TELECOM INFRA PROJECT & SK telecom

Unbundled RAN Architecture

An Open RAN Architecture for Multi-vendor Interoperability

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Table of Contents

Executive Summary

The Telecom Infra Project (TIP) is an initiative driven by operators, infrastructure providers, system integrators, and other technology companies that aims to reimagine the traditional approach to building and deploying telecom network infrastructure.

The growth of the internet and the rise of data-intensive and latency-sensitive services like high-definition video, autonomous vehicles and virtual reality require the development of new architecture and technologies to enable simplicity, flexibility, and efficiency of open network deployments. The next generation architecture needs to meet the ever-growing demand for higher performance and simplified operations while still providing cost advantages for different elements of the network, i.e., access, management, transport and core network.

TIP is working to rethink the industry from the access network all the way to the central office and the Unbundled RAN project aligns with this approach. The project will help create the telecom infrastructure needed for the future by leveraging open interfaces, virtualization and cloud computing technologies.

Through this project and others, TIP intends to reimagine ways to build and deploy the next generation of telecom infrastructure and to unbundle the closed market.

Project Overview

The Unbundled RAN Architecture project is developing an open RAN architecture for multi-vendor interoperability.

The objectives of the project are to separate the eNodeB into functional components aligned around the LTE protocol layers; define standard interfaces for those components to communicate via Open APIs; and build a test-bed to validate the interfaces as well as the viability of the solution using functional and performance end-to-end testing. In order to allow fast integration and limit the need for any proprietary hardware, the project relies on the use of network function virtualization (NFV) where many components are deployed as virtual network functions (VNFs) hosted on top of general-purpose hardware.

The project scope covers two types of RAN deployment models:

- Type 1 - Centralized Layer 2 and Layer 3 VNFs deployed over generic x86 hardware interface with distributed Layer 1 and Layer 2 functions implemented on small-cell form factor hardware. Communication between the centralized unit and the distributed nodes is over Ethernet.
- Type 2 - Centralized Layer 2 and Layer 3 VNFs deployed over generic x86 hardware interface with a second tier of Layer 1 and Layer 2 functions implemented on generic x86 hardware. This second tier connects to remote radio heads using an adopted open radio interface (ORI).

By unbundling the current supply model of 4G radio access networks, this solution reduces the cost of operations, resulting in more scalable and cost effective networks to support next generation services and 5G migration.

The Changing Telecoms Industry Landscape

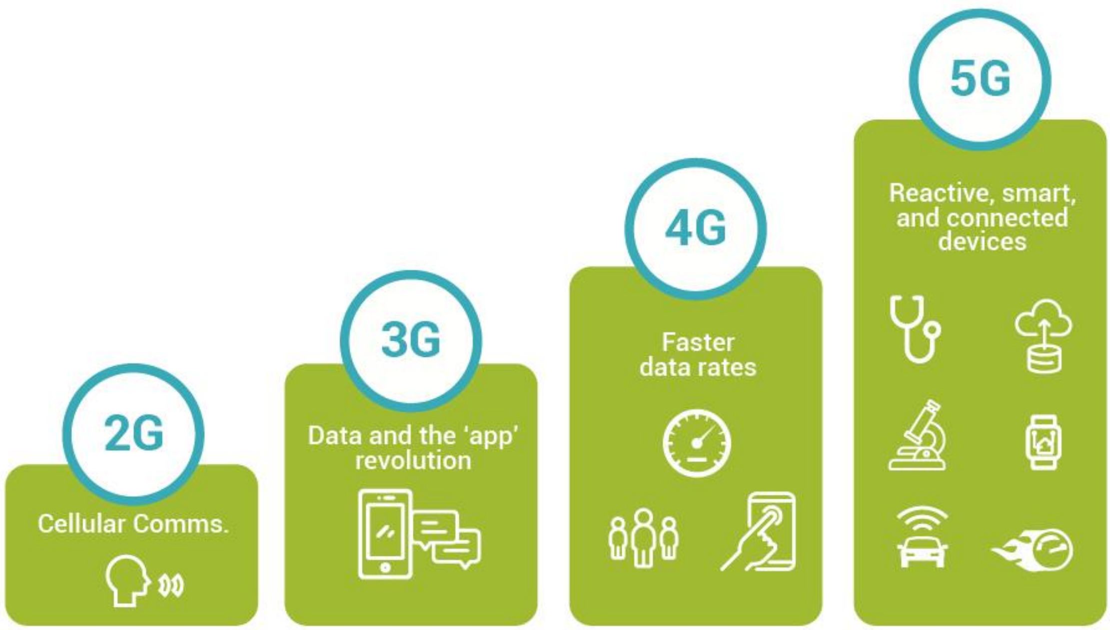
The evolution of the network to support an increasing number of uses highlights the need for new ways of enabling connectivity.

Data usage continues to increase for the majority of applications in use today and mobile networks are becoming the primary method to access the Internet. Furthermore, operators see the data usage vary dramatically based on various factors, including:

- Special days/holidays
- Demography (usage of data varies by certain areas in the day vs. the night)
- Social or political events
- Sudden disasters

As networks continue to evolve, it is important to introduce new approaches and technologies to address the consumer demand and increasing Quality of Service (QoS) requirements to support mobile applications. This changing landscape includes the move toward Cloud RAN (cRAN) and now Virtual RAN (vRAN), Network Functions Virtualization (NFV), and Software Defined Networking (SDN).

The RAN network evolution from 2G to 4G has a focus on people and mobile devices. In 5G, the RAN will expand to encompass connected devices.



In addition, by moving most of the computation centric functionality to the cloud, the cost to increase scale for the access network is significantly reduced compared to a few years ago.

The continued improvements in the capabilities of hardware and the enabling of acceleration technologies have supported wider adoption of NFV supported solutions. NFV allows general-purpose hardware to support a variety of different applications and services in a software implementation. NFV enabled on general-purpose hardware supports various requirements from standard LTE to NB-IoT and Multi-Access Edge Computing (MEC).

Virtualization of cRAN layers assists in the dynamic scaling up/down and orchestration of resources based on a set of parameters. The policies can be tuned for each deployment. Various network usage data can be collected to dynamically predict and utilize the compute resources efficiently.

The deployment of cRAN allows the network operator to share the resources across different areas within the network. In addition, cRAN provides easy scaling capability preventing the need for costly retrofits typical for traditional operations and management (OAM) hardware.

In recent years, software defined networks (SDN) have been introduced to help steer the data through the edge networks based on dynamic parameters and policies. This programmability allows for the optimum use of available network resources.

Many operators have publicly announced their move to these new technologies in order to control resource utilization with minimal wastage. In this pursuit, operators are trying to provide open interfaces to their edge network platforms, allowing vendors an opportunity to provide low latency, local geography specific applications like regional games. It is this changing landscape and emerging technologies that have enabled the development of the Unbundled RAN Architecture project.

The Unbundled RAN Architecture Project

Today's state-of-the-art 4G RAN comes from a single vendor. Typically, a single vendor provides its eNodeB in purpose-built hardware along with ancillary components such as antennas, site-specific equipment (power, shelter, alarming) as well as IP/Ethernet equipment and centralized operational support system equipment. In most cases, the same vendor is responsible for deploying, configuring and commissioning the equipment. Even with the more recent advances in cloud RAN technology, the monolithic eNodeB software continues to be provided by a single supplier. Typically the same vendor owns the systems integration of off-the-shelf hardware for RAN along with cloud enabler software and its own eNodeB software.

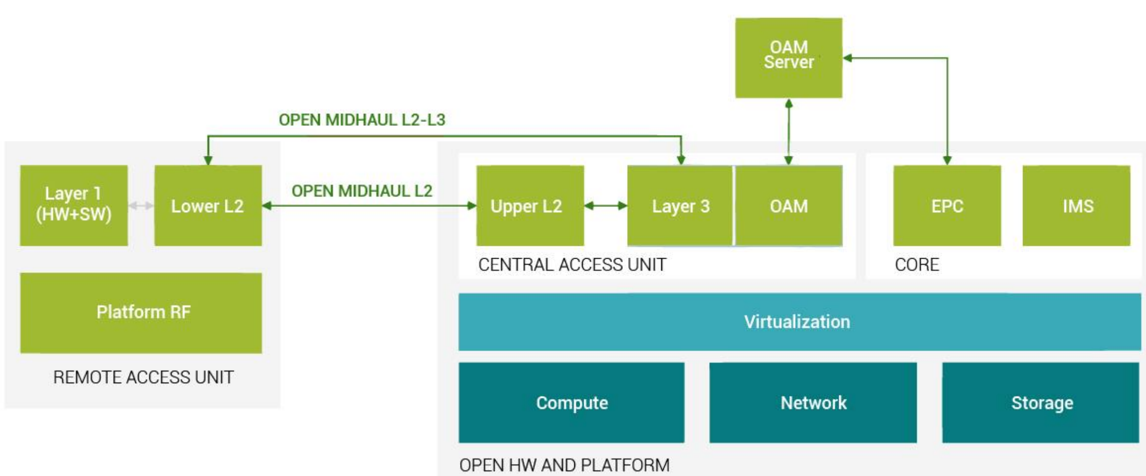
The objective of the Unbundled RAN Architecture project is to partition the eNodeB functionality into various components, map these on the relevant hardware, and define open interfaces among these components. This partitioning of eNodeB will allow multiple vendors to provide different components of the access network. The partitioning will also help create open hardware based software components as well as software components tied to hardware. Unbundling moves the industry away from proprietary hardware and instead brings in more software centric solutions from multiple vendors resulting in a faster roll out of features and lower CAPEX.

Architecture

The project aims to create an end-to-end unbundled 4G access solution with simpler designs based on an Open API concept, resulting in a lower total cost of ownership for service providers. With this vision, the project is pursuing two different architectures for unbundling 4G eNodeB. Once the technology is available, the project will migrate to 5G.

eNodeB contains complex software pieces carrying out various protocols, resource management, OAM, SON functions, etc, as well as radio functions. Software functions contain real time and near-real time tasks. Both architectures aim to virtualize various eNodeB components and propose virtualizing near-real time tasks of eNodeB software. The two architectures primarily differ on whether the radio function will be virtualized or non-virtualized.

Type 1 Architecture (Radio Non-virtualized)



As shown in the above figure, the type 1 architecture consists of:

1. **Remote access unit** – this unit will host:
   - The platform for the radio
   - Layer 1 software and hardware
   - Lower L2 software, which is the real time portion of the eNodeB, i.e. MAC (scheduler) and RLC.

   This function works in a non-virtualized environment. The remote access unit will be placed at the cell site to provide the radio coverage.

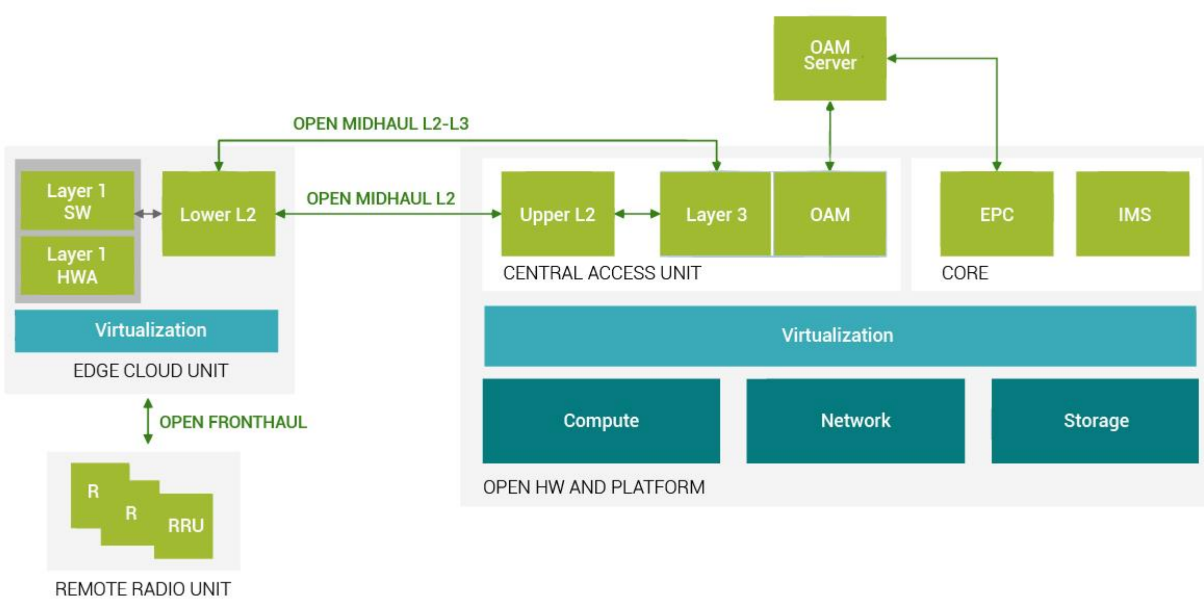
2. **Open hardware and platform** – the architecture envisages hosting the remaining eNodeB functions on an open hardware in contrast to proprietary hardware being used in a traditional eNodeB solution. The architecture further aims to virtualize the eNodeB software functions, directly helping operators to reduce CAPEX. The project will use an OCP based platform as a data center to host the other near-real time eNodeB software functions. eNodeB software is unbundled in the Layer 3 function and the near-real time Layer 2 function. These functions are virtualized and hosted on this open hardware platform.

   eNodeB software is unbundled in following components:

   - Layer 3 software: consists of RRC, S1AP, X2AP, SCTP, RRM and SON. These are Layer 3 modules and are near-real-time
   - Upper L2 software: consists of eGTP and PDCP function. It is the near-real time portion of the eNodeB Layer 2

3. **Core Network**: EPC/IMS interfaces with eNodeB on standard S1 interface. EPC/IMS may be hosted on the same open hardware and platform that is used for the unbundled RAN access solution, hosted on a different virtual platform, or traditional boxed solution.

Type 2 Architecture (Radio Virtualized)



As shown in the above figure, the type 2 architecture consists of:

1. **Remote radio unit** – constituting of the remote radio heads (RRH) for RF. The units are placed at the cell site. The RRH are connected with the Edge Cloud Unit using ORI.

2. **Edge Cloud Unit** - this unit will host:
   - Layer 1 software and hardware accelerators on a virtualized platform.
   - Lower L2 software, which is the real-time portion of the eNodeB, i.e. MAC (scheduler) and RLC.

   In addition to having L1 and lower L2 software virtualized on the Edge Cloud Unit, the deployment architecture also enables complete eNodeB processing, for some or all sectors, together with Mobile Edge Compute and applications on the same open platform.

3. **Open hardware and platform** – in type 2, all layers of the eNodeB are virtualized and running on virtual machines of standard high-volume servers.

As part of this project, the interfaces shown in dark green will follow an Open API concept. The open interfaces, defined as part of the project, will form the building blocks to an unbundled 4G access solution with multi-vendor interoperability.

Open Interface

A deployed LTE eNodeB solution consists of many varying interfaces between different components. These interfaces could be defined by 3GPP (e.g., eNodeB and Packet Core) or proprietary (e.g., among various sub-components of eNodeB). In addition to virtualization of various eNodeB components, the innovative eNodeB unbundling solution aims to open up the interfaces among all components of a deployed eNodeB solution (including the proprietary interfaces).

As part of this solution building, the following interfaces are being defined and will be published by the TIP community.

1. OAM – eNodeB

   The interface will define the management needs of an eNodeB. As part of the activity, the deployment experience available with community participants will be used to define the configuration parameters, alarms, and KPIs that are needed for a field deployable solution. OAM – eNodeB interface will be based on TR-069 protocol. The interface will terminate on OAM client. OAM client is a functional component of eNodeB Layer 3 and communicates with OAM server.

2. eNodeB Internal Interfaces

   Internal interfaces of eNodeB are proprietary in nature. As part of the unbundling, the TIP community is defining the interfaces for open usage, with the understanding that there are a lot of possible vendor dependent solutions. Based on the collective experience of participating community members, the following philosophy is used to define the interfaces.

   - Procedures are being grouped in logical object functions/API
   - 3GPP is being referred as much as possible

- Changes to the core state machine should be avoided
- Applicability for the same definition for both architecture type 1 and 2

  I. Layer 3 - Upper L2: The interface between eNodeB Layer 3 (RRC, SON, RRM, OAM Client) and Upper Layer 2 (PDCP, GTP). The interface carries APIs e.g., Radio Bearer Creation/Deletion, Security Configuration, Tunnel Creation/Deletion, Data Suspend/Resume etc.

  II. Layer 3 – Lower L2: The interface with eNodeB Layer 3 and eNodeB Lower Layer2 (RLC/MAC). The interface will cater to the need for information exchange between L3 and Lower L2 e.g., cell bring up, UE connection establishment, RRC re-establishment etc. The interface will also define the information that needs to be exchanged between L3 and Layer 1.

  III. Lower L2 – Upper L2: The interface between eNodeB Lower Layer 2 and eNodeB Upper Layer 2. The interface will cater to the need of APIs e.g., uplink/downlink data exchange, data delivery status, etc.

3. Lower L2 – Layer 1

This interface is between eNodeB Lower Layer 2 and eNodeB Layer 1. The two proposed architectures have different needs. Based on the architecture and silicon needs, two different interface definitions are being specified.

4. L1 – L1 HW Acceleration

This interface enables a modem software design on standard x86 based servers. The interface enables simple software development by using standard software programming (language, compiler, etc.) and accelerate L1 signal processing elements using a hardware acceleration (HWA) platform.

The interface, based on the Modem Processing Language (MPL), enables abstraction of most general HW accelerators

5. L1 – RRH

This interface is between the L1 and the Remote Radio Head (RRH) is based on existing standards: CPRI and ETSI ORI.

6. OAM – Packet Core

It is the interface between OAM and Packet Core (EPC/IMS/HSS). Collective experience of community members is being used to specify the configuration parameters, KPI, and alarms for the interface.

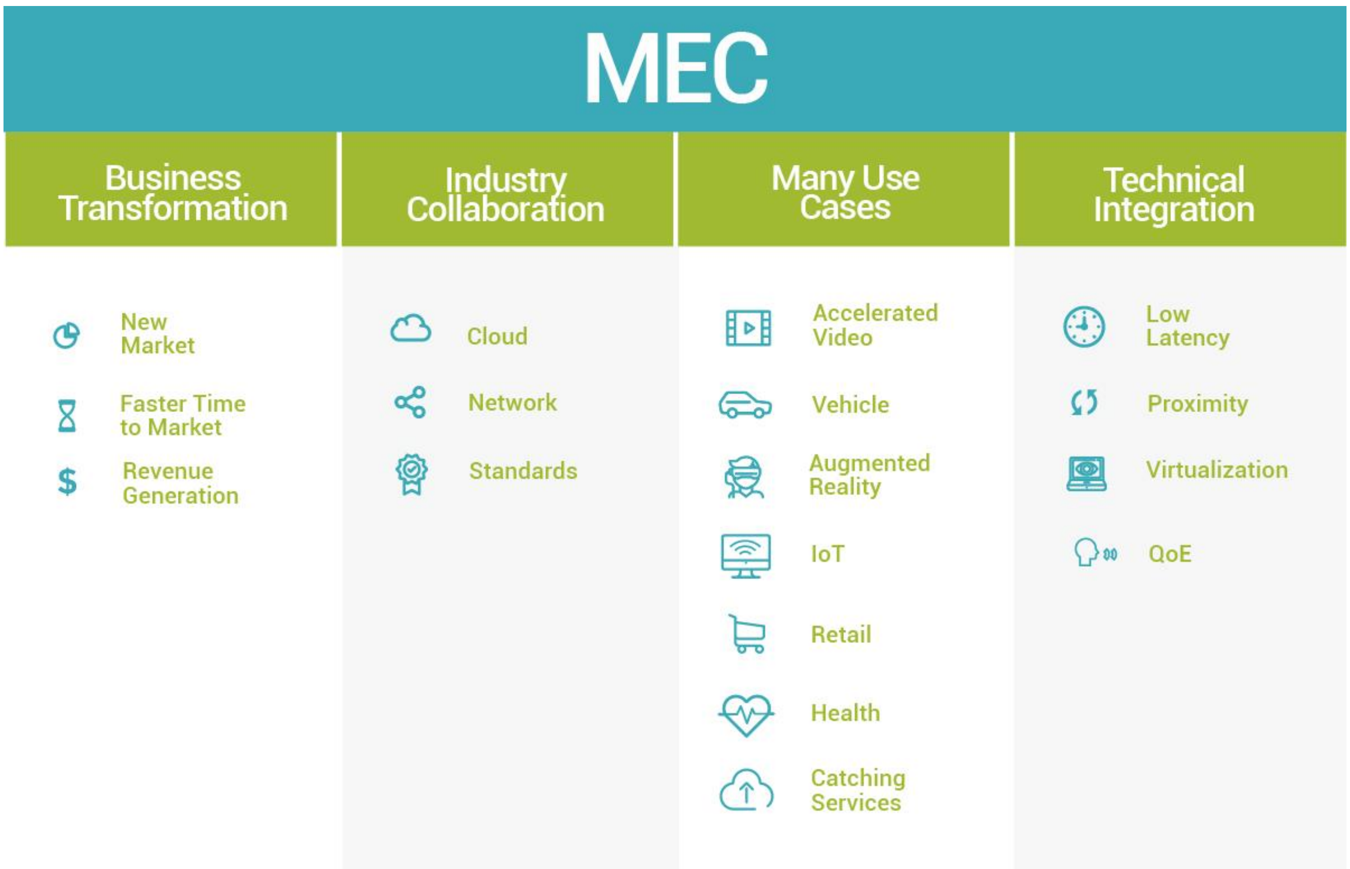
Use Cases

The use cases will cover include indoor, outdoor, and rural deployments where RAN connectivity can be provided in cloud architecture with open interfaces to enable the support of existing and new services and applications in scale across the radio access networks.

The services and applications, including those with higher capacity, span various end-user devices such as smart phones, tablets, and the new categories of IoT devices (including wearables and sensors). The architecture proposed by the Unbundled RAN Architecture project will enable new/different SLAs, low latency, CAPEX and OPEX optimization, and network analytics in the cloud in order to support higher-capacity services and applications across all devices.

Different applications and architectures for 5G need dense deployment of cells. Cloud infrastructure for RAN leverages the gains of the data center for deploying Commercial Off The Shelf (COTS) hardware with NFV. Cloud infrastructure provides the benefit of using the resources according to the overall need of the network. Operators do not need to plan resources according to peak demand at each location.

As the data demands increase, the quality of services and low-latency requirements increase, and augmenting the RAN infrastructure equipment at the edge of the network becomes important. One example is with Multi-Access Edge Computing (MEC), which enables various use cases as shown in the diagram below.



Certain mobile edge use cases and applications that are latency sensitive, require high bandwidth or need data security, including virtual reality, high bandwidth live mobile video, or Vehicle to Infrastructure (V2I) gain enhanced user experience when running all layers of the base station at the Edge Cloud Unit (see type 2 architecture).

Running applications on the Edge Cloud Unit provides significant reduced latency between user devices and such applications, as well as reducing bandwidth requirements on the transport network between the Edge Cloud Unit and Central Office and or the Evolved Packet Core for data that can be terminated locally.

Benefits and Challenges

Current mobile infrastructure is a composite of closed and proprietary hardware and software with a lack of interoperability.

Because the hardware, software, and each part of the system are tightly composed, operators are facing big challenges when optimizing and developing new features. The roadmap of existing vendors is not entirely consistent with the operators' demands, and other vendors have no chance to access the network due to the private interfaces between existing vendors. This higher entry threshold and limited competition among existing vendors hurts innovation within the industry.

In response to a new and changing landscape of future networks, inspiring innovation and more data-intensive experiences like augmented reality and virtual reality, the unbundled project defines a flexible and programmable composition of all the components with an open interface and full optimization.

Unbundling the components and defining standard interface between OAM-eNodeB, OAM-EPC/IMS, Layer 3-Upper L2, Upper L2-Lower L2, Lower L2-L1 and etc., will help operators to obtain flexible, replaceable, and feasible coordination between components, and reduce maintenance and management costs.

With the open interface, the features and the components will be modularized. The modular parts can be easily expanded, relocated or reused. This flexibility will allow operators to easily adapt to future changes or upgrade. Standardized components provide complete consistency throughout any additions and expansions allowing for a new feature or application to be developed quickly. In addition, because of the open and standardized interface, the ecosystem will mature quickly and reduce costs.

Lastly, the Unbundled RAN Architecture project will also help operators improve system performance and users experience by giving them the ability to choose which vendor is the most suitable for each subsystem. Separate vendors can develop various applications for data and analysis management and help operators build intelligent network management features such as real-time monitoring of network quality and real-time managing of customer experience.

However, there are several challenges that will need to be addressed for successful implementation of the unbundled architecture. As an innovative solution, unbundling requires the definition of an Open API among eNodeB components and eNodeB software experts, who can specify the interface definition as more features are added.

The move to a multi-vendor ecosystem would require two levels of integration to successfully deploy unbundled architecture. An eNodeB software expert will be required for the first level of integration between different eNodeB components (adhering to TIP open interface specifications) from multiple vendors.

The next integration will be at the system level (standard nodes of network). It will require operators to work with multiple system integrators, who specialize at each level of integration, to resolve interoperability issues among network components from different vendors.

Though there are challenges, the potential of the unbundled project is undeniable with benefits that will drive a faster pace of innovation in telecom infrastructure and unlock new opportunities for everyone in the ecosystem.

Milestones

The **Unbundled RAN Architecture** project continues to progress, with the following key milestones:

- Completed the first call using draft interface specifications
- Published the interface specifications
- Complete end-to-end functional/performance lab testing for Type 1
- Complete end-to-end functional/performance lab testing for Type 2

The above milestones only describe the development and lab integration within the TIP community. It is expected that operators will take advantage of the innovative solution when it becomes available in the TIP community.

Technical Acronyms

TERM	ACRONYM
Application Programming Interface	API
Cloud Radio Access Network	cRAN
Commercial Off-the-Shelf	COTS
Enhanced Packet Core	EPC
GPRS Tunneling Protocol	GTP
Hardware	HW
Home Subscriber Subsystem	HSS
IP multimedia subsystem	IMS
Medium Access Control	MAC
Mobile Edge Computing	MEC
Modem Processing Language	MPL
Network Functions Virtualization	NFV
Open Compute Project (or Platform)	OCP
Open Radio Interface	ORI
Operations and Maintenance	OAM
Packet Data Convergence Protocol	PDCP
Quality of Service	QoS
Radio Access Network	RAN
Radio Frequency	RF
Radio Link Control	RLC
Radio Resource Control	RRC
Radio Resource Management	RRM
Remote Radio Head	RRH
Self-Optimizing Network	SON
Software Defined Networking	SDN
Virtual Radio Access Network	vRAN

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