INTERACTION AND CONTROLLING MECHANISMS FOR TERMINAL UPDATE

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ABSTRACT

Reconfigurable terminals roaming among different regions covered by heterogeneous radio networks requires terminal upgrade in terms of terminal reconfiguration such that the task of radio connection is fulfilled. However, upgrading technologies belonging to different operators are different in different roaming region, Public Land Mobile Network (PLMN), this will also impose different enabling technology and methods for upgrading. Although The Home Location Register (HLR) has specified restricted regions where certain terminal cannot get access to, but there are still great number of region where terminal can be roamed to with different standardization as in the home region. Therefore it is necessary that an interaction procedure between the terminal and the visited radio network to take place before the real upgrade/ reconfiguration is carried out. In this paper we introduce an interaction procedure between reconfigurable terminal and radio network such that unnecessary software download is avoided and hence radio resources and cost related to remote service download are saved. Moreover we introduce the concept of establishing Software Download Boxes (SDB)/proxies in the home network for terminal roaming in foreign networks. Simple forwarding of all mass software upgrades to the location of the terminal would generate a lot of undesired download traffic and additional cost to be paid, hence SDB will solve this problem.

1. INTRODUCTION

Software Defined Radio (SDR) as an emerging technology is expected to provide efficient and inexpensive mechanisms for the production of multi-mode, multi-band and multi functional mobile terminals. Reconfigurable terminals are able to adapt to large variety of regional radio access technologies as well as compensate for the lack of globally deployed universal radio standard and also facilitate improved and flexible services for better personalization and choice for the mobile users. Manufacture maintains the rights to upgrade their delivered terminal with different degrees of flexibility; whereas, the upgrade process includes upgrade of modulation schemes, coding mechanisms, speech codec, language set, etc [1]. However the upgrading technologies belonging to different operators, enabling technology are different in different roaming region (PLMN). And although home location register (HLR) has specified the restricted region where certain terminal can not get access, there are still great number of region where terminal can be roamed to, but with different standardisation as in the home region. For such terminals roaming among different regions covered by heterogeneous radio networks, and affiliated with PLMN which doesn't support the added feature on the Mobile Terminal MT, certain method should be invented to avoid unnecessary MT update through software download (SD). This paper describes a method to avoid unnecessary terminal update; especially the situation where a local area RAN is not able to support terminal upgrade. This situation occurs when a terminal registered in a region, where the local radio network does not support added features of MT, the recommended controlling mechanism can be applied in order to avoid unnecessary terminal upgrade. The paper is organized as follows: involving entities in the upgrade procedures are firstly introduced in section 2. The scenarios considered are described in section 3, followed by the proposed controlling avoiding unnecessary terminal update in section 4. Section 5 summaries the paper.

2. INVOLVING ENTITIES AND SIGNALLING

General Terminal update procedure can be triggered by the terminal itself (terminal centric) or by the network (network centric). In both cases, the terminal itself serve as gateway connects the manufacture server to radio sub-network. In order to identify the terminal, the EIR (equipment Identity Register) is also needed. In order to support terminal reconfiguration, proxies controlling the reconfiguration process in levels of RAN are necessary [1][2] In the following the definition and functioning of all the involved entities are described:

- Reconfigurable Terminal: The terminals access to radio network to fulfil radio connections. The terminal can be reconfigurable which could support radio scanning to allow its base band transceiver chain upgraded to the current radio air interface. The terminal might not be reconfigurable terminal, but allows push service from manufacture server or operator server to be upgraded. Each mobile terminal consists of a unique international mobile equipment identity (IMEI) and an international mobile subscriber identity (IMSI) stored in the subscriber identity module (SIM).

- SGSN: An SGSN delivers packets to mobile stations within its service area. The SGSN sends queries to the Home Location Register (HLR) to obtain profile data of mobile subscribers. The SGSN detects new mobile stations in a given service area, processes registration of new mobile subscribers and keeps a record of their location inside a given service area.

- GGSN: A GGSN is used as an interface to external Packet Data Networks (PDNs). The GGSN maintains routing information, which are necessary to tunnel the Protocol Data Units to the SGSN serving a particular mobile station. Other functions include network and subscriber screening and address mapping. GGSN has higher hierarchy level than SGSN.

- HLR: The HLR is a database located in the user's home network. HLR stores the different profiles of the subscriber and services as well as the routing information. The service profile consists for example of information on allowed services, forbidden roaming areas etc. For the purpose of routing incoming transactions to the UE, the HLR also stores the UE location on the level of SGSN (i.e. on the level of serving system) as well as other packet domain subscription data. The HLR is accessible both from the SGSN and GGSN via the Gr and Gc interface respectively, as shown in Figure 1.

- EIR: The EIR is a central database that stores data related to the mobile station. The EIR interfaces both to the MSC/VLR for circuit-switched services and to the SGSN for packet-switches services, as shown in Figure 1. The EIR stores the International Mobile Equipment Register (IMEI) of all mobile stations. The IMEI is a unique key allocated to MEs upon granting of type-approval [5]. The IMEI can uniquely identify a mobile station and functions therefore as the key by which network operators can identify terminals targeted for upgrades.

- Reconfiguration Managers: Three different levels of reconfiguration managers can be classified: proxy reconfiguration manager (PRM) residing in RAN, serving reconfiguration manager (SRM) residing in core network, e.g, SGSN level and home reconfiguration manager (HRM) runs exclusively by home operators. The PRM serves as download proxy that performs short-term caching. It supports both individual software downloads initiated by the terminal and supplier-initiated mass software upgrades of terminals using cell broadcast mechanisms. The PRM should support resumption of interrupted software downloads. The SRMs act as system of distributed software download servers providing requested software to the PRMs. Software is obtained from the HRM and long-term caching is performed for scalability reasons. HRM provides support for individual software downloads, coordinates mass software upgrades and communicates with external software suppliers. Each mobile network operator runs just one HRM; scalability of software downloads is achieved by delegating tasks to the SRMs.

In case the manufacture triggers updating procedure, the EIR consults the home location register. With the mapping table between the IMEI and IMSI, network operator pages the mobile terminal. Once the RRC connection between the radio network and mobile terminal is established, terminal update is carried out [8].

However, in most cases, the network is not aware of what information the mobile terminal has received, what kind of features the terminal will acquire after the update. In many cases, the network will not be capable to support the updated terminal; therefore the reconfiguration/update procedure is a waste of radio resource.

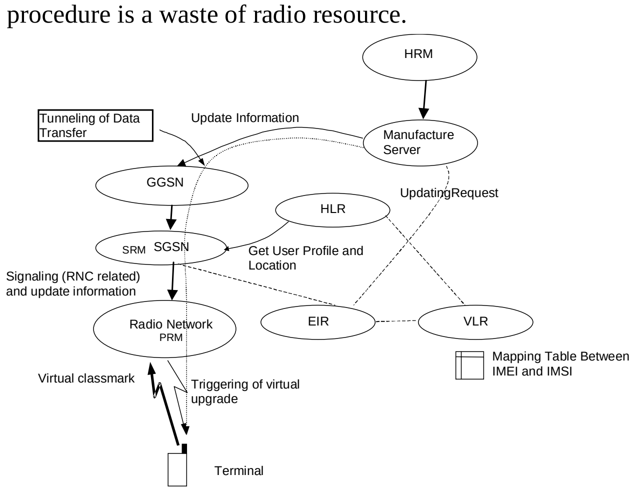

Figure 1, Involving Entities and Signaling

3. SCENARIOS

With the on-going mobile business, manufacture will play a roll more towards the direction as service provider and to maintain a relationship with their customers long after the terminal has been sold. Terminal manufactures look up the mobile profile registry to keep their products always with up-to-date functionalities [9]. In many cases the terminal receive paging information (contain the upgrade request) from the manufacture server or home network operator for carrying certain upgrades, to save radio resources, we propose a scenario where an interaction procedure will take place between local radio network and the terminal to

upgraded before a real download starts, so that unnecessary delivery of updating patch/reconfiguration is avoided.
Besides to the above-mentioned scenario, issues related with terminal limitation and cost model also restrict the Software Download (SD) procedure. For instance, upon the SD, terminal memory is heavily occupied by other applications, which also results in limited execution power; High expected cost of the download exceeding the cost restrictions specified in the user preferences (e.g. on expensive low-bandwidth connections or when roaming in a foreign country).

The above-mentioned reasons are in favor of a rejection of a particular software upgrade. In all cases, the problem with the simple rejection strategy is that the software upgrade may be required at a later time, but then the mass upgrade will probably already be finished and the terminal will get no notification concerning the existence and severity of the upgrade. Moreover, when roaming in foreign networks, the terminal does not get any information about software upgrades at all as the mass software upgrade mechanisms does not propagate into foreign network domains. Simple forwarding of all mass software upgrades to the location of the terminal would generate undesired download traffic and additional cost to be paid either by the software supplier or by the mobile subscriber. To solve this problem we propose establishing Software Download Boxes (SDB)/proxies in the home network for terminal roaming in foreign networks.

4. CONTROLLING MECHANISMS AVOIDING UNNECESSARY SD

All mentioned problems can be solved by introducing signaling involved in RAN with support of decoding classmark from terminal entities. Furthermore, to avoid unnecessary SD, especially SD related with application layer services, can be solved by introducing an additional element that we called *Software Download Box (SDB)* in the home network. For each mobile subscriber an individual entry in Software Download Box is configured. Based on rules configured by the user the Software Download Box decides autonomously whether a software upgrade should be accepted (i.e. forwarded to the current location of the terminal), rejected once and for all, or delayed (i.e. stored in the software download box and executed at a later date when the situation is conforming with the rules specified by the user). The case of delayed software download will be described in more detail in the next section. Also the local solution and the SDB solution will be compared to the classic mechanism supporting terminal upgrade, which is straightforward without considering whether the current radio network could support the upgraded features of terminals [4][5].

4.1. Interactions between Terminal and Local RAN

Before the update procedure is carried out, the mobile terminal answers request from radio network by sending its ‘virtual’ characteristics (virtual classmark) allowing the network to be inform about the terminal capability after update. Where, the term ‘Virtual’ means the terminal future feature if the upgrade is carried out. In case the RAN supports the future terminal capabilities, software download and reconfiguration can proceeds. The SD procedure will be terminated with non-success indication registered in ELR, i.e. in case that the current network doesn’t support the future terminal capabilities as depicted in Figure 3.
The future terminals are expected to have numerals features, which will dramatically increase the uplink signaling and on the other hand, it will bring more time to the radio network to add more delays in the decision process. In the uplink when the network asks the terminal features, the terminal could send its future classmark (virtual classmark) in a compressed version, so that uplink signaling is saved [7]. Thanks to the mapping table in the terminal profiles in core network, radio network could consult the mapping table to inform the terminal its capability.

Intermediate nodes shown in Figure 3 could also intervene the upgrade procedure, e.g., the proxies could identify user profile to judge the upgrade can be carried out or not.

A certain cache function could also be added into RAN. In step ① depicted in Figure 3, right after the upgrade request step, the MS could transfer data to RAN. RAN or PRM (proxy reconfiguration manager [1][10]) could cache the transferred data. If the terminal refuses the upgrade, the buffer should be reshuffled. The cache function will reduce the delay of terminal update.

Terminal could still fulfil update even the network could not support the future upgraded features, as step ① in Figure 3 shows. In case the terminal has the ability of relatively super capability and high mobility (e.g. leave the current PLMN soon). This procedure can be finished by user interaction, e.g., by pressing a button.

With the reporting virtual classmark from MT, network could also cancel RRC connection at step ① in Figure 3. This is for reliability reason from network point of view. It is not negligible that wrong re-configuration/update of terminal might bring negative effect to the operation of radio system.

4.2. Delayed SD Supported by SDB

A Software Download Box (SDB) can be involved in five different kinds of actions [11]:

- Update of SDB configuration: The user initiates or changes the configuration of the SDB, i.e. adds, modifies or deletes rules describing the behavior of the

SDB. The rules are analyzed in the following situations: When a mass software upgrade occurs, a decision about rejection, acceptance or delaying of the upgrade has to be made. When the user or terminal context changes, a decision about the execution of delayed software upgrades has to be made.

- Notification of context change: The terminal sends information on changes of user or terminal context to the SDB; the SDB analyzes the context information and triggers a software upgrade if the situation complies with according execution rules for delayed software upgrades
- Treatment of software upgrade notification: When performing a mass software upgrade, the HRM sends software upgrade notifications to all SDBs. Each SDB investigates its rules and decides, whether the upgrade has to be rejected, or accepted and forwarded to the terminal if that is roaming in a foreign network, or delayed and performed at a later date. The HRM receives acceptance reports from all SDBs.
- Execution of delayed software upgrade: After reception of a context change notification, the SDB checks if any of the pending software upgrades are now appropriate to be performed. If this is the case, the SDB sends a request to the HRM to trigger the respective software upgrades for the terminal.
- Reporting of successful software upgrade: After a delayed software upgrade has been performed and the terminal has reconfigured / verified the software successfully, an upgrade report is sent to the SDB. The SDB forwards the report to the HRM in order to support the reporting mechanism for mass software upgrades.

In Figure 2, scenarios illustrating the sequence of events for these five actions are described. At the bottom of the diagram, the treatment of a software upgrade notification is shown. The mass SD can be triggered by an administrator or by an automatic upgrade manager. Before performing the mass software upgrade, the HRM sends an upgrade notification to the SDB. The SDB checks the upgrade rules and decides that the upgrade has to be delayed as the user is currently roaming. It stores the notification internally and sends an according acceptance notification to the HRM. The HRM sends a compilation of all acceptance notifications received from the SDBs to the administrator. SDB is responsible for filtering and delaying software upgrades on behalf of the user's terminal. It manages download of software upgrades that have been stored in the software registry to the terminal in an asynchronous and situation-aware manner. The network operator maintains one SDB per user; therefore, the SDB has possibly to keep track of the states of several terminals belonging to one user.

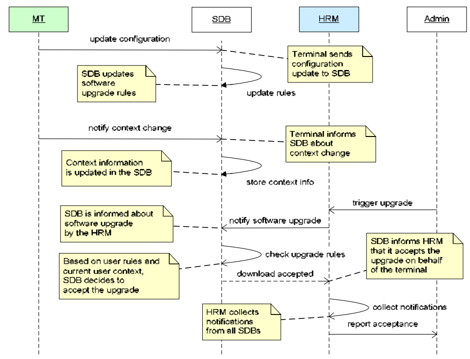

Figure 2, Configuration update, context change notification and software upgrade notification

5. CONCLUSIONS

This contribution suggests added procedure to the terminal upgrade. Such an interaction between mobile terminal and radio network prior to the upgrade is necessary to avoid software download and hence save the radio resources and reduce the down-link burden. Moreover, open signaling structure will allows remote PLMN intervene terminal update procedure and effectively avoid unnecessary update. With the reporting virtual classmark from MT, network could also cancel RRC connection and this will ease judgement decision, so that the radio network could response terminal with less delay.
Proxy solution in home network is another solution avoiding unnecessary SD. In these cases, the design of the network infrastructure has to be reconsidered.

Reconfigurable radio may well be used together with traditional network infrastructure, which does not provide any support for the features of re-configurable radio. However, the full benefit of SDR show up only if the network infrastructure takes into account the specifics of a particular terminal and provides support for it.

The distribution pattern of terminal and user-related information (profiles) is changed compared to conventional networks. Indexing scheme like classmark can be used to efficiently support terminal upgrade and SD control. On the other hand, software download support must be integrated into network infrastructure. Focus on fixed radio standards is likely to be reduced in favor of greater flexibility.

Technical solutions for one particular problem related with software download have been indicated in this contribution. Further study and system realization are required to establish a full-blown concept for a future network infrastructure supporting terminal reconfiguration.

ACKNOWLEDGEMENT

The authors would like to acknowledge the contribution of their colleagues Christoph Niedermeier and Reiner Schmid from Siemens AG.

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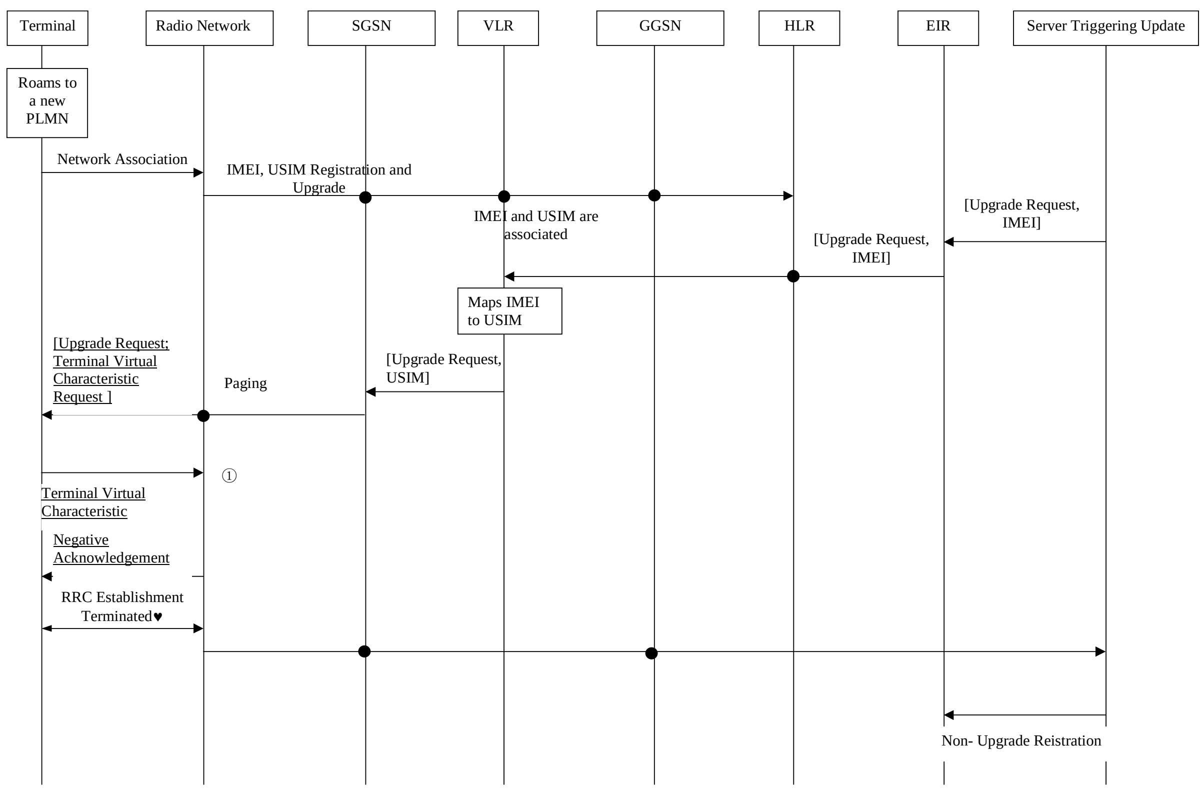

Figure 3, Terminal Upgrade with Negative Acknowledgement