

CELL SELECTION IMPROVEMENTS
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Rev 005

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After review comments from MSB

NOTE: In the table shown above, the name of the person who made the changes as well as the approval authority is displayed in hidden text and does not print as part of the final document. Click on the paragraph symbol icon in the toolbar to show or hide this information.

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1

Current Implementation

The Cell Selection algorithm has been implemented across Layer1,
ALR, RR, MM and MMI entities. In this document we will examine
parts of the Cell Selection algorithm in ALR and RR entities.

1.1 Power Measurement Phase

In this phase the power measurements are done across all supported
bands. MPH_C_INIT_L1_REQ is used to reconfigure L1 across different
band modes.

Figure 1 MSC during Power Measurement Phase

1.2

Synchronization Phase

In this phase, an attempt is made to synchronize to a carrier from MPH_POWER_CNF carrier list. If a stored BA list is available, then carriers from the BA list are attempted first. This phase continues until the FB burst and SB burst of a carrier are detected by the Layer1 and a MPH_BSIC_CNF with cause=CS_NO_ERROR is received by the RR.

Figure 2 MSC during Synchronization Phase

1.3

Search for Requested Service ("Full Service" or "Limited Service")

In this phase RR is looking to find requested service from MM. This can be either "Full Service" or "Limited Service". After a successful synchronization, ALR starts reading BCCH messages. After the entire set of BCCH messages is decoded, RR makes the decision if the carrier is suitable for the requested service. If the requested service is "Full Service", then the carrier must belong to the requested PLMN. If the requested service is "Limited Service", then any carrier is chosen which allows emergency calls. If the carrier is not suitable, then RR continues with the Synchronization Phase, where the synchronization of the next carrier is attempted.

Figure 3 MSC during Search for Requested Service

If the requested service from MM is for "Full Service", the entire carrier list in MPH_POWER_CNF may be scanned twice.

* First Scan: - In this scan RR is essentially looking for "Full Service" on the requested PLMN. This scan is divided into 2 attempts. In the First attempt, all carriers with "Normal Priority" are searched for the requested PLMN. In the Second attempt carriers with "Low Priority" are searched for the requested PLMN. This scan is stopped after a carrier is found where "Full Service" is possible. NOTE: "Normal Priority" and "Low Priority" are from 3GPP TS 05.08. Priority of a carrier can be decoded from the SI messages of that carrier.

In the First Scan, each carrier is read from the top of the MPH_POWER_CNF carrier list, to the end of the list. If the BCCH of a carrier can be read, its PLMN is decoded. If this matches the PLMN requested and the carrier is marked Normal Priority, the scan stops and the carrier is selected. If the PLMN matches and the BCCH is marked Low Priority, this information is stored to be used later for the second attempt. If the end of the list is reached without camping on a Normal Priority carrier from the current PLMN, the carriers marked Low Priority are tried in the second attempt.

* Second Scan: - If the First Scan did not end with a carrier with "Full Service", the Second Scan is started. In this scan, the entire list of carriers (from MPH_POWER_CNF) is searched for "Limited Service". The scan is stopped after a carrier is found where all system information could be read and "Limited service" is possible. The mobile enters "Limited service", even if "Full

Service" is available (see Section 2.1 Error! Reference source not found.)

If the requested service from MM is "Limited Service", the carrier list in MPH_POWER_CNF is scanned only once.

2

Problem Descriptions

2.1 Stuck in "Limited Service"

Refer to the two scans described in Section Error! Reference source not found., under "Search for Requested Service". Consider the scenario where the MS is looking for "Full Service" and in the First Scan, synchronization attempt has failed on a carrier of the requested PLMN (due to very low signal strength). During the Second Scan the synchronization attempt is successful. RR ends up selecting a carrier for "Limited Service" where "Full Service" is possible. The mobile stays in "Limited Service" for an indefinite period of time.

This problem has also been observed in the Chicago drive test during customer acceptance.

2.2 CDMA Carriers

The current implementation of Cell Selection algorithm does not consider the impact of CDMA carriers encountered on the field. CDMA carriers themselves do not cause a problem normally, as it is not possible to synchronize on them. The current implementation has a problem when there are several strong CDMA carriers and the requested PLMN is on a weak carrier.

In this case large amounts of time are spent on "Synchronization Phases". This leads to longer time to finish Cell Selection. If a Cell Selection is started after a Downlink Failure, MS needs more time to recover service. In an area of weak coverage this may happen quite frequently.

This problem has been observed in parts of U.S (Chicago drive test) where there is coverage of both CDMA and GSM carriers. ALR sends 40 strongest carriers per Frequency band to RR in a MPH_POWER_CNF primitive. It is possible that all these carriers are CDMA carriers. As a result mobile will never be able to achieve synchronization and remain in "No Service" state forever.

2.3 Multiple Frequency Bands in a Region

According to 3GPP TS 03.22, MS should scan a certain minimum number of carriers on each frequency band. The numbers of carriers to be searched are 30 for GSM 850, 30 for GSM 900 and 40 for DCS 1800 and PCS 1900 Band. The current implementation of Cell Selection algorithm was designed with an assumption that there are only 2 regions, and carriers would belong to one of the two regions:

US region: This region contains cells from GSM 850 Band and PCS 1900 Band.

European and Asia Pacific region: This region contains cells from GSM 900 Band and DCS 1800 Band

In MPH_POWER_CNF a maximum of 80 carriers are sent to RR. Consider a region where there are DCS 1800, PCS 1900, and GSM 900 carriers. In such a case a Triband MS should scan at least 110 carriers. The Protocol Stack does not strictly meet the conformance requirements in such an environment.

This problem has been observed in Thailand where there are networks in GSM 900, DCS 1800 and PCS 1900 Bands.

2.4 Region Selection Problem

This problem is related to the problem mentioned in Section Error! Reference source not found. "Error! Reference source not found."

In the current implementation of the Cell Selection Algorithm, a Region is selected after the first successful synchronization of any carrier. After this synchronization, carriers from other region are removed. This could cause a problem in places where there are multiple frequency bands.

Consider a scenario where the HPLMN is in the PCS 1900 Band, in a region where there are also GSM 900 and DCS 1800 carriers. Assume the MS is operating in an area where the carriers from DCS 1800 Band are stronger than PCS 1900 Band carriers. In such a case the DCS 1800 carriers will be attempted first. After the first synchronization success on a carrier from the DCS 1800 Band, the region is set to "European Region" and PCS 1900 carriers are ignored. This will result in missing a good carrier (in PCS 1900 Band) where coverage of HPLMN is possible.

2.5 BA list and Last Used Serving Cell storage and usage

The last Serving Cell and its BA list, where the MS was camped ON for "Full Service" is stored on the FFS. Since ARFCN's from the DCS 1800 and PCS 1900 Band overlap, information about the frequency band of the Serving Cell must also be stored.

2.6 Multiple requests from MM during Cell selection

If RR receives a RR_ACTIVATE_REQ while a cell selection is running this request is either rejected or stored until the end of the procedure.

If the MS is switched ON, the following scenario may occur:

- * MM requests "Limited service", because the user hasn't entered the PIN. No PLMN is specified for this request. RR starts the scan.

- * The user has entered the PIN and MM requests "Full service" now. The request is stored, until the search for limited service is finished. Then a completely new scan for full service is started, including a new power scan and rereading system information for all carriers read during search for limited service. All results which were gathered during the search for limited service are removed and will not be reused.

2.7 Frequent searching of carriers during 2 Scans

Refer to the two scans described in Section Error! Reference source not found., under "Search for Requested Service". The First Scan is divided into two attempts.

As described in Section Error! Reference source not found., during First Scan and first attempt, RR is looking for Normal Priority carriers. During First Scan and second attempt, RR is looking for Low Priority carriers.

During First Scan and first attempt, RR tries to read system information from each carrier, and remembers carriers that are marked Low Priority. At the end of the First Scan and first attempt, if RR did not find "Full Service", a First Scan and second attempt is started if a single carrier is marked with Low Priority. During First scan and second attempt all carriers are searched for "Full Service".

A similar problem exists during the Second scan. During First Scan (first attempt and second attempt) RR marks all carriers where "Limited Service" is possible. At the end of the First Scan, if RR did not find "Full Service", a Second Scan is started if a single carrier is marked with "Limited Service". However, in the Second scan, not only the carriers marked with "Limited Service", but all carriers are searched.

It is possible in extreme situations; RR may scan each carrier in MPH_POWER_CNF three times.

3

Proposals

3.1 Stuck in "Limited Service"

A fix has been proposed under CQ 24416.

3.2 CDMA Carriers

3.2.1 Black List

The "Black List" is intended to contain carriers that cannot be synchronized (like CDMA carriers), and will be maintained dynamically. Unfortunately, it is not possible to definitively determine if a carrier is a CDMA carrier. However the Layer3 can make use of stored knowledge about carriers that it has failed to synchronize in the past. For more details about assembling and composition of a Black List refer to Section Error! Reference source not found. "Error! Reference source not found.". This list may be stored on the FFS when the MS is Switched OFF.

The carriers in the Black List will not be used during certain parts of the search process to reduce the scan times for finding a suitable carrier.

3.2.2 White List

The White List should contain carriers that are good candidates for "Full Service". This list will be useful in areas of weak coverage, where the MS goes into "Limited Service" or "No Service" quite often. Good candidates for the White List would be the last used Serving Cell in "Full Service" and the BA list of that Serving Cell. Other candidates are possible.

3.2.3 New Search Modes

New Search Modes will be used during Cell Selection Process.

3.2.3.1 FAST SEARCH

This Search mode is started after a Downlink Failure on a carrier with "Full Service" or a BCCH Read Failure on a carrier with "Full Service".

* A new timer, TFAST_CS, will be started when FAST SEARCH is activated. The duration of this Timer will be "4" minutes. This timer can be configured by the CONFIG command in PCO during run time.

* The Black List, the White List and the search mode are passed as parameters in MPH_POWER_REQ to ALR.

* ALR will make only one Power Measurement across all supported Frequency bands.

* The MPH_POWER_CNF returned by the ALR must not contain any carriers from the Black List.

* The MPH_POWER_CNF returned by the ALR shall contain all carriers from the White List whose Rxlev is more than the

LOWER_RXLEV_THRESHOLD. These carriers will be filled first in the

MPH_POWER_CNF array. The rest of the MPH_POWER_CNF array will hold carriers (not from the Black List) whose Rxlev is more than LOWER_RXLEV_THRESHOLD from strongest to weakest. This means, that the MPH_POWER_CNF carrier list may include weaker carriers (from the white list) and not include other stronger carriers (neither belonging to the white list nor the black lists) due to space limitations.

* Refer to the two scans described in Section Error! Reference source not found., under "Search for Requested Service". First Scan is made on White List Carriers and "Reasonably Strong Carriers" for "Full Service". First scan shall be divided into 2 attempts, for Normal Priority carriers and Low Priority carriers, just like in the current implementation.

"Reasonably Strong Carriers" are those carriers whose Rxlev > MEDIUM_RXLEV_THRESHOLD and which do not belong to Black List.

* If no suitable carrier was found, the Second Scan is made on all carriers in MPH_POWER_CNF for "Limited Service". During the Second Scan, if a carrier is found where "Full Service" is possible, it is selected. However the scan should stop at the first available carrier where either "Limited Service" or "Full Service" is possible. This Second Scan is necessary to ensure the availability of any emergency call capable cell.

* FAST SEARCH is stopped after a carrier is found where "Full Service" is possible.

* If no suitable carrier is found where "Full Service" is available, FAST SEARCH will be used as long as the timer TFAST_CS is active.

Figure 4 MSC during FAST SEARCH CELL SELECTION

3.2.3.2 NORMAL SEARCH

NORMAL SEARCH is carried out normally when a Cell Selection is required, for example after power ON, after expiry of TFAST_CS timer, MS has stayed in dedicated mode for more than 30 seconds, etc.

* A new timer, TNORMAL_CS, will be started when NORMAL SEARCH is started. The duration of this Timer will be "4" minutes. This timer can be configured by the CONFIG command in PCO during run time.

* The Black List, the White List and the search mode are passed as parameters in MPH_POWER_REQ to ALR.

* 5 power measurements are made across each carrier in all supported bands spread over 3-5 seconds.

* The MPH_POWER_CNF returned by the ALR must not contain any carriers from the Black List.

* The MPH_POWER_CNF returned by the ALR shall contain all carriers from the White List whose Rxlev is more than the LOWER_RXLEV_THRESHOLD. These carriers will be filled first in the MPH_POWER_CNF array. The rest of the MPH_POWER_CNF array will hold carriers (not from the Black List) whose Rxlev is more than LOWER_RXLEV_THRESHOLD from strongest to weakest. This means, that the MPH_POWER_CNF carrier list may include weaker carriers (from the white list) and not include other stronger carriers (neither belonging to the white list nor the black lists) due to space limitations.

- * Refer to the two scans described in Section Error! Reference source not found., under "Search for Requested Service". First Scan is made on all carriers from the MPH_POWER_CNF list for "Full Service". The First scan shall be divided into 2 attempts, for Normal Priority carriers and Low Priority carriers, just like in the current implementation.
- * If no suitable carrier was found, the Second Scan is made on all carriers from the MPH_POWER_CNF for "Limited Service". During the Second Scan, if a carrier is found where "Full Service" is possible it is selected. However the scan should stop at the first available carrier where either "Limited Service" or "Full Service" is possible. This Second Scan is necessary to ensure the availability of any emergency call capable cell.
- * NORMAL SEARCH is stopped after a carrier is found where "Full Service" is possible.
- * If no suitable carrier is found where "Full Service" is available, NORMAL SEARCH will be used as long as the timer TNORMAL_CS is active.
- * After the expiry of TNORMAL_CS, the next Cell Selection would be a FULL SEARCH, if the MS has still not reached "Full Service". However only 1 attempt of FULL SEARCH will be done, and then NORMAL SEARCH will be restarted. This cycle of "4" minutes of NORMAL SEARCH (duration of TNORMAL_CS), 1 FULL SEARCH, "4" minutes of NORMAL SEARCH and 1 FULL SEARCH will continue till a carrier is found where "Full Service" is possible.

Figure 5 MSC during NORMAL SEARCH CELL SELECTION

3.2.3.3 FULL SEARCH

FULL SEARCH is carried out after expiry of TNORMAL_CS timer. Only one attempt of FULL SEARCH is done and NORMAL SEARCH is restarted.

- * The Black List, the White List and the search mode are passed as parameters in MPH_POWER_REQ to ALR.
- * 5 power measurements are made across each carrier in all supported bands spread over 3-5 seconds.
- * The MPH_POWER_CNF returned by the ALR can contain carriers from the Black List.
- * The MPH_POWER_CNF returned by the ALR shall contain all carriers from the White List whose Rxlev is more than the LOWER_RXLEV_THRESHOLD. These carriers will be filled first in the MPH_POWER_CNF array. The rest of the MPH_POWER_CNF array will hold carriers (may contain some carriers from the Black List also) whose Rxlev is more than LOWER_RXLEV_THRESHOLD from strongest to weakest. This means, that the MPH_POWER_CNF carrier list may include weaker carriers (from the white list) and not include other stronger carriers due to space limitations.
- * Refer to the two scans described in Section Error! Reference source not found., under "Search for Requested Service". First Scan is made on all carriers from the MPH_POWER_CNF list for "Full Service". The First scan shall be divided into 2 attempts, for Normal Priority carriers and Low Priority carriers, just like in the current implementation.
- * If no suitable carrier is found, the Second Scan is made on all Carriers from the MPH_POWER_CNF for "Limited Service". During the Second Scan, if a carrier is found where "Full Service" is

possible it is selected. However the scan should stop at the first available carrier where either "Limited Service" or "Full Service" is possible.

Figure 6 MSC during FULL SEARCH CELL SELECTION

3.2.3.4 BLACK LIST SEARCH

BLACK LIST SEARCH is used to refresh carriers from the Black List. This type of search is done after a cell reselection to a cell belonging to a different Location Area or Routing Area.

* The Black List and search mode are passed as parameter in MPH_POWER_REQ to ALR.

* ALR will make only one Power Measurement on the Black List carriers only.

* ALR returns all carriers from the black list whose rxlev has fallen below LOWER_RXLEV_THRESHOLD. (For more details refer Section Error! Reference source not found. Error! Reference source not found. "Error! Reference source not found.")

Figure 7 MSC during BLACK LIST SEARCH

3.2.3.5 Difference between FULL SEARCH and NORMAL SEARCH

The only difference between a FULL SEARCH and a NORMAL SEARCH is in the usage of Black List. In a FULL SEARCH the Black List is used during the search process. While in a NORMAL SEARCH the Black list is not used.

3.3 Multiple Frequency Bands in a Region

See Implementation in Section Error! Reference source not found. "Error! Reference source not found."

3.4 Region Selection Problem

See Implementation in Section Error! Reference source not found. "Error! Reference source not found."

3.5 BA list and Last Used Serving Cell storage and usage

See Implementation in Section Error! Reference source not found. "Error! Reference source not found."

3.6 Multiple requests from MM during Cell selection

Proposal not ready yet.

3.7 Frequent searching of carriers during 2 Scans

See Implementation in Section Error! Reference source not found. "Error! Reference source not found."

4

Implementation

4.1 CDMA Carriers

4.1.1 Addition of carriers to Black List

* If a synchronization attempt fails on a strong carrier (i.e. Rxlev \geq UPPER_RXLEV_THRESHOLD), then add the carrier to the Black List after the first failure.

* If synchronization attempt on a "Reasonably strong carrier" fails repeatedly (i.e. UPPER_RXLEV_THRESHOLD $>$ Rxlev \geq MEDIUM_RXLEV_THRESHOLD), then add the carrier to the Black List after MAX_SYNC_FAILURES of Synchronization failures.

* A carrier shall never be added to the Black List, if it is present in the White List.

4.1.2 Storing of Black List carriers on the FFS

* During Switch OFF if the MS is camped on for "Full Service", then the Black List is stored on the FFS.
* One Black List is maintained for all frequency bands, and during storage information of frequency bands and ARFCN numbers should be retained.

4.1.3 Erasing the Black List

* During Switch OFF if the MS is camped on for "Limited Service" or "No Service", then the Black List should be erased from the FFS.

* After power ON the Black List, White List and the last used Serving Cell along with its Location Area are read from the FFS. The MS attempts to find "Full Service" on the last used Serving Cell and cells from the White List, before other carriers in MPH_POWER_CNF.

MS shall use the Black List if it finds "Full Service" in the same Location Area, where it was switched OFF. MS shall erase the Black List if it enters "Limited Service" or "No Service". MS shall also erase the Black List if it finds "Full Service" in a different Location Area, from the one on which it was switched OFF.

(The decision to use or erase the Black List should not be based on the comparison to the last used Serving Cell or its BA list, because the same ARFCN may be used in different Location Areas.)

4.1.4 Removal of individual carriers from the Black List

While in NORMAL or FAST SEARCH, it is impossible to camp on a carrier on the Black List, no matter how its accessibility has changed since the carrier entered the Black List. Therefore, it is important to be able to modify the Black List when network conditions change.

* The availability of a carrier in a BA list means that it cannot be a CDMA carrier. Therefore a carrier should be removed from the Black List when it is found in a BA list (which may be received in either Idle or Dedicated Mode). This BA list may be received on any carrier, irrespective of service state of the mobile.

* A carrier should be removed from the Black List when a carrier is found in a MA list of any Layer3 message.

* During a "Normal Search" or "Full Search" the Rxlev measurements on the Black List are made as part of the Power Measurement phase. This allows the ALR to determine if the Black List should be modified or not. If Rxlev of any carrier in the Black List falls below LOWER_RXLEV_THRESHOLD it means that the MS has moved away from the CDMA carrier. This carrier can then be removed from the Black List. A new primitive shall be added,

MPH_UPDATE_BLACKLIST_IND. This primitive will be sent from ALR to RR, and this shall contain all carriers that should be removed from the Black List. RR will erase carriers from the Black List if there is at least one strong carrier (which is not in the Black List) in that area. This will avoid the erasure of all Black List carriers in no coverage situations, e.g. "elevator".

* A Location Area / Routing Area may contain several cells. A change in Location Area / Routing Area indicates significant mobility. After every such change, a check for "inactive" Black List carriers can be made. After a cell reselection where a Location Area or Routing Area has changed MS performs a Location Area Update or a Routing Area Update. After the update procedure

MS can perform a search for all inactive Black List carriers, by a BLACK LIST SEARCH. This will allow the MS to update the Black List. Refer Section Error! Reference source not found. "Error! Reference source not found." for more details.

* During a "Full Search" the MPH_POWER_CNF is built without regard to the Black List. If a carrier from the Black List can be successfully synchronized during the Synchronization Phase (as described in Section Error! Reference source not found. "Error! Reference source not found."), RR will remove this carrier from the Black List.

4.1.5 Storage of White Lists in Full Service

* If the MS is in "Full Service" state during switch OFF, the Serving Cell and its BA list is stored on the FFS. Information about the frequency band and the Location area code of the Serving Cell must also be stored. After power ON the BA list is read from the FFS and used as a White List.

4.1.6 Management of New Search Modes

The following table lists different scenarios and details which type of Cell Selection that should be used.

In each scenario, 3 parameters should be considered to determine the type of Cell Selection that should be started.

- * status of TFAST_CS timer
- * status of TNORMAL_CS timer
- * previous cell selection

NOTE:

1. In the below table, parameters like timer TFAST_CS and timer TNORMAL_CS, sometimes have the value "Cannot be active". This value should be interpreted, as the Timer cannot be active (or running) in that particular scenario.
2. In the below table, "n.a." should be interpreted, as that parameter is not considered in deciding the type of Cell Selection, in that scenario.
3. It is not possible that timers TFAST_CS and TNORMAL_CS are running at the same time.
4. After reaching "Full Service", TFAST_CS and TNORMAL_CS are stopped, if either of them is running.
5. The expiry of the timer TFAST_CS, or the timer TNORMAL_CS does not trigger a Cell Selection. The expiry states of the above timers are used to make a decision on what type of Cell Selection should be used?
6. In scenarios 11, 12, 13 and 14 when RR is in "Limited Service", the type of search, parallel or non-parallel will be decided as per Section Error! Reference source not found..
7. FAST SEARCH is only used if requested service is "Full Service".

Sr No.
Scenario

Timer TFAST_CS
Timer TNORMAL_CS
Previous Type of Cell Selection
Type of Cell Selection / Action

Parameters

1

Power ON
cannot be active
cannot be active
n.a

FULL SEARCH

2

After Dedicated Mode for more than 30 seconds, Cell Reselection started, and fails.

cannot be active
cannot be active

n.a

NORMAL SEARCH

start timer

TNORMAL_CS

3

After Dedicated Mode less than 30 seconds but not for a Location Area Update or Routing area update.

cannot be active
cannot be active

n.a

MS continues to camp on the same cell

4

After Dedicated Mode less than 30 seconds for a Location Area Update or Routing area update.

cannot be active
cannot be active

n.a

MS continues to camp on the same cell and

BLACK LIST SEARCH.

5

In "Full Service", cell reselection started and fails.

Cell Reselection was started for any of the following reasons

- "Downlink Failure"
- "BCCH Read Failure"
- C1 / C2 criterion

cannot be active
cannot be active

n.a

FAST SEARCH

start timer TFAST_CS

6

In Dedicated Mode and "Radio Link Failure" or "Data Link Failure".

A Cell Reselection is started and fails.

cannot be active
cannot be active
n.a

FAST SEARCH
start timer TFAST_CS
7

In "Limited Service", cell reselection started and fails.

Cell Reselection was started for any of the following reasons

- "Downlink Failure"
- "BCCH Read Failure"
- C1 / C2 criterion

active
not active
n.a

FAST SEARCH
8

In "Limited Service", cell reselection started and fails.

Cell Reselection was started for any of the following reasons

- "Downlink Failure"
- "BCCH Read Failure"
- C1 / C2 criterion

not active
active
n.a

NORMAL SEARCH
9

In "Limited Service", cell reselection started and fails.

Cell Reselection was started for any of the following reasons

- "Downlink Failure"
- "BCCH Read Failure"
- C1 / C2 criterion

not active
not active
NORMAL SEARCH

FULL SEARCH
10

In "Limited Service", cell reselection started and fails.

Cell Reselection was started for any of the following reasons

- "Downlink Failure"
- "BCCH Read Failure"
- C1 / C2 criterion

not active
not active
FULL SEARCH

or
FAST SEARCH
NORMAL SEARCH

start timer
TNORMAL_CS

11

"Limited Service / No Service" and TREG timer expiry.
active
not active
n.a
FAST SEARCH

12
"Limited Service / No Service" and TREG timer expiry.
not active
active
n.a
NORMAL SEARCH

13
"Limited Service / No Service" and TREG timer expiry.
not active
not active
NORMAL SEARCH
FULL SEARCH

14
"Limited Service / No Service" and TREG timer expiry.
not active
not active
FULL SEARCH
or
FAST SEARCH
NORMAL SEARCH
start timer
TNORMAL_CS

15
Manual Network Search and MS in "Full Service".
cannot be active
cannot be active
n.a
parallel FULL SEARCH

16
Manual Network Search and MS in "No Service / Limited service"
n.a
n.a
n.a
parallel FULL SEARCH
Stop TFAST_CS or TNORMAL_CS if running.

17
HPLMN Search in "Full Service" state.
cannot be active
cannot be active
n.a
parallel FULL SEARCH.

18
HPLMN Search in "No Service / Limited Service" state.
n.a
n.a
n.a
parallel FULL SEARCH if MS in Limited Service

non-parallel FULL SEARCH if MS in No Service.

do not stop TFAST_CS or TNORMAL_CS if either of them is active.

18a

HPLMN Search in "No Service" state.

n.a

n.a

n.a

non-parallel FULL SEARCH

do not stop TFAST_CS or TNORMAL_CS if either of them is active.

19

MM Originated "Limited Service" search.

n.a

n.a

n.a

FULL SEARCH

20

Request from GRR, after a failure of Cell Change Order.

cannot be active

cannot be active

n.a

NORMAL SEARCH

start timer

TNORMAL_CS

21

MM originated FUNC_PLMN_SEARCH.

RR in "Full Service"

cannot be active

cannot be active

n.a

FULL SEARCH

22

MM originated FUNC_PLMN_SEARCH.

RR in "Limited Service / No Service"

may or may not be active

may or may not be active

n.a

FULL SEARCH

stop TFAST_CS or TNORMAL_CS if active.

4.1.7

Refreshing carriers with BLACK LIST SEARCH

As discussed in Section Error! Reference source not found. "Error!

Reference source not found.", MS could look for inactive Black

list carriers after a cell reselection to a different Location

Area or a Routing Area. BLACK LIST SEARCH is intended to be used

for this purpose.

4.1.7.1 After Location Area Update / Routing Area Update

After a Location Area Update (or Routing Area Update), and RR

reaches Idle state (or Packet Idle), RR shall initiate a parallel

BLACK LIST SEARCH to look for inactive carriers in the Black List.

During the parallel search, MS can look for inactive Black List

carriers only in the region it is operating at. Carriers from the

other region cannot be measured and hence shall be deleted from

the Black List.

The disadvantage of using a parallel search is that, active Black List carriers could be removed (from the other region). The only way MS could look for inactive Black List carriers across all regions is by a non-parallel search, and to do this, MS would have to stop monitoring the Paging channel. This solution is unacceptable and hence the tradeoff is made.

Please also refer Error! Reference source not found. "Error! Reference source not found."

4.1.7.2 RR in "Limited Service", requested service is "Full Service" and it has done a cell reselection to a carrier to another Location Area

When RR is in "Limited Service" and a cell reselection has been done to a carrier to another Location Area (or Routing Area), then in theory, this is a good point to do a BLACK LIST SEARCH. However, the expiry of TREG timer could be used to look at Rxlev values of Black List carriers.

After the cell reselection completes, the TREG timer shall be restarted with a duration of one second (the reg_counter value that decides the duration of TREG timer is preserved). At its expiry RR would do a NORMAL SEARCH or FAST SEARCH or FULL SEARCH as described in scenarios 11, 12, 13 and 14 in Section Error! Reference source not found. "Error! Reference source not found.". This gives the MS a chance to look for inactive Black List carriers.

If the MS is operating in an area where multiple frequency bands are present, (described later in Section Error! Reference source not found. "Error! Reference source not found.") then the Black List can contain carriers from both regions. So a non-parallel search is the only way to look for inactive Black List carriers from both regions. The type of search, parallel or non-parallel, will be decided as per Section Error! Reference source not found..

4.1.7.3 RR in "Limited Service", requested service is "Limited Service" and it has done a cell reselection to a carrier to another Location Area

After the cell reselection completes, RR shall initiate a parallel BLACK LIST SEARCH. During the parallel search, MS can look for inactive Black List carriers only in the region it is operating at. Carriers from the other region cannot be measured and hence shall be deleted from the Black List.

The disadvantage of using a parallel search is that, active Black List carriers could be removed (from the other region). However, the situation where the requested service is "Limited Service" is not considered as important as "Full Service".

4.2 Multiple Frequency Bands in a Region

4.2.1 Increasing the size of carrier list in MPH_POWER_CNF

According to 3GPP TS 03.22, MS should scan a certain minimum number of carriers on each frequency band. The numbers of carriers to be searched are 30 for GSM 850 Band, 30 for GSM 900 and 40 for DCS 1800 and PCS 1900.

This requirement is not strictly met as described in Section Error! Reference source not found..

* The size of the carrier list in MPH_POWER_CNF should be increased to 120 (40 *3) for a Triple band handset.

* The size of the carrier list in MPH_POWER_CNF should be increased to 160 (40 *4) for a Quad band handset. The following rules will be observed in filling the carrier list in MPH_POWER_CNF.

* Only those carriers are added whose Rxlev is greater than LOWER_RXLEV_THRESHOLD. Carriers are added in descending order of field strengths, irrespective of which frequency bands (and region) it belongs to.

* Carriers from the White List are added first. (The maximum number of carriers in a White List is 32.)

* There should be a minimum of 40 carriers for each supported frequency band. If there are not enough carriers available in a particular band to fill 40 elements, then an exception to 40 carriers per band rule is made for that band.

* If space is still available in MPH_POWER_CNF list more carriers can be added. The maximum limit of carriers per individual band that can be added to MPH_POWER_CNF list is 60. This is done to keep the carrier list in MPH_POWER_CNF small.

4.3 Region Selection

In the current implementation of Cell Selection Algorithm, a region is selected after the first successful synchronization of any carrier. The problem with this approach has been described in Section Error! Reference source not found. "Error! Reference source not found."

The Region Selection should be done after the MS has found a cell where either "Limited Service" or "Full Service" is possible.

4.3.1 Searching for Full Service, when MS is camped on in Limited Service (in an area where multiple frequency bands are present)

In the current implementation of Cell Selection Algorithm, if the MS has found "Limited Service" in an area where multiple regions are present and the TREG timer expires, MS would search for "Full Service" only in the region where it has found "Limited Service". Consider the following scenario; requested PLMN is on the PCS 1900 Band, in an area where there is strong coverage of DCS 1800 Band carriers. If the MS cannot find the requested PLMN (on PCS 1900 Band), it enters "Limited Service" on a DCS 1800 Band carrier. Thereafter MS will look for "Full Service" on DCS 1800 Band and GSM 900 Band carriers only. In such a case, MS will never find "Full Service" until it is able to scan across all supported Frequency Bands.

One way to solve the above problem is MS could do a non-parallel search (FAST SEARCH or NORMAL SEARCH or FULL SEARCH as described in scenarios 11, 12, 13 and 14 in Section Error! Reference source not found. "Error! Reference source not found.") across all supported frequency bands after a TREG timer expires. Any assumption made of the Selected Region (according to the first found suitable cell; see above), can also be cleared at the expiry of TREG timer, and the MS can start looking for "Full Service" across carriers from all regions. (Non-parallel search shall be used only if the MS is operating in an area which contains multiple frequency bands belonging to different regions.) The disadvantage of the above solution is that MS cannot make emergency calls while searching for "Full Service".

4.4 Searching of carriers during 2 Scans

4.4.1 FIRST SCAN and FIRST ATTEMPT

When requested service is "Full Service", RR searches all carriers from MPH_POWER_CNF for "Full Service". During this search RR will mark carriers as "Emergency cell" and "Low Priority cell" as it finds one. The scanning stops when RR finds a "Full Service" on a carrier with Normal Priority, or if the entire list is scanned. When the requested service is "Limited Service", RR searches all carriers from MPH_POWER_CNF for "Limited Service".

4.4.2 FIRST SCAN and SECOND ATTEMPT

This is only applicable if requested service is "Full Service". RR shall search only those carriers that are marked as Low Priority.

4.4.3 SECOND SCAN

This is only applicable if requested service is "Full Service". RR shall try to reach "Full Service" or "Limited Service", but will stop searching if it finds a carrier where either service mode is possible.

RR shall first search carriers that are marked as "Emergency cell", and then all other carriers from the MPH_POWER_CNF list. Searching carriers that are not marked as "Emergency cell" may seem unnecessary, but on the field, it works well in areas of weak coverage.

5

Testing

5.1 Conformance Tests

The new implementation of Cell Selection algorithm will affect GCF tests. Test Cases from 20.x and 26.x series should be retested and validated.

5.2 Alcatel Tests

The new implementation of Cell Selection algorithm will affect several Alcatel Test Cases.

All Test Cases from the following packages should be retested: SOS, MML, NAC, and PLM & SEL.

Selected Test Cases from the following packages should be retested: FRE, LOW & CCH.

5.3 PC Simulation Tests

Several PC Simulation TC's in ALR and RR entity have to be rewritten. New TC's should be written in ALR and RR entities to test the changes described in this document.

5.4 Field Tests

It is very important that the new implementations be tested in problematical areas. Such areas are regions with more than two frequency bands (Thailand) and places with influence of CDMA carriers (USA, Southern California, and Chicago). The results should be studied to adapt parameters listed in Error! Reference source not found. "Error! Reference source not found.". (Details -> Error! Reference source not found. "Error! Reference source not found.").

Appendix A. Configurable Parameters

1. TFAST_CS: 4 minutes.

FAST SEARCH should be dynamically configurable.

Example:

```
CONFIG      TFAST_CS      <value>
```

<value> value in minutes.

FAST SEARCH should be disabled when value = 0

2. TNORMAL_CS : 4 minutes

NORMAL SEARCH should be dynamically configurable.

Example:

```
CONFIG      TNORMAL_CS      <value>
<value> value in minutes.
```

3. UPPER_RXLEV_THRESHOLD, MEDIUM_RXLEV_THRESHOLD,
LOWER_RXLEV_THRESHOLD : Values to be determined

4. MAX_SYNC_FAILURES : 5

5. A new CONFIG Primitive to erase the Black List.

6. A new CONFIG Primitive to erase the White List.

7. BLACK LIST SEARCH should be enabled / disabled dynamically.

BLACK LIST SEARCH should be dynamically configurable.

Example:

```
CONFIG      BL_CS      <mode>
mode = OFF or ON
```

BLACK LIST SEARCH should be disabled when mode = OFF

BLACK LIST SEARCH should be enabled when mode = ON

Appendix B. Delivery and Field Testing

The Delivery of the improvements can be done in 3 packages.

Package 1: Contains implementation of Section Error! Reference source not found. "Error! Reference source not found."

This package addresses the following problems described under:

- * CDMA Carriers

- * Device stuck in "Limited Service"

- * BA list and Last Used Serving Cell storage and usage

Field Testing is required in areas where there is CDMA coverage.

The Chicago Drive test should be retested.

Package 2: Contains implementation of Section Error! Reference source not found. "Error! Reference source not found."

This package addresses the problem described under Multiple Frequency Bands in a region.

Field Testing is required in areas where there are multiple frequency bands (Thailand or Microsoft premises in Seattle).

Package 3: All other improvements and Section Error! Reference source not found. "Error! Reference source not found."

This package addresses the problem described under Region Selection Problem.

Field Testing is required in areas where there are multiple frequency bands (Thailand or Microsoft premises in Seattle).

Appendix C. Open Questions

1. Can the black list be stored independent of the service at switch off? This is useful in cases where the device does not have a SIM inserted, and after power on the device has to find limited service as soon as possible?

Maybe it makes sense to store the Black List during switch OFF if the TFAST_CS timer is active. This might be useful when a user in bad signal conditions try to "reset" the mobile.

2. What are the other possible candidates for the White List?

o Cells contained in the IE BA List Pref from the message Channel Release

o a cell, which is used very often as a serving cell in the past.

3. Is the FAST SEARCH also useful if requested service is "Limited Service"? In these scenarios a quick re-finding of at least limited service is also important.

4. MS cannot do a BLACK LIST SEARCH during Dedicated mode (voice call or GPRS Packet Transfer). If the MS has moved several Location Areas (or Routing Areas) during Dedicated mode, then the Black List may become inconsistent.

How do we handle this?

Can the Black list be erased if the MS has moved several location areas in PTM or dedicated mode?

Current Implementation