NEC's Technological Developments and Solutions for Open Networks

Amidst the rapid changes in the social and technological landscape surrounding information and communication networks, NEC is promoting open innovation of networks to adapt to these trends. The latest networks, exemplified by 5G (fifth-generation mobile communication system), are generally composed of the RAN, transport, and core network domains as well as cross-domain management and value-added services. This special issue introduces the overall picture as well as NEC's efforts and solution examples towards the open innovation in each domain and layer.

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1. Introduction

Networks serve as a means for connecting people and things to enable communication and data sharing. Throughout the course of history, from the era of analog telephony onward, concerted efforts have been made to establish open and standardized communication interfaces to facilitate connections across different telecommunication carriers and countries. As network technology advanced and became more complex, particularly with the advent of mobile data networks, the construction of entire network systems have often relied on the expertise of specific vendors, resulting in the use of non-open proprietary technologies. However, in the era of 5G and Internet of Things (IoT) which aims to connect every person, thing, and event, there is a growing need to efficiently provide diverse network services tailored to different purposes on a standardized network system. To address this evolving trend, the adoption of an open architecture for networks is being contemplated that would allow for greater flexibility in meeting diverse needs and facilitating seamless connectivity across a variety of networks and services.

For over a decade, NEC has been leading the way in promoting open innovation and placing a dedicated focus on technological advancements in this field. Starting with our efforts to separate functions of core networks and promote open interfaces, we have recently taken an active role in advancing the openness of radio networks and optical transmission systems as well. Concurrently, NEC is committed to contributing to carbon-neutral goals by curbing energy consumption associated with network operations. NEC's dedication to open networks extends across a wide variety of technological fields, network domains, and network utilization solutions. In this special issue, we present initiatives that are representative of and highlight our ongoing efforts in this regard (**Fig.**).

2. Open RAN and Supporting Virtualization Technologies

One of the most notable trends in the field of open network technologies is the opening up of the radio access network (RAN), which is commonly known as Open RAN. Open RAN involves disaggregating the RAN stack into functional units and creating open interfaces between

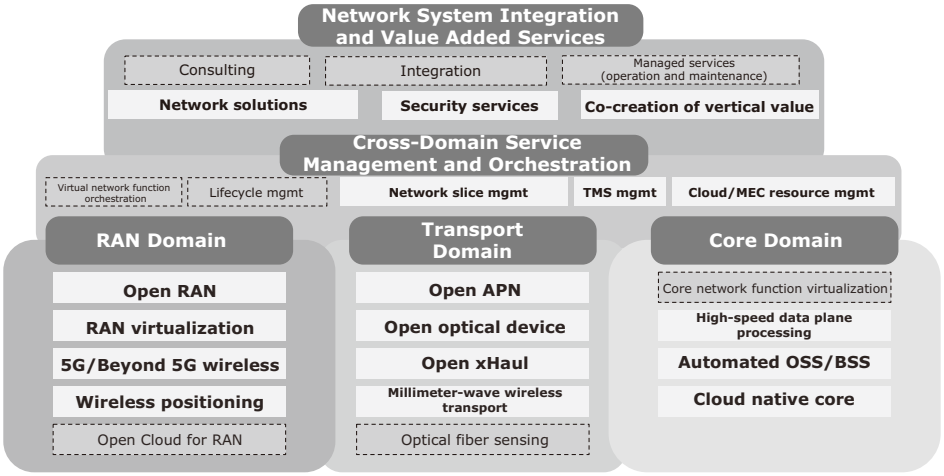

Fig. Representative technological assets and value provided through the NEC Open Networks.

them. In the 5G era, instead of a single vendor constructing the entire RAN system, Open RAN enables the combination of functional units and superior components offered by multiple vendors. This approach allows for the creation of an optimal system tailored to the specific requirements of network utilization. NEC is actively involved in forging partnerships through Open RAN to build a robust ecosystem and propel innovation forward.

The innovations brought by Open RAN transcend the 5G era and continue to evolve into the realms of Beyond 5G and 6G. As services connecting people, things, and events become more advanced, the number of network accesses and communication traffic will significantly increase. Consequently, the functions and performance requirements of RAN systems will diversify to accommodate the unique characteristics of these services. Virtualization technology is anticipated to be the solution to these challenges. Widely adopted in the IT system field, virtualization technology separates software and hardware components of a system and implements the software on general-purpose computers wherever possible. Open RAN incorporates this virtualization technology (vRAN) to optimize system operations. This special issue introduces NEC's approach to Open RAN and presents examples of vRAN to optimize Open RAN operations.

3. Wireless Technologies for 5G/Beyond 5G

The advancement of 5G services, enabling ultra-high-speed and high-capacity-connections, is set to bring about a significant increase in both accesses and traffic. In order to achieve the carbon neutrality objectives associated with the utilization of 5G, it becomes crucial to address the issue of mitigating energy consumption. NEC recognizes the significance of incorporating advanced 5G hardware and optimal control technologies to tackle this challenge. This paper focuses on wireless technologies and outlines the configuration of a radio base station system based on the Open RAN specifications. It emphasizes the efforts made toward energy conservation through optimized system control. Furthermore, considering the ability of 5G and Beyond 5G wireless communications to utilize ultra-high frequencies, including millimeter waves, we also provide an overview of cutting-edge wireless technology developments for such frequencies. This special issue presents several representative technologies in this domain.

4. Initiatives in Open APN (Open Optical/All Photonics)

The concept of open networks that was popularized by the Open RAN initiative, has now expanded to the realm of optical transmission, which serves as the backbone of networks. Telecom Infra Project (TIP), an organization comprised of leading global IT service providers, is exploring the idea of using open standards in its Open Optical & Packet Transport (OOPT) project to disaggregate functions within the optical transmission system and to create open interfaces between components. The Open ROADM MSA is another initiative that promotes open innovation by defining interoperability specifications for optical devices used for transmitting data while also considering optical conditions. NEC actively participates in these initiatives and contributes to promoting open optical networks.

Besides openness, all-photonics networks (APN) is also a crucial aspect of optical transmission systems.

Typically, optical signals are converted into electrical signals to suppress interference distortion at multiplexing for high-speed transmission. However, this extra step can lead to unnecessary processing delays and energy consumption. The development of APN technology, which transmits optical signals directly throughout the entire optical transmission section, including multiplex modulation, can help to address these challenges and achieve low-latency and energy-efficient optical communication. The IOWN Global Forum, an international collaborative organization, initiated the investigation of this open APN. In this special issue, we showcase NEC's efforts towards developing the APN technology.

5. Initiatives in Core & Value Networks

To encourage greater network openness, one initiative involves the disaggregation of the data plane (DP) that handles the actual data transfers and the control plane (CP) that controls how data is transferred, followed by the virtualization of the network functions that comprise both planes. This approach will facilitate the realization of value networks where diverse values can be achieved through network interactions.

For example, network slicing involves connecting a diversity of network resources based on the requirements of each service and it is expected to provide a simultaneous and stable delivery of a variety of services on a shared network. It will also allow for the flexible combination of low-latency edge server resources with high-precision cloud server resources. Furthermore, by utilizing virtualized IT resources offered by public cloud providers for network construction, it is possible to respond to the needs of users who want to use network services quickly and easily. This special issue highlights NEC's efforts in these areas and introduces energy-saving technologies for managing the rapid increase in data plane traffic.

6. Enhancing Network Services through Initiatives in Autonomous Networks and Security

The evolution of open and virtualized network has allowed for the delivery of more sophisticated services, but at the same time, network configurations are becoming increasingly complex. This presents challenges in maintaining safety, security, and efficiency of open networks. NEC develops advanced technologies that can automate the entire process from network construction to operation, maintenance, and management so that these issues can be efficiently addressed. NEC is also working on technologies to increase the transparency in the security of open networks and their constituent devices as well as strengthening supply chain management to ensure the safe use of open networks.

7. Network Utilization Solutions and Supporting Technologies

Due to features such as high speed, low latency, and multiple connections, 5G is expected to be widely used in mission-critical environments such as automated manufacturing plants, construction sites, and advanced mobility services. However, to meet the demanding requirements of 5G applications — including high-precision location information, optimized traffic characteristics, stable connections, and minimal latency — advanced technologies are required. In this special issue, we will introduce examples of typical network utilization solutions and the supporting technologies that enable the successful deployment of 5G services in harsh usage environments.

8. Global 5G xHaul Transport Solutions

This special issue introduces the NEC xHaul network solution suite, which has been successfully deployed in global markets, and the advanced technologies that support this solution. The xHaul pertains to the transport domain that links the radio access network (RAN) to the core network. In the Open RAN architecture, RAN functions are disaggregated into radio units (RUs), distributed units (DUs), and central units (CUs). As part of xHaul, the backhaul connects the core network to the DUs and CUs, whereas the fronthaul connects the CUs and DUs to the RUs. Both of these network domains require ultra-high-speed, high-capacity transmissions, which are commonly achieved through optical or millimeter-wave technology. NEC's xHaul solutions are widely adopted to link remote sites with high-speed communications. These remote sites often face a shortage of human resources with the required expertise to set up, operate, maintain, and manage telecommunications infrastructure. NEC is also developing technology to automate the entire process from xHaul system setup to service operation, making it significantly easier to implement and use.

9. Toward Beyond 5G/6G

In conclusion, this special issue provides an overview of NEC's vision and initiatives for future networks. We are also continuously working to strengthen our lineup of open network technologies — some of which could

not be covered in this issue. To keep our customers and stakeholders informed, we will continue to introduce new initiatives through NEC press releases and exhibitions, so stay tuned for more updates.

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