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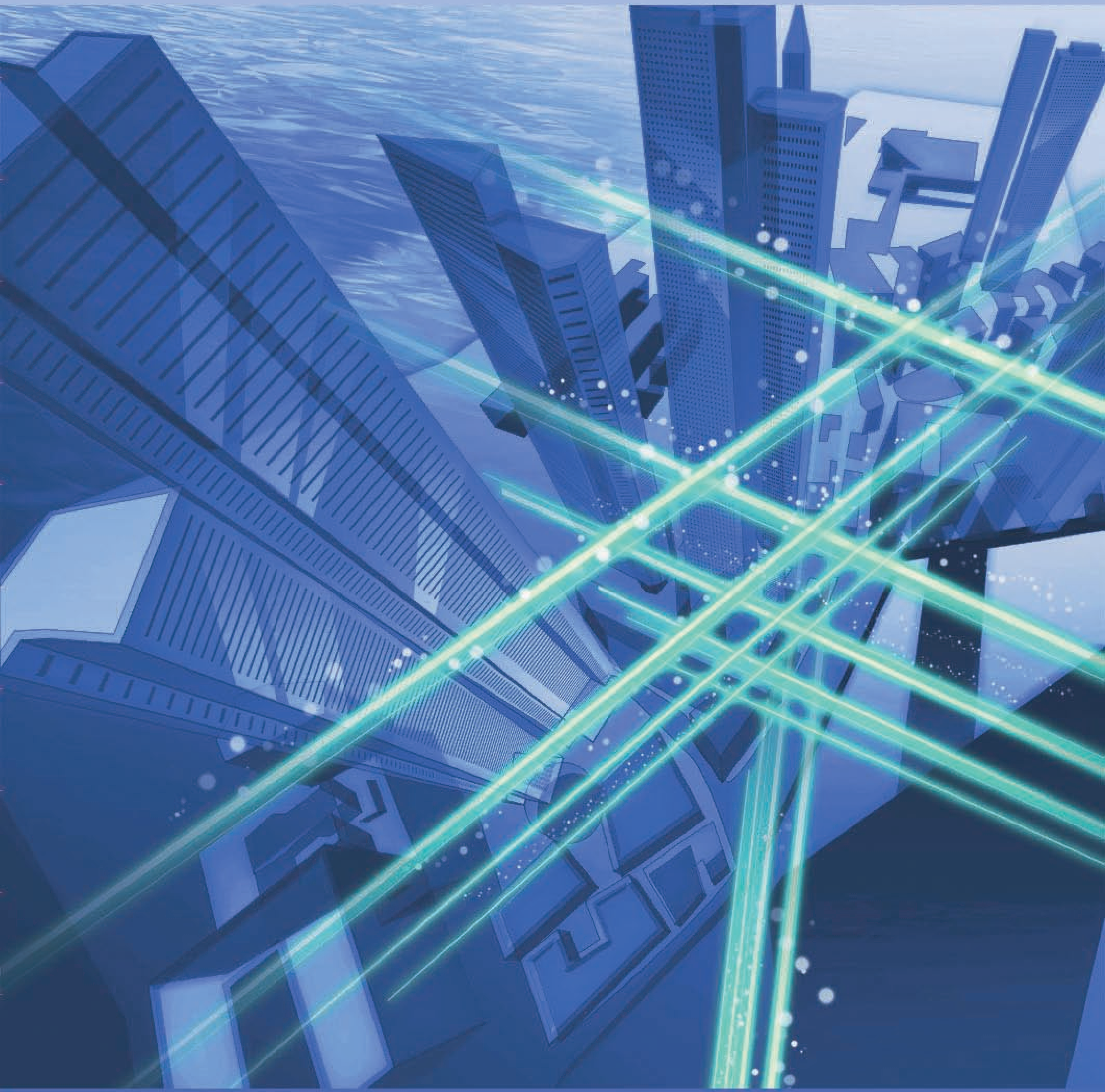

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Latest Topics in Optical Fiber Technology Research

Yuji Azuma

Abstract

This article introduces some of the latest research topics related to new optical fiber technologies. These technologies enable functional and efficient operation and maintenance of networks while maintaining high reliability, and will support future high-speed, high-capacity networks. The Feature Articles in this month's issue are based on lectures given at the NTT Tsukuba Forum 2012 workshop held on October 19, 2012.

1. Forty years of optical fiber technology research

It has been 40 years since the NTT Research and Development Center was opened in 1972 in Tsukuba. The research and development of optical fiber technology also has a history of roughly 40 years. The current optical broadband service infrastructure, which connects 17 million customers, is the result of developing technologies such as single-mode fiber, optical cables, optical interconnects, and operation and maintenance systems. Initially, optical fiber equipment was intended to create an optical fiber network that was as easy to handle as wired networks. However, to obtain high speed and a wide bandwidth, sophisticated skill or knowledge was often needed to build, maintain, and operate the equipment, and, depending on the amount of information being transmitted, the additional care resulted in time-consuming work. The situation was gradually improved through technical innovations, but several issues remained. By resolving these issues and achieving ease of use comparable to or better than that of metal cable, we will be able to provide services of even better quality and at lower cost compared with the efficiency benchmark of working with wire.

2. Rapid fault handling

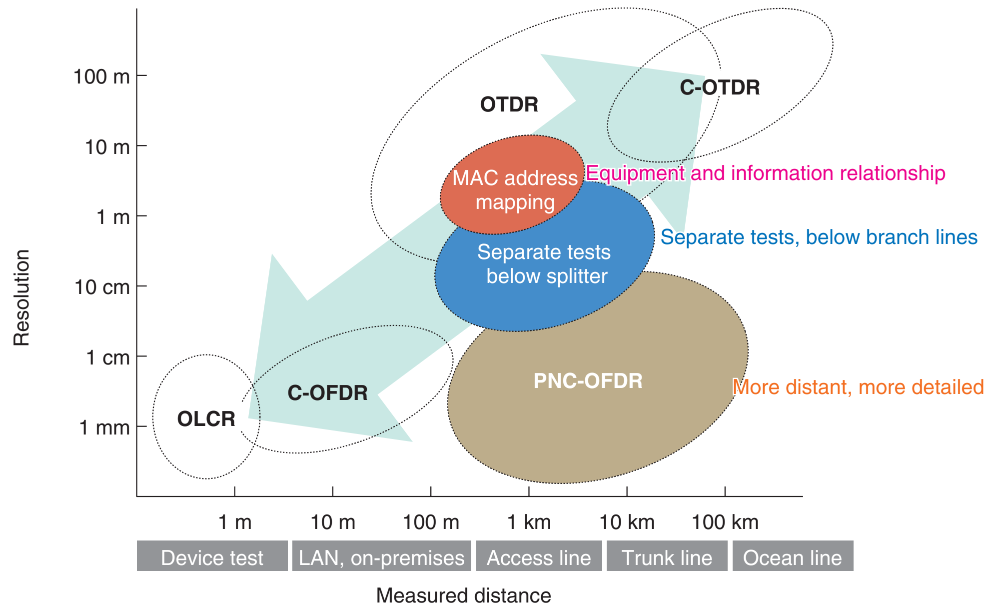
Optical access equipment extending outward from communications buildings is designed to be highly reliable and to withstand harsh environments. However, in extremely rare cases, faults can occur that interrupt service. To repair such faults and quickly restore service, the location and cause of the fault must be narrowed down as much as possible before sending maintenance staff to the site. To achieve this, we are working on three new approaches that will allow us to categorize such faults remotely (**Fig. 1**).

2.1 Accurate measurement of remote fault points

The optical time domain reflectometry (OTDR) technique currently used in the field to measure the distances to fault points is not highly accurate, so it is therefore difficult to determine the precise location and cause of a fault. The phase-noise-compensated optical frequency domain reflectometry (PNC-OFDR) technique that we are researching overcomes these problems. In addition to locating faults, we can also detect tiny identification (ID) patterns embedded in remote connectors, creating the potential for entirely new facility operation scenarios.

2.2 Measurement to distinguish fault points below a splitter

In passive optical networks (PONs), optical splitters are placed at locations close to the customers to increase the efficiency of equipment sharing. However, if a fault occurs between a splitter and the customer's residence, the location of the fault cannot be determined correctly using conventional OTDR. We



C-OFDR: coherent optical frequency domain reflectometry
C-OTDR: coherent optical time domain reflectometry
LAN: local area network
MAC: media access control
OLCR: optical low coherence reflectometry
PNC-OFDR: phase-noise-compensated optical frequency domain reflectometry

Fig. 1. Three approaches to categorize remote fault locations.

have devised a principle that enables us to obtain measurements below individual splitters using a physical phenomenon called Brillouin scattering*, which occurs within the optical fiber, and have demonstrated this principle for the first time. If this approach can be implemented practically, it will overcome one of the major difficulties with PONs.

2.3 Information linkage between an optical fiber and transmission systems

When a fault occurs, we use different instruments and systems to diagnose the fault in each transmission path (optical fiber) and transmission system. We have focused on measuring the round-trip times between an optical line terminal (OLT) and each optical network unit (ONU). This approach is often employed with PON systems, and we have shown that we can convert the measurement data to an optical fiber length and map ONU MAC (media access control) addresses to the location of reflections at the end of an optical fiber. By establishing this technology, we will be able to use it both to locate faults and to detect potential faults, thus providing preventative maintenance.

* Brillouin scattering: Optical scattering that occurs within a medium due to phonons (sound waves) and that involves changes in frequency.

3. Building an equipment database, and safe and secure work navigation

Communication services are provided through various types of equipment. This equipment is complex, and there is a large amount of it, so a lot of work is involved in carefully managing and maintaining a database for each type of equipment. If we are to increase the efficiency of this administration work, we must construct an inexpensive mechanism that can build and update the database autonomously without requiring manual intervention. The mechanism must assign a unique ID to each element of the equipment. We are conducting applied research on an equipment management system using image processing and augmented reality (AR) technologies as an effective means of achieving this. An example of the use of AR technology on optical patch panels in a communications building is shown in **Fig. 2**. The optical patch panel has connector terminals densely arranged with 4 × 7 mm spacing. The positions of markers attached to the patch panel beforehand are

Fig. 2. Navigating on-premises terminal panels using AR technology.

captured with a camera. Then an AR image of the terminal matrix is drawn on the monitor based on a unique ID, and this can be used to direct the work. Also, because the state of the work is being monitored, the database can be built and updated autonomously. Moreover, failsafe functions can be implemented to prevent errors. Thus, we are progressing with research and development (R&D) of a navigation system that can maintain a database that is always up to date and that facilitates safe and secure maintenance work.

4. Flexible branching of an optical fiber

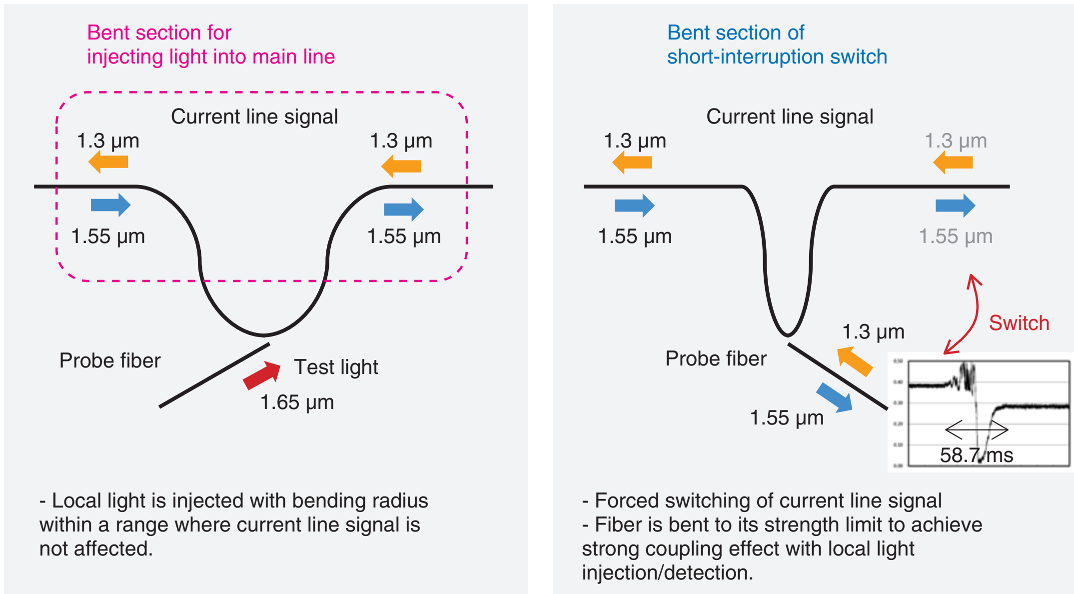
With metal cables, current flows as long as there is contact, so branches can be established anywhere. If optical fibers could be similarly branched, it would expand the range of operations and maintenance scenarios in which they could be used. Local light injection technology involves placing a probe fiber near a bent section of optical fiber and injecting light through the probe fiber (**Fig. 3(a)**). Light radiating from the optical fiber passes through the insulation, so some corresponding losses are unavoidable. However, the system should be practically usable if a stable level of coupling efficiency that is suitable for the operational application can be ensured by optimizing the refractive-index-matched materials, optical lenses, and probe position. For example, until now, it was necessary to have a person in the communications building who would inject optical test signals into fibers. However, this line illumination work would change significantly if such test signals could be injected at arbitrary locations. We are also studying applications for tasks such as checking the link status of a line, and for short-interruption optical media switching, which is described below.

5. Switching optical media in the broadband era

Twenty years ago, when telephone services were dominant, if work was undertaken only when lines were not being used, there was little effect on customers. Now, however, in the optical broadband era, information flows nonstop, 24 hours a day, 365 days a year, via Internet, cloud computing, video distribution, and other services. Therefore, the old approach cannot be used without affecting customers. We are conducting R&D to find ways of switching optical media that are appropriate for the modern era.

5.1 Uninterruptible optical access line switching system

Approximately four years ago, we conceived principles that enable media to be switched without the disconnection or suspension of services and were able to demonstrate the practical implementation of this approach. Our technique involves (1) connecting an optical fiber (the detour path) of approximately the same length as the current optical fiber (the main path) in parallel with it, (2) disconnecting the main path and transmitting the optical signal over the detour path, (3) performing the switch work while the main path is offline, (4) adjusting the length of the detour path while it is transmitting the signal so that it is approximately the same as that of the main path after switching, (5) reconnecting the main path as the new line in parallel with the detour path, and (6) disconnecting the detour path. All of the steps in this procedure can be performed without interrupting the



(a) Optical injection, tested at arbitrary location

(b) Short-interruption optical media

Fig. 3. Local optical injection/detection technology.

signal. The system is complex and requires precise control of path lengths, measurements, loss compensation, and the cancellation of interference. We are therefore undertaking R&D to build a system that is compact, smart, and compatible with a variety of scenarios in the field. If this system can be realized, we will be able to change an optical access line at any time.

5.2 Momentarily interrupted optical access line switching system

We are also conducting R&D on another approach to switching media. We can mechanically switch the transmission path in an instant by using a local light injection technique that involves bending the optical fiber close to its breaking limit to maximize the efficiency of the optical link. This approach does not require us to cut the optical fiber (**Fig. 3(b)**), but it causes a momentary interruption. We have already confirmed the ability to switch within approximately 60 ms. This can only be applied to certain types of optical fiber, but if this simple system is realized, it will be applicable to many work scenarios including cable switching or replacing an OLT.

6. Expanding applications of bending-loss-resistant fiber

Our free-bending optical cord has overturned the common belief that optical fiber cannot be bent. In the past, great care had to be taken not to bend optical fiber, but we have expanded the range of application scenarios with the implementation of hole-assisted fiber (HAF), which produces almost no losses even when bent. Recently, these optical fibers have even been passed through narrow gaps such as those around doors and window sashes. There is a maintenance and operability trade-off with these technologies, but by applying HAF where it is needed, interruptions due to bending can be eliminated, and it may be possible to simplify the optical cable structure.

7. Next-generation optical fiber research for the ultrahigh-speed, high-capacity era

Internet traffic is increasing exponentially with the accelerating spread of services such as social networking and video content services. The bandwidth of optical fiber communications systems that form the backbone for this communication is also being increased yearly. However, there are limits to the increase in bandwidth and speed that can be achieved

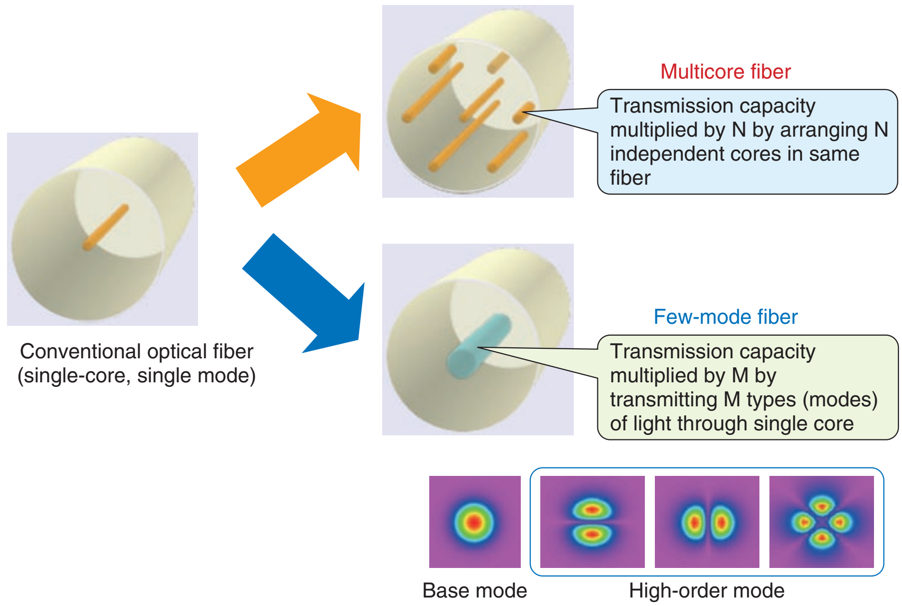


Fig. 4. Next-generation fiber for space-division multiplexing.

with the single-mode optical fiber currently in use, and it is estimated that these limits will be reached in ten years. Therefore, a new transmission medium that overcomes these limitations will need to be created. We are focusing on ways to spatially extend the transmission area of optical fiber, which is one way to overcome these limitations (**Fig. 4**). Current optical fibers transmit optical signals using a single mode, through a single core (transmission path) within a strand of quartz glass. However, optical fiber design and production technology is advancing because of the employment of complex cross sections such as hole structures, and digital transmission processing technology. Fiber with multiple cores in a single strand of quartz glass, and multi-mode fiber capable of transmitting stable signals with multiple modes in a single core are presenting new possibilities for novel fiber structures with higher spatial multiplexing. We have continued to demonstrate the possibilities of multicore fiber with, for example, a successful 1-Pbit/s transmission over a single 12-core optical fiber of 52 km, which is a world record (ECOC (European Conference on Optical Communication) International Exhibition, Sept. 2012, and NTT News Release).

Profile

■ Career highlights

Executive Manager, Senior Research Engineer, Supervisor, Access Media Project, NTT Access Network Service Systems Laboratories.

Yuji Azuma received the B.E. degree in electrical engineering from Doshisha University, Kyoto, in 1984. He joined Nippon Telegraph and Telephone Public Corporation (now NTT) and engaged in research on the characteristics of multicore optical fiber and fiber nonlinearity. From 1989, he was engaged in the troubleshooting and development of optical fiber networks and IP networks. He moved to NTT Access Network Service Systems Laboratories in 2006 and has been engaged in R&D of access media and equipment maintenance. He is a member of the Institute of Electronics, Information and Communication Engineers.

R&D Trends in Communications Infrastructure to Achieve Safe and Secure Access Networks

Fumihide Sugino

Abstract

NTT Access Network Service Systems Laboratories is working on the Civil Systems Project, which involves conducting research and development (R&D) on infrastructure facilities such as conduits and manholes. This article reviews the current state of infrastructure facilities, provides details of our current R&D, and touches on future developments. This article is based on a lecture given at the NTT Tsukuba Forum 2012 workshop held on October 19, 2012.

1. Environment surrounding infrastructure facilities

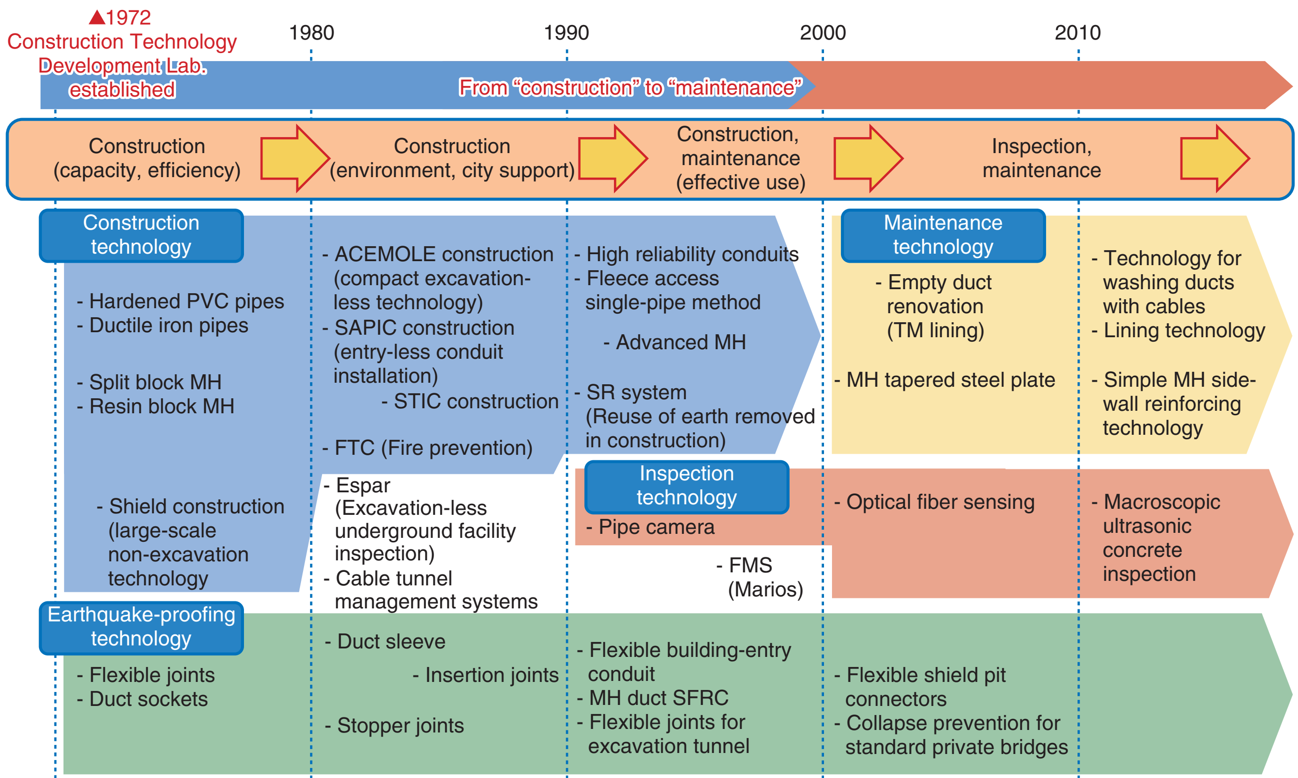
In 2012, NTT Access Network Service Systems Laboratories marked 40 years since its predecessor, the Construction Technology Development Laboratories, was established in Tsukuba (**Fig. 1**). At the time of establishment, a lot of construction was being done to install telecommunication infrastructure such as cable tunnels, manholes, and conduits throughout Japan, so construction technology was the main focus of research and development (R&D). The period from the mid-1960s to the end of the 1970s was a time of rapid construction, and approximately 80% of NTT's conduits and manholes were built during that time. Consciousness of environmental issues increased in the 1980s, and during this time, the focus shifted to developing technology to build conduits without having to excavate, and as the amount of construction gradually decreased, R&D themes shifted from construction to maintenance. Currently, maintenance technologies such as inspection, diagnosis, and repair are the major R&D themes.

1.1 Advancing deterioration of facilities

If current trends continue, in 20 years, approximately 80% of all conduits and manholes will be more than 50 years old and entering their old age (**Fig. 2**). Approximately half of existing conduits are steel and have advanced rust and corrosion, which is becoming an obstacle in installing cable. Moreover, weakening of concrete components such as manholes and cable tunnels due to cracking, peeling, and corrosion of rebar is becoming a concern. It would be ideal to handle these age-related issues by systematically renewing the facilities, but the cost and time required to renew the large amount of infrastructure buried underground would be huge, and it is therefore not practical. Excavation of roadways also significantly disrupts the surrounding environment. Accordingly, a major R&D issue is determining how to enable continuous use of old facilities without renewing them.

1.2 The need to earthquake-proof existing facilities

Developing technology for earthquake-proofing infrastructure facilities has been an ongoing theme at the laboratories ever since its inception. Many large earthquakes have occurred since then, and the knowledge gained from each experience has been accumulated and used to improve earthquake-proofing technologies. The 1964 Niigata earthquake, the 1978 Miyagi earthquake, and the 1995 Kobe earthquake in particular provided opportunities to radically revise



FMS: facility management system
FTC: fire tight compartment
MH: manhole
PVC: polyvinyl chloride
SAPIC: safe pipe construction
SFRC: steel fiber reinforced concrete
SR: soil recycling
STIC: shield tunnel interfaces with conduits
TM: thick membrane

Fig. 1. Trends in infrastructure R&D.

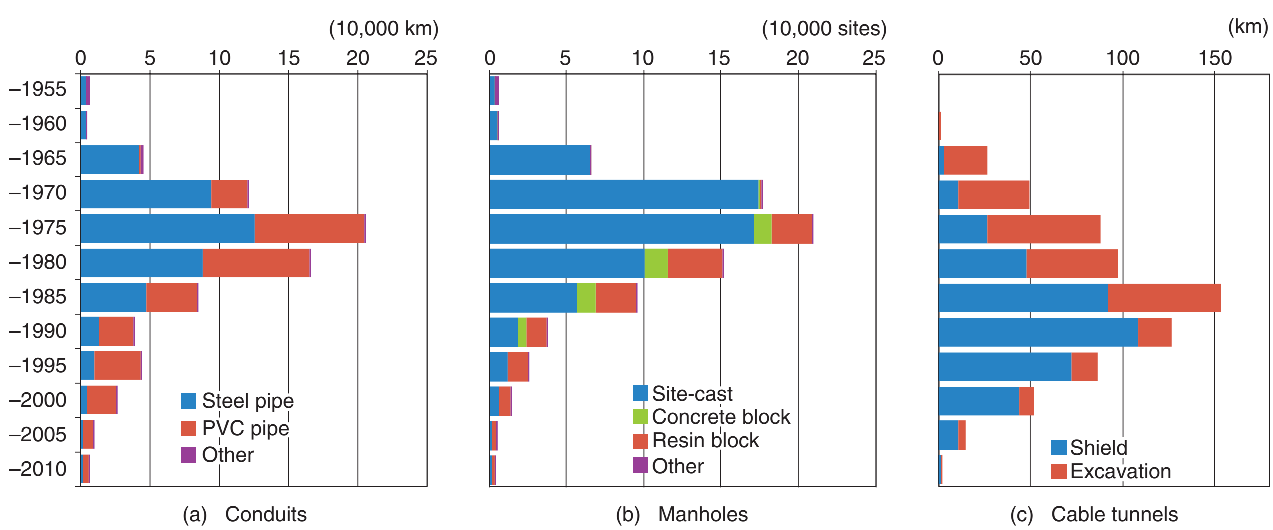


Fig. 2. Amount of infrastructure construction, indicated in 5-year periods.

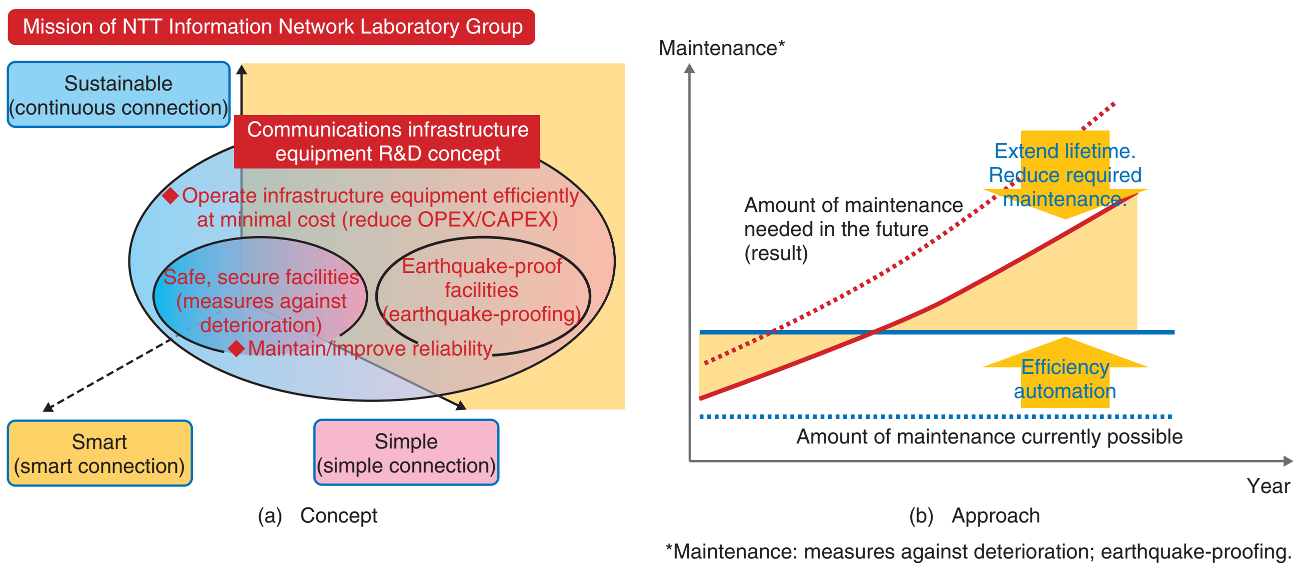


Fig. 3. Infrastructure construction R&D concept and approach.

earthquake-proofing capabilities because of the extent of the damage that occurred.

The Great East Japan Earthquake in 2011 was the largest in recorded history in Japan, and it provided an opportunity to evaluate the performance of infrastructure earthquake-proofing technology applied up to that point. The evaluation revealed that only 1–3% of infrastructure facilities were damaged in most cases, a very low figure. This verified that underground facilities are highly earthquake-proof infrastructures. Furthermore, the facilities that were damaged were built during periods when older standards applied and earthquake-proofing capabilities were lacking. This also confirmed the effectiveness of current standards. In fact, there are still many older facilities that were built before the current standards were introduced. However, even if the renewal of such facilities was restricted to those along major routes and in areas where earthquakes were expected to occur, the cost of renewing all of them to current standards would still be prohibitive and impractical, just as it is in the case of aging infrastructure. Consequently, we expect that developing effective methods of predicting damage to facilities and applying earthquake-proofing measures where they are most needed will be an important R&D theme in the future.

2. Current R&D

In order for customers to use NTT services with confidence, the infrastructure supporting these services must, itself, be safe, secure, and very resistant to earthquakes. Measures against aging and earthquakes, as described above, must be steadily advanced in order to ensure this, but in view of the intensely competitive communications market surrounding NTT and the declining number of skilled specialists in this technology in the industry, the role of R&D is to create technologies that can implement these measures quickly, effectively, and at minimal cost.

Currently, the amount of inspection and maintenance work carried out to address the aging of facilities is limited because of the required cost and labor. However, this aging continues nonetheless, and the number of facilities requiring work increases each year. R&D will use two approaches to fill in this widening gap (**Fig. 3**). The first one involves the use of automation and optimization technologies to increase the number of facilities that can be inspected and maintained. The other one involves the use of technology to extend the lifetime of facilities or make them maintenance-free, which will reduce the number of facilities requiring work. Next, we introduce some technologies used in these approaches.

2.1 Concrete pole inspection technology (automating and streamlining inspection)

NTT has approximately eight million concrete poles nationwide. Inspections of these poles are done mainly by visually inspecting them for cracks, which

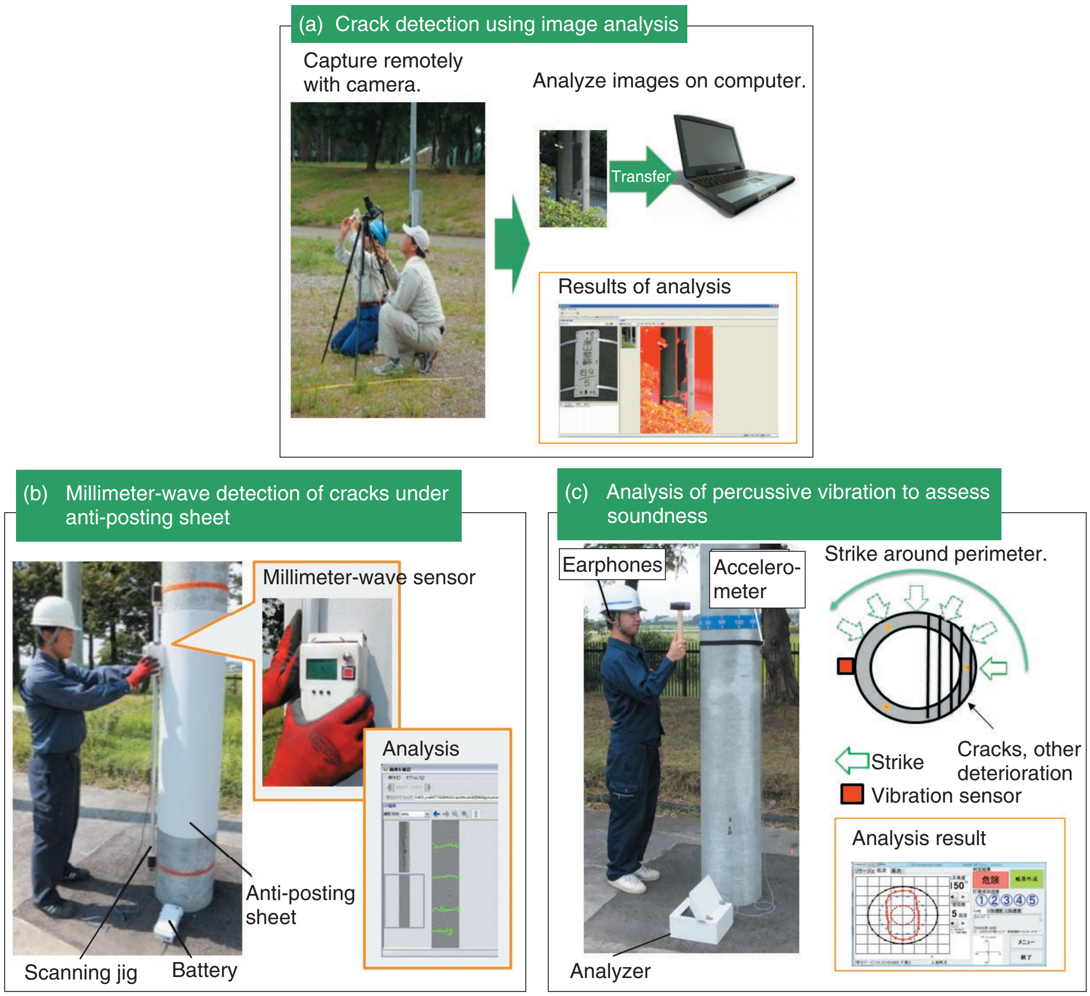


Fig. 4. Technology for inspecting concrete telephone poles.

requires a certain level of skill. Furthermore, the upper part of concrete poles must be checked using binoculars, which is labor intensive and raises concerns that problems could be overlooked. Three technologies have been developed to enable this inspection work to be done more efficiently and effectively (**Fig. 4**).

The first is a technology to detect cracks using image processing. Software is used to eliminate factors such as cables and dirt, which obstruct the detection of cracks, from the color and texture of images captured using an off-the-shelf digital camera. This enables automatic detection of cracks.

The second technology uses millimeter-wave radiation to detect cracks underneath the anti-posting sheet placed on the concrete pole. The previous image-processing technique is unable to detect cracks hidden by the anti-posting sheet, but millimeter waves are reflected by cracks and scattered in all directions, and this can be used to automatically detect cracks that are concealed by the anti-posting sheet.

The third technology is used to assess the condition of the pole by analyzing the vibrations that result from striking it. The purpose of this is not to detect cracks, but to measure the characteristic frequencies generated when striking the concrete with a hammer to automatically determine if the pole's rigidity has decreased.

2.2 PIT (pipe insertion type) new-conduit method for facility repair, maintenance-free conversion, and earthquake-proofing

One problem with conduit facilities is deterioration of steel pipes. Over 60% of conduits, where multi-

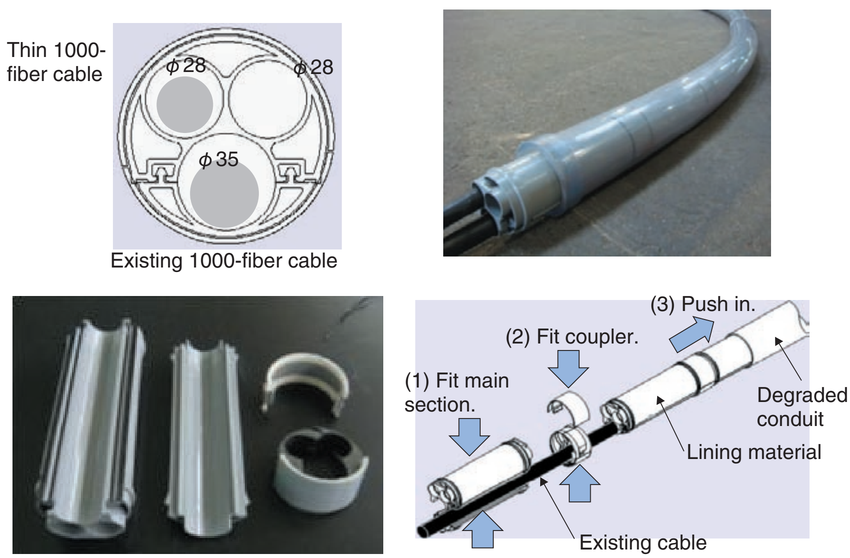


Fig. 5. PIT new-conduit method.

cable installations are planned, are diagnosed as faulty. Most of this is due to rust and corrosion of steel pipes. Technology to repair empty conduits that were faulty due to rust and corrosion already existed, but there was no way to repair them after the cable had been installed. The PIT new-conduit method resolves this issue (**Fig. 5**).

This method involves inserting a PVC inner pipe into a metal conduit that already has a cable installed. This new pipe encompasses the existing cable. The duct is replaced by the PVC pipe, so rust is no longer an issue, and no further maintenance is required. Use of this method can create capacity for three cables in one duct. The space for the existing cable (35 mm in diameter) accommodates up to a 1000-fiber optical cable, and the remaining two spaces (28 mm in diameter) can accommodate two new thin 1000-fiber cables, for a total capacity of 3000 fibers. The inner conduit also protects the cables, which increases the earthquake resistance of the conduit. This enables conduit earthquake-proofing without having to do the construction work of excavating roadways.

We are currently studying ways to expand the range of application areas for this technology. This includes reducing the diameter of the PVC pipe to apply it to narrower conduits that are *weak* or *deteriorated*, increasing the lengths of spans in which installation is possible, and supporting use in colder regions where cables must be protected from freezing groundwater.

3. R&D in the future

NTT currently uses a preventative maintenance approach in managing the maintenance of infrastructure facilities. Preventative maintenance reduces the risk of equipment failure because periodic inspections are conducted of all equipment comprehensively, uniformly, and indiscriminately, and repairs and renovation are carried out as needed. However, with NTT's large amount of infrastructure and with the advancing deterioration, even conducting only the inspections entails a high cost and a large amount of work. As such, future R&D will continue to focus on finding ways to reduce the cost and the amount of work required for inspections and repairs as much as possible so that preventative maintenance can be done smoothly. We will also take on the challenge of redefining what maintenance the facilities will require in the future and revise it if necessary. Maintenance standards based on a preventative maintenance approach are already established, but when compared to people, it is like applying the same medical examination to all patients regardless of their age, physical condition, lifestyle, or medical history. The fact that a facility is old means that useful data for individual evaluation have been gathered from that facility.

Analytical technology is advancing throughout the industry. More advanced preventative maintenance is possible by evaluating the state of each facility,

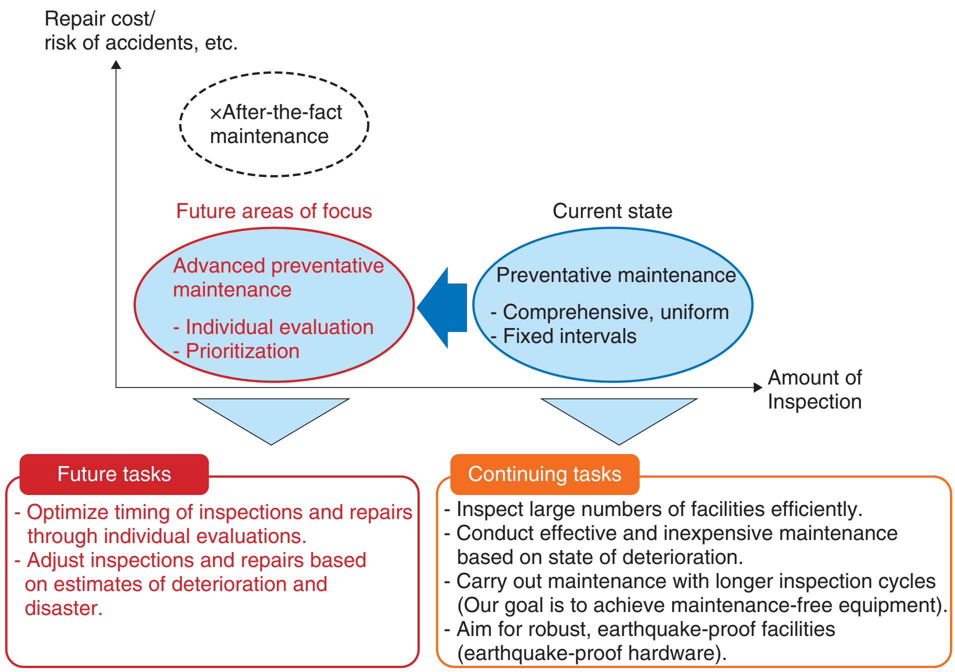


Fig. 6. R&D in the future.

estimating the degradation or damage, and conducting inspections and repairs effectively at the optimal times. We have already begun initiatives in this area. For example, we are researching ways to prioritize manhole inspections for manholes that are likely to be in more advanced states of deterioration by doing a rough estimate of their condition (soundness and deterioration) based on type of construction, installation environment, and external load conditions. This enables us to find deteriorated equipment quickly and to control inspection costs. We are also researching methods to evaluate the level of earthquake resistance by estimating the susceptibility to earthquake damage for each span of a conduit based on factors such as conduit line type or ground conditions. This enables us to apply effective earthquake-proofing measures starting where they are needed most (**Fig. 6**).

4. Future development

Currently, most initiatives in infrastructure facility R&D involve so-called hard technologies such as inspection tools and maintenance methods. In the future, research and development will advance in areas such as facility management based on specialist knowledge and past experience in order to manage infrastructure facilities appropriately while minimizing cost. We hope that the NTT Group will be able to contribute in these areas.

Profile

■ Career highlights

Executive Research Engineer, Civil Engineering Project, NTT Access Network Service Systems Laboratories.

Fumihide Sugino received the B.E. degree in civil engineering from Hokkaido University in 1987, after which he joined NTT. He has studied ACEMOLE construction technology, which is a method of construction without road excavation. He has also worked at NTT Access Network Service Systems Laboratories and NTT EAST, where he mainly worked on telecommunication infrastructure including cable tunnels and underground pipeline systems. He has been in his present position since 2012. His current work involves studying NTT infrastructure.

A Comparison of Approaches to Incident Response in Japan and the United States and an Introduction to the International Standard ISO 22320

Mitsuhiro Higashida, Naoko Kosaka, and Yuji Maeda

Abstract

NTT Secure Platform Laboratories has been researching and developing incident responses for when disasters occur. We introduce the approaches to incident response taken in the United States and compare them with those in Japan. We also introduce the disaster management standard ISO 22320: *Societal security—Emergency management —Requirements for incident response*, issued by the International Organization for Standardization (ISO) in November 2011.

1. Introduction

Natural disasters occur regularly in Japan, and every year there is a great loss of lives and property due to these events. Additionally, the tendency for heavy downpours to occur throughout the country is increasing and seems to be a long-term trend.

It has been pointed out with a great sense of urgency that Japan may be struck by large-scale earthquakes in the next few decades in areas such as the Nankai Trough and inland in the Tokyo area. The Central Disaster Management Council has estimated the potential damage for 18 types of Tokyo Inland Earthquakes. The Council assumes that an earthquake with a magnitude (M) of 7.3 with an epicenter in the northern part of Tokyo Bay would cause extensive damage and result in a death toll of approximately 11,000 people, a total collapse of 85,000 buildings, and a maximum economic loss of 112 trillion yen.

We cannot prevent the occurrence of natural disasters. Therefore, disaster mitigation is necessary in order to recover as quickly as possible from the damage caused by a disaster. This means to be prepared by implementing both structural and non-structural measures and by considering how we should prepare for a disaster. In this article, we discuss the concept of crisis management in the future.

2. Activities to improve incident response capabilities

The International Organization for Standardization (ISO) issued ISO 22320 as an international standard for incident management in November 2011. Incident response consists of various response operations by different institutions and organizations. In some cases, activities need to be carried out throughout the country. Consequently, effective incident response requires structured command and control, as well as coordination and cooperation among the various organizations. ISO 22320 specifies the minimum requirements to carry out an efficient and effective incident response. Before this standard was issued, incident response was considered separately by different organizational units in Japan. With the introduction of ISO 22320, incident response plans are gradually being standardized. In the following sections, the approach toward incident response in the United States (U.S.) is introduced and compared with that in Japan. Then, an overview of ISO 22320 is given.

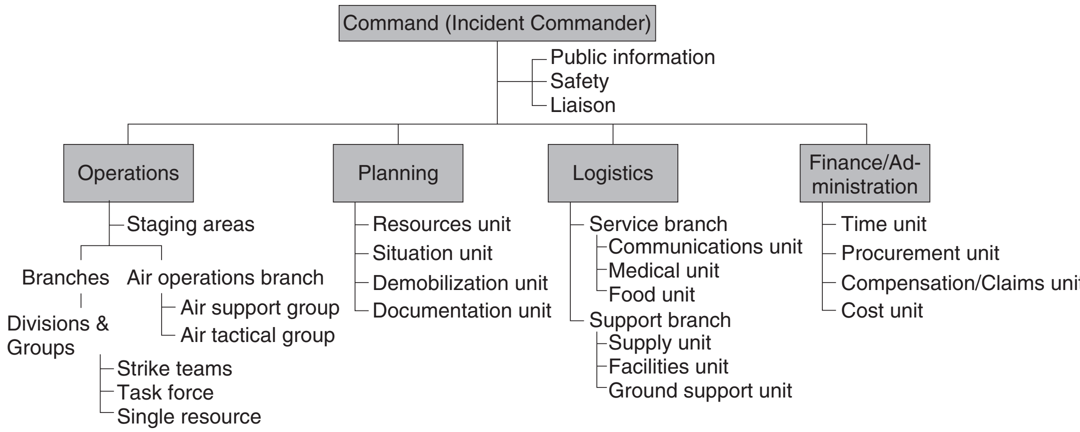


Fig. 1. ICS structure.

3. Incident Command System

The Incident Command System (ICS) is a standardized on-scene incident management concept designed specifically to allow responders to adopt an integrated organizational structure that can meet the complexity and demands of any single incident or multiple incidents without being hindered by jurisdictional boundaries.

The original ICS was established in the mid-1970s by the U.S. Forest Service and a number of California agencies. It was designed to improve and help coordinate responses to catastrophic wildfires in California. The ICS was developed to manage rapidly moving wildfires and to address the following problems: too many people reporting to one supervisor; different emergency response organizational structures; lack of reliable incident information; inadequate and incompatible communications; lack of structure for coordinated planning among agencies; unclear lines of authority; terminology differences among agencies; and unclear or unspecified incident objectives. Federal officials transitioned the ICS into a national program called the National Incident Management System (NIMS), which became the basis of a response management system for all federal agencies. Since then, many federal agencies have endorsed the use of ICS, and several have mandated its use.

The ICS divides an emergency response into five manageable functions essential for emergency response operations: Command (Incident Commander), Operations, Planning, Logistics, and Finance and Administration. A typical ICS structure is shown in **Fig. 1**.

The Incident Commander (IC) is responsible for all aspects of the response, including developing incident objectives and managing all incident operations. The ICS defines various information processing forms required for an incident response, which are known as ICS Forms. ICS Forms are designed to assist emergency response personnel in the use of ICS and the corresponding documentation during incident operations.

In addition, many ICT systems have been set up to support ICS activities. Training programs are conducted in various institutions in order to prepare for disasters, for example, HSEEP (Homeland Security Exercise and Evaluation Program), and a grant program to support these activities has been established by the U.S. government.

As described above, the response management system in the United States is based on ICS.

In Japan, the Self-Defense Forces, National Police Agency, and National Fire Department have established a command and control system. When the Great East Japan Earthquake struck in 2011, these organizations were able to respond quickly to the disaster area by sending units that are dispersed across the country. By contrast, local governments in Japan do not have a system like this.

4. Difference in incident response approaches between Japan and the United States

The Local Disaster Management Plan is common in Japan. This is a plan established by each prefectural and municipal disaster management council, subject to local circumstances and based on the Basic

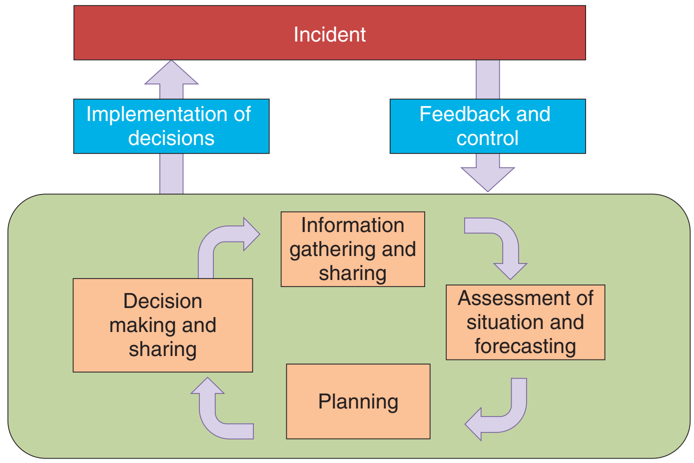


Fig. 2. Command and control process specified in ISO 22320.

Disaster Management Plan.

By contrast, ICS in the U.S. is applied nationally. It is flexible and can be used for incidents of any type, scope, and complexity. ICS allows its users to adopt an integrated organizational structure to match the complexities and demands of single or multiple incidents.

ICS is used by all levels of government—federal, state, tribal, and local—as well as by many nongovernmental organizations and the private sector. It is also applicable across disciplines.

In Japan, the role of state agencies is limited, and they do not have a system to perform disaster responses in place of local governments.

The role of state agencies is to provide support to the local governments.

Furthermore, in Japan, disaster responses are planned based on an extension of command and control operations during ordinary times. Thus, the disadvantage is that the response may not be sufficient during a disaster that is beyond the response capacity.

In contrast, in the United States, the corresponding organization expands according to the size of the disaster. The organization also has the authority to command and control the response operations.

In addition, there are full-time professional disaster response teams in the United States. However, disaster response personnel change every few years in Japan.

Fig. 3. Process of providing operational information (ISO 22320).

5. ISO 22320

ISO 22320 is an international standard that was issued to enhance the ability of private and public organizations to handle all kinds of emergencies such as flooding, earthquakes, and accidents.

The standard specifies the following requirements for an effective incident response:

a) Requirements for command and control (**Fig. 2**)
b) Requirements for operational information (**Fig. 3**)
c) Requirements for cooperation and coordination

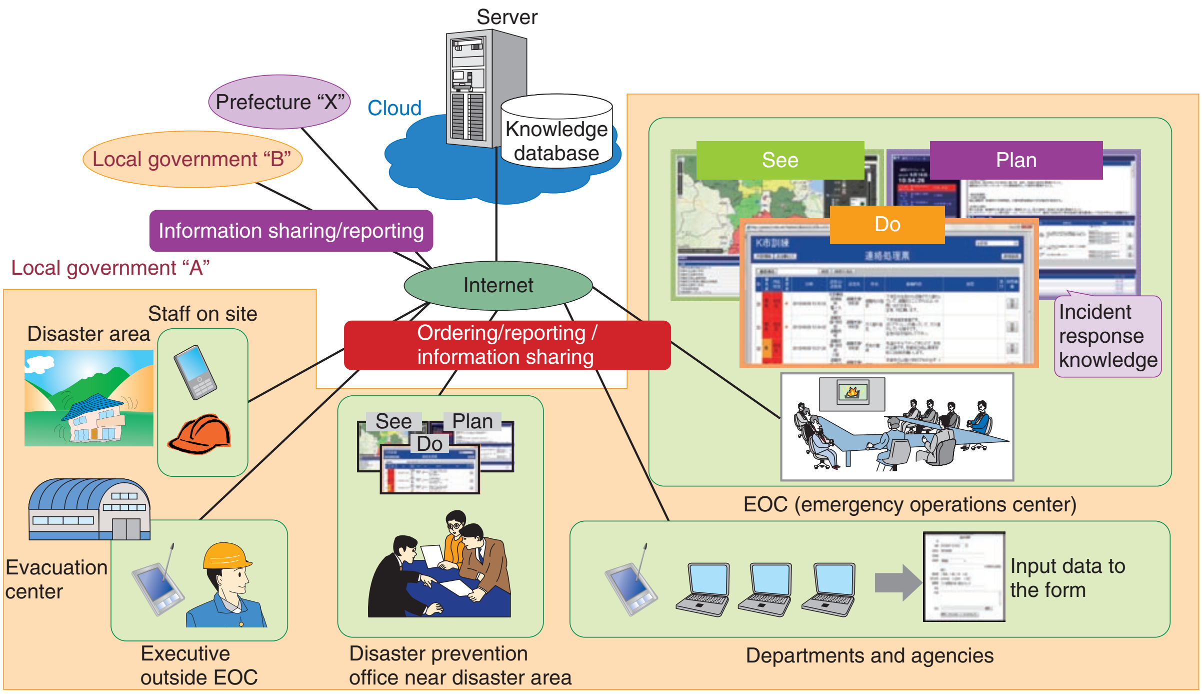


Fig. 4. Strategic emergency management support system.

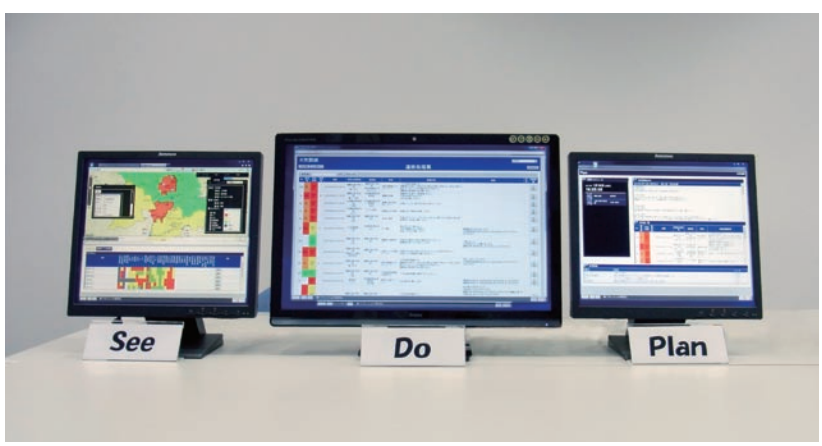


Photo 1. Screen shots of strategic emergency management support system.

Thus, ISO 22320 is a standard that allows inter-organizational cooperation among the involved organizations, agencies, and other parties.

After ISO 22320 was issued, a committee was formed in 2012 by the Japanese Standards Association (JSA) to establish Japanese Industrial Standards (JIS), which will be issued in the summer of 2013 at the earliest.

6. Conclusion

Until now, there was no common agreement on how to implement an incident response in Japan. Therefore, ISO 22320 will play an important role in the standardization of a domestic incident response plan in the future. We will work on developing *a strategic emergency management support system* based on ISO

22320 (**Fig. 4**). Key personnel will use the support system to prepare a common operational picture and carry out effective emergency management through the summarizing, managing, and sharing of information and foresight utilizing incident response knowledge (**Photo 1**). If the system is provided on a cloud, users can use it whenever necessary, including during training. As a result, local governments that have not had any experience in dealing with disasters can utilize the knowledge of other local governments stored on the knowledge database of the system.

NTT Secure Platform Laboratories is continuing to research and develop ways to improve incident response capabilities through the management support system based on ISO 22320.

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Recent Trends in Standardization of Japanese Character Codes

Taichi Kawabata

Abstract

Character encodings are a basic and fundamental layer of digital text that are necessary for exchanging information over the Internet. Character codes are used in plain text files as well as in structured text files such as XML (extensible markup language), MIME (multipurpose Internet mail extensions), and HTML (hypertext markup language).

This article explains the basic architecture of character encodings and reviews Japanese and International standardization activities.

1. Overview of character code standardization history

Character codes are used everywhere on the Internet. They form the most basic layer of the digital text hierarchy. This means that above the plain raw character codes lie layers of variant glyph encodings, text encoding formats such as HTML (hypertext markup language) and XML (extensible markup language), and instructions for the placement of such character codes, such as those given in CSS (cascading style sheets), as shown in **Fig. 1**.

The first attempt to standardize character codes for electronic information interchange was initiated in the early 1960s by the International Organization for Standardization (ISO), followed by the American Standards Association (ASA, now called the ANSI (American National Standards Institute)) and the European Computer Manufacturer's Association (ECMA) as 6-bit and 7-bit character codes. Since then, character codes have been standardized by individual countries or organizations[*1]. The first 2-byte (14-bit) character coding system was standardized by Japan in 1978. Later, China, Korea, and Taiwan also standardized their own 2-byte character codes. These various character codes were not compatible with each other. As a result, some characters were doubly encoded in different character encodings, thus making their combined use practically difficult.

In the late 1980s, some software companies began an attempt to unify these various character codes into a single coding system, which was called Unicode. Similar attempts were also made within the ISO, and with some vicissitudes, these two attempts achieved a *pari passu* (literal meaning: on equal footing) advance, resulting in two technically identical standards, namely, ISO 10646 and Unicode. Since then, both ISO/IEC (International Electrotechnical Commission) and Unicode have continued to publish technically identical standards to this day.

The first version of ISO 10646, whose official name is the Universal Coded Character Set (UCS), was published in 1993. Since then, it has gradually been disseminated all over the world. In Japan, JIS (Japanese Industrial Standards) and its variant character encoding systems (such as Shift_JIS) have been widely adopted, but now UCS prevails on the Japanese Internet[*2]. Today, Japan has already ceased creating its own standards and now proposes new characters to UCS[*3]. A brief history of the standardization achievements over the years is shown in **Fig. 2**.

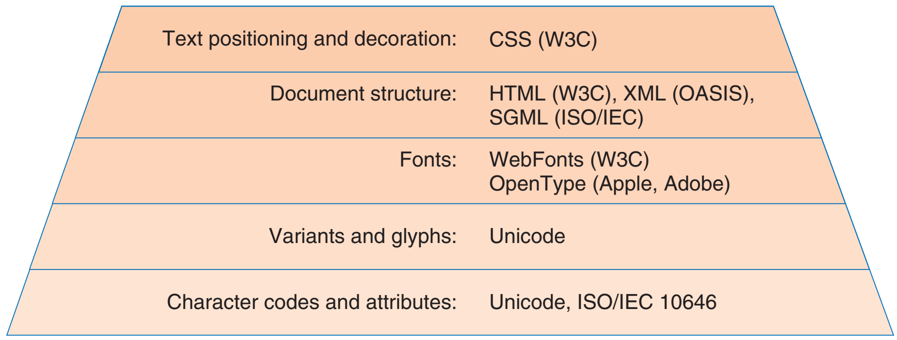
2. Architecture of UCS

The UCS character coding system consists of 17 planes; each plane has 65,534 character code points, which are numerical values representing the code

*1 Basic character encoding frameworks were standardized internationally as ISO 646 or ISO 2022.

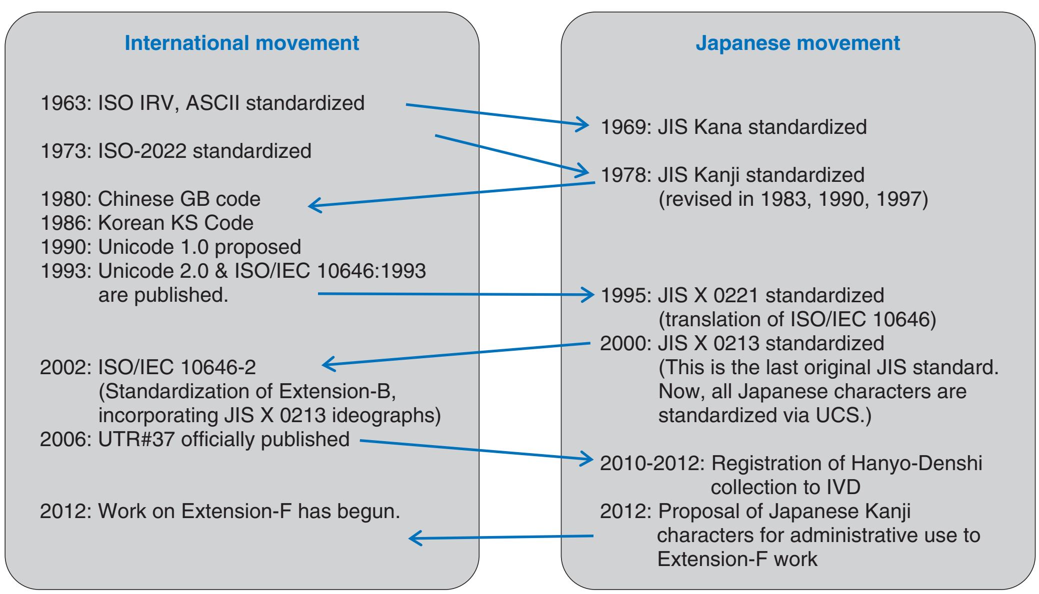
*2 Except for email, in which the JIS coding system is still widely employed.

*3 The JIS translation of UCS is referred to as JIS X 0221.



ISO/IEC: International Organization for Standardization/International Electrotechnical Commission
OASIS: Organization for the Advancement of Structured Information Standards
SGML: standard generalized markup language
W3C: World Wide Web Consortium

Fig. 1. Digital text hierarchy showing character/coding characteristics and details related to their standardization.



ASCII: American Standard Code for Information Interchange
IRV: International Reference Version
IVD: Ideographic Variation Database
UTR: Unicode Technical Report

Fig. 2. Brief history of character encoding standardization.

space. This results in nearly 1.1 million code points for all 17 planes, as shown in **Fig. 3**. In the UCS, unique code points are assigned to characters from all over the world. Today, approximately 100,000 character code points have been assigned, as shown in the figure[*4].

The UCS code points are represented in the form of `U+XXXX`, where `XXXX` is a 4 to 6 hexadecimal digit. For example, the Latin character *a* is assigned the code point `U+0061`, and the kanji character 漢 is assigned the code point `U+6F22`. Since its standardization in 1993, most characters in modern scripts have been encoded; however, efforts to assign archaic

*4 About 70% of them are CJK (Chinese/Japanese/Korean) Unified Ideographs.

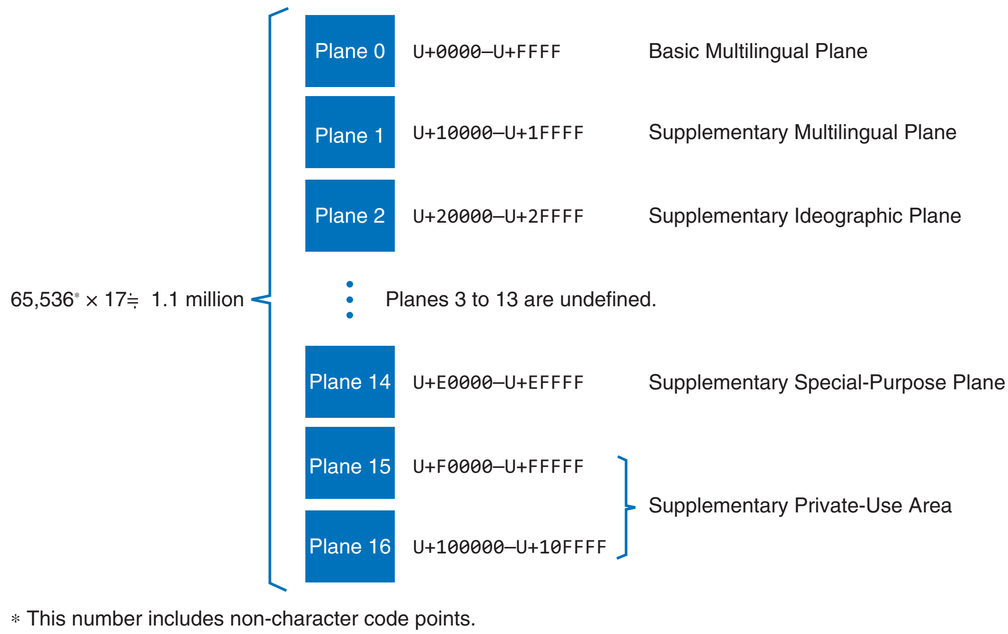


Fig. 3. Planes of UCS character coding system.

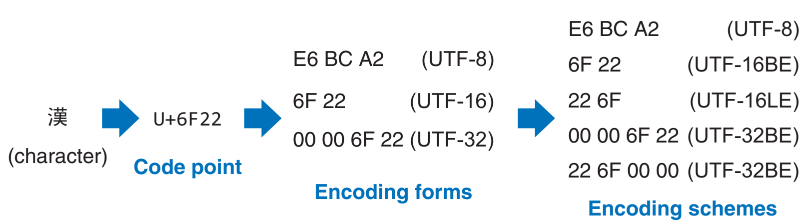


Fig. 4. Example of a character and its codepoints and encoding forms/schemes.

characters and scholarly symbols are still continuing.

For actual communication or memory storage of characters, code points must be *encoded* and *serialized*. This means that these character code points will be converted to one or more 8-bit or 16-bit code unit sequences. UCS defines three encoding forms, namely UTF (UCS Transformation Format)-8, UTF-16, and UTF-32, and seven encoding schemes, namely, UTF-8, UTF-16, UTF-16BE, UTF-16LE, UTF-32, UTF-32BE, and UTF-32LE. An example of their use is shown in **Fig. 4**.

Among these, UTF-8 is upward compatible with ASCII (American Standard Code for Information Interchange) character codes and is widely used in UNIX-based operating systems (OSs) and in communication over the Internet. Windows OS and Java VM (Virtual Machine) have adopted UTF-16 for their internal representation and storage.

UTF-8 will encode UCS code points to one to four 8-bit code units. UTF-16 will encode UCS code points to one or two 16-bit code units. The correspondence between UCS code points and their UTF-8 encodings are shown in **Table 1**. As shown in this table, the first unit of UTF-8 code units can be easily distinguished among the remaining code units.

3. Ideographic Variation Database and its selectors

UCS is used to encode abstract characters. For example, the ideograph 葛 would have the same character code regardless of its shape or font. However, for some special scholarly, publishing, or administra-

Table 1. UTF-8 codepoints.

Codepoints	Bit arrays	Byte sequences
U+0000–U+007F	0xxx xxxx	00-7F
U+0080–U+07FF	110yyyyx 10xxxxxx	C2-DF 80-BF
U+0800–U+FFFF	1110zzzz 10yyyyyy 10xxxxxx	E0-EF 80-BF 80-BF
U+10000–U+10FFFF	11110uuu 10uuzzzz 10yyyyyy 10xx xxxx	F0-F7 80-BF 80-BF 80-BF

tive usages, slight differences in shape that would otherwise be ignored during encoding have sometimes resulted in significant differences.

For example, in Japanese administrative systems, Katsushika Ward in Tokyo (葛飾区) and Katsuragi City (葛城市) in Nara Prefecture would have the same character "葛" with ordinary character encoding, yet they might be displayed differently in official administrative documents.

UCS provides a method to differentiate such variants that would otherwise be unified with the Ideographic Variation Database (IVD) and Ideographic Variation Sequence (IVS). IVD was introduced in 2006 as the Unicode Technical Standard (UTS) #37.

This scheme involves attaching the variation selector after the character code, which makes it possible to represent ideographic variations.

In the above examples of 葛 (Katsushika) and 葛 (Katsuragi), the different variations can be specified as U+845B U+E0103 and U+845B U+E0102, respectively, as shown in **Fig. 5**. There are 240 variation selectors for ideographs assigned from U+E0100 to U+E01EF of the UCS 14th plane.

Currently, the IVD is maintained by the Unicode Consortium, a nonprofit organization that develops the Unicode Standard.

According to UTS #37, when someone wants to register a variation of an ideograph, he/she applies for registration of variations along with its name to the Unicode Consortium (along with the requested variants).

Then the Unicode Consortium opens the application to public review for three months. After the public review has closed and comments have been reflected in the application, the Unicode Consortium will assign an IVS to each glyph.

Currently, two collections are registered: Adobe-Japan1 and Hanyo-Denshi. The latter collection of variants is registered by the Hanyo-Denshi committee of Japan for the administration systems of national and local Japanese governments.

Fig. 5. Registered Hanyo-Denshi variation of "葛".

4. Relationship between domestic and international standardization committees

The character coding system is one of the standards in the information technology (IT) field. International standards in the IT field are currently established by Joint Technical Committee One (JTC 1) of the ISO and the IEC, which is referred to as ISO/IEC JTC 1. There are about 20 subcommittees in JTC 1, and the subcommittee working on character encoding standardization is subcommittee 2 (SC 2). SC 2 has one working group, called WG 2, which is working on ISO/IEC 10646. WG 2 has entrusted the Ideographic Rapporteur Group (IRG) with specifically creating the repertoire of CJK Unified Ideographs for standardization. These committees and subcommittees are often referred to by their abbreviations. For example, WG 2 is officially known as ISO/IEC JTC 1/SC 2/WG 2.

In Japan, the Information Technology Standards Committee of Japan (ITSCJ), a division of the Information Processing Society of Japan (IPSJ) and entrusted by the Ministry of Economy, Trade and Industry, is a corresponding domestic standardization body for most subcommittees of ISO/IEC JTC 1. SC 2 in Japan is working with ISO/IEC JTC 1/SC 2, SC 2/WG 2, and SC 2/WG 2/IRG, to reflect the Japanese concerns and requirements in international character codes. The relationship between the inter-

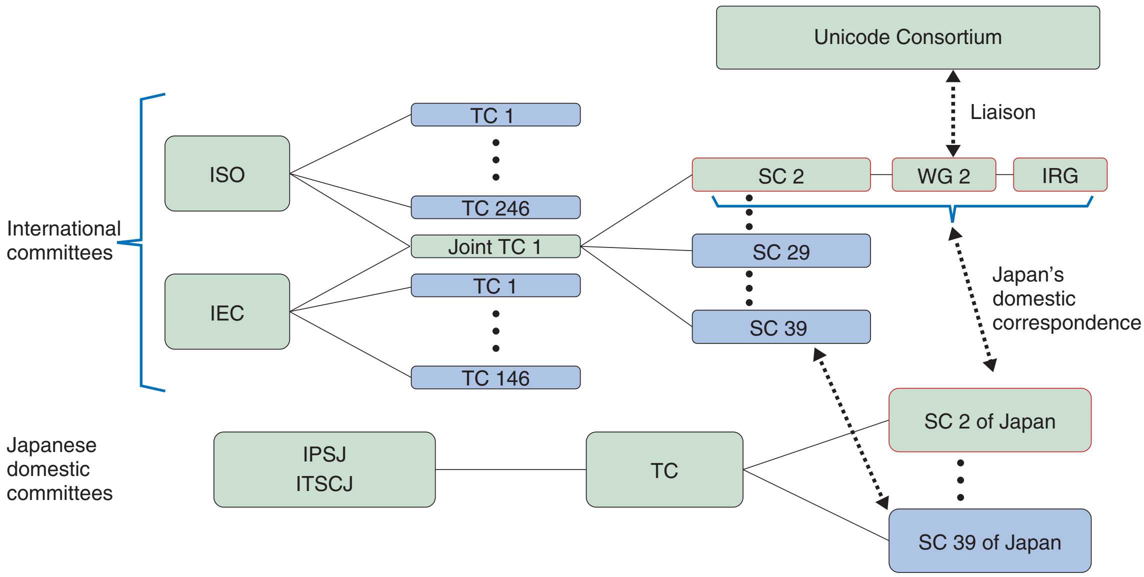


Fig. 6. International and Japanese committees working on character code standardization.

national organizations and the Japanese organizations is shown in **Fig. 6**.

5. Future outlook

Most kanji (CJK Unified) ideographs needed for Japanese governmental administration systems are proposed to the IRG as part of Extension F standardization efforts*5. They are expected to be standardized within the next several years.

As devices such as e-books and studies on the digital humanities evolve, the character encodings for kanji ideographs used in classical documents will follow the same path of standardization that ideographs needed for administration systems have. In the current work being done on Extension F, the kanji ideographs that appear in the classical Buddhist canon *Taishō Revised Tripiṭaka* are in the process of being standardized. These efforts mean that many more classical documents will be available on e-books or the Internet in the future.

Emojis (Japanese-style pictorial characters) were also developed by Japanese mobile phone carriers, but their standardization in the UCS was initiated by Apple and Google, who have developed operating systems for cellular phones. Emoji characters also have numerous variations, and to date, nearly 700 characters have been standardized as emoticons and pictographs.

NTT recognizes that standards and technologies related to character encodings will be crucial in applications involving the web, email, and e-books and services, and will therefore stay engaged in this technology.

*5 Standardized CJK Ideographs are currently grouped into Unified Repertoire and Ordering (URO) character sets identified with Extensions. Extensions A to D have already been standardized. Extension E has just passed the vote and will be officially published next year. The work on Extension F has just begun.

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A Study of a Noise Measurement Method for Efficient and Smooth Troubleshooting

Abstract

This article describes a study carried out on a noise measurement method in telecommunication lines to make fault troubleshooting more efficient and smooth. This is the seventeenth in a bimonthly series on the theme of practical field information on telecommunication technologies. This month's contribution is from the EMC Engineering Group, Technical Assistance and Support Center, Maintenance and Service Operations Department, Network Business Headquarters, NTT EAST.

1. Introduction

Measures for saving energy in electrical and electronic equipment have become more sophisticated in recent years. Such measures include the adoption of energy-saving inverter circuits in the power-supply parts of equipment. The energy-saving performance of such circuits is high, but the level of radio interference can also be high if no anti-noise measures are taken. Noise can also be generated as a result of faults or insufficient insulation in the power-supply part. Such noise can penetrate telecommunications equipment in a user's building or home via a power-supply line or space and can cause malfunctions in asymmetric digital subscriber line (ADSL) or very-high-speed DSL (VDSL) modems or in the generation of audible noise.

Measuring the voltages between a telecommunication line and earth ($V_{L1\text{-}E}$ or $V_{L2\text{-}E}$) in telecommunication lines when inspecting telecommunication equipment for noise-related faults is one of the most important means of troubleshooting the causes of such faults. However, this method unfortunately results in the measurement of noise components not in isolation, but as components of telecommunication signals. As a result, there are times when the noise cannot be clearly identified, which makes it all the more difficult to troubleshoot the causes of noise. We propose a simple method for separating the external noise and the signals and have developed a separation probe as a prototype product incorporating this method. We describe the results of tests that were conducted in our laboratory and in the real field to evaluate the effectiveness of the noise-separation method and the separation probe in troubleshooting noise-related faults.

2. Background

The measurement of common mode noise in telecommunication lines when troubleshooting noise faults is shown in **Fig. 1**. This method measures voltage between the telecommunication line and a ground ($V_{L1\text{-}E}$ or $V_{L2\text{-}E}$). When the telecommunication line is not in a communication state, the common mode voltage is equivalent to voltage caused by noise. An example of the results of measuring common mode noise is shown in **Fig. 2**. In this case, only the noise waveform was measured, which made it relatively easy to check for noise. Next, the common mode noise was measured when noise was superposed on an ADSL/VDSL line when the line was in a communication state (**Fig. 3**). In this case, a signal is continuously applied on the telecommunication lines so that the measured common mode voltage corresponds to the signal + noise. An example of the results of measuring common mode noise associated with a dropped link in the ADSL service is shown in **Fig. 4**. The measured waveform shows that noise is superposed on the signal, which makes it difficult to check

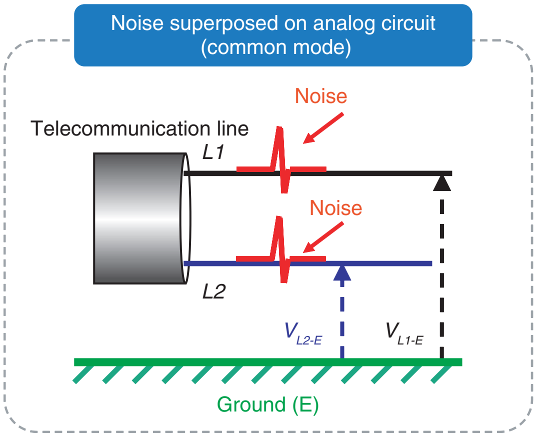

Fig. 1. Noise measurement on analog line.

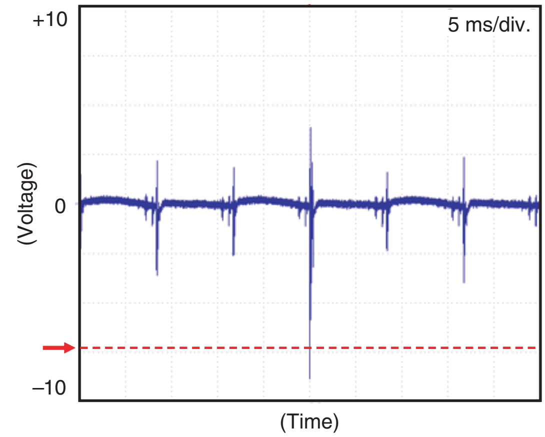

Fig. 2. Noise waveform superposed on analog line.

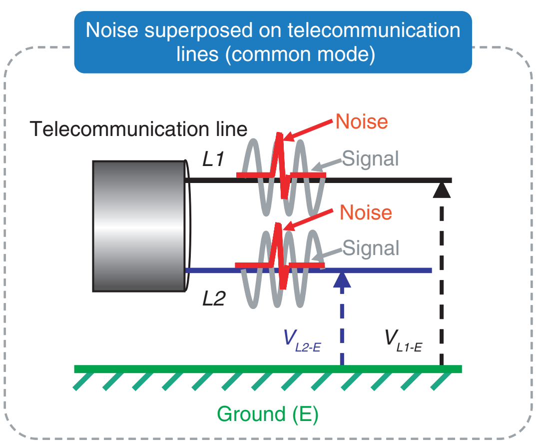

Fig. 3. Noise measurement on ADSL/VDSL line.

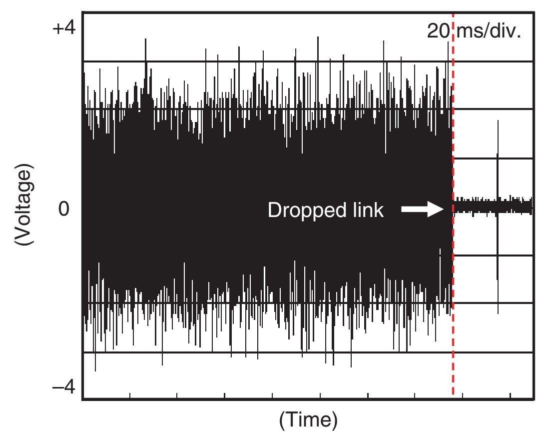

Fig. 4. Noise waveform superposed on ADSL line.

for the presence of the noise and adds to the time required for fault troubleshooting. A device such as a separation probe was therefore needed that could make fault troubleshooting more efficient by separating and extracting the fault-causing noise from the signals.

3. Separation of noise and signals

The conventional method of measuring common mode noise ($V_{L1\text{-}E}$ or $V_{L2\text{-}E}$) involves measuring voltage when the noise and the signal are superposed, as described above. In order to separate the noise, we use the results of two measurements: the common mode voltage between *L1* and *E* and that between *L2* and *E*. It is known that noise can be approximately determined by Eq. (1) according to the definition of common mode voltage [1].

$$\text{noise} \approx \frac{V_{L1\text{-}E}+V_{L2\text{-}E}}{2} \qquad (1)$$

At the same time, the signal can be approximately determined by Eq. (2).

$$\text{signal} \approx V_{L1\text{-}E} - V_{L2\text{-}E} \qquad (2)$$

4. Separation probe and test results

4.1 Overview of separation probe

Our prototype separation probe achieves the functions expressed by Eqs. (1) and (2). The configuration of the probe is shown in **Fig. 5**, and an external view

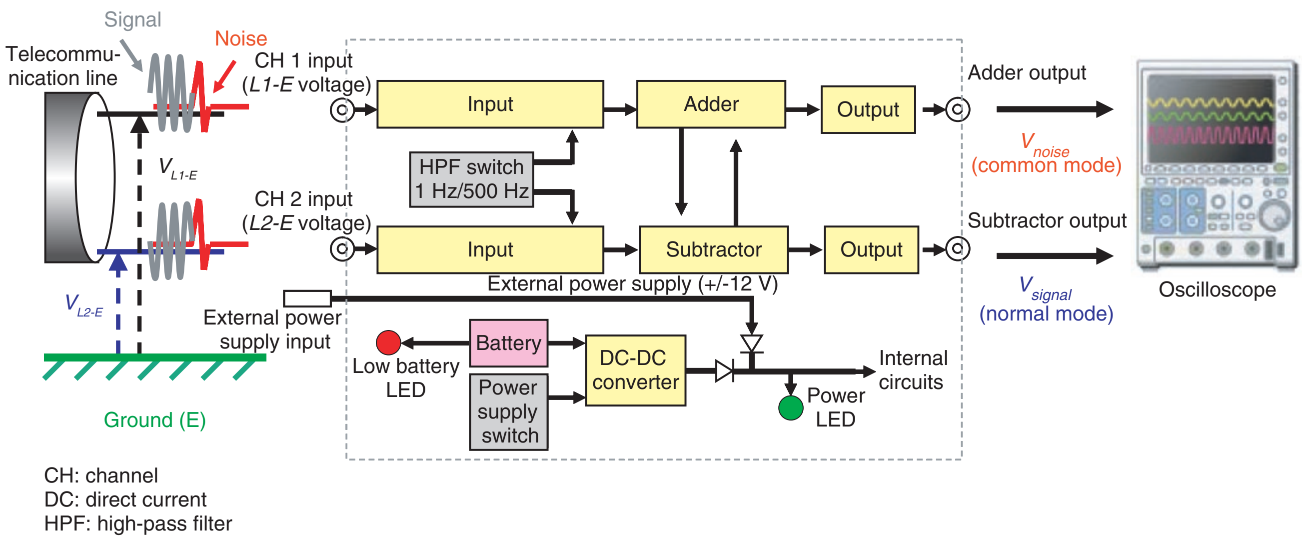

Fig. 5. Configuration of separation probe.

of the probe is shown in **Fig. 6**. The separation probe consists of input parts, an adder and subtractor, output parts, and a power supply. In common mode measurement, the *L1-E* and *L2-E* voltages are measured by using a high-impedance probe connected to each of the input parts. The results of these measurements are processed in an analog manner by additive (V_{noise}) and subtractive (V_{signal}) processing and then output to an oscilloscope. The power supply can be fed to the probe's main unit by either an internal battery or an external power supply from the oscilloscope.

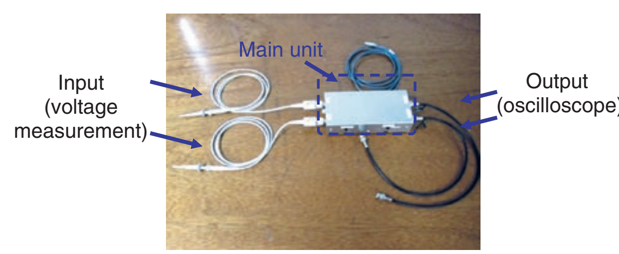

Fig. 6. External view of separation probe.

4.2 Results of laboratory test

In order to test the separation probe, we applied an external 160-kHz sinusoidal wave as common mode noise to the signals of an ADSL line. The measurement results using the separation probe are shown in **Fig. 7**. The upper half of the figure shows the noise voltage waveform and the lower half the signal voltage waveform. These results show that the 160-kHz sinusoidal wave applied as the noise was able to be extracted, which made it possible to observe the signal waveform with the noise component separated from it. In other words, the results of this test demonstrated that the separation probe functioned effectively. For reference, the V_{L1-E} and V_{L2-E} voltage waveforms measured by the conventional technique are shown in **Fig. 8**. These results show that it is difficult to confirm the existence of a 160-kHz sinusoidal wave applied as noise from conventionally measured waveforms.

4.3 Results of field test

We also examined the effectiveness of applying our separation probe for troubleshooting in the case of a dropped link in ADSL services. In the following, we introduce one of three tests that we performed in the field.

(1) Fault description

Dropped links in the ADSL line in a tenant building frequently occurred between 9:00–10:00 AM.

(2) Facilities overview and noise measurement

An overview of the actual facilities in the field is shown in **Fig. 9**. The ADSL line was connected to the tenant's ADSL modem via a main distributing frame (MDF). The noise voltage on the signal line was measured at the MDF using the separation probe.

(3) Measurement results

The noise waveform at the time the ADSL

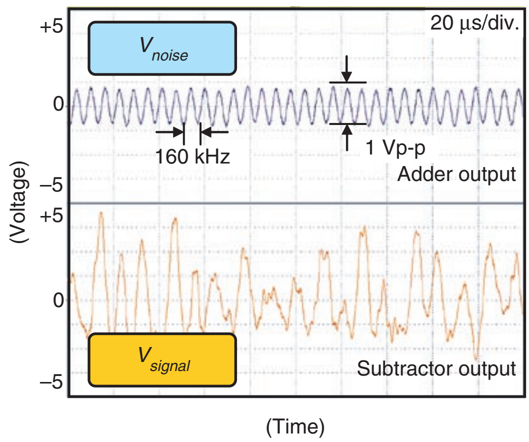

Fig. 7. Waveforms measured by separation probe.

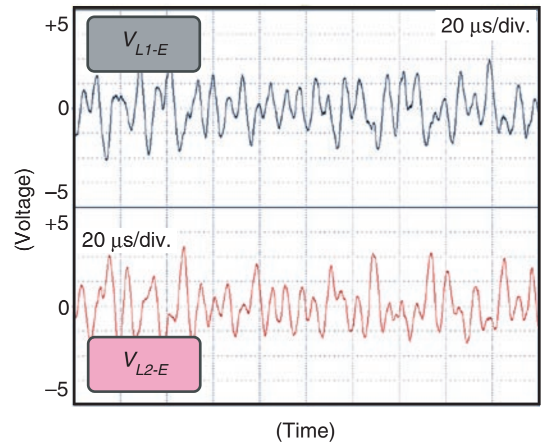

Fig. 8. $V_{L1\text{-}E}$ and $V_{L2\text{-}E}$ measured waveforms.

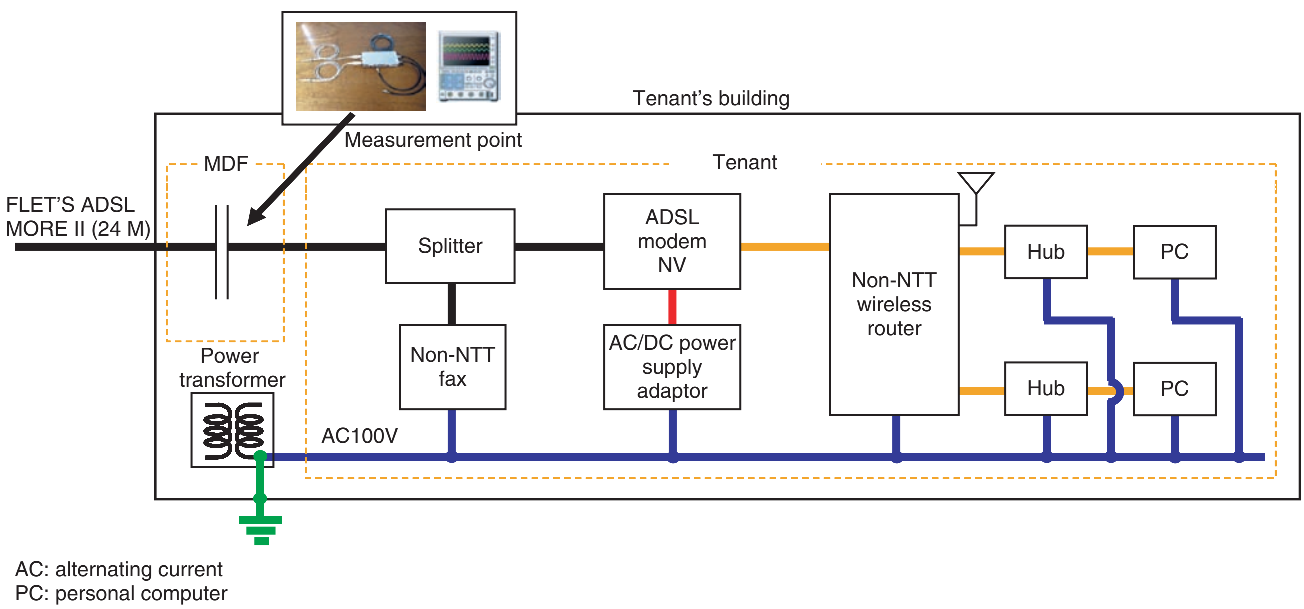

Fig. 9. Overview of actual facilities in the field.

signal is lost is shown in **Fig. 10**. The upper half of the figure shows the noise waveform and the bottom half the signal waveform. An examination of the noise waveform on top shows that the measurement of noise was unaffected by the signal.

The frequency spectrum obtained by subjecting this noise waveform to fast Fourier transform (FFT) analysis is shown in **Fig. 11**. When the waveforms of Fig. 11(a) (with noise) and Fig. 11(b) (without noise) are compared, it can be seen that the noise level is high in the frequency band of 80 kHz–1 MHz. The noise was found to fall within the frequency band used for ADSL signals (28 kHz–3.75 MHz). This particular test case therefore clarified that the superposing of the noise on the signal resulted in a dropped link of the ADSL line. Additionally, we found that the separation probe used in this test and other tests was effective for quickly checking for noise and reducing the time required to troubleshoot faults. In this test case, moreover, the signal voltage level was 9 Vp-p, which was much higher than the noise voltage level

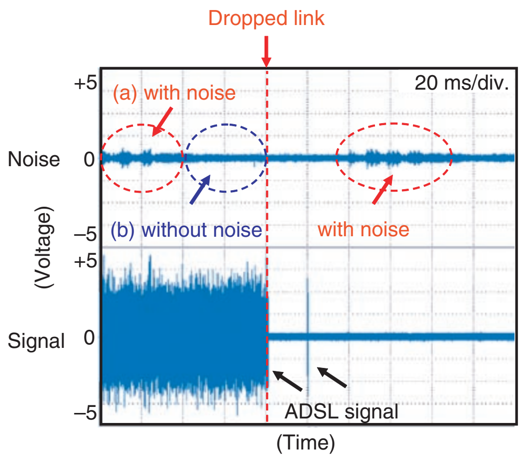

Fig. 10. Waveforms measured by separation probe.

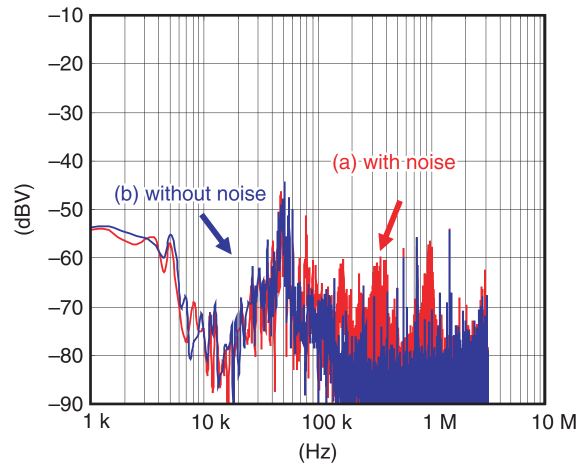

Fig. 11. Comparison of FFT analysis results.

of 1 Vp-p. This suggests that use of the conventional method would make it difficult to check for the presence of noise at such a low level and would require more time to troubleshoot the cause of the fault.

5. Conclusion

We developed a probe for separating noise from a telecommunication signal and tested it in both the laboratory and the field using ADSL lines. Test results showed that the separation probe was effective in extracting the noise component even if the noise level was lower than that of the signal. In the future, we plan to conduct more evaluations in the field to improve the accuracy of the probe and to study the feasibility of commercializing it. We are committed to developing methods for quickly solving noise faults and will continue to carry out work that supports the provision of safe and secure telecommunication services.

Reference

[1] Y. Ogura, K. Tominaga, Y. Okugawa, H. Itou, and K. Murakawa, “Experimental studies of separation between telecom signal and noise of common mode noise,” IEICE Technical Reports, Vol. 112, No. 201, EMCJ2012-58, pp. 35–40, 2012 (in Japanese).

External Awards

International Workshop on Nitride Semiconductors 2012 Best Paper Award

Winners: Yoshitaka Taniyasu†1, Jean-François Carlin†2, Antonino Castiglia†2, Raphaël Butté†2, and Nicolas Grandjean†2

†1 NTT Basic Research Laboratories

†2 Ecole Polytechnique Fédérale de Lausanne

Date: October 19, 2012

Organization: International Workshop on Nitride Semiconductors

For "AlInN/GaN MQW UV-LEDs".

Among III-Nitride semiconductors, the AlInN can only be grown lattice-matched to GaN. The lattice-matched AlInN/GaN structure should be free from cracks and strain-driven defects, which limit the performance of UV/Visible LEDs and LDs using conventional lattice-mismatched AlGaN/GaN and InGaN/GaN structures. In addition, the AlInN/GaN structure has a larger bandgap discontinuity and a larger refractive index contrast, which more strongly confine the injected carriers in the quantum wells and the emitted light in the active region. Thus, the AlInN/GaN structures are expected not only to improve the device properties but also to increase the design flexibility for novel III-nitride devices. Here we report the achievement of p-type doping in AlInN and describe AlInN-based light-emitting devices.

Fellowship in the American Physical Society

Winner: William John Munro, NTT Basic Research Laboratories

Date: November 3, 2012

Organization: American Physical Society

For his extensive contributions to applied quantum information.