Wireless World Research Forum (WWRF)

End-to-End Reconfigurability - Architectural Research

Title of research item

End-to-End Reconfigurability - Architectural Research

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Subject area: WG 6 Reconfigurability

Relevance of the topic to the above subject area

This contribution presents the Architectural Research work conduct in the framework of the End-to-End Reconfigurability (E²R) European FP6 Integrated Project [1]. The project has officially started on 01.01.04 and the key objective of the E²R project is to devise, develop and trial architectural design of reconfigurable devices and supporting system functions to offer an expanded set of operational choices to the actors of the wireless world; In particular, the architectural work of E²R aims at devising the overall system architecture that ensures the consistency and interoperability of the different building blocks.

This contribution is candidate to help in the identification of the research areas, elaboration of WG6 white paper and in the development of reference models for the Wireless World.

Abstract

The End-to-End Reconfigurability (E²R) [1] research aims at bringing the full benefits of the valuable diversity within the Radio Eco-Space, composed of a wide range of systems such as Cellular, Wireless Local Area and Broadcast. The European FP6 Integrated Project E²R has officially started on 01.01.04 and the key objective of the E²R project is to devise, develop and trial architectural design of reconfigurable devices and supporting system functions to offer an expanded set of operational choices to the actors of the wireless world.

One of the main E²R scientific and technological goals is to develop and evaluate an overall reconfigurability architecture and deployment concept considering user requirements, operator views and regulator perspectives, and master key enabling technologies associated barriers.

In particular, the architectural work of E²R aims at devising the overall system architecture that ensures the consistency and interoperability of the different building blocks.

The expected results of the research are:

- To deliver an end-to-end architecture enabling reconfigurability of services, equipments and radio usages. This is achieved throughout the following steps:
    - Description of a ‘logical architecture’, in which the business ‘control points’ are identified as management points for specific operations, like roaming, security management, SLA management.

  - From the 'logical architecture', identification of the corresponding 'functional architecture' describing the functional network elements, peer connections among such network elements (e.g. 'logical interfaces')
  - The 'functional architecture' should, in turn, drive research about the identification of the 'Telecom Functions' (procedures to ensuring the transport of re-configuration data' as well as the 'Operations and Maintenance Functions' (procedures to ensure system fault monitoring and consequent repair).
- To provide an open and adaptable architecture enabling a fast deployment of new services or business models.
- To promote such architecture to standardisation, regulation bodies and other foras.

State of the art in the area

The first models presented in this paper benefits from the September 2002 published white paper: "Reconfigurable SDR Equipment and Supporting Networks Reference Models and Architectures" [3]. This document gathered various vision produced by experts in the field of Software Defined Radio which have defined SDR reference models, SDR system architectures including supporting network architectures.

A rather new but efficient contributor to the domain is the Object Management Group (OMG) which is a standardisation body. The OMG Software-Based Communication Domain Task Force (SBC DTF) is committed to develop specifications supporting the development, deployment, operation and maintenance of software-based communication systems. The SBC DTF has issued a "Specification for PIM and PSM for SWRADIO Components" [4].

Possible approach

E²R Architectural Vision of the Beyond 3G System

E^{2}R project expects that the topology presented in Figure 1 will correspond to the transition from multi-mode to smart reconfigurable equipments and related reconfiguration support. Several extrinsic important aspects to this vision will also be investigated, such as dynamic spectrum allocation, regulatory issues, and business models.

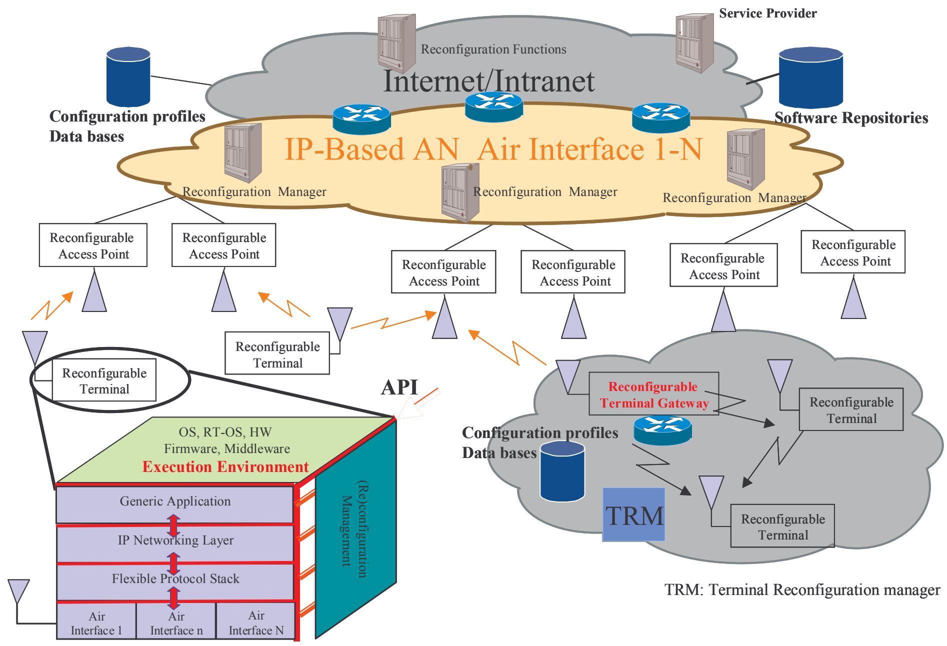

Figure 1: E²R Architectural Vision

From the actors perspective, the vision of E2R for Beyond 3G systems will be developed into reference scenarios, which in turn will generate technical requirements and system specifications. Key functionalities and core-technologies innovative research will be identified and then carried out within the reference architecture(s).

Reconfigurability Eco-System Functional Architecture

In the E2R scope, all the layers of the protocol stack are subject to reconfiguration, implying that the interface between the terminals, the radio access networks and the core network entities needs to be devised adequately.

Figure 2 depicts the notion of network support for Reconfiguration in the form of Reconfiguration supporting functions that comprise several logical tiers (i.e. SW download management, mode management). They expand across the logical architecture that separates the protocol structure into three layered subsystems, namely transport, radio network and system network layers, and complements the current user, control and operation and maintenance planes with an additional dimensioning captured in the Reconfiguration management horizontal plane. By further decoupling the interfaces, the system reference architecture also shows distribution in (Radio) Access and Serving (Core) Networks of the Reconfiguration support functions.

The Reconfiguration management horizontal plane can be decoupled in abstraction layers, configuration service discovery, negotiations, configuration control and data as shown in the Figure 2. Moreover, interactions between the abstraction layers in order to further optimise the configuration and usage of the open platforms can be imagined.

These interactions are defining also taking into account the ‘ownerships’ of the different abstraction layers. For instance, the configuration data might be stored in a manufacturer-owned database. On the contrary, configuration service discovery and negotiations could be ensured by a service provider. This situation can occur when the manufacturer wishes to maintain confidentiality on the configuration data that it owns. In this case, a specific one-to-one business relationship arises between the manufacturer and the service provider. Specifically, the manufacturer keeps a database of encrypted data, such data being decrypted only at the peer side (for instance, the terminal).

Note also, given the potential burden introduced by the flexibility provided by open platforms, policy-based management of user, terminal, radio access networks profiles and location are means to minimise the complexity of such reconfigurable radio terminal and networks. These profiles and policies are stored in databases in the terminal, radio access networks or core network.
Along these lines, multi-dimensional mobile information networks concept (i.e. 3GPP All-IP, Virtual Home Environment) is set in place for the introduction of pervasive architectures. Hereafter, physical and functional separations are considered to allow a network supporting Reconfiguration capabilities to fit within the context of the Beyond 3G family of networks.

The Reconfiguration managers are located in terminals and radio access network (i.e. transmitter/receiver/controller) elements. Reconfiguration managers provide the local intelligence and platforms enabling the reconfiguration of the distributed elements of Reconfigurable equipment.

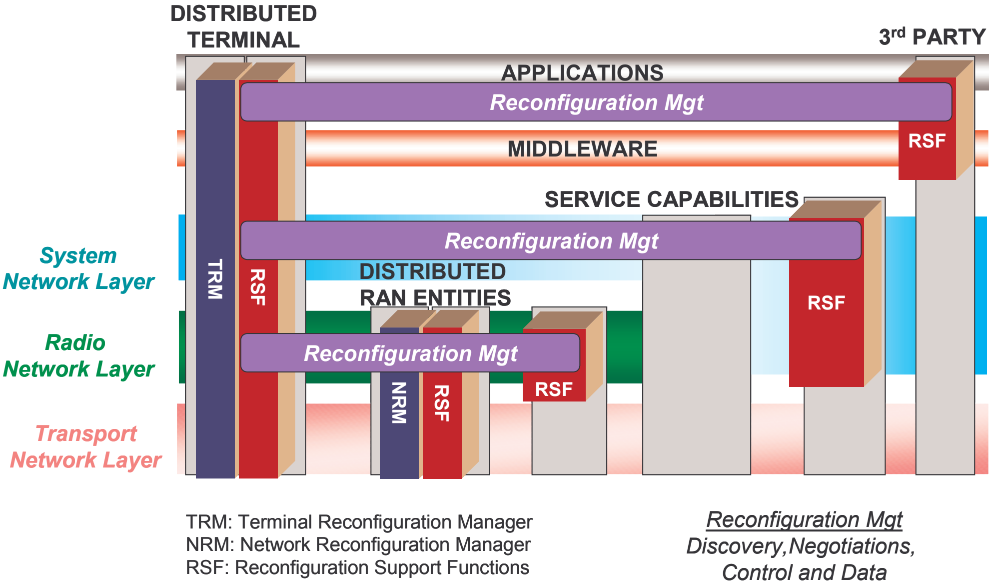

Figure 2: End-to-End Reconfigurability Functional Architecture

Process – Elaboration

For system engineering, analysis is much more significant than design. For that purpose a dedicated process is established aiming at Architecture definition. We defined 4 planes to address the system:

- User/Operational plane
  - Organisation
  - System Environment
  - Control point identification
  - Upper-system functions and logical architecture
- Functional plane
  - System functions
  - Object of the domain
  - Object of interface
  - Dynamic
- Logical plane
  - Logical component
  - Dynamic

- Physical plane
    - Deployment
    - Hardware component

The first 2 planes will be analysed and the last 2 planes will be designed. As focus of the E2R project is on reconfigurability, we will focus on the discovery and modelling of reconfigurability framework. This framework is, obviously supposed to be distributed over various parts of the system. For example, sub-parts of this system framework will be on the terminal, network, access point, …

Model creation requires 2 activities: scenario elaboration and model elaboration. Scenarios are useful to capture information and to combine the various views. Scenarios are of highest importance as they address all the subjects or point of view on the system, worst cases, errors or as well as malfunction. The high-level scenarios have been breakdown decomposed exhibiting connection with other WP technical scenario. An iterative interaction with WP (spiral cycle) allowing refinement, ensuring common understanding and definition of the various actors and component of the system.

The following stage is the analysis of the scenario to enable the requirement capture. Obviously it is a critical activity as it will drive the next stages and consequently the architecture behaviour. Capabilities of the system are identified and associated requirements are defined based on refinement of the existing scenarios and use-cases or sequence diagrams elaboration. During this analysis a great attention is given to express requirements as needs avoiding any reference to solution to preserve an open-minded research approach. Feasibility will be checked in relation to the other technical WPs.

Already identified requirements which are impacting the architecture

In the timeframe of the project, the actual activity is the requirement capture and architecture candidate proposal inventory.

Usually, an architecture is not driven only by functional requirements, but besides those emphasis is given to some required overall qualities collectively named Qualities of Architecture (QoA):

- *Portability*,
- *Compatibility (e.g. backward compatibility with existing networks)*,
- *Scalability*,
- *Flexibility*,
- *Interoperability*,
- *Security (according to the business-related ‘control points’)*,
- *Robustness (e.g. fault tolerance)*,
- *Maintainability*.

Most of the above qualities are appearing through the scenario analysis.

The analysis of the scenarios conducts to the capture of capabilities assign to the system as for example:

- *Download*: of data for reconfiguration purpose
- *Resume*: the previous activity in case of battery failure or phone call or …
- *Authentication*: of downloaded data
- *Undo*: the previous reconfiguration in case of …
- *User transparency*: nominal working process has to be maintained
- *Spectrum reallocation*

The previous list already exhibits the complexity of the architecture to be created because requirements are antinomic or paradoxal. *Spectrum reallocation* can lead to a complete protocol stack modification but without interrupting the service offered to the user.

The list clearly shows that the reconfigurability framework needs to be distributed and cooperating among various entities. *Spectrum reallocation* imply a cooperation between, at least, the terminal and the access point. The core network can also be concerned, in case this operation implies different encryption/decryption requirements and / or change of administrative domain. *Undo* necessitates to elaborate rules for testing and verifying the device working.

Coordination and synchronisation between the various Reconfiguration Manager entities needs to be defined and convey between them. Of course such interaction must be *Interoperable*, independent of the device provider or of the network provider, i.e. technology agnostic. To this goal, proper protocols residing 'on top' of the existing connectivity must be designed, engineered and developed.

The various Reconfiguration Manager entities mapped on various elements of the network are linked to the actors and their roles in the system. Beside the technical signals needed to be exchanged for technical purposes, economical data and agreements needs to be convey depending of the reconfiguration to be achieved. This will be the objective of the mapping of the business entities on the technical model.

One of the first orientation of this rough analysis is that the foreseen functional architecture is still valid and needs to be refined in conjunction with the other technical WPs. On the other hand, complexity of the problem, number of actors and actual stock of legacy material imply clearly that to succeed in the elaboration of the reconfigurability framework, the design shall elaborate on existing technologies, enable proprietary solution and anticipate a wide dissemination leading to standardisation.

Next Steps/Research

Next steps will be to identify the mapping of actors and roles to the presented business entities/domains and to identify the various technical, financial and regulatory relations between the actors/domains. Furthermore, we will elaborate on the proposed layered approach for the identification of business model aspects for end to end reconfiguration.

Acknowledgement

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List of references (if available)

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[2] Didier Bourse and al "The End-to-End Reconfigurability (E^2R) Research", WWRF10 New-York Meeting – WG6.

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[4] Specification for PIM and PSM for SWRADIO Components, OMG document swradio/2004-01-01, www.omg.org