ETSI TS 103 648 V1.1.1 (2020-01)

Reconfigurable Radio Systems (RRS);
Radio Equipment (RE) reconfiguration architecture

Reference
DTS/RRS-0221

Keywords
architecture, radio, SDR

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

The present document can be downloaded from:
http://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

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 https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

Contents

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables 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 (https://ipr.etsi.org/).

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.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

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

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).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1 Scope

The scope of the present document is to define the radio reconfiguration related architecture for reconfigurable Radio Equipment. The work is based on the system requirements defined in ETSI TS 103 641 [1] and the Use Cases defined in ETSI TR 103 062 [i.1], ETSI TR 102 944 [i.2] and ETSI TR 103 585 [i.3].

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 TS 103 641: "Reconfigurable Radio Systems (RRS); Radio Equipment (RE) reconfiguration requirements".

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 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] ETSI TR 103 585: "Reconfigurable Radio Systems (RRS); Radio Equipment (RE) reconfiguration use cases".

[i.4] ETSI EN 303 095: "Reconfigurable Radio Systems (RRS); Radio reconfiguration related architecture for Mobile Devices (MD)".

[i.5] Recommendation ITU-T M.60: "Maintenance Terminology and Definitions".

[i.6] ETSI TS 103 436: "Reconfigurable Radio Systems (RRS); Security requirements for reconfigurable radios".

[i.7] ETSI TR 103 087: "Reconfigurable Radio Systems (RRS); Security related use cases and threats".

[i.8] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of Radio Equipment and repealing Directive 1999/5/EC.

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

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.

broadcast identifier (broadcast ID): identifier linking a data packet to all available radio computers

Communication Services Layer (CSL): 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.

computational resources: part of Radio Equipment hardware working under OS control and on which Applications, among others, are executed

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 an Unified Radio Applications (URA) created by FC to send to or receive data elements (octets, packets or other granularity) from URA

distributed computations: computational model in which components located on networked computers communicate and coordinate their actions by passing messages interacting with each other in order to achieve a common goal

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.

multicast identifier (multicast ID): identifier linking a data packet to a group of radio computers

NOTE: A group of radio computers consists of at least two radio computers. The way for implementing the radio computer grouping is the choice of the manufacturers.

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 Radio Equipment working under ROS control and on which RAs are executed

NOTE 1: A radio computer typically includes programmable processors, hardware accelerators, peripherals, software, etc. RF part is considered to be part of peripherals.

NOTE 2: The Radio Platform is the hardware part of the radio computer.

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: A RC, which may operate in computational resources 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 Equipment (RE): As defined in the Radio Equipment Directive, Article 2(1)(1) [i.8].

NOTE: Excerpt from the Radio Equipment Directive: *"'radio equipment' means an electrical or electronic product, which intentionally emits and/or receives radio waves for the purpose of radio communication and/or radiodetermination, or an electrical or electronic product which must be completed with an accessory, such as antenna, so as to intentionally emit and/or receive radio waves for the purpose of radio communication and/or radiodetermination"*.

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: 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: A 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 Radio Equipment hardware which relates to radio processing capability, including programmable hardware components, hardware accelerators, RF transceiver and antenna(s)

NOTE 1: A Radio Platform is a piece of hardware capable of generating RF signals or receiving RF signals, including Base-Band and RF processing. 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.

NOTE 2: In case of multiple radio computers, there is an independent Radio Platform for each of the radio computers.

radio reconfiguration: reconfiguration of parameters related to air interface

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

NOTE: A 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 Radio Equipment: Radio Equipment with radio communication capabilities providing support for radio reconfiguration

NOTE: Reconfigurable Radio Equipment includes Smartphones, Feature phones, Tablets, Laptops, Connected Vehicle communication platform, Network platform, IoT device, etc.

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.5].

routing entity: entity which directs network packets from their source toward their destination through intermediate network nodes by specific packet forwarding mechanisms

NOTE 1: In the present document, source and destination relate either to CSL or radio computers.

NOTE 2: The directing of packets may include decision making and physical routing.

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.

unicast identifier (unicast ID): identifier linking a data packet to a specific radio computer

Unified Radio Application (URA): Radio Application which complies with the reconfigurable RE framework defined in the present document

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

API	Application Programming Interface
ASF	Administrator Security Function
ASIC	Applications-Specific Integrated Circuit
BBU	BaseBand Unit
BE	Back End
BPA	Baseband Parameter Aggregation
CII	Context Information Interface
CM	Configuration Manager
C-RAN	Cloud-Radio Access Network
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
gMURI	generalized MUltiRadio Interface
gRPI	generalized Radio Programming Interface
gRRFI	generalized Reconfigurable Radio Frequency Interface
gURAI	generalized Unified Radio Applications Interface
GPRS	General Packet Radio Service
GPS	Global Positioning System
HAL	Hardware Abstraction Layer
HW	HardWare
ICIC	Inter-Cell Interference Coordination
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
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
RAN	Radio Access Network
RAP	Radio Application Package
RAT	Radio Access Technology
RC	Radio Controller
RCF	Radio Control Framework
RCM	Radio Connection Manager
RE	Radio Equipment
RERC	Radio Equipment Reconfiguration Class
RF	Radio Frequency
RM	Resource Manager
ROS	Radio Operating System
RPI	Radio Programming Interface
RRFI	Reconfigurable Radio Frequency Interface
RRH	Remote Radio Head
RRS-CM	RRS Configuration Manager
RRS-CP	RRS Configuration Provider
RVM	Radio Virtual Machine
SDN	Software-Defined Networking
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 Radio Equipment

4.1 Introduction

The present deliverable describes those elements of a Radio Equipment which is 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 Radio Equipment which is out of the scope of the present document.

The present document is organized as follows:

- Clause 4.2 describes the reconfigurable Radio Equipment 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 Radio Equipment.
- Clause 5 describes the (logical) interfaces between the identified components/entities.
- Clause 6 lists the operating procedures of a reconfigurable Radio Equipment.
- Clause 4 includes a list of Tables mapping the system requirements as defined in [1] to the different entities/components/units which have been identified. In general, according to the Radio Equipment Reconfiguration Class (RERC) [1], all the related mandatory functional requirements described in [1] shall be implemented.

4.2 Reconfigurable Radio Equipment - Architecture Components for Radio Reconfiguration

4.2.1 High level description

Figure 4.2.1-1 shows the reconfigurable Radio Equipment architectural components related to the radio reconfiguration as well as the related entities. The main difference between the mobile device architecture [i.4] and the generalized Radio Equipment architecture defined in the present document is that a mobile device includes only one radio computer, while the generalized Radio Equipment may include one or more radio computers. As shown in Figure 4.2.1-1, the following components can be identified:

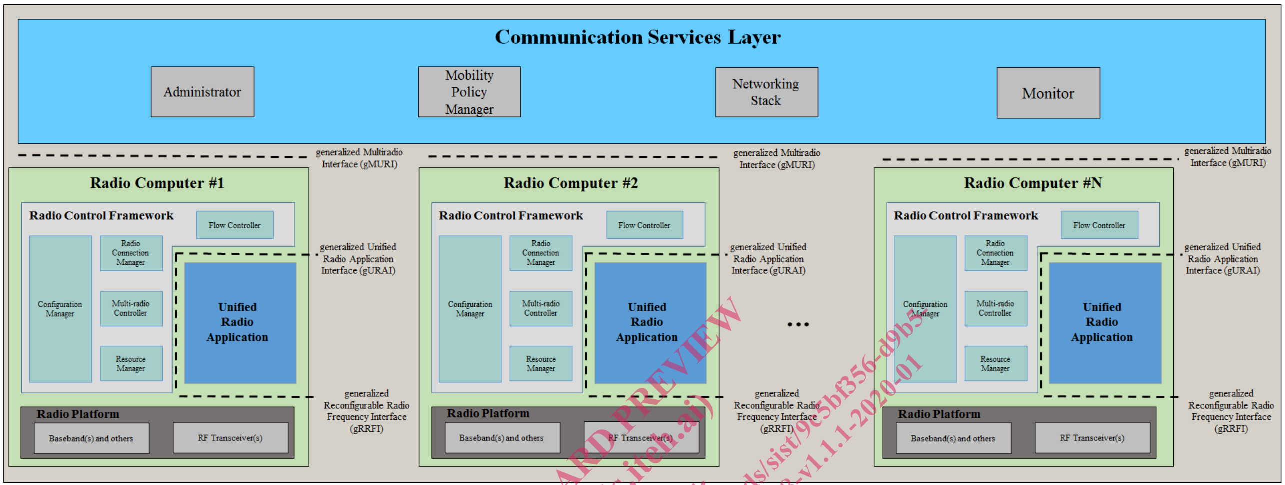
- Communication Services Layer (CSL):
  - 4 logical entities: Administration, Mobility Policy Manager, Networking Stack and Monitor.
- Radio Control Framework (RCF):
  - 5 logical entities: Configuration Manager, Radio Connection Manager, Multi-Radio Controller, Resource Manager and Flow Controller.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

NOTE: When the Radio Platform consists of multiple baseband processors and/or RF transceivers, the reconfigurable Radio Equipment architecture supports the computational/spectral load balancing.

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:

- Generalized Multiradio Interface (gMURI) between CSL and RCF.
- Generalized Unified Radio Application Interface (gURAI) between RCF and URA.
- Generalized Reconfigurable Radio Frequency Interface (gRRFI) between URA and RF transceiver(s).

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



NOTE: Interfaces gMURI, gURAI and gRRFI in Figure 4.2.1-1 are used to interconnect components of different stakeholders.

Figure 4.2.1-1: Reconfigurable Radio Equipment Architecture Components for Radio Reconfiguration

For each components, the required entities depend on the RERC [1]. A Reconfigurable Radio Equipment shall support all the components and their entities as required by the corresponding RERC as shown in Table 4.2.1-1. In case that a Reconfigurable Radio Equipment supports multiple RERCs, the concerned Reconfigurable Radio Equipment shall support all the components and entities related to the highest supported RERC.

Table 4.2.1-1: Required Components of the Reconfigurable Radio Equipment Architecture in function of the Radio Equipment Reconfiguration Class

Radio Equipment Reconfiguration Class	Required CSL Entities	Required RCF Entities	Interfaces
RERC-0	None	None	None
RERC-1	Administrator, Mobility Policy Manager, Networking Stack, Monitor	Configuration Manager, Radio Connection Manager, Flow Controller	gMURI
RERC-2, RERC-5	Administrator, Mobility Policy Manager, Networking Stack, Monitor	Configuration Manager, Radio Connection Manager, Multi-Radio Controller, Flow Controller	gMURI, gURAI, gRRFI
RERC-3, RERC-6	Administrator, Mobility Policy Manager, Networking Stack, Monitor	Configuration Manager, Radio Connection Manager, Multi-Radio Controller, Flow Controller	gMURI, gURAI, gRRFI
RERC-4, RERC-7	Administrator, Mobility Policy Manager, Networking Stack, Monitor	Configuration Manager, Radio Connection Manager, Multi-Radio Controller, Resource Manager, Flow Controller	gMURI, gURAI, gRRFI

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 providing multiradio and non-radio functionalities. The typical examples of communication services related to multiradio functionalities are management for activating corresponding radio application or controlling data flows for each radio application. The typical example of communication services related to non-radio functionalities is Internet access using TCP (Transmission Control Protocol) and IP (Internet Protocol). A Radio Equipment shall support one or multiple radio computers. The CSL shall assign a Unicast ID, Multicast ID or Broadcast ID which is linking a data packet to a specific radio computer, a group of radio computers or all available radio computers respectively.

NOTE 1: In the present document, the scope of applications has been extended from Mobile Devices [i.4] to Radio Equipment including one or multiple radio computers. Consequently, the assignment of a Unicast ID, Multicast ID or Broadcast ID is added in the present document. In the case of [i.4], such IDs were not required, because only a single radio computer is supported.

The CSL shall be interconnected with all radio computers through a routing entity.

NOTE 2: The implementation of the routing entity and its interfaces is the choice of the manufacturer and thus out of scope of the present document.

Figure 4.2.2-1 is a conceptual diagram showing the routing of the CSL data packets to the corresponding radio computer (and vice versa, i.e. from radio computer to CSL) in the case of unicast. The routing entity interprets the Unicast ID and forwards the data packets from the CSL to the corresponding radio computer (i.e. address translation is performed) and vice versa (i.e. from radio computer to CSL).

Figure 4.2.2-2 is a conceptual diagram showing the routing of the CSL data packets to the corresponding radio computers in the case of multicast. The routing entity interprets the multicast ID and forwards the data packets from the CSL to the corresponding radio computers (i.e. address translation is performed). For the reverse link (i.e. from radio computer to CSL), unicast is applied.

Figure 4.2.2-3 is a conceptual diagram showing the routing of the CSL data packets to the corresponding radio computers in the case of broadcast. The routing entity interprets the broadcast ID and forwards the data packets from the CSL to the all available radio computers. For the reverse link (i.e. from radio computer to CSL), unicast is applied.

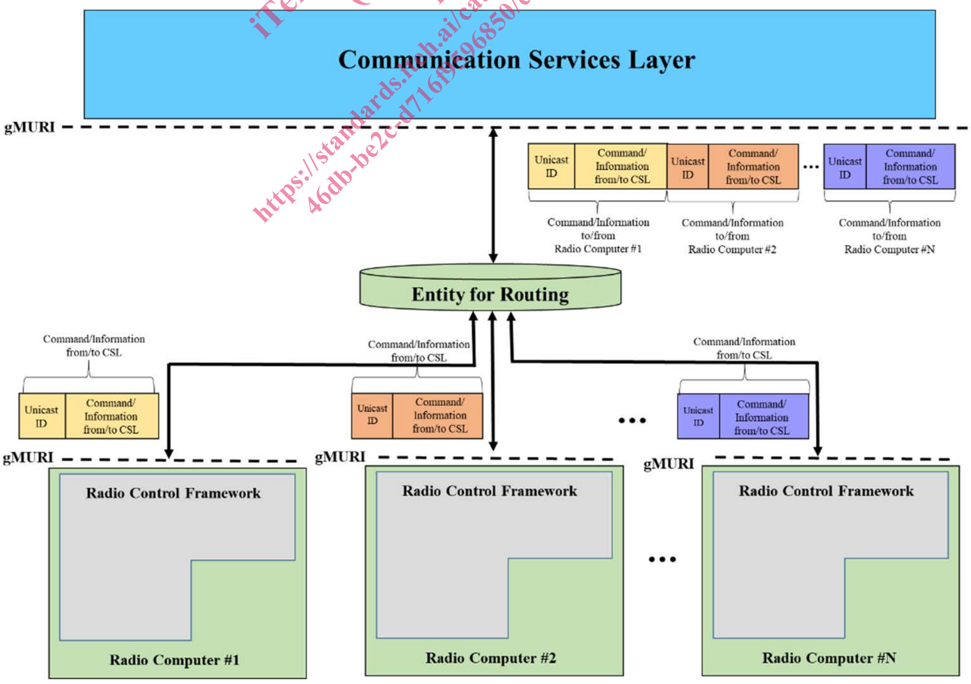


Figure 4.2.2-1: Conceptual diagram showing the routing of the CSL message(s) to the corresponding radio computer(s) and the routing of each radio computer's information to the CSL in the case of unicast transmission