Open Innovation and Demonstrations of Communication Equipment Interoperability

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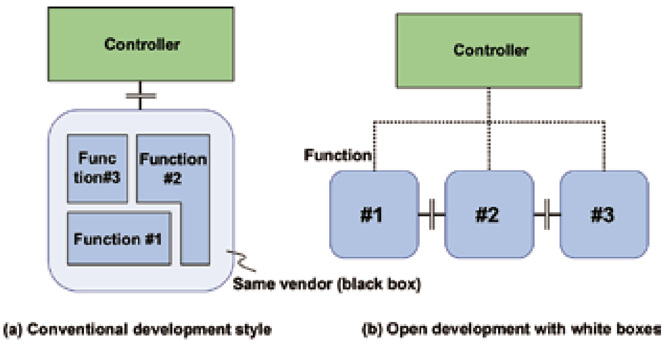
1. Introduction

Why is the importance of demonstrating interoperability between communication equipment increasing? The background to this question lies in white box development that provides specialized technology in the form of building blocks to speed up development as system and network functions become increasingly advanced and complex. Since this involves deciding on and developing interfaces, interoperability must be ensured, so it can be said that the interoperability of such interfaces is more important than the specifications written on paper. "Interoperability" means checking specifications, showing their feasibility, and establishing an overall concept, and going further, having communication carriers gather together communication equipment vendors and conducting demonstration experiments targeting actual operation. Here, it would be difficult if vendors were to independently gather together to verify interoperability since know-how leaks could occur, so historically speaking, the approach has been to establish consortiums centered about universities or other institutions with the aim of securing demonstration sites. In Japan too, as presented in this special issue, ShowNet of Interop Tokyo is a typical communication-equipment interoperability demonstration experiment, and the Keihanna Info-Communication Open Laboratory of the National Institute of Information and Communications Technology (NICT), which promotes interoperability focusing on optical technology, is steadily exchanging know-how. This article describes open innovation and interoperability demonstrations and reports on future network and system development styles.

2. What is open development?

Change in the style of developing communication equipment is shown in Figure 1. As shown in Figure 1(a), the conventional style was to accumulate extensive know-how within a single vendor and develop all functions likewise by a single vendor, which meant that internal details and interfaces would be developed in a black-box manner. This method simplified and accelerated fault isolation and recovery at the time of a network problem. It also clarified responsibility in terms of quality guarantees and made operation easy by essentially leaving it up to a single vendor. Under this method, communication carriers configured "vendor islands" that form communication networks with single-vendor equipment and promoted interoperability demonstrations along with the standardization of the physical and control interfaces between those vendor islands. In the Automatically Switched Optical Network (ITU-T ASON) era of about 20 years ago, the Optical Internetworking Forum (OIF) and the Keihanna Info-Communication Open Laboratory conducted interoperability demonstrations on a global scale as Generalized Multi-Protocol Label Switching (GMPLS). However, with a system becoming ever larger in scale and increasingly complex, all development by a single vendor meant that specialized and non-specialized functions would be mixed, which would prevent the adoption of any superior functions even if another vendor had already developed them. In response to this drawback, the development style has been changing to one that modularizes the interior of the black box in a function-by-function manner, precisely determines inter-module interfaces, and promotes the free development of each module as a white box in an open environment as shown in Figure 1(b). This evolution permits partial entry into the market and encourages competition and collaboration. However, the conventional black box made it easy to optimize performance, and it was thought that the white-box format would make it difficult to optimize the entire system even if individual functions could be optimized. In particular, it was considered that a system in which physical performance easily affects the performance of the entire system would have many problems with the white-box format making it difficult to adopt such a development style. In recent years, though, the Open Radio Access Network (O-RAN) of the 5G radio base station system and the Open Reconfigurable Optical Add-Drop Multiplexer (Open ROADM) of the optical transmission network system, for example, have been changing to open development even for

Figure 1: Change in communication-equipment development style



super-advanced technology for which physical performance is important. At the same time, increasing the flexibility of each function through software has been evolving and the possibility of extracting optimal combinations of functions has been verified through interoperability tests.

For vendors, this flow toward open development means a reduction in competitive costs while also making it easy to enter the market with only some function modules, to enter a market composed of several carriers, or to even enter a global market. In the case of RAN, for example, Radio Unit (RU) equipment is a strong point of Japanese companies, and in the case of optical networks, many companies around the world are adopting high-speed transporters increasing the possibility that they will come into practical use.

3. Consortium-based activities

As described above, standardization is, of course, essential to dealing with open development, and equally important are early discussions and demonstrations with other vendors and carriers centered about diverse consortiums. We, as well, have cooperated with ISOCORE (sponsored by George Mason University) based in Washington D.C. in the United States for more than 20 years and have mainly conducted demonstrations of standard interfaces for Multi-Protocol Label Switching-Transport Profile (MPLS/MPLS-TP) and GMPLS at the Internet Engineering Task Force (IETF). These activities provided us with excellent opportunities to understand specifications not shown in standardization documents and to grasp real development trends and strategies around the world including those of other companies.

This special issue introduces the results of the Interop Tokyo ShowNet demonstration that has been extremely effective over many years and the results of the iPOP2024 international conference that mainly performs public experiments on the interoperability of optical technologies (including the Innovative Optical and Wireless Network (IOWN)). The Keihanna Info-Communication Open Laboratory, Photonic Internet Lab, etc. are the mother bodies of these iPOP consortium activities.

4. Keio Future Photonic Network Open Lab

Before conducting interoperability demonstrations, it is important to construct an environment in which multiple communication-equipment vendors, communication carriers, and academia can exchange technologies, global technology trends can be grasped, and experiments and discussions can be held in an open format. At Keio University, with the support of the "Research and Development of Advanced Optical Transmission Technology for Green Society (JPMI00316)" project of the Ministry of Internal Affairs and Communications, the Keio Future Photonic Network Open Lab opened in April 2023 to accelerate such open innovation (Figure 2). It was on the campus of the Open Lab that hollow-core fiber (in which the optical core consists of air) was laid for the first time in the world. Making free use of this fiber, the research of breakthrough technologies is being conducted through the collaboration and cooperation of communication carriers, equipment vendors, and academia.

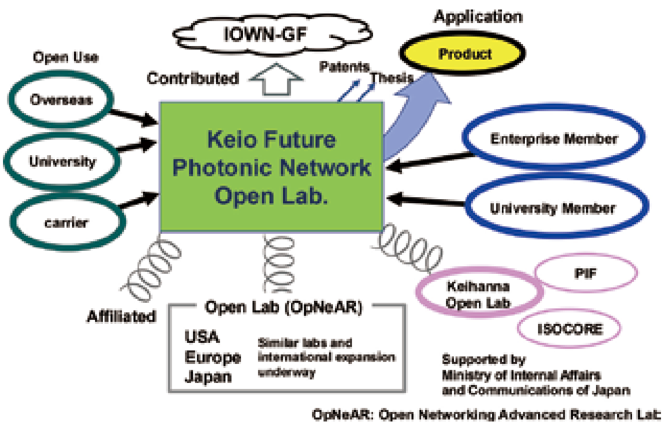
Examples of research topics at Keio Future Photonic Network Open Lab are given below.

(1) Research of Power over Fiber (PWoF): Hollow-core fiber, whose damage resistance is 1,000 times higher than existing optical fiber (since the core consists of air), can transmit energy simultaneously while maintaining the communication broadband performance of optical fiber.

(2) Research of analog Radio over Fiber (RoF): Due to an air core, linearity is high and signal distortion due to nonlinear effects is nearly nonexistent. As a result, studies are being performed on future beam extension of millimeter waves, etc. combined with PWoF and on the wraparound of radio signals by optical fiber instead of metasurfaces.

(3) Research of super-multi-wavelength, low-latency communications: In an era of one wavelength per person, there will be no need for multiplexing the signal along the time axis (a single wavelength bandwidth for high-speed use will be occupied even at low speeds). It will be possible to change the wavelength bandwidth as desired and to achieve a network with no multiplexing delay. Also being researched are networks using the large amount of energy entering optical fiber and networks using new functional fiber that is expected to ease the bandwidth limitation of light.

Figure 2: Structure of the Keio Future Photonic Network Open Lab



5. Conclusion

This article described the importance of interoperability accompanied by open innovation and network open development, research collaboration based on consortiums, and means of cooperation. Looking to the future, consortium-based research involving mutual collaboration and cooperation in contrast to single-company research will become increasingly important as will activities that provide viewpoints from third parties such as academia, NICT, and the WIDE Project.