Ratio: Capgemini RIC for intelligent OpenRAN operations

This brochure describes the features of Capgemini's O-RAN-compliant RIC, and the xApps and rApps developed over a range of RIC Platforms.

Capgemini

Introduction

Capgemini has developed a set of software frameworks that enable communications service providers (CSPs) and original equipment manufacturers (OEMs) to accelerate the development and launch of their 5G products and solutions.

The frameworks cover the entire end-to-end 5G open network ecosystem.

As part of this effort, Capgemini has developed RATIO, a highly scalable Open RAN-compliant RIC (RAN Intelligent Controller), which is a software-defined platform, responsible for controlling and optimizing RAN functions. Our RIC is based on hardened open-source components from the O-RAN Software Community.

RATIO includes Near-RT RIC, Non-RT RIC, and Service Management and Orchestration (SMO). Capgemini is also developing xApps and rApps to leverage the capabilities of the O-RAN RIC platform to perform intelligent RAN operations (see Figure 1).

RATIO supports a fully disaggregated architecture, which is completely aligned with the O-RAN Alliance specifications. It supports multi-vendor centralized units (CUs) and distributed units (DUs) through standard O-RAN interfaces.

RATIO helps avoid vendor lock-in and allows CSPs the flexibility to choose different vendors for CU/DU and xApps/rApps. Capgemini Engineering xApps and rApps are O-RAN compliant applications that can run on any RIC platform and are pre-integrated with the Capgemini Engineering RIC and 5G CU/DU nodes.

Capgemini RATIO was developed to allow intent-based RAN management, which is built on principles of automation, Artificial Intelligence (AI) and Machine learning (ML). The Non-RT RIC brings innovative capabilities to the system and addresses use cases that were previously out of reach, with the ability to set policies per user and data enrichment information for RAN optimization.

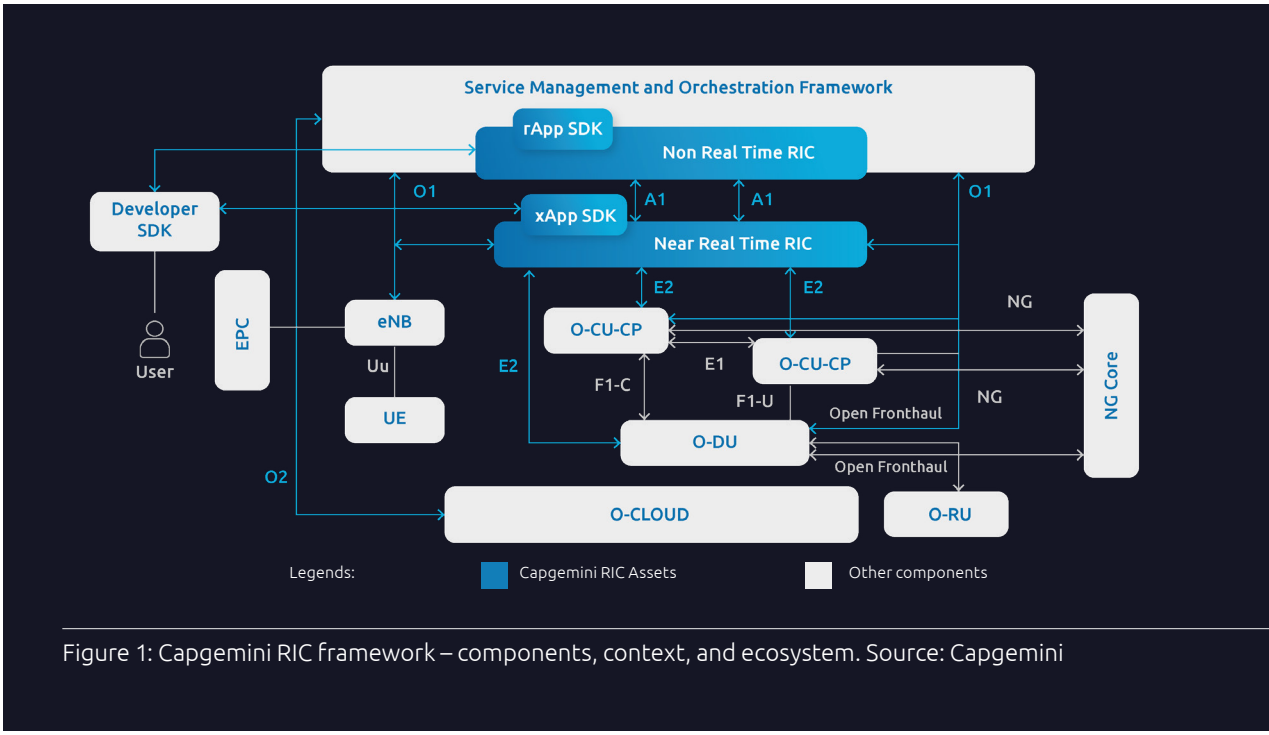


Figure 1: Capgemini RIC framework – components, context, and ecosystem. Source: Capgemini

Near-RT RIC

The Capgemini Near-RT RIC is a fully containerized microservices-based solution that can be deployed as Kubernetes or Docker containers. It complies with O-RAN architecture and specifications, which supports multi-vendor xApps and the standard E2 interface with O-CU/O-DU.

The entire Near-RT RIC is based on a disaggregated architecture that enables flexible integration with any third-party O-RAN component. In addition, it supports high availability and fault tolerance, with a horizontally scalable RIC cluster (see Figures 2 and 3).

- Standardized E2 interface for communication between Near-RT RIC and O-CU/O-DU
- Standardized A1 interface for communication between Near-RT RIC and Non-RT RIC
- Secured E2, A1, and O1 interfaces for communication with E2 nodes, secure onboarding, and role-based access control (RBAC) for xApp access management
- Third-party xApps can be ported on the Capgemini Near-RT RIC platform using xApp SDK, which abstracts the complexity of the underlying platform so that xApp application developers can focus on crucial business logic
- Integrated with the Capgemini NetAnticipate platform (described below), which supports multiple machine learning (ML) models and can be leveraged by xApp developers
- Supports the development of custom service models to enable new innovative applications
- Secures onboarding of xApps by validating the authenticity and integrity of xApp Artifacts
- Cloud native modules that can be hosted on any infrastructure of choice (public/private cloud and on-premises)
- Conflict Mitigation service to address conflicting interactions between different xApps

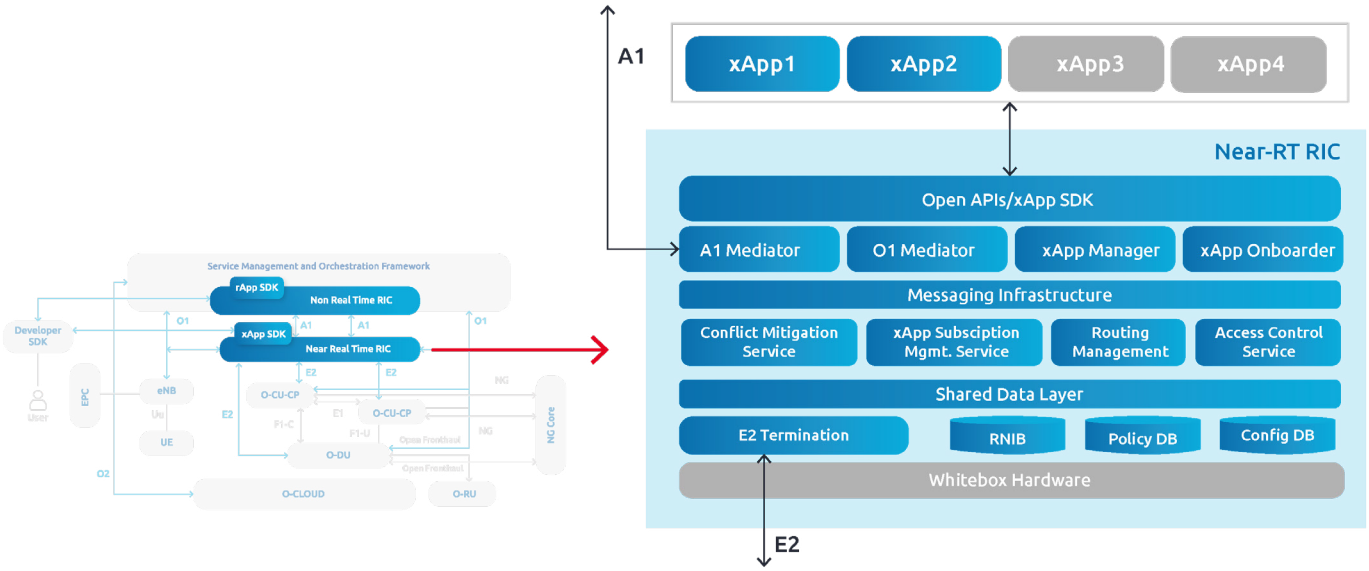


Figure 2: Capgemini Near-RT RIC framework – components, context, and ecosystem. Source: Capgemini

Non-RT RIC

The Capgemini Non-RT RIC acts as the centerpiece of the ORAN Ecosystem. It not only hosts applications from multiple third-party vendors, it also integrates with SMO systems to support ORAN-Complaint RAN. The Non-RT RIC can integrate with a RAN Element Management System (EMS) to support legacy RAN, and with different network elements, like AI/ML engines, data lakes, etc.

The Capgemini Non-RT RIC is a fully containerized, microservices-based solution that can be deployed as Kubernetes or Docker containers. It complies with O-RAN architecture and specifications, which support multivendor rApps (RAN automation applications) working in synchronization with the multi-vendor Near-RT RIC through standard O-RAN interfaces.

The entire Non-RT RIC is realized as a set of logical modules that enable flexible integration with any third-party O-RAN component.

It is a fault-tolerant solution with horizontally scalable components to ensure high availability.

The Non-RT RIC has a rich UI that supports operations including rApp life cycle management, AI/ML model training, monitoring, and KPIs. The platform includes:

- A rich A1 interface, supporting APIs for A1-P (policy management service), A1-ML (ML model management service), and A1-EI (enrichment information service)
- A rich developer experience with an R1 compliant interface and rApp service exposure function. The R1 interface (i.e. Open APIs for rApps) provides an interface between rApps and the Non-RT RIC platform, which exposes a rich set of platform services to rApps for creating differentiated services
- Third-party rApps can be ported on the Capgemini Non-RT RIC platform using the rApp SDK, which makes it easy to develop xApps by exposing simplified APIs
- Service Management and Data Management Exposer services (SME and DME) to allow rApps to use data and services exposed by other rApps

- Supports integration with legacy RAN systems
- Integrated with the Capgemini NetAnticipate platform, an award-winning, flexible self-learning data science platform to manage the life cycle of ML models
- rApp and platform configuration management and monitoring
- Alarm management and event monitoring
- User and role based access management
- Alignment with decoupled SMO architecture, with a flexible interface between the Non-RT RIC and SMO. Pre-integration with multiple SMO solutions
- Cloud native modules that can be hosted on any infrastructure of choice (public/private cloud and on-premises)

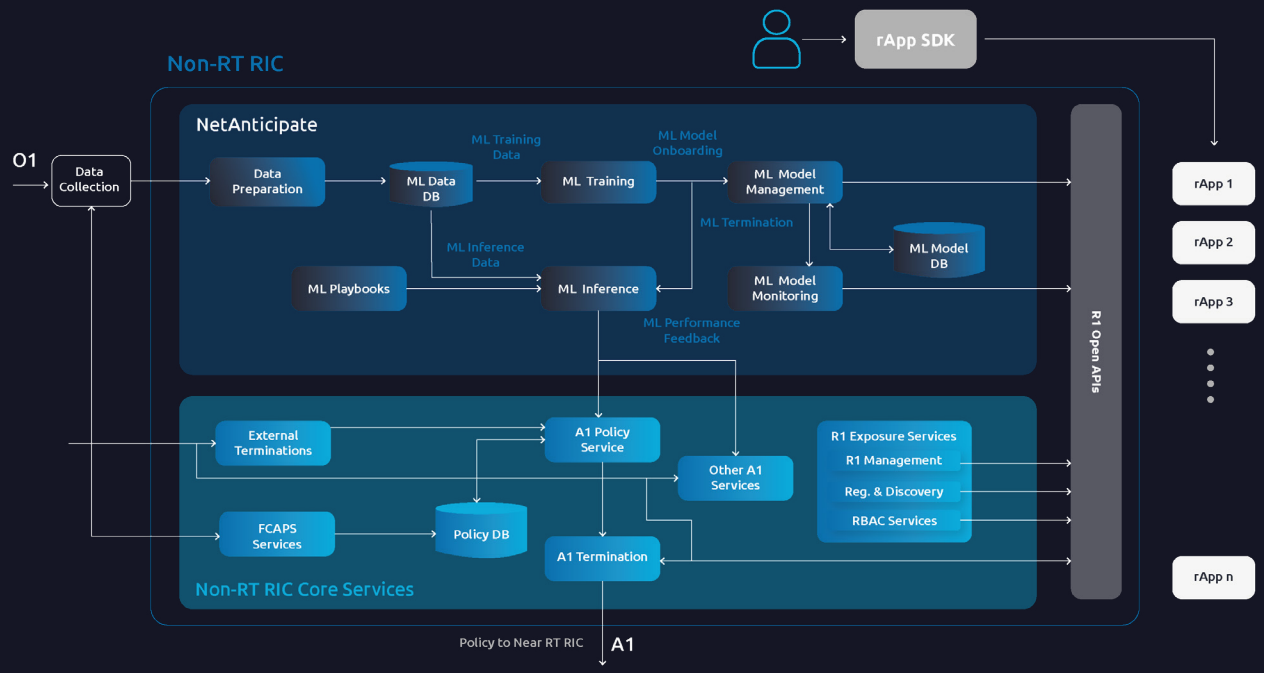


Figure 3: Capgemini Non-RT RIC framework – high level architecture. Source: Capgemini

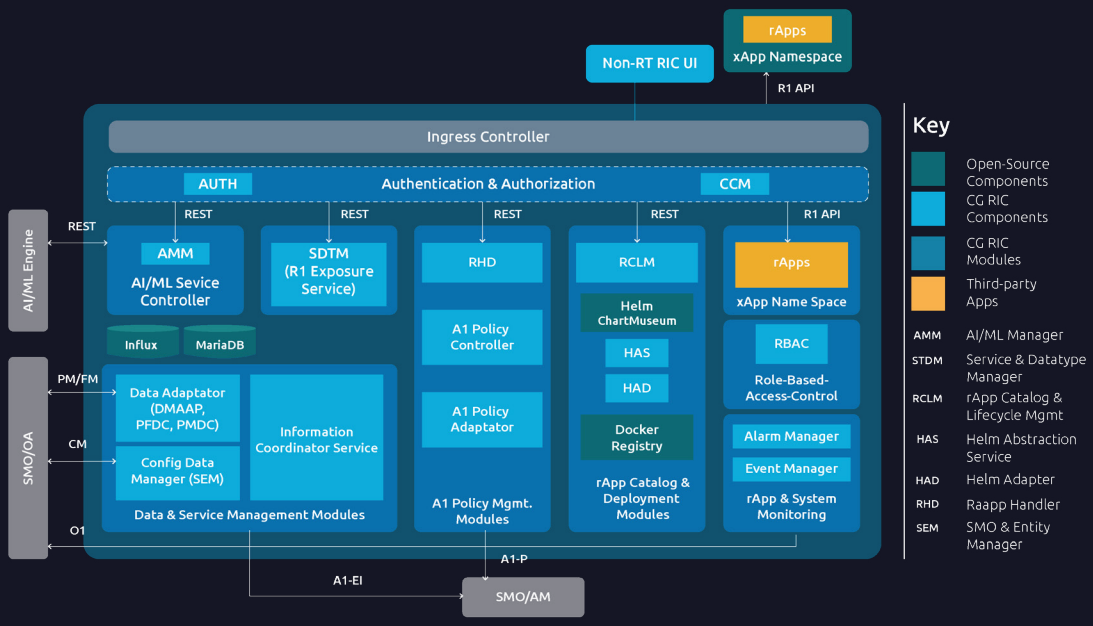


Figure 4: Features of the Capgemini non-RT RIC solution. Source: Capgemini

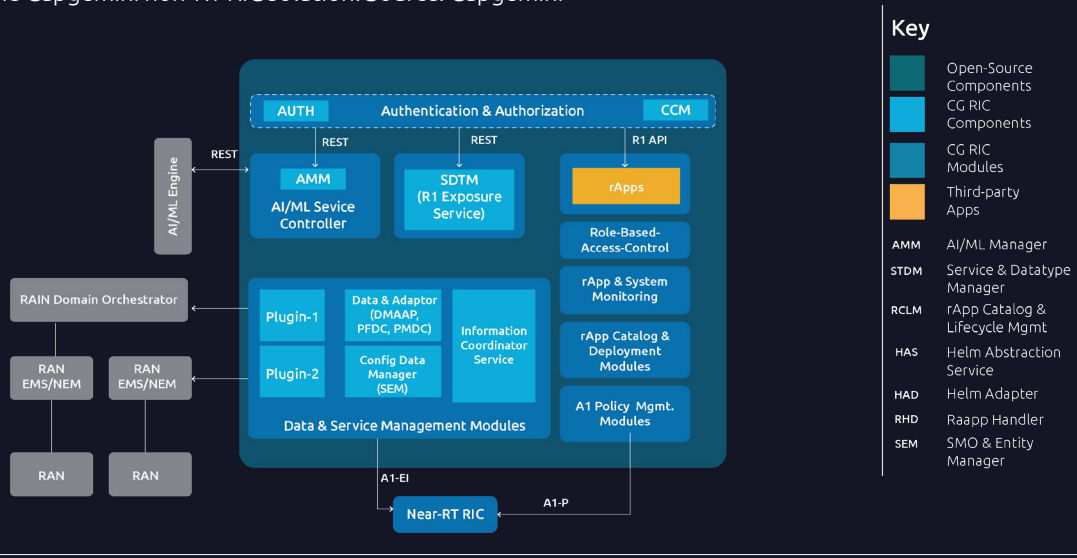


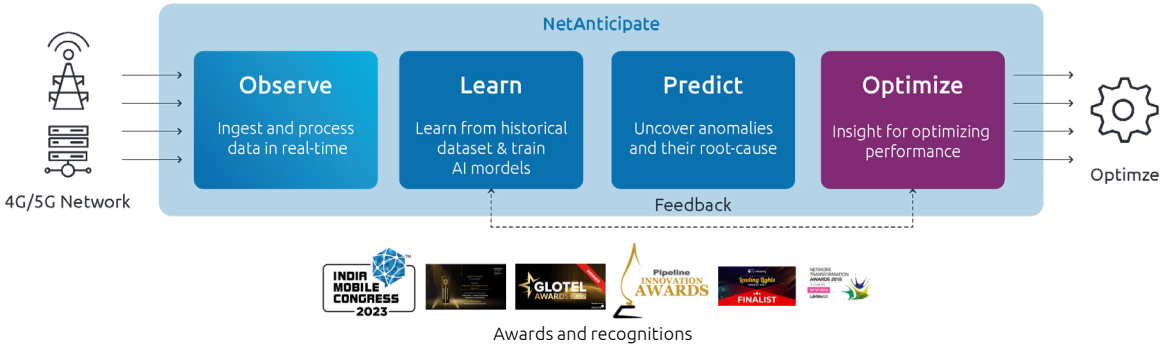
Figure 5: Non-RT RIC integration with legacy RAN. Source: Capgemini

NetAnticipate machine-learning platform

NetAnticipate is an award winning, self-driving NetworkAI Ops platform that manages AI-ML workflow services for O-RAN use case development in distributed environments. This framework supports O-RAN WG2 specification compliant architecture to provide various AI/ML procedures explained in Figure 3. The platform enables automated model training and the publishing of models in a catalog with seamless integration in a production environment. Playbooks provide automation workflows by packaging ML models with the associated business logic.

Salient features:

- Allows MLOps to build a comprehensive ML pipeline for continuous operation and self-learning of ML models through feedback loops
- Support for various AI/ML deployment scenarios, including:
  a. Training at SMO/Non-RT RIC and inference in Non-RT RIC
  b. Training at SMO/Non-RT RIC and inference in Near-RT RIC
  c. Training at SMO/Non-RT RIC and inference in O-CU/ O-DU
- Supports integration of third-party models
- Proven interoperability and scalability
- Advanced machine learning algorithms to enable a broad range of O-RAN use cases
- Model accuracy and drift management
- Intent-Based Networking
- Support Multi-Agent Framework



Capgemini O-RAN use-case portfolio
(xApp and rApps)

Capgemini has developed multiple xApps and rApps aligned with the O-RAN Alliance specifications. The xApp and rApp architecture allows them to be integrated with any third-party RIC platform. Here are some cases we have implemented.

QoS Admission Control

- Ensuring the RAN user plane serves the guaranteed bit rate (GBR) QoS flows with expected performance. This is achieved by keeping track of the RF resource that is already being used by the admitted QoS flows and evaluating admission control for incoming GBR QoS flow requests
- Support based on the latest E2AP and E2SM specifications
- Decision logic to determine whether to reject the new flow request, or release some existing flows that are a lower priority in order to admit the new flow
- The xApp-based design allows flexible QoS metric selection, as well as the evolution of resource prediction and evaluation algorithms, as the xApp is now decoupled from the sophisticated RAN software. This gives CSPs more control over RAN radio resource management (RRM).
- Integration with the Capgemini RIC platform, as well as with third-party RIC platforms

Traffic Steering

- Using intelligent trigger conditions and application logic, the xApp and rApp steer the UEs to the right serving cell to ensure per-user SLAs and QoS requirements are met and, in turn, improve overall network performance
- The logic is performed on UE or a group of UE cells, and support is based on the latest E2AP and E2SM specifications
- Support for traffic steering is based on measurements and KPIs from O-CU/O-DU
- Handover triggers using E2SM-RC include intra-CU/ inter-DU and inter-CU related scenarios
- ML models are used to make predictions based on KPIs, and help in traffic steering decisions made by the xApp
- Integration with the Capgemini RIC platform, as well as with third-party RIC platforms

RAN Slice Assurance

- xApps and rApps ensure RAN slice SLA assurance using AI-based triggers and KPIs received from O-RAN components
- Near-RT RIC obtains the SLA objectives as A1 policies from the Non-RT RIC and provides guidance or control to the E2 nodes to achieve SLA assurance enforcement at O-CU/O-DU
- Slice-level metrics collected from O-CU/O-DU are used in the xApp, and AI-based inference is also made using trained models
- The xApps control the E2 nodes in adjusting PRB allocation levels per slice, based on which MAC schedulers are expected to handle the PRB allocation per slice
- Near-RT RIC supports and interfaces with SMO requests for the creation, activation, modification, de-activation, and termination of RAN slices
- Slice assurance per UE (or UE group) is based on the E2SM-CCC service model specifications

Energy Saving

- The energy saving rApp/xApp is an ORAN-compliant application developed to enable energy saving in the 5G RAN network
- Even during idle/low traffic periods, the RAN still consumes considerable energy. So, these periods are ideal for triggering energy optimization procedures to maximize energy saving and minimize QoE impact
- The Energy Saving xApp/rApp monitors traffic load conditions in the RAN and identifies the cells where energy saving procedures should be triggered, based on predicted traffic patterns
- Using the model and live data, this application intelligently controls the sleep and shutdown of cells or frequency carriers during low cell loads, without any QoS impact
- Capgemini's AI/ML platform NetAnticipate, an industry leading AIOps platform, is the core AI/ML engine used for cell traffic model training and inference
- Its ORAN-compliance ensures seamless interoperability with third-party RIC platforms
- A network topology aware holistic solution with no QoE compromise. It has a very low footprint and is highly scalable

The Application Partner Ecosystem

Along with the xApps and rApps mentioned above, Capgemini has a rich ecosystem of partner xApps and rApps that can be used along with the Capgemini RIC to realize various O-RAN use cases. These include self organizing networks (SONs), MU-MIMO, and other potential xApps and rApps. Capgemini is also helping customers develop and build rApp/xApp use cases, based on their requirements.

About Capgemini

Capgemini is a global business and technology transformation partner, helping organizations to accelerate their dual transition to a digital and sustainable world, while creating tangible impact for enterprises and society. It is a responsible and diverse group of 340,000 team members in more than 50 countries. With its strong over 55-year heritage, Capgemini is trusted by its clients to unlock the value of technology to address the entire breadth of their business needs. It delivers end-to-end services and solutions leveraging strengths from strategy and design to engineering, all fueled by its market leading capabilities in AI, cloud and data, combined with its deep industry expertise and partner ecosystem. The Group reported 2023 global revenues of €22.5 billion.

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