**Title of the research item**

## The End-to-End Reconfigurability (E$^2$R) Research

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**Subject Area**

## WG6: Reconfigurability

### (a)    Objectives of the Required Research

The End-to-End Reconfigurability (E²R) research [1] 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 key objective of the E$^2$R research 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 users, applications and service providers, operators, regulators in the context of heterogeneous mobile radio systems.

Innovative Research, development and proof of concept should be sought over six years in an end-to-end aspect, stretching from user device all the way up to Internet protocol, and services, and in reconfigurability support, intrinsic functionalities such as management and control, download support, spectrum management, regulatory framework and business models.

### (b)    State of the Art in the Area

Since the late nineteen eighties, several initiatives, projects and project frameworks pursuing SDR and reconfigurability research have been initiated (SDR Forum, MVCE, EU ACTS, ESPRIT, IST Projects [2]). While early efforts concentrated on the facilitation of multimode terminals and base stations and had a clear military focus, later initiatives discovered the importance of Software Definable Equipment for the commercial arena. Early initiatives aimed for the 'cheap' platform wherein Velcro styles multiple terminals were integrated together implementing as many air interfaces. Terminals that are "in-as-much-as-possible" defined in software followed this.

A very strong heritage in reconfigurability was gained through former FP5 IST projects [3] like TRUST, SCOUT, MOBIVAS and CAST where expertise in the functions offered to 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 $E^2R$ research scope is set to create opportunities across entire value chain. The provision of protocols stacks, applications and services which are flexible, sharable and adaptable in an heterogeneous radio network environment will bridge the gap between hardware/software technologies on one side and applications and services on the other side.

## (c)    Possible Approach

Reconfigurable equipments and systems will generally provide much higher flexibility, scalability, configurability and interoperability than currently existing mobile communications systems. Reconfiguration will stretch over all OSI layers, on open platforms where the complete protocol stack  (Virtual Radio Engines) will be subject to reconfiguration. Engineering practices will therefore include reconfigurable computing methodologies to cope with the new technology challenges. In order to drive the $E^2R$ research work to success, the following approach is foreseen over 6 years:

- Capture compelling use cases, establish a model architecture of the $E^2R$ system and define end-to-end reconfiguration overall framework,
- Design and prove the concepts of technical solutions to implement reconfigurability in all the layers of an end-to-end wireless communications system,
- Develop a flexible, modular and evolutionary proof of concept environment for validation purposes,
- Disseminate, contribute to related standardisation bodies, organise training sessions and ensure worldwide recognition of the $E^2R$ Research and its results.

## (d)    Work Plan

The approach adopted by the $E^2R$ Research is depicted in Figure 1, wherein three main components are depicted:

1. *E²R System Research, Business Path and Technology Roadmaps* will focus towards compelling scenarios and user requirements of the Radio Eco-System, building on FP5 projects and interacting with other ongoing Research initiatives. In addition, the corresponding roadmap of the identified key enabling technologies within an overall architecture, re-enforced by regulatory rules, will help to set out a clear path of End-to-End reconfigurability within the Radio Eco-Space,

2. *Core Technology Research, Design and Proof of Concept* will constitute another area of work within the E²R Research charter. Research work will encompass the technologies needed to transform embedded flexibility into end-to-end reconfigurability, while finding the right balance between integrated versus distributed approaches. This would yield the optimisation of resources (spectrum, radio, network and equipment) and reconfiguration functions (discovery, negotiations, control and triggering),

3. *E²R Proof of Concept Evolutionary Platform* will enable the validation of the charter of E²R Research as a whole, thus establishing the proof of concept of the overall system within the Radio Eco-Space.
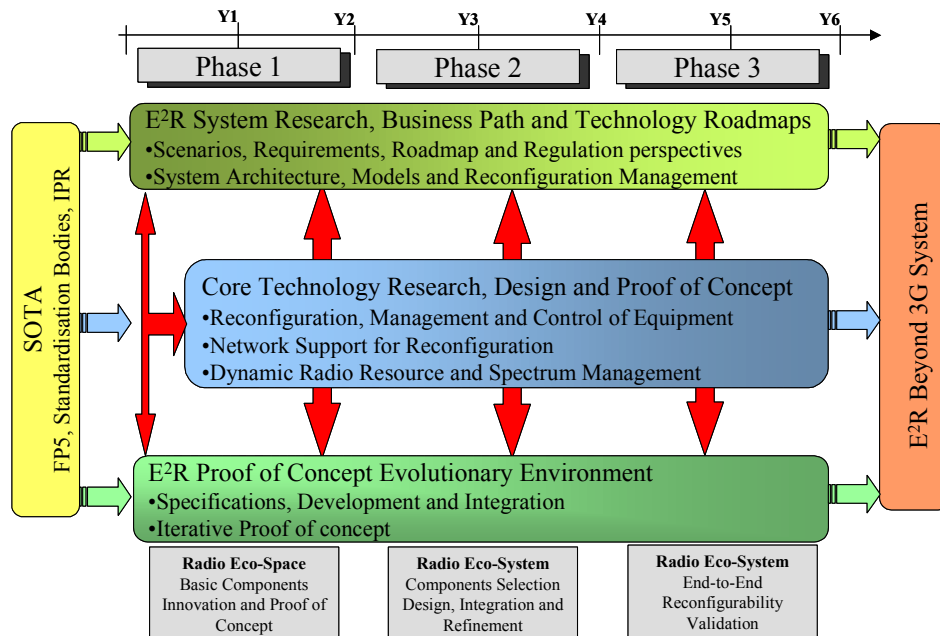


**Figure 1: Approach of E²R Research**

## (e)    Expected Results

The advent of End-to-End reconfigurability will influence the structure of the industry, creating new markets and new employment opportunities, notably in the area of content creation, new services and service/content creation tools but also in wireless information technology administration (WIT). Thus impact on standards, industry and users can be identified as follows:

- Efficient, advanced & flexible end-user service provision. The reconfigurability management of the network and systems will be also serving the optimal provision of end-user services and applications. The aspect of end-to-end reconfigurability encompasses the tailoring of application and service provision to user preferences and profile, taking also into consideration the network/terminal capabilities, configuration and profile, as well as service/charging/security profiles and related context,

- Efficient spectrum, radio and equipment resources utilization. With close collaboration with the Regulations authorities and local regulators, enabling technologies for flexible spectrum resources and the associated security issues will be devised. The aftermaths of such a regulation would be to simplify the process of optimising resource usage, in particular with simpler Flexible Spectrum Allocation (FSA) in order to provide equipments and systems capable to operate in a situation where grant is given to private users to access to a portion of bandwidth that would be unlicensed,

- Reduced cost to upgrade fielded systems. The communications standard used by a device will be field upgradeable through software downloads e.g. over the air. The economics of expensive infrastructure systems will be improved, since the cost of the hardware and deployment can now be amortized over a longer lifetime,

- Multi-standard platforms. A single hardware platform will be shared dynamically amongst multiple applications, with channel resources shifting among different communications standards as the load shifts. This will significantly reduce the cost of infrastructure to support a mixture of legacy and newly deployed fixed-standard radio devices, as long as the duty cycles of the individual devices are acceptably low,

- Better support for customised solutions. A developer will be able to modify the communications standard of a device without investing in a new hardware design. Users who need relatively small volumes of devices, for whom the cost of custom hardware is prohibitive, will gain the ability to improve their operations with devices optimised to their special needs. For instance, equipment management will control remotely the devices,

- Reduced standards risk. An operator will deploy expensive infrastructure or large numbers of mobile devices without locking in the communications standard that will be used. This insulates the operator from potential changes in the standard and from market uncertainty.

## (f)     Time Frame to get the Expected Results

End-to-End Reconfigurability ($E^2R$) Research aims at bringing full benefits of the Radio Eco-Space diversity making heterogeneous environments transparent, flexible and intelligent. Today's multimode terminals and networks offer emerging multimedia applications. In a medium term vision, multimode 2.5G/3G terminal platform will contribute to smart reconfigurable terminal and network that will offer more flexible way to communicate. The ultimate vision of $E^2R$ Research is to reach an all-IP fully integrated networks with reconfigurable equipments and associated discovery, control and management mechanisms. Therefore, research in the end-to-end aspect (stretching from user device all the way up to internet protocol and services) and in reconfigurability support (intrinsic functionalities such as management and control, download support, spectrum, regulatory issues and business models) is required to realise this vision.

## (g)     References

[1]     FP6 End-to-End Reconfigurability ($E^2R$) Project Proposal, Presentation at the EU Concertation Meeting, Brussels, September 9th, 2003.

[2]     "Software Defined Radio: Origins, Drivers and International Perspectives" Wiley Book.

[3]     "Software Defined Radio: Architectures, Systems and Functions" Wiley Book.