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Title: **Cell Selection and Cell Reselection Criteria**

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1 Introduction

In this contribution, we describe the cell selection and cell reselection together with the evaluation criteria. The criteria are presented together with the parameters connected to it.

2 Discussion

2.1 General

The cell selection and reselection criteria described in this document are intended for idle mode. However, they can also be the basis for the development of the corresponding criteria in connected mode.

Important characteristics of the cell selection and reselection procedures are that they are simple and that the power consumption in the UE is minimised. There is no need to be on the optimal cell all the time, since this will have impact on the power consumption in the UE.

In this document we propose introduction of a new procedure, Immediate Cell Evaluation. This procedure evaluates, very fast, if a neighbour cell has better conditions than the serving cell and is used preferably before an access on the RACH or when the quality of the serving cell is drastically worse. By introducing this procedure the requirement on how often a cell reselection evaluation has to be performed is decreased. This will improve the stand-by times in the UE.

2.1.1 Measured quantity

The criteria described in this document are independent of the quantity that is measured to select the optimal cell (E_c/N_0, SIR, RSCP or path loss etc in UMTS [1] or RSSI etc in GSM). Which quantity (quantities) to use shall be decided in WG1 and is therefore out of scope of this document. In case alternative measurement quantities shall be possible, mechanisms for co-ordination of this need further study. For example, one measurement quantity could be the default quantity used by the UE until changed by the network (via e.g. system information).

2.1.2 How to select optimal cell

There are discussions on how to select the optimal cell. Is the optimal cell the one where the UE uses the lowest output power or is it enough to choose the cell with highest E_c/N_0 (or highest SIR, RSCP or lowest path loss [1]) in downlink (DL)? In the first case the uplink (UL) interference level of each neighbour cells has to be available for the UE. These levels can be included in the system information of the serving cell. This requires more signalling in the network. Alternatively, the UL interference levels can be included in the system information of each neighbouring cell respectively, and be read by the UE. This will increase the UE power consumption and slow down the cell selection and cell reselection procedures. Our proposal is to avoid using the UL interference in the calculation of the optimal cell.

2.1.3 Reading of System Information

The parameters controlling the cell selection and reselection procedurees shall be included in the system information sent on BCCH. This will permit the network to optimise the network performance through the whole lifetime of the system.

We propose that the measurement control information elements in the system information of the serving cell give all information needed about each cell the UE is to consider when performing measurements for cell reselection. We propose to introduce the parameter Qoffset per serving cell to neighbouring cell relation, in order to give network operators flexibility to control traffic between the cells. In normal conditions, specifically for intra-frequency measurements, Qoffset=0. The parameter Qhyst is introduced to prevent from ping-pong cell reselections. This parameter is not defined per serving cell to neighbouring cell relation.

UE does not need to read system information of the neighbouring cells until the quality of a neighbouring cell is better than the quality in the serving cell. Before the UE can switch to the new cell it shall check that the cell selection value (S, see below) is greater than 0 and that there is no restrictions to choose the new cell. For this purpose parts of the system information of the neighbouring cell has to be read.

2.1.4 Relation to the PLMN Selection and Reselection

The PLMN selection and reselection process is assumed to have higher priority than the cell selection and reselection process. This means that once coverage from the selected PLMN is obtained, the measurement control information elements and cell reselection parameters in system information control the choice of radio access system (RAS).

Input to the cell selection and cell reselection process is the selected PLMN and a priority list of radio access systems (FFS). The priority list is used for instance when the criteria for selecting the best cell are fulfilled in more than one radio access system.

2.1.5 Inter-Frequency and Inter-Radio Access System Cell Reselection

Both inter-frequency and inter-RAS cell reselection evaluations are typically performed less frequent than the intra-frequency evaluations. This is mainly due to that such evaluations consume more UE power than the intra-UTRA evaluations and that the UE is not able to listen for a page during the measurement period on another frequency or radio access system.

2.2 Process Description

2.2.1 General

The interaction between the different procedures in this document is shown in the following figure. For the discussion of each procedure, see the description below.

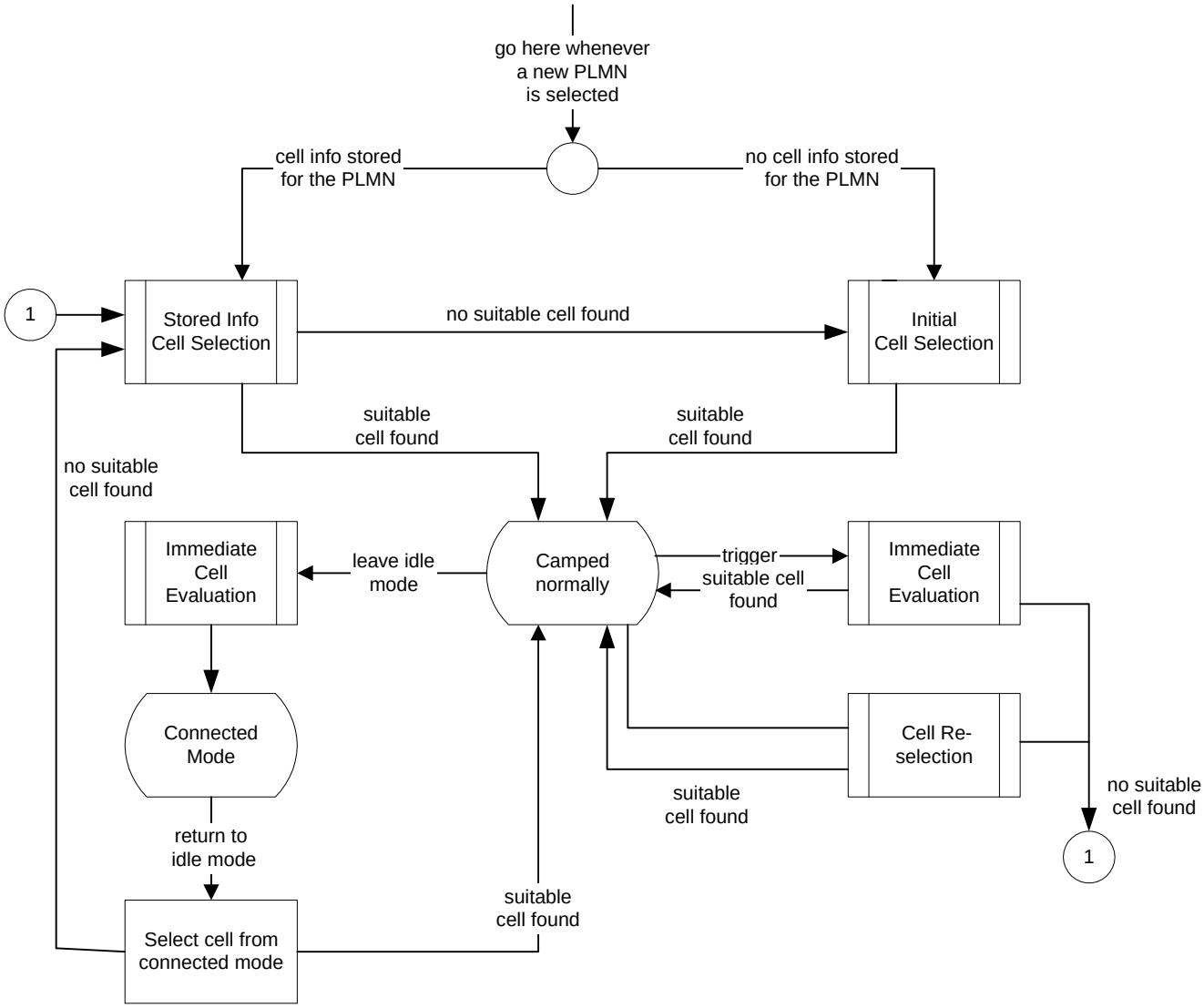

Figure 1. Cell selection and reselection

Whenever a PLMN has been selected, the UE attempts to find the most suitable cell of that PLMN to camp on. This cell selection can be performed either using information stored in the UE, or by applying initial cell selection.

While camped on a cell of the selected PLMN, the UE may trigger Immediate Cell Evaluation or Cell Reselection. If no suitable cell is found, Stored information cell selection is initiated.

When UE leaves idle mode in order to enter connected mode, the UE performs an Immediate Cell Evaluation in order to select the best cell for the access attempt. On return to idle mode, the UE chooses to camp on the best cell of the cells used when leaving connected mode.

2.2.2 Cell Selection

The goal with the cell selection procedures is to fast find a cell to camp on. To speed up this process, at “power up” or when returning from “out of coverage”, the UE shall start with the stored information from previous network contacts. If the UE is unable to find any of those cells the Initial cell search will be initiated. The cell shall be selected according to the RAS priority list (FFS) of the highest prioritised PLMN. If a service requests a certain RAS this is taken care of when the connection has been established (handover command from the network).

If it is not possible to find a cell from a valid PLMN the UE will choose a cell in a forbidden PLMN and enter a “limited service state”. A new cell selection is initiated on timeout basis to find a valid PLMN.

For each cell found the UE has to read the system information. The parameters needed for the cell selection procedure are the PLMN identity, the minimum required quality in the cell and the maximum allowed transmission power for the UE in the cell. These parameters must be distributed in system information often to improve the cell search procedure.

2.2.3 Immediate Cell Evaluation

It is important that the UE chooses the best cell (according to the chosen criteria) prior to a random access on the RACH. In idle mode, this applies to RRC message RRC Connection Request. We believe that an immediate cell evaluation before a RACH transmission is needed in the standard. This procedure shall also be used when the quality of the serving cell is bad (FFS), there are signalling failures (FFS) or the cell becomes barred or forbidden (FFS). This procedure shall be fast and there shall not be any hysteresis requirements between the different cells.

However, it must be possible to rank two neighbouring cells by means of an offset. This offset is unique between two cells. This implies that this value must be a part of the system information in the serving cell.

The immediate cell evaluation measures quality of the neighbouring intra- and inter-frequency UTRA cells (i.e. not inter-radio access system neighbour cells) and compares this with the quality of the serving cell, taking an offset into consideration). This offset is introduced for system tuning purposes, in order to ‘move’ the ‘cell border’. If a neighbouring cell with a better quality is found, the UE evaluates if the S (formula below) is greater than 0. To evaluate S, the UE has to read a part of the system information of the neighbouring cell. If S >0 then the UE shall change cell.

Before the access on the RACH can be initiated the UE also needs to check the relevant parts of system information for making the access. The time it takes to perform an immediate cell evaluation and select a new cell is dependent on the time it takes to read the system information. This can be optimised by the scheduling of the system information at the BCCH, the better scheduling the faster cell evaluation. If the cell reselection is not needed this procedure is very fast (depending on the time it takes to measure the neighbouring cells FFS).

2.2.4 Cell Reselection

The cell reselection procedure is a procedure to check the best cell to camp on. This procedure is always active, in idle mode, after the cell selection procedure has been completed and the first cell has been chosen. The goal of the procedure is to always camp on a cell with good enough quality even if it is not the optimal cell all the time.

In the cell reselection procedure also inter-radio access system neighbour cells are considered which is not the case for the immediate cell evaluation procedure. It is also possible to have a time to trigger and hysteresis criteria in the cell reselection to control the number of cell reselections.

The parameters needed for the cell reselection procedure (the offset value and the hysteresis) are unique for the serving cell. These have therefore to be distributed, together with time to trigger value, in system information in the serving cell. This implies that the UE does not need to read the system information in the neighbouring cells before the cell reselection procedure finds a neighbouring cell with better quality. To be able to calculate and check that S>0 the system information (the minimum required quality in the cell and the maximum transmission power) in the neighbouring cell has to be read.

Before the cell reselection procedure can be completed the UE has to check there is no restrictions to enter the new cell. If no restrictions exists the UE changes cell and reads complete system information in the new cell.

3 Proposal

This chapter contains the proposed changes to 3GPP TS 25.304 V1.2.0: “UE Procedures in Idle Mode”, 1999-06.

We propose to rename the subsections of section 5.2, and introduce the following text to subsections 5.2.1-5.2.3. Existing section 5.2.2.1 ODMA probing sub-process is proposed to be lifted to subsection 5.2.4.

5 Process Descriptions

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5.2 Cell Selection and Reselection

5.2.1 Cell Selection ~~Process~~Procedure

5.2.1.1 Description

The purpose of the cell selection procedure is to find the most suitable cell for the UE to camp on.

A suitable cell must fulfil all the following requirements.

1. The cell is part of the selected PLMN.
2. The cell is not barred [details are FFS].
3. The cell is not part of a forbidden registration area [details are FFS].
4. The cell selection criteria are fulfilled (see below).

Whenever a PLMN is selected, the UE shall attempt to find the most suitable cell of that PLMN according to the following steps.

1. Create a candidate list of potential cells to camp on. Two procedures are possible for searching the most suitable cell.
   a) Initial Cell Selection

      This procedure requires no prior knowledge of which RF channels are UTRA carriers. The UE shall scan all RF channels in the UTRA band to find all carriers [details are FFS]. On each carrier, the UE searches for all scrambling codes. The candidate list contains the cells corresponding to all carriers and scrambling codes found.

   b) Stored Information Cell Selection

      This procedure requires stored carrier frequencies and scrambling codes information from previously received measurement control information elements. The candidate list contains the cells corresponding to all carriers and scrambling codes found.
2. Read the following information from the system information of each cell of the candidate list.
   - PLMN Identity
   - Cell Barred [details are FFS]
   - Registration area
   - Cell selection parameters
3. For each cell on the candidate list belonging to the selected PLMN and not barred or forbidden, calculate the cell selection value, S, and the quality value, Q, defined below.
4. Among the cells with S > 0 choose the cell with the highest Q value to camp on.

If no suitable cells are found and the stored information cell selection procedure was used in step 1, the Initial cell selection procedure is started and the steps are repeated. If the UE is unable to find any suitable cell using the Initial cell selection procedure, it attempts to camp on any acceptable cell and enters “limited service state”.

[Note: In PLMN selection, automatic mode, this would normally result in a new PLMN selection.]

5.2.1.2 Criteria

The cell selection value, S, is defined as follows.

$$S = Q - Qmin - Pcompensation$$

S	Cell Selection value, (dB)
Q	Quality value. The quality of the received signal, (dB/dBm)
Qmin	Minimum required quality level in the cell (read in system information and dependent on the quantity to measure), (dB/dBm)
Pcompensation	max(MS_TXPWR_MAX – P_MAX, 0), (dB)
MS_TXPWR_MAX	Maximum TX power level an UE may use when accessing the cell (read in system information), (dBm)
P_MAX	Maximum RF output power of the UE, (dBm)

The cell selection criterion is fulfilled if:

$$S > 0$$

Note: (NOT TO BE INCLUDED IN 25.304)

Using Ec/N_0, RSCP or SIR as the measured quantity for the quality, the formula becomes:

Ec/N_0: $S = Ec/N_0 – Ec/N_0min – Pcompensation$

RSCP: $S = RSCP – RSCPmin – Pcompensation$

SIR: $S = SIR – SIRmin – Pcompensation$

If the output power of the Primary CCPCH is considered in the RSCPmin the RSCP formula also reflects the path loss.

5.2.2 Immediate Cell Evaluation Procedure

5.2.2.1 Description

The purpose of the immediate cell evaluation is to quickly find the best cell.

Triggers of immediate cell evaluation are:

1) Prior to RACH transmission
2) $S \leq 0$
3) Downlink signalling failure [details are FFS]
4) Cell has become barred or forbidden [details are FFS]

The following steps are carried out when an immediate cell evaluation has been triggered.

1. The candidate list of potential cells to camp on consists of the cells for intra- and inter-frequency measurements in system information of the serving cell.
2. Calculate the Q value and the S value for each cell on the candidate list.
3. Select the best neighbouring cell n fulfilling the criteria defined below.

5.2.2.2 Criteria

The UE shall perform cell reselection if the following criteria are fulfilled.

$$S_n > 0$$

$$Q_n > Q_s + Qoffset_{s,n}$$

S_n Cell Selection value of the neighbouring cell, (dB)

Q_n Quality of the neighbouring cell, (dB/dBm)

Q_s Quality of the serving cell, (dB/dBm)

$Qoffset_{s,n}$ Offset between the two cells considered in the evaluation (read in system information), (dB)

If more than one neighbouring cell fulfils the criteria, the UE shall choose the cell where the difference between Q_n and (Q_s + Qoffset) is highest. If no neighbouring cell fulfils the criteria, the UE shall keep the serving cell if the immediate cell evaluation was triggered prior to a RACH transmission otherwise a new cell selection shall take place.

5.2.3 Cell Reselection ~~Process~~Procedure

5.2.3.1 Description

The purpose of the cell reselection is to regularly look for the best cell for the UE to camp on (according to some criteria). The serving cell is changed when a better cell is found. The criterion for a better cell is different for intra/inter-frequency and inter-RAS reselections (see below).

The following steps are carried out when evaluating cells for cell reselection.

1. The candidate list of potential cells to camp on consists of the cells for intra- and inter-frequency measurements and intra-radio access system measurements in system information of the serving cell.
2. Calculate the Q value and the S value for each cell in the candidate list.
3. Depending on which type of cells are on the candidate list (intra-frequency, inter-frequency and inter radio access system), select the cell that fulfils the corresponding criteria best.

Better cells are prioritised in the following order when several cells fulfil their corresponding criteria:

1) Intra-frequency neighbouring cells
2) Inter-frequency neighbouring cells
3) Inter-radio access system neighbouring cells

5.2.3.2 Intra-Frequency Cell Reselection Criteria

The criteria for a better intra-frequency cell are:

$$S_n > 0$$

$$Q_n > Q_s + Qoffset_{s,n} + Qhyst$$

S_n	Cell Selection value of the neighbouring cell, (dB)
Q_n	Quality of the neighbouring cell, (dB/dBm)
Q_s	Quality of the serving cell, (dB/dBm)
$Qoffset_{s,n}$	Offset between the two cells considered in the evaluation (read in system information), (dB)
Qhyst	Hysteresis value, (dB)

The timer Treselection puts a time-to-trigger criteria for cell reselection. The timer shall be started when the cell reselection criteria is fulfilled. At timer expiry, the UE shall reselect the new cell, if the cell reselection criteria are still fulfilled. The timer is reset if the cell reselection criteria are no longer fulfilled.
The value of the Treselection is presented in system information.

Note: (NOT TO BE INCLUDED IN 25.304)

Using Ec/N_0, RSCP or SIR a cell reselection will be performed if the following expressions are fulfilled at time Treselection:

$Ec/N_{0:}$	$E_c/N_{0neighbour} > (E_c/N_{0serving} + Qoffset_{Ec/N0} + Qhyst_{Ec/N0})$
RSCP:	$RSCP_{neighbour} > (RSCP_{serving} + Qoffset_{RSCP} + Qhyst_{RSCP})$
SIR:	$SIR_{neighbour} > (SIR_{serving} + Qoffset_{SIR} + Qhyst_{SIR})$

5.2.3.3 Inter-Frequency Cell Reselection Criteria

The inter-frequency cell reselection evaluation uses the same criteria as intra-frequency cell reselections.

5.2.3.4 Inter Radio Access System Cell Reselection Criteria

Measurements on another radio access system (RAS) are not carried out unless the quality in the current radio access system is lower than a threshold, Qsearch. The quality of the target cell in the other radio access system has to exceed a threshold, Qaccept, before a reselection takes place. The following quantities are defined for inter-RAS cell reselection evaluations:

Qaccept	Minimum quality required for a cell in the new system.
Qsearch	Below this limit in the serving cell, the UE shall take measurements of inter-RAS cells if such entries exist in the measurement control information elements.

The UE shall consider inter-RAS cells with a quality Q > Qaccept, for reselection. The UE shall select the cell with the highest quality Q. Qaccept and Qsearch are included in the system information of the serving cell.

If the present quality is below Qsearch but no cells of the other systems reach the Qaccept quality, the cell reselection should not be performed. However, the measurements shall still continue.

If several RASs fulfils Qaccept the UE shall choose the RAS with the highest priority [FFS].

5.2.4 ~~5.2.2.1~~ ODMA probing sub-process

6 References

[1] 3GPP TSG1#5(99)646, Additional required measurements in UTRA/FDD"
[2] 3GPP TS 25.304 V1.2.0: "UE Procedures in Idle Mode", 1999-06

APPENDIX A

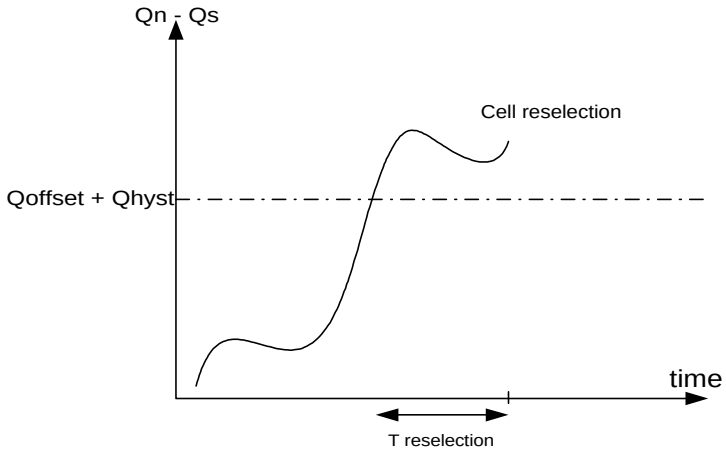

Figure 2. Description of the usage of Qoffset, Qhyst and Treselection.

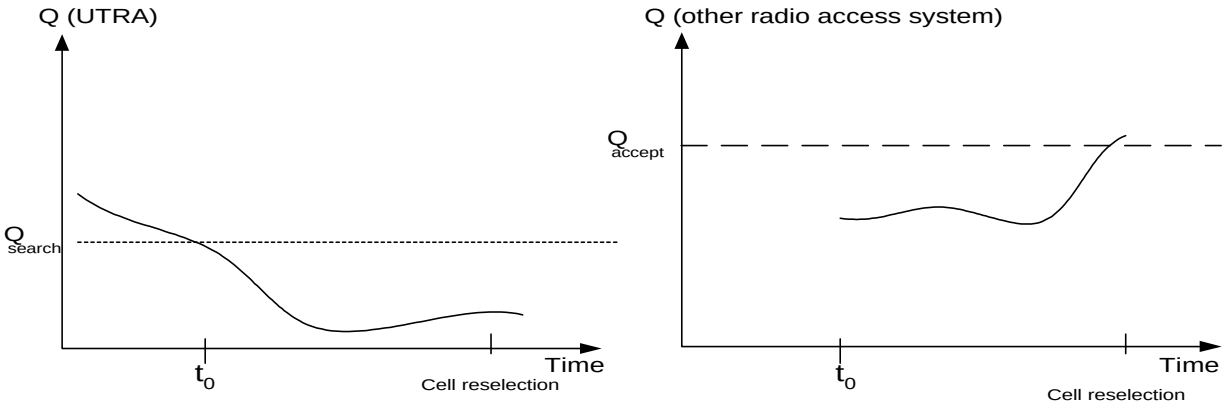

Figure 3. Description of the usage of Qsearch and Qaccept.