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Reconfigurable Radio Systems (RRS); Radio reconfiguration related architecture for Mobile Devices (MD)

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Foreword

This European Standard (EN) has been produced by ETSI Technical Committee Reconfigurable Radio Systems (RRS).

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Modal verbs terminology

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1 Scope

The scope of the present document is to define the radio reconfiguration related architecture for reconfigurable Mobile Devices. The work will be based on the system requirements defined in ETSI EN 302 969 [1] and the Use Cases defined in ETSI TR 103 062 [i.1] and ETSI TR 102 944 [i.2].

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI EN 302 969 (V1.3.1): "Reconfigurable Radio Systems (RRS); Radio Reconfiguration related requirements for Mobile Devices".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 103 062: "Reconfigurable Radio Systems (RRS) Use Cases and Scenarios for Software Defined Radio (SDR) Reference Architecture for Mobile Device".

[i.2] ETSI TR 102 944: "Reconfigurable Radio Systems (RRS); Use Cases for Baseband Interfaces for Unified Radio Applications of Mobile Device".

[i.3] Recommendation ITU-T M.60: "Maintenance Terminology and Definitions".

[i.4] ETSI TS 103 436: "Reconfigurable Radio Systems (RRS); Security requirements for reconfigurable radios".

[i.5] ETSI TR 103 087: "Reconfigurable Radio Systems (RRS); Security related use cases and threats in Reconfigurable Radio Systems".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Application Processor (AP): part of mobile device hardware working under OS control and on which User Applications, among others, are executed

Baseband Parameter Aggregation (BPA): unit collecting all the context information to be transferred to the monitor

NOTE: The BPA unit converts the context information into metric(s) such that a minimum bandwidth is consumed during the procedure of transferring the context information to the monitor. Those metrics may include Received Signal Strength Indication (RSSI) measurement, multi-RAT performance metrics, etc.

communication services layer: layer related to communication services supporting generic applications

NOTE: A communication services layer supports generic applications like Internet access. In the present document, it consists of Administrator, Mobility Policy Manager (MPM), Networking stack and Monitor.

configcodes: result of compiling the source codes of a Radio Application (RA), which is either configuration codes of Radio Virtual Machine (RVM) or executable codes for a particular target platform

NOTE: In the case when RA provider makes a high level code based on a target platform, a result of compiling RA source codes is configcodes which is executable on the target platform. In the other case, when RA provider makes a high level code without considering a target platform, a result of front-end compiling of RA source codes is an Intermediate Representation (IR) which should be back-end compiled for operating on a specific target platform.

data flow: logical channel between Flow Controller (FC) and a Unified Radio Applications (URA) created by FC to send to or receive data elements (octets, packets or other granularity) from URA

environmental information: set of values that can affect the execution of RAs on a Radio Computer

NOTE: Environmental information consists of information related to the execution of RA(s), such as Buffer Overflow, Resource Allocation, etc.

Functional Block (FB): function needed for real-time implementation of RA(s)

NOTE 1: A functional block includes not only the modem functions in Layer1 (L1), Layer2 (L2), and Layer 3 (L3) but also all the control functions that should be processed in real-time for implementing given RA(s).

NOTE 2: Functional blocks are categorized into Standard Functional Blocks (SFBs) and User Defined Functional Blocks (UDFBs). In more details:

1) *SFB* can be shared by many RAs. For example, Forward Error Correction (FEC), Fast Fourier Transform (FFT)/Inverse Fast Fourier Transform (IFFT), (de)interleaver, Turbo coding, Viterbi coding, Multiple Input Multiple Output (MIMO), Beamforming, etc. are the typical category of standard functional block.

2) *UDFB* include those functional blocks that are dependent upon a specific RA. They are used to support special function(s) required in a specific RA or to support a special algorithm used for performance improvement. In addition, a user defined functional block can be used as a baseband controller functional block which controls the functional blocks operating in baseband processor in real-time and to control some context information processed in real-time.

NOTE 3: Each functional block has its unique name, Input, Output, and properties.

peer equipment: any communication counterpart of a reconfigurable radio equipment

NOTE: The peer equipment can be reached by establishing a (logical) communications link (i.e. an association) between the reconfigurable radio equipment and peer equipment. Examples of peer equipment include Wide Local Area Network (WLAN) access points, Internet Protocol (IP) access nodes, etc.

Radio Application (RA): software which enforces the generation of the transmit RF signals or the decoding of the receive RF signals

NOTE 1: The software is executed on a particular radio platform or an RVM as part of the radio platform.

NOTE 2: RAs might have different forms of representation. They are represented as:

- Source codes including Radio Library calls of Radio Library native implementation and Radio HAL calls.
- IRs including Radio Library calls of Radio Library native implementation and radio HAL calls.
- Executable codes for a particular radio platform.

radio computer: part of mobile device hardware working under ROS control and on which RAs are executed

NOTE: A Radio Computer typically include programmable processors, hardware accelerators, peripherals, etc. RF part is considered to be part of peripherals.

Radio Control Framework (RCF): control framework which, as a part of the OS, extends OS capabilities in terms of radio resource management

NOTE: RCF is a control framework which consists of Configuration Manager (CM), Radio Connection Manager (RCM), Flow Controller (FC) and Multiradio Controller (MRC). The Resource Manager (RM) is typically part of OS.

Radio Controller (RC): functional component of RA for transferring context information from corresponding RAs to monitor

NOTE: An RC, which may operate in an application processor in non real-time, accesses RAs which operates in Radio Computer in real time. The monitor, to which the context information is transferred using RC, provides context information to Administrator and/or Mobility Policy Manager (MPM) for application(s) to be performed using the context information, for example, terminal-centric configuration.

Radio Frequency Transceiver (RF Transceiver): part of radio Platform converting, for transmission, baseband signals into radio signals, and, for reception, radio signals into baseband signals

Radio Library (RL): library of SFB that is provided by a platform vendor in a form of platform-specific executable code

NOTE 1: SFBs implement reference codes of functions which are typical for radio signal processing. They are not atomic and their source codes are typed and visible for RA developers.

NOTE 2: An SFB is implemented through a Radio Hardware Abstraction Layer (HAL) when the SFB is implemented on hardware accelerators. Radio HAL is part of ROS.

Radio Operating System (ROS): any appropriate OS empowered by RCF

NOTE: ROS provides RCF capabilities as well as traditional management capabilities related to management of RP such as resource management, file system support, unified access to hardware resources, etc.

radio platform: part of mobile device hardware which relates to radio processing capability, including programmable components, hardware accelerators, RF transceiver, and antenna(s)

NOTE: A radio Platform is a piece of hardware capable of generating RF signals or receiving RF signals. By nature, it is heterogeneous hardware including different processing elements such as fixed accelerators, e.g. Application-Specific Integrated Circuit (ASIC), or reconfigurable accelerators, e.g. FPGAs, etc.

Radio Virtual Machine (RVM): abstract machine which supports reactive and concurrent executions

NOTE: An RVM may be implemented as a controlled execution environment which allows the selection of a trade-off between flexibility of base band code development and required (re-)certification efforts.

reconfigurable mobile device: mobile device with radio communication capabilities providing support for radio reconfiguration

NOTE: Reconfigurable mobile devices include but are not limited to: smartphones, feature phones, tablets, and laptops.

reference point: conceptual point at the conjunction of two non-overlapping functions that can be used to identify the type of information passing between these functions

NOTE: This definition is introduced by Recommendation ITU-T M.60 [i.3].

shadow radio platform: platform where configcodes can be directly executed when it corresponds to the target radio platform or, when it corresponds to an RVM, compiled and executed

NOTE: If the Shadow radio platform is equivalent to the target radio platform, then a front-end compiler will generate the executable code for the target radio platform and configcodes are equivalent to the executable code for that radio platform.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

M_1	Number of SFBs implemented on Radio computer
M_2	Number of SFBs implemented on hardware accelerators

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AOT	Ahead-Of-Time
AP	Application Processor
ASF	Administrator Security Function
ASIC	Applications-Specific Integrated Circuit
BE	Back End
BPA	Baseband Parameter Aggregation
CM	Configuration Manager
CSL	Communication Services Layer
FC	Flow Controller
FEC	Forward Error Correction
FFT	Fast Fourier Transform
FM	File Manager
FPGA	Field Programmable Gate Array
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
GPS	Global Positioning System
HAL	Hardware Abstraction Layer
HW	HardWare
ID	Identification
IFFT	Inverse Fast Fourier Transform
IP	Internet Protocol
IR	Intermediate Representation
JIT	Just-In-Time
KMS	Key Management System
MAC	Medium Access Control
MD	Mobile Device
MDRC	Mobile Device Reconfiguration Class
MIMO	Multi-Input-Multi-Output
MPM	Mobility Policy Manager
MRC	MultiRadio Controller
MURI	MUltiRadio Interface

OEM	Original Equipment Manufacturer
OS	Operating System
RA	Radio Application
RAP	Radio Application Package
RAT	Radio Access Technology
RC	Radio Controller
RCF	Radio Control Framework
RCM	Radio Connection Manager
RF	Radio Frequency
RL	Radio Library
RM	Resource Manager
ROS	Radio Operating System
RPI	Radio Programming Interface
RRFI	Reconfigurable Radio Frequency Interface
RRS	Reconfigurable Radio Systems
RRS-CA	Reconfigurable Radio Systems Configuration Authority
RRS-CM	RRS Configuration Manager
RRS-CP	RRS Configuration Provider
RVM	Radio Virtual Machine
SDR	Software Defined Radio
SFB	Standard Functional Block
SW	SoftWare
TAD	Transfer of Authority Document
TX/RX	Transmission/Reception
UDFB	User Defined Functional Block
URA	Unified Radio Applications
URAI	Unified Radio Applications Interface
WLAN	Wireless Local Area Network

4 Architectural Reference Model for Reconfigurable Mobile Devices

4.1 Introduction

The present document describes those elements of a mobile device which are related to the software radio reconfiguration only. For this reason,the usage of the term "architecture" is limited to those elements and not to the overall HW/SW architecture of a mobile device which is out of the scope of the present document.

The present document is organized as follows:

Clause 4.2 describes the reconfigurable mobile device architecture in term of its components and entities.

Clause 4.3 describes the architecture reference model for multiradio applications.

Clause 4.4 describes the "Radio Computer".

Clause 4.5 describes the Radio Virtual Machine as part of the architecture.

Clause 4.6 describes the Unified Radio Application.

Clause 4.7 describes the security architecture for reconfigurable mobile devices.

Clause 5 describes the (logical) interfaces between the identified components/entities.

Clause 6 lists the operating procedures of a reconfigurable mobile devices.

Clause 4 includes a list of tables mapping the system requirements as defined in ETSI EN 302 969 [1] to the different entities/components/units which have been identified. In general, according to the MDRC [1] the reconfigurable mobile device belongs to, all the related mandatory functional requirements described in ETSI EN 302 969 [1] shall be implemented.

4.2 Reconfigurable Mobile Devices - Architecture Components for Radio Reconfiguration

4.2.1 High level description

Figure 4.1 shows the reconfigurable mobile device architectural components related to the radio reconfiguration as well as the related entities. As shown in the figure, the following components can be identified:

- Communication Services Layer (CSL):
  - 4 logical entities: Administration, Mobility Policy Manager, Networking Stack and Monitor.
- Radio Control Framework (RCF):
  - 5 logical entities: Configuration Manager, Radio Connection Manager, Multi-Radio Controller, Resource Manager and Flow Controller.
- Unified Radio Applications (URA).
- Radio Platform (consisting of RF Transceiver, Baseband, etc.).

These 4 components consist of Software (CSL, RCF) and/or Hardware (radio platform) entities and they shall be interconnected through well defined interfaces as follows:

- Multiradio Interface (MURI) between CSL and RCF.
- Unified Radio Application Interface (URAI) between RCF and URA.
- Reconfigurable Radio Frequency Interface (RRFI) between URA and RF Transceiver.

The above mentioned interfaces are not covered by the present document.

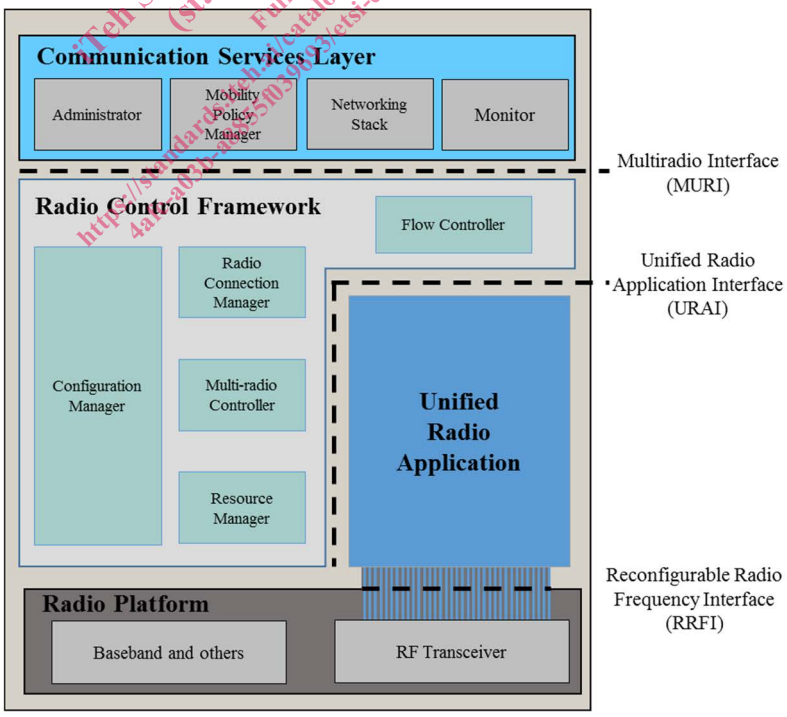

Figure 4.1: Reconfigurable mobile device architecture components for radio reconfiguration

For each component, the required entities depend on the MDRC [1]. A Reconfigurable Mobile Device shall support all the components and their entities as required by the corresponding MDRC as shown in Table 4.1. In case that a Reconfigurable Mobile Device supports multiple MDRCs, the concerned Reconfigurable Mobile Device shall support all the components and entities related to the highest supported MDRC.

Table 4.1: Required Components of the Reconfigurable Mobile Device Architecture in function of the Mobile Device Reconfiguration Class

Mobile Device Reconfiguration Class	Required CSL Entities	Required RCF Entities	Required Interfaces
MDRC-0	None	None	None
MDRC-1	Administrator, Mobility Policy Manager, Networking Stack, Monitor	Configuration Manager, Radio Connection Manager, Flow Controller	MURI
MDRC-2, MDRC-5	Administrator, Mobility Policy Manager, Networking Stack, Monitor	Configuration Manager, Radio Connection Manager, Multi-Radio Controller, Flow Controller	MURI, URAI, RRFI
MDRC-3, MDRC-6	Administrator, Mobility Policy Manager, Networking Stack, Monitor	Configuration Manager, Radio Connection Manager, Multi-Radio Controller, Flow Controller	MURI, URAI, RRFI
MDRC-4, MDRC-7	Administrator, Mobility Policy Manager, Networking Stack, Monitor	Configuration Manager, Radio Connection Manager, Multi-Radio Controller, Resource Manager, Flow Controller	MURI, URAI, RRFI

The following clauses describe in more details the identified components as well as the related logical entities.

4.2.2 Communication Services Layer (CSL)

The CSL is a layer related to communication services supporting both generic applications and specific applications related to multiradio applications. CSL includes the following 4 entities:

- **Administrator entity**

  The Administrator entity shall include at least functions to request installation or uninstallation of URA, and creating or deleting instances of URA. This typically includes the provision of information about the URA, their status, etc. Furthermore, the Administrator includes two sub-entities: the Administrator Security Function (ASF) and the RRS Configuration Manager (RRS-CM).

NOTE: In case that a snapshot function is required, the Administrator entity may store relevant RAPs, their configuration parameters and information on the URA installation and execution history. When required, the same steps can be executed by the Administrator entity to fall back to a previous snapshot.

- **Mobility Policy Manager (MPM) entity**

  The MPM shall include at least functions for monitoring of the radio environments and MD capabilities, to request activation or deactivation of URA, and to provide information about the URA list. It shall also make selection among different radio access technologies and discover peer communication equipment and arrangement of associations.

- **Networking stack entity**

  The Networking stack entity shall include at least functions for sending and receiving of user data.

- **Monitor entity**

  The Monitor entity shall include at least functions to transfer information from URA to user or proper destination entity in MD.

4.2.3 Radio Control Framework (RCF)

The RCF provides a generic environment for the execution of URA, and a uniform way of accessing the functionality of the Radio Computer and individual RAs. RCF provides services to CSL via the Multiradio Interface (MURI).

The RCF includes the following 5 entities for managing URA [i.2]:

- **Configuration Manager (CM) entity**

  The CM shall include at least functions for installing/uninstalling and creating/deleting instances of URA as well as management of and access to the radio parameters of the URA.

- **Radio Connection Manager (RCM) entity**

  The RCM shall include at least functions for activating/deactivating URA according to user requests, and to management of user data flows, which can also be switched from one RA to another.

- **Flow Controller (FC) entity**

  The FC shall include at least functions for sending and receiving of user data packets and controlling the flow of signalling packets.

- **Multiradio Controller (MRC) entity**

  The MRC shall include at least functions to schedule the requests for radio resources issued by concurrently executing URA, and to detect and manage the interoperability problems among the concurrently executed URA.

- **Resource Manager (RM) entity**

  The RM shall include at least functions to manage the computational resources, to share them among simultaneously active URA, and to guarantee their real-time execution.

4.2.4 Unified Radio Application (URA)

As described in clause 4.2.3, the RCF, which represents functionalities provided by the Radio Computer, requires all RAs to be subject to a common reconfiguration, multiradio execution and resource sharing strategy framework (depending on the concerned MDRC). Since all RAs exhibit a common behaviour from the reconfigurable MD perspective, those RAs are called URAs. The services relate to activation and deactivation, peer equipment discovery and maintenance of communication over user data flows are provided at Unified Radio Application Interface (URAI), which is an interface between URA and RCF.

4.2.5 Architectural Components System Requirements mapping

The logical entities above described are mapped to the system requirements described in ETSI EN 302 969 [1] as shown in Table 4.2.