

CAPGEMINI ENGINEERING

Presenter: Arun Singh
March-2023



EMERGING TRENDS IN RAN ANALYTICS, AUTOMATION & CONTROL

AGENDA

- Introduction
- Market Pulse on 5G & O-RAN
- Capgemini - Intel Engagements
- Capgemini Solutions
- RAN Analytics, Automation & Control use cases

INTRODUCTION



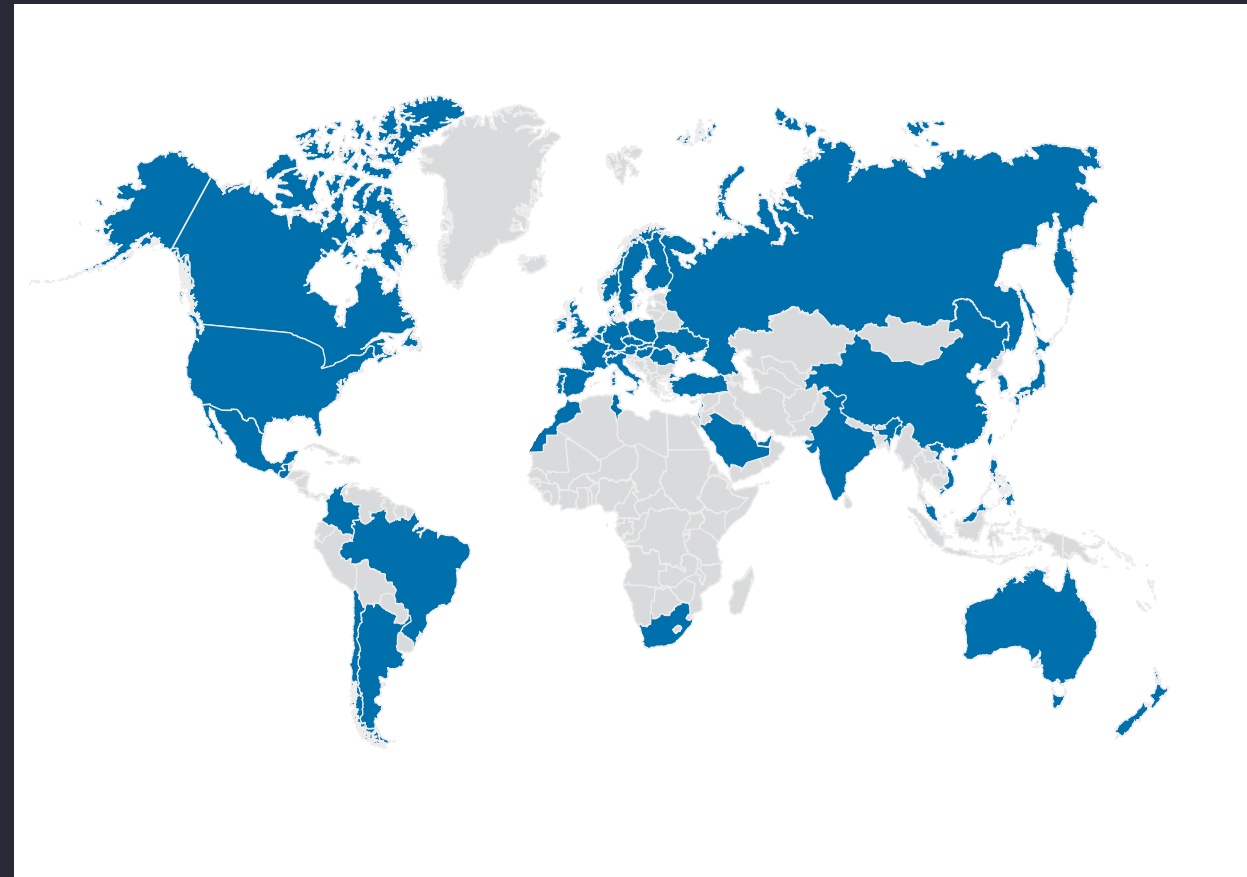
CAPGEMINI, A LEADER FOR LEADERS



As a global leader in consulting, digital transformation, technology and engineering services – with unmatched industry expertise – we enable our clients to **design and build tomorrow's businesses, boost their competitiveness and agility.**

Nearly 50 countries
with more than 120 nationalities

STRONG INTERNATIONAL FOOTPRINT



Capgemini invent

10 000+ employees in
36 offices worldwide

 **PURPOSE**

Capgemini engineering

37 creative studios worldwide

52 000+ employees in

30+ countries

frog Part of Capgemini Invent

 Cambridge Consultants
Part of Capgemini Invent

sogeti
Part of Capgemini 

SYNAPSE

Capgemini

340 000 employees in

40+ countries from

120+ nationalities

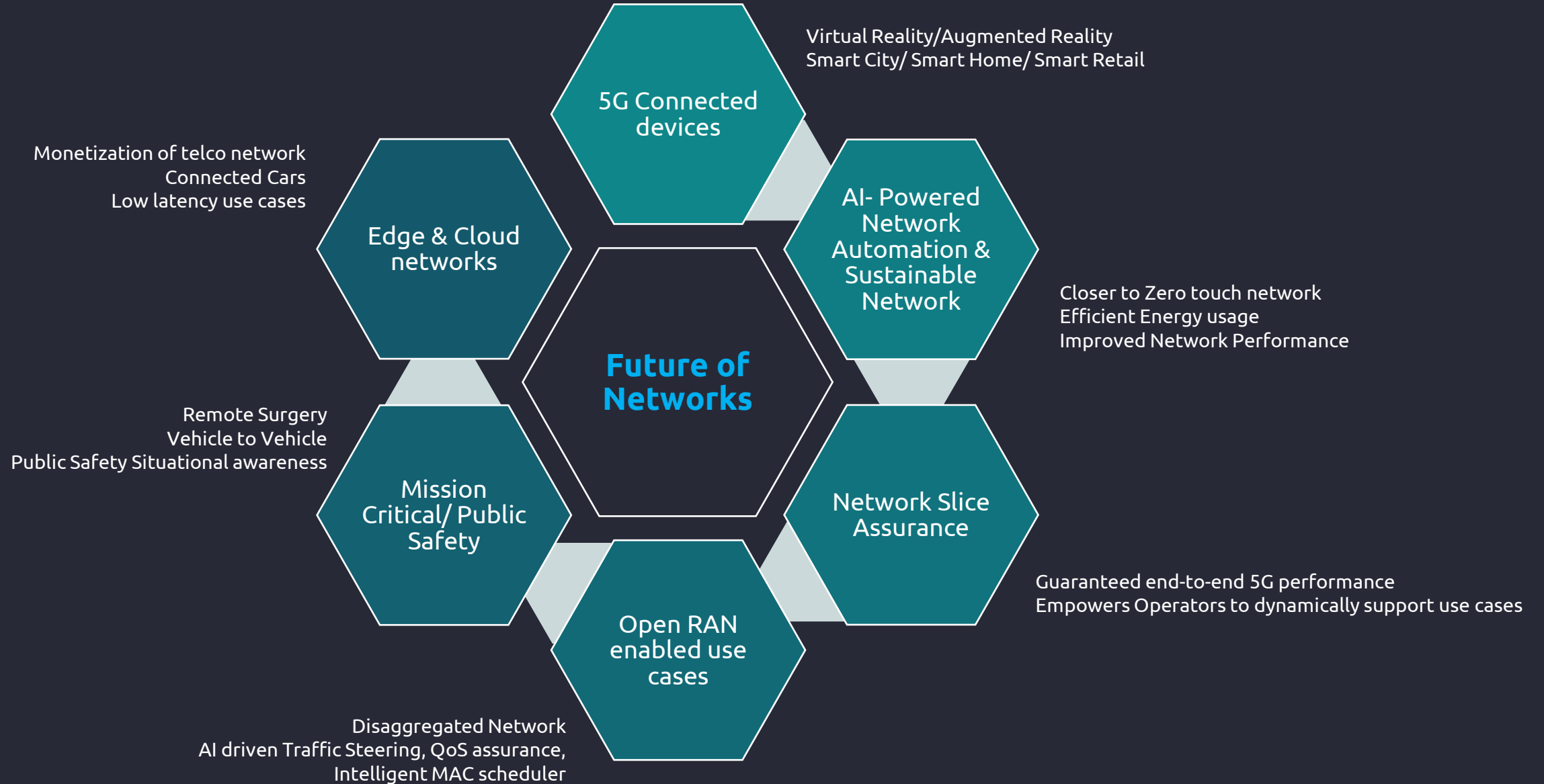
16 000 employees in

15+ countries

MARKET PULSE ON 5G & O-RAN



MARKET PULSE ON 5G & O-RAN



CAPGEMINI - INTEL ENGAGEMENTS



GLIMPSE OF CAPGEMINI – INTEL ENGAGEMENTS



- Capgemini Engineering and Intel® have been working together since 2008 and achieved many significant milestones together.
- Capgemini Engineering was the first Independent software vendor (ISV) to bring its Intelligent Switching Software (ISS) on FM4000 and FM6000 series to enable low latency 10G switches.
- Capgemini Engineering's ISS software and Intel® chipsets have powered some of the world's first low-latency 24x10G blade switches inside the x86 blade systems.
- **Capgemini 5G-Based Smart Road side unit (RSU):** Capgemini's 5G Smart Road Side Unit (RSU) solution integrates Intel® technologies like 5G FlexRAN and Converged Edge Reference Architecture (CERA) to enable smart city/transportation application.

<https://networkbuilders.intel.com/solutionslibrary/capgemini-5g-based-smart-rsu-helps-deliver-on-the-promise-of-5g>

- **Project Bose - A smart way to enable sustainable 5G networks:** Project Bose is an innovative solution built on top of Capgemini 5G Network Data Analytics Function (NWDAF) which is integrated with Intel® observability framework. This is to realize sustainable 5G network and beyond, using a data-driven approach. It uses five energy-saving levers that work in tandem to optimize energy consumption in the network and associated IoT devices, reduce CO2 emissions, and deliver cost savings, with no negative impact on end user QoE.

<https://networkbuilders.intel.com/solutionslibrary/project-bose-a-smart-way-to-enable-sustainable-5g-networks>

- **ENSCONCE for Retail Solutions:** The Smart Retail solution from Capgemini Engineering integrates key Intel® hardware and software ingredients to deliver a scalable visual computing edge platform for emerging retail solutions.

<https://networkbuilders.intel.com/solutionslibrary/ensconce-for-retail-solutions>

GLIMPSE OF CAPGEMINI – INTEL ENGAGEMENTS



- **Unlocking Edge Performance with the Capgemini Engineering ENSCONCE/ Intel® Smart Edge Open Platform:** Increased performance in result was observed when Intel® Smart Edge Open toolkit is integrated into the Capgemini ENSCONCE multi-edge compute platform. Benchmarking data shows increased throughput and reduced latency and jitter in typical edge computing use-cases when utilizing Intel Smart Edge Open optimizations that leverage CPU pinning and I/O acceleration features found within Intel® Xeon® Scalable processors.

<https://networkbuilders.intel.com/solutionslibrary/unlocking-edge-performance-with-the-capgemini-engineering-ensconce-intel-smart-edge-open-platform>

- **Intelligent 5G L2 MAC Scheduler: Powered by Capgemini NetAnticipate 5G on Intel Architecture:** The Smart Retail solution from Capgemini Engineering integrates key Intel® hardware and software ingredients to deliver a scalable visual computing edge platform for emerging retail solutions.

<https://networkbuilders.intel.com/solutionslibrary/intelligent-5g-l2-mac-scheduler-powered-by-capgemini-netanticipate-5g-on-intel-architecture>

...

CAPGEMINI ENGINEERING OFFERINGS



CAPGEMINI SFS PORTFOLIO - INDUSTRY VERTICALS



Communication Networks

Base station, Core networks
Aggregation Routers, Optical
Transport, Carrier Ethernet
switches, MEF services



Enterprise 5G and Data Center Networks

Small Cells, Switches, Routers, Edge
Compute, Firewall, Wifi Networks, uCPE,
SD-WAN, vRouter, Private LTE/5G
Network



Satcom

Satellite User terminals, Ground
station Networks, MEF services,
Infrastructure/base station nodes for
HAPS, LEO, MEO & GEO Constellations



Defense Networks

Network in Box, Backpack System,
Portable Networks, LTE /5G base
station, Core Network, high-capacity
Industrial Switches, AVG Systems



Public Safety

Backpack Systems, Ruggedized
Vehicular Routers, Network in box,
E2E Public safety networks



Industrial and Utilities

Industrial Switches, Outdoor small
Cells, AIOPS platform for Predictive
Maintenance, anomaly detection



Automotive

V2X stacks (multiple variants (DSRC,
C-V2X, China C-V2X)), Auto grade
Bluetooth stack, AVB Switches, End
points



Factory Automation

Private 5G Networks, UPF enabled
edge compute, Industrial Switches
and Routers, Firewall

SOFTWARE FRAMEWORKS

25+ years

of investment in new technologies

500+

clients across Tier1 and Tier2 networks equipment providers, OEMs and ISVs across the globe

125+

licensable software frameworks and solutions across legacy and next generation technologies

1,000+

strong engineering staff



Our range of **connected** solutions comes with a **powerful** eco-system comprised of silicon vendors, platform builders and cloud providers, as well as **innovative** business models for **co-creation** and **co-development** of new technology.



5G FRAMEWORKS

- A wide range of software frameworks supporting E2E 2G to 5G wireless technologies: RAN, Transmission, Core
- Ensconce: Capgemini Edge Computing framework based on open-source edge platform.



NETWORKING

- Wired connectivity solutions across segments fixed broadband, metro networks, optical transport, datacenter, enterprise networks and industrial networks.
- Offering includes Software-Defined Networks, WAN connectivity.



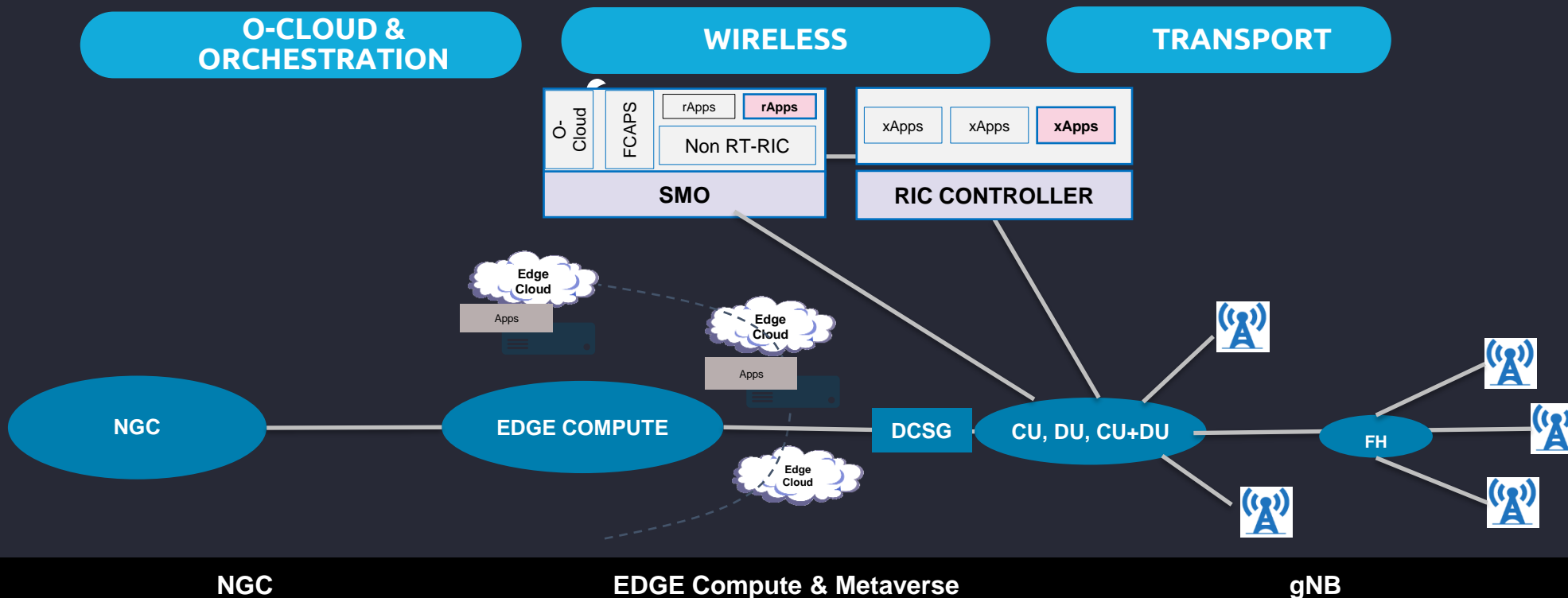
EDGE & ORCHESTRATION

- Low-latency edge compute middleware software to enable high-performance Cloud applications, cloud gaming, etc.
- AR/VR Applications, Metaverse applications
- AI/ML frameworks for Network Management

CAPGEMINI'S 5G SOFTWARE - IP Investments

(ASSETS To Accelerate OPEN NETWORK INTEGRATION)

Software Frameworks and solutions to accelerate time-to-market for new intelligent 5G services with AI, ML, RAN Automation solutions and building blocks for Open Networks



- 25+ customers
- 10+ Network Services for rich support of services
- NSA/SA mode support
- Cloud Native Architecture and modular Architecture
- Focus on Private network use cases for Industrial, Public Safety and Mining

- 15+ customers
- gMEC Federation Group
- Kubernetes based & Developer Centric Model
- Edge Host Platform to latency Sensitive Apps
- Cloud based host Discovery,
- Node Management
- Enabler for Industry 4.0 use cases
- POCs with leading CSPs across the globe

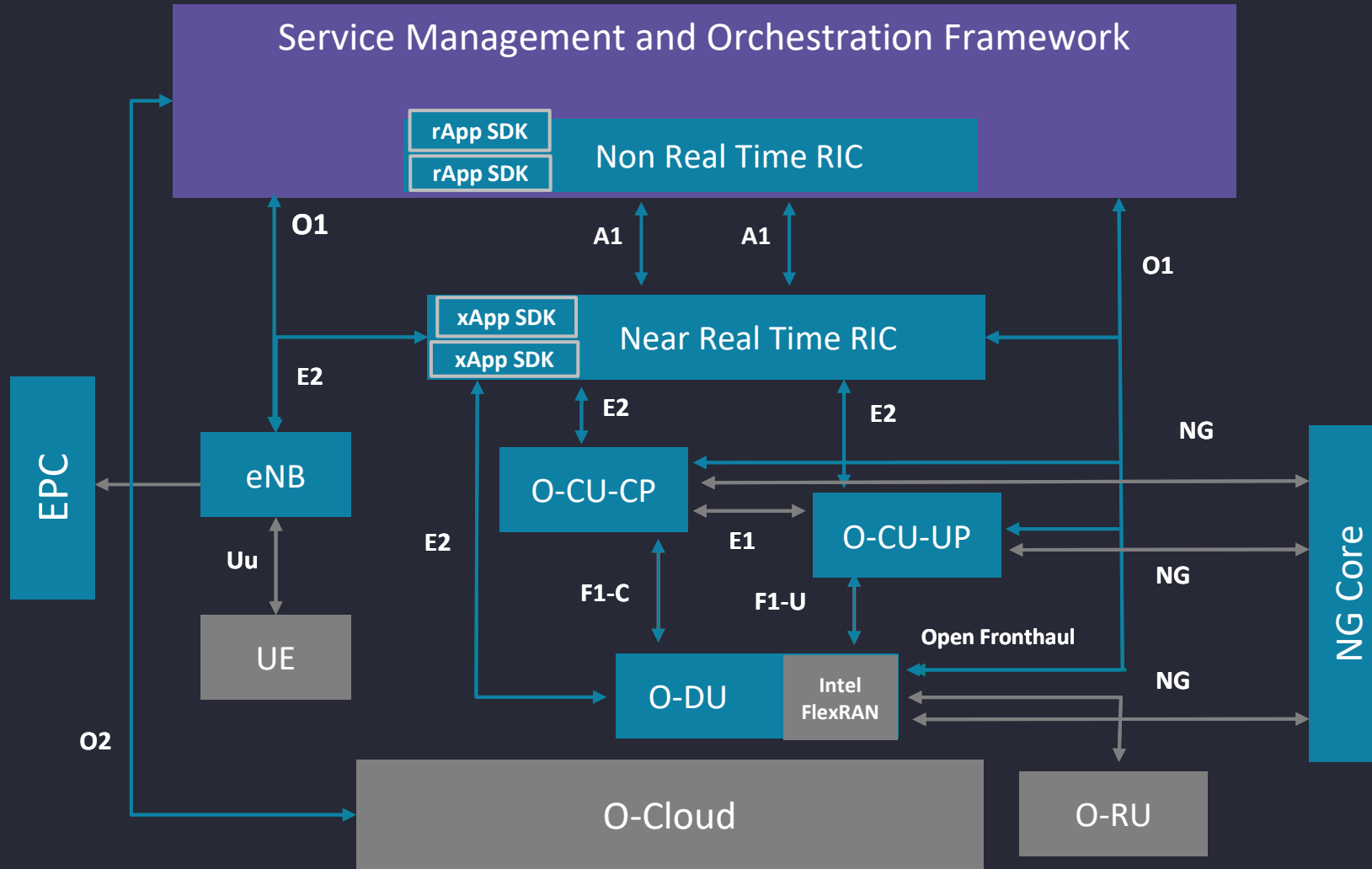
- 70+ Customers
- ORAN Architecture vCU, vDU (SA/NSA, TDD/FDD, FR1/FR2)
- Support for multiple deployment and form-factors
- AI/ML based RAN, Private Networks, IAB

- Pioneering the FHG solution with Intel, Pegatron, Ufispac
- Timing, ORAN Interfaces, RRH ring/star/daisy-chain configuration
- Segment Routing, MPLS etc
- Management for CPRI/eCPRI/ROE

RAN ANALYTICS, AUTOMATION & CONTROL USE CASES



CAPGEMINI SOLUTION ARCHITECTURE FOR O-RAN



Legends

■ Capgemini Assets

■ Partner components

■ Joint Development with Partner

R&D PARTNERS FOR O-RAN RIC PROGRAM



RATIO O-RAN RIC & SMO

- Capgemini's O-RAN RIC & SMO framework that includes Near RT RIC, Non-RT RIC and SMO.
- Highly scalable platform based on hardened opensource components from O-RAN SC.

Use Cases O-RAN xApp & rApp

- Capgemini's xApps & rApps – QoS, Traffic Steering & RAN Slice Assurance, Energy Saving, etc.
- Development of new apps.
- Development of E2SM required for xApp development and integrating with RIC platform
- Validation of performance/functionality of xApps & rApps with vendor CU/DU solution

Testing Services Simulator & RIC Testing

- E2 simulator for RIC verification, capacity and load testing . Support for multiple E2 nodes, multiple UEs, E2SM profiles (per UE group), E2SM models to validate RIC
- Test framework for validation of RIC modules and internal interfaces/flows to other RICs including O1, O2, A1 & E2

RIC Features On 3rd Party RIC

- Development of new xApps & rApps – design / implementation and unit-testing
- Development of E2SM required for xApp development and integrating with RIC platform
- Validation of performance/functionality of xApps & rApps with vendor CU/DU solution

CU & DU gNB with E2 Support

- Capgemini can provide real CU/DU with E2SM support for validation of xApps and rApps with respective E2SM support.
- Capgemini can do the enhancements in CU/DU framework for E2SM part, and deliver CU/DU SW (running in PHY by-pass mode) and UESim

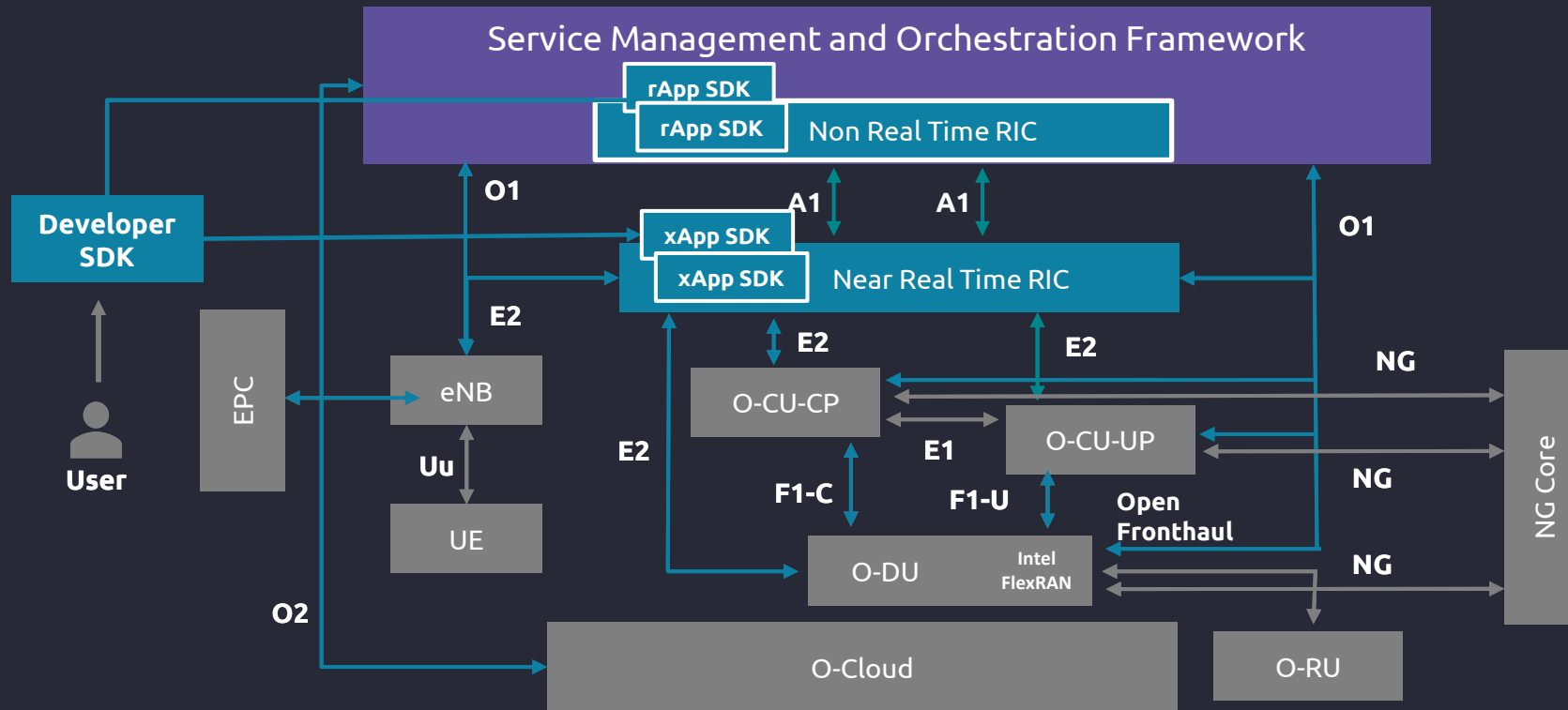
CAPGEMINI RIC FRAMEWORK

COMPONENTS CONTEXT & ECOSYSTEM



Capgemini RIC, named “**Ratio**”, is a highly scalable platform, which is fully aligned with O-RAN Alliance specification. It supports multi-vendor CU/DU through standard O-RAN interfaces. This allows operator to choose different vendors for CU/DU, SMO, and xApps/rApps.

Capgemini RIC supports a fully disaggregated RIC architecture, which is based on hardened O-RAN SC components and Capgemini’s *NetAnticipate framework*.



Legends

■ Capgemini RIC Assets

■ Joint Development with Partner

CAPGEMINI'S NEAR-RT RIC SOLUTION

SALIENT FEATURES OF CAPGEMINI'S NEAR-RT RIC SOLUTION



ORAN COMPLIANT SOLUTION

CLOUD NATIVE SOLUTION

Uses Container and Container Orchestration primitives such as Docker and Kubernetes. Can be hosted on any infrastructure of choice (Public/Private Cloud, On-Prem)

xApp SDK

for quick design and development of new xApps by abstracting the underlying complexities of E2 Interface

EXTENSIBLE ARCHITECTURE BASED ON O-RAN

Modular architecture. O-RAN Aligned Interfaces. Easy Integration with third-party CU/DU Nodes / Open-Source SMO/AI & ML

DISAGGREGATED ARCHITECTURE

Multiple platform components run as independent microservice

CONFLICT MITIGATION SERVICE for addressing conflicting interactions between different xApps. Support to mitigate direct, indirect and implicit conflicts

Secured RBAC Provides comprehensive RBAC (Role Based Access Control) functionality for securely identifying and authorizing the RIC Users & xApps.

CAPGEMINI ADDITIONAL FEATURES

SINGLE UI ACCESS PORTAL

for RIC Platform & xApp management. Support easy onboarding of xApp.

DISTRIBUTED DATABASE

Distributed Active-Active Redis Applications

DEVELOPER SDK

Drag and drop based xApp designer helps to abstract out complexity of xApp development for operator, so that user can focus only on the key business logic

ACCELERATED DATAPLANE

for low latency communication between xApp & E2 Nodes

SECURED ONBOARDING OF xApp by validating the authenticity and integrity of xApp Artifacts. Secured interface with E2 Nodes.

RESILIENCY & AUTO-SCALING ensure the highly availability of RIC Components along with support of auto-scaling to handle the unplanned load fluctuations

CAPGEMINI'S NON-RT RIC SOLUTION

SALIENT FEATURES OF CAPGEMINI'S NON-RT RIC SOLUTION



ORAN COMPLIANT SOLUTION

CAPGEMINI ADDITIONAL FEATURES

CLOUD NATIVE SOLUTION

Uses Container and Container Orchestration primitives such as Docker and Kubernetes. Can be hosted on any infrastructure of choice (Public/Private Cloud, On-Prem)

SMO INTERFACE

loosely coupled SMO interface for integrating with ONAP or other third-party SMOs quickly.

UI ACCESS PORTAL for RIC Platform, AI/ML Model Management & rApp management

DISTRIBUTED DEPLOYMENT
Distributed deployment of Non-RT RIC components for supporting disaggregated architecture

EXTENSIBLE ARCHITECTURE BASED ON O-RAN SC Modular architecture. O-RAN Aligned Interfaces. Easy Integration with third-party near-RT RIC Nodes.

rApp SDK
for designing and deploying new rApps. R1 interface for seamlessly integrality third-party rApps.

DEVELOPER SDK
Drag and drop based rApp designer helps to abstract out complexity of rApp development for operator, so that user can focus only on the key business logic

PROVEN AI/ML SOLUTION 'NETANTICIPATE' for effective management of AI/ML lifecycle

IMPLEMENTATION VARIABILITY
for improved ML model lifecycle management, getting external models

A1 INTERFACE
for comprehensive A1-P, A1-ML & A1-EI functions toward Near RT RIC

SECURED ONBOARDING of rApp by validating the authenticity and integrity of rApp Artifacts

RESILIENCY & AUTO-SCALING
ensure the highly availability of RIC Components along with support of auto-scaling to handle the unplanned load fluctuations

CAPGEMINI O-RAN USE CASE PORTFOLIO



Capgemini and Partner Applications

QoS

QoS based resource optimization in RAN in accordance with defined policies and configuration.

Traffic Steering

Traffic management in RAN with defined intents, policies, and configurations

RAN Slice Assurance

RAN slice SLA assurance based on slice performance measurement

QoE

QoE based proactive network optimization while ensuring efficient radio resource utilization.

Energy Saving

Dynamically optimize cells across different power and capacity modes.

Anomaly Detection

Detection of abnormalities based on KPIs received per UE

SON use-cases

Support for PCI, optimization, MLB

Indoor Positioning

Intelligent positioning optimization.

Sleeping Cell Detection

Predict sleeping cells and raise alarms

Dynamic Transmit Power Optimization

Prevent coverage holes

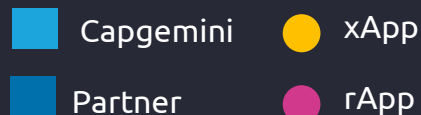
Multicell Interference Management

Real time coordinated multi-cell interference management

MU MIMO

Multiuser MIMO resource scheduler optimization

Legends



Partner Ecosystem

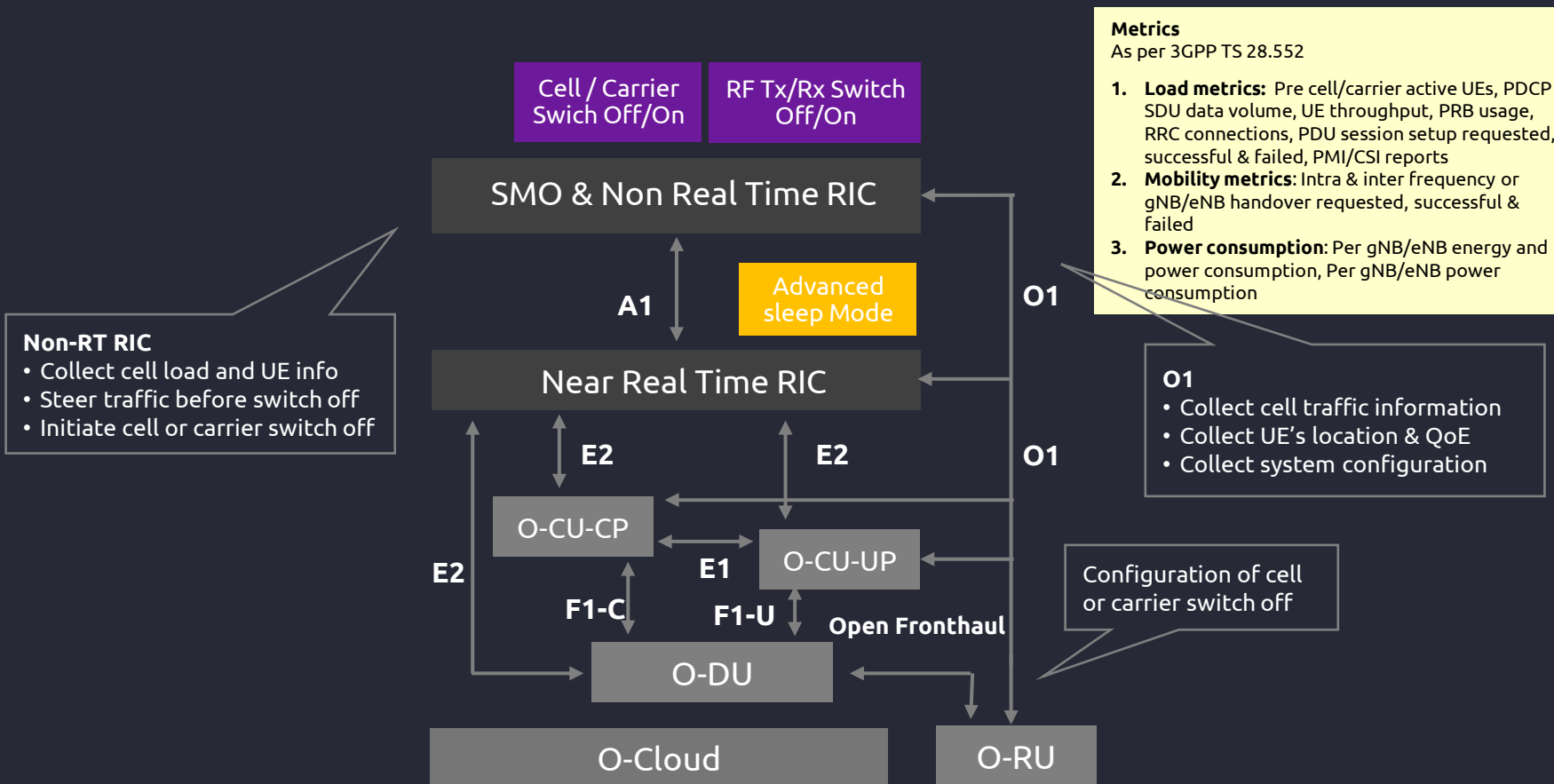


PROJECT BOSE (CAPGEMINI – INTEL)



Energy Saving in ORAN

The O-RAN is responsible for major part of energy consumption of a mobile network, and the O-RU consumes a large portion of the energy within the RAN. The solution through multiple use cases enables energy saving in O-RU by switching off certain components in the RAN. It leverages AI/ML-assisted methods for determining the switch off/on and configuration times in order to maximize energy saving gain while not compromising the network performance.



Energy Optimization Drivers

Cell Switch Off ●

Switches off capacity booster cell that is fully or partially overlaid by candidate cell(s)

Carrier Switch Off ●

Empties one or more carriers at low load and switches them off

RF Tx/Rx Switch Off ●●

Switches off certain RF channels in MIMO antenna at low load

Advanced Sleep * ●●

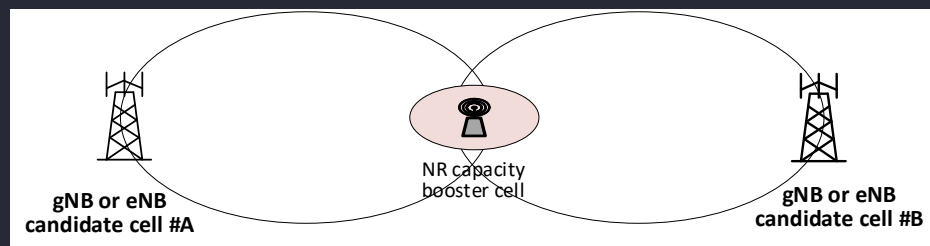
Activates ASMs at certain low traffic conditions. ASMs switch off certain RRH to reduce its energy consumption

ENERGY SAVING APPLICATION



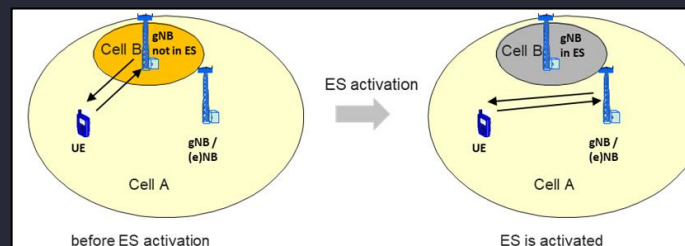
The RAN is responsible for major part of energy consumption of a mobile network, and the O-RU consumes a large portion of the energy within the RAN. The xApp through multiple use cases enables energy saving in O-RU by switching off certain components in the RAN. It leverages AI/ML-assisted methods for determining the switch off/on and configuration times in order to maximize energy saving gain while not compromising the network performance.

1. Cell switch off – partial overlay



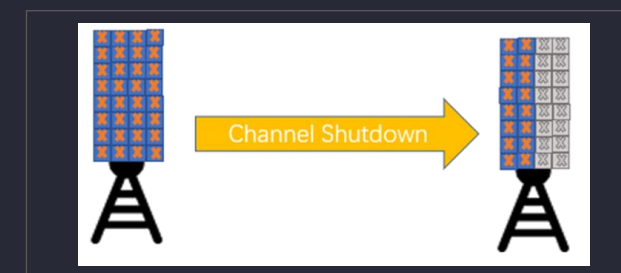
Capacity booster cell partially overlaid by candidate cell(s)

2. Cell switch off – full overlay

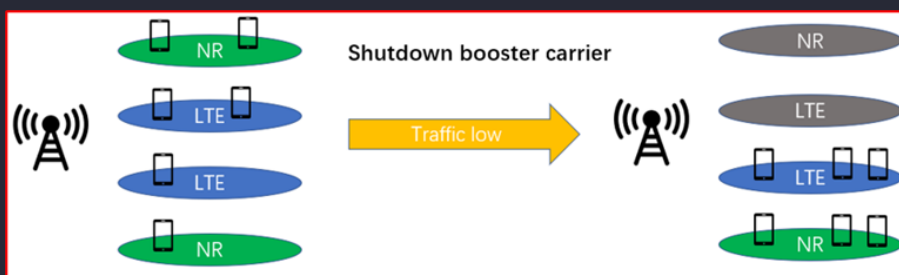


Capacity booster cell fully overlaid by candidate cell(s)

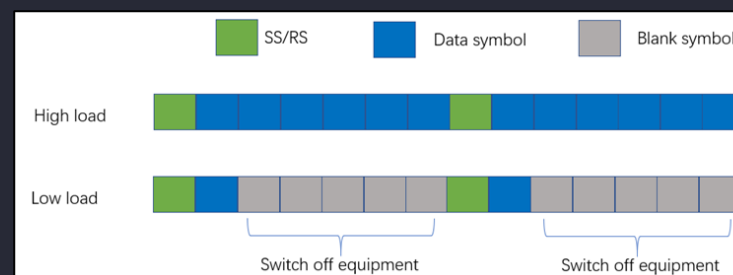
3. RF Channel switch off



4. Carrier switch off

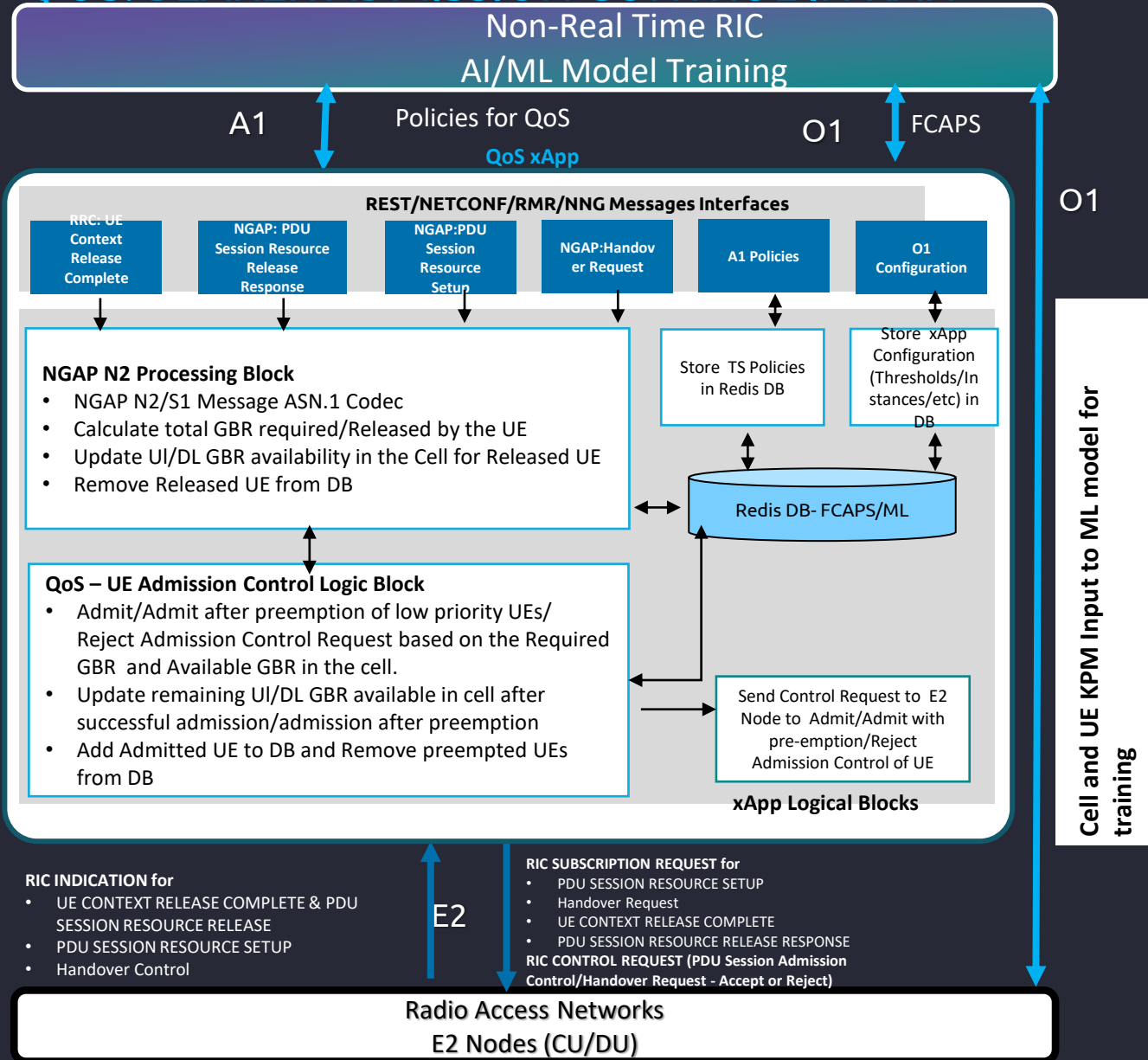


5. Advanced Sleep Mode



CAPGEMINI QOS XAPP

QOS: BEARER ADMISSION CONTROL IN RAN



Objective

- QoS enhancements for Bearer admission control
- PDU admission in case GBR limit for cell will not exceed
- PDU admission along with list of low priority UEs to be released to fulfil the GBR requirements
- PDU admission failure if GBR limit for cell exceeds (even after preemption of low priority UEs)

TS xApp E2 Compliance

- E2AP- O-RAN.WG3.E2AP-v02.00
- E2SM- ORAN-WG3.E2SM-v02.00
- E2SM-RC- O-RAN.WG3.E2SM-RC-v01.00
- E2SM-NI - ORAN-WG3.E2SM-NI-v01.00
- E2SM-KPM - ORAN-WG3.E2SM-KPM-v02.00

TS xApp A1 Compliance

- Integration of xApp with Capgemini's Non-RT RIC and Netanticipate framework for ML based handling
- A1- Proprietary

O1 Compliance

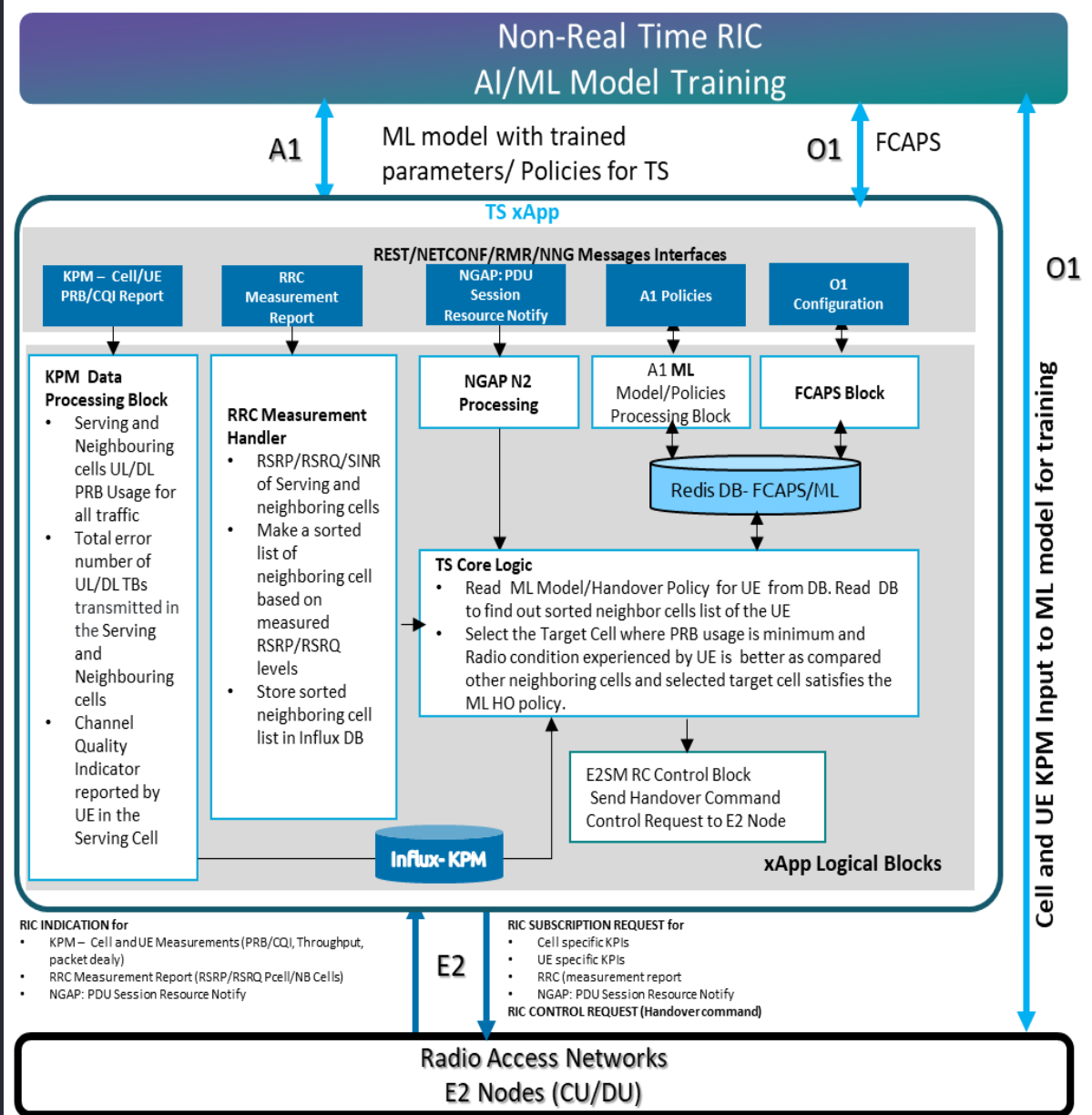
- Supports FCAPS handling via O1 interface towards SMO
- Proprietary Models used for xApp Configuration
- Alarms and Metrics supported via O1 towards SMO

Enhanced RIC Portal

- Enhance RIC Portal for commissioning and management of xApp in Near RT RIC.

CAPGEMINI TRAFFIC STEERING XAPP

TRAFFIC MANAGEMENT IN RAN WITH DEFINED INTENTS, POLICIES, AND CONFIGURATIONS



Objective

- Enable the flexibility for the operator to control the serving cell of a UE from RIC so that the RIC can optimize serving cell for a UE.
- xApp in Near RT RIC will be enabled trigger intra-RAT handover of a UE from one NR cell to another based on Cell/UE KPM measurements, RRC Measurements, NGAP N2 Resource select to Notify and trained HO Policy from Non-RT RIC.

Enhanced RIC Portal

- Enhance RIC Portal for commissioning and management of xApp in Near RT RIC.

Emulation models for Cells, Nodes and UEs

- Model – Ids, QOS, SINR/RSRP/RSRQ Values, Location
- Cell Model – Ids, coverage, geo location, Tx/Rx power, Max/Min UEs, Neighbour cells, cell load etc., Total PRB, Ues
- Node Model - E2Node Ids, E2SMs models, Cells and UEs being serve, RAN KPM thresholds

Data Source & Pipelines

- REST APIs to inject KPM data both at UE and Cell level. -- PRB Usage, CQI, Radio Measurements
- REST APIs to define/Update Cell and UE configurations -- Neighbour cells, location, Power management
- Random generators for UE mobility, Radio Measurements, CQI Measurements
- RC Measurements – NI and RRC Messages (PDU Session setup, UE Context Management)

Testing Environment

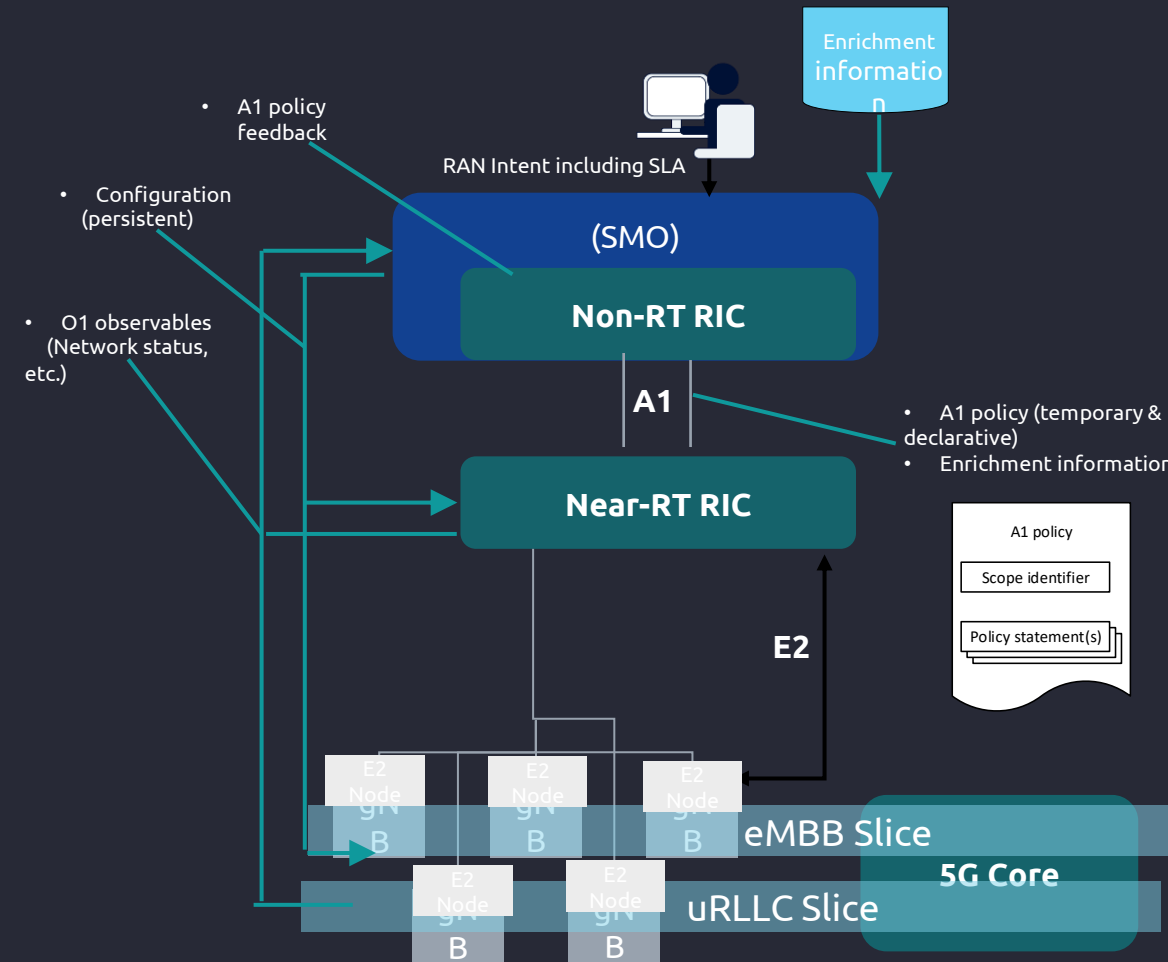
- 2 E2Node (CU-UP and DU)
- 5 Cells (1 serving, 4 neighbours)
- 20 UEs

RAN SLICE SLA ASSURANCE



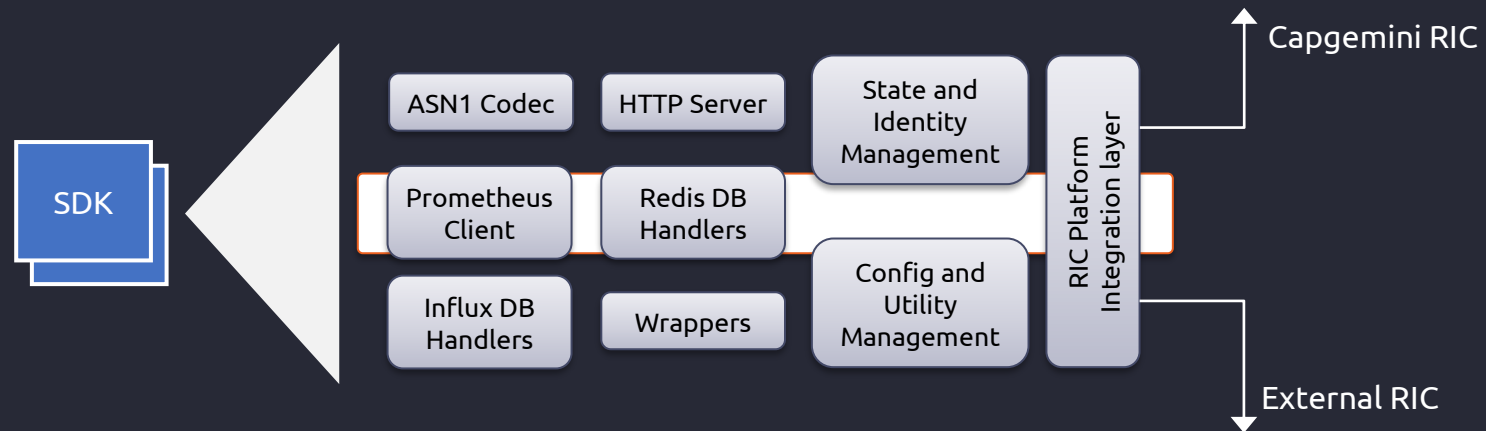
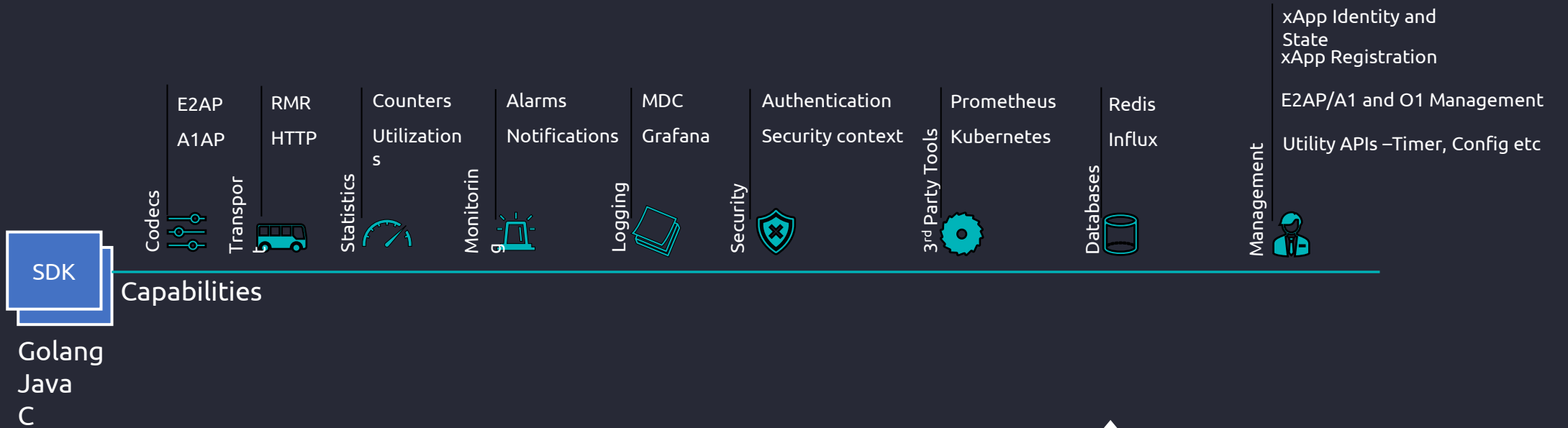
RAN Slice SLA Assurance xApp/ rApp monitor and maintain the Slice SLA during periods of rapidly changing UE behavior and RF conditions

- Input Data: Slice SLA from SMO/NSSMF, RAN Counters/KPIs (3GPP TS 28.552, 3GPP TS 28.552)
- Data processing: rApp monitors RAN performance to determine breach/near breach of SLA and initiates corrective actions over O1 and/or A1 interface
- Data processing: xApp monitors RAN performance over E2 and applies/provides feedback to A1 policies
- Operational Logic: Long term monitoring of RAN Slice performance data reveals patterns and trajectory of different kind of Traffic. Combining this with real-time Traffic data enables to predict future traffic with certain degree of confidence and Policy decisions can be made.



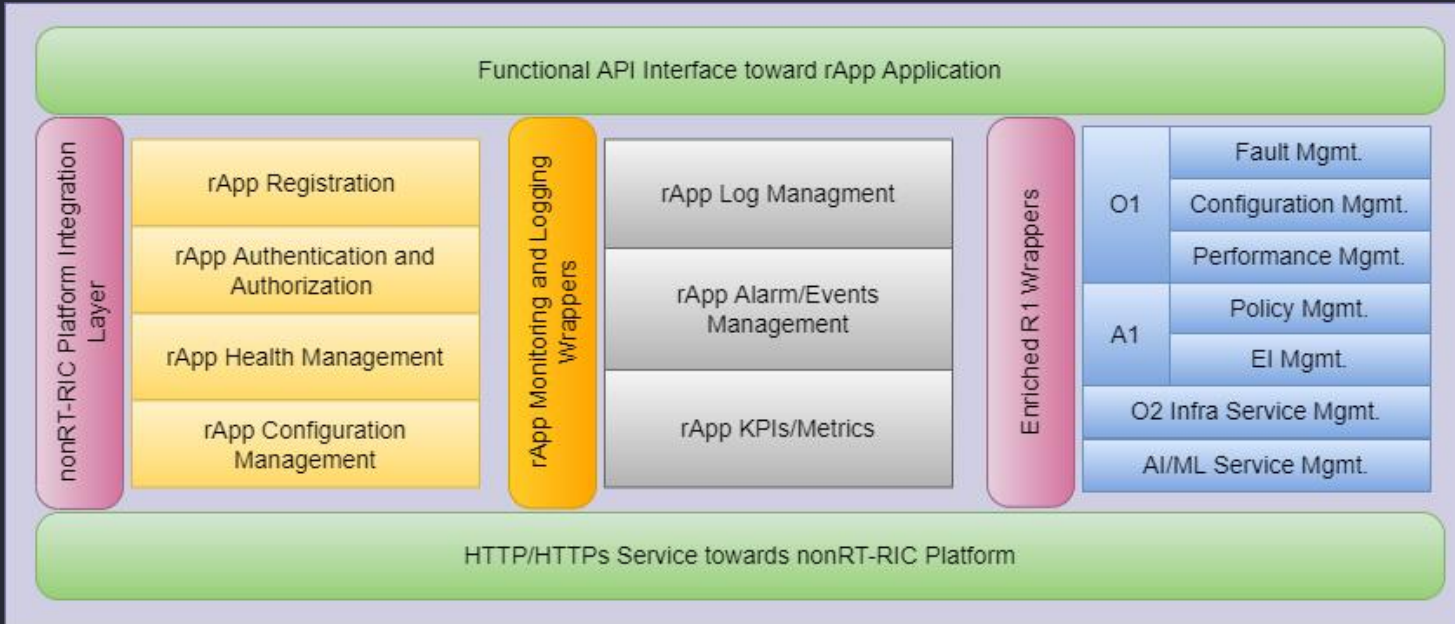
CAPGEMINI'S NEAR-RT RIC XAPPS SDK

DESIGN AND CAPABILITIES

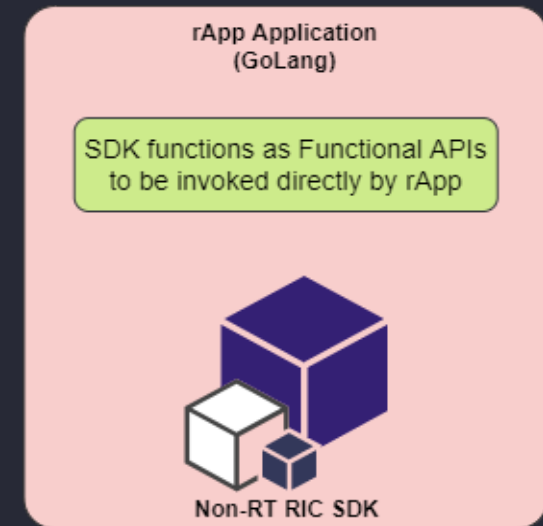


CAPGEMINI'S NON-RT RIC SDK

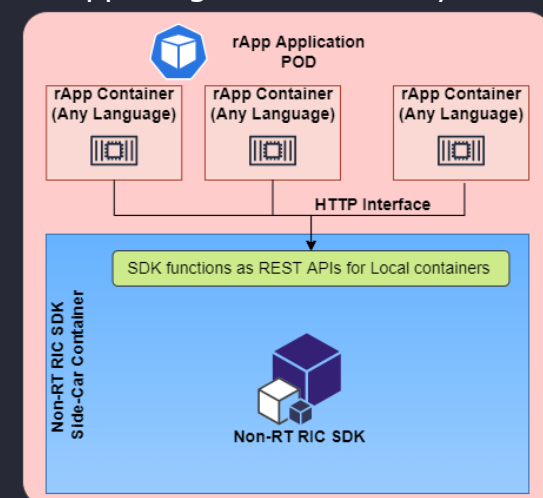
NON-RT RIC SDK FOR RAPPS



Functionally Integrated rApp



rApp Integrated over REST/HTTP



CG Non-RT RIC provides rApp SDK (for Golang)

- SDK hides all the complexities of integration of rApp with Non-RT RIC Platform
- Provides Easy to Use Functional Interface to rApp Applications (Golang based applications)
- SDK also Hosts an HTTP interface which exposes all the Functional APIs as REST APIs - This is useful in case rApp applications are not based on Golang
- Exposes an enriched R1 interface to rApps for easy access

ORAN PLUGFEST: TRAFFIC STEERING & QOS RESOURCE OPTIMIZATION USING CAPGEMINI RIC & XAPP AND VIAVI RIC TESTER



Hosted in TIM Lab

- Demonstrated Traffic Steering of UEs based on the E2-SM KPM Reports using **Capgemini RIC, Capgemini Traffic Steering xApp and Viavi RIC Tester**
- Successfully tested Capgemini RIC & Traffic Steering xApp compliance to E2 Standards and interoperability with VIAVI
- Traffic Steering xApp is onboarded on Capgemini RIC, completes the authentication & registration procedure and subscribe to E2SM-KPM & E2SM-RC
- Simulated E2 Nodes successfully register themselves on RIC and Traffic Steering xApp receives data from E2 nodes via Near-RT RIC
- Traffic Steering xApp receives KPM indications from E2 Nodes and policy configuration from Non-RT RIC. It handover the UE to a optimal cell based on the KPIs received over E2 Interface and the policy received from Non-RT RIC

Hosted in Cablelabs Lab

- Demonstrated Resource Optimization of high priority UEs using **Capgemini RIC, Capgemini QoS xApp and Viavi RIC Tester**
- Successfully tested Capgemini RIC & QoS xApp compliance to E2 Standards and interoperability with VIAVI
- QoS xApp is onboarded on Capgemini RIC, completes the authentication & registration procedure and subscribe to E2SM-KPM & E2SM-RC
- Simulated E2 Nodes successfully register themselves on RIC and QoS xApp receives data from E2 nodes via Near-RT RIC
- QoS xApp receives KPM and RC indications from E2 nodes and produces configuration change decisions of QoS priority

https://assets-global.website-files.com/60b4ffd4ca081979751b5ed2/639a06a616d8421844aca43f_O-RAN.EC.2022-12-14.O-RAN%20Global%20PlugFest%20Fall%202022.pdf

<https://www.viavisolutions.com/en-us/news-releases/viavi-provides-benchmarking-and-validation-global-o-ran-plugfest-technology-gains-acceptance-across>

About Capgemini

Capgemini is a global leader in partnering with companies to transform and manage their business by harnessing the power of technology. The Group is guided everyday by its purpose of unleashing human energy through technology for an inclusive and sustainable future. It is a responsible and diverse organization of 325,000 team members in more than 50 countries. With its strong 55-year heritage and deep industry expertise, Capgemini is trusted by its clients to address the entire breadth of their business needs, from strategy and design to operations, fueled by the fast evolving and innovative world of cloud, data, AI, connectivity, software, digital engineering and platforms. The Group reported in 2021 global revenues of €18 billion (about \$21 billion USD at 2021 average rate).

Get the Future You Want | www.capgemini.com

This message is intended only for the person to whom it is addressed. If you are not the intended recipient, you are not authorized to read, print, retain, copy, disseminate, distribute, or use this message or any part thereof. If you receive this message in error, please notify the sender immediately and delete all copies of this message.

