Standardization

RAN Open O-RAN

Special Articles on Standardization Trends toward Open and Intelligent Radio Access Networks

O-RAN Alliance Standardization Trends

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NTT DOCOMO and other major global operators founded the O-RAN Alliance in February 2018 with the aim of promoting open and intelligent radio access networks in the 5G era. Since then, O-RAN Alliance membership has grown to include many operators and vendors. This article explains the background to the founding of the O-RAN Alliance and describes its vision, reference architecture, and the focus areas of its workgroups.

1. Introduction

The volume of data traffic in mobile communications is spiraling upward with no signs of slowing down as mobile services such as social networking, video streaming, and online gaming continue to expand. At the same time, there is an increasing desire to achieve the Internet of Things (IoT) connecting just about everything to the Internet, create new industries through collaborative ventures between mobile communications and other industries, and contribute to the solving of social issues. However, these initiatives cannot be achieved solely from the viewpoint of increasing the speed and capacity of the mobile network. It will also be important to reduce power consumption, expand coverage, lower prices, reduce latency, and improve reliability while being able to connect many devices simultaneously (massive connectivity).

The fifth-generation mobile communications system (5G) [1] formulated by the 3rd Generation Partnership Project (3GPP), an international standards development organization for mobile communications, meets the above requirements, and there are many interested parties that are looking forward to its early commercialization.

NTT DOCOMO is no exception, and it plans to launch 5G pre-services in September 2019 and full-scale 5G commercial services in spring 2020. However, to provide not only services geared to existing mobile terminals and smartphones but to also create new industries through collaborations with other industries and achieve new value-added services, it will be necessary to construct an open Radio Access Network (RAN)*1 that can combine and utilize various types of equipment and modules. It is also important that the network be made intelligent to efficiently provide a wide variety of services. In response to these needs, NTT DOCOMO joined up with other operators to found the Open RAN (O-RAN) Alliance in February 2018 with the aim of promoting open and intelligent RAN.

This article provides some background to the founding of the O-RAN Alliance and describes its vision, reference architecture, and the focus areas of its technical workgroups.

2. Background to Founding of O-RAN Alliance

The O-RAN Alliance was founded in February 2018 by five operators—AT&T, China Mobile, Deutsche Telekom, NTT DOCOMO, and Orange—with a view to integrating the xRAN Forum*2 and C-RAN Alliance*3 (**Figure 1**). The xRAN Forum mainly consisted of American enterprises but also included among its members NTT DOCOMO and Japanese, Korean, and European enterprises. Its counterpart, the C-RAN Alliance, mainly consisted of Chinese enterprises. Both organizations were involved in interoperable open interfaces, intelligent control using big data, and virtualization in RAN. In this way, it was thought that the integration of these two organizations would have many benefits.

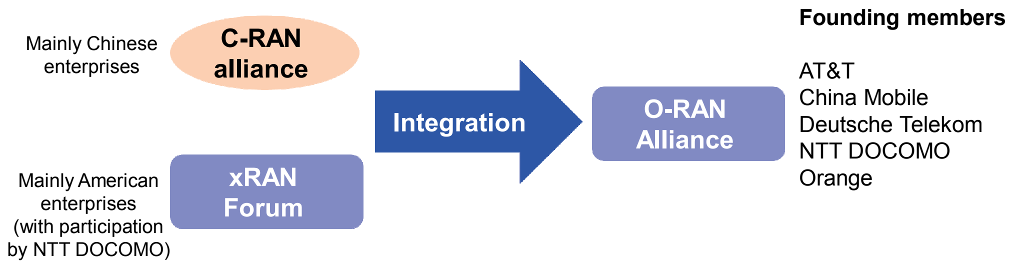


Figure 1　Founding of O-RAN Alliance

*1　RAN: The network consisting of radio base stations situated between the core network and mobile terminals to perform radio layer control.

*2　xRAN Forum: An industry organization that had been active in promoting highly extensible radio access networks. It is presently integrated with the O-RAN Alliance.

*3　C-RAN Alliance: An industry organization that had been active in promoting C-RAN. It is presently integrated with the O-RAN Alliance.

Following its founding, the first O-RAN board meeting was held in June 2018 and the first workgroup meetings in September 2019. As of March 2019, the O-RAN Alliance has come to consist of 19 operator members and 55 contributor members including major vendors and venture firms (**Figure 2**). Activities have begun in earnest.

3. O-RAN Alliance Vision and Reference Architecture

In the face of increasing volumes of mobile traffic, the mobile network and its constituent equipment are required to be more software-based, virtualized, flexible, intelligent and energy efficient. The O-RAN Alliance seeks to achieve these goals by evolving RAN to a higher level of openness and intelligence. Specifically, the O-RAN Alliance specifies reference designs consisting of virtualized network elements using open and standardized interfaces. It also calls for a more intelligent network through real-time information collection at those network elements and the use of machine learning[*4] and AI technology. The following describes the O-RAN Alliance vision and reference architecture.

3.1 Vision

1) Open

The O-RAN Alliance sees the need for building open RAN that can combine and use various types of equipment and modules to achieve more cost-effective and flexible function extensibility. By specifying open interfaces, the O-RAN Alliance aims to build a more vibrant ecosystem[*5] in which original services can be constructed in a short period of time through component-based function extensions, networks can be customized to meet specific needs and requirements, and networks using multi-vendor equipment can be achieved. The O-RAN Alliance also considers that Open Source Software (OSS) and hardware reference designs can be effective in stimulating and accelerating innovation.

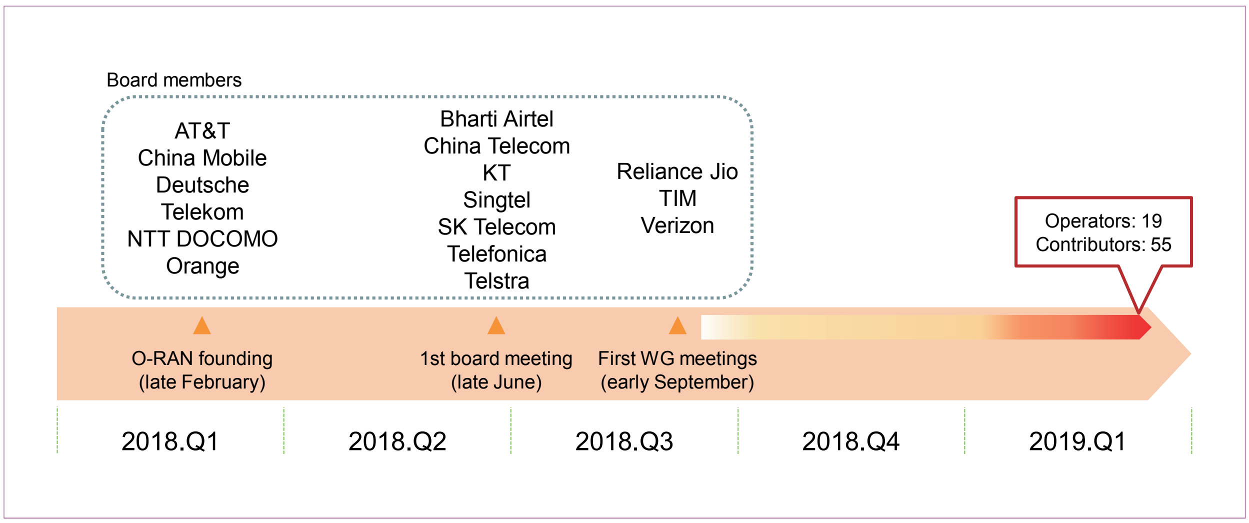


Figure 2 O-RAN Alliance development after founding

*4 **Machine learning:** A framework that enables a computer to learn useful judgment standards through statistical processing from sample data.

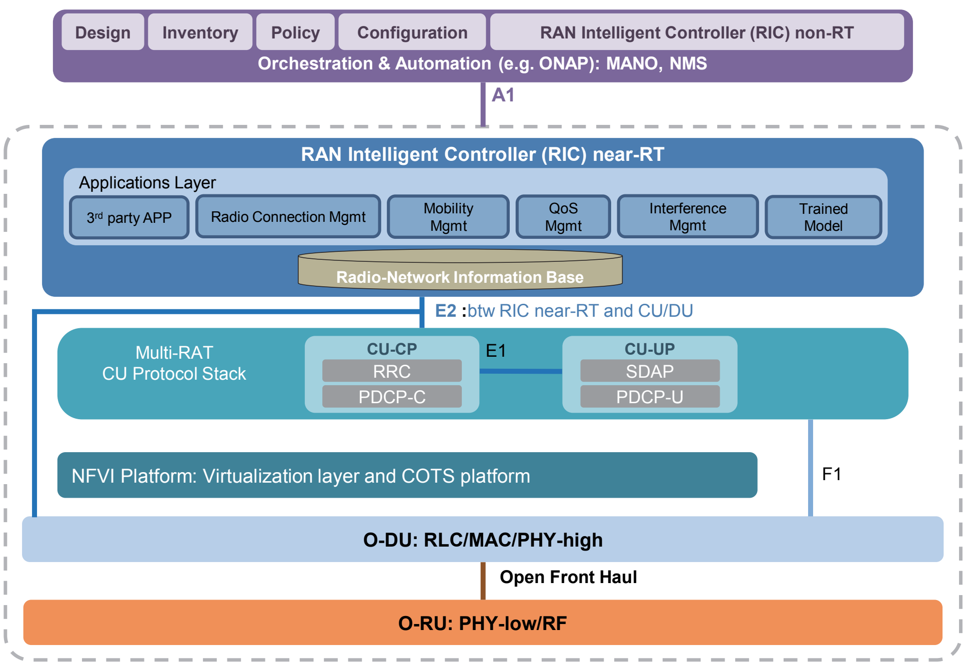
*5 **Ecosystem:** A symbiotic mechanism in which multiple enterprises collaborate in business activities making the most of each other's technologies and assets as part of a flow ranging from research and development to sales, advertising, and consumption encompassing even consumers and society.

2) Intelligent

The O-RAN Alliance expects that the network of the 5G era will become increasingly complex in order to support all kinds of applications, which should make it increasingly difficult to manage operations and achieve network optimization by traditional labor-intensive means. To solve this problem, autonomous and automatic network operations using machine learning are essential, and to this end, the O-RAN Alliance aims to leverage rapidly evolving deep learning*6 to make RAN intelligent and optimize the entire network. In addition, AI-optimized automation in combination with O-RAN open interfaces is expected to open up a new era in network operations.

3.2 Reference Architecture

On commencing activities, the O-RAN Alliance created reference architecture as a foundation for all future activities. The O-RAN Reference Architecture is shown in **Figure 3**. The following summarizes the components of this architecture.



Source: O-RAN Alliance

CP: Control Plane
MAC: Media Access Control
MANO: Management and Orchestration
NFVI: Network Functions Virtualisation Infrastructure
ONAP: Open Network Automation Platform
PDCP: Packet Data Convergence Protocol

PHY: PHYsical layer
RAT: Radio Access Technology
RF: Radio Frequency
RLC: Radio Link Control
RRC: Radio Resource Control
SDAP: Service Data Adaptation Protocol
UP: User Data Plane

Figure 3 O-RAN Alliance reference architecture

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*6 **Deep learning:** Machine learning using a neural network with a many-layer structure.

1) RAN Intelligent Controller (RIC)*7 non-Real Time (non-RT RIC)

The O-RAN Alliance defines the controller for the intelligent RAN as the RIC and divides it into non-RT (> 1s) and near-RT (< 1s) layers. The non-RT RIC performs policy management, RAN analytics, and AI-based function management. Here, the A1 interface is defined between the network management platform governing orchestration and automation including non-RT RIC and evolved NodeB (eNB)*8/gNB*9 including near-RT RIC.

2) RIC near-Real Time (near-RT RIC)

The near-RT RIC layer provides Radio Resource Management (RRM)*10 functions with embedded intelligence. In addition to legacy RRM functions such as load balancing*11 per unit of User Equipment (UE) and Resource Block (RB)*12 management, this layer will provide new functions such as Quality of Service (QoS)*13 management and seamless handover*14 control. As for interfaces, the A1 interface described above is defined between this layer and the non-RT RIC layer while the E2 interface is defined between this layer and the Central Unit (CU)*15/ O-RAN Distributed Unit (O-DU)*16.

3) Multi-RAT CU Protocol Stack

This function layer supports various protocol stacks including 4G and 5G multiple radio access. It supports virtualization and consists of functions that execute commands issued by the non-RT RIC. It also supports F1/W1/E1/X2/Xn interfaces specified by 3GPP.

4) O-DU and O-RAN Radio Unit (O-RU)*17

The O-DU and O-RU functions consist of real-time Layer 2 (L2)*18 functions and a function group performing baseband signal*19 processing and radio signal processing. Open fronthaul*20 interfaces are newly specified between O-DU and O-RU.

4. Focus Areas of O-RAN Alliance Workgroups

The O-RAN Alliance conducts technical studies to fulfill its vision in a total of eight Work Groups (WGs) each having a different focus area. The Technical Steering Committee (TSC) oversees the work of these WGs (**Table 1**).

These eight WGs can be broadly divided into WG1 for studying use cases and overall architecture, WG2 and WG3 for optimizing and automating (making intelligent) RAN RRM, WG4 and WG5 for achieving interoperability (open interfaces) between RAN equipment supplied by different vendors, and WG6, WG7, and WG8 for commoditizing (virtualizing and modularizing) the RAN software and hardware platform.

Each WG adopts a co-chair format consisting of three or four chairpersons selected from two operators and one or two vendors. NTT DOCOMO is serving as a co-chair of WG4 and WG5 focused on open interfaces. The following introduces the activities of these two WGs.

1) WG4 (Open Fronthaul Interfaces WG)

In C-RAN, a baseband processor is placed in an aggregating node and connected to multiple distributed nodes each with radio equipment*21 via fronthaul interfaces. Thanks to its performance and cost benefits, this configuration has been introduced in networks in many countries from the beginning of the LTE era and has similarly been adopted by NTT DOCOMO in its LTE network [2]. On the

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*7 RIC: The controller that makes the RAN intelligent.
*8 eNB: A radio base station for LTE radio access.
*9 gNB: A radio base station for NR radio access.
*10 RRM: A generic term applied to control functions for appropriately managing limited radio resources, making smooth connections between terminals and base stations, etc.
*11 Load balancing: The process of distributing load between frequencies or cells.
*12 RB: A unit of frequency to be allocated when scheduling radio resources.
*13 QoS: A level of quality on the network that can be set for each service. Controlling the bandwidth available to a service controls the amount of delay or packet loss in that service.
*14 Handover: The technique of switching from one cell to another without interrupting communication when a terminal moves between base stations.

Table 1 O-RAN Alliance technical workgroups

Technical WG		Focus area
TSC		Overall management
WG1	Use Cases and Overall Architecture	Use cases and overall architecture
WG2	Non-real-time RIC and A1 Interface	Non-Real-Time RAN Intelligent Controller (non-RT RIC) that supports optimization of radio higher-layer procedures in RAN and RAN policies from a management platform consisting of MANO, NMS, etc. supporting orchestration and automation, and the A1 interface between non-RT RIC and RAN
WG3	Near-real-time RIC and E2 Interface	Near-Real-Time RAN Intelligent Controller (near-RT RIC) that supports optimization of radio connection management, mobility management, QoS management, interference management, etc. making use of big data and machine learning, and the E2 interface between near-RT RIC and various RAN components
WG4*	Open Fronthaul Interface	Open fronthaul interfaces achieving interoperability between the baseband processor and radio equipment supplied by different vendors
WG5*	Open F1/W1/E1/X2/Xn Interface	Open interfaces achieving interoperability between different vendors, targeting in particular 3GPP-specified interfaces (F1, W1, E1, X2, Xn) between network equipment
WG6	Cloudification and Orchestration	Reference designs that enable the decoupling of RAN software from hardware platforms (virtualization) and the use of commodity hardware platforms
WG7	White-box Hardware	Hardware platform that combines commodity components and a reference design that enables that platform
WG8	Open Source	Provision of RAN software in open source form

* NTT DOCOMO co-chair

other hand, the Common Public Radio Interface (CPRI)*22 specifications widely used by commercial C-RAN in LTE is seen as insufficient in terms of specifying standards for fronthaul interfaces. This has resulted in many parts having original specifications by different vendors so that, on a global basis, it has only been possible to connect between a baseband processor and radio equipment from the same vendor [3].

To solve this problem, WG4 is releasing O-RAN fronthaul specifications [4] to enable interoperability and promoting multivendor interoperability using that interface. In actuality, the O-RAN fronthaul specifications inherited the xRAN fronthaul specifications created and released by the xRAN Forum prior to its integration in the O-RAN Alliance. NTT DOCOMO has made major contributions to the formulation of these fronthaul specifications based on its own experience in achieving multivendor interoperability via the fronthaul in collaboration with vendor partners in the LTE network.

2) WG5 (Open 3GPP Interface WG)

WG5 promotes activities with the aim of achieving multivendor interoperability and improving

*15 CU: An aggregating node equipped with non-real-time L2 functions and RRC functions, etc. of the radio base station.

*16 O-DU: A functional section performing real-time L2 functions, etc. of the radio base station.

*17 O-RU: The radio equipment of a radio base station specified in O-RAN.

*18 L2: The second layer of the OSI reference model (data link layer).

*19 Baseband signal: The digital signal before conversion to radio frequencies.

*20 Fronthaul: The circuit between radio equipment and the baseband processor of base-station equipment achieved by optical fiber, etc.

*21 Radio equipment: The equipment that connects with the baseband processor via the fronthaul.

performance targeting network equipment interfaces specified by 3GPP (F1 and E1 equipment interfaces within base stations (see Fig. 3), X2 interface between eNB and gNB, Xn interface between gNBs, etc.). These interfaces have been designed with a relatively high degree of freedom to cover every conceivable operation scenario and equipment implementation to the degree possible. This has enabled operators and vendors to achieve their original operations and implementations while resulting in degradation of connectivity and other performance issues (for example, temporary data interruptions and degraded user throughput) in multivendor deployment.

An example of such a problem in multivendor operation is shown in **Figure 4**. First, Fig. 4 (a) shows the case in which vendor-A and vendor-B implement a 3GPP interface with different interpretations of parameter (X) of the interface. As a result, the equipment behaves differently between vendors A and B, which can raise concerns that a problem may occur causing degradation of connectivity and other performance issues. Fig. 4 (b), on the other hand, shows the case in which vendors A and B implement parameter X with the same interpretation. In this case, both units of equipment perform the same operation with respect to this parameter thereby enabling connectivity and performance to be maintained even in a multivendor scenario.

In this way, WG5 is working to clarify the interpretation of parameters specified by 3GPP and the expected behavior of equipment with the aim of achieving a multivendor environment with any combination of vendor equipment.

5. Conclusion

This article explained the background to the founding of the O-RAN Alliance, its vision and reference architecture, and the focus areas of each workgroup. The O-RAN Alliance is drawing much interest and expectation and currently includes

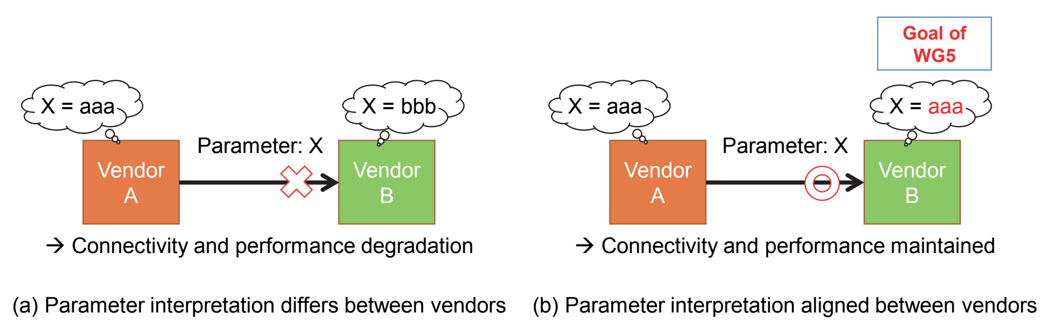

Figure 4 Problem in multivendor operation

*22 CPRI: Internal interface specification for radio base stations. CPRI is also the industry association regulating the specification.

many global operators and vendors as members. The O-RAN Alliance vision of "achieving open and intelligent RAN" reflects a commitment to developing radio access networks in the 5G era and expanding the ecosystem. Going forward, NTT DOCOMO will continue to promote and participate in O-RAN activities as part of this vision.

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