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An architecture for converging reconfigurable radio systems

Van den Bergh, Ryan Michael

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Abstract

Since mobile telecommunication systems were first introduced in the early 1980s they have become a pervasive part of modern life, with an estimated 85% of the global population believed to be in possession of a mobile communications device. To address the ever-increasing demand for fast ubiquitous provision of multimedia and data services, new Radio Access Technologies (RATs) capable of meeting those demands are constantly being developed and standardised. Currently the fourth generation of RATs is being deployed by network operators around the world, with standards bodies already working to develop and standardise even more advanced RATs.

The introduction of any new, and often upgraded, RATs almost always requires network operators to purchase new hardware systems capable of supporting the new RATs, which must then be integrated with the plethora of RATs already present in the network operator's heterogeneous Radio Access Network (RAN). This process is costly and poses risks for network operators, as they must first invest significant amounts of capital on new network hardware and then they have to convince their subscribers to purchase new mobile devices which are capable of supporting the new RAT. Reconfigurable Radio Systems (RRSs) are a relatively new approach to developing, implementing and managing RATs within a RAN. A RRS differs from a traditional radio system, in that each RAT is defined in software which can be reused across multiple generic hardware platforms. Many RRSs also provide the functionality to manage and control the dynamic implementation of different RATs in network elements throughout a RAN.

Although RRSs are the subject of numerous research efforts, there is currently no unifying approach or set of requirements for an RRS architecture or framework. Instead various researchers focus their efforts on specific topics relating to RRS, such as the reconfigurable management system, or how RATs are modelled and implemented in software. This lack of formal standardisation or approach to developing RRSs represents a hindrance to the widespread adoption of RRSs.

After having reviewed and analysed the architectures and functionality of all major RRSs developed by researchers and standardisation initiatives, this thesis defines a set of combined functional requirements which forms the basis for the development of a Converged RRS Architecture (CRRSA) capable of both managing and controlling the reconfiguration operations of a RAN, and dynamically implementing any RAT at runtime. The CRRSA was developed using a greenfield approach, thereby avoiding the limitations of existing RRSs, which cannot be simply upgraded or modified to support all of the defined functional requirements, both for practical reasons and due to architectural and technological limitations.

The CRRSA is an extremely flexible and scalable architecture which defines a series of technology-independent logical components and interfaces for managing and performing reconfiguration operations in the Subscriber, Access Network and Core Network domains. The CRRSA is unique in that it provides the capability to customise and upgrade its reconfiguration management system through the use of logical components called Reconfigurable Algorithms.

The implementation of RATs in the CRRSA is achieved by decomposing each RAT into its fundamental components, and encapsulating the resulting functions within software components called Reconfigurable Components, which are then used to construct the RAT during reconfiguration operations. The primary benefit of this methodology is that any RAT can be implemented simply by choosing and connecting the appropriate Reconfigurable Components.

In order to prove the CRRSA's practical viability, the CRRSA was implemented and tested in a series of simulations using two RAT models derived from the IEEE 802.16 and 3GPP LTE standards. The results of these simulations confirmed that the CRRSA is capable of managing and controlling all reconfiguration operations throughout a RAN, and that it is capable of practically implementing RATs via Reconfigurable Components, which are not only able to successfully transmit signals in a simulated environment, but which are also able to transmit and receive signals carrying data through the wireless environment using an actual SDR hardware platform.

The CRRSA thus provides a key contribution to the field of RRS by delivering a detailed unified logical architecture which can be used to develop and standardise RRSs, and which possesses flexible and scalable methods for reconfiguring and adapting the functionality of its reconfigurable management system and RATs in a real wireless environment using SDR hardware platforms.