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Title: **Issues relating to use of radio access technology (RAT) in the periodic PLMN scan**

Agenda item: **9.22**

Document for: **Discussion**

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1. Introduction

This document has been drafted to provide an overview of the current situation regarding the use of radio access technology (RAT) in the periodic PLMN scan and to highlight some of the areas of concern that Motorola have with regards to the current proposal.

It is understood that not all the issues raised will be of immediate concern but any changes to the 3GPP specifications must take into account all possible scenarios and situations to provide as full and complete a set of specifications as possible.

The intention is to provide a basis for discussion so that those issues that need to be resolved in the specifications can be clearly identified.

It is also necessary that any issues that are not resolved by changes to the specifications should be clearly documented to minimise the risk of these issues being opened again, some time in the future, causing further instability to the specifications.

The issues raised in this document are those that have been identified up to now and, as further work is done on the proposed use of the RAT in the periodic PLMN scan, it is possible that other issues may come to light.

2. Initial proposal

In order to avoid a UMTS subscriber logging onto a GSM network, when UMTS coverage is available, it has been proposed that:

> The periodic PLMN scan could be used to 'force' the UE to re-select to the UMTS part of the serving PLMN.

The basis of the proposal is:

1. To provide the UMTS subscriber with a UICC with a USIM application containing an unused 'home' PLMN code in the IMSI. This will mean that, since the subscribers 'real' home network uses a different PLMN the subscriber will have no Home PLMN and will therefore always be roaming and always on a VPLMN.
2. Set the following prioritisations for the UMTS subscriber
   a. MCC MNC Operator 1 UMTS
   b. MCC MNC Operator 2 UMTS
   c. MCC MNC Operator 2 GSM
   d. MCC MNC Operator 1 GSM

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Based of these settings it has been assumed that, with such a priority list, a mobile will reselect back to UMTS whenever it does a PLMN search. That is, it has been assumed that a mobile camped on Operator 1 GSM will re-select to Operator 1 UMTS when the periodic PLMN scan is performed.

Note: The priority list above is very limited and a mobile is required to support much large lists with many various combinations.

3. Problems with proposal

This proposal is not in line with Motorola's understanding of the 3G specifications or with the way dual-mode networks (i.e. a network supporting GSM and UMTS access using a single PLMN Identity) are designed to work.

The 3GPP TSG SA workshop on UE in idle mode (7 – 8 February 2001) discussed the issues relating to periodic PLMN scanning and decided, that:

> "Also it was agreed that for the purpose of the background scan only PLMN code on the preferred list is to be taken into account not the RAT".

This decision was presented to and accepted by TSG SA#11 and the development of the specifications has been carried out in light of this decision.

The issue of RAT dependent rejection was also discussed by the workshop. It was noted that even if two RATs were separated by Location Area, it would still not provide the correct solution if, e.g., roaming was only allowed to one RAT of the network. This was due to the fact that the available rejection causes #12 and #13 would either make the UE stay in the location area without service or make the UE perform a PLMN selection. However, it was identified that it was possible for an operator to use separate PLMN IDs for each different RATs which would then enable the operator to have differentiated access rights to different RATs. It was also identified that a set of new rejection causes allowing to reject the access to one RAT might be a possibility. The workshop agreed that it was not essential for the workshop itself to provide a recommendation on this issue as it seemed only to impact the 3GPP TSG CN specifications.

Subsequent to the workshop the assumption when drafting changes and modifications to the specifications has been that an operator wishing to have differentiated access rights to the RATs under his control will do this using separate PLMN IDs. This solution is already provided in the 3GPP specifications and would solve the current national roaming issue, which lead to the proposed use of RAT in the periodic PLMN scan, without destabilising the specifications.

Up until this point in time the 3GPP specifications have been developed on the basis that the Core Network and Radio Network aspects of the system should be as independent as possible and that wherever possible the different protocol layers are separate entities. As such a number of features, such as the Equivalent PLMN List, have been included which are designed around the assumption that the radio access technology is not used during the periodic PLMN scan.

A mobile implementing a periodic PLMN scan using the radio access technology may end up 'hopping' between radio access technologies of the same PLMN causing unnecessary signalling load in the PLMN as well as adversely impacting battery life.

4. Current Situation

It has been recognised that the initial proposal to make use of the RAT in the periodic PLMN scan leads to a potential 'hopping' issues where a mobile will change RATs, within a single PLMN, unnecessarily. In fact, since the issue was originally raised a CR has been agreed by TSG SA WG1 to explicitly forbid a mobile from reselecting another RAT on the registered PLMN due to the periodic PLMN scan.

To overcome the 'hopping' problem, while enabling the use of the radio access technology in the periodic PLMN scan, a change to TS 23.122 has been proposed which the originators believe will solve the issue while providing the mobile functionality they are seeking.

At present Motorola have identified several issues that need to be reviewed and resolved prior to the proposal being considered acceptable.

5. Issues that need to be considered

5.1 General

Given the decision taken at TSG SA#11 there is a need to clarify exactly what the 3GPP service requirements are relating to the use of RAT in the periodic PLMN scan.

TSG SA WG1 needs to review and comment on the proposed use of the RAT in the periodic PLMN scan.

In addition the proposal has only been presented to the 3GPP TSG CN WG1 group even though it may impact aspects of the Radio Network.

5.2 Impact on 2G and 2.5G mobiles

Work will have to be done to clarify the impact on single-mode (or limited-mode) terminals.

For a GSM only mobile it would seem that the PLMN list to be used should only consist of those PLMNs which are on the GSM frequency. So based on the originally proposed list, in section 2 (i.e. PLMN1 UMTS, PLMN2 UMTS, PLMN2 GSM, PLMN1 GSM), the requirement would seem to be that PLMN2 GSM is a higher priority than PLMN1 GSM and therefore it would need to be clarified in the specifications that a GSM only mobile should not take PLMN1 UMTS and PLMN2 UMTS into account at all.

Clarification to TS 23.122 and perhaps TS 24.008 will be needed.

5.3 Registration failure due to radio conditions etc.

The current proposal includes the following requirement: "If the PLMN of the highest available PLMN/access technology is the current serving VPLMN or it is in the "Equivalent PLMNs" list, the MS shall remain on its current PLMN/access technology".

What is not clear is what actions the MS is expected to take if a previous registration attempt on the higher priority RAT failed due to either radio conditions or registration rejection.

Is the higher priority RAT to be considered as available or not?

What about the case that the cell in the higher priority RAT is barred?

Should the mobile consider the different settings of CBA, CBQ and CBQ3 relative to its own capabilities and use these as a measure of availability?

In the case that the LA of the higher priority is on the list of forbidden LAs should the mobile consider the RAT as available or should it look for the RAT in another LA?

Clarifications to TS 23.122, TS 24.008 and possible the radio specifications need to be considered.

5.4 Possible problem with new definitions

The proposal introduces a definition of an available PLMN/RAT but it would seem that the definition should be included in the relevant radio specifications.

Also, GERAN Iu mode does not appear to be covered by the proposed new definition. References to GERAN and RAN specifications can no longer be based on A/Gb and Iu Mode alone.

5.5 What about mobile behaviour in networks which are not coordinated

The proposal is based on the assumption that the PLMN, that the mobile is registered on, is a coordinated PLMN. That is, there is an assumption that the cell reselection parameters have caused the mobile to move to one access technology or the other.

The introduction of the requirement that the presence of one RAT causes the mobile to stay on another RAT of the same PLMN will impact those operators who are effectively running independent networks (i.e. same PLMN code but no cell re-selection between the different RATs) and will prevent the behaviour that they might expect if the RAT is to be used as part of the periodic PLMN scan.

In the case that a mobile has registered within a particular RAT and is being kept there, for example because the neighbour cell list does not include any cells of the other RAT, what should the mobile do if it loses coverage and moves to the other RAT of the same PLMN?

It is not clear if this issue was discussed when TSG SA WG1 agreed the CR to TS 22.011 introducing the requirement that “Periodic network selection shall not lead to change of access technology within the registered PLMN”.

The introduction of the requirement to not move RATs within a PLMN would also seem to impact those operators that are in the early phases of rolling out a coordinated PLMN. In many cases it is impossible to update a network in ‘one go’ and there will often be an extended phase during which the neighbour cell lists are not complete. In these cases an operator may require the mobile to move RAT during the periodic PLMN scan, in contradiction of the latest proposal.

TSG SA WG1 need to review the proposed CR to TS 22.011 and decide if there is a service requirement to allow for mobiles to move between RATs in certain circumstances.

5.6 Equivalent PLMN list interactions

The 3GPP specifications, including the Equivalent PLMN list concept, have been drafted with the assumption that the RAT should not be used for the periodic PLMN background scan, amongst other reasons to avoid a ping-pong effect between RATs of the same PLMN. Therefore the EPLMN list does not include RAT information.

If the EPLMN list is used then the proposed functionality will be disabled as all RATs of a PLMN will be considered to have the same priority. In effect this means that for the proposal to work the EPLMN list will have to be disabled in the visited network and, while it is understood that this will be decided on a case by case basis, it would seem that this issues needs to be reviewed further. For example, what would happen if at some future date an operator decided to use the EPLMN list to coordinate his FDD and TDD networks?

It is Motorola’s understanding that several operators are planning to use the EPLMN list, particularly in border regions where the EPLMN list provides a useful tool for border frequency coordination. The EPLMN list can be used to ensure that normal cell border re-selection criteria apply when crossing the border and prevents mobiles from causing interference due to dragging networks across borders.

In the case a VPLMN is using an EPLMN list there is the likelihood that the use of the list will nullify the proposed use of RAT in the periodic PLMN scan.

The proposal to CN1 clarifies how the EPLMN list is to be used, i.e. all RATs of a PLMN are considered to have the same priority, but there is a risk that its use could have unforeseen effects in other areas.

It needs to be ensured that the proposed change to TS 23.122 is sufficient and that nothing is needed in TS 24.008.

5.7 Impact on other specifications

At present there is an assumption that the proposal only impacts TS 23.122 however it is not clear that this is the case.

TS 24.008 has a number of instances where Location Area Update and Routing Area Update attempts can be rejected with causes that instruct the mobile to perform a "PLMN selection as defined in TS 23.122."

With the introduction of the use of RAT into the PLMN selection procedures there needs to be a clear definition in TS 24.008 as to whether PLMN or PLMN+RAT is to be used in the cases where the mobile is rejected from registering in a particular Location Area or Routing Area.

This is probably a minor issue but must be considered when trying to elaborate a complete solution.

5.8 Need to break RAT into the different frequency bands

If the RAT is going to be used in the periodic PLMN scan then it would seem that the RAT should be identified not just as UMTS but rather as FDD, TDD high rate and TDD low rate. If this is not done then it is possible that once TDD is launched that a request to introduce this requirement into the specifications will be raised.

Within GERAN, for example TS 45.008 (section 8.1.5), it is clear that FDD, TDD and cdma200 are already treated as separate radio access technologies. As an example:

i. For UTRAN FDD cells the measurement quantities to be used are CPICH Ec/No and CPICH RSCP and RSSI.
ii. For UTRAN TDD cells , the measurement quantity to be used is PCCPCH RSCP.
iii. For cdma2000 cells, the measurement quantity to be used is PILOT_STRENGTH of the pilot.

Once RAT is used, then not only will there be a need to separate FDD and TDD, there is a strong possibility that some operator will present a requirement for choosing PLMNs based on the different GSM frequencies (e.g., 1800, 1900, 900, 850 etc). In fact this has already been proposed within 3GPP2.

Additions of new code points to the specifications are needed to identify the different RATs.

A clear decision needs to be taken by TSG SA WG1 regarding the need or not to separate out the different RATs and frequency bands. In Motorola's view there should be a clear statement that the GSM frequencies are not separated out while it seems reasonable to identify the different UMTS access technologies (i.e. FDD, TDD (high and low)).

5.9 Mobile behaviour in case of manual selection

If the RAT is to be included in the background search it would imply that the user should be able to enter the PLMN RAT via the user interface (see following section 5.11).

Also if RAT is to be considered it seems reasonable that for Manual mode and for Automatic mode user selection should be clarified to be specific with respect to PLMN/RAT combinations.

In the case of Manual mode selection should the mobile attempt to register on another RAT of the serving PLMN, if it is available, or should the mobile behave as proposed for Automatic Mode and remain on the current RAT?

To ensure consistent behaviour of mobiles this issue needs to be reviewed by TSG SA WG1 and a clear service requirement identified.

Depending on the decision within TSG SA WG1 changes to TS 23.122, and perhaps TS 24.008, would need to be considered.

5.10 Relationship to other activities ongoing within 3GPP

5.10.1 Network Sharing

Given the work that is currently being done within 3GPP on Core Network Sharing it needs to be clarified what relationship, if any, the use of RAT in the periodic PLMN scan will have with the work being done. It should also be considered what relationship there is, if any, to 'private' access networks.

5.10.2 WLAN

The work on WLAN is also specifying requirements for PLMN selection and a check needs to be made to identify the relationship, if any, that exists between the proposal and the WLAN work.

The potential interactions between WLAN and multiple access networks on a core network needs to be considered. Perhaps the way forward on this would be to organise a workshop on access network selection.

5.11 Impact on User Interface

5.11.1 User ability to enter RAT information

If the RAT is to be taken into account then there is likely to be an impact on the user interface.

If the RAT is going to be part of the periodic PLMN scan then there may be a need to ensure that the facility is provided for the user to enter PLMN + RAT combinations.

While this functionality may not be required by all operators, it is possible that user expectation may not be meet if they can't choose the RAT they require and that other markets may require the functionality.

It needs to be clarified if there is a service requirement for the user to be able to enter the PLMN+RAT and whether it has to be provided by the mobile. The concern here is that the EU has strong rules regarding anti-competitive behaviours which could severely impact the mobile vendor if not met.

As the specifications are common to all 3GPP markets this issue needs to be considered (it was one of the original reasons for not using RAT in the periodic PLMN scan).

5.11.2 Impact of user input on operator's choice

Any user input (i.e. User Preferred PLMN list) is given higher priority that operator input (i.e. User Preferred PLMN list) which potentially means the user can nullify the operator choices.

It is assumed that this particular issue can not be solved within the specifications.

5.12 Interaction with RRC Connected States

In some RRC Connected States the mobile is required to perform periodic PLMN scanning using the procedures defined in TS 23.122. It needs to be ensured that changes in TS 23.122 do not impact the expected RRC behaviour defined in TS 25.331.

Also, when the mobile is in the CELL_DCH and CELL_FACH states the periodic PLMN scan is disabled which means that these states have an impact on how quickly a mobile returns to a higher priority PLMN. While this issue is not directly related to the proposal it is worth noting that the mobile can be in the CELL_DCH or CELL_FACH state for a considerable amount of time (measured in hours).

5.13 Possible impacts on 'traditional' national roaming

The proposal breaks the principle that the mobile can never assume availability of a Network/Location Area/RAT without having an active communication with a cell of that Network/Location Area/RAT. In general, the only exception to this principal is for emergency camping.

With the proposal that the mobile should not move RATs within a PLMN it is possible that the use of the existing national roaming cause values in TS 24.008 (in particular cause #13 'Roaming not allowed in this location area') may be nullified.

> Note: With the current specifications it is possible to use cause #13 to force the mobile to perform a PLMN selection.

Currently, a mobile attempting to register on PLMN1 UMTS can be sent cause #13 to 'force' it to perform a PLMN selection with the intention that it would register on PLMN2 UMTS (assuming both PLMNs are available).

With the TSG SA WG1 change to TS 22.011 and the related parts of the proposal seen in TSG CN WG1, if the mobile is on PLMN1 GSM it will never attempt the registration on PLMN1 UMTS and therefore can not be made aware of the national roaming restriction. It also means that the mobile will remain within PLMN1 GSM even though PLMN2 UMTS is available and able to provide service.

TSG SA WG1 need to review the proposed CR to TS 22.011, which prevents moving between RATs of the same PLMN, to ensure that the impact on the existing national roaming scenarios are understood and accepted.

5.14 Other general issues

There have been suggestions in the past to have the RAT introduced into the different location update rejection causes and proposed limitations in the call set-up based on the RAT. All of these have been seen to break the fundamental principle of layer independence, and have been rejected.

6. Conclusion

Before any decision is taken by TSG CN there is a clear requirement that TSG SA (TSG SA WG1) define and approve the service requirements for the use of RAT in the periodic PLMN scan.

Once TSG SA has approved the service requirements, work then needs to be done to ensure that the use of RAT in the periodic PLMN scan introduces as few problems as possible into the current 'stable' specifications. Work also needs to be done to ensure that the proposed solution is as complete as possible so as to avoid a string of consequential changes to the specifications at some later stage.

The issues raised in this document are those that have been identified up to now and it is possible that other issues may come to light.

Motorola would be happy to work on resolving the issues listed above with the intention of having a complete set of changes to the 3GPP specifications agreed at the June TSG plenary meetings.