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Reconfigurable Radio Systems (RRS);
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Part 2: Reconfigurable Radio Frequency Interface (RRFI)

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Contents

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Reconfigurable Radio Systems (RRS).

The present document is part 2 of a multi-part deliverable covering the Mobile Device Information Models and Protocols, as identified below:

Part 1: "Multiradio Interface (MURI)";

Part 2: "Reconfigurable Radio Frequency Interface (RRFI)";

Part 3: "Unified Radio Applications Interface (URAI)";

Part 4: "Radio Programming Interface (RPI)".

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document defines an information model and protocol for reconfigurable radio frequency interface for reconfigurable mobile devices. The work will be based on the Use Cases defined in ETSI TR 102 944 [i.1], on the system requirements defined in ETSI EN 302 969 [1] and on the radio reconfiguration related architecture for mobile devices defined in ETSI EN 303 095 [i.8].

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 http://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 (V1.2.1): "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.

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 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 102 944: "Reconfigurable Radio Systems (RRS); Use Cases for Baseband Interfaces for Unified Radio Applications of Mobile Device".

[i.2] Recommendation ITU-T Q.1290: "Glossary of Terms used in the Definition of Intelligent Networks".

[i.3] ETSI TR 102 839: "Reconfigurable Radio Systems (RRS); Multiradio Interface for Software Defined Radio (SDR) Mobile Device Architecture and Services".

[i.4] IEEE 1900.4-2009: "IEEE Standard for Architectural Building Blocks Enabling Network-Device Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Access Networks".

[i.5] ETSI TS 103 146-1: "Reconfigurable Radio Systems (RRS); Mobile Device Information Models and Protocols; Part 1: Multiradio Interface (MURI)".

[i.6] DigRFSM Working Group: "MIPI® Alliance Specification for DigRFSM v4".

[i.7] Recommendation ITU-T X.680:"Information technology - Abstract Syntax Notation One (ASN.1): Specification of basic notation".

[i.8] ETSI EN 303 095 (V1.2.1): "Reconfigurable Radio Systems (RRS); Radio Reconfiguration related Architecture for Mobile Devices".

3 Definitions 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

channel: designated part of the information transfer capability having specified characteristics, provided at the user network interface

NOTE: It is the over-the-air wireless propagation channel which is used to convey an information signal from transmitter to receiver. This definition is specified in [i.2].

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.

link: connecting one location to another through a given Radio Access Technology for the purpose of transmitting and receiving digital information

NOTE: Each Link is conveyed over a given Channel.

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 includes 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 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 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.

3.2 Abbreviations

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

ACK	Acknowledge
ASIC	Application Specific Integrated Circuit
ASN	Abstract Syntax Notation
ASN.1	Abstract Syntax Notation One
BBIC	BaseBand Integrated Circuit
BLER	Block Error Rate
CSL	Communication Services Layer
EU	European Union
MD	Mobile Device
MDRC	Mobile Device Reconfiguration Class
MIMO	Multi-Input Multi-Output
MPM	Mobility Policy Manager
MURI	MUltiRadio Interface
NACK	Negative-Acknowledge
OOB	Out-Of-Band
OS	Operating System
RA	Radio Application
RAN	Radio Access Network
RAP	Radio Application Package
RAT	Radio Access Technology
RCF	Radio Control Framework
RF	Radio Frequency
RFIC	Radio Frequency Integrated Circuit
ROS	Radio Operating System
RPI	Radio Programming Interface
RRFI	Reconfigurable Radio Frequency Interface
RVM	Radio Virtual Machine
RX	Reception
SINR	Signal to Interface plus Noise Ratio
UML	Unified Modeling Language
URA	Unified Radio Applications
URAI	Unified Radio Applications Interface

4 Introduction

A reconfigurable MD is capable of running multiple radios simultaneously and of changing the set of radios by loading new Radio Application Package (RAP). All Radio Applications (RAs) are called Unified Radio Applications (URAs) when they exhibit a common behavior from the reconfigurable MD's point of view [1]. In order to run multiple URAs, the reconfigurable MD will include Communication Services Layer (CSL), Radio Control Framework (RCF), Radio Platform and 4 sets of interfaces for their interconnection.

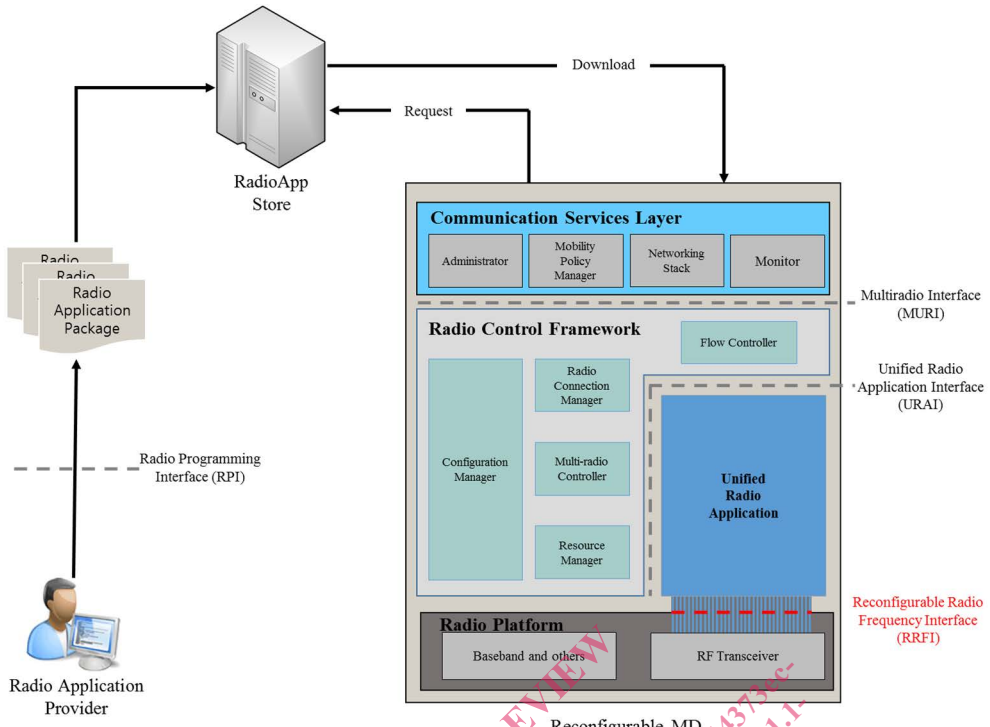

Figure 4.1: Four sets of interfaces for Reconfigurable MD

Figure 4.1 illustrates the Reconfigurable MD architecture with the 4 sets of interfaces, i.e.:

- MURI for interfacing CSL and RCF [i.5];
- RRFI for interfacing URA and RF Transceiver, which is the scope of the present document;
- URAI for interfacing URA and RCF [i.3];
- RPI for allowing an independent and uniform production of RAs [i.3].

The present document defines RRFI.

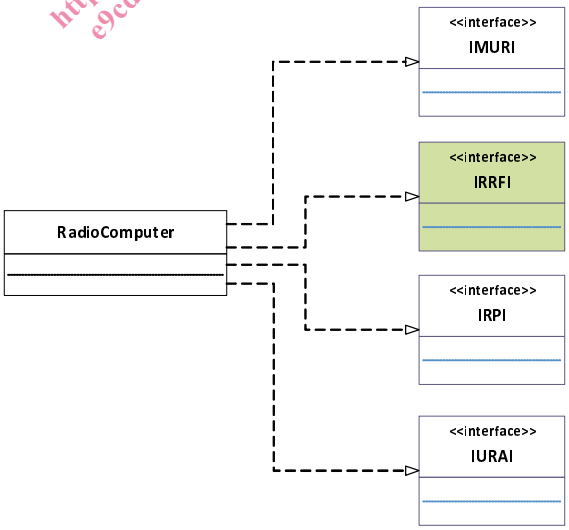

Figure 4.2: UML® class diagram for Radio Computer interfaces

Figure 4.2 illustrates UML® class diagram for Radio Computer interfaces. The reconfigurable MD may be seen as a Radio Computer where individual URAs are engineered as software entities [i.8].

The present document is organized as follows:

- clause 5 describes the system identification;
- clause 6 describes the notational tool for defining both information model classes and interface classes;
- clause 7 describes the information model for radio computer; and
- clause 8 describes the interface definition.

While UML® is used for defining the information model and protocol related to RRFI, other modeling languages could be used as well.

5 System Identification

5.1 Radio Computer Structure

Figure 5.1 illustrates how URA and RF Transceiver interact with each other using RRFI.

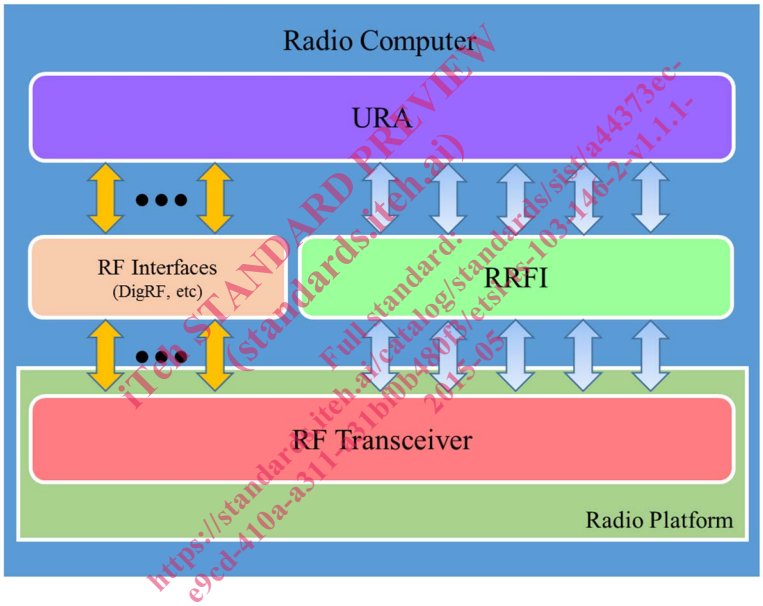

Figure 5.1: Interconnection between URA and RF Transceiver using RRFI for Reconfigurable MD

As shown in figure 5.1, RRFI can support up to 5 kinds of services depending on the applicable MDRC [1].

Note that a Reconfigurable Mobile Device supports all the services as required by the corresponding MDRC as shown in table 5.1 and fully detailed in clause 8 of the present document. In case that a Reconfigurable Mobile Device supports multiple MDRCs, the concerned Reconfigurable Mobile Device supports all the services as defined in table 5.1.

Table 5.1: Required services of RRFI according to each MDRC

Mobile Device Reconfiguration Class	*Spectrum Control services*	*Power Control services*	*Antenna Management services*	*Tx/Rx Chain Control services*	*RVM Protection services*
MDRC-0	No	No	No	No	No
MDRC-1	Yes	Yes	No	No	Yes
MDRC-2, MDRC-5	Yes	Yes	Yes	Yes (note)	Yes
MDRC-3, MDRC-6	Yes	Yes	Yes	Yes	Yes
MDRC-4, MDRC-7	Yes	Yes	Yes	Yes	Yes
NOTE: Among the various Tx/Rx Chain Control services, only the service related with Tx/Rx timing is required in this case.					

A corresponding summary of the services is given below.

- **Spectrum Control services**

  These services are used to set up spectrum-related parameters such as carrier frequency, bandwidth of carrier frequency, sampling frequency, etc. that will be determined according to the URAs they are related to.

- **Power Control services**

  These services are used to set up RF power-related parameters such as maximum transmit (Tx) power level, Tx power level per antenna, receive (Rx) gain, etc. Specific power schemes which have to be controlled according to the communication circumstance around the reconfigurable MD are also included in the Power Control services.

- **Antenna Management services**

  These services are used to determine the antenna configuration. Antenna radiation pattern, antenna gain, antenna direction, sector configuration, polarization, etc. are some factors to be considered in the Antenna Management services.

NOTE: Antenna management services depend on the configurability of the antenna.

- **Tx/Rx Chain Control services**

  These services are used to provide parameters related to real-time control of the RF transceiver chain. Parameters to be controlled using the Tx/Rx Chain Control services include (but are not limited to) Tx start/stop time, Rx start/stop time, spectrum- and/or power-related values.

- **RVM Protection services**

  These services are used to provide parameters related to the selection of RVM protection class. Parameters to be controlled using the RVM Protection services include (but are not limited to) selection and/or request of RF protection class as well as, RF Front-end indication of input data signals modification.

The following clauses describe the components/entities shown in figure 5.1.

5.2 URA

RAs need 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 [i.8].

5.3 RF Transceiver

RF Transceiver, which includes transceiver chain(s), is part of the Radio Platform in Radio Computer that transforms, in Tx mode, the baseband signal to radio signal, and in Rx mode, the radio signal to baseband signal.

5.4 RF Interfaces

The RF Interfaces depicted in figure 5.1 denote digital interfaces which define the physical interconnections between base-band and RFIC (Radio Frequency Integrated Circuit), for example, the DigRF^{SM} specification defining the interface between an RFIC and a BBIC (Base-Band Integrated Circuit) in a mobile device. RRFI defined in the present document complements such RF interfaces by defining services which are required for Reconfigurable MDs.

5.5 Radio Computer RF System Requirement Mapping

The Radio Computer components above described shall support the RF system requirements shown in table 5.2 and described in clause 6.5 of ETSI EN 302 969 [1].

NOTE: The transceiver requirements defined in clauses 6.5.5, 6.5.6 and 6.5.8 of ETSI EN 302 969 [1] are not related to the RF Interface defined in the present document and therefore do not appear in table 5.2.

Table 5.2: Mapping of Radio Computer Components to the system requirements described in ETSI EN 302 969 [1]

Entity/Component/Unit	System Requirements [1]	Comments
Unified Radio Applications	R-FUNC-RFT-02	Radio Application selects a suitable number of antenna inputs/outputs. The requirement is described in clause 6.5.2 of [1].
RF Transceiver	R-FUNC-RFT-03	The reconfigurable MD supports multiple Radio Applications using distinct frequency bands. The requirement is described in clause 6.5.3 of [1].
	R-FUNC-RFT-04	RF transceiver manages input/output signals from/to one or several Radio Applications. The requirement is described in clause 6.5.4 of [1].
Reconfigurable RF Interface	R-FUNC-RFT-01, R-FUNC-RFT-07	The RRFI provides a suitable interface for RF transceiver configuration. The requirement is described in clauses 6.5.1 and 6.5.7 of [1].
	R-FUNC-RFT-09	The RRFI supports a suitable selection of an RF protection class. The requirement is described in clause 6.5.9 of [1].

6 Notational Tools

6.1 Notational Tool for Information Model Classes

Table 6.1 shows a template for defining information model classes [i.4]. Each information model class is defined in clause 7.2 in accordance with the template shown in table 6.1.

Note that ASN.1 is used throughout the present document for abstract type definitions; however, alternative ways are possible and are not excluded.

Table 6.1: Template for defining Information Model Classes

<table>
<tr><td colspan="4">Class<Class name>[(abstract class)]</td></tr>
<tr><td colspan="4"><Description of the class></td></tr>
<tr><td>DERIVED FROM</td><td colspan="3"><List of super-classes></td></tr>
<tr><td colspan="4">ATTRIBUTES</td></tr>
<tr><td><Attribute name>
[<optional>]</td><td>Value type:
<Attribute value type></td><td>Possible access:
<Attribute access qualifier></td><td>Default value:
<Default value></td></tr>
<tr><td colspan="4"><Description of the attribute></td></tr>
<tr><td>CONTAINED IN</td><td colspan="3"><List of classes, whose instances may contain an instance of this class. If this class is an abstract class, that is, it is used for further refinement only and will never be instantiated, then this list is empty.></td></tr>
<tr><td>CONTAINS</td><td colspan="3"><List of classes, whose instances may be contained in an instance of this class. Constraints used are:
• [*] - zero or more instances,
• [+] - one or more instances,
• [<n>] - exactly n instances,
• [<m> - <n>] - not less than m and not more than n instances.></td></tr>
<tr><td>SUPPORTED EVENTS</td><td colspan="3"><List of event names that are detected by this class and lead potentially to a corresponding event report></td></tr>
</table>

Further details on the template in table 6.1 are given below.

- <Class name> is the name of the Class as it appears in the corresponding model. Additional information is also included in case the class in question has been specified as an abstract one.
- DERIVED FROM field identifies the super class of the class in case of sub-classing.
- ATTRIBUTES field describes the attributes that have been defined in the class. More specifically:
    - <Attribute name> identifies the name of an attribute, as it is included in the class definition.