TSG-RAN Working Group 2 (Radio layer 2 and Radio layer 3)
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Title: **UE Measurement Concept for Intra-Frequency Measurements**

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1 Introduction

There are a number of measurements the UE has to perform and report as input to different functions in the UTRAN. Naturally, the control of these measurements has to be standardised within the TSG RAN group.

In S2.31 [1], a general Measurement Control Procedure has been defined. The UE measurements are not tightly coupled to any radio network function, but instead classified into different types that are characterised of what the UE shall measure.

By defining the UE measurement control in this general way, the standard will not specify any function or implementation specific UE measurements (that might be hard to change later), but rather only give the necessary measurement tools for the functions in UTRAN. Furthermore, the network manufacturers and operators will be allowed to use the UEs as flexible, general measurement tools for radio network optimisation and performance supervision. For instance, it should be possible to order a UE to perform and report an intra-frequency measurement, independently of the handover function in UTRAN.

In section 2.1, we exemplify this general UE measurement control approach by proposing a concept for control of intra-frequency measurements that could be used for e.g. handover evaluation in UTRAN. In chapter 3, we also propose a change request to the section 8.3.7 in S2.31 [1], as a consequence of the presented concept.

2 UE Measurement Concept

An important example of UE measurements is intra-frequency measurements that could be used for handover evaluation. To facilitate UTRAN controlled handover, the UE needs to perform and report intra-frequency measurements of the radio environment to UTRAN. It is the UTRAN that makes the final decision regarding radio link addition and removal since UTRAN has the radio resource management responsibility.

Traditionally, there have basically been two approaches to handover measurements:

- Periodical measurement reports from the UE and handover evaluation in the network.
- Handover evaluation in the UE, using the concept of active, candidate and neighbour sets.

Using only periodical measurement reports, there is a trade-off between the reporting intensity and the ability of the network to react fast on changes in the radio environment. Hence, there is a risk of either getting too much signalling in the system, or adapting too slowly to new conditions.

By employing handover evaluation in the UE, large parts of the evaluation function will have to be standardised in the UE, and will consequently be hard to change later on. It is truly difficult to design and standardise a detailed, optimum, soft handover evaluation function in the first release of UTRAN. Even if we would succeed in doing that, we cannot guarantee that it would be good enough for future traffic and radio scenarios.

Furthermore, by using handover evaluation in the UE, the UE measurements would be tightly coupled to the handover evaluation function, which would be a step from the concept of a general measurement control. UTRAN should be able to receive radio environment measurement reports from the UE, even though it is not needed for the handover evaluation.

A third approach to control of UE measurements that counteracts the above stated problems is presented below in section 2.1.

2.1 Event-triggered measurement reporting

The aim of the UE measurement reporting, intended for handover evaluation in UTRAN, is that the UTRAN should receive real-time knowledge of the conditions measured by the UE when it is needed, without too much signalling. This can be achieved by defining a set of important “events” that triggers measurement reports to be sent from the UE. The reports contain the necessary information for the UTRAN to perform the handover evaluation. The standardised reporting events must be so comprehensive that all the needs of the UTRAN functions are covered. By using such event-triggered reporting, the network can react fast on significant changes in the radio environment, without having excessive UE measurement reporting.

In the event-triggered measurement reports, mandatory information connected to the actual event will be reported. Additionally, other set of information that the UTRAN requires should be able to optionally append to the report. The UTRAN notifies the UE in the Measurement Control message which events that should trigger a report and what the corresponding reports should contain.

For this measurement control approach, the standard would basically only have to specify:

1. The necessary UE measurements and their performances, which are not specified in WG 2.
2. The list of events that can trigger a report, and what the corresponding report must include.
3. The list of quantities the UE should be able to optionally report.

By employing this concept of event-triggered reports, UTRAN will be able to control the UE measurements and reports in a flexible manner. Since the events should be defined in a general sense and not tightly coupled to a specific handover evaluation algorithm, it is expected that each network manufacturer will be able to develop an optimal evaluation of the UE mobility in connected mode. With this general approach, it will be possible to change the handover evaluation algorithm in the UTRAN, and still have the necessary UE measurement support.

Additionally, the handover evaluation could easily be made user and area specific by defining different events and reports for different users and areas. The UE ability to measure and report in a flexible way, not tightly coupled to a specific UTRAN function, will also make it possible to use the actual UEs for radio network optimisation and fault finding, and hence, reducing the need for doing e.g. drive testing.

In addition to the event-triggered reports, the UTRAN can order the UE to send periodical or immediate reports, as already indicated in section 8.3.7.1 in S2.31 [1]. In fact, if this concept is standardised in a sufficiently general and comprehensive way, both the traditional approaches given in section 2 above could be implemented by the UTRAN manufacturers/operators.

Below in sections 2.1.1-2.1.3, we propose a number of UE measurements, reporting events, and quantities to report, which would be useful to support the intra-frequency handover evaluation function in UTRAN.

2.1.1 Intra-frequency measurement quantities

The reporting events are detected with respect to a quantifiable quality parameter that is given in the Measurement quantity field of the Measurement Control message. Examples of measurement quantities that may be used for intra-frequency handover evaluation are:

1. Downlink received signal power after despreading.
2. Downlink signal-to-interference ratio.
3. Downlink path loss.
4. Downlink path loss plus UL interference.

All these quality quantities could be filtered in the UE before reporting. If there are several types of filters with different parameters, the filter type and parameters to use are also given in the Measurement quantity field of the Measurement Control message. The measurement quantity is measured for the Primary Common Control Physical Channels (Primary CCPCH) that should be monitored by the UE. The scrambling codes of these Primary CCPCHs are given in the Measurement object field of the Measurement Control message.

The specification of these intra-frequency measurements, i.e. filter types, measurement accuracy and resolution, dynamic range, etc, is not performed by WG 2.

2.1.2 Intra-frequency reporting events

In the Measurement reporting criteria field in the Measurement Control messages, the UTRAN notifies the UE which events that should trigger a measurement report. Examples of intra-frequency reporting events that may be useful for handover evaluation are given below. All the illustrated events are measured with respect to any of the measurement quantities given in section 2.1.1. The measurement objects are the monitored Primary Common Control Physical channels (P CCPCH). The reporting events are marked with vertical arrows in the figures below.

2.1.2.1 Reporting event 1: A Primary CCPCH enters or leaves the reporting range

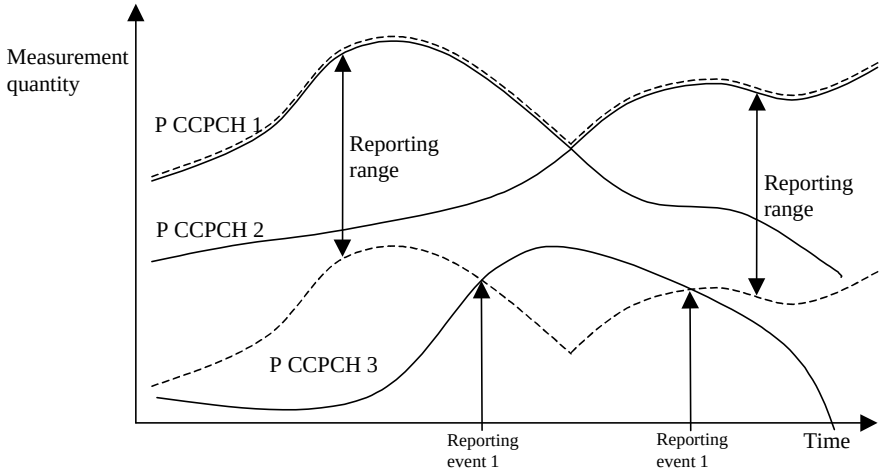

Figure 1: Event-triggered report when a Primary CCPCH enters or leaves the reporting range.

The reporting range is defined relative to the best Primary CCPCH and is given in the Reporting criteria field in the Measurement Control message. If any of the monitored Primary CCPCHs enters or leaves the reporting range, it is an event that could trigger a report. The corresponding report identifies the Primary CCPCH that entered or left the range.

2.1.2.2 Reporting event 2: A Primary CCPCH becomes better than another Primary CCPCH and both are within the reporting range

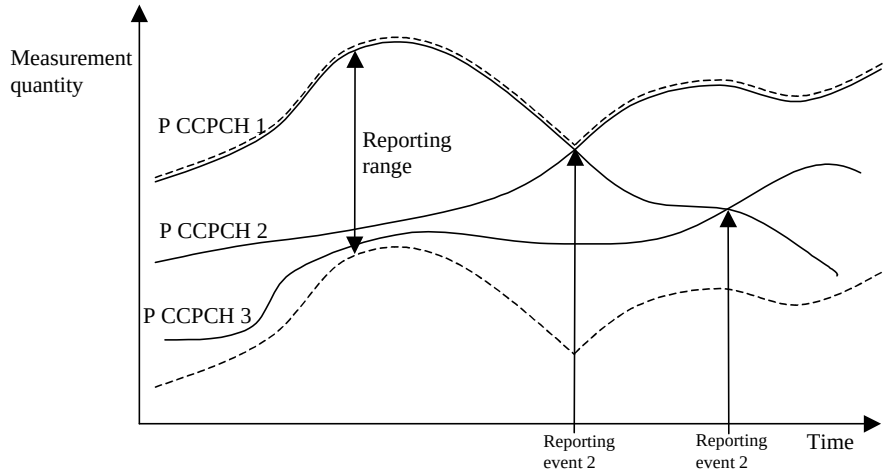

Figure 2: Two Primary CCPCHs crosses each other and both are within the reporting range.

If any of the Primary CCPCHs within the reporting range becomes better than another Primary CCPCH, it is an event that could trigger a report. The corresponding report identifies the two involved Primary CCPCHs.

2.1.2.3 Hysteresis and time-to-trigger

To limit the amount of event-triggered reports, a hysteresis parameter may be connected with each event. In the example in figure 3, the effect of the hysteresis is that the fact that Primary CCPCH 2 becomes better than Primary CCPCH 1 is not reported until the difference is equal to the hysteresis. The fact that Primary CCPCH 2 becomes worse than Primary CCPCH 1 again, is not reported at all in the example since the Primary CCPCH 2 does not become sufficiently much worse than the Primary CCPCH 1.

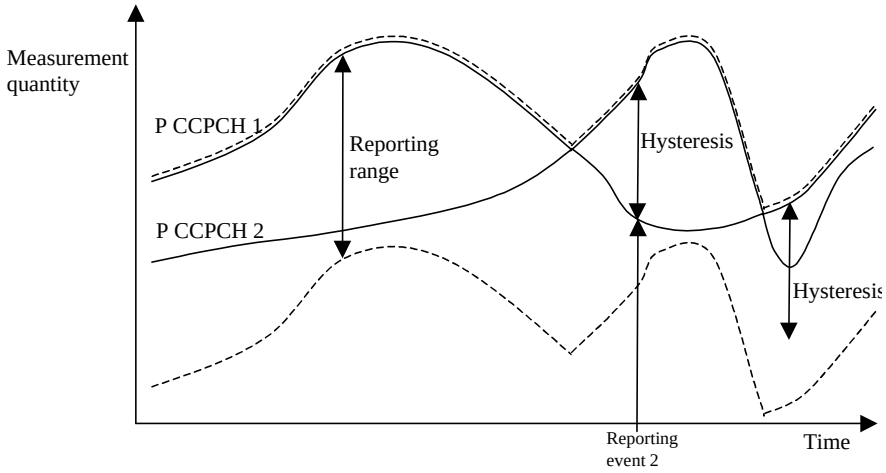

Figure 3: Hysteresis limits the amount of measurement reports.

Furthermore, to limit the signalling load, a time-to-trigger parameter could be connected with each event, i.e. the report is triggered after that the conditions for the event have existed for the specified time-to-trigger. In the example in figure 4, the effect of the time-to-trigger is that the event that Primary CCPCH 3 enters the reporting range is not reported until is has been within the range for the time given by the time-to-trigger parameter.

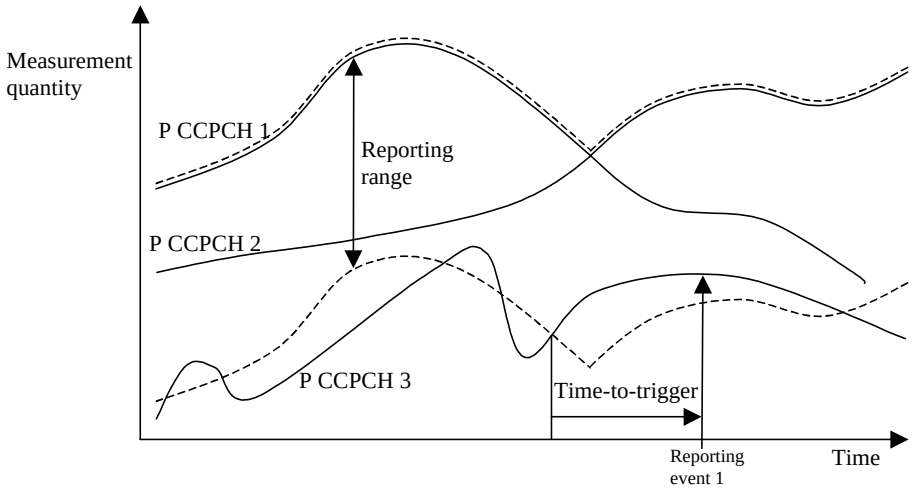

Figure 4: Time-to-trigger limits the amount of measurement reports.

The hysteresis and time-to-trigger can be set individually per reporting event, and the values of them are given to the UE in the Reporting criteria field of the Measurement Control message.

The hysteresis and time-to-trigger mechanisms provide UTRAN with efficient tools to balance the trade-off between the amount of measurement signalling, and how exact awareness of the radio environment the network will obtain.

2.1.3 Report quantities

In the event-triggered measurement reports, mandatory information connected to the events is automatically reported. For instance, at the event "a Primary CCPCH enters the reporting range" the corresponding report identifies the Primary CCPCH that entered the range.

However, besides this mandatory information, UTRAN should be able to optionally require additional different set of information to be included in the report. That will allow the UTRAN to use the UE as a general tool for radio network optimisation, if necessary.

Examples of report quantities that may be appended to the measurement reports are:
[Note: This list is general and does also apply for reports of other measurement types than the intra-frequency type. The list is not final.]

- Downlink transport channel block error rate
- Downlink transport channel bit error rate
- "Time difference between the received Primary CCPCH frame-timing from the target cell and the earliest received existing DPCH path". *[Note: This measurement is already identified in S1.11 [2] (***$\mathbf{T_m}$** *in chapter 7)]*
- UE transmit power
- UE position (FFS)

[Note: This additional, optional quantities that could be included in the measurement report have to be notified to the UE by UTRAN. Hence, we propose to add a new parameter field in the Measurement Control message called Report quantities, see the example in section 2.1.4 and the section 8.3.7.2 in the change request below.]

2.1.4 Example of Measurement Control message information

Below we give an example of a Measurement Control message meant for handover evaluation based on event-triggered report. The example corresponds to the Reporting event 2 that a Primary CCPCH becomes better than another and both are within the reporting range, which was presented above.

Measurement type:	intra-frequency measurement
Measurement identity number:	#X
Measurement command:	setup
Measurement objects:	Primary CCPCH 1: Scrambling code, Primary CCPCH power. Primary CCPCH 2: Scrambling code, Primary CCPCH power. ... Primary CCPCH *N:* Scrambling Code, Primary CCPCH power.
Measurement quantity:	Downlink path loss, filter parameters
Report quantities:	UE transmit power
Measurement reporting criteria:	At the reporting event 2 (A Primary CCPCH becomes better than another and both are within the reporting range). Hysteresis, Reporting range, Acknowledged data transfer report

[Note: The optional parameter Report quantities is new and is proposed to be included in the Measurement Control message.]

3 Change request to section 8.3.7 in S2.31

Below is the proposed change request to section 8.3.7 in S2.31 [1].

8.3.7 Procedures related to measurement and monitoring

~~*[Note: The following text needs to be reviewed at the next 3GPP WG2 meeting]*~~

~~In idle mode, the UE monitors and measures neighboring cells according to information received on BCH.~~

~~After sending the initial random access message, the UE may continue measurements using the 'idle' mode parameters until a MEASUREMENT CONTROL message is received from the serving RNS. This message indicates the parameters to be used for monitoring in ´connected` state.~~

~~Monitored cells are grouped in the UE into three different categories:~~

~~1. Cells that belong to the active **set.** User information is sent from all these cells and they are simultaneously demodulated and coherently combined. These cells are involved in soft handover.~~

~~2. Cells that are identified as feasible for handover belong to the **candidate set.** The UE may request that a cell in the candidate set is moved to the active set in a MEASUREMENT REPORT message.~~

~~3. Other cells that are known, but not currently feasible for handover, belong to the **neighbour set.** The UE does not notify the serving RNS when it moves a cell from the candidate set to the neighbour set or from the neighbour set to the candidate set.~~

From an RRC point of view, the ~~mobile station~~ UE measurements can be grouped with respect to the type of measurement performed in the ~~mobile station~~ UE, i.e., what ~~and how~~ the ~~mobile station~~ UE shall measure. Examples are:

- ~~Radio link measurements: measurements on downlink radio links in the active set.~~
- Intra-frequency measurements: measurements on downlink physical channels with the same frequency as the active set.~~that do not belong to the active set, but have the same frequency as the active set.~~
- Inter-frequency measurements: measurements on downlink physical channels with frequencies that differ from the frequency of the active set.
- Inter-system measurements: measurements on downlink physical channels belonging to another radio access system than ~~WCDMA~~ UTRAN, e.g. PDC or GSM.
- Traffic volume measurements: measurements on uplink traffic volume.
- Quality measurements: Measurements of quality parameters, e.g. downlink transport block error rate.

The same type of measurements can be used as input to different functions in UTRAN. For instance, ~~A~~ a ~~radio link~~ intra-frequency measurement in the ~~mobile station~~ UE can be used for handover, power control or operation and maintenance purposes in the network. However, it should be possible to have a number of ~~mobile station~~ UE measurements running in parallel, where each measurement is controlled and reported independently of each other.

Each type of ~~mobile station~~ UE measurement is associated with a standardised measurement method that can be described with a limited number of parameters (threshold levels, triggering conditions etc) in the measurement control message from the network. This is described in section 8.3.7.1 for each measurement type.

~~The measurement control message to the mobile station can be sent using either acknowledged or unacknowledged data transfer (L2 LAC-C) on the DCCH. The acknowledged mode would be employed for critical control messages, e.g. inter-frequency measurements intended for handover. The unacknowledged mode may be used for less critical measurements, e.g. mobile station measurements intended for operation and maintenance purposes.~~

The measurement report to the network can ~~likewise~~ be sent by either acknowledged or unacknowledged data transfer on the DCCH. The acknowledged mode may be employed for e.g. event-triggered measurement reports, while the unacknowledged mode may be used for e.g. periodical reporting with small periodicity. The network ~~can~~ indicates (~~report~~ in the ~~mobile station~~ UE measurement control message) which reporting alternative the ~~mobile station~~ UE should use for the corresponding measurement.

~~Elementary RRC procedures that are required for UE measurements, and UE measurement reporting to the UTRAN, are identified and described below. The procedures are used in connected mode.~~

After sending the initial random access message, the UE may continue measurements performed in idle mode until a MEASUREMENT CONTROL message is received from UTRAN. This message indicates e.g. the parameters to be used for monitoring in connected mode.

8.3.7.1 Measurement and reporting mechanisms

[Note: This section is proposed to describe the general measurement mechanisms that could be used for many measurement types, e.g. reporting range, hysteresis, time-to-trigger, and the list of optional report quantities that may be included in the measurement reports.

Information that is specific for each measurement type, like measurement objects, measurement quantities, reporting events and the mandatory information to be reported for each event, is given for each measurement type in the subchapters below.]

8.3.7.1.1 Intra-frequency measurements

Intra-frequency measurements are measurements on downlink physical channels with the same frequency as the active set.

Below are some Measurement objects, Measurement quantities and Reporting events given, which could be used for intra-frequency measurements.

[Note: The lists are not final, but only give some examples and show the proposed structure.]

Measurement objects

- Primary Common Control Physical Channel (Primary CCPCH)

Measurement quantities

- Downlink received signal power after despreading.
- Downlink signal-to-interference ratio
- Downlink path loss.
- Downlink path loss plus UL interference.

Reporting events

- A Primary CCPCH enters or leaves the reporting range: The corresponding report includes:
  1. The Primary CCPCH that entered or left the range.
- A Primary CCPCH becomes better than another Primary CCPCH and both are within the reporting range: The corresponding report includes:
  1. The two involved Primary CCPCH s

8.3.7.1.2 Inter-frequency measurements

8.3.7.1.3 Inter-system measurements

8.3.7.1.4 Traffic volume measurements

8.3.7.1.5 Quality measurements

8.3.7.~~1~~2 Measurement control

Figure 1) Measurement Control procedure

This procedure is initiated from the UTRAN side to control a measurement in a specific UE. The UTRAN sends a MEASUREMENT CONTROL message to the UE on the DCCH. The message includes the information that controls the UE measurement. Examples of such information are:

1. **Measurement type**: One of the types from a predefined list where each type describes what the UE shall measure.
2. **Measurement identity number**: A reference number that is used by the UTRAN at modification of the measurement and by the UE in the measurement report.
3. **Measurement command**: One out of three different measurement commands
   - Setup: Setup a new measurement.
   - Modify: Modify a previously specified measurement, e.g. change the reporting criteria.
   - Release: Stop a measurement and clear all information in the UE that are related to that measurement.
4. **Measurement objects:** The objects the UE shall measure on, and corresponding object information.
5. **Measurement quantity:** The quantity the UE shall measure. This also includes the filtering of the measurements.
6. **Report quantities:** The additional optional quantities the UE shall include in the report.
7. **Measurement reporting criteria**: The triggering of the measurement report, e.g. periodical, event-triggered or immediate reporting. Here is also specified if the measurement report should be transmitted using either acknowledged or unacknowledged data transfer on the DCCH.

[Editor's note: Details of how this procedure can make use of slotted mode operation is still under investigation]

8.3.7.~~2~~3 Measurement reporting

Figure 2) Measurement Report procedure

The Measurement Report procedure is initiated from the UE side when the reporting criteria are met. The message is sent using either acknowledged or unacknowledged data transfer on the DCCH. The UE sends a MEASUREMENT REPORT message to the UTRAN that includes the measurement identity number and the measured values of the mandatory and optional report quantities that were defined in the corresponding MEASURMENT CONTROL message. ~~requested measurement objects~~

[Note: UE measurement reports can be sent without prior Measurement Control message, e.g. reports of measurements that are predefined in the standard or defined via system information.]

4 Conclusions and Proposal

In this contribution, we have outlined a general and flexible concept for control and reporting of UE intra-frequency measurements. The concept is based on adaptable event-triggered reports. Both the events and the corresponding measurement reports can be controlled in a flexible way by the UTRAN. Therefore, UTRAN will still be able to receive the necessary UE measurement support, even if the radio network functions needs to be changed or adapted to new scenarios in the future.

Another advantage with the presented framework is that it provides UTRAN with tools to balance the important trade-off between the amount of measurement signalling, and how good awareness of the radio environment the network will achieve. Furthermore, the concept allows the network manufacturer and operators to use the UEs as measurement tools for radio network optimisation and performance supervision.

The concept presented in this contribution would preferably also be used for other measurement types than intra-frequency measurements.

We propose to change the section 8.3.7 in S2.31 [1] according to the text in chapter 3 above.

5 References

[1] TS RAN S2.31 V0.0.1, “RRC protocol specification”
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[2]

[3] TS RAN S1.11 V0.1.0, “UTRA FDD; Transport channels and physical channels”
Source: TSG RAN WG 1