LOCAL SOFTWARE UPDATE FOR TERMINAL RECONFIGURATION USING AD HOC NETWORKS

Lian Yao and Christian Prehofer
(DoCoMo Communications Laboratories Europe GmbH, Munich, Germany;
{*yao, prehofer*}*@docomolab-euro.com*)

ABSTRACT

This paper introduces a local software update server for terminal reconfiguration and proposes a loose control concept. Our approach uses ad hoc network connectivity for software download via high bandwidth, short-range radio access technologies, like WLAN, Bluetooth, which allows more efficient software downloads and cuts down the overall terminal update time. The data and signaling flows of the terminal reconfiguration process are separated. They are performed independently in the ad hoc network and the cellular network. In this way, the scarce radio resource of the cellular network can be largely saved.

1. INTRODUCTION

Software Defined Radio (SDR) is considered as one of the promising technologies for future mobile communication systems. Mobile users will only benefit from this global telecommunication environment if they are equipped with reconfigurable terminals, which provide universal multi-mode, multi-band functionality within one reconfigurable platform. These terminals have to be capable of operating in several modes of different radio access networks and to support the whole range of applications available on the specific devices in heterogeneous networks.

A terminal reconfiguration process typically includes five phases: available mode lookup, mode negotiation, decision making, reconfiguration (including software download) and location update [1]. Among these phases, software download is a key enabler for ubiquitous reconfigurable terminals.

There are different methods for software download, e.g. smart cards, fixed connections and over-the-air (OTA). Software download over the air interface is the most versatile method to provide the reconfigurable terminals with new application services, software updates, networking protocols and configuration software etc. However, it is also a time and radio resource consuming phase in the whole reconfiguration process. In the conventional approaches of network support for terminal reconfiguration, such as the IST TRUST Project [1] and Mobile VCE RMA (Reconfiguration Management Architecture) [2], the whole terminal reconfiguration process only can happen when the Mobile Terminal (MT) is reachable by the network, i.e. there is connection between the MT and the Reconfiguration Manager (RM). When the network load is very high or if the connection between the MT and the RM is not good, the software download process cannot be carried out successfully. On the other hand, when a large number of terminals demand reconfiguration at the same time (e.g. mass upgrade), the reconfiguration process will have large impact on the conventional voice and data mobile communication.

In order to save the scarce radio resource of the cellular network and cut down the overall terminal update time, we propose a loose control concept. For this, we introduce a local software update server – Local Software Repository (LSW-Re) using ad hoc network connectivity for software download via high bandwidth, short-range radio access technologies, like WLAN, Bluetooth.

In the following sections, the overall functional architecture for local software update is presented at first. Interactions between the functional components are illustrated by software download scenarios afterwards. The last section concludes our paper.

2. FUNCTIONAL ARCHITECTURE

We define the combination of the centralized cellular network (i.e. cellular network) and the decentralized ad hoc network as a hybrid network. Both of the cellular network and the ad hoc network are interworking with each other. Our goal is to provide optimal support for terminal reconfiguration in hybrid networks.

A local software update server – LSW-Re located in the ad hoc network is used for software download via high bandwidth, short-range radio access technology. A Reconfiguration Manager (RM) located in the cellular network takes the role of reconfiguration control and management (see Figure 1).

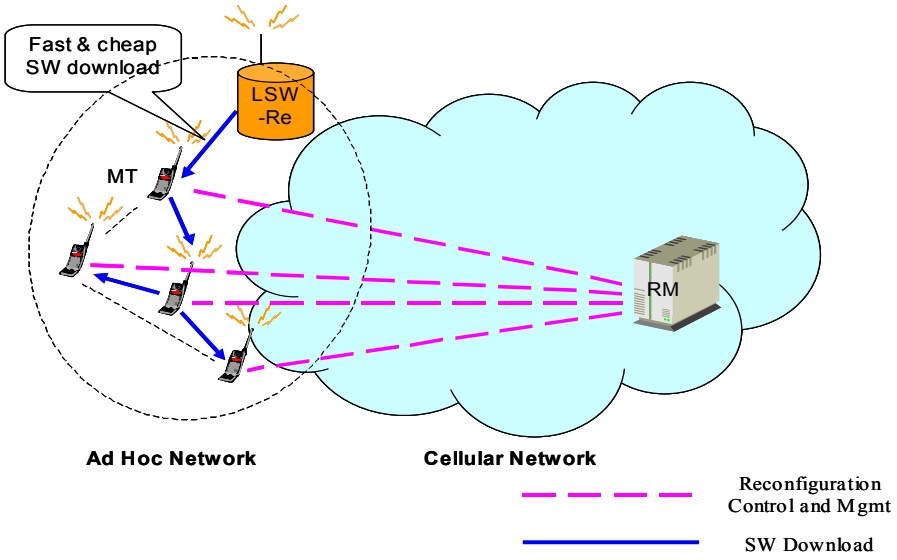

Figure 1:Overall Functional Architecture

We assume that every MT has two wireless connections, one is for the cellular network connection and the other is for the ad hoc network connection.

2.1. Loose Control Concept

As shown in Figure 1, the data flow is passed through within the ad hoc network, and only the signaling flow is carried out in the cellular network. The MT acts like an intermediate for signaling between the LSW-Re and the RM, but operates independently. The MT can find the local software update server – LSW-Re by service discovery mechanisms without the help from the RM, then starts software download and performs the reconfiguration. It is only necessary for the MT to notify the RM of the success of reconfiguration (and completeness of software download) when the connectivity is available between the MT and the RM. Section 3 will detail the interactions between the different functional components by sequence diagrams.

2.2. Local Software Update Server

The LSW-Re located in the ad hoc network provides the local resource for software download. It can be operated either by the network operator or a trusted third party. However, in case it is operated by the trusted third party, depending on the software to be downloaded, a relationship with the operator could be necessary for security reason. In order to avoid downloading of malicious software, security checks must be performed before a software module is installed and executed to ensure that the software originates from a trusted source and it has not been tampered with [3]. Security consideration must be taken into account within the software download control for some sensitive software, which may cause severe problem to the mobile terminal.

Besides some common software modules for terminal reconfiguration, the LSW-Re may also provide specific software for reconfigurable terminals in the ad hoc networks, e.g. ad hoc routing protocols. This allows a MT to serve as an intermediate mobile router for another MT to download software.

In addition, the LSW-Re should have the following functionalities as well:

- Service discovery mechanism: to provide the interface to the MT, i.e. the MT can find the LSW-Re by advertisement or solicitation without the help from the RM (e.g. [4][5]) and also include lookup service.
- Software download control: to provide access control and fault management for the terminal update.

The LSW-Re can be located in a high user density area, such as hot spots in some urban areas, e.g. airports, shopping malls, hospitals, etc. These areas are basically in the coverage of cellular networks. By introducing the LSW-Res, the scarce radio resource of cellular networks can be saved, and also software downloads can be more efficient with higher transmission rate. The LSW-Re can be also located in some rural area as an extension of the mobile network where there is no cellular network coverage.

Depending on where the LSW-Re is located, it contains the most frequently asked software modules in the respective areas. Strategies to manage the software modules in the limited storage of LSW-Re are needed by considering

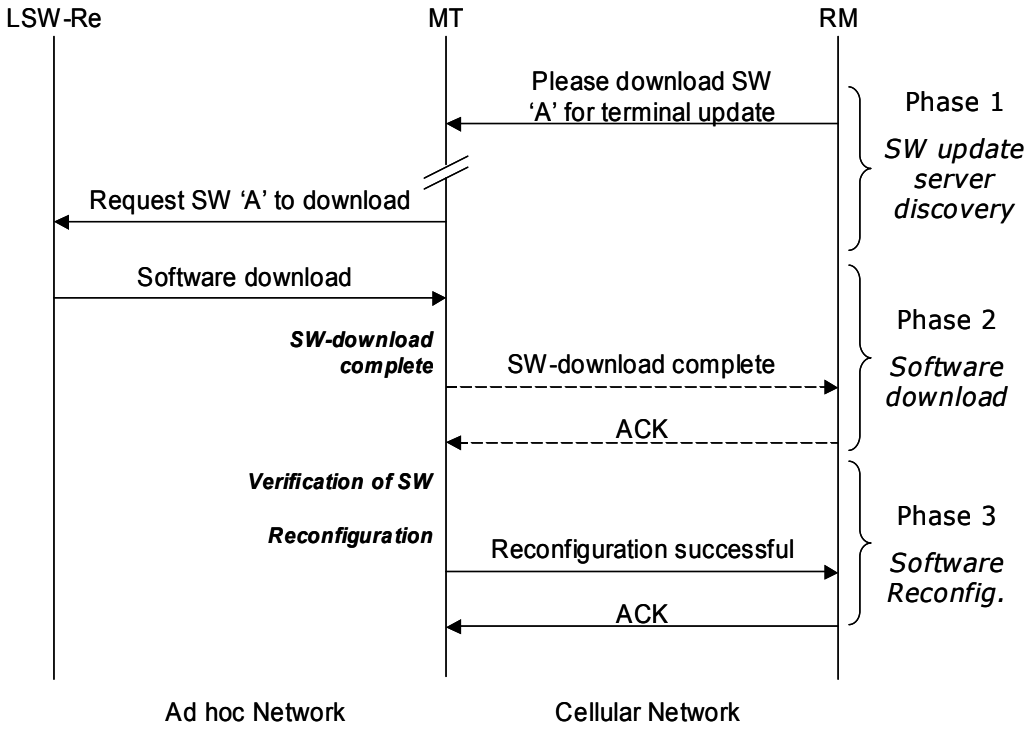

Figure 2: Ideal Software Download Procedure

the factors such as location or user density surrounding the LSW-Re.

3. SOFTWARE DOWNLOAD SCENARIOS

We have identified three major software download scenarios in the loose control approach. They present the essential idea of the loose control concept, though there are many other variations.

In the following examples, we assume that there is no time constraint for the software download, i.e. the terminal reconfiguration process is not time critical, which allows the loose control for terminal reconfiguration. Please note that the sequence diagrams only show the software download phase in the whole reconfiguration process.

3.1. An Ideal Software Download Process

An ideal network-initiated software download process is depicted in Figure 2, which consists of three phases:

- Phase 1: SW update server discovery
- Phase 2: Software download
- Phase 3: Software reconfiguration

The symbol '//' in Phase 1 represents the time elapsed, which means that depending on the priority of the kind of reconfiguration, it is possible for the MT to download the software after a certain time (e.g. one hour or even longer), but not immediately after getting the notification from the RM to download software 'A'.

There are different means to find an LSW-Re for software download in Phase 1:

- The RM sends a list of available LSW-Res to the MT
- The MT finds the LSW-Re by means of service discovery mechanisms (either solicitation by the MT, or the advertisement from the LSW-Re)

In Phase 2, after a successful software download, the MT notifies the RM of the software download completion. Since this notification does not have much impact of the following reconfiguration phase, the signaling messages is depicted in dotted line as well as the acknowledgement message from the RM.

The MT verifies the SW after completion of the software download and performs the reconfiguration. Finally the MT notifies the RM of the success of the reconfiguration (Phase 3).

3.2. No Connectivity between the MT and the RM

Figure 3 shows a reconfiguration process where the connection to the RM is not available (depicted in dotted line). The reconfiguration process can take place only if the

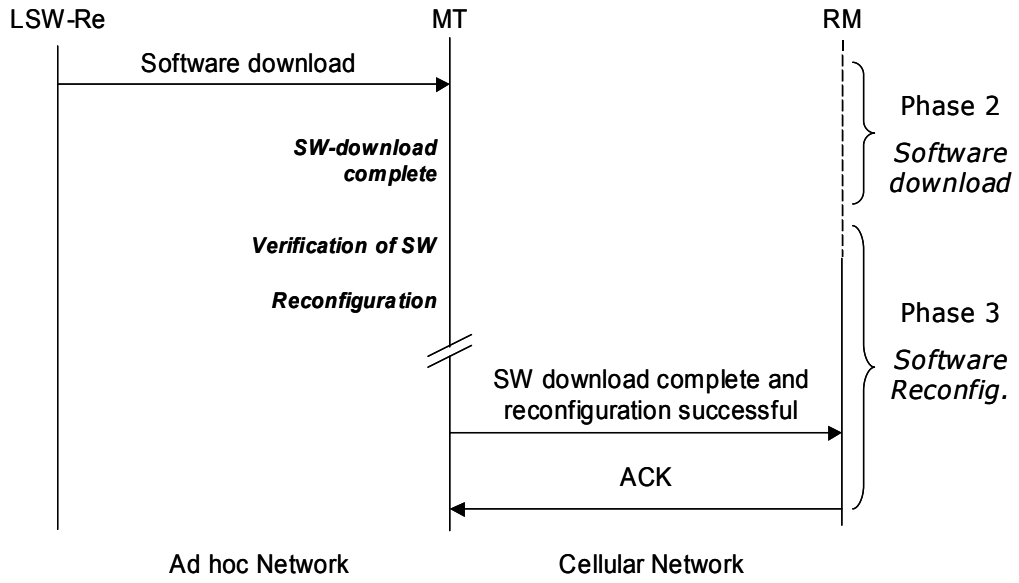

Figure 3: The MT Loses the Connectivity with the RM

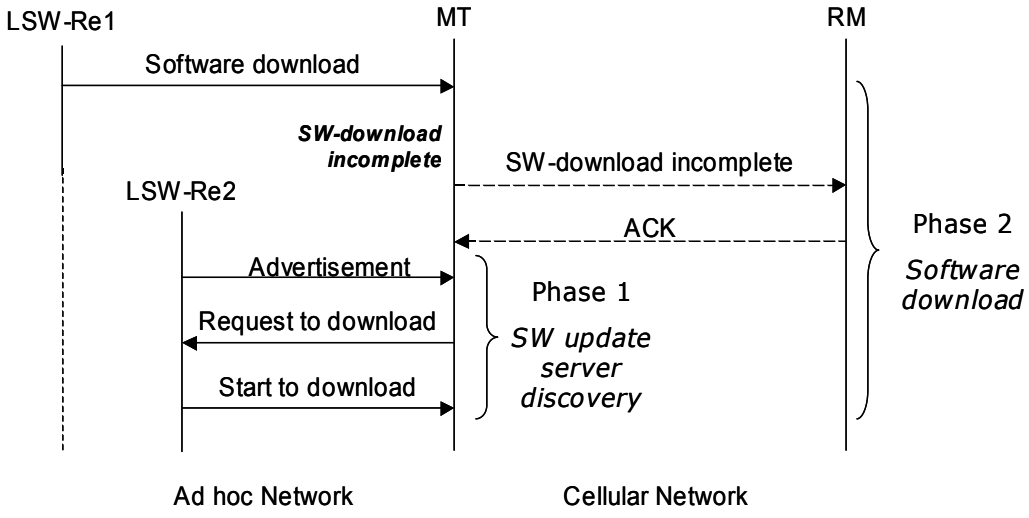

Figure 4: Software Download From Different LSW-Res

MT knows the specific software update it needs (e.g. SW 'A'). For example the mobile network operator can inform the subscribers to reconfigure their terminals for some new service.

The MT downloads the SW from the LSW-Re, performs the SW verification and starts the reconfiguration without notifying the network. After some time, the RM might be reachable again. The MT should inform the RM the status and success of the reconfiguration.

3.3. The MT Loses the Connection to the LSW-Re

In a software download phase (Phase 2), if the MT loses the connection to the LSW-Re, e.g. the MT moves out of the coverage of the LSW-Re, then the software download is not completed. In order to get the complete software, Phase 1 has to start again after an incomplete Phase 2.

The MT may keep the already downloaded software and try to download the remaining parts following the same

process (i.e. Phase 1) to find an LSW-Re. Figure 4 shows an example of service discovery mechanism.

3. CONCLUSIONS

In this paper, we have shown a new approach for flexible software download support in hybrid networks using the ad hoc network integrated into the cellular network. We have proposed a loose control concept and introduced a local software update server for terminal reconfiguration. The approach is designed for non time-critical terminal reconfiguration process. The data and signaling flows of reconfiguration process are performed in the ad hoc network and the cellular network, respectively. Our approach takes advantages of the hybrid networks, which makes the software download process more efficient via high bandwidth, short-range wireless technologies. Scarce radio resources of cellular networks can be saved in case of mass upgrade.

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