Agenda Item: 17.2

Source: QUALCOMM Europe

Title: **UE Intra-Frequency Measurement Schemes**

Document for: Discussion and decision

1. Introduction

In section 15 of 25.331 "RRC Protocol Specification" [1] six intra-frequency reporting events are outlined. In [3] two new intra-frequency measurement schemes have been proposed. During TSG-RAN WG2 #6 the formula used to define the proposed events has been agreed. It has also been agreed to extend events 1A and 1B in order to incorporate the two events proposed in [3]. This contribution proposes the detailed text change to 25.331.

Liaison TSGR2#6(99)737 from TSG-RAN WG1 [4] indicated that SIR should not be used for the intra-frequency measurements. Liaison TSGR2#6(99)738 from TSG-RAN WG1 [5] indicated that CPICH should be used instead of the Primary CCPCH for the intra-frequency measurements. This contribution proposes changes to 25.331 that are in line with the above Liaisons.

2. Description of the proposed schemes

The six intra-frequency reporting events already defined in chapter 15 of 25.331 [1] are:

- Reporting event 1A - A Primary CCPCH enters the reporting range;

- Reporting event 1B - A primary CCPCH leaves the reporting range;

- Reporting event 1C - A non-active primary CCPCH becomes better than an active primary CCPCH;

- Reporting event 1D - Change of best cell;

- Reporting event 1E - A Primary CCPCH becomes better than an absolute threshold;

- Reporting event 1F - A Primary CCPCH becomes worse than an absolute threshold.

All the above reporting events are based on the measurement of one or two Primary CCPCH; the events are triggered when an inequality between the measurement values (or between a measurement value and a fixed quantity) is no more satisfied. According to [5] the CPICH should be used in all the above measurements.

We propose to extend the reporting event 1A and 1B by using a measurement that is function of more than one CPICH. In particular we propose the renaming of the reporting events 1A and 1B as follows:

- Reporting event 1A – A CPICH enters the dynamic reporting range;

- Reporting event 1B – A CPICH leaves the dynamic reporting range.

The new definition of these reporting events is provided in the following two sections.

We also propose to change the names of other reporting events as follows:

- Reporting event 1C - A non-active CPICH becomes better than an active CPICH;

- Reporting event 1D - Change of best cell;

We propose as well to delete the reporting events 1E and 1F since they can be defined by properly setting the parameters that define the proposed reporting events 1A and 1B.

3. Reporting event 1A – A CPICH enters the dynamic reporting range

This event is triggered when:

$$10 \cdot Log\left(\frac{NewCPICH\_E_c}{I_o}\right) \geq Max\left[AddTh \quad , \quad S \cdot 10 \cdot Log\left(\sum_{i=1}^{1+AS \cdot (N_A - 1)} \frac{CPICH_i\_E_c}{I_o}\right) + I_A\right]$$

where: NewCPICH = CPICH not in the Active Set (candidate for inclusion in the Active Set)

AddTh = Add Threshold

N_A = Number of CPICH in the Active Set

S = Slope

I_A = Add Intercept

AS = Active Set included (0 or 1)

$CPICH_i$ = i-th CPICH in the Active Set, where $CPICH_1$ is the strongest CPICH in the Active Set, $CPICH_2$ is the second strongest, and $CPICH_{N_A}$ is the weakest CPICH in the Active Set.

If AS is set to 1, then all the CPICH in the Active Set will be considered in the formula. Otherwise, if AS is set to 0, then only the strongest CPICH in the Active Set will be considered in the formula.

Note that if S and I_A are set to 0, then this reporting event is equivalent to the reporting event 1E described in Chapter 15 of TS RAN 25.331 [1].

If AS, AbsoluteAddTh and I_A are set to 0 and S is set to 1, then this reporting event is equivalent to the reporting event 1A described in Chapter 15 of TS RAN 25.331 [1].

4. Reporting event 1B – A CPICH leaves the dynamic reporting range

This event is triggered when:

$$10 \cdot Log\left(\frac{OldCPICH\_E_c}{I_o}\right) \leq Max\left[DropTh \quad , \quad S \cdot 10 \cdot Log\left(\sum_{i=1}^{1+AS \cdot (N_{A'} - 1)} \frac{CPICH_i\_E_c}{I_o}\right) + I_D\right]$$

where: OldCPICH = CPICH in the Active Set (candidate for exclusion from the Active Set)

$N_{A'}$ = Number of CPICH in A' (Active Set excluding the OldCPICH under investigation)

DropTh = Drop Threshold

S = Slope

I_D = Drop Intercept

AS = Active Set included (0 or 1)

$CPICH_i$ = i-th CPICH in A' (Active Set excluding OldCPICH), where $CPICH_1$ is the strongest CPICH in A', $CPICH_2$ is the second strongest, and $CPICH_{N_{A'}}$ is the weakest CPICH in A'.

If AS is set to 1, then all the CPICH in A' (Active Set excluding OldCPICH) will be considered in the formula. Otherwise, if AS is set to 0, then only the strongest CPICH in A' will be considered in the formula.

Note that if S and I_D are set to 0, then this reporting event is equivalent to the reporting event 1F described in Chapter 15 of TS RAN 25.331 [1].

If AS, DropTh and I_D are set to 0 and S is set to 1, then this reporting event is equivalent to the reporting event 1B described in Chapter 15 of TS RAN 25.331 [1].

5. Text changes in 25.331 "RRC Protocol

15 Specific functions

15.1 Intra-frequency measurements

15.1.1 Intra-frequency measurement quantities

Downlink E_c/I_0 (chip energy per total received channel power density)

Downlink path loss. (FFS)

Downlink received signal code power (RSCP) after despreading. (FFS)

~~*Downlink signal-to-interference ratio (SIR) after despreading on a specific DL physical channel (RSCP/ISCP).(FFS)*~~

15.1.2 Intra-frequency reporting events

Within the measurement reporting criteria field in the Measurement Control message the UTRAN notifies the UE which events 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 which 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 15.1.1. The measurement objects are the monitored ~~primary common control physical channels (PCCPCH)~~common pilot channel (CPICH). 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 labeled 1X, inter-frequency reporting events would be labeled 2X, and so on for the other measurement types.]

15.1.2.1 Reporting event 1A: A CPICH enters the dynamic reporting range~~A Primary CCPCH enters the reporting range~~
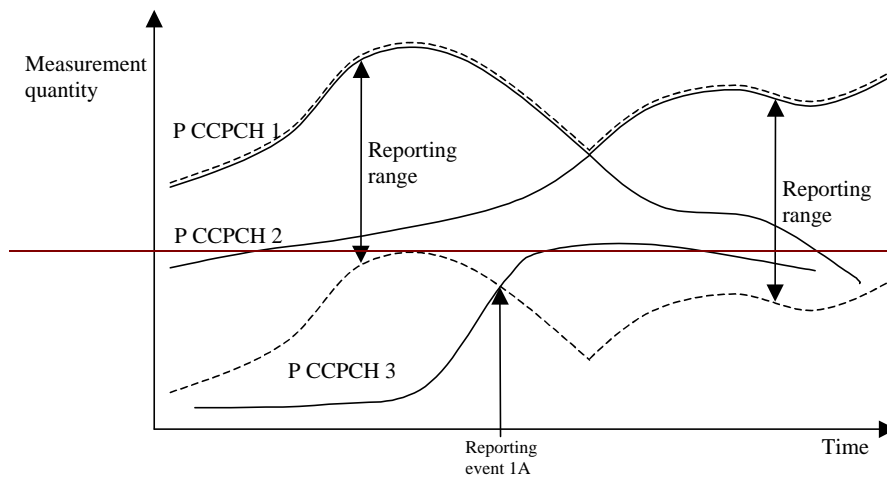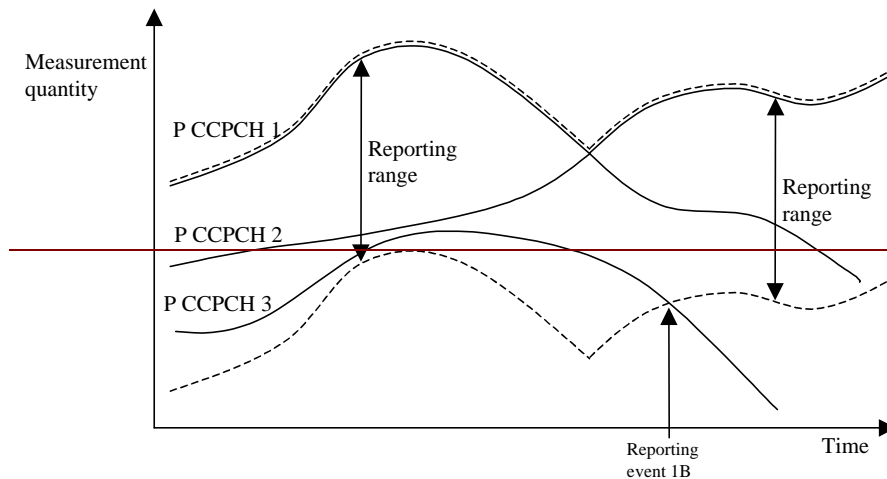
Figure 49 Event-triggered report when a primary CCPCH enters the reporting range.

When event 1A is ordered by UTRAN in a measurement control message, the UE shall send a measurement report when a ~~primary CCPCH~~CPICH enters the dynamic reporting range as defined by the following formula:

$$10 \cdot Log\left(\frac{NewCPICH\_E_c}{I_o}\right) \geq Max\left[AddTh \quad , \quad S \cdot 10 \cdot Log\left(\sum_{i=1}^{1+AS \cdot (N_A - 1)} \frac{CPICH_i\_E_c}{I_o}\right) + I_A\right]$$

where: NewCPICH = CPICH not in the Active Set (candidate for inclusion in the Active Set)

AddTh = Add Threshold

N_A = Number of CPICH in the Active Set

S = Slope

I_A = Add Intercept

AS = Active Set included (0 or 1)

$CPICH_i$ = i-th CPICH in the Active Set, where $CPICH_1$ is the strongest CPICH in the Active Set, $CPICH_2$ is the second strongest, and $CPICH_{N_A}$ is the weakest CPICH in the Active Set.

If AS is set to 1, then all the CPICH in the Active Set will be considered in the formula. Otherwise, if AS is set to 0, then only the strongest CPICH in the Active Set will be considered in the formula.

~~.~~ The ~~reporting range is defined relative to the best primary CCPCH and is~~ parameters (AddTh, S, I_A, AS) that define this reporting event are given in the measurement reporting criteria field in the MEASUREMENT CONTROL message. They should also be included in the Intra-frequency measurement information field of the SYSTEM INFORMATION message.

~~The addition window of cells in event 1A is configured with the **reporting range** parameter common to many reporting events and an optional **hysteresis** parameter, which can be used to distinguish the addition window from reporting windows related to other measurement events.~~

The occurrence of event 1A is conditional on a **report deactivation threshold** parameter. This parameter indicates the maximum number of cells allowed in the active set for measurement reports to be triggered by event 1A to be transmitted.

Event 1A may be enhanced with an addition timer, which is configured with the **time-to-trigger** parameter (see section 15.1.4.2). If a time-to-trigger value is used, a cell must continuously stay within the dynamic reporting range for the given time period, before the UE shall send a measurement report.

[Note: It is FFS, whether the cells triggering event 1A may be in the active set.]

15.1.2.2 Reporting event 1B: A CPICH leaves the dynamic reporting rangeA primary CCPCH leaves the reporting range

~~**Figure 50 Event-triggered report when a primary CCPCH leaves the reporting range.**~~

When this event is ordered by UTRAN in a measurement control message, the UE shall send a measurement report when a ~~primary CCPCH~~CPICH leaves the dynamic reporting range as defined by the following formula:

$$10 \cdot Log\left(\frac{OldCPICH\_E_c}{I_o}\right) \le Max\left[DropTh \quad , \quad S \cdot 10 \cdot Log\left(\sum_{i=1}^{1+AS \cdot (N_{A'}-1)} \frac{CPICH_i\_E_c}{I_o}\right) + I_D\right]$$

where: OldCPICH = CPICH in the Active Set (candidate for exclusion from the Active Set)

   $N_{A'}$ = Number of CPICH in A' (Active Set excluding the OldCPICH under investigation)

   DropTh = Drop Threshold

   S = Slope

   I_D = Drop Intercept

   AS = Active Set included (0 or 1)

   $CPICH_i$ = i-th CPICH in A' (Active Set excluding OldCPICH), where $CPICH_1$ is the strongest CPICH in A', $CPICH_2$ is the second strongest, and $CPICH_{N_{A'}}$ is the weakest CPICH in A'.

If AS is set to 1, then all the CPICH in A' (Active Set excluding OldCPICH) will be considered in the formula. Otherwise, if AS is set to 0, then only the strongest CPICH in A' will be considered in the formula.

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.-The reporting range is parameters (DropTh, S, I_D, AS) that define this reporting event defined relative to the best primary CCPCH and is are given in the measurement reporting criteria field in the MEASUREMENT CONTROL message. They should also be included in the Intra-frequency measurement information field of the SYSTEM INFORMATION message.

The drop window of cells in event 1B is configured with the **reporting range** parameter common to many reporting events and an optional **hysteresis** parameter, which can be used to distinguish the drop window from reporting windows related to other measurement events.

Event 1B may be enhanced with a drop timer, which is configured with the **time-to-trigger** parameter. If the timer is used, the weakening cell must continuously stay below the dynamic reporting range for the given time period before the UE may send a measurement report. The corresponding report contains (at least) the involved CPICH.

[Note: It is FFS whether cells triggering event 1B may belong to the monitored set cells, which are currently not in the active set]

15.1.2.3 Reporting event 1C: A non-active CPICH becomes better than an active CPICHA non-active primary CCPCH becomes better than an active primary CCPCH
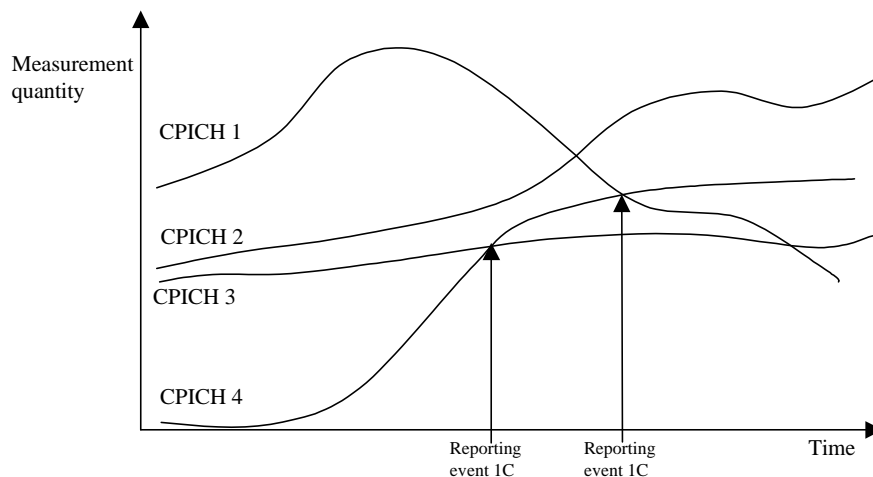

Figure 3 A primary CCPCHCPICH that is not included in the active set becomes better than a primary CCPCH CPICH that is in the active set.

In this example the cells belonging to CPICH PCCPCH 1, 2 and 3 are supposed to be in the active set, but the cell transmitting CPICH PCCPCH 4 is not (yet) in the active set.

If a CPICH primary CCPCH that is not included in the active set becomes better than a CPICH primary CCPCH that is in the active set, and event 1C has been ordered by UTRAN, this event shall trigger a report to be sent from the UE.

This event may be used for replacing cells in the active set. It is activated if the number of active cells is equal to or greater than a **replacement activation threshold** parameter that UTRAN signals to the UE in the MEASUREMENT CONTROL message. This parameter indicates the minimum number of cells required in the active set for measurement reports triggered by event 1C to be transmitted.

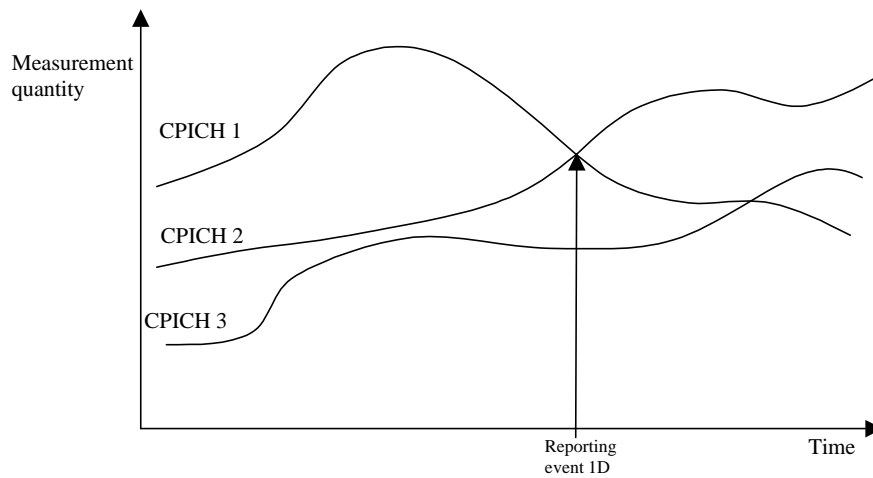## 15.1.2.4 Reporting event 1D: Change of best cell

Figure 4 A CPICH ~~primary CCPCH~~ becomes better than the previously best CPICH~~primary CCPCH~~.

If any of the ~~primary~~ CPICH~~CCPCH~~s within the reporting range becomes better than the previously best CPICH~~primary CCPCH~~, and event 1D has been ordered by UTRAN then this event shall trigger a report to be sent from the UE. The corresponding report contains (at least) the new best CPICH~~primary CCPCH~~.

~~15.1.2.5 Reporting event 1E: A Primary CCPCH becomes better than an absolute threshold~~
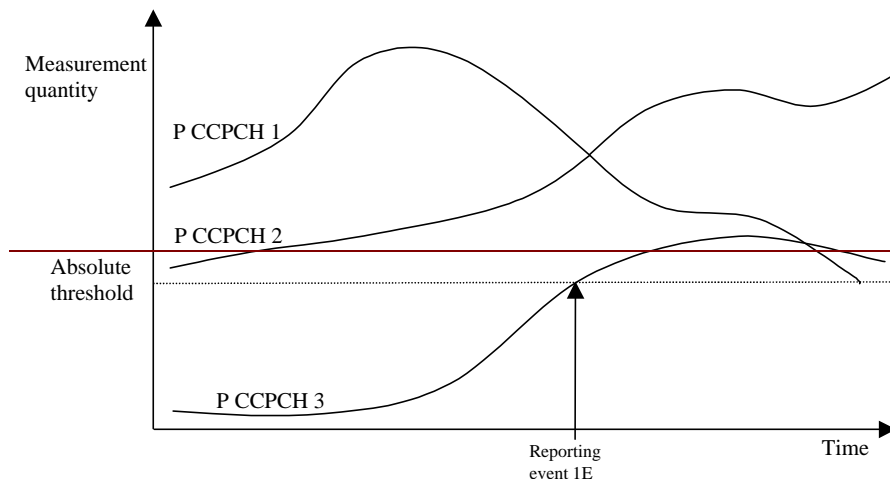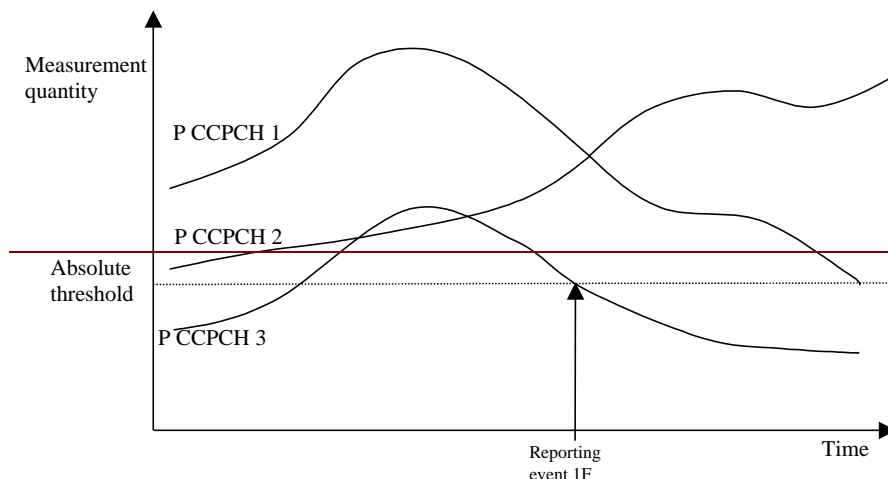

~~Figure 53 Event-triggered report when a Primary CCPCH becomes better than an absolute threshold.~~

~~When this event is ordered by UTRAN in a measurement control message the UE shall send a report when the Measurement quantity of a Primary CCPCH becomes better than an absolute threshold. The corresponding report contains (at least) the involved Primary CCPCH.~~

15.1.3 Event-triggered periodic intra-frequency measurement reports

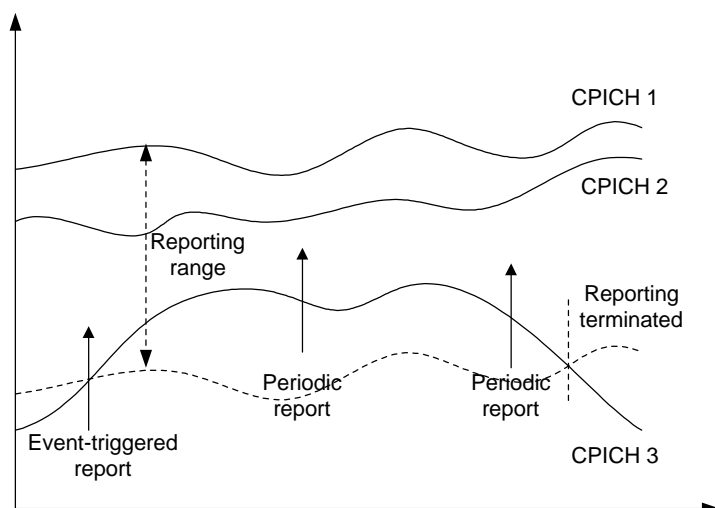### 15.1.3.1 Cell addition failure

Figure 7 Periodic reporting triggered by event 1A

When a cell enters the reporting range and triggers event 1A, the UE shall transmit a MEASUREMENT REPORT to the UTRAN and typically this may result in an update of the active set. However, in some situations the UTRAN may be unable to add a strong cell to the active set typically due to capacity shortage for example.

The UE shall continue reporting after the initial report by reverting to periodical measurement reporting if the reported cell is not added to the active set. This is illustrated in Figure 7Figure 7. During periodic reporting the UE shall transmit MEASUREMENT REPORT messages to the UTRAN at predefined intervals. The reports shall include reporting information of the cells in the current active set and of the monitored cell(s) in the reporting range.

Event-triggered periodic measurement reporting shall be terminated either when there are no longer any monitored cell(s) within the reporting range or when the UTRAN has added cells to the active set so that it includes the maximum number of cells (defined by the **reporting deactivation threshold** parameter), which are allowed for event 1A to be triggered.

The reporting period is assigned by the UTRAN. If the reporting period is set to zero event-triggered measurement reporting shall not be applied.
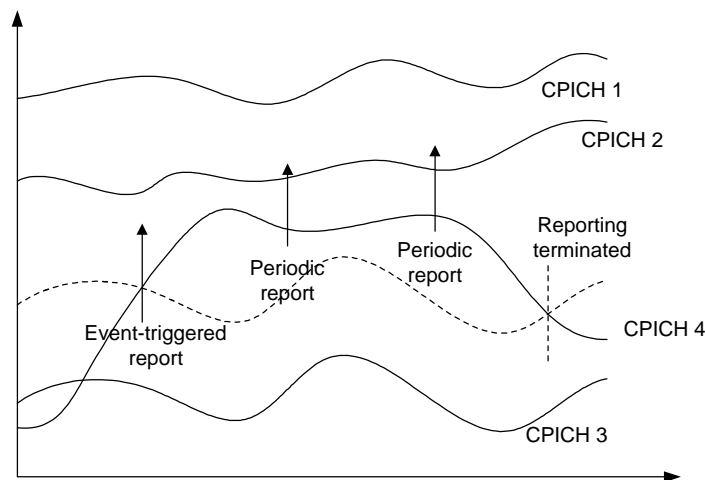
15.1.3.2 Cell replacement failure

Figure 8 Periodic reporting triggered by event 1C

When a cell enters the replacement range and triggers event 1C, the UE shall transmit a MEASUREMENT REPORT to the UTRAN and typically this may result in the replacement of the weakest active cell. If the UTRAN is unable to replace the cell due to for example capacity shortage, it is beneficial to receive continuous reports in this case as well.

The UE shall revert to periodical measurement reporting if the UTRAN does not update the active set after the transmission of the measurement report. This is illustrated in Figure 8Figure 8. During periodic reporting the UE shall transmit MEASUREMENT REPORT messages to the UTRAN at predefined intervals. The reports shall include reporting information of the cells in the current active set and of the monitored cell(s) in the replacement range.

Event-triggered periodic measurement reporting shall be terminated either when there are no longer any monitored cell(s) within the replacement range or when the UTRAN has removed cells from the active set so that there are no longer the minimum amount of active cells for event 1C to be triggered (as defined by the **replacement activation threshold** parameter).

The reporting period is assigned by the UTRAN. If the reporting period is set to zero, event-triggered measurement reporting shall not be applied.

15.1.4 Mechanisms available for modifying intra-frequency measurement reporting behaviour

15.1.4.1 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 9Figure 9, the hysteresis ensures that the event 1D (primary CCPCHCPICH 2 becomes the best cell) is not reported until the difference is equal to the hysteresis value. The fact that CPICH primary CCPCH 1 becomes best afterwards is not reported at all in the example since the CPICH primary CCPCH 1 does not become sufficiently better than the CPICH primary CCPCH 2.
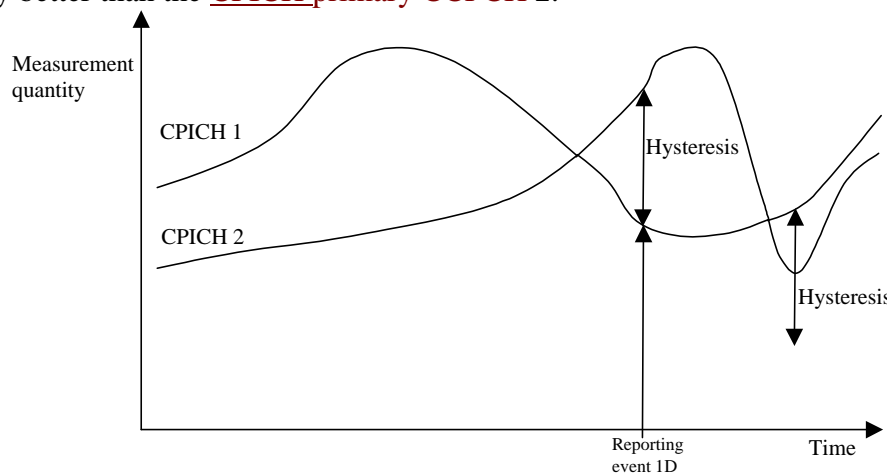

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Figure 9 Hysteresis limits the amount of measurement reports.

15.1.4.2 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 only after the conditions for the event have existed for the specified time-to-trigger. In the example in Figure 10~~Figure 10~~, the use of time-to-trigger means that the event (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.
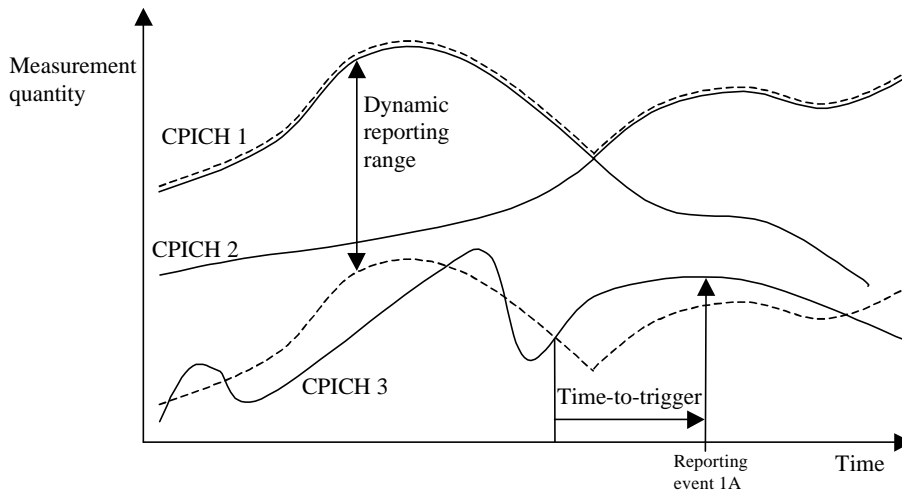

Figure 10~~10~~ Time-to-trigger limits the amount of measurement reports.

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.

15.1.4.3 Cell individual offsets

For each cell that is monitored, an offset can be assigned with inband signalling. 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 CPICH ~~primary CCPCH~~ in the measurement object field of the MEASUREMENT CONTROL message.

For example, in Figure 11~~Figure 11~~, since an offset is added to CPICH ~~primary CCPCH~~ 3, it is the dotted curve that is used to evaluate if an event occurs. Hence, this means that measurement reports from UE to UTRAN are triggered when CPICH ~~primary CCPCH~~ plus the corresponding offset, i.e. the dotted curve, leaves and enters the reporting range and when it gets better than CPICH ~~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 CPICH~~primary CCPCH~~.

By applying a positive offset, as in Figure 11~~Figure 11~~, the UE will send measurement reports as if the CPICH~~primary CCPCH~~ is offset *x* 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 11Figure 11, the operator might know by experience that in this area CPICHprimary CCPCH 3 can become good very quickly (e.g. due to street corners) and therefore that it is worthreporting more intensively. Depending on the implemented handover evaluation algorithm, this may result in the cell with CPICH primary CCPCH 3 being included in the active set earlier than would have been the case without the positive offset.
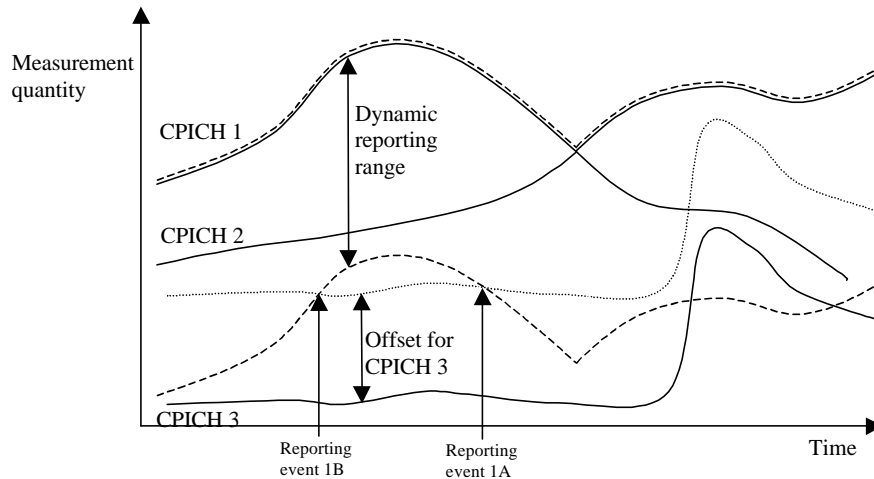

Figure 1111 A positive offset is applied to CPICHprimary CCPCH 3 before event evaluation in the UE.

Correspondingly, the operator can choose to apply a negative offset to a CPICHprimary CCPCH. Then the reporting on that CPICH primary CCPCH is limited and the corresponding cell may be, at least temporarily 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. the offset is added by 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.

15.1.4.4 Forbid a CPICH 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 CPICHPrimary CCPCH. However, there could be cases where it is good to forbid a specific CPICH Primary CCPCH to affect the reporting range. For example in Figure 12Figure 12 the network has requested the UE to not let CPICH Primary CCPCH 3 affect the reporting range. This mechanism could be effective if the operator knows by experience that the quality of CPICH Primary CCPCH 3 is very unstable in a specific area and therefore should not affect the reporting of the other CPICHPrimary CCPCHs.
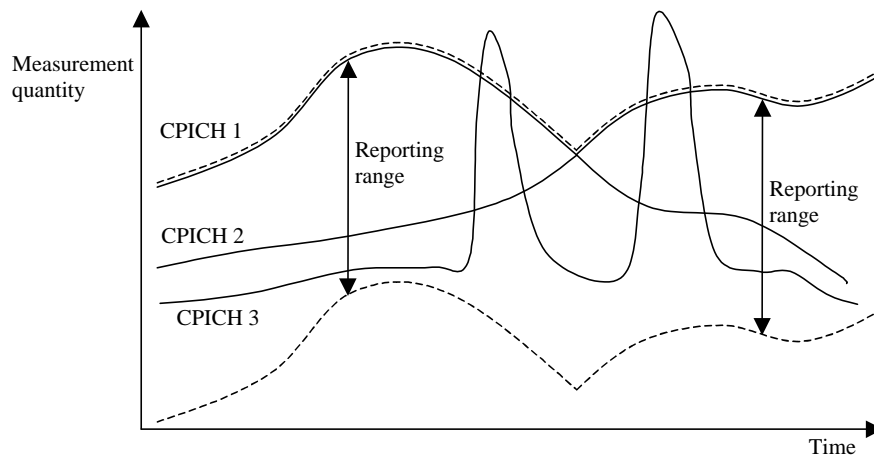
Figure 12~~12~~ ~~Primary CCPCH~~CPICH 3 is forbidden to affect the reporting range.

15.1.5 Report quantities

In the event-triggered measurement reports, mandatory information connected to the events is always reported. For instance, at the event "a CPICH ~~primary CCPCH~~ enters the dynamic reporting range" the corresponding report identifies the CPICH ~~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 E_c/I_0 on CPICH ~~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 DPCH path. *[Note: This measurement is identified in 25.211 [2] (denoted $\mathbf{T_m}$ in chapter 7)]*

UE transmit power

UE position (FFS)

Downlink SIR (RSCP/ISCP) on the traffic channels after RAKE combining (FFS)

~~*Downlink SIR (RSCP/ISCP) on primary CCPCH (e.g. used for initial DL power setting on new radio links.)(FFS)*~~

6. Conclusions

In this contribution a new definition of the intra-frequency reporting events 1A and 1B are proposed. Since the new definitions include, as a special case, the reporting event 1E and 1F it is here proposed to delete the reporting events 1E and 1F.

The proposed text changes to section 15.1 of 25.331 "RRC Protocol Specification" [1] are included in section 5 of this document.

Section 15.1 of 25.331 has been modified to be in line with the Liaisons Statements TSGR2#6(99)737 and TSGR2#6(99)738, indicating that SIR should not be used for the intra-frequency measurements and that CPICH should be used instead of the Primary CCPCH for the intra-frequency measurements.

7. References

[1] TS RAN 25.331 V1.3.0, "RRC protocol specification"
     Source: TSG RAN WG 2
[2] TSGR2#5(99)591, "UE Measurement Concept for Intra-Frequency Measurements"
     Source: Ericsson
[3] TSGR2#6(99)781, "UE Measurement Schemes for Intra-Frequency Measurements"
     Source: QUALCOMM Europe
[4] TSGR2#6(99)737, Liaison statement on 'Physical layer measurement'
     Source: TSG RAN WG 1
[5] TSGR2#6(99)738, Answer to Liaison statement on TS 25.302, 'Services provided by the Physical

     Source: TSG RAN WG 1