WIRELESS WORLD
RESEARCH FORUM

Business Models for End-to-End Reconfigurable Systems

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Abstract— The objectives of the End-to-End Reconfigurability (E^2R) research are to bring the full benefits of the valuable diversity within the radio eco-space, composed of a wide range of systems and to devise, develop and trial architectural design of reconfigurable devices and supporting system functions to offer an expanded set of operational choices to the different actors of the value chain in the context of heterogeneous mobile radio systems. The end-to-end reconfigurability will help operators to better exploit their investments on infrastructures and terminals and should ensure that the infrastructure will be flexible and reconfigurable to accommodate evolving standards, applications and the end-user needs. The end-to-end reconfigurability is seen by many actors of the wireless industry as a core technology to enable the full potential of beyond 3G systems. It has the potential to revolutionize wireless just as the PC revolutionized computing. This paper introduces the E^2R system research then focuses on the business modelling research. The business actors, domains and use-cases investigated by the End-to-End Reconfigurability research project are presented.

Index Terms— End-to-End Reconfigurability (E^2R), Business Modelling, Actors, Business Domains, Business Use-cases.

Introduction

The key objective of the End-to-End Reconfigurability (E2R) [1] 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 different actors of the value chain in the context of heterogeneous mobile radio systems. Innovative research, development and proof of concept are sought in an end-to-end aspect, stretching from user device through all system levels. Furthermore reconfigurability support intrinsic functionalities, such as management and control, download support, spectrum management, regulatory framework and business models complete the project scope. It is already recognised that the technologies, features and associated business aspects developed in E^2R can potentially provide new streams of revenue within a time frame of 2010, by creating new eco-system compatible business models to ignite the economic growth for the different European actors, such as users/people, manufacturers, operators, and service and/or software providers. This paper introduces the project system research then focuses on the business modelling research, the business domains and actors, as well as the business use cases.

E^2R System Research

Communication systems that are composed, to a significant degree, of dynamically configured distributed components, whereby optimised resources should be anticipated while keeping its complexity hidden, are emerging. Furthermore, in the past years, the wireless telecommunications sector has lead to the development of a wide range of technologies, representing a valuable diversification of the radio eco-space that has already made a technology push towards multimode devices and produced significant investment into research of new technologies, services and business models adapted for collaborative heterogeneous radio systems. The ultimate vision of E^2R is to reach all-IP fully integrated networks with reconfigurable equipments and associated discovery, control and management mechanisms. Within this ambient space, the users will benefit from end-to-end reconfigurability by reaching the required services, at affordable cost, in different heterogeneous contexts, using diverse equipments and through several technologies.

Within this context, the aim of the system research for end-to-end reconfigurability is to aggregate the technical, business and regulatory visions from the different actors of the telecommunications system (from user to service provider) and this, across the different layers of the system, from physical layer to application layer and across the different equipments. To provide this overall vision, realistic and futuristic scenarios have been elaborated in order to enable E^2R requirements capture.

Building on the scenarios, relevant associated requirements have been identified. Those results were analyzed to elaborate a generic system architecture enabling end-to-end reconfigurability architecture. Results are also valuable to address the current regulatory framework (e.g. material

conformance, security, spectrum…) and evaluating the impact of the scenarios on security, privacy, electromagnetic compatibility, frequency sharing rules, responsibilities… These families of scenarios have been derived as a result of the analysis of the merged scenario contributions from the different research areas of the project [6]. They are grouped in three main families representing a common thematic and corresponding to an anticipated coherent timeframe of technical availability: (1) ubiquitous access, (2) pervasive services, and (3) dynamic resources management. The E^2R high-level scenarios are describing some general context highlighting the benefits of reconfigurable equipment without describing the underlying technologies neither detailing the various possibilities as it is done in the other technical workpackages. In parallel of this scenarios creation, the business path regarding economical paradigm is being elaborated. The purpose is to depict business models regarding the technological roadmaps, and to suggest a coherent business path with the technology evolution towards reconfigurability for each identified actor of the value chain.

The impact on the end-to-end system in providing communications and the requirements for supporting each family of scenarios is also addressed. This is achieved with a particular focus on the various parts involved in the reconfiguration of the communication protocol in order to cover all the layers. Moreover, all types of reconfigurations are captured: static, quasi-static or dynamic reconfiguration, on-demand/periodic reconfiguration, partly/complete reconfiguration, and run-time/offline reconfiguration. These scenarios, and the requirements implied by them, are the entry points for the definition of overall system architecture. The aim of the E^2R architecture is to describe a framework support for reconfigurability. This framework is obviously supposed to be distributed over various parts of the system. The methodology tries to avoid the choice of a technological solution for this framework. So, the purpose is to be techno-agnostic. Finally, end-to-end reconfigurability will need a very flexible regulatory approach to develop its full potential. Major changes in the regulatory framework for telecommunication may be required. E^2R aims to significantly contribute to this process. This will be done, by first of all addressing the current regulatory framework and the associated limitations and boundaries, and evaluating the impact of the E^2R scenarios.

In this context, the concept of responsibility chain was introduced by E^2R, investigating the relations of actors involved in (re)configuration and identifying the potential threats and their associated responsibilities when devices are reconfigured in (foreign) environments or administrative domains.

Business Modelling Research

The objective of the business model research task is to depict business models regarding the technological roadmaps, and to suggest a coherent business path with the technology evolution towards reconfigurability for each identified actor of the value chain. Knowledge and expertise of the partners is being used to contribute to create a wide study of the market.

Dedicated questionnaires were created to identify each actor of the market, define its position and its role, but also business entities, business relationships, techno-economic costs, business relationships, business agreements, business responsibilities. Three questionnaires were elaborated for the end-users, vendors and mobile operators.

The research is based on existing standards, enabling and emerging techniques and technologies and will propose as result business model to the scientific community with regard to the end-to-end reconfigurability concept.

An E^2R business framework is under definition: analysis of business relationships in the three scenarios, study of existing market and foreseen near future evolutions, study of E^2R participant operators considerations were completed in the first year of the project. Moreover, several business model workshops were organised in October 04 and June 05 in Brussels, including brainstorming sessions.

Business Actors and Domains

The actors involved in service provision to mobile users over reconfigurable networks can be grouped in six main business domains as presented in Figure 1, namely:

- The Regulatory Domain which includes authorities that handle regulatory issues related to wireless systems and services (e.g. spectrum allocation/management),
- The Trusted Third Party Domain which includes trusted actors for special actions such as security and standard conformance,
- The Privileged Party Domain which includes reconfigurability related business actors,
- The Service Provision Domain which includes actors related to service discovery and provision,
- The Network Operator Domain which includes actors related to connectivity provision,
- The User Domain which includes user related business actors.

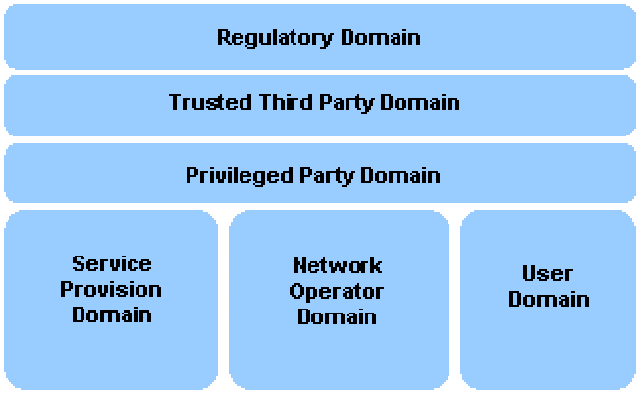

Figure 1: Business Domains

All the business actors are described in the following paragraphs.

Certification Entities certify the conformance of reconfigurable equipment and reconfiguration software to the respective standards, and also guarantee the integrity of the software and the authenticity of its origin.

Configuration Software Providers develop and/or distribute software modules to run on reconfigurable network elements and/or user devices.

Content Providers create and maintain multimedia repositories (including applications, information, digital content, etc.) and make them available to Service Providers (or Value Added Service Providers), which in turn offer them to their users. The content provider also includes the management and integration of content coming from different sources into the services offered by Service Providers.

Equipment Suppliers include the equipment manufacturers and vendors. The equipment manufacturers design and manufacture the equipment (e.g., mobile terminals, base stations) that is to be used in the Service Provision, Network Operator and User domains. They can also distribute software modules for their products acting as a Configuration Software Provider. The Equipment Vendors market and distribute the equipment (e.g., mobile terminals, base stations) that is to be used in the Service Provision, Network Operator and User domains. They can also distribute software modules for these products acting as a Configuration Software Provider. This entity is envisioned for future exploration and investigation.

Fixed Network Operators provide telecommunications services to fixed subscribers. Their infrastructure can also be used for transport by other network operators.

Mobile Network Operators (MNOs) provide radio resources, mobility management and fixed capabilities to switch, route and handle the traffic associated with the services offered to users by themselves and/or by service providers.

Mobile Virtual Network Operators (MVNOs) may be considered a special case of Mobile Network Operator. MVNOs offer network connectivity services, but do not own spectrum allocation or radio access network infrastructure. To provide network access to their customers, they buy/rent network capacity belonging to a mobile network operator and usually also include additional services to their offerings. An MVNO may possess a distinct mobile network code, issue its own (U)SIM cards and operate proprietary cellular core network infrastructure. In this case, the capacity bought/rented from a mobile operator concerns only the radio access network.

Reconfigurable Equipments are the devices used to provide access to communication services which can be modified with several kinds of reconfiguration processes, regarding the installed software (programs, codecs, and protocols). These entities are envisioned for future exploration and investigation.

Reconfiguration Managers are responsible for the reconfiguration process management and respective interactions between the actors involved in certain reconfiguration processes**.**

Regulators set the legal environment for the mobile business development, that is, laws and guidelines that determine the operation of the whole system.

Security Entities in cooperation with the rest of the actors of the system guarantee the security of system operations by providing the security reconfiguration information and the security context for the system. In the case of reconfigurability, this implies that both reconfiguration software download and installation are performed securely.

Service Aggregators mediate between VASPs, Service Providers and Users keeping them aware of the available services. They act as a single point of contact for VASPs that want to have their services deployed over possibly multiple networks, even of different technologies. Service aggregators provide users facilities for service discovery, downloading and execution (e.g., through a portal-like interface). They may also provide VASPs facilities for packaging their services for specific networks, context or service providers (e.g., to preserve uniform look and feel, or construct pre-compiled service configuration for specific environments). They also handle the storage and management of service profiles (provided by VASPs). Service profiles include information necessary for optimal, context-aware provision of the service, such as terminal/network requirements, localization and user preferences.

Service Providers (SPs) maintain a direct business relationship with mobile subscribers and

provide them at a minimum, a set of basic telecommunication services (such as voice or SMS) and potentially value-added services. The service provider undertakes tasks such as subscriber management (including end customer charging and billing) and revenue sharing between mobile service provision stakeholders.

Spectrum Managers are responsible for the allocation of the different spectrum bands to different technologies (GSM, UMTS, WLAN, etc). They are furthermore responsible for the allocation of this spectrum to the different entities either through the use of exclusive licenses that grant an entity the ability to operate exclusively a portion of the spectrum (as in UMTS), or by allowing free access to a certain spectrum band (as in WLAN). Finally, they are responsible for the approval of spectrum transfer between entities, if permitted by the regulator.

Subscribers are the persons or entities engaged in a Subscription with a Service Provider, allowed to subscribe and unsubscribe services, to register a user or a list of users authorized to access the services as well as set the limits relative to the consumption of these services by associated users.

Users are the persons actually making use of the reconfigurable end-user terminal and accessing the services contracted by the subscriber.

Value Added Service Providers (VASPs) provide services other than basic telecommunications services. A VASP may be also the developer of such services. A value-added service (VAS) in the context of this study can be defined as an information technology product that is accessible by a mobile end-user and whose value resides mostly in functionality and content, rather than transport or connectivity. The notion of VAS includes a wide variety of end-user applications like web-based access to multimedia content, mobile commerce, location-based services and many others. The consumption of VAS may incur additional charges for the mobile subscriber. The reason for differentiating between Service Providers and VASPs is that normally a user wishes to maintain only one subscription for basic telecommunication services (with one service provider), and then may access a set of other advanced services through different VASPs (such a VASP could be the service provider offering the basic services). Thus, the user has a single agreement with the SP and does not need to establish direct business relationships with individual VASPs. However, the latter case is not precluded.

Figure 2 summarises the domains and actors in the reconfigurability business model framework.

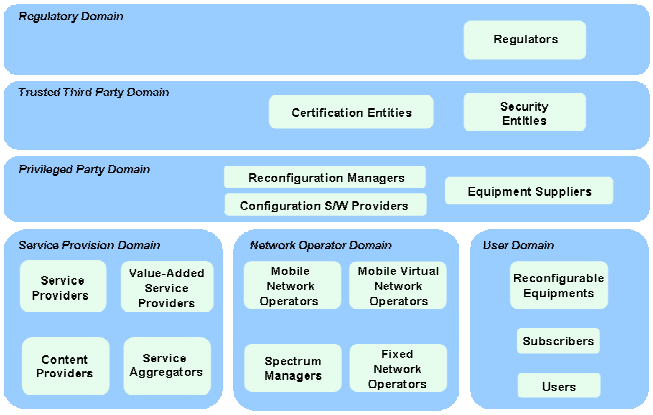

Figure 2: Business Model Framework Domains and Actors

Business Use Cases

The following use cases have been identified within the project and are currently being analysed:

1. Terminal reconfiguration: Home network and roaming cases,
2. Network reconfiguration,
3. Dynamic spectrum management,
4. Value added service deployment,
5. Dynamic value added service provision (including discovery, downloading, execution and adaptation).

Terminal reconfiguration

The "Home network case" is related to the case in which the terminal has to perform software modules download from a remote server, e.g. of the user home network. These modules are used to reconfigure the terminal and they can be downloaded independently on user, network operator or service provider request. The "Roaming case" is related to the case in which a user switches on his device in a new wireless environment to which he has not been previously connected (roaming is a particular example of this scenario). In the case that the terminal hasn't stored on its own memory the right software modules to reconfigure itself, it is necessary to download these modules to access the new network. The download procedure can be initiated independently by the user or by the network. It must be noted that if a transparent procedure is needed, only the second option is possible). When the download has been completed, the reconfigurable terminal installs and uses the new software modules in order to connect to the new wireless environment.

Network reconfiguration

In this case, the network operator modifies the configuration of its network infrastructure. Reconfiguration could be triggered for reasons such as optimal service delivery, support of users with diverse terminal and/or addressing the varying conditions of traffic. The reconfiguration process can

be as simple as a change in parameter values or as complex as a complete RAT change in the Access Network. Theoretically, the introduction of reconfigurability allows the network operator to perform dynamic network planning and management in real-time. However these processes are quite complex and should be performed over long enough periods of time in order to avoid recurrent updates of the network configuration caused by transitory variations in traffic. It must be kept in mind that as any reconfiguration in network nodes takes a certain time to perform, the corresponding nodes are not available for service provision to the users.

Dynamic spectrum management

In current systems, operators are assigned certain frequency bands in which they can offer access to users, using certain radio access technologies determined by the regulator. This allocation is static and operators have to pay for the right to use the allocated spectrum. A part of this spectrum could be used by other operators, leading to a more efficient use and allowing the operator to make a profit from its unused spectrum. This can be accomplished by schemes enabling dynamic leasing of an operator's spectrum by other interested operators. Similarly, the regulator could decide to assign certain frequency bands not for exclusive use of one operator, but for common access by all of them. The spectrum could be allocated dynamically to whoever needs it. In both cases this will lead to a situation in which spectrum is allocated dynamically to the different operators.

Value added service deployment

To be made globally available in heterogeneous environments beyond 3G, value-added services have to be deployed over infrastructures that are highly variable in terms of parameters like terminal equipment and network characteristics (e.g. radio access technologies, network capacity). Such a task requires complex intelligent context-aware logic that is not feasible to be built for every service by the corresponding VASP. Middleware functionality that takes as input service metadata declaratively specified by the VASP and undertakes the automated deployment of the service is a viable solution for this issue. The term deployment in this context refers to the setting up of the network infrastructure so that the VAS can be dynamically discovered, downloaded and executed by the mobile user. Typical deployment functions may include, among others, reconfiguration of network elements (e.g., routers, switches, base stations) for achieving the appropriate quality of service.

Dynamic value added service provision

To support a dynamic service delivery model, where no prior relationship exists between user and VASP, mechanisms for service discovery, downloading and secure execution are required. However, the realisation of this particular use case is highly likely to be dependant upon whether or not the VASP that the user wishes to select has a direct business relationship with either: Mobile Network Operator (MNO) also acting as a Service Aggregator, Third Party Service Aggregator with a relationship with the MNO, or is an internet based Service vendor who has been accessed transparently through the Operator's Network with no relationship with the Operator or guarantee by the Operator as to the quality of that service and in fact may be unknown to the Operator.

Conclusions

This paper has presented the project system research then focused on the business modelling research, the business domains and actors, as well as the business use cases. The five business use cases described encapsulate those elements which are believed to enable a reference business model framework to be derived that will ultimately allow all the potential actors working within the end-to-end reconfigurable networks business eco-system to determine how they must interoperate in order to derive an acceptable business case. However there may be other aspects yet to be addressed which may modify the complete approach.

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