ETSI TR 102 680 V1.1.1 (2009-03)

Technical Report

Reconfigurable Radio Systems (RRS); SDR Reference Architecture for Mobile Device

Reference
DTR/RRS-02002

Keywords
architecture, radio

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

Individual copies of the present document can be downloaded from:
http://www.etsi.org

The present document may be made available in more than one electronic version or in print. In any case of existing or perceived difference in contents between such versions, the reference version is the Portable Document Format (PDF). In case of dispute, the reference shall be the printing on ETSI printers of the PDF version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
http://portal.etsi.org/tb/status/status.asp

If you find errors in the present document, please send your comment to one of the following services:
http://portal.etsi.org/chaircor/ETSI_support.asp

Contents

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://webapp.etsi.org/IPR/home.asp).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Reconfigurable Radio Systems (RRS).

Introduction

The present document provides a feasibility study on creating a reference architecture for such mobile devices which are capable to use technological elements known as Software Defined Radio. Such mobile devices will operate as functional elements in reconfigurable radio systems by using multiple different radio standards simultaneously.

As a feasibility study the present document provides basis for decision making at ETSI Board level on standardization of some or all topics of the SDR Reference Architecture for Mobile Device.

1 Scope

The present document describes the reference architecture for SDR equipped mobile devices, which allows them to operate as part of reconfigurable radio systems. The reference architecture is outlined in the present document to the extent which is necessary to identify architectural elements (components and interfaces) as candidates for further standardization. As a basis for the reference architecture common requirements for such a SDR mobile device are also in the scope of the present document. Since the feasibility of standardization of architectural elements for SDR mobile devices also depends on already standardized or ongoing activities on such architectural elements the present document also provides a survey on SDR standardization in other SDOs.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
  - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
  - for informative references.

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.

2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area**.** For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] OMG sbc/07-06-07: "Software Radio Specification Overview".

[i.2] IEEE P1900.4: "Draft Standard for Architectural building blocks enabling network-device distributed decision making for optimized radio resource usage in heterogeneous wireless access networks".

[i.3] IEEE P802.22: "Draft Standard for White Spaces".

[i.4] IEEE P802.21: "Draft Standard for Local and Metropolitan Area Networks: Media Independent Handover Services".

[i.5] The MIPI Alliance.

NOTE: Web page at http://www.mipi.org/wgoverview.shtml.

[i.6] ETSI TR 125 913: "Universal Mobile Telecommunications System (UMTS); LTE; Requirements for Evolved UTRA (E-UTRA) and Evolved UTRAN (E-UTRAN) (3GPP TR 25.913 version 8.0.0 Release 8)".

[i.7] 3GPP TR 36.913: "Technical Specification Group Radio Access Network; Requirements for Further Advancements for E-UTRA (LTE-Advanced) (Release 8)".

[i.8] RP-080758 Work Item: "Description on RF requirements for Multicarrier and Multi-RAT BS", TSG-RAN Meeting #41, Kobe, Japan, 9 - 12 September 2008.

[i.9] "The Khronos Group OpenMAX Integration, Development and Application Layer Programming Interface Specifications, 2008".

3 Definitions and abbreviations

3.1 Definitions

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

mobile device: personal communication device (e.g. mobile phone, PDA, laptop PC etc) capable of communicating either locally (e.g. Bluetooth), through a network (e.g. GSM) or both by using one or more radio technologies

radio application: software application executing in a software defined multiradio equipment

NOTE: Radio application is typically designed to use certain radio frequency band(s) and it includes agreed schemes for multiple access, modulation, channel and data coding as well as control protocols for all radio layers needed to maintain user data links between adjacent radio equipments, which run the same radio application

radio equipment: equipment using radio technology

radio system: system, which consists of a number of radio equipments using at least one common radio technology

radio technology: technology for wireless transmission and/or reception of electromagnetic radiation for information transfer

software defined radio: radio in which the RF operating parameters including, but not limited to, frequency range, modulation type, or output power can be set or altered by software, and/or the technique by which this is achieved

NOTE 1: Excludes changes to operating parameters which occur during the normal pre-installed and predetermined operation of a radio according to a system specification or standard.

NOTE 2: SDR is an implementation technique applicable to many radio technologies and standards.

NOTE 3: SDR techniques are applicable to both transmitters and receivers.

software defined multiradio: device or technology where multiple radio technologies can coexist and share their wireless transmission and/or reception capabilities, including but not limited to regulated parameters, by operating them under a common software system

NOTE 1: Examples of the regulated parameters are frequency range, modulation type, and output power.

NOTE 2: Common software system represents radio operating system functions.

NOTE 3: This definition does not restrict the way software is used to set and/or change the parameters. In one example, this can be done by the algorithm of the already running software. In another example, software downloading may be required.

software defined radio equipment: radio equipment supporting SDR technology

3.2 Abbreviations

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

API	Application Programming Interface
ASIC	Application Specific Integrated Circuit
ASIP	Application Specific Instruction Processor
BB	BaseBand
BBIC	BB Integrated Circuit
CDR	Computer Defined Radio
CM	Configuration Manager
CMOS	Complementary Metal-Oxide Semiconductor
CORBA	Common Object Requesting Broker Architecture
CR	Cognitive Radio
DSP	Digital Signal Processor
EMR	Electro-Magnetic Radiation
FC	Flow Controller
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio System
HW	HardWare
IP	Internet Protocol

NOTE: As in TCP/IP.

IP	Intellectual Property

NOTE: As in semiconductor IP.

JTRS	Joint Tactical Radio System
LTE	Long Term Evolution
MDA	Model Driven Architecture
MIH	Media Independent Handover
MIHF	Media Independent Handover Function
MIPI	Mobile Industry Processor Interface
MRC	MultiRadio Controller
MURI	MUltiRadio access Interface
OFDM	Orthogonal Frequency Division Multiplexing
OMD	Object Management group
PDA	Personal Digital Assistant
PIM	Platform Independent Model
PMSE	Program Making and Special Events
PSM	Platform Specific Model
RCM	Radio Connection Manager
RF	Radio Frequency
RFIC	RF integrated circuit
RM	Resource Manager
RPI	Radio Programming Interface
RRFI	Reconfigurable RF Interface
RRS	Reconfigurable Radio System
SCA	Software Communications Architecture
SDF	Synchronized Data Flow
SDO	Standards Development Organization
SDR	Software Defined Radio
SIMD	Single Instruction Multiple Data
TCP	Transport Control Protocol
URA	Unified Radio Application
URAI	Unified Radio Application Interface
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network

4 Requirements on SDR equipment for mobile device

This clause collects the requirements on SDR equipments for mobile devices as presented by a number of stakeholders, including but not limited to radio chipset vendors, mobile device manufacturers and network operators. These requirements have been taken into account in the reference architecture described in the present document.

Requirements discussed below are categorized into 5 groups:

1) General architectural requirements.
2) Capability requirements.
3) Operational requirements.
4) Interface requirements.
5) Other requirements.

The potential business relationships between different mobile device SDR stakeholders are illustrated in figure 1.

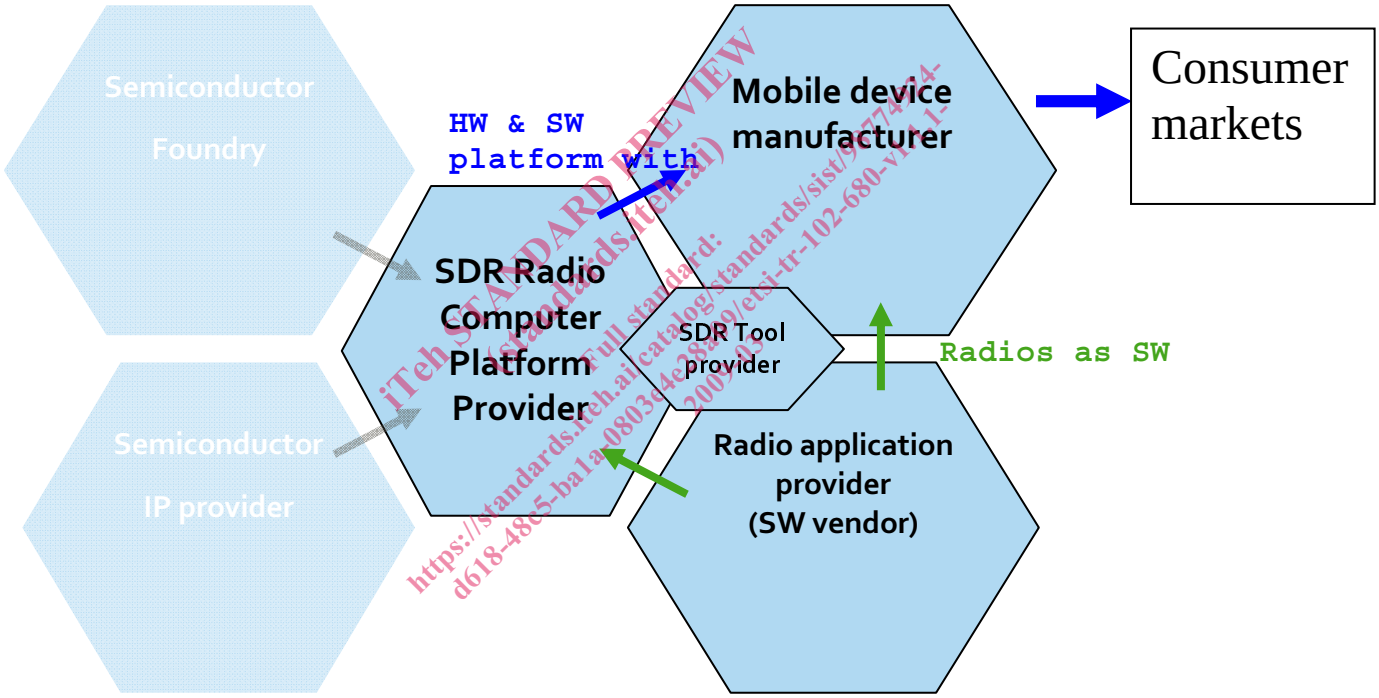

Figure 1: Future SDR value network

With the introduction of the SDR technology the radio chipset vendors will become responsible for integration of complete radio computers. They may use separate manufacturing companies (semiconductor foundries) and integrate also IP blocks from other semiconductor vendors e.g. outer modem HW accelerators. Such radio computers, which may include some built-in radio applications, are provided as radio platforms to mobile device manufacturers. Mobile device manufacturers develop their consumer products, like mobile phones, multimedia computers and PDA devices, which use the radio computers as subsystems for communications purposes. Mobile device manufacturer may also choose to implement itself some radio applications into the radio computer platform. While radios continue to be used for multiple different purposes and new radio technologies continue to emerge development of radio applications as software entities may become a business of itself. Such radio application providers may develop and market their radio applications to multiple radio computer vendors and mobile device manufacturers. This kind of value network may also allow some software companies to become radio software tool vendors having multiple radio developer companies as their customers.

From the regulatory point of view the mobile device manufacturer remains responsible of all radio equipment functionality embedded into its consumer market product.

4.1 Architecture requirements

The SDR reference architecture for mobile devices needs to cover radio functionalities from antenna interface up to the networking interface.

The SDR reference architecture needs to follow modern design principles, such as model driven and component-based design practices in order to end up into a modular architecture, which can support integration of radio application software from different providers. Also portability of radio applications from one SDR platform to another is to be seen as important design criteria.

The SDR platform is designed as multiradio computer platform, which may be composed of one or more general purpose control processor(s) and of one or more specialized co-processors (e.g. digital signal processor clusters, vector processors etc). This kind of heterogeneous multi-processor architecture operates under tight real-time constraints (in µsec range) and is bound by a tight power budget. Dynamic reconfiguration of the hardware platform also needs to be supported by the architecture. How to provide secure execution environment for all radio applications running on a common radio computer platform is also an important design criteria.

4.2 Operational requirements

The SDR radio applications will operate on multiple frequency bands (e.g. from 400 MHz to 10 GHz) and use multiple bandwidths (e.g. from 200 KHz to 500 MHz). They also cover multiple radio technologies, including existing cellular access and non-cellular radio technologies as well as new ones which are likely to emerge with the introduction of cognitive radio systems. The radio applications in the SDR equipments will continue to conform to their specific radio interface specifications and standards.

Both connectivity radios (for user data transfer) and other types of radios, such as digital media broadcasting, geopositioning and wireless sensing radios need to be supported by the common SDR reference architecture.

SDR equipment may execute radios on both licensed and unlicensed frequency bands.

4.3 Capability requirements

Multiradio configuration capability: SDR equipment in mobile device is expected to install, load and activate a radio application while running a set of radio systems already. Correspondingly it allows active radio systems to become deactivated, unloaded and uninstalled.

Multiradio operation capability: SDR equipment in mobile device is expected to execute number of radio systems simultaneously by taking into account temporal coexistence rules designed for their common operation to mitigate inter-radio interference.

Multiradio resource sharing capability: SDR equipment in mobile device is expected to execute number of radio systems simultaneously by sharing computation, memory, communications and RF circuitry resources available on the radio computer platform by using appropriate resource allocation, binding and scheduling mechanisms.

4.4 Interface requirements

The interfaces in the SDR reference architecture are defined in order to support the requirements defined in clauses 4.1 to 4.3. Especially those interfaces which can enable business boundaries between different stakeholders need to be identified in the reference architecture.

First of all the SDR equipment will provide a service interface to its user entities representing the network protocol stack (e.g. TCP/IP) and other user domain entities in the mobile device. Such a **Multiradio access interface** provides a uniform way to access all radio applications in the SDR equipment.

Another important system-wide interface needs to be specified at the boundary between the common radio computer platform and the specific radio applications. This **Unified radio application interface** is used to adapt and align all kinds of radio applications under the common reconfiguration, multiradio execution and resource sharing framework of the SDR reference architecture.

One of the key objectives of the SDR reference architecture is to allow uniform production of radio applications as software entities. This can be achieved by introducing as part of the architecture a **Radio programming interface**. This is both a radio software development time concept as well as a run-time interface between radio software entities and the radio computer platform. This interface needs to include a uniform radio programming model that combines required run-time dynamism with real-time guarantees and efficiency. The programming model needs to be platform neutral and allow multiple radio compilers to be used for generating run-time radio packages for different platforms from the same source program. Additional aspects to be taken into account in the radio programming interface are virtualization of hardware peripherals of the radio computer such as reconfigurable RF devices.

Due to the foundational role of RF circuitry in any radio equipment the SDR reference architecture may benefit a lot from the ongoing technical evolution in the RF circuit design area. We anticipate the emergence of a more generic **reconfigurable RF interface**, which will support multiple radio applications and may even support sharing of the same circuitry among simultaneously active radio applications with similar enough RF properties.

4.5 Other requirements

Besides the architectural and technological requirements discussed above the SDR equipments will bring new kinds of usage scenarios, which are likely to require additional mechanisms to become accepted in mass markets. The conformance of all radios and their combinations on the same platform will still fulfil the EMR and other product safety regulations. The conformance testing of SDR equipments may require additional measures, which need to be investigated also.

The introduction of computerized SDR equipments is bringing programmability of mobile devices into a new level, which needs to be accompanied with appropriate mechanisms to ensure authentication and secure operation of installed radio applications on every SDR platform.

5 SDR reference architecture for mobile device

5.1 Operating environment

SDR equipments will operate in the same kinds of networking environments as today's mobile phones, PDAs and laptops. Both licensed and unlicensed frequency bands will remain in use. SDR equipments will be used in user terminals in operators' networks as well as peer equipments in short range, personal and ad hoc networks. Radio and TV broadcasting stations and geopositioning satellites will also be used as distant communication peers of SDR equipments.

Besides existing radio technologies new radio technologies and frequency bands will become available to SDR equipments. Therefore the design of SDR equipment architecture will be prepared for new frequency bands and radio systems - among them especially the ones supporting introduction of cognitive radio systems. More flexible schemes to use available radio frequencies will also emerge by introduction of spectrum sensing techniques, distribution of cognitive control information and use of commonly agreed spectrum etiquettes. From the SDR equipment architecture point of view both network-centric control schemes and autonomously operating mobile devices are equally valid in such future spectrum utilization cases.