Evolution of E^2R Prototyping Environment

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ABSTRACT

Intense efforts within the mobile telecommunications sector have lead to the development of a wide range of wireless systems such as Cellular, Wireless Local Area Networks and Broadcast as well as their associated equipments. In order to optimise resource usage, increase network/equipment capabilities and versatility, scalable and reconfigurable infrastructure and devices are foreseen. The presented research targets the development of a flexible, modular and evolutionary prototyping environment in order to illustrate the vision of End-to-End Reconfigurability (E^2R).

I. INTRODUCTION

Aiming at offering an expanded set of operational choices to the users, applications and service providers, operators, regulators in the context of heterogeneous mobile radio systems, an end-to-end prototyping environment is under development within the IST FP6 Project End-to-End Reconfigurability (E^2R) [1]. By experimenting the architectural design of reconfigurable devices and supporting systems functions, this proof of concept environment is foreseen to demonstrate end-to-end reconfigurability features.

The paper describes the main objectives of this prototyping environment in Section II. Section III presents the different network and terminal components that will constitute this proof of concept. The targeted scenarios and the foreseen architecture are depicted in section IV. Conclusions about the End-to-End Prototyping Environment initiative are drawn in the last section.

II. OBJECTIVES

A very strong heritage in reconfigurability domain was gained through former European-funded research projects of the 5th Framework Program (FP5) like TRUST [2], SCOUT [3], MOBIVAS [4] and CAST [5], where expertise in the functions offered to the user terminals, applications and services was capitalized. Each of these projects concentrated on a variety of different technical aspects such as terminals, value-added service provision, enabling technologies, applications, reconfigurable devices, network provisions, security, proof of concept of reconfigurability.

The end-to-end reconfigurability wireless system vision is fairly new and the work carried out so far has not induced any significant breakthrough. Moreover, although several experimentations have been set-up within these projects, they focused on a specific aspect of the reconfigurability.

There was no end-to-end prototyping platform for validating the end to end principles, hence the work on specifying, developing and integrating the proof of concept has the following objectives of:

- Demonstrating end-to-end reconfigurability features,
- Providing an open, flexible and evolutionary experimental environment for anyone who wants to test and assess services; or technologies related to the reconfigurability domain,
- Bridging the work undergone in the other technical areas of the E^2R project by providing experimental experience and pragmatic feedback on critical issues with respect to the integration.

III. E^2R PROTOTYPING COMPONENTS

During phase 1 (2004-2005) of E^2R project, the aim of this research work is to leverage from the various FP5 projects and partners experience. For that purpose, various elements will be integrated together to build an end-to-end prototyping environment. Hence the following components will be used:

- A GPRS experimental network infrastructure,
- A UMTS-TDD software radio platform,
- A multimode integrated terminal,
- A software deployment platform,
- Multi-mode terminals,
- A middleware and service platform,
- Alternative radio access technologies such as WLAN or DVB.

A. GPRS Experimental Network Infrastructure

The GPRS testbed infrastructure is provided by Motorola and available at its premises in Saclay, France. It supports 6 Cells (900 MHz/1800MHz bands and different capacities). It is connected to the corporate intranet with several Virtual LAN (VLAN) clouds. New VLANs can be added and deleted as needed. A hub controls the routing intra-VLAN and inter-VLAN. The testbed is based on IPv4, and IPv6 could be introduced via tunneling or IWFs… Several VLAN can be created and dedicated to special tasks: one for the Algorithms (RRM, SDR Repository, QoS server…), a second one for the AAA (RADIUS supported…) and Billing, and a third one for the Session Management (SIP, Mobile IP…). This infrastructure was used in the FP5 CREDO project.

B. UMTS-TDD Software Radio Platform

The PC-based testbed [6] of Institut Eurecom is implemented using a hard real-time micro-kernel known as RTLinux, running beneath the Linux operating system, for providing real-time end-to-end functionality. The testbed runs on a variety of Intel Pentium-based computing platforms including laptops and high-end servers. Layers 1 and 2 are compliant with the 3GPP specifications for TDD operation and layer 3 currently provides a direct interconnection with an IPv6 core network. The current setting at Eurecom premises comprises: a BTS (range 100m, Power = +34 dBm) and a mobile terminal, Real-Time duplex, uses the UMTS/TDD transmission/reception mode, and a protocol stack that allows a IP connectivity (IPv4 or IPv6).

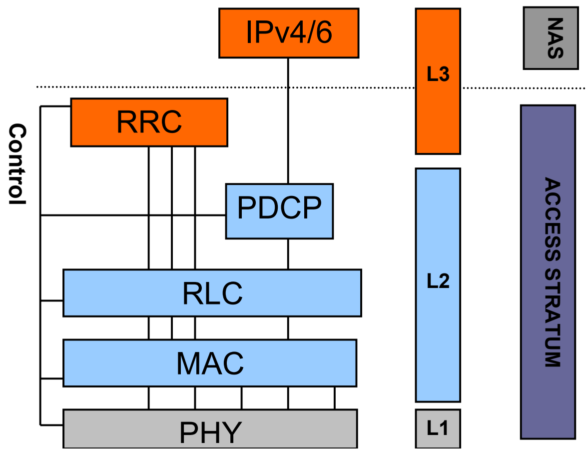

Figure 1: Current Software Part of the Eurecom Platform

The hardware portion, for both the BTS and the MT, consists of: a standard micro-processor-based CPU (e.g. P4, namely a DELL server for the BTS and a laptop for the MT), a PCI-bus based data acquisition card (PMC/CARDBUS/PCI form-factors), an analog/digital interface (14-bit IF sampling), and an up/down conversion RF card using TDD multiplexing. The software portion is currently the following: a Non Access Stratum (NAS), with mainly an adaptation layer to IP v4/v6, and an Access Stratum (AS): Physical Layer, Medium Access Control (MAC), Radio Link Control (RLC), Packet Data Convergence Protocol (PDCP), Radio Resource Control (RRC).

C. Software Deployment Platform

The Software Deployment Platform (see Figure 2) provided by Thales Communications realises code or file deployment in a decentralised and automated way. It is based on the concept of Active Network (fixed network equivalent of Mesh Networks), which allows customised application-level transport protocols between Active nodes. This platform's main purpose will be for the Mass Upgrade scenario, to ensure policy-based deployment of some file (or code) to a large number of entities. The actual platform is implemented in Java Standard and communicates over UDP or TCP, and provides functionality like secure exchange and dynamic routing between Active nodes.

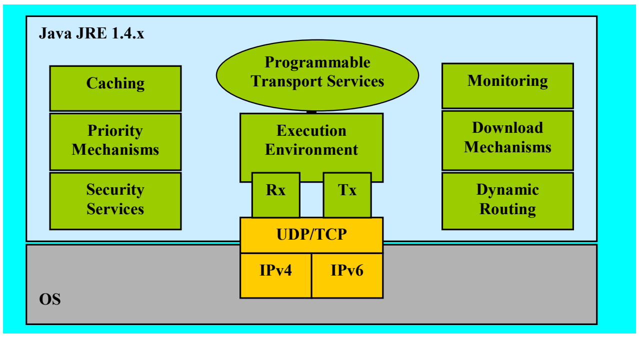

Figure 2: Active Deployment Platform

D. Multi-Mode Terminals

Most of the experimentation in context of reconfigurable systems or multi-mode terminals are based on laptops or PDAs (Personal Digital Assistants) with several PCMCIA cards providing the radio connectivity with various radio access technologies. Obviously, such terminals will be used in the E^2R prototyping environment for development but an integrated terminal will be used too, for assessing more closely the user (and market) acceptance of the features and services enabled by the reconfigurability framework.

The integrated terminal depicted at Figure 3 is a PDA, currently serving mainly for the courier private data market. It includes several features such as Bluetooth RF communication, IrDA port, a dual band (850, 1900 MHz) GPRS modem. The processor is running at 206MHz and the terminal supports PocketPC 2003 as operating system.

Figure 3: Integrated multimode terminal

E. Middleware and Service Platform

The MOBIVAS middleware platform, provided by the University of Athens, aims to address a variety of issues related to provision of value-added end-user services in 3G and beyond mobile environments. The platform acts as a single point of contact for end-users as well as value-added service providers (VASPs).

The main functionality offered by the platform to mobile users is the following: Personalised service discovery, Secure on-demand service downloading and execution, Context management, User profile management, and Generation of itemized bill.

The platform provides VASPs with the following functionality: Automated service registration, update and deletion, Management of network reconfiguration for optimal service provision, Apportioning of the revenue resulting from service consumption, and Service metadata interpretation and management.

The MOBIVAS platform resides "outside" the network that is used for wireless access (e.g., beyond the GPRS GGSN and the WLAN access router). It can be part of the private IP network of an operator (in a tight coupling scenario) or the public IP backbone (in a loose coupling situation).

F. WLAN and DVB-T components

A WLAN commercial solution will be integrated in the overall prototyping environment. The 802.11b coverage will be provided by one or several access points. The terminals (laptop-based, desktop-based, PDA) will be equipped with WLAN PCMCIA or PCI cards.

The overall prototyping environment will include a Terrestrial Digital Video Broadcasting (DVB-T) segment. In general, the DVB-based platform realizes an asymmetric communication, in the sense that the wireless terminals receive at high bit rate (~30 Mbps), while their requests reach the service provider at lower data rates. Mobile terminals use the wireless IP-based return channel such as those offered by GPRS or WLAN. The DVB-T platform comprises a DVB-T gateway as well as a modulator, and will be provided by Motorola.

IV. TARGETED SCENARIOS & ARCHITECTURE

A. Foreseen architecture

All the above mentioned elements will be integrated into a single prototyping environment as illustrated by the Figure 4. This architecture will be refined and confirmed during the early months of the project.

B. Mode Switching and Mobility

The first scenario will demonstrate mode switching and mobility of a multi-RAT mobile terminal, namely UMTS-TDD/WLAN/GPRS, in a heterogeneous network including the 3 RAT (with QoS aspects):

- An end-user terminal is consuming a service with a specified QoS,
- Based on some service-based events, the service platform decides a mode switching (enhanced handover, negotiation…) for this terminal to ensure another QoS. These service-based events can originate from a VASP (e.g., change of a tariff, introduction of a cheaper variant of a service) or the user (e.g., change of status from home to business mode, which leads to suppression of tariff restrictions on service usage),
- The switch is done either between the UMTS-TDD and WLAN, or between the GPRS and WLAN,
- The continuity of service is ensured with modified QoS and potentially modified parameters in the protocol stack in order to better adapt to the new air interface.

C. Software Upgrade

The second scenario will demonstrate software upgrade with partial reconfiguration of terminal and network entities:

- The objective is to upgrade the software or to fix a bug in the terminal,
- The software deployment framework is running under the service platform. This means that the service platform is able to trigger software deployment operations to be performed by the software deployment platform.
- A piece of code is downloaded to the terminal(s) and/or the network equipment(s) thanks to legacy communication technology. For instance, the UMTS-TDD base station will upgrade its software release thanks to an Ethernet connection while the UMTS-TDD terminal will upgrade its modem software thanks to WLAN or GPRS access.
- Once both sides are upgraded, a new communication could be established thanks to the new (or upgraded air interface).

From this basic scenario, various alternatives could be defined depending on:

- The terminal type (UMTS-TDD or GPRS/Java-enabled mobile phones or WLAN case): depending on the terminal openness, the reconfiguration could be done at different layers: all layers in the case UMTS-TDD software radio terminal but only higher layers for WLAN cases).
- The initiator of the reconfiguration action: terminal or network oriented

V. CONCLUSION

The final overall proof of concept of End-to-End Reconfigurability is targeted at the end of the 6-year period of the E^{2}R project. This final platform will include the outcomes of the other workpackages, especially reconfigurable terminals, networks and the end-to-end protocols to enable efficient reconfiguration at all layers. In the meantime, the E^{2}R prototyping environment will be based on the integration of past projects (mainly FP5 projects) and partners' own testbeds. This environment, combining the experience from the various E2R partners as well as the most advanced results in the reconfigurability domain will be unique. It will allow assessing the maturity of reconfigurable systems for easier market adoption. Of course, several demonstration are planned for 2005 to provide a high visibility on the concrete results of E^{2}R project.

ACKNOWLEDGEMENTS

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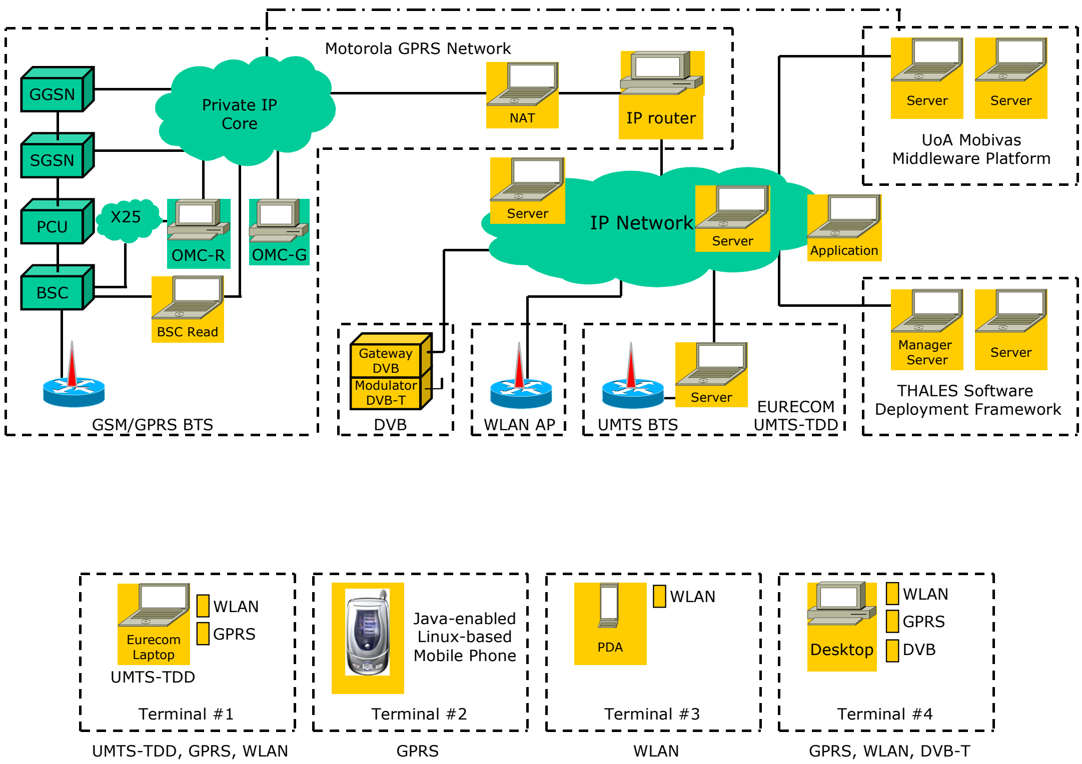

Figure 4: Foreseen overall architecture