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| *Technical Specification* |
| **O-RAN Working Group 3**  **Near-Real-time RAN Intelligent Controller**  **Near-RT RIC Architecture** |
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# Foreword

This Technical Specification has been produced by the O-RAN Alliance.

The contents of the present document are subject to continuing work within O-RAN and may change following formal O-RAN approval. Should the O-RAN Alliance modify the contents of the present document, it will be re-released by O-RAN with an identifying change of release date and an increase in version number as follows:

Release x.y.z

where:

x the first digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc. (the initial approved document will have x=01).

y the second digit is incremented when editorial only changes have been incorporated in the document.

z the third digit included only in working versions of the document indicating incremental changes during the editing process.

# 1 Scope

The present document specifies the overall architecture of the Near-RT-RIC (RAN Intelligent Controller) and function descriptions, including the interaction between hosted applications and common functions in the Near-RT RIC.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] O-RAN-WG3.E2GAP, “O-RAN Working Group 3, Near-Real-time RAN Intelligent Controller, E2 General Aspects and Principles”.

[3] O-RAN-WG3.E2AP, “O-RAN Working Group 3, Near-Real-time RAN Intelligent Controller, E2 Application Protocol (E2AP)”.

[4] O-RAN-WG1.OAM Architecture, “O-RAN Operations and Maintenance Architecture”.

[5] O-RAN-WG1.O1-Interface, “O-RAN Operations and Maintenance Interface Specification”.

[6] 3GPP TS 33.401: “3GPP System Architecture Evolution (SAE); Security architecture”.

[7] 3GPP TS 33.501: “Security architecture and procedures for 5G System”.

[8] O-RAN-WG2.A1.GA&P, “O-RAN Working Group 2, A1 interface: General Aspects and Principles”.

[9] O-RAN-WG2.A1AP, “O-RAN Working Group 2, A1 Interface: Application Protocol”.

[10] O-RAN-WG1.O-RAN Architecture, “O-RAN Working Group 1, O-RAN Architecture Description”.

[11] 3GPP TS 36.401: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Architecture Description".

[12] 3GPP TS 38.300: “NR; NR and NG-RAN Overall Description; Stage 2”.

# 3 Definitions and Abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply.   
A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**Near-RT RIC (**O-RAN Near-real-time RAN Intelligent Controller): a logical function that enables near-real-time control and optimization of RAN elements and resources via fine-grained (e.g. UE basis, Cell basis) data collection and actions over E2 interface.

**Non-RT RIC**(O-RAN Non-real-time RAN Intelligent Controller):a logical function that enables non-real-time control and optimization of RAN elements and resources, AI/ML workflow including model training and updates, and policy-based guidance of applications/features in Near-RT RIC.

**O-CU**: O-RAN Central Unit: a logical node hosting RRC, SDAP and PDCP protocols.

**O-CU-CP**: O-RAN Central Unit – Control Plane: a logical node hosting the RRC and the control plane part of the PDCP protocol.

**O-CU-UP**: O-RAN Central Unit – User Plane: a logical node hosting the user plane part of the PDCP protocol and the SDAP protocol.

**O-DU**: O-RAN Distributed Unit: a logical node hosting RLC/MAC/High-PHY layers based on a lower layer functional split.

**O-RU**: O-RAN Radio Unit: a logical node hosting Low-PHY layer and RF processing based on a lower layer functional split.  This is similar to 3GPP’s “TRP” or “RRH” but more specific in including the Low-PHY layer (FFT/iFFT, PRACH extraction).

**O-eNB** (O-RAN eNB):an eNB [10] or ng-eNB [11] that supports E2 interface.

**O1**: Interface between orchestration & management entities (Orchestration/NMS) and O-RAN managed elements, for operation and management, by which FCAPS management, Software management, File management and other similar functions shall be achieved.

**SMO**: Service Management and Orchestration system.

**A1**: Interface between Non-RT RIC and Near-RT RIC to enable policy-driven guidance of Near-RT RIC applications/functions, and support AI/ML workflow.

**E2**: Interface connecting the Near-RT RIC and one or more O-CU-CPs, one or more O-CU-UPs, and one or more O-DUs.

**E2 Node**: a logical node terminating E2 interface. In this version of the specification, ORAN nodes terminating E2 interface are:

- for NR access: O-CU-CP, O-CU-UP, O-DU or any combination as defined in [4];

- for E-UTRA access: O-eNB.

**xApp:** An application designed to run on the Near-RT RIC. Such an application is likely to consist of one or more microservices and at the point of on-boarding will identify which data it consumes and which data it provides. The application is independent of the Near-RT RIC and may be provided by any third party. The E2 enables a direct association between the xApp and the RAN functionality.

**O-Cloud:** O-Cloud is a cloud computing platform comprising a collection of physical infrastructure nodes that meet O-RAN requirements to host the relevant O-RAN functions (such as Near-RT RIC, O-CU-CP, O-CU-UP, and O-DU), the supporting software components (such as Operating System, Virtual Machine Monitor, Container Runtime, etc.) and the appropriate management and orchestration functions.

## 3.2 Abbreviations

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

API Application Programming Interface

FM Fault Management

LCM Life-Cycle Management

ML Machine Learning

Non-RT RIC Non-real-time RAN Intelligent Controller:

Near-RT RIC Near-real-time RAN Intelligent Controller

O-CU O-RAN Central Unit

O-CU-CP O-RAN Central Unit – Control Plane

O-CU-UP O-RAN Central Unit – User Plane

O-DU O-RAN Distributed Unit

O-RU O-RAN Radio Unit

PM Performance Management

SMO Service Management and Orchestration

# 4 General Principles

The Near-RT RIC architecture shall follow the general architecture principles specified in [2], and the following principle(s):

* The Near-RT RIC architecture and internal interfaces shall be open to support 3rd party xApps.

# 5 Near-RT RIC Architecture

## 5.1 Requirements

The Near-RT RIC architecture shall follow the Near-RT RIC requirements specified in [2], and the following requirements:

* The Near-RT RIC shall consist of multiple xApps and a set of platform functions that are commonly used to support the specific functions hosted by xApps.

### 5.1.1 Platform Requirements

* The Near-RT RIC shall provide a database function that stores an up-to-date RAN information, history of its time-varying network state, as well as the configurations relating to E2 nodes, Cells, Bearers, Flows, UEs and the mappings between them. This information will be provided as a service to any xApp that requests it.
* The Near-RT RIC shall provide ML tools that support data pipelining.
* The Near-RT RIC shall provide a messaging infrastructure.
* The Near-RT RIC shall provide logging, tracing and metrics collection from Near-RT RIC platform and xApps to SMO.
* The Near-RT RIC shall provide security functions.
* The Near-RT RIC shall support conflict resolution to resolve the potential conflicts or overlaps which may be caused by the requests from xApps.
* The Near-RT RIC shall communicate with xApp(s) via Near-RT RIC APIs.
* The Near-RT RIC shall register the Near-RT RIC APIs it produces.
* The Near-RT RIC shall be capable of discovering the Near-RT RIC APIs it consumes.
* The Near-RT RIC shall provide a mechanism for avoiding compatibility clashes between xApps and the RIC services they access.
* The Near-RT RIC shall support subscription merging from multiple xApp to avoid unnecessary network load.

### 5.1.2 xApp Requirements

* xApps may enhance the RRM capabilities of Near-RT RIC.
* An xApp may be associated with zero, one or more E2SMs.
* An xApp shall be able to use the Information Elements (IEs) of E2SMs that are associated with the xApp via Near-RT RIC APIs.
* xApps that are associated with a given E2SM shall be able to interface with any E2 Node that supports that E2SM without any intermediary xApps.
* xApps shall be able to receive event-triggered information on RAN information and time-varying network state.
* xApps shall provide logging, tracing and metrics collection to the Near-RT RIC.
* xApps shall provide a descriptor that will include basic information (configuration, metrics and control) about the xApp.
* xApp descriptor components shall include the following:

- Configuration: The xApp configuration specification shall include a data dictionary for the configuration data, i.e., meta data such as a yang definition or a list of configuration parameters and their semantics. Additionally it may include an initial configuration of xApps.

- Control: xApp controls specification shall include the types of data it consumes and provides that enable control capabilities (e.g. xApp URL, parameters, input/output type).

- Metrics: The xApp metrics specification shall include a list of metrics (e.g., metric name, type, unit and semantics) provided by the xApp.

* The xApp descriptor shall also provide the necessary data to enable their management and orchestration. The specific requirements for these descriptors shall be aligned with [4].
* xApps shall communicate with Near-RT RIC platform via Near-RT RIC APIs.
* xApps shall register the Near-RT RIC APIs they produce.
* xApps shall be capable of discovering the Near-RT RIC APIs they consume.

### 5.1.3 Near-RT RIC API Requirements

* Near-RT RIC shall provide a Near-RT RIC API enabling the hosting of 3rd party xApps and xApps from the Near-RT RIC platform vendor.
* Near-RT RIC APIs shall not adversely impact the desired low-latency and high message throughput operations of the Near-RT RIC. Specifically, the Near-RT RIC APIs shall support Near-RT RIC control loop with execution time of 10ms to1second.
* Near-RT RIC shall provide a Near-RT RIC API decoupled from specific implementation solutions, including a Shared Data Layer (SDL) that works as an overlay for underlying databases and enables simplified data access.
* Near-RT RIC shall provide a Near-RT RIC API repository / registry for the services provided by the RIC platform and/or the xApp(s)
* Near-RT RIC shall provide a mechanism for the xApp(s) to discover the published Near-RT RIC APIs based on the xApp(s) interest.
* Near-RT RIC shall provide a mechanism to restrict the discovery of the published Near-RT RIC API information by the xApp(s) based on configured policies.
* Near-RT RIC shall provide a Near-RT RIC API ensuring that all xApps can directly use the information elements of E2SMs with which they are associated.
* Near-RT RIC shall provide a Near-RT RIC API aiming to simplify the development of xApps and enable rapid innovation.
* Near-RT RIC shall provide a Near-RT RIC API supporting xApp development in multiple programming languages (e.g. C, C++, Python, Go).
* Near-RT RIC APIs shall support xApp subscription based on operators’ policies. An xApp may interface with only a subset of the E2 Nodes that are identified by such policies. Near-RT RIC shall route messages between this xApp and subset of E2 Nodes.

Note: Communication between xApps is for further study.

## 5.2 Overall Architecture Description

The overall architecture of O-RAN described in [10] specifies the location and interfaces of Near-RT RIC, as well as possible deployment options.

The RRM functional allocation between the Near-RT RIC and the E2 node is described in [2].

# 6 Near-RT RIC Functions Description

## 6.1 General

The Near-RT RIC hosts the following functions:

* Database, which allows reading and writing of RAN/UE information;
* xApp subscription management, which merges subscriptions from different xApps and provides unified data distribution to xApps;
* Conflict mitigation, which resolves potentially overlapping or conflicting requests from multiple xApps;
* Messaging infrastructure, which enables message interaction amongst Near-RT RIC internal functions;
* Security, which provides the security scheme for the xApps;
* Management services;

- Fault management, configuration management, and performance management as a service producer to SMO;

- Life-cycle management of xApps;

- Logging, tracing and metrics collection, which capture, monitor and collect the status of Near-RT RIC internals and can be transferred to external system for further evaluation;

* Interface Termination

- E2 termination, which terminates the E2 interface from an E2 Node;

- A1 termination, which terminates the A1 interface from the Non-RT RIC;

- O1 termination, which terminates the O1 interface from SMO;

* Functions hosted by xApps, which allow services to be executed at the Near-RT RIC and the outcomes sent to the E2 Nodes via E2 interface.

This is summarized in the figure below.

* API management services to support capabilities related to Near-RT RIC API operations (API repository/registry, authentication, discovery, generic event subscription)

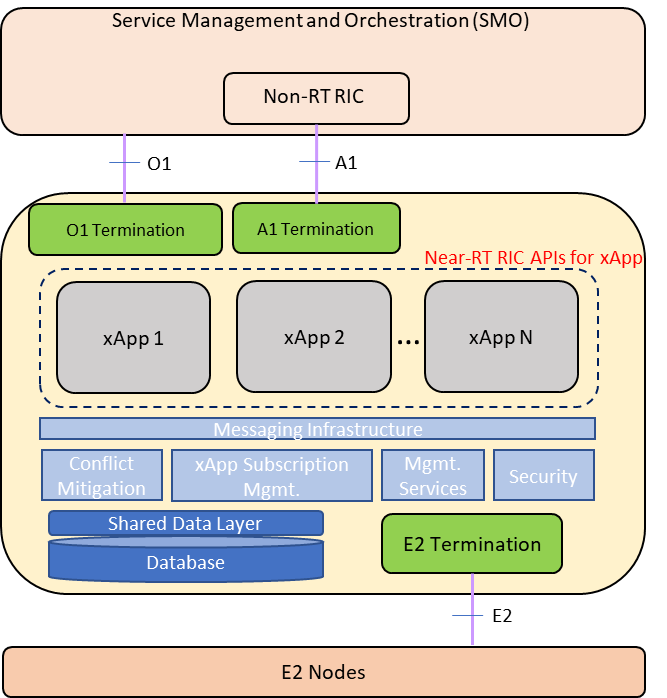


Figure 6.1-1: Near-RT RIC Internal Architecture

## 6.2 Platform Functions

### 6.2.1 Database

#### 6.2.1.1 UE-NIB

xApps may provide UE related information to be stored in the UE-NIB (UE-Network Information Base) database.

* UE-NIB maintains a list of UEs and associated data.
* UE-NIB maintains tracking and correlation of the UE identities associated with the connected E2 nodes.

#### 6.2.1.2 R-NIB

xApps may provide radio access network related information to be stored in the R-NIB (Radio-Network Information Base) database

* The R-NIB stores the configurations and near real-time information relating to connected E2 Nodes and the mappings between them.

### 6.2.2 xApp Subscription Management

* xApp subscription management manages subscriptions from the xApps to the E2 Nodes.
* xApp subscription management enforces authorization of policies controlling xApp access to messages.
* xApp subscription management enables merging of identical subscriptions from different xApps into a single subscription to the E2 Node.

### 6.2.3 Conflict Mitigation

In the context of the Near-RT RIC, Conflict Mitigation is about addressing conflicting interactions between different xApps. An application will typically change one or more parameters with the objective of optimizing a specific metric. Conflict Mitigation is necessary because xApps objectives may be chosen/configured such that they result in conflicting actions.

The control target of the radio resource management can be cell, UE or bearer, etc. The control contents of the radio resource management can cover the access control, the bearer control, the handover control, the QoS control, the resource assignment and so on. The control time span indicates the valid control duration which is expected by the control request. The conflicts of control can be illustrated as below.

1. Direct Conflicts: The conflicts can be observed directly by Conflict Mitigation. Some cases are described as below:

- Two or more xApps request different settings for the very same configuration of one or more parameters of a Control Target. Conflict mitigation processes the requests and decides on a resolution.

- The new request from an xApp may conflict with the running configuration resulting from a previous request of another or the same xApp.

- The total requested resources from different xApps may exceed the limitation of the RAN system, e.g. the sum of resources required by the two different xApps may be far beyond the resource limitation of the RAN system.

1. Indirect Conflicts: The conflicts cannot be observed directly, nevertheless, some dependence among the parameters and resources that the xApps target can be observed. Conflict Mitigation may anticipate the possible conflicts and take actions to mitigate them. For instance, different xApps target different configuration parameters to optimize the same metric according to the respective objective. Even though this will not result in conflicting parameter settings, it may have uncontrollable or inadvertent system impacts. One example of such indirect conflicts can occur when the changes required by one xApp create a system impact which is equivalent to a parameter change targeted by another xApp. E.g., antenna tilts and Measurement offsets are different control points, but they both impact the handover boundary.
2. Implicit Conflicts: The conflicts cannot be observed directly, even the dependence between xApps are not obvious. For instance, different xApps may optimizing different metrics by (re-)configuring different parameters. Nonetheless, optimizing one metric may have implicit, unwanted, and maybe adversary side effects on one of the metrics optimized by another xApp. E.g., protecting throughput metrics for GBR users may degrade non GBR metrics or even Cell Throughput.

For mitigating these conflicts, different approaches exist:

1. Direct conflicts typically can be mitigated by pre-action coordination, i.e., the xApps or a Conflict Mitigation component needs to make the final determination on whether any specific change is made or in which order the changes are applied.
2. Indirect conflicts can be resolved by post-action verification. Here, the actions are executed and the effects on the target metric are observed. Based on the observations, the system has to decide on potential corrections, e.g., rolling back one of the xApp actions.
3. Implicit conflicts are the most difficult to mitigate since these dependencies are difficult or impossible to observe and therefore hard to model in any mitigation scheme. In some cases, it may be possible to design around such conflicts by ensuring that Use Cases (xApps) target different parameters, thus falling back to approach 2), but preferably, a generic approach to managing such conflicts is established.

The individual xApp goals are defined by A1 policies, but it is also important to define utility metrics that incorporate the relative importance of each of the metrics targeted by the xApps as well as the importance of the optimization (use case). A Conflict Mitigation function may also use ML approaches, e.g., Reinforcement Learning, to a-priori assess, for each proposed change, the likely probability of degrading a metric versus the potential improvement.

### 6.2.4 Messaging Infrastructure

Messaging infrastructure provides low-latency message delivery service between Near-RT RIC internal endpoints.

* It supports registration/discovery/deletion of endpoints.

- Registration: Endpoints register themselves to the messaging infrastructure;

- Discovery: Endpoints are discovered by the messaging infrastructure initially and registered to the messaging infrastructure;

- Deletion: Endpoints are deleted once they are not used anymore.

* It provides the following kinds of APIs:

- An API for sending messages to the messaging infrastructure;

- An API for receiving messages from the messaging infrastructure.

* It supports multiple messaging modes, e.g. point-to-point mode (e.g. message exchange among endpoints), publish/subscribe mode (e.g. real-time data dispatching from E2 termination to multiple subscriber xApps).
* It provides message routing, namely according to the message routing information, messages can be dispatched to different endpoints.
* It supports message robustness to avoid data loss during a messaging infrastructure outage/restart or to release resources from the messaging infrastructure once a message is outdated.

### 6.2.5 Security

The security function given in this section only applies to the Near-RT RIC. One target of security function is to prevent malicious xApps from abusing radio network information (e.g. exporting to unauthorized external systems) and/or control capabilities over RAN functions. The security requirements for the 3GPP LTE eNB is defined in [6] and for the 5G NR gNB in [7].

Note: The description of security functions is not included in the release.

### 6.2.6 Management Services

#### 6.2.6.1 Life-Cycle Management of xApp

The life-cycle management of xApps provides the following functions.

* Onboarding xApps: It receives and stores xApp descriptor that contains configuration data for the xApp.
* Deployment of xApps: It retrieves xApp name and other information (e.g. helm chart of the xApp) from stored xApp descriptor and deploys the xApp.
* Resource management (RM): It does comprehensive resource provisioning/control for xApps on Near-RT RIC as well as monitors their latency and resource consumption characteristics to see if individual xApps meet their latency requirements. It may trigger the alarm event when they miss the critical latency requirements.
* Termination of xApps: It terminates a running xApp if the xApp is no longer needed. The resource used by the xApp will be released.

Note: It is assumed that LCM of xApps is performed by the SMO.

#### 6.2.6.2 FCAPS Management of Near-RT RIC

The FCAPS management consists of fault, configuration, accounting, performance and security management. The FCAPS management follows O1 related management aspects defined in [4].

To support FCAPS management services, Near-RT RIC provides the following capabilities in the current version of specification:

* Logging: logging is to capture information needed to operate, troubleshoot and report on the performance of the Near-RT RIC platform and its constituent components. Log records may be viewed and consumed directly by users and systems, indexed and loaded into a data storage, and used to compute metrics and generate reports. Near-RT RIC components log events according to a common logging format. Different logs can be generated (e.g., audit log, metrics log, error log and debug log).
* Tracing: tracing mechanisms are needed to monitor the transactions or a workflow. An example subscription workflow can be broken into two traces namely, a subscription request trace followed by a response trace. Individual traces can be analyzed to understand timing latencies as the workflow traverses a particular Near-RT RIC component.
* Metrics collection: metrics for performance and fault management specific to each xApp logic and other internal functions are collected and published for authorized consumer (e.g., SMO). A metrics collection mechanism is needed to collect and report metrics.

### 6.2.7 Interface Termination

#### 6.2.7.1 E2 Termination

* E2 Termination terminates the SCTP connection from each E2 Node.
* E2 Termination routes messages from the xApps through the SCTP connection to the E2 Node.
* E2 Termination decodes the payload of an incoming ASN.1 message enough to determine message type.
* E2 Termination handles incoming E2 messages related to E2 connectivity.
* E2 Termination receives and respond to the E2 Setup Request from the E2 Node.
* E2 Termination notifies xApps of the list of RAN functions supported by an E2 Node based on information derived from E2 Setup and RIC Service Update procedures [3].
* E2 Termination notifies the newly connected E2 Node of the list of accepted functions.

#### 6.2.7.2 A1 termination

A1 termination provides a generic API for the Near-RT RIC by means of which it can receive and send messages via A1 interface [8]. These include, e.g., A1 policies and enrichment information received from the Non-RT RIC, or A1 policy feedback sent towards the Non-RT RIC.

#### 6.2.7.3 O1 termination

Note: Presence of O1 termination at Near-RT RIC depends on the different deployment options described in [4], i.e. when Near-RT RIC is modelled as a stand-alone Managed Element.

O1 termination communicates with SMO via O1 interface and exposes O1-related management services [5] from Near-RT RIC.

* O1 termination exposes provisioning management services from Near-RT RIC to O1 provisioning management service consumer.
* O1 termination supports managing xApps via NETCONF.
* O1 termination supports translation of NETCONF to Near-RT RIC internal APIs.
* O1 termination exposes FM services to report faults and events from Near-RT RIC to O1 FM service consumer.
* O1 termination exposes PM services to report bulk and real-time PM data from Near-RT RIC to O1 PM service consumer.
* O1 termination exposes file management services to download ML files, software files, etc. and upload log/trace files.
* O1 termination exposes communication surveillance services to O1 communication surveillance service consumer.

### 6.2.8 API management services

In the context of Near-RT RIC, the Near-RT RIC APIs can be categorized based on the interaction with the RIC platform and can be APIs related to E2-related/Control services, A1-related services, Management services, Database services.

The API management services provide support functionalities for the registration, discovery and consumption of Near-RT RIC APIs within the Near-RT RIC scope. In particular, the API management services include:

* + Repository / Registry services for the Near-RT RIC APIs
  + Services that allow discovery of the registered Near-RT RIC APIs
  + Services to authenticate xApps for use of the Near-RT RIC APIs
  + Services that enable generic subscription and event notification
  + Means to avoid compatibility clashes between xApps and the RIC services they access

The API management services may be accessed via an “enablement” API by the xApp(s), for supporting the API discovery, providing authentication and generic subscription & event notification.

NOTE: The provided enablement APIs may need to consider the level of trust related to the xApp (e.g. 3rd party xApp, RIC-owned xApp, etc.).

## 6.3 xApps

xApps consist of xApp descriptor and xApp image. xApp descriptor describes the packaging format of xApp image. xApp image is the software package.

The xApp descriptor provides xApp management services with necessary information for the LCM of xApps, such as deployment, deletion, upgrade etc. The xApp descriptor also provides extra parameters related to the health management of the xApps, such as auto scaling when the load of xApp is too heavy and auto healing when xApp becomes unhealthy. The xApp descriptor provides FCAPS and control parameters to xApps when xApp is launched.

The definition of xApp descriptor includes:

* The basic information of xApp, including name, version, provider, URL of xApp image, virtual resource requirements (e.g. CPU), etc. This information is used to support LCM of xApps.
* The FCAPS management specifications that specify the options of configuration, performance metrics collection, etc. for the xApp.
* The control specifications that specify the data types consumed and provided by the xApp for control capabilities (e.g. PM data that the xApp subscribes, the message type of control messages).

The xApp image contains all the files needed to deploy an xApp. An xApp can have multiple versions of xApp image, which are tagged by the xApp image version number.

# 7 Near-RT RIC APIs for xApp

## 7.1 Overall Description of API

Near-RT RIC APIs are a collection well-defined interfaces between the xApps and all Near-RT RIC platform services. These APIs need to explicitly define the possible types of information flows and data models. Near-RT RIC APIs are essential to host 3rd party xApps in an inter-operable way on different Near RT RIC platforms.

Near-RT RIC provides the following Near-RT RIC APIs for xApps as showed in Figure 7.1-1:

* A1 related APIs: the APIs between xApps and A1 Termination.
* E2 related APIs: the APIs between xApps and E2 Termination.
* Management APIs: the APIs between xApps and management related functions, such as O1 termination, management services and logging, tracing, metrics collection.
* Control APIs: the APIs between xApps and the functions which are responsible for control, such as conflict mitigation, xApp subscription management, etc.
* SDL APIs: the APIs between xApps and Shared Data Layer.



Figure 7.1-1: Overview of Near-RT RIC APIs

7.2 A1 related APIs

The xApps in Near-RT RIC provide value added services based on the policies or enrichment information or both which are transferred through A1 interface by Non-RT RIC. A1 related APIs enable the exchange of information between xApps and A1 termination, which includes:

* Policy Enforcement API: used for policy enforcement request/response.
* Enrichment Information API: used for enrichment information transfer/response.

## 7.3 E2 related APIs

E2 related APIs enable the exchange of information between xApps and E2 termination.

## 7.4 Management APIs

Management APIs support the following APIs, including xApp life-cycle management related APIs, PM and FM related APIs.

xApp life-cycle management related APIs include the following functions:

* ML Model Deployment Request.
* ML Model Update Request.
* ML Model Uninstall Request.

FCAPS related APIs include the following functions:

* Configuration API: The xApp is configured by SMO via O1 interface. The API transfers the configurations from SMO to xApp.
* PM API: xApps provide PM related data to O1 PM Consumer via PM API.
* FM API xApps provide faults and events information to O1 FM Consumer via FM API.

## 7.5 Control APIs

The APIs provide the exchange of control related information between xApps and the functions which are responsible for control such as conflict mitigation, xApp subscription management. For example, the analysis results, decisions or requests from xApps can be transferred via the API for conflict mitigation, xApp subscription management or other necessary functions.

## 7.6 SDL APIs

SDL APIs provide a simple yet flexible way to store and retrieve data while hiding details such as type and location of database, management operations of database layer such as high availability, scaling, load-balancing. SDL APIs allow multiple xApps to access the data independently of each other.

* Register API: xApps can register at SDL for the permissions to access the database.
* Deregister API: xApps can request to delete the API which has been registered in SDL.
* Modify API: It allows to modify or delete data from the database.
* Fetch API: It allows the xApps to fetch data from the database.
* Store API: It allows the xApps to store data in the database.
* Notification API: The database can notify the xApps the update information on the database via the notification API. The database will ignore the notification to the xApp when update occurs if the notification API is not registered by the xApp.

# 8 External Interfaces of Near-RT RIC

## 8.1 E2 Interface

O-RAN-WG3.E2GAP [2] specifies E2 interface general aspects and principles.

O-RAN-WG3.E2AP [3] specifies E2 interface application protocols.

## 8.2 A1 Interface

O-RAN-WG2.A1.GA&P [8] specifies A1 interface general aspects and principles.

O-RAN-WG2.A1AP [9] specifies A1 interface application protocols.

## 8.3 O1 Interface

Note: Presence of O1 termination at Near-RT RIC depends on the different deployment options described in [4], i.e. when Near-RT RIC is modelled as a stand-alone Managed Element.

O-RAN-WG1.O1-Interface [5] specifies O1 interface related aspects.

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