R&D Spirits

The GE-PON System as a Means to Achieve Competitive Superiority in the World FTTH Market

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NTT Access Network Service Systems Laboratories has developed a GE-PON (gigabit Ethernet-passive optical network) that conforms to the IEEE 802.3ah standard approved in June 2004. This technology will reduce the expense of the FTTH (fiber to the home) access system and encourage its widespread adoption. We asked Yukihiro Fujimoto, a Senior Research Engineer in NTT who is involved in GE-PON development and standardization activities, about future use of this technology and about international development and technological applications.

Using LAN Ethernet technology for a more economical access system

—Could you tell us about the research that is currently in progress?

The access network is my current research topic. As a research topic, the access network covers a very wide variety of things, ranging from equipment such as metallic and optical telephone lines and optical network units (ONUs) to access system construction methods and network design (**Fig. 1**). Of those, my research mainly concerns the application of the Ethernet technology that is generally used in local area network (LAN) systems to optical fiber access systems.

—What are the objectives of this research? What can be implemented with it?

Ethernet is currently used in the LAN interface of all personal computers. It is capable of data transfer speeds ranging from 10 Mbit/s to 10 Gbit/s and the hardware of Ethernet systems is dramatically lower in cost than that of conventional telecom carrier system equipment. Thus, cost was the first motivation for this research into applying Ethernet technology to the access system.

Another objective is to replace so-called legacy systems. In this context, a legacy system is an old system from the era in which a carrier's only business was telephony. Equipment from 20–30 years ago is still in use, though spare parts may no longer be available. Of course, future replacement with a FTTH (fiber to the home) access system is likely, but customer decisions are also involved, so total replacement within the next 10 years is unlikely. Therefore, replacing failing legacy systems by Ethernet technology is one path toward effective future use of facilities. This affects all carriers, not just NTT, so it is a simple but important mission.

—What are the main technical points of the research?

The key technical problem is how Ethernet, which is a LAN technology, can best be incorporated into a carrier-grade network system. What makes this difficult is that Ethernet was originally an enterprise-centric technology and used mostly within a company, so

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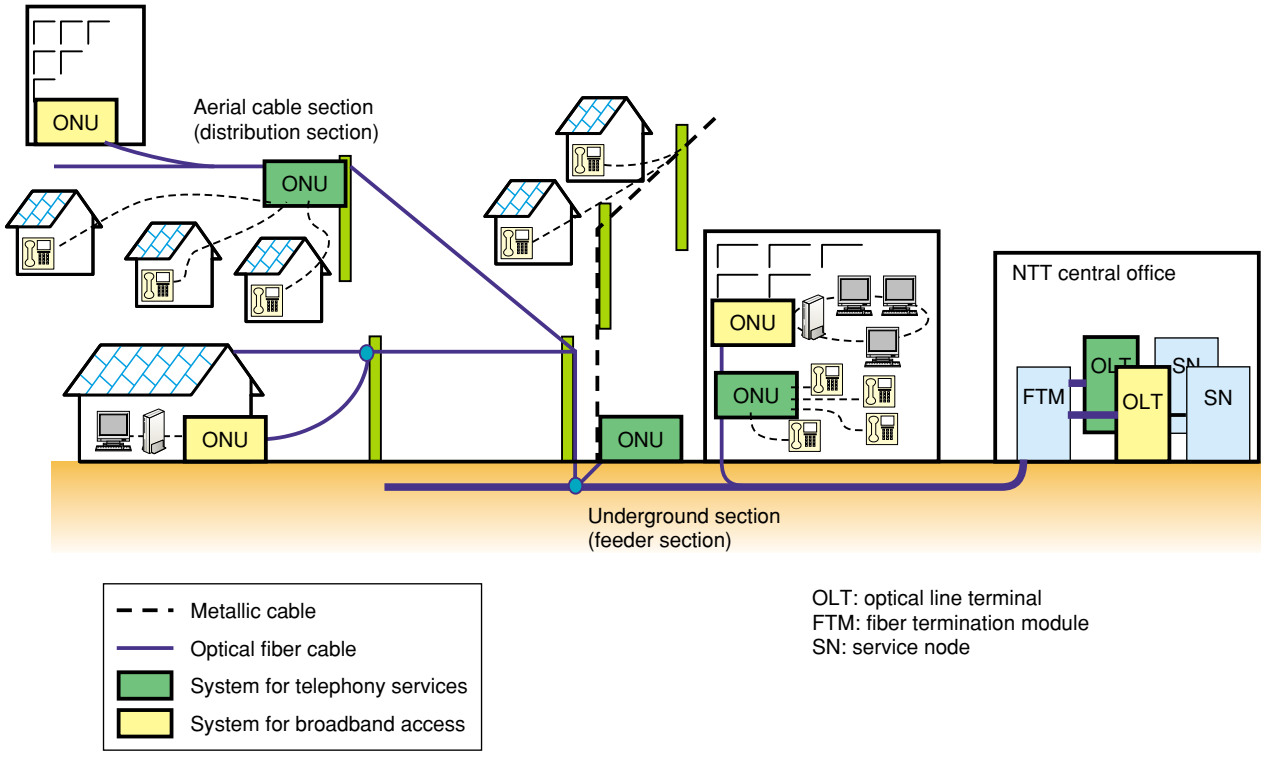

Fig. 1. Fiber optic access network system.

many of the functions are inadequate for use in a carrier's network. The most obvious examples are the lack of operation, administration, and maintenance (OAM) functions. To use this technology in a public network without supplementing such functions would be a fatal mistake. However, to make the system economical, we must decide between simplicity on the one hand and the functionality required for a public network on the other. Making the best choices in that respect so as to achieve a well-balanced system is the biggest issue for this research.

—What is the current state of development?

At present, an FTTH access system that applies GE-PON (gigabit Ethernet-passive optical network), a media converter (ONU), and other Ethernet technology is being used in NTT's B FLET'S service (**Fig. 2**). In particular, GE-PON, which allows the Ethernet frames generally used in LAN systems to be sent and received without any modification, is expanding by millions of lines per year. Concerning the standardization activities that we have participated in from the beginning, the IEEE 802.3ah standard was approved in June 2004. While that was a departure from work on the FTTH access system, from now on, I will continue with a serious study of legacy systems. I am pursuing the application of Ethernet technology to these systems and the development of economical telephony services, while keeping the current service level.

Attraction of GE-PON to carriers in Asian countries

—Could you tell us about international trends related to this research?

To date, NTT is alone in having introduced GE-PON to the extent of several million lines. However, seeing the expansion of economical FTTH in Japan, carriers in other Asian countries are following this lead. The approach in Europe and North America, on the other hand, is somewhat different. While our FTTH service provides all types of data on the same platform, different protocols are used for telephony, video, and the Internet in Europe and North America, in a scheme known as "triple-play". Consequently, the specifications for systems based on ATM (asynchronous transfer mode) such as B-PON (broadband-

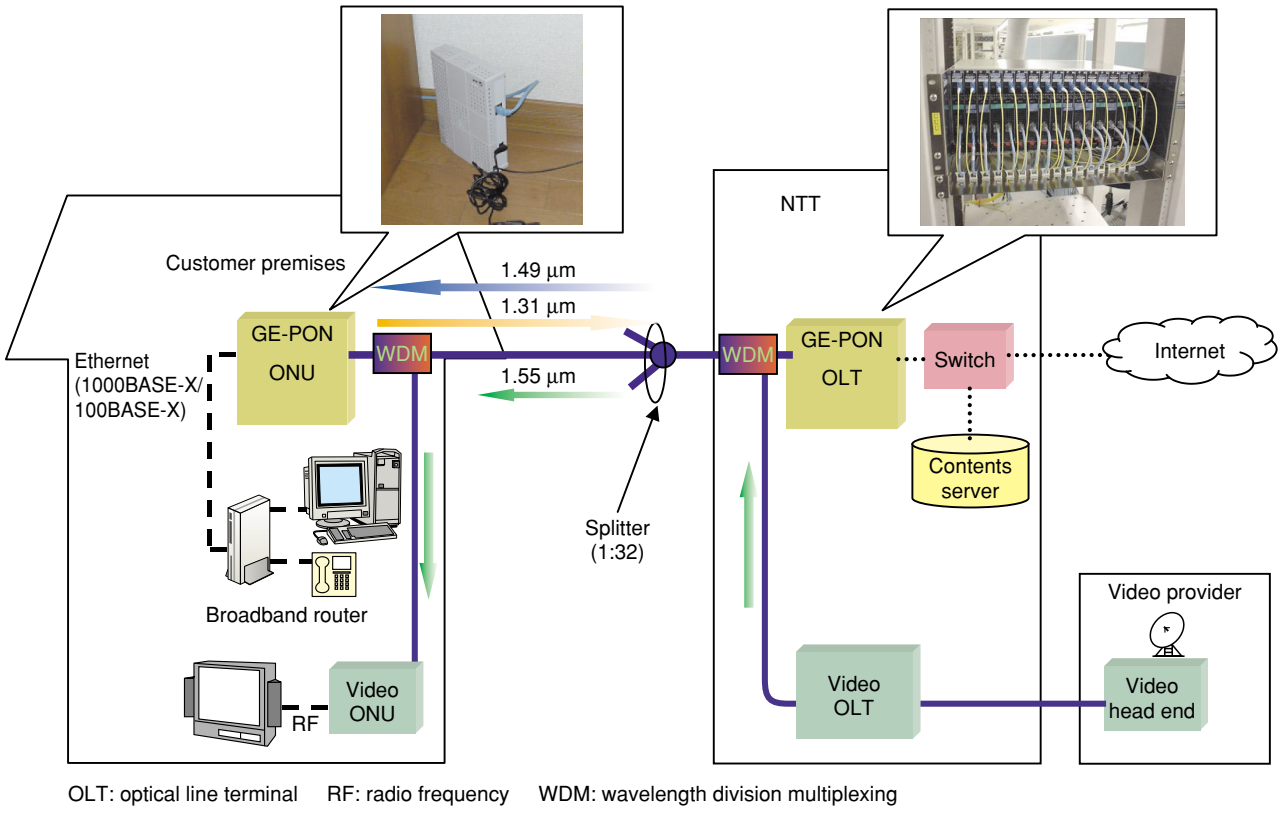

Fig. 2. GE-PON system with multi-channel video overlay.

PON) and G-PON (gigabit-PON), which is a faster version of B-PON, are being formulated by ITU-T (International Telecommunication Union Telecommunication Sector). However, the economical advantages of GE-PON are being recognized in Europe and North America, too, so I think the development of NTT's FTTH is attracting attention there as well.

Although IEEE 802.3ah is now finished, there are still areas that it does not cover. In particular, there is a question of whether it would be good to have specifications for the maintenance and administration functions that are unified to some extent. There is a growing movement to transfer these activities from IEEE to ITU-T. NTT is also participating in that, even though we are a different group.

—Are any international collaboration efforts in progress?

No formal collaborative research has begun yet, but we are already engaged in loose cooperative activities with carriers in Taiwan and Korea that include exchanging visits and information several times a year. GE-PON is attracting the attention of carriers in Taiwan, Korea, and other countries in Asia. Since many countries in Asia have the technology to build systems on their own, we would like to actively support to those carriers.

—How do you feel NTT is regarded in international standardization activities?

At the onset of standardization efforts, the participants were mostly LAN system vendors and venture businesses. We were the only company with experience in actual development of PON and FTTH. It was therefore inevitable that we took on a leadership role in identifying the requirements for applying Ethernet technology in the access network. However, the LAN vendors, as might be expected, wanted to avoid the excessively high system cost associated with implementing sophisticated requirements. There was thus some conflict between our posture regarding investigating service provisioning and their posture regarding investigating greater economy. We had rather intense discussions in weekly teleconferences, but

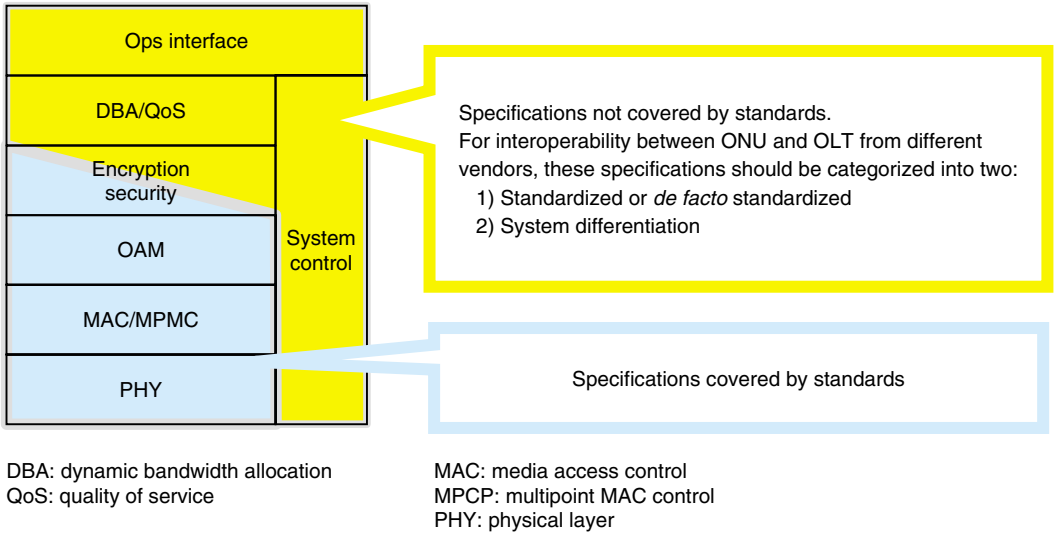

Fig. 3. GE-PON system function layer.

basically our view was held in high regard.

—What problems might there be in future for international expansion?

One reason we have for actively supporting the carriers of other countries with GE-PON is the economy of scale and technological progress that come with mass implementation. The Japanese market scale is about 50 million, which is not at all small. Nevertheless, if we limit our market to Japan, then that is where development of this system will probably end. We believe that GE-PON is an excellent technology, so we want to avoid limiting its use to NTT alone. We think that, for systems such as GE-PON, the old way in which the system is constructed by system vendors selected only on the basis of the carrier's technology will not work. Actually, Ethernet is a technology for which openness is very advanced, and there are many companies throughout the world that manufacture components and equipment for it. It therefore is not something that we could control even if we had a mind to. In such a situation, the support for carriers in other countries is accompanied by an important risk. Accordingly, even if the technology is driven by standard specifications, I believe that in the future product differentiation in which control is achieved through proprietary technology will be important (**Fig. 3**).

R&D efforts under the major theme of FTTH

—What is your scholastic background?

As a graduate student, my major study was urban planning in the graduate course on construction in the Department of Environmental Science. My specific research area was the simulation of urban fires after earthquakes. I created evaluation simulators for determining where to focus firefighting efforts when fires break out and how to construct cities so as to reduce the likelihood of disastrous fires as much as possible. My current direction has changed a good deal, and you probably wonder why I joined NTT Laboratories. There is some overlap in the study of network wiring methods and urban planning, so I personally don't feel that research on the NTT access network is so great a departure from my background.

—What research have you been involved in at NTT Laboratories so far?

From 1990 to 1993, right after joining NTT's Communication Network Technology Division, I worked on the transition to an optical subscriber network, investigating mainly the viewpoint and order for an economical transition from existing metallic lines to FTTH. In 1994, I was transferred to the User System Division and worked on the development of optical fiber laying methods and the development of practical optical fiber cable and other wiring products.

Then, in 1997-98, I spent a year as a guest researcher at Lucent Technologies Bell Labs in the Netherlands. At that time, Lucent was one of the system hardware vendors for the STM-PDS (synchronous transfer mode-passive double star) system that was referred to as the "π system" in NTT. I was doing development work such as attending specification meetings and conducting factory inspections. After returning from Lucent, I joined NTT Access Service System Laboratories and helped to develop the π-system-based STM-shared system to a practical stage. The STM-shared system was an FTTH system that provided a data transfer speed of 10 Mbit/s. It became the precursor to NTT's commercial FTTH system. From 2001 until last year, I was involved in GE-PON standardization activities at IEEE.

—What are your thoughts looking back on the R&D accomplished so far?

The major R&D theme has been FTTH, but at the time I began R&D work, we had the slogan "provide 10 Mbit/s for 10,000 yen per month". Incidentally, although the current GE-PON provides customers with a transfer rate of 100 Mbit/s, it actually has a transmission capacity of 1 Gbit/s, and the monthly charge for today's typical FTTH access service is less than 5000 yen. This means that we are now offering 100 times the speed at half the cost relative to that '90 target, so looking back I would have to say that I am again struck by the truly remarkable technological progress and at the same time feel deeply moved.

—What about the future direction of R&D?

Today, there is a demand for R&D to be rapid. Because many researchers have their own research inclinations, they are often not satisfied unless they can work on their own research topics from start to finish. However, the real world does not afford us the time to do as we would like, so it is important to positively tackle technology that is peripheral to us, even if it means putting less emphasis on the technology where our own strength lies. GE-PON involves LSI (large-scale integration) chips and other components that are made by suppliers outside Japan. While they are assembled as a system in another country, the functions implemented in those chips must of course be designed by us. Unless we do this in an open system with complete division of labor, we will lose out to our competitors in development.

On the other hand, it is difficult to make appealing products without independence in research. For example, when our competitors first begin to use GE-PON for FTTH, it would have been embarrassing if the system had been exactly the same as that used by NTT. One must incorporate functions that other companies cannot implement. That means we must identify differentiating functions, determine their targets, develop functions that other companies cannot imitate, and incorporate them into our systems.

The importance of a sense of balance between independence and cooperation in R&D

—How do you think your own research will proceed in the future?

I think I will continue work that is mainly focused on the access network as the major theme. Among electronic communication systems, the access network has hardly evolved at all in basic form in the last 100 years or so. Because the services have steadily advanced during that time, I believe that there is tremendous room for improvement. In particular, when new and old systems exist side-by-side as they do now, how the old systems can be updated and replaced is an important issue. I would like to consider methods for applying Ethernet technology to economical system updating and future re-use. I believe the rapid development of those methods is also important.

—What is your dream as an R&D scientist?

I don't have a specific plan, but I'd like to try to develop active international cooperation in access network research. We pride ourselves on NTT's access network research being top class in the world. It would be a great waste to keep the fruits of our work here in Japan, so I'd like to see more extensive international collaboration. My dream is to involve system vendors and component vendors as well as carriers, if possible, to work towards better access networks throughout the world.

—What do you think of NTT Laboratories?

The greatest feature of NTT Laboratories is the extremely wide scope of our research topics. Even taking the area of access alone, the topics range from the optical fiber core to wiring methods and on to entire systems. Another merit is the ability to develop technology to the actual business stage and thus have

a great impact on society. Also, the integration of the process from basic research to system-level research and on to practical development is unique to NTT Laboratories. I think there are many topics that, like our research on network access, can be done only by NTT.

Another special feature of NTT Laboratories is an overall open atmosphere. In particular, when participating in practical development work such as the access network research, there is a strong attitude of adopting good technology that was not our own. That is all extremely different from the image of a "research laboratory" that I had in my student days.

—Finally, what advice do you have for young researchers?

To begin with, I think you should develop a sense of balance in research methodology, athough recent R&D has departed from the style of working on something from beginning to end. This idea should apply to fields like basic research. Moreover, when you are getting close to practical implementation, cooperation with external concerns has become very important. From now on, the R&D style in which researchers work on their own fields of strength independently, but add to it excellent technology from outside their laboratories to complete overall systems will probably become the norm. That kind of environment requires us to strike a balance between independence and cooperation.

Another piece of advice is that "perseverance is power". No matter what topics you pursue, follow this principle and conduct your research with determination. If you do so, then even if you are initially recognized simply as being "from NTT" at academic meetings, you will gradually gain recognition as an individual. Once you do, you may be called on to make a keynote speech or submit an invited paper. Being known by name is an honor for a researcher, so continue your research with determination and you may go on to become known as the foremost person in your field.

Interviewee profile

■ Career highlights

Yukihiro Fujimoto received the B.A. in education from Nagasaki University, Nagasaki and the M.S. degree in environmental sciences from the University of Tsukuba, Ibaragi in 1988 and 1990, respectively. He joined NTT Telecommunications Networks laboratories in 1990 and engaged in a study of evaluation methods of fiber-optic access network design. In 1994, he moved to NTT network systems development department and worked on the development of fiber-rich access network systems. In 1997 and 1998, he was at Lucent Technologies Bell Labs in the Netherlands as a guest researcher for the development of passive optical network systems. In 1998, he moved to NTT Access Network Systems Labs and engaged in the development of FTTH systems including STM-PON, GE-PON, and standardization activities in IEEE802.3.

■ Publications

"FTTH Textbook," coeditor and coauthor, IDG Japan, August 2003 (in Japanese).

M. Abrams, P. C. Becker, Y. Fujimoto, V. O'Byrne, and D. Piehler, "FTTP Deployments in the United States and Japan—Equipment choices and service provider imperatives," IEEE/OSA J. Lightwave Technol., Vol. 23, No. 1, pp. 236-246, Jan. 2005.