.

**Proposal**: TBD.

It has not yet been decided which methods (for instance, UE/NW/hybrid-side or input/output-based monitoring) of model monitoring will be used, so the following question is with respect to data collection for model monitoring. Because only offline training is being discussed, this question will not apply to training during this meeting.

**Question 7**: Should the analysis of data collection for each model sidedness and use case combination separately consider data collection for the input and output for monitoring? FFS on how to capture the details.

|  |  |  |
| --- | --- | --- |
| Answers to Question 7 | | |
| Company | Yes/No | Technical Arguments |
| Nokia, Nokia Shanghai Bell | Yes | Please see the answer to Q6 above. While more study is required to determine what types of model monitoring could be considered, we think that the concept of data collection for input for model monitoring should at least be considered if model monitoring requires that a dataset is transmitted to the UE for the purpose of monitoring. |
| Huawei, HiSilicon | No | Same comments to Q6.  In addition, for monitoring, we think RAN1 has spent lots of time on discussing (almost everything including solutions). We are not sure whether to wait for more RAN1 progress. In our opinion, if RAN1 can figure out the requirements and some principles, it will not be difficult for RAN2 to continue our study. |
| Qualcomm | No | Wait for RAN1 progress. One of the purposes of this study item is to reduce data reporting over the uU interface. Therefore, the overhead of data collection for monitoring should be examined first by RAN1. |
| Apple | No | Same comments to Q6. And we also prefer to wait RAN1 on monitoring. |
| Xiaomi | No | It’s unclear what input and output for monitoring means. |
| Ericsson | No | Similar to Q6. No need for this at the moment. |
| Spreadtrum | No | Suggest to wait for RAN1 progress. |
| OPPO | No | Similar comments to Q6 |
| NEC | See comments | This discussion may depend on the RAN1 input. |
| LGE | No | For model monitoring, we need more ran1 input. It seems that it is still ambiguous what decision(output) will come out for which input for each use case. |
| Intel | No | See response to Q6. |
| Fujitsu | No | Similar to our answer of Q6. For model monitoring, at least for some minor cases (e.g., assisted POS) there may have some spaces for discussing model input/output separately, however it still depends on more RAN1 input. |
| ZTE | No | Model monitoring is still not crystal clear to us, we need more information from RAN1. |
| vivo | No | Similar to our answer to Q6. The exchange of performance KPI of model monitoring is in the scope of data collection, while the exchange of monitoring configuration or model control (deactivation/switch) is not. |
| Lenovo | No | Same comment as in Q6 |
| CATT | See comments | Similar comments to Q6 |
| CMCC | No | Prefer to wait for RAN1 progress. |
| Interdigital | See comments | Same as Q6. |
| TCL | No | Suggest to wait for RAN1 input |
| Mediatek | No | Same comment as in Q6 |

**Summary 7**: TBD.

**Proposal**: TBD.

The following are examples of data collection for which the data collection frameworks being discussed might be deficient.

1. Downlink cell-specific and UE-specific reference symbol configuration (CSI-RS, POS-RS, etc.) as input to a model. For which LCM purposes is FFS.
2. Uplink physical layer transmission configuration (SRS, etc.)
3. Provision of data as model input for network-side or hybrid model monitoring

**Question 8**: If Q6 and/or Q7 are agreed: for data collection as input to a model for the purpose of inference and/or monitoring, could the list above be used as a starting point? Please provide comments on additional types of data collection for input that should be considered.

|  |  |  |
| --- | --- | --- |
| Answers to Question 8 | | |
| Company | Option(s) | Technical Arguments |
| Nokia, Nokia Shanghai Bell | All | We think these are a good starting point and that considering these could help better understand the scope of data collection that is required, even if some of these are not part of the final list, or if more types of data collection for inference, monitoring, and/or offline training are added to the list. |
| Huawei, HiSilicon | No | We have some questions as well as comments for Q6 and Q7. |
| Qualcomm | No | The question is not clear. Furthermore, for 2, the network knows the SRS configuration. Therefore, no need for reporting from UE. |
| Apple | No | 1 / 2 / 3 should be what RAN1 can conclude and then notify RAN2. We are not sure why RAN2 can conclude it. |
| Ericsson | No | Those inputs may be correct, but it is premature to discuss them at this stage. First RAN2 should discuss on the suitability of the various collection frameworks on the basis of the expected requirements of each LCM function, irrespective of the specific inputs/outputs of those frameworks. At this stage, let RAN1 discuss those inputs/outputs details. |
| Spreadtrum | No | Suggest to wait for RAN1 progress. |
| OPPO | No | Too far to go according to comments for Q6 and Q7. |
| LGE | No | It would be good to ask ran1 what inputs are needed for each use case. |
| Intel | No |  |
| Fujitsu | No | Similar to our answers of Q6 and Q7, at least it is not necessary at this stage. |
| ZTE | No | See our comments in Q6 and Q7 |
| vivo | No | The configuration is not in the scope of data collection. The proposal seems to count all the signaling procedures into data collection. |
| Lenovo | No |  |
| CATT | No | Too early to discuss this in this meeting. |
| CMCC | No |  |
| Interdigital | See Comments | Same comments as Q6 |
| TCL | No |  |
| Mediatek | No |  |

**Summary 8**: TBD

**Proposal**: TBD

## New Content

Based on inputs from [6-23], the following table (Table 3) captures the majority views provided by companies for each LCM purpose and use case to data collection framework mappings.

Table 3 – Predominant Views of Data Collection Frameworks Mapped to LCM Purpose

|  |  |  |  |
| --- | --- | --- | --- |
|  | CSI | BM | Positioning |
| Inference | L1 Measurement Reports | L1 Measurement Reports (CSI), L3 Reporting (RRM) | LPP |
| Monitoring | L1 Measurement Reports (CSI), L3 Reporting (RRM) | L1 Measurement Reports (CSI), L3 Reporting (RRM) | LPP |
| Offline Training | Logged MDT, Immediate MDT | Logged MDT, Immediate MDT | LPP, Logged MDT, Immediate MDT |

For the following question, please limit the discussion to whether the individual contents of Table 3 are agreeable or disagreeable. Then, in the next meeting, proposals to add further mappings of LCM purpose and use case to data collection frameworks can be discussed.

**Question 9**: Regardless of the eventual table structure(s), could the data in Table 3 be used as a starting point for mapping LCM purpose and AIML use case to data collection frameworks?

|  |  |  |
| --- | --- | --- |
| Answers to Question 9 | | |
| Company | Yes/No | Technical Arguments |
| Nokia, Nokia Shanghai Bell | Yes | From our understanding, these are the majority views. |
| Huawei, HiSilicon | No | Firslty, we are not convinced by Table 3, as it is related to the preivous question. We think RAN2 has already agreed to extend the previous table, so what is the point of creating a new table?  Secondly, we have the following comments:  For inference+CSI, for CSI prediction use case (UE-sided model), we assume that the UE just uses its information and does the inference, so why it needs L1 reports?  For inference+CSI/BM, L1 Measurement Reports is confusing, and it is better to list the concrete functionalities.  For inference+Positioning, LPP is too general.  For monitoring+CSI/BM, what is L3 Reporting? And what is “(RRM)”?  For offline training, we are ok to consider loggd MDT but it may need to put a FFS as the RRC states are idle/inactive for it (while CSI/BM is for connected state).  In general, we think there are lots of issues for the content for this table. |
| Qualcomm | No | Before discussing Table 3, we would prefer to conclude the discussion on Table 2 to capture the requirements of LCM and how different data collection frameworks can meet these requirements or not. |
| Apple | No | We agree with Huawei and Qualcomm that this discussion is premature. |
| Xiaomi | No | For inference of BM, the latency requirement is unclear. We’re not sure whether L3 report can fulfil the requirement.  For offline training, L3 measurement should also be considered. We don’t see the rationale to exclude L3 measurement at this stage. |
| Ericsson | No | From this table 3 above, it seems that those legacy frameworks can be applied as they are to the various LCM purposes. But this is not correct, or it least it should be studied.  For example, in this table, it is missing the sidedness of the model, and also the location of the LCM function, e.g. UE, gNB, OAM, LMF, etc. That is fundamental to assess the suitability of the various frameworks, i.e. a framework working well for a gNB-centric data collection, may not work equally well if applied to an OAM-centric data collection LCM. Additionally, it is missing a placeholder (column) to discuss possible issues with those legacy frameworks.  So in general we are not sure about the usefulness of this table. It is enough in our view to just adopt one of the tables discussed in Q3 |
| Spreadtrum | No | This discussion is premature. |
| OPPO | No | The similar view with HW and QC. |
| NEC | See comments | This discussion may depend on the RAN1 input. |
| LGE | No | Agree with Qualcomm |
| Intel | No | As we commented earlier, it’s premature to discuss data collection per use case based. |
| Fujitsu | No | Agree with companies that this discussion is premature. |
| ZTE | See comments | According to the comments above, we firstly need to confirm that the data collection for the functionality residing at the UE side is not in the discussion scope since all the current candidate frameworks are focusing on the date flow from UE to NW. |
| vivo | No | Similar view with HW and QC.  But if we would have a baseline. For offline training, remove Logged MDT for beam and CSI; remove MDT for POS. |
| Lenovo | No | Even though we have some sympathy on the proposal, based on the current discussion, it's better to postpone the per use case and per sidedness discussion. |
| CATT | No | Prefer to focus on table 2. |
| CMCC | No | We share the similar view with Huawei and Qualcomm. Prefer to focus on Table 2. |
| Interdigital | No | We agree with the views expressed by most companies above that for this offline discussion the focus should be on the main data collection table (discussed in Q1-8) |
| TCL | No | We need to wait RAN1 progress |
| Mediatek | No | We also doubt the usefulness of table 3 for further study. Without identifying and analyzing the key criterion to evaluate which data collection frameworks is applicable for which LCM purposes and use cases, it’s hard to agree the table. |

**Summary 9**: TBD

**Proposal**: TBD

Companies are encouraged to provide their views. During this offline session there may not be sufficient time to capture all the views from different companies, therefore views can be captured in the next Tdocs and can be discussed in the upcoming meeting. To help focus the discussion, companies can provide views below on the types of information that should be added to the table.

**Question 10**: What type of content is missing from the tables that should be considered to help build a complete view of the data collection requirements and the capabilities and characteristics of each existing data collection framework?

|  |  |
| --- | --- |
| Answers to Question 10 | |
| Company | Technical Arguments |
| Huawei, HiSilicon | Based on our paper:  **R2-2303894 Discussion on data collection Huawei, HiSilicon discussion**  We will like to identify two issues for RAN2 study:  **Issue 1: data size issue**  *Observation 1: For logged MDT, the UE is required to support 64KB for the buffer, and the logMeasAvailable-r16 and UEInformation procedure are used for transferring the whole report. There may be multiple procedures for the transferring.*  *Observation 2: The segmentation of UL RRC message is only applicable to UECapabilityInformation and MeasurementReportAppLayer, and it is not applicable to other UL RRC messages (related to data collection mechanisms).*  And our proposal is:  *Proposal 1: For data collection mechanisms (i.e. the UE generates and transfers data only in RRC connected state), if the data size is more than 9KB, the current mechanisms can not work, and some enhancements can be considered, e.g. the segmentation of UL RRC message.*  **Issue 2: understand more about requirements for data collection for different LCM aspects**  Have some discussions on the requirements for data collection for offline training/inference/monitoring. E.g. |
| Qualcomm | Note that for each sub-use case, RAN1 may define data collection requirements based on nominal inputs and outputs of the sub-use case. However, the actual inputs/outputs to/from the models used at the device may be different from the nominal inputs and outputs. For example, a model at UE may take auxiliary inputs such as SNR, Doppler, sensor measurements, etc. that do not need to be standardized.  Therefore, we believe that data collection of non-standardized data for UE side model should be considered. |
| Xiaomi | As discuss online and in our paper, we understand how many data sets can be included in one report procedure should be considered. This may be important to reduce the report signalling, especially for the data collection for training. Training may require data collected in a period of time, not just the latest data. |
| Ericsson | Following information should be included:   * Table (or entry in a table) on the LCM expectations/requirements (similar to HW proposal, or Table 2 in R2-2304112) and the expected “reporting type”, i.e. whether a single sample measurement taken in a time interval, or multiple samples measurements taken in multiple time intervals are needed (similar to Xiaomi proposal). * Table (or entry in a table, e.g. in the table discussed in Q3) capturing any possible issue related to a certain candidate framework, when it is applied to a given LCM purpose and based on the entity performing the data collection, i.e. UE, gNB, OAM, LMF |
| OPPO | Please try to fill Table 2 and then see how to improve; otherwise, how companies can evaluate which is missing or can be improved without initial picture? |
| Lenovo | We tried to give some qualitative analysis on the latency and data size requirements in our paper [13]. We agree that the first priority now is trying to extend the previously agreed table as discussed online. |
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**Summary 10**: TBD.

**Proposal**: TBD.

# References

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[2] R2-2302286 “Summary of [AT121][025]: Progress table of analyzing data collection framework (Apple)”, Apple, March 2023

[3] R2-2302401 “RAN2#121 Meeting Report”, MCC, April 2023

[4] R2-2301440 “Outcome of [Post120][054][AIML18] Data Collection (Ericssion / vivo)”, Ericsson, vivo, March 2023

[5] R2-2302954 “Discussion on data collection”, vivo, April 2023

[6] R2-2302489 “AIML Data Collection”, NEC, April 2023

[7] R2-2302548 “Data Collection for LCM Purposes”, OPPO, April 2023

[8] R2-2302650 “AI/ML Data collection”, Nokia, April 2023

[9] R2-2302747 “Further analysis on data collection framework”, Intel, April 2023

[10] R2-2302954 “Discussion on data collection”, vivo, April 2023

[11] R2-2303018 “Considerations on data collection of AI/ML for NR air-interface”, CATT, Turkcell, April 2023

[12] R2-2303121 “Discussion on data collection”, Xiaomi, April 2023

[13] R2-2303241 “Qualitative analysis on data collection requirements”, Lenovo, April 2023

[14] R2-2303373 “Further discussion on data collection for AI/ML”, Apple, April 2023

[15] R2-2303522 “Discussion on data collection”, CMCC, April 2023

[16] R2-2303581 “Discussion on data collection”, Spreadtrum Communications, April 2023

[17] R2-2303668 “Further discussion on Data Collection for AI/ML”, Samsung, April 2023

[18] R2-2303761 “Discussion on Data Collection”, MediaTek Inc., April 2023

[19] R2-2304035 “Data collection for AIML methods”, TCL Communication, April 2023

[20] R2-2304112 “Data collection for AI/ML”, Ericsson, April 2023

[21] R2-2304127 “Discussion On the Purpose Driven Data Collection in LCM”, ZTE Corporation, Sanechips, April 2023

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[23] [23] R2-2303627 “Data collection for AIML” Interdigital Inc., April 2023

# Conclusion

TBD.