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Contents

Foreword

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Introduction

Optimization of the coverage and capacity performance of the network represents an important SON use case, which requires appropriate support functions in the standard. This technical report studies NM Centralized Coverage and Capacity Optimization (CCO) SON function with the focus on necessary support in the 3GPP specifications.

An NM centralized CCO function would help operators in reducing OPEX related to the maintenance and optimization of network coverage and capacity by automating these functions. An NM centralized CCO function would observe network coverage and capacity performance, automatically detect problems and intervene with necessary actions or raise a notification toward the operator, when operator action is needed.

1 Scope

The present document summarizes the result of the study on NM Centralized Coverage and Capacity Optimization SON function. A CCO function that resides outside the NM is out of the scope for this study.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 37.320: "Universal Terrestrial Radio Access (UTRA) and Evolved Universal Terrestrial Radio Access (E-UTRA); Radio measurement collection for Minimization of Drive Tests (MDT); Overall description; Stage 2".

[3] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRAN); Radio Resource Control (RRC) Protocol Specification".

[4] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures".

[5] 3GPP TS 36.210: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements".

[6] 3GPP TS 32.425: "Performance Management (PM); Performance measurements Evolved Universal Terrestrial Radio Access (E-UTRAN)"

[7] 3GPP TS 32.422: "Telecommunication management; Subscriber and equipment trace; Trace control and configuration management".

3 Abbreviations

3.1 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

C-RNTI Cell Radio Network Temporary Identity
CCO Coverage and Capacity Optimization
E-DCH Enhanced Dedicated Channel
GNSS Global Navigation Satellite Systems
HOF Handover Failure
OPEX Operating Expense

SINR	Signal to Interference plus Noise Ratio
RCEF	RRC Connection Establishment Failure
RLF	Radio Link Failure
TAC	Type Allocation Code
TCE	Trace Collection Entity
TR	Trace Reference
TRSR	Trace Session Recording Reference

4 NM centralized CCO function

4.1 Architecture

The logical architecture that applies in case of NM centralized CCO SON function is shown in Figure 4.1-1.

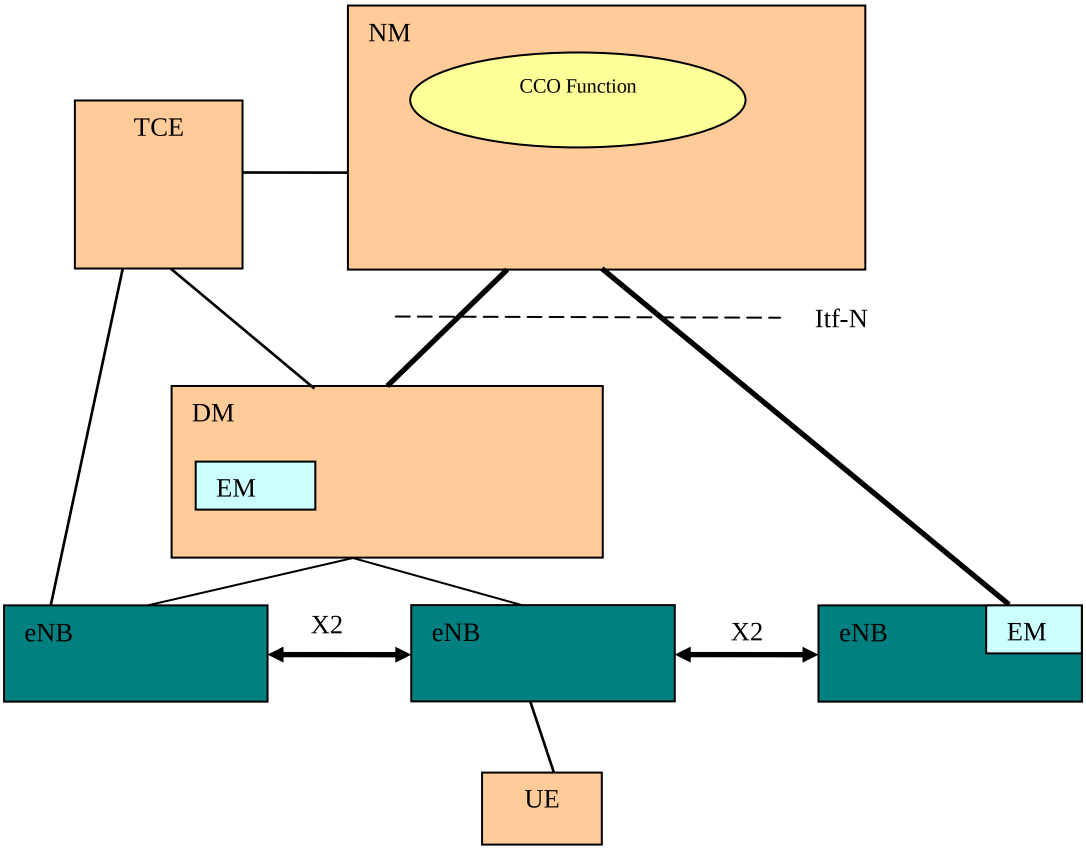

Figure 4.1-1: NM Centralized CCO function logical architecture

The NM centralized CCO function needs to monitor the network and collect UE and network measurements. Based on the analysis of received data the CCO algorithm may identify potential coverage or capacity problems or improvement possibilities and may execute change of network configuration accordingly. The CCO function may also provide information to the operator about the executed changes, performance improvements or indications where some operator interaction is needed.

4.2 Example CCO use cases

4.2.1 General

Coverage and capacity are two closely related characteristics of a cellular network, which largely determine the network capabilities in terms of providing a certain grade of service for a given number of customers in a given geographical area and on a given set of radio spectrum. In order to utilize cell resources in the most efficient way and to serve as many customers as possible with the required level of service, there is a need to configure cell resources according to the actual radio conditions, propagation environment and traffic needs.

Such an optimization process should be automated with no or minimal manual intervention and has to be based upon actual network conditions, i.e., measured data obtained from UEs and from the network. Looking for coverage holes or finding capacity improvement potentials manually is particularly time consuming, costly and requires expert knowledge. Therefore, an automated CCO function can significantly contribute to OPEX reductions and at the same time respond to coverage or capacity problems faster and with better solutions than any human based manual method may provide.

4.2.2 Downlink coverage map

To do the detection of coverage and capacity problems, the geographical area could be divided into bins. Using MDT measurements (RSRP for E-UTRA, UE location information, etc., see TS 37.320 [2]) and some network performance measurements related to the bins, the CCO function could know the coverage situation of the target region by coverage map and do the optimization later. The accuracy of coverage problem detection and effectiveness of optimization depend on several factors, such as the size and number of bins, the accuracy of MDT and network measurement data, and the number of MDT UEs.

A downlink coverage map example is shown in figure 4.2.2-1: Target CCO optimization region – the cells area covered by eNB a and b, is divided into many bins and marked by different colours that show the corresponding signal strength (e.g. cell downlink RSRP).

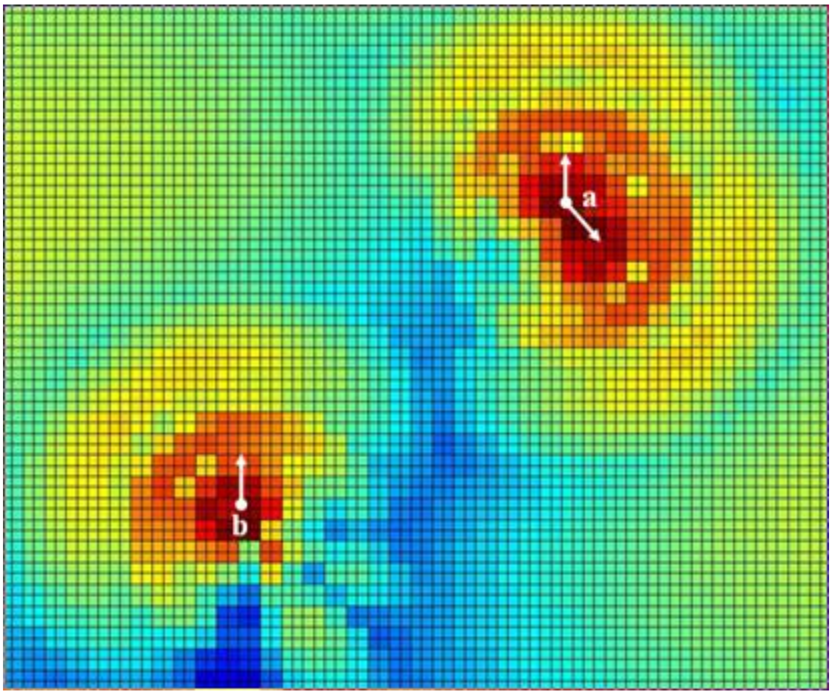

Figure 4.2.2-1 Target CCO optimization region divided into bins with different colours that show corresponding cell downlink signal

4.2.3 Cell coverage adapting to traffic demand use case

Cell coverage is typically decided at time of network planning, where exact distribution of users is hard to take into account. However, the service performance as seen by the user will depend among others on the traffic load in the particular cell, e.g. on the number of users that has to share the cell resources at a particular location. Therefore, there may be a need to adapt cell sizes to the typical distribution of traffic demand from time to time when the distribution of users or the environmental situation are changing (e.g. rush hours).

The NM centralized CCO function needs to detect such service performance problems caused by load imbalances, for which it may need to collect for example, information about number of active UEs, IP Throughput, Packet Delay, Drop, Loss Rate, Data Volume measurements and environmental information (e.g., the location of freeway, stadiums). Based on the collected information, the CCO function may decide to adjust capacity or coverage areas of the related cells.

4.2.4 Coverage and accessibility use case

Typically, the network has to provide basic coverage that ensures accessibility and connectivity. Basic coverage could mean, for example, that a certain level of signal strength should be reached in the cell area and accessibility attempts, i.e., RRC connection attempts and random access attempts must reach certain level of success rate. The NM centralized CCO function may collect RSRP/RSRQ measurements (with or without location information included), RLF events, RRC setup failure reports and random access performance measurements, which could be indications of bad coverage. To further separate uplink and downlink related coverage problems, uplink interference, signal quality and power measurements may be used. The different types of reports related to the same incident and user should be possible to be correlated so the CCO function can identify the source of the problem and can take the right corrective action.

4.2.5 LTE Coverage holes with underlaid UTRAN/GERAN use case

LTE is typically deployed in areas with dense population in an attempt to mitigate traffic congestion during the peak hours. Therefore, initial LTE deployment may be patchy with underlaid UTRAN/GERAN networks that provide basic coverage. Figure 4.2.5-1 shows that there may be coverage holes between LTE cells.

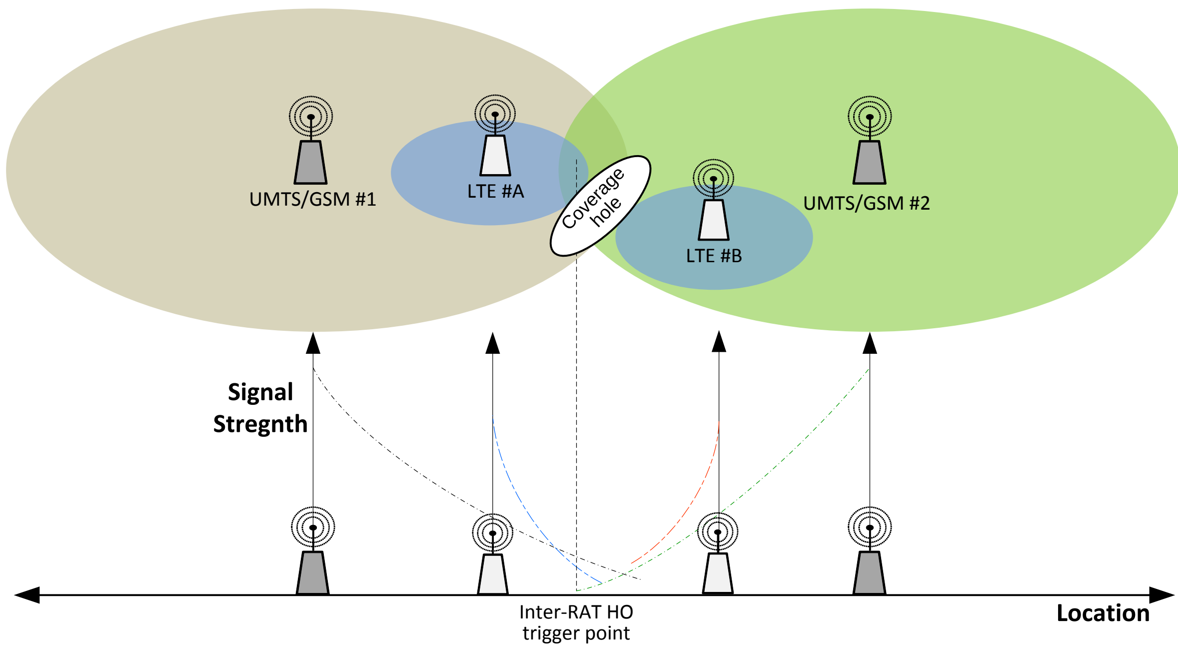

Figure 4.2.5-1: LTE coverage holes with underlaid UTRAN/GERAN

The LTE coverage holes may be detected by the Inter-RAT measurements. The network can capture measurements (e.g., RSRP, RSRQ, cell ID, location, time stamp at the time of Inter-RAT handover), which can be collected for the CCO function and used to identify coverage holes in the LTE network.

The LTE coverage holes may be detected also using measurements performed by UEs in the idle mode.

4.2.6 LTE Connection failure use case

While in idle mode UE enters an area of weak coverage. UE attempts to establish the RRC Connection but fails (RCEF report is logged).

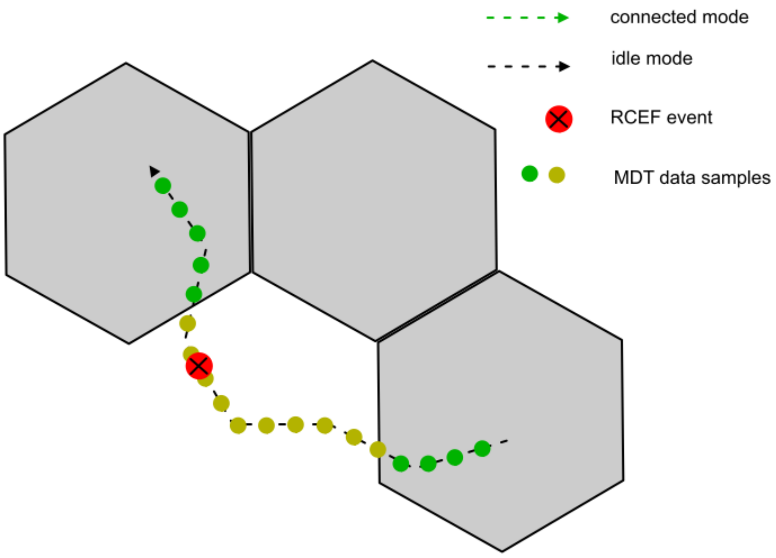

Figure 4.2.6-1 Correlation of RCEF with MDT data

Another case is when UE is in connected mode, loses the connection and then tries to reconnect to the network but it fails.

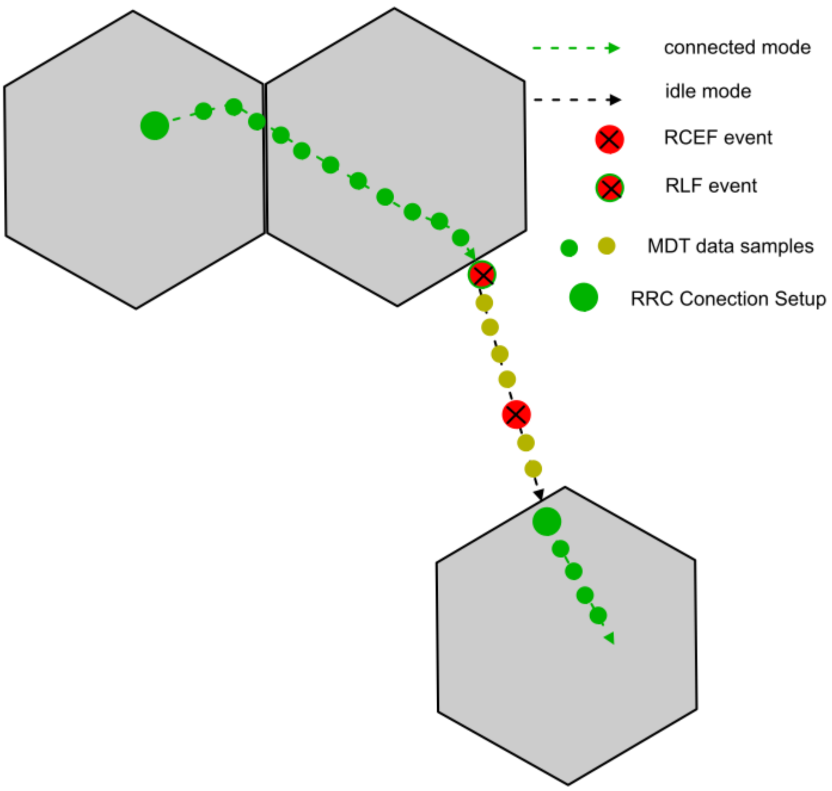

Figure 4.2.6-2 Correlation of RLF and RCEF with MDT data

In both cases the CCO function would need to identify the reason of failure, for which it may need to combine the logged RCEF report with other measurement data, potentially including also measurements made by the RAN or with other incidents and measurements reported by the UE (e.g., RLF report, RSRP/RSRQ reports, etc...). For detailed analysis of connection failures and Coverage and Capacity Optimization, all the different pieces of information connected to the occurrence of the same incident need to be combined, and the combined data will be used by the CCO function.

For detailed analysis of connection failures and CCO, information may be required about the radio conditions of the network prior to and at the moment when the connection failure occurs. In E-UTRAN this data may be collected e.g. by utilizing the potentially enhanced Logged MDT and/or immediate MDT procedures depending on the specific failure scenario.

4.2.7 Radio link quality use case

The service performance (e.g., throughput) as seen by the user is largely dependent on the quality of the radio link (e.g., CQI [4]), which is influenced by signal strength, interference, and other conditions. It should be possible for the NM centralized CCO function to collect information about the radio quality combined with user performance (e.g., IP throughput, CQI, UL SINR) and determine whether the radio link is a bottleneck in service performance. The CCO function may decide to change the signal strength of the investigated cell or that of an interfering nearby cell e.g., by modifying antenna tilt or power settings in order to improve radio link quality.

The CQI can be used as a direct indicator of the Signal to Interference and Noise Ratio (SINR) conditions seen by the UE at actual data transmissions, for which neither RSRP [5] nor RSRQ [5] 36.213 for would be suitable. Note that RSRP is indicative only to the signal strength of the Reference Symbol (RS), while RSRQ is derived from RSRP as the ratio of RSRP versus RSSI (i.e., total received signal power in the RSSI measurement bandwidth), which is not equal to SINR. Moreover RSRP and RSRQ are measured separately from actual user plane transmissions, while CQI is measured and reported when data is actually transmitted.

For example, by observing the UE reported CQI values during a collection period (similarly to the collection period as used in case of existing MDT measurements) it is possible to determine whether the UE was in a poor radio condition at that time. Although the instantaneous CQI value is influenced by fast link variations (e.g., by fast fading), the fast fluctuations are typically around some centre value, which is characteristic to the particular radio environment and can be used by the CCO function to evaluate radio link quality.

Collecting the UE reported Rank Indicator (RI) in a similar way could be used to evaluate radio link quality from spatial multiplexing point of view. The RI reports give information about whether the UE has found the radio link quality good enough to use spatial multiplexing.

4.3 Requirements

5 UE and network measurements

5.1 General

The NM centralised CCO function needs to collect various measurements for its operation. The set of necessary measurements contains already standardised measurements, as well as, new measurements. The measurements can be statistical measurements such as PM measures or UE and network measurements or events, for example, MDT measurements. Existing measurements are indicated with names and references to specifications where they are specified.

5.2 E-UTRAN measurements

5.2.1 UE measurements

5.2.1.1 Connected mode measurements

- Signal strength and quality measurements: RSRP/RSRQ measurements by UE, same as used also for MDT, see TS 37.320 [2] and references therein.

- Accessibility measurements: including the accessibility measurements by UE, as defined for MDT, see TS 37.320 [2] and references therein.

- Radio link failure reports: as defined in TS 36.331 [3].
- Location information – GNSS reports: including GNSS coordinates when reported by the UE in MDT measurements, see TS 32.422 [7] and 37.320 [2].
- Location information – Timing reports: including UE rx-tx time difference when reported by the UE in MDT measurements, see TS 32.422 [7] and 37.320 [2].
- UE reported CQI: The distribution of UE reported CQI values, as defined in [4], to be collected per collection period. The CQI samples reported for single stream transmission (i.e. CQI for single codeword) and for spatial multiplexing transmission (i.e. CQI for multiple codewords) shall be collected separately, in separate distributions.
- UE reported RI (Rank Indicator): The distribution of the UE reported Rank Indicator, as defined in [4], to be collected per collection period.

5.2.1.2 Idle mode measurements

- Logged measurements for the serving cell as well as the Intra-frequency, Inter-frequency and Inter-RAT neighboring cells (see clause 5.1.1.3.3 in TS 37.320 [2]).

5.2.2 Network measurements

5.2.2.1 UE specific

- Power headroom measurement: as defined for LTE M2 MDT measurement, see TS 37.320 [2] and references therein.
- Scheduled IP throughput measurements (UL/DL): same as measurements used for MDT, see TS 37.320 [2] and references therein.
- Location information – Timing reports: eNB rx-tx time difference measurements, when available in the network, see TS 32.422 [7] and 37.320 [2].
- Measurements related to LTE Inter-RAT handover: existing Immediate MDT UE measurements (i.e. RSRP, RSRQ, with corresponding cell ID and location when available) of the serving LTE cell with a new trigger related to the Inter-RAT HO event (the availability/feasibility of the new trigger is FFS).

Editor's note: Discussion with RAN2 is needed.

5.2.2.2 Non-UE specific

- Uplink received interference power measurement: as defined for LTE M3 MDT measurement, see TS 37.320 [2] and references therein.

5.3 UTRAN measurements

5.3.1 UE measurements

5.3.1.1 Connected mode measurements

- Signal strength and quality measurements: RSCP and Ec/No (carrier energy per noise) measurements as supported by immediate MDT, see TS 37.320 [2], clause 5.3.1.
- Location information – GNSS reports: including GNSS coordinates, when available in the UE MDT measurements, see TS 32.422 [7] and 37.320 [2].

5.3.1.2 Idle mode measurements

- Logged measurements for the serving cell as well as the Intra-frequency, Inter-frequency and Inter-RAT neighboring cells (see clause 5.1.1.3.3 in TS 37.320 [2]).

5.3.2 Network measurements

5.3.2.1 UE specific

- Uplink SIR measurement: as defined for UMTS M3 MDT measurement, see TS 37.320 [2] and references therein.
- Power headroom measurement (for E-DCH only): as defined for UMTS M4 measurement, see TS 37.320 [2] and references therein.

5.3.2.2 Non-UE specific

- Received Total Wideband Power (RTWP): as defined for UMTS M5 MDT measurement, see TS 37.320 [2] and references therein.

5.4 Aggregation of measurements

5.4.1 General

In cases when it is sufficient for the CCO function to observe the cell performance via PM measurements, e.g., before making a detailed analysis based on MDT data, it is useful to support the aggregation of some selected MDT measurements into PM measurements. The necessary standard support shall include the definition of such PM measurements in TS 32.425 [4] and the mechanisms for triggering and configuring the underlying data collection. While the data collection is assumed to use MDT collection, section 5.4.2 discussed the method to trigger this collection.

5.4.2 PM measurements

The following PM measurements, aggregated from corresponding MDT measurements, are useful for CCO function purposes.

- RSRP distribution measurements: The distribution of the serving cell RSRP values of MDT M1 measurements. When the eNodeB receives a *MeasurementReport* message [3] with *MeasId* IE corresponding to the MDT M1 measurement, it shall increase the appropriate subcounter of the RSRP distribution measurement corresponding to the value of the *rsrpResult* IE.
- RSRQ distribution measurements: The distribution of the serving cell RSRQ values of MDT M1 measurements. When the eNodeB receives a *MeasurementReport* message [3] with *MeasId* IE corresponding to the MDT M1 measurement, it shall increase the appropriate subcounter of the RSRQ distribution measurement corresponding to the value of the *rsrqResult* IE.

5.4.3 Method for triggering measurements for PM purposes

In order for the above RSRP and RSRQ distribution PM measurements to receive input samples, there is a need to activate (and deactivate) the collections over Itf-N. There are several possible alternatives.

One possibility is to reuse an existing mechanism. Candidates are: Trace IRP or PM IRP.

Another possibility is to invent a new mechanism. Candidates are: inventing a new IRP or extending an existing IRP.

Which mechanism to use is FFS.

6 User privacy and anonymization

6.1 General

The following specific aspects of user privacy handling need to be considered when the data is collected for the NM centralized CCO function purposes.

- User identification: There is no need to identify specific users in the UE and network measurements collected for CCO SON function purposes at any time. The CCO SON function is concerned with the optimization of network and user performance but not for specifically selected customers. Therefore, it is important that the collected data can reveal per user performance, as well as, network level performance but it is not needed to identify specific subscribers (e.g., based on IMSI or IMEI).

- User consent: For the efficient operation of the CCO SON function it is important that sufficient amount of UE and network measurements is collected. Therefore, it should be possible to collect UE and network performance measurements for CCO SON function purposes without limitation of user consent, provided that proper anonymization is employed, i.e., the function is to be designed so that at no point in time it is possible to pinpoint a specific user.

- Data handling: When the data is collected for an automated SON function, like CCO, the data is used for the regular operation of the network.

6.2 Privacy requirements by SA3

The privacy protection requirement is related to the service that the user has signed up to in a contract with the operator. The operator can collect and process data needed to be able to deliver the service ordered by the user i.e. data related directly to the service delivery. However, user consent is needed for the collection of location data for the purpose of MDT and SON, even if it is for direct service delivery.

Even if the user has given consent for collection and processing of its data for the purpose of SON / MDT, then data collection should still be restricted to the minimal data set needed to perform SON / MDT.

6.3 Solution descriptions

If CCO related data of the same UE need to be correlated, then a generic mechanism to anonymize the user data like using specific identifiers, e.g. pseudonym or temporary identity can be used. This kind of method is good for privacy protection but does not replace user consent.

7 Correlation of measurements

7.1 Description of functionality

The correlation functionality is to be used for associating various UE and network measurements that are reported separate (e.g., in different cells) but belong to the same user session occurrence. The correlation enables the CCO function to perform a more detailed analysis to identify sources of potential problems and to take the appropriate corrective actions. The data collection method used for CCO needs to have the necessary support function such that the correlation can be performed later in NM layer.

7.2 Solution descriptions

7.2.1 Correlate RLF/RCEF and MDT data

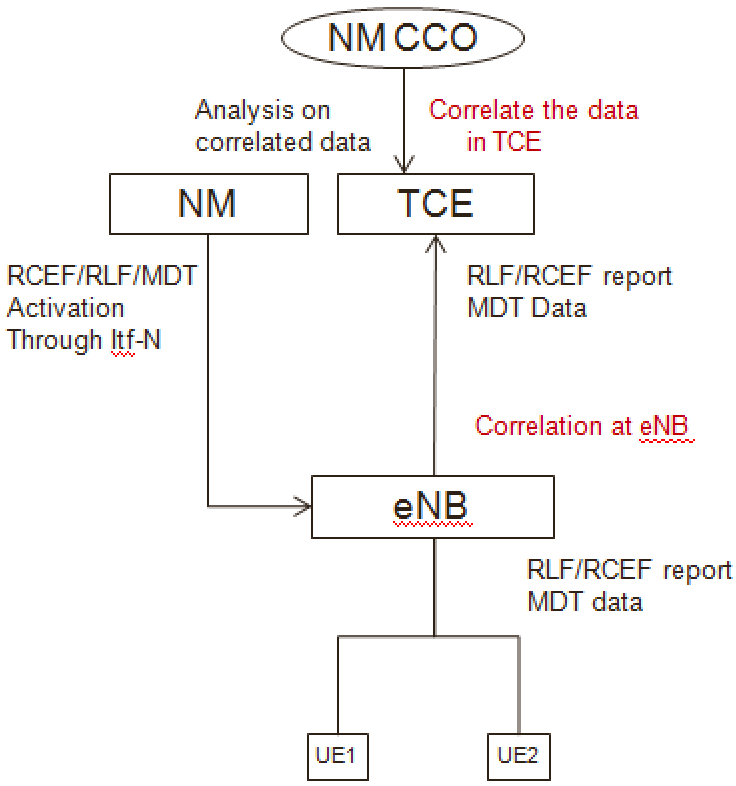

Figure 7.2.1-1 Correlation the RCEF/ RLF and MDT data

Correlation at eNB: the RLF and MDT data may be correlated at eNB.

Correlation in TCE: the RLF/RCEF and MDT data may be correlated in TCE.

The NM CCO function can then use the correlated data for further analysis.

7.2.1.1 Correlation at the eNB Scenarios

7.2.1.1.1 Issues with correlation of Immediate MDT and RLF Reports

RLF (Radio Link Failure) reports contain information related to the latest connection failure experienced by the UE. The connection failure can be Radio Link Failure (RLF) or Handover Failure (HOF). The content of the RLF reports, the procedures for report creation and retrieving by the eNB are described in [2] and [3]. The important detail about RLF is that the UE was in RRC Connected state prior to the failure and the MDT measurements preceding the failure are connected mode measurements (Immediate MDT). In this section we analyze the correlation of Immediate MDT data and RLF report.

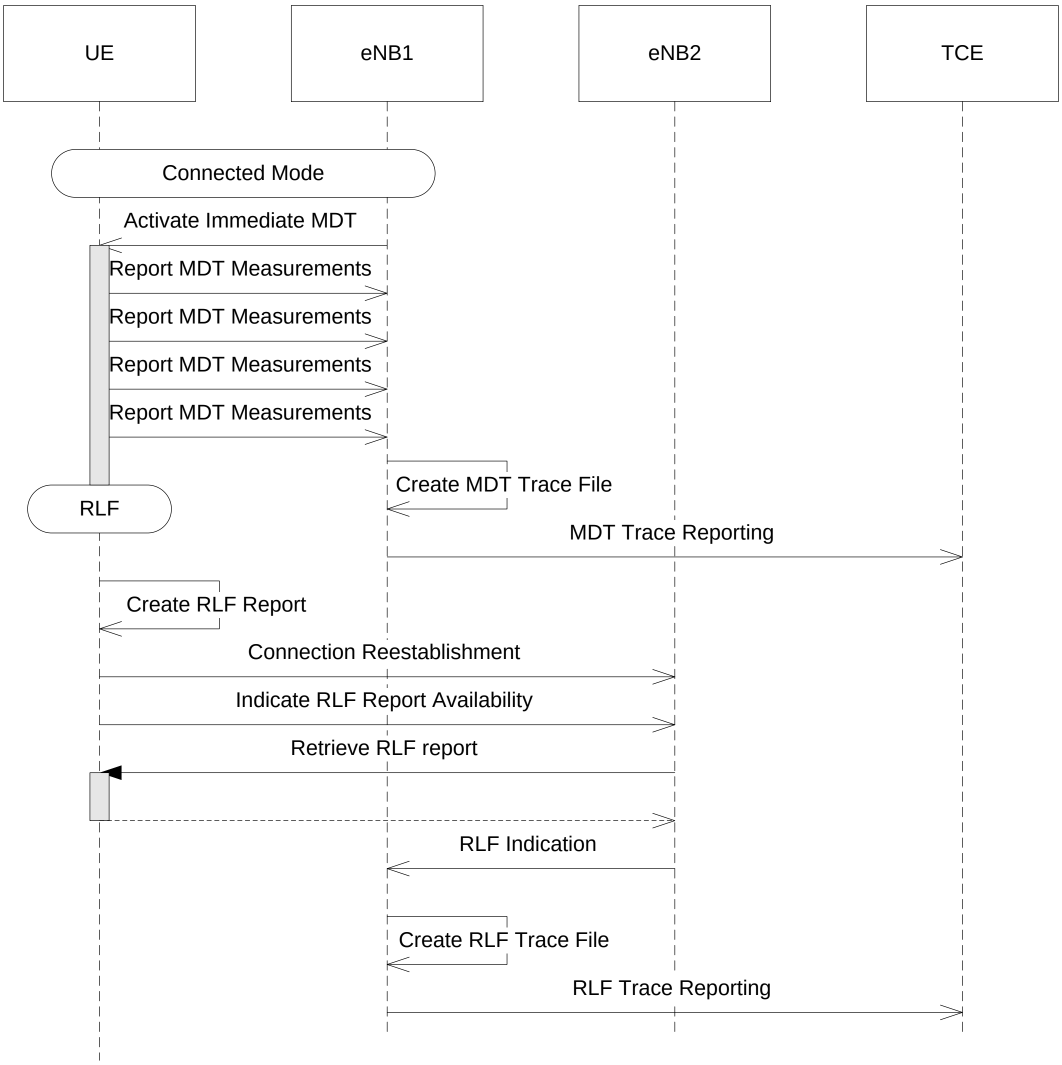

Figure 7.2.1.1.1-1: RLF during an active Immediate MDT session (re-establishment to a different eNB)

The figure 7.2.1.1.1-1 illustrates a scenario where a connected mode UE participates in an Immediate MDT session with eNB1 and experiences a Radio Link Failure. The UE creates a RLF report and attempts to re-establish the connection to a different eNB2. The UE indicates to eNB2 that it has a RLF report available. The eNB2 retrieves the RLF report from the UE and after examining it forwards the RLF report in X2 RLF_Indication procedure to the eNB1 where the Radio Link Failure has occurred. The eNB1 may have the RLF collection Trace Job active, therefore it packs the RLF report received from the UE in a Trace File and forwards it to the TCE.

As section 7.2.1 claims, the RLF report and MDT data may be correlated at the eNB. However, a couple of potential problems exist. The LTE Connection failure Use Case (documented in section 4.2.6) requires correlating the RLF report not with just any MDT data, but with MDT measurements from a very specific interval immediately preceding the Radio Link Failure. In an active Immediate MDT session, the eNB would periodically (specific details are not standardized and are implementation specific) pack the collected measurements received from the UE into Trace Data Files and send them to the TCE. Also, after experiencing the Radio Link Failure, UE may not be able to re-establish the connection immediately (it may take some time e.g. to get out of the coverage hole, etc...) and it is not guaranteed that the RLF report will be retrieved immediately after the first successful connection reestablishment. There is a possibility that eNB1 may pack and send Immediate MDT data to the TCE before it receives the RLF report. In this case the correlation of Immediate MDT data with RLF report at the eNB will not be possible (no MDT data for the time interval preceding the RLF). Another potential problem is that the RLF report may arrive to the eNB1 even later and the UE context (and corresponding MDT session) for this UE may not exist anymore which also makes the correlation at the eNB impossible.

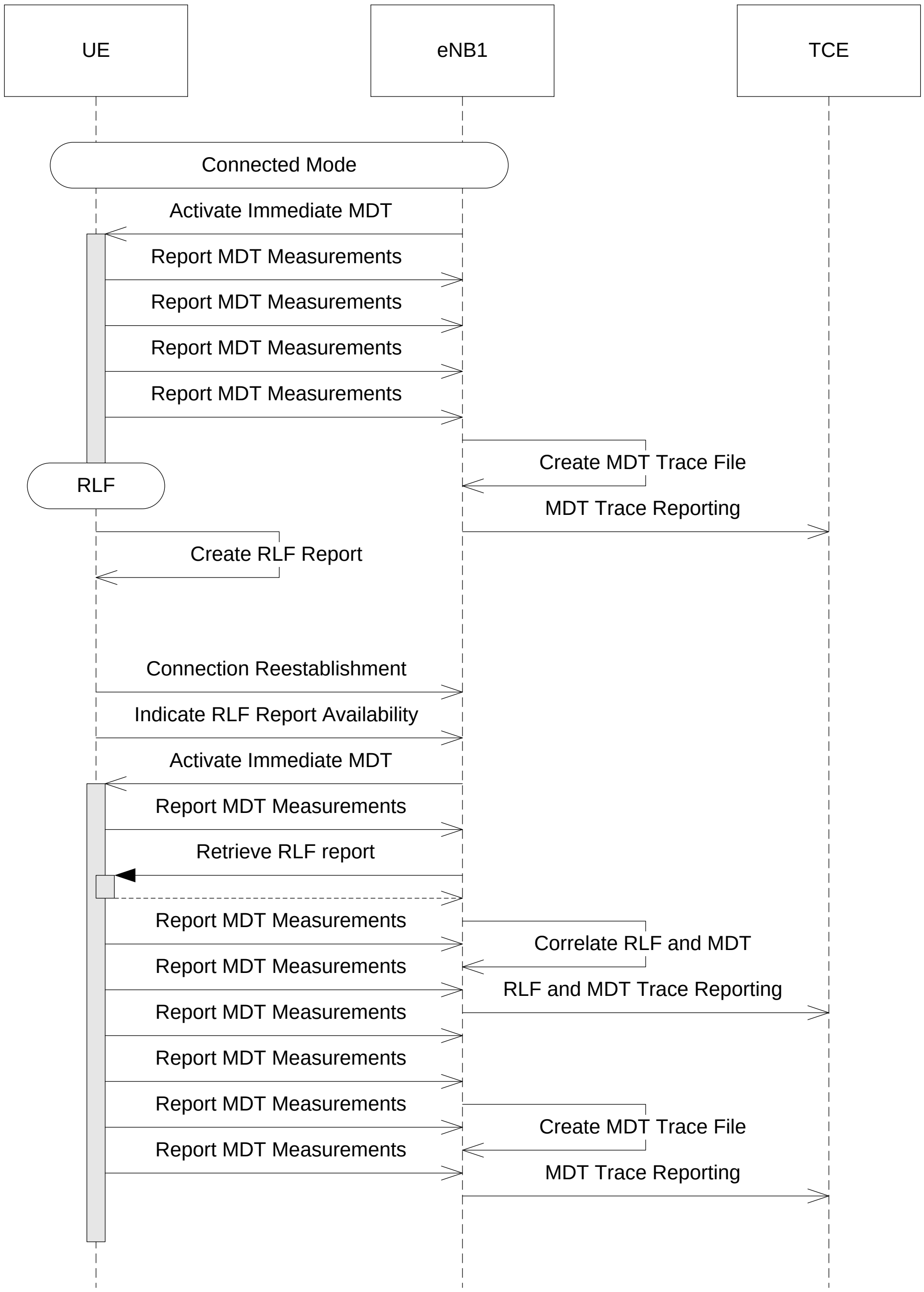

Figure 7.2.1.1.1-2: RLF during an active Immediate MDT session (re-establishment to the same eNB)

The figure 7.2.1.1.1-2 illustrates a similar scenario to the one illustrated by figure 7.2.1.1.1-1 with one exception – the UE successfully re-establishes connection to the same eNB. eNB re-activates the Immediate MDT session and retrieves the RLF report. As it was previously mentioned, the UE may not be able to re-establish the connection immediately (it may take some time e.g. to get out of the coverage hole, etc...) and it is possible that eNB has already packed the MDT data for the interval immediately preceding the Radio Link Failure and already sent it to the TCE. However, eNB may "correlate" the retrieved RLF report with the new set of MDT data (both pieces of data came from the same UE), but the correlation will not add any clarity to the RLF investigation (correlation to the wrong MDT data).

7.2.1.1.2 Issues with correlation of Immediate MDT, RLF and RCEF Reports

RCEF (RRC Connection Establishment Failure) reports also called "accessibility measurements" (see section 5.1.6 of [2]) are created by the UE when RRC connection establishment procedure fails. The content of the RCEF reports, the procedures for report creation and retrieving by the eNB are described in [2] and [3]. RCEF reports contain information useful for NM CCO and have already been identified in section 4.2.6. The section 7.2.1 states that RLF/RCEF and MDT data may be correlated at the TCE.

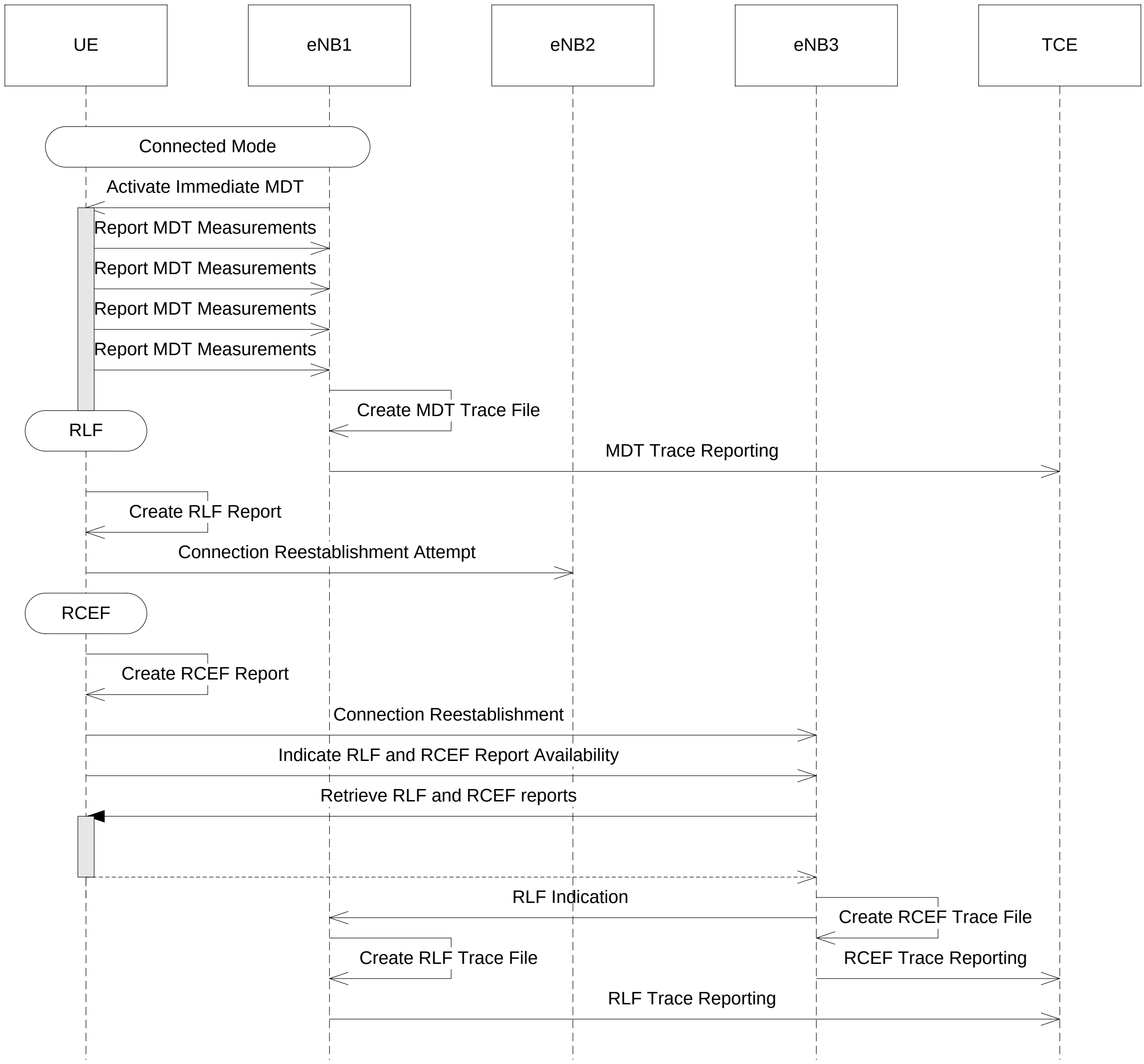

Figure 7.2.1.1.2-1: RLF followed by RCEF during an active Immediate MDT session

Figure 7.2.1.1.2-1 illustrates a scenario where UE experiences a RLF at eNB1 followed by RCEF to eNB2 and then successfully re-establishes connection to an eNB3. It has been agreed in SA5 during online discussion that in such scenarios it is impossible to correlate RLF/RCEF and MDT data at the eNB. It was also mentioned that if there was a mechanism for RCEF forwarding to the base station where the problem has occurred (similar to the RLF_Indication over X2), the correlation of RLF/RCEF and MDT data at the eNB would be possible.

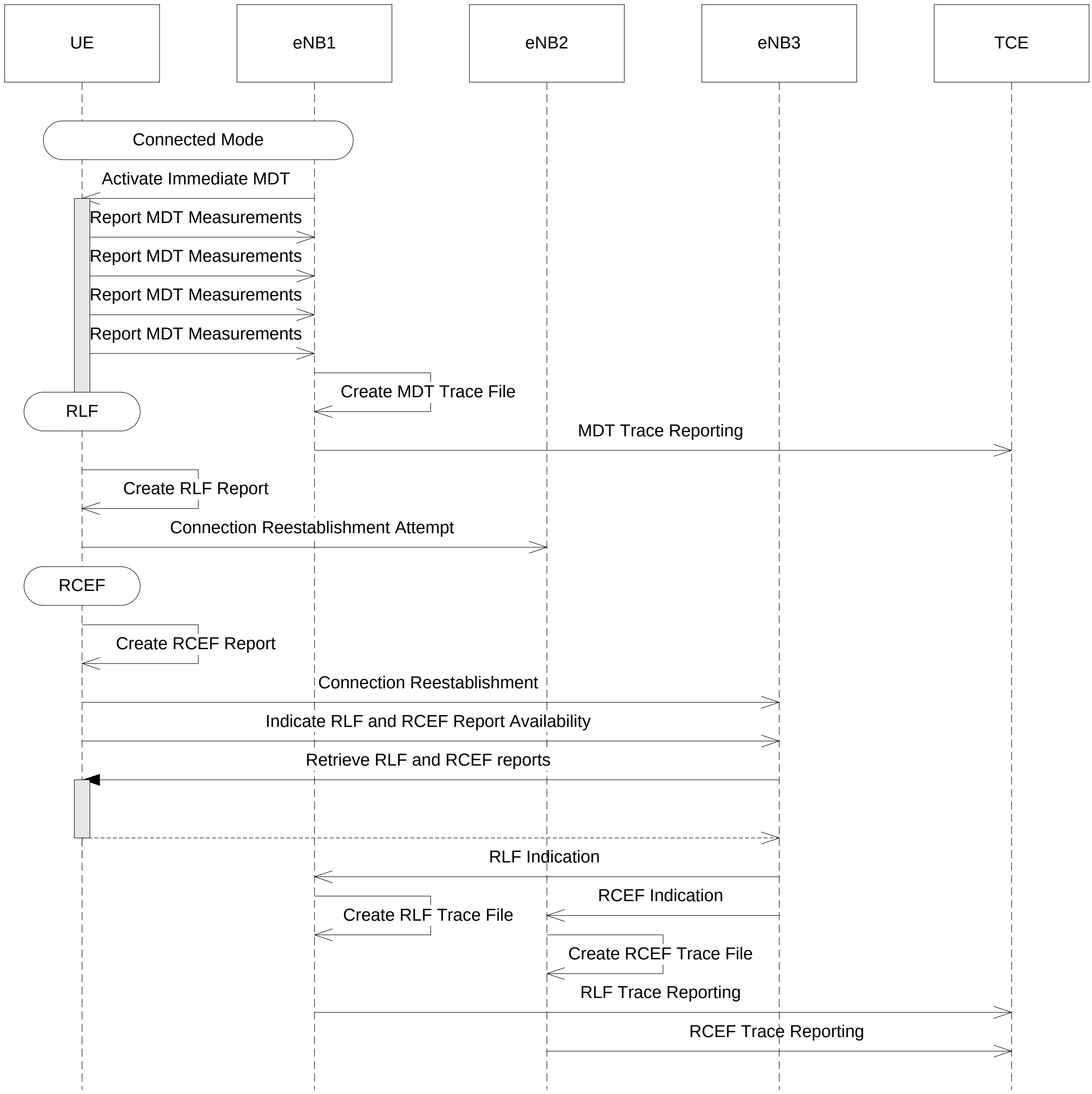

Figure 7.2.1.1.2-2: RLF followed by RCEF during an active Immediate MDT session (with RCEF_Indication)

Figure 7.2.1.1.2-2 illustrates a hypothetic scenario (currently impossible due to lack of standardized RCEF_Indication procedure or something similar like enhancing the RLF_Indication procedure with RCEF information) where RCEF report retrieved from the UE by the eNB3 is forwarded to the eNB2 where RRC Connection Establishment failed. As it is shown on figure 7.2.1.1.2-2, even with the new RCEF_Indication procedure in place, it is still impossible to correlate RLF/RCEF and MDT at the eNB.

7.2.1.2 Correlation at the TCE Scenarios

7.2.1.2.1 Introduction

Correlation of RLF/RCEF and MDT data at the TCE documented in section 7.2.1 is a possible solution – it is not affected by the specific problems outlined in the section 7.2.1.1 above. However, the strict user privacy and MDT anonymization requirements make it challenging. When it is not allowed to store/forward true UE identities (that are directly associated with a user, e.g. IMSI) with MDT/RLF/RCEF data to the TCE. In full anonymization mode such UE identities are stripped completely, in partial anonymization only the IMEI-TAC is sent to the TCE. Unfortunately, the

IMEI-TAC is not sufficient for per-UE/per-session correlation at the TCE. The TR/TRSR combination can not be used for RLF/RCEF and MDT correlation at the TCE.

3GPP SA3 approved the potential use of temporary identities or pseudonyms (not traceable back to the true UE/user identity).

7.2.1.2.2 Correlation of Immediate MDT and RLF Reports

Below, we try to analyze the possibility to use the C-RNTI as a specific identifier (temporary identity) for correlation of RLF reports and Immediate MDT data at the TCE:

- The combination of C-RNTI, the Cell ID and a corresponding timestamp (the timestamp is only needed to roughly identify the timeframe when a particular C-RNTI was in use, the accuracy should be within the UE context lifetime or C-RNTI re-cycle time) uniquely identifies UE for correlation of RLF reports and Immediate MDT data;
- The eNB knows the C-RNTI of the UE reporting the Immediate MDT;
- The eNB knows the last C-RNTI before the RLF of the UE reporting a RLF during re-establishment;
- The last C-RNTI before the RLF occurred ("C-RNTI used in the PCell upon detecting radio link failure or the C-RNTI used in the source PCell upon handover failure" as defined in [3]) is part of the RLF report – this provides the C-RNTI for all RLF reports, including those retrieved not during re-establishment;
- The RLF timestamp (as "*timeSinceFailure* field used to indicate the time that elapsed since the connection establishment failure" as defined in [3]) is part of the RLF report. The RLF_Indication procedure used for forwarding of the RLF reports to the eNB where failure occurred (and where it is packed into Trace File) takes time in order of milliseconds and is significantly shorter than C-RNTI re-cycle time.

```
RLF-Report-r9 ::=                     SEQUENCE {
 measResultLastServCell-r9                SEQUENCE {
     rsrpResult-r9                            RSRP-Range,
     rsrqResult-r9                            RSRQ-Range          OPTIONAL
 },
 measResultNeighCells-r9              SEQUENCE {
     measResultListEUTRA-r9               MeasResultList2EUTRA-r9         OPTIONAL,
     measResultListUTRA-r9                MeasResultList2UTRA-r9          OPTIONAL,
     measResultListGERAN-r9               MeasResultListGERAN             OPTIONAL,
     measResultsCDMA2000-r9               MeasResultList2CDMA2000-r9      OPTIONAL
 }   OPTIONAL,
 ...,
 [[  locationInfo-r10                 LocationInfo-r10        OPTIONAL,
     failedPCellId-r10                        CHOICE {
         cellGlobalId-r10                         CellGlobalIdEUTRA,
         pci-arfcn-r10                            SEQUENCE {
             physCellId-r10                           PhysCellId,
             carrierFreq-r10                          ARFCN-ValueEUTRA
         }
     }                                                               OPTIONAL,
     reestablishmentCellId-r10        CellGlobalIdEUTRA               OPTIONAL,
     timeConnFailure-r10              INTEGER (0..1023)               OPTIONAL,
     connectionFailureType-r10        ENUMERATED {rlf, hof}           OPTIONAL,
     previousPCellId-r10              CellGlobalIdEUTRA               OPTIONAL
 ]],
 [[  failedPCellId-v1090              SEQUENCE {
         carrierFreq-v1090                ARFCN-ValueEUTRA-v9e0
     }                                                               OPTIONAL
 ]],
 [[  basicFields-r11                  SEQUENCE {
         c-RNTI-r11                       C-RNTI,
         rlf-Cause-r11                    ENUMERATED {
                                              t310-Expiry, randomAccessProblem,
                                              rlc-MaxNumRetx, spare1},
         timeSinceFailure-r11             TimeSinceFailure-r11
     }                                                               OPTIONAL,
     previousUTRA-CellId-r11          SEQUENCE {
         carrierFreq-r11                  ARFCN-ValueUTRA,
         physCellId-r11                   CHOICE {
             fdd-r11                          PhysCellIdUTRA-FDD,
             tdd-r11                          PhysCellIdUTRA-TDD
         },
         cellGlobalId-r11                 CellGlobalIdUTRA            OPTIONAL
     }                                                               OPTIONAL,
     selectedUTRA-CellId-r11          SEQUENCE {
```

```
        carrierFreq-r11                  ARFCN-ValueUTRA,
        physCellId-r11                   CHOICE {
            fdd-r11                          PhysCellIdUTRA-FDD,
            tdd-r11                          PhysCellIdUTRA-TDD
        }
    }                                                                OPTIONAL
 ]]
}
```

Figure 7.2.1.2.2-1: RLF report content as defined in TS 36.331[3]

7.2.1.2.3 Correlation of Logged MDT and RCEF Reports

Both the RRC Connection Establishment Failure and Logged MDT happen when UE is in the Idle Mode. When UE experiences a RCEF and has the Logged MDT active, the data recorded in the Logged MDT session before and after the RCEF may provide a complete picture and help in the root cause analysis. Therefore, the correlation of RCEF reports and Logged MDT is important.

One possible way to link the RCEF report to the Logged MDT data and avoid correlation (either at the eNB or at the TCE) completely is to record the RCEF as an event in the Logged MDT if Logged MDT session was already active at the UE.

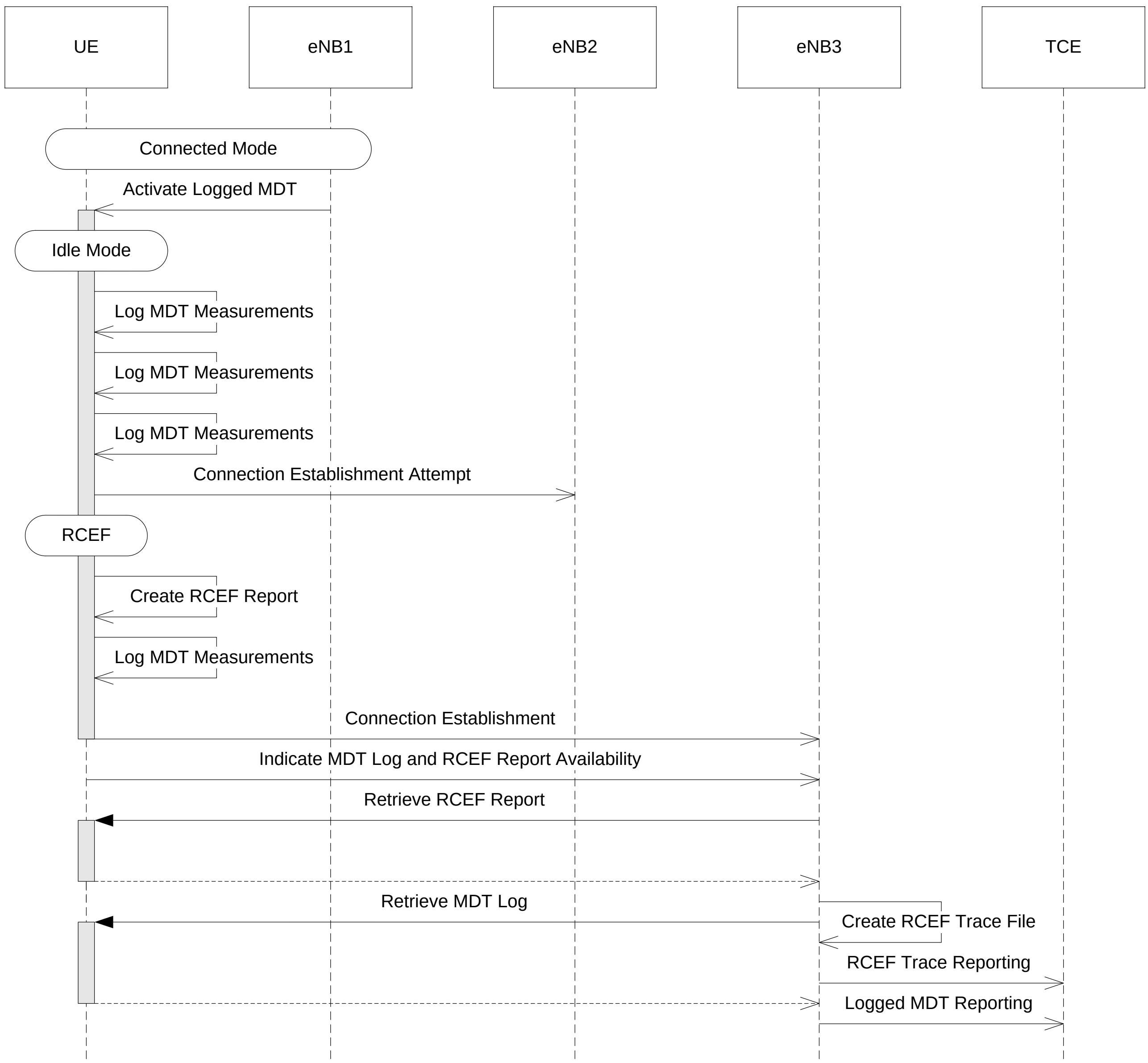

Figure 7.2.1.2.3-1: Logged MDT and RCEF reporting

Figure 7.2.1.2.3 illustrates the scenario where UE is configured for a Logged MDT session by eNB1, goes into Idle Mode and logs MDT measurements. The UE attempts to establish connection to eNB2 and experiences a RCEF. It logs the RCEF Report and continues to log the MDT measurements. The UE successfully establishes connection to eNB3 and indicates the RCEF Report and MDT Log availability. The eNB3 retrieves the RCEF report and, if the RCEF collection session was activated earlier at the eNB3, creates the RCEF Trace File and forwards it to the TCE. The eNB3 also retrieves the MDT Log from the UE and forwards it to the TCE. Since at the time of RCEF occurrence the UE was in the Idle Mode, there is no C-RNTI (at the time of failure) associated with it. The RCEF reporting and MDT Log reporting to the TCE happen independently (RCEF reporting requires an active reporting job at the eNB, MDT Log reporting does not). But it may be possible to logically link RCEF Report and MDT Log indicating that both were retrieved from the same UE without adding the UE identity and violating the MDT anonymization requirements by use of a temporary identifier (e.g. by adding the C-RNTI of the UE at the retrieval time to the MDT log and RCEF report being sent to the TCE).

8 Measurement collection mechanism

9 Configuration attributes

10 Recommendations

Annex A: Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2012-08					First version with document structure created with scope and introduction.		0.1.0
2012-09					Post-SA5#84 Berlin changes. Based on TR skeleton draft S5-122169 plus pCRs S5-122140, S5-122170, S5-122174, S5-122175, S5-122176, and S5-122190.	0.1.0	0.2.0
2012-10					Post-SA5#85 Kyoto changes. pCRs S5-122557, S5-122601, S5-122565 and S5-122566.	0.2.0	0.3.0
2013-01					Post-SA5#87 Malta changes. pCR S5-130249.	0.3.0	0.4.0
2013-05					Post-SA5#88 Qingdao changes: pCRs S5-130796, S5-130797, S5-130769, S5-130771	0.4.0	0.5.0
2013-06					Post-SA5#89 Sophia Antipolis changes: pCRs: S5-131076, S5-131078, S5-131087	0.5.0	0.6.0
2013-09					Editorial updates prior to sending to SA for information	0.6.0	0.7.0
2013-09	SA#61	SP-130451			Presented for information	0.7.0	1.0.0