

Agenda Item: 9.2.2

Source: Ericsson

Title: **UE Measurement Concept for Intra-Frequency Measurements**

Document for: Decision

1 Introduction

[Note: This is an updated version of the previously submitted contribution TSGR2#3(99)250 with the same title. The new information is mainly in sections 3.1, 3.2.3-3.2.6 and 3.3.3-3.3.4. Please note the new numbering of the events in section 3.2]

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 25.331 [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 measurement 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 chapter 3, we extend this general UE measurement control approach by proposing a concept for intra-frequency measurement control that could be used for e.g. handover evaluation in UTRAN. Sections 3.1-3.4 are proposed to be included in chapter 15 "Specific functions" of 25.331 [1]. In chapter 4, we also propose a change request to section 8.3.7 "Procedures related to measurement and monitoring" of 25.331 [1].

2 UE Measurement Concepts

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 chapter 3.

3 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 therefore 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 optionally requires should be able to 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 have to specify:

1. The necessary UE measurements, i.e. measurement quantities for each measurement type.
2. The list of events that can trigger a report, and what the corresponding report must include.
3. The list of report 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 UEs’ 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 reports, as already indicated in section 8.3.7.1 in 25.331 [1]. In fact, if this concept is standardised in a sufficiently general and comprehensive way, both the traditional approaches given in chapter 2 above could be implemented by the UTRAN manufacturers/operators.

Below in sections 3.1-3.3, we propose a number of UE measurements, reporting events, and quantities to report, to support the intra-frequency handover evaluation function in UTRAN.

3.1 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. Measurement quantities that are very useful for intra-frequency handover evaluations are:

1. Downlink path loss.
2. Downlink received signal code power (RSCP) after despreading.
3. Downlink signal-to-interference ratio (SIR) after despreading on a specific DL physical channel (RSCP/ISCP).
4. Downlink E_c/I_0 (chip energy per total received channel power density)

The main difference between SIR and E_c/I_0 is that the interference in SIR is measured on a specific physical channel after despreading (ISCP = Interference Signal Code Power), and therefore reflects the actual interference on that channel. On the other hand, I_0 in E_c/I_0 is simply the total received power density in the frequency band and is not measured on a specific channel. Hence, SIR reflects the orthogonality between downlink channels, which is a valuable feature in many radio scenarios. Therefore, SIR is a more precise indicator of the channel quality on a radio link. E_c/I_0 is on the other hand very easy to measure in the UE and may be a good enough quality indicator in many scenarios. Therefore, both measurement quantities could be justified as a basis for intra-frequency handover evaluations.

The downlink SIR (or E_c/I_0) could be used for optimising the handover evaluation with respect to the downlink performance. To optimise the evaluation with respect to the uplink performance instead, the downlink pathloss or downlink received signal code power (RSCP) after despreading may be employed. This is particular the case if cell individual offsets that reflect the uplink interference in each cell are used, as described in section 3.3.3.

If it is mandatory for all UEs to be able to measure downlink SIR (and/or E_c/I_0), it does not constitute any significant extra UE complexity to be able to measure path loss or received signal code power (RSCP).

All these measurement quantities are preferably 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 on the Primary Common Control Physical Channels (Primary CCPCH) that should be monitored by the UE. The scrambling codes of these Primary CCPCHs (and the Primary CCPCH TX power if path loss should be measured) are given in the Measurement object field of the Measurement Control message.

3.2 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 would be useful for intra-frequency handover evaluation are given below. Note that normally the UEs do not need to report all these events. The listed events are the toolbox from where the UTRAN can choose the reporting events that are needed for the implemented handover evaluation function, or other radio network functions.

All the illustrated events are measured with respect to any of the measurement quantities given in section 3.1. 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.

[Note: The events below are numbered 1A, 1B, 1C,... since all intra-frequency reporting events would be labelled 1X, inter-frequency reporting events would be labelled 2X, and so on for the other measurement types.]

3.2.1 Reporting event 1A: A Primary CCPCH enters the reporting range

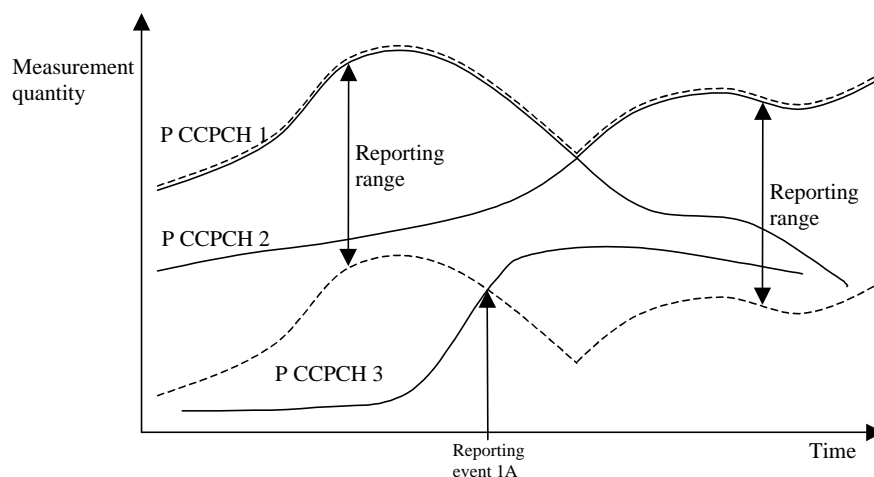


Figure 1: Event-triggered report when a Primary CCPCH enters the reporting range.

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

The corresponding report contains (at least) the Primary CCPCH that entered the range.

3.2.2 Reporting event 1B: A Primary CCPCH leaves the reporting range

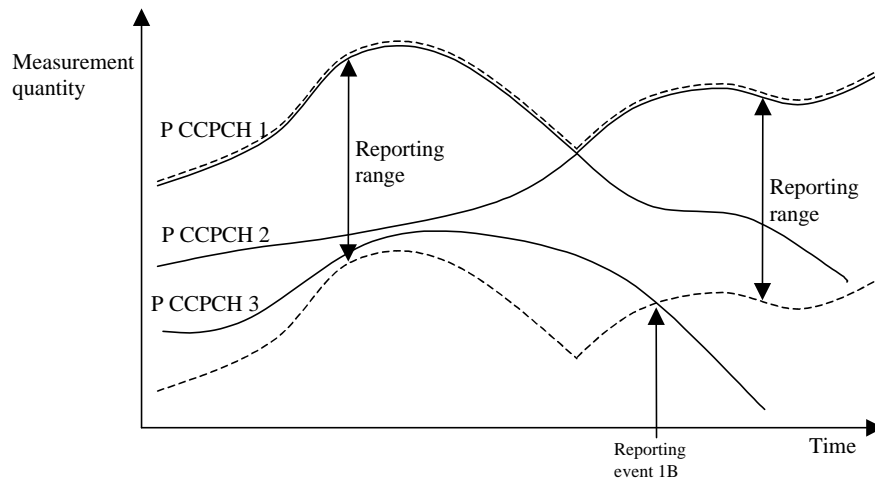


Figure 2: Event-triggered report when a Primary CCPCH leaves the reporting range.

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

The corresponding report contains (at least) the Primary CCPCH that left the range.

[Note: The reason to have separate reporting events for a Primary CCPCH entering (1A) and leaving (1B) the reporting range is that different hysteresis and time-to-triggers (see section 3.3) should be possible to connect to the two events.]

3.2.3 Reporting event 1C: A non-active Primary CCPCH becomes better than an active Primary CCPCH

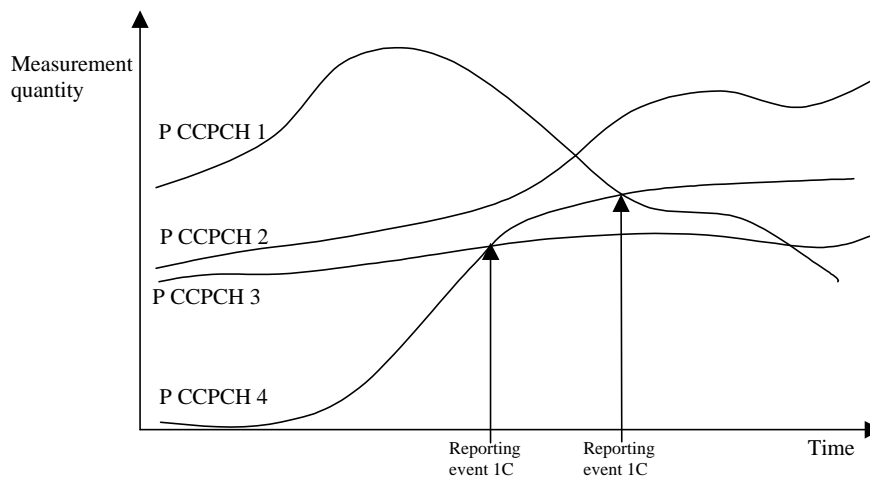


Figure 4: A Primary CCPCH that is not included in the active set becomes better than a Primary CCPCH that is in the active set. In this example the cells belonging to P CCPCH 1, 2 and 3 are supposed to be in the active set, but the cell transmitting P CCPCH 4 is not (yet) in the active set.

If a Primary CCPCH that is not included in the active set becomes better than a Primary CCPCH that is in the active set, it is an event that could trigger a report. The corresponding report contains (at least) the two involved Primary CCPCHs.

This event is mainly intended for replacing cells in the active set. It is activated if the number of active cell is equal or greater than a “Replacement activation threshold” parameter that UTRAN signals to the UE in the Measurement Control message.

3.2.4 Reporting event 1D: Change of best cell

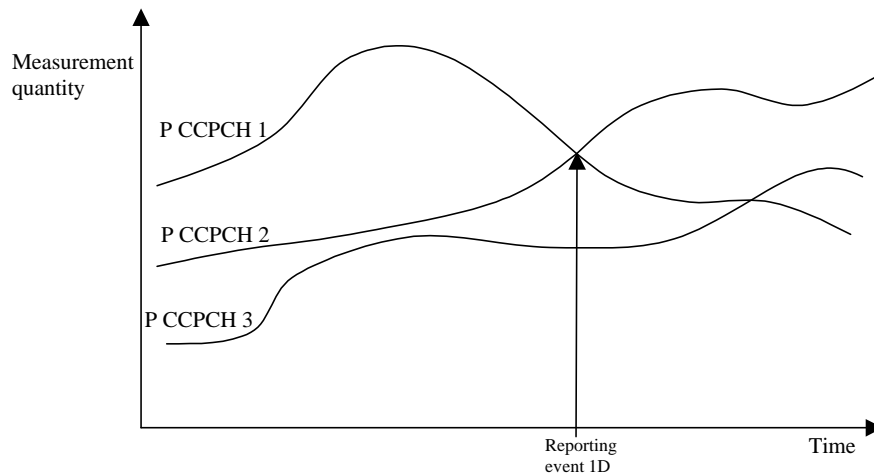


Figure 3: A Primary CCPCH becomes better than the previously best Primary CCPCH.

If any of the Primary CCPCHs within the reporting range becomes better than the previously best Primary CCPCH, it is an event that could trigger a report. The corresponding report contains (at least) the new best Primary CCPCH.

3.2.5 Reporting event 1E: A Primary CCPCH becomes better than an absolute threshold

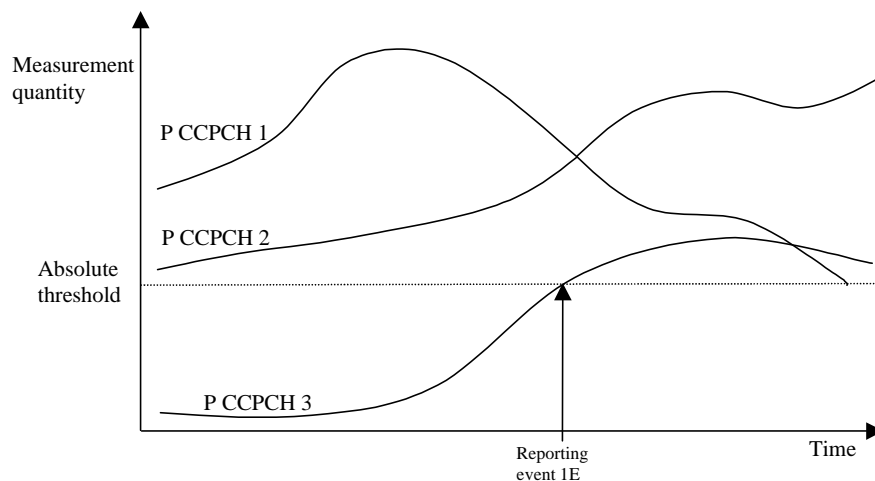


Figure 5: Event-triggered report when a Primary CCPCH becomes better than an absolute threshold.

This event is defined as that the Measurement quantity of a P CCPCH becomes better than an absolute threshold. The corresponding report contains (at least) the involved Primary CCPCH.

3.2.6 Reporting event 1F: A Primary CCPCH becomes worse than an absolute threshold

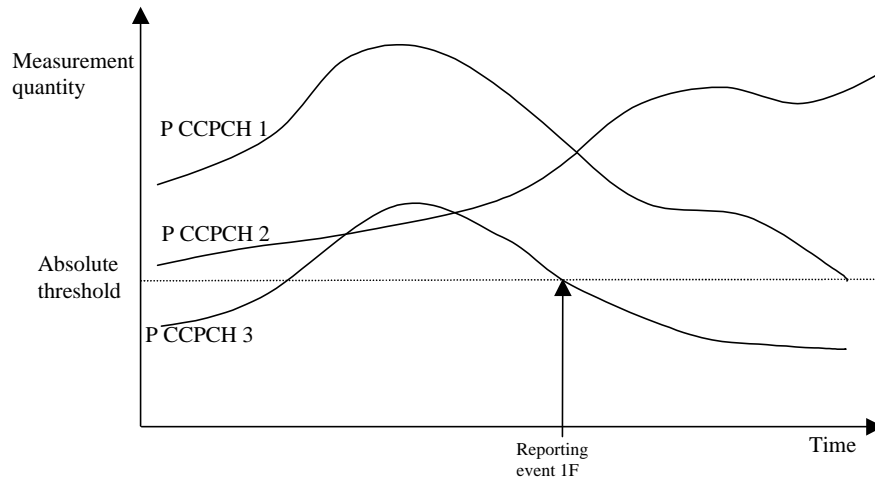


Figure 6: Event-triggered report when a Primary CCPCH becomes worse than an absolute threshold.

This event is defined as that the Measurement quantity of a P CCPCH becomes worse than an absolute threshold. The corresponding report contains (at least) the involved Primary CCPCH.

3.3 Intra-frequency reporting mechanisms

3.3.1 Hysteresis

To limit the amount of event-triggered reports, a hysteresis parameter may be connected with each reporting event given above. The value of the hysteresis is given to the UE in the Reporting criteria field of the Measurement Control message.

In the example in figure 7, the hysteresis results in that the event 1D that Primary CCPCH 2 becomes the best cell is not reported until the difference is equal to the hysteresis. The fact that Primary CCPCH 1 becomes best afterwards is not reported at all in the example since the Primary CCPCH 1 does not become sufficiently much better than the Primary CCPCH 2.

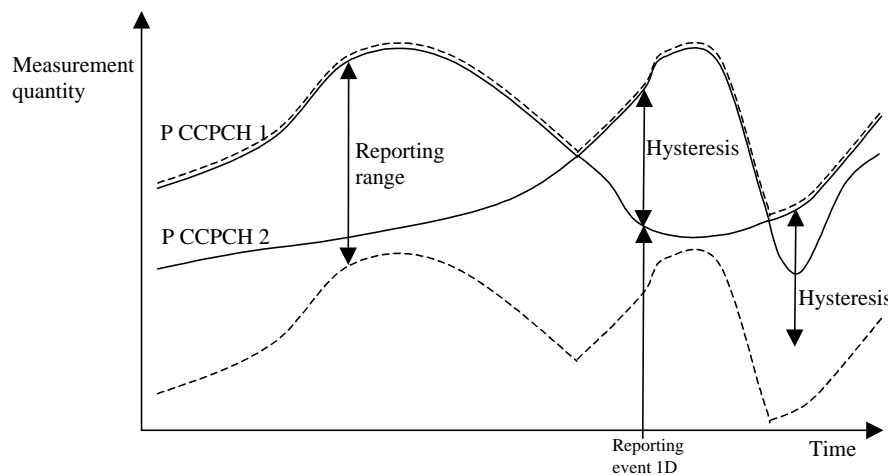


Figure 7: Hysteresis limits the amount of measurement reports.

3.3.2 Time-to-trigger

To limit the measurement signalling load, a time-to-trigger parameter could be connected with each reporting event given above. The value of the time-to-trigger is given to the UE in the Reporting criteria field of the Measurement Control message.

The effect of the time-to-trigger is that the report is triggered after that the conditions for the event have existed for the specified time-to-trigger. In the example in figure 8, the time-to-trigger causes that the event that Primary CCPCH 3 enters the reporting range is not reported until it has been within the range for the time given by the time-to-trigger parameter.

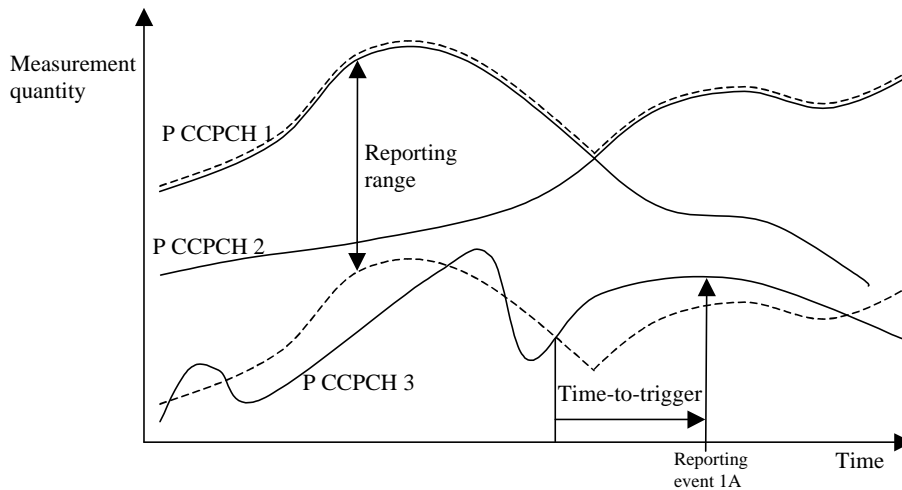


Figure 8: Time-to-trigger limits the amount of measurement reports.

Note that the time-to-trigger could be combined with hysteresis, i.e. a hysteresis value is added to the measurement quantity before evaluating if the time-to-trigger timer should be started.

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.

3.3.3 Cell individual offsets

To each cell that is monitored, an offset can be connected. The offset can be either positive or negative. The offset is added to the measurement quantity before the UE evaluates if an event has occurred. The UE receives the cell individual offsets for each Primary CCPC in the Measurement object field of the Measurement Control message.

For example, in figure 9, since an offset is added to Primary CCPCH 3, it is the dotted curve that is used to evaluate if an event occurs. Hence, it results in that measurement reports from UE to UTRAN are triggered when Primary CCPCH plus the corresponding offset, i.e. the dotted curve, leaves and enters the reporting range and when it gets better than Primary CCPCH 1 (if these events have been ordered by UTRAN). This offset mechanism provides the network with an efficient tool to change the reporting of an individual Primary CCPCH.

By applying a positive offset, as in figure 9, the UE will send measurement reports as if the Primary CCPCH is offset dB better than what it really is. This could be useful if the operator knows that a specific cell is interesting to monitor more carefully, even though it is not so good for the moment. In the example in figure 9, the operator might know by experience that in this area Primary CCPCH 3 can become good very fast (e.g. due to street corners) and therefore is good to report more intensively. Depending on the implemented handover evaluation algorithm, this may result in that the cell with Primary CCPCH 3 is included in the active set earlier than would have been the case without the positive offset.

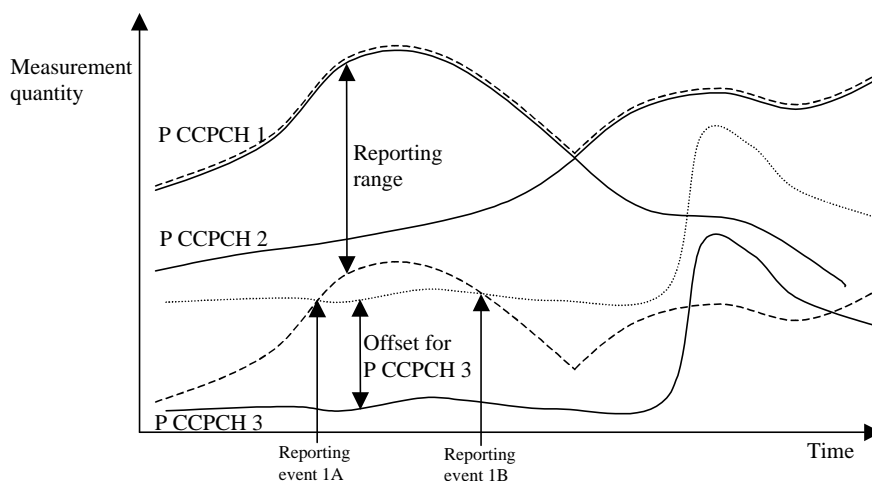


Figure 9: A positive offset is applied to Primary CCPCH 3 before event evaluation in the UE.

Correspondingly, the operator can choose to apply a negative offset to a Primary CCPCH. Then the reporting on that Primary CCPCH is limited, and the corresponding cell may be, at least temporary, excluded from the active set.

The cell individual offset can be seen as a tool to move the cell border. It is important to note that the offset is added before triggering events, i.e. in the UE before evaluating if a measurement report should be sent, as opposed to offsets that are applied in the network and used for the actual handover evaluation.

Furthermore, if downlink pathloss is used as measurement quantity, UTRAN may (optionally) include a filtered value of the uplink interference in each cell individual offset. In this way, the measurement quantity “path loss plus uplink interference”, which optimises the handover evaluation with respect to the uplink performance can be implemented.

3.3.4 Forbid a Primary CCPCH to affect the reporting range

The reporting range affects the reporting events 1A and 1B presented above. The reporting range is defined relative to the best Primary CCPCH. However, there could be cases where it is good to forbid a specific Primary CCPCH to affect the reporting range. For example in figure 10, the network has notified the UE to not letting Primary CCPCH 3 affect the reporting range. This mechanism could be effective if the operator by experience knows that the quality of Primary CCPCH 3 is very unstable in a specific area and therefore should not affect the reporting of the other Primary CCPCHs.

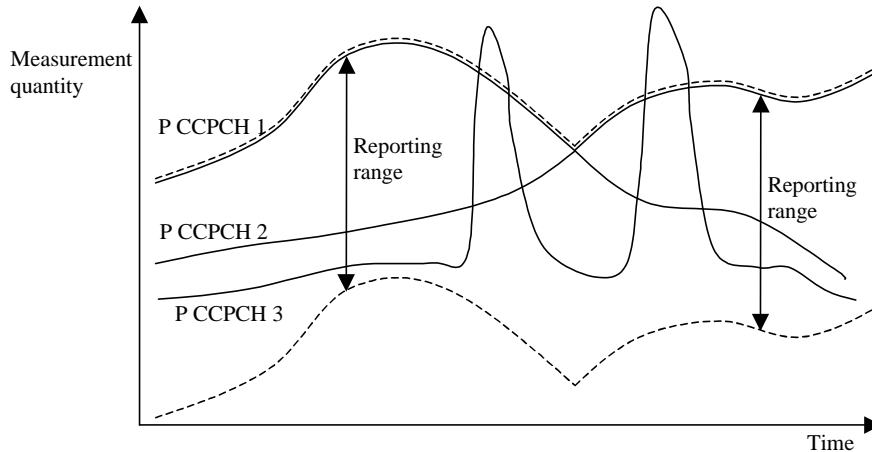


Figure 10: Primary CCPCH 3 is forbidden to affect the reporting range.

3.4 Report quantities

In the event-triggered measurement reports, mandatory information connected to the events is always 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 measurement information in the report to support the radio network functions in UTRAN. Furthermore, it 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
- Downlink SIR (RSCP/ISCP) on the traffic channels after RAKE combining
- Downlink SIR (RSCP/ISCP) on Primary CCPCH (e.g. used for initial DL power setting on new radio links.)
- Downlink E_c/I_0 on Primary CCPCH (e.g. used for initial DL power setting on new radio links.)
- “Time difference between the received Primary CCPCH frame-timing from the target cell and the earliest received existing
[Note: This measurement is identified in 25.211 [2] (denoted 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 section 8.3.7.1 in the change request below.]

4 Change request to section 8.3.7 in 25.331

Below is the proposed change request to section 8.3.7 in 25.331 [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 an 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.

~~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 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.
- 6.7. **Measurement reporting criteria:** The triggering of the measurement report, e.g. periodical; or 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 Measurement reporting

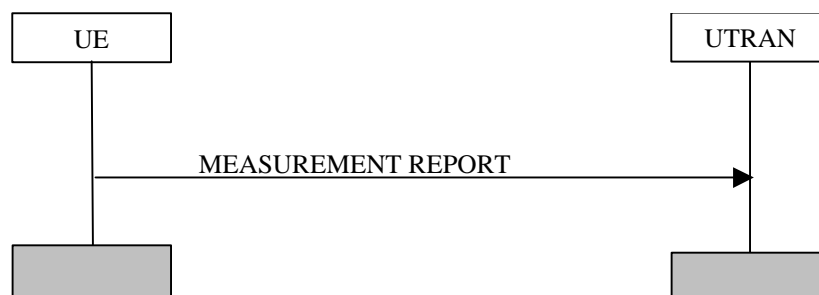


Figure 2) Measurement Report procedure

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 measurement results measured values of the mandatory and optional report quantities that were defined in the corresponding MEASUREMENT 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.]

5 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 include the contents of sections 3.1-3.4 of this document into chapter 15 “Specific functions” of 25.331 [1].

Furthermore, we propose to change the section 8.3.7 in 25.331 [1] according to the text in chapter 4 above.

6 References

- [1] TS RAN 25.331 V1.0.1, “RRC protocol specification”
Source: Editor
- [2] TS RAN 25.211 V2.0.0, “Physical channels and mapping of transport channels onto physical channels (FDD)”
Source: TSG RAN WG 1