Future Network Technologies for the 5G/IoT Era

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Abstract

The social environment is changing rapidly, and with these changes, society is coming to have great expectations for the future network. NTT is researching and developing technologies for achieving a flexible and smart network as a new social infrastructure that will be able to meet a wide variety of needs. This article describes the direction of research and development at NTT with an eye to 2020 and beyond centered on the three pillars of 5G/IoT (fifth-generation mobile communications/Internet of Things), Network-AI (NTT's artificial intelligence applied to networks), and open source software, while providing an overview of activities done in collaboration with NTT Group companies.

Keywords: 5G/IoT, Network-AI, OSS

1. Environmental changes and social issues surrounding the network

The social environment and structure are changing against a background of technical innovations and paradigm shifts in many fields. The field of information and communication technology (ICT) is no exception. Numerous social problems and issues in business operations are occurring due to external factors such as globalization, a decline in the working-age population, climate variability, natural disasters, and internal factors originating within the network such as digitization, the explosive growth in Internet traffic, and cyberattacks. Despite these issues, the ICT industry is rapidly entering an era highlighted by the convergence of communications and information thanks to the Internet and by co-creation driven by mobile communications and cloud computing. In response to these changes, NTT has defined a business-to-business-to-X (B2B2X) model, and with an eye to new business and market formats, it has undertaken the research and development (R&D) of technologies to support changes in the business models of service providers and changes in lifestyle brought on by subsequent creation of new value.

In this era of change, we consider fifth-generation mobile communications and Internet of Things (5G/IoT) and artificial intelligence applied to networks (Network-AI) to be key underlying technologies for achieving a smart and flexible network to meet the diverse demands of society and to solve the social and business issues surrounding the network. Additionally, as part of this flow, we are studying open source software (OSS) for use as the core technology in the transformation of network system development at NTT. We therefore treat these three technologies as pillars of R&D targeting the NTT network system. In this article, we describe how each of these three key technologies relates to the NTT network, and we touch on future challenges.

2. Future network architecture toward the 5G/IoT era

In anticipation of the arrival of the 5G/IoT and B2B2X era, NTT aims to contribute to new services and value creation by providing many and varied functions desired by diverse service providers in diverse industries in a simple and speedy manner [1].

Here, the virtualization of network functions (softwarization) is an underlying technology to be implemented in the next-generation network. In recent years, the R&D of virtualization technologies, namely, network functions virtualization and software-defined networking, has been progressing along with the standardization of interfaces between segmented functions. A network or computing resource that has been virtually constructed on a physical resource or device is called a *network slice*. To achieve such slices as part of a telecommunications carrier's network, the NTT laboratories have undertaken R&D of slice-management and slice-isolation technologies [2].

In the future, the access network, which serves as the customer's gate to services, will provide higher speeds and capacities, guaranteed and optimal end-to-end quality, and flexible placement of functions (including softwarization). The aim here is to provide high-value-added services and enable new lifestyles by giving the access facilities supporting the access network smart design, maintenance, and operation capabilities [3].

3. Advanced and smart network operation through AI technologies

In May 2016, the NTT Group unified its AI-related technologies and some initiatives using those technologies under the brand name corevo® [4]. The AI technologies that make up corevo are classified into Agent-AI, Heart-Touching-AI, Ambient-AI, and Network-AI. In the following, we report on Network-AI technologies.

In an environment of diversified ICT services driven by various changes happening in society (e.g., a decline in the working population) and expansion of the B2B2X business model, the technical development of AI for networks (Network-AI) is progressing with the aim of making network operation more efficient and providing greater value [5]. The business areas deemed favorable to the application of Network-AI and issues surrounding its practical use have been clarified based on a series of technical developments and field trials.

The NTT laboratories have selected two business areas for further R&D of Network-AI applications. The first area is the use of AI to achieve automated and skill-less processes. In this area, the target is to find cause-and-effect relationships (rules and logic) using AI. The second area is the use of AI to provide human assistance. The target here is to uncover abnormal trends in a process from massive amounts of log data by using deep learning or other techniques to give the operator of that process an enhanced sense of awareness.

An example of the former would be using AI to infer cause-and-effect in the occurrence of alarms and failures or to visualize work traditionally performed by people and to formulate rules with respect to that work. This would be accomplished by using machine learning to analyze documents that freely record behavior when responding to a failure and visualizing the procedures taken in response to a problem (implicit knowledge) as workflow. The goal here is to raise efficiency by having AI do the work that people have been doing up to now. An example of the latter would be using AI in failure judgment and proactive (design and) operation that up to now has been based on threshold values. In particular, AI would be used to spot the seeds of an abnormal occurrence that a human operator has not been capable of noticing and to then predict future behavior and provide feedback to the operator.

To achieve practical use of Network-AI, it is becoming clear that (1) correct answers (correct decisions) must be continuously learned, (2) the decision-making process is a black box unknown to people, and (3) 100% correct answers cannot be derived. Here, a mechanism that uses AI while continuously learning is necessary, and since 100% accuracy in detecting signs of a failure cannot be guaranteed, there is a need for an operation that uses AI output skillfully, taking this limitation into account. At the time of its introduction, AI will not be adept at all business tasks but will be more like an entry-level employee that has to learn and develop just like the rest of us. However, a day will come when this *entry-level employee* starts to provide human employees with assistance.

To resolve these issues surrounding the practical use of AI, the plan is to further accelerate trials using actual data (set up learning environments) and to promote a revolution in work style making good use of AI-based support tools toward advanced and smart network operation.

4. An open and community-based development of network system

The types of participants in the ICT product market including communications equipment is diversifying thanks to the growing influence of OTT (over-the-top) operators, the use of ICT products in the communications industry, the increasing percentage of communication functions and services provided by software, and the standardization of procurement specifications by industry groups. At the same time, the movement promoting the use of OSS is growing in the network and network-management area while continuing in the cloud area, and the network-related OSS community continues to expand.

In response to these changes, the NTT laboratories are working to transform their network system development techniques. While the future network system will be based on the *right product in the right place* principle that places demands on business and service needs, the use of OSS and white box-type hardware is expected to increase even further. The NTT laboratories will explore network system development techniques using the wisdom of the open community and will become actively involved in community activities while leveraging the technological competence and know-how of a telecommunications carrier [6]. In this way, we hope to reduce development investment costs and to heighten corporate value through dissemination of our technical capabilities.

From the perspective of those who advocate using an open network system, the problem arises as to who takes responsibility for handling frequent version upgrades and fatal security holes that become evident in OSS operation. To deal with this problem, the entire NTT Group and global players, including both developers and operators, need to create and enhance OSS products and raise the skills of personnel who use OSS on an ongoing basis. This effort will proceed in collaboration with NTT Group companies.

Another issue of a medium- and long-term nature is the building of collaborative and co-creative relationships with commercial vendors that have many and varied products. Far from becoming fixed on only the open community, the NTT laboratories seek to establish a scheme of applying the knowledge and techniques obtained through OSS to commercial products in cooperation with diverse vendors. In this way, we aim to reduce investment costs and operating expenses and improve service quality through the use of commercial products [7, 8].

5. Challenges for 2020 and beyond

In the world of 2020 and beyond, where cyberspace and physical space converge, the information and communication network will come to support mission-critical social infrastructures. One example of such an infrastructure is connected cars. There is also no doubt that information and communication networks will support high-definition video transmission, remote medicine, and other functions and will become increasingly important as new social infrastructures. Becoming a social infrastructure requires that the quality, reliability, fault resilience, neutrality, and security demanded by society be satisfied.

Amid these changes, we can expect an exponential increase in digital service traffic. The nature of traffic is also bound to change. For example, we can expect an increase in geographically restricted traffic and inter-device traffic as in IoT. NTT is working to solve these problems by developing technologies for increasing the capacity of the optical access and core networks, controlling quality and traffic on a software-implemented network, and dealing with local traffic. Multi-access edge computing (MEC) is one such promising technology. There are growing expectations that MEC will enable distributed placement of optimal functions by bringing the network even closer to devices and enabling diverse forms of access. To this end, the technical development of MEC is progressing.

Going forward, the NTT Group plans to use network, AI, IoT, and security technologies and promote open collaboration with diverse industries with the aim of solving social problems, increasing industrial value and competitiveness, and creating a more secure and enriching society.

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