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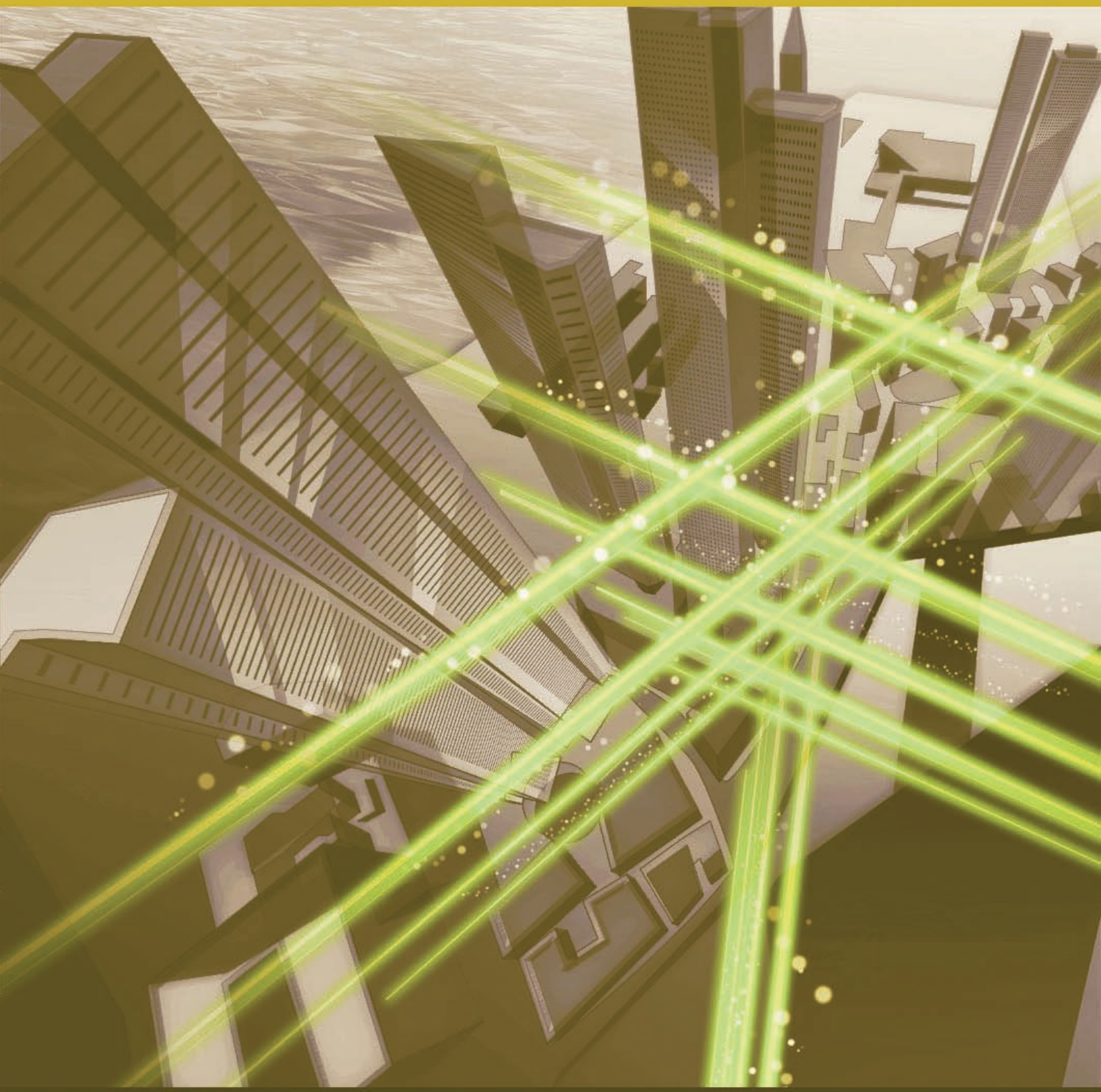

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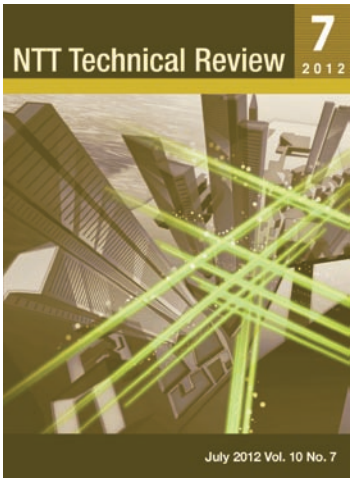


Aim for the "Only One" by Strengthening Advantages Rather Than Overcoming Disadvantages

Seishi Takamura
Distinguished Technical Member
NTT Media Intelligence Laboratories

Seishi Takamura is a Distinguished Technical Member who has approached video encoding research with creative thinking and received remarkable attention from various fields. We asked him to give us an easy-to-understand explanation of video encoding and to give us some insight into the circumstances that give rise to his way of thinking and how he nurtures such thinking. We also asked for some specific suggestions on how to bring ideas to fruition.

Evolutionary video encoding is a made-to-order video compression technology for a richer life

—Would you tell us something about your current research?

What I'm working on now is called evolutionary video encoding. Transmitting digital video data takes a lot of time and accumulating it in personal computers consumes a lot of their capacity because it is so voluminous (**Fig. 1**). One way around that problem is to compress the data, and my work is to develop video compression technology.

Until now, all types of video have been compressed by the same technology and methods, but what we are working on is the application of compression methods that are appropriate for each particular video. By analogy to clothing, past technologies are like ready-made suits, but what we are aiming for is made-to-measure technology tailored to the video.

Examples of current compression technology are JPEG for still images and H.264 for video (**Fig. 2**). There is also discussion in international standardization activities on HEVC (high efficiency video coding), which aims for double the compression efficiency of H.264. However, each compression technology uses the same algorithm for all types of video.

To achieve even higher compression efficiency, however, we can easily imagine that we should select the compression algorithm best suited for the particular video. For example, the most suitable algorithm differs for video of people and video of scenery. It is impossible to choose the optimal algorithm for each case manually, so we are investigating processing based on a computer algorithm that selects the optimal compression automatically. Moreover, that computer algorithm evolves over time, so we achieved a predictive equation that no human could have produced. We call that evolutionary video encoding.

Although evolutionary video encoding attains a higher compression ratio over time, it is currently still too slow for practical use. Now that we have proven that it is possible in principle, our research will focus

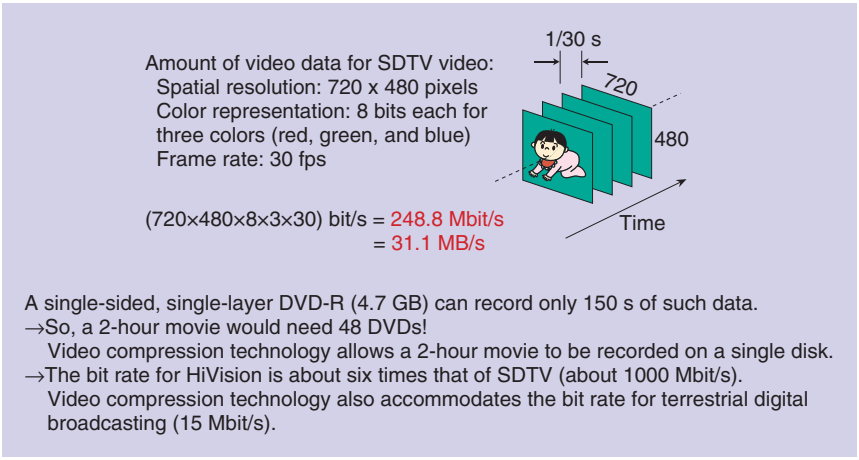


Fig. 1. Need for video compression.

- Personal computer image data (JPEG, MPEG-2, etc.)
- Digital camera (JPEG)
- Digital video camera (MPEG-2, H.264, etc.)
- Terrestrial and satellite digital broadcasting (MPEG-2)
- 1-seg broadcasting (H.264)
- DVD recorder (MPEG-2)
- Blu-ray disc (MPEG-2, H.264, VC-1)
- Internet video distribution (H.264 etc.)
- Videophone (MPEG-4 etc.)
- Digital cinema (JPEG 2000) etc.

Fig. 2. Examples of image compression technologies in use.

on shortening the processing time (**Fig. 3**).

If we can make this technology practical, we will be able to exchange video data rapidly and also be able to store even more video data on a single disc. It will also let us enjoy a more vivid video experience.

You do not choose a place to do research. You gain a firm grasp of basic knowledge and past methods and do the work with care and deliberation.

—What inspired you to do this research?

When I heard a lecture on evolutionary image processing given by Professor Nagao at the Yokohama National University, it made me wonder if that idea could somehow be applied to compression technology. It was about ten years ago. Five years later, a specific plan occurred to me when I was considering research topics and concepts for a freshman researcher.

—Was there some aspect of your work that was particularly hard?

The pressure is great and that can certainly be hard on the researcher, but I wouldn't go as far as to call it a hardship. Results and productive research are very important, and the strain involved in continuously producing results is great.

We cannot simply give up when things do not go well; all we can do is to have faith in ourselves and press on. Looking back on my research process and experience, it seems that I have mostly been clear-headed in my work. Nevertheless, it seems that there is a lot that I have forgotten. In research, it is not unusual to encounter problems that we cannot handle well even when we try hard to apply different kinds of knowledge. I don't think that it is appropriate to call that failure. It is important and necessary in research to know how to set milestones. A good track record in setting deadlines is probably important in any line of work. Nevertheless, when I was unable to keep to the milestones, then rather than giving in to perplexity, I chose to clear my mind to think and deal with the problem and move forward.

For example, sometimes I come up with a good idea for solving a problem while I'm not in the workplace.

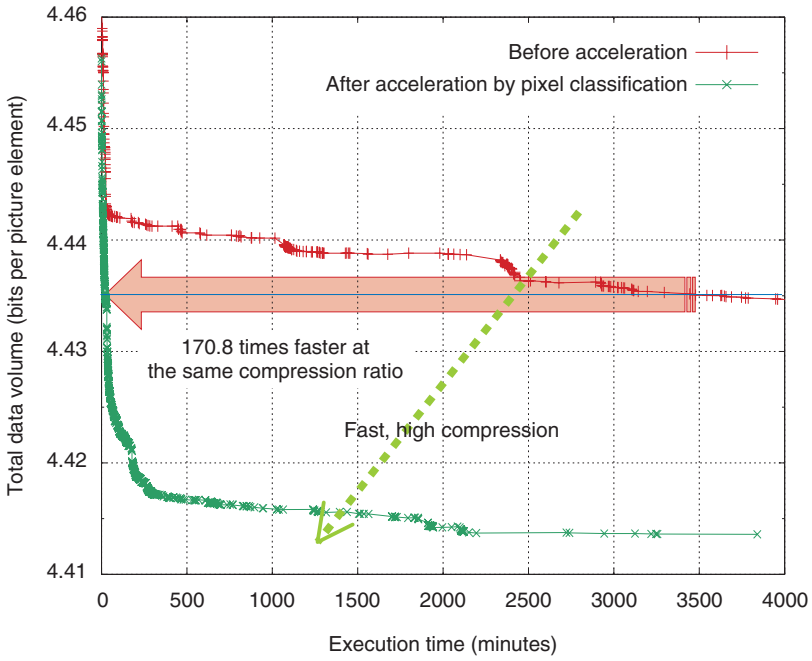


Fig. 3. Example of accelerated evolution.

About ten years ago, I was struggling with a certain problem and thinking about it from different angles, but could not think of a good solution. Then, one Sunday while I was lying on a beach at the Kamakura seashore near home, a solution flashed into my mind. That idea actually worked, and it led to my receiving the Niwa-Takayanagi Best Paper Award from the Institute of Image Information and Television Engineers.

Many researchers probably say this, but even when I am away from my research work, research is not absent from my mind.

Looking at it the other way, although there is some work that must be done at the workplace or other particular location, you do not have to be selective about where to conduct experiments in your head. For that, it is only important to be thoroughly familiar with various kinds of basic knowledge and methods.

To regard your own field of specialization as simply something to study and understand will not produce good results. I think a good approach is to do careful thought experiments first. Such thought experiments prior to the execution of an idea will fail to provide guidance unless you have various types of knowledge in your mind. Of course, it is also true that most of the time you do not know the outcome until you actually try it.

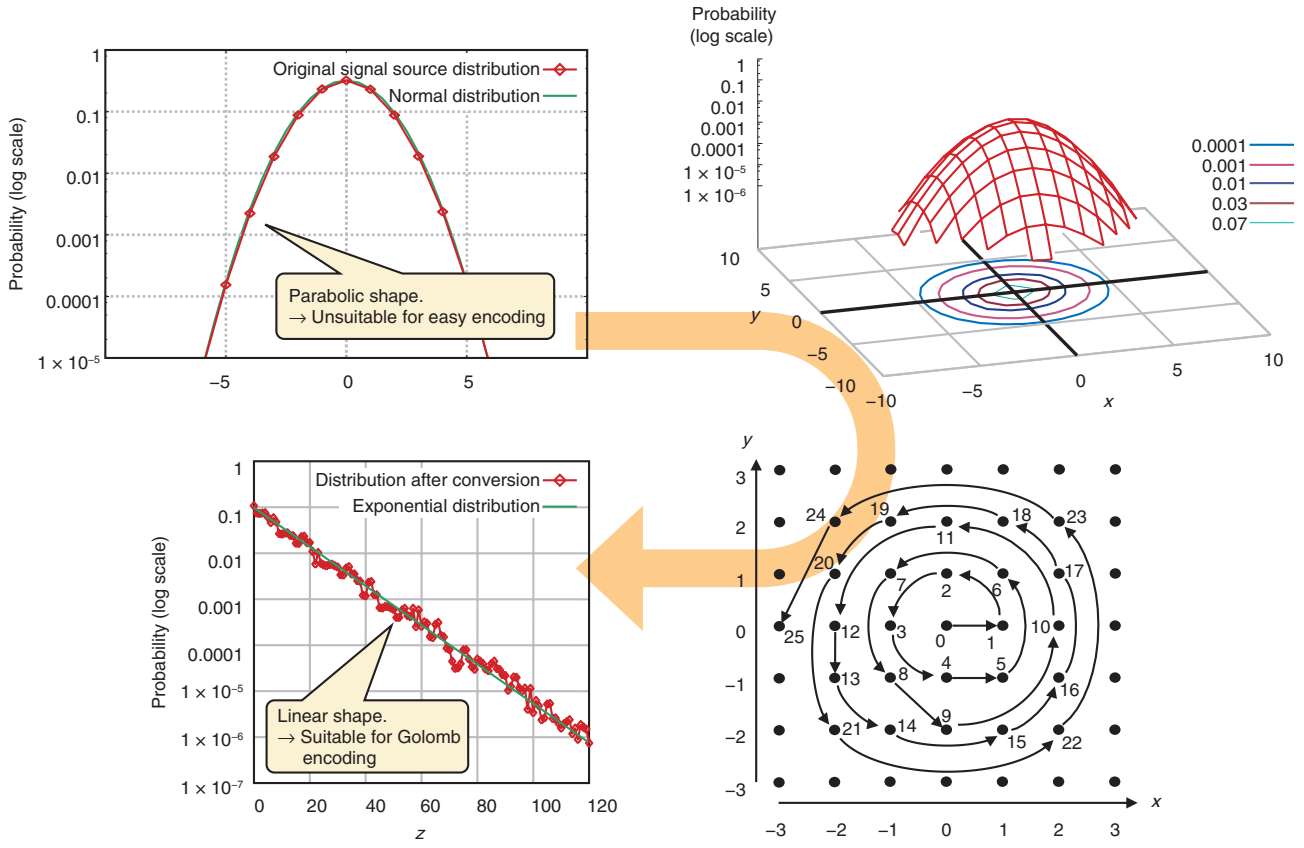
Incidentally, a happy time for me is when doing various thought experiments while I'm in bed at night and ready for sleep. I also like to do programming while riding trains or buses.

We should apply our energy to praise and encouragement rather than hardship

—So, you think that even hardship is not really a hardship. Could you tell us something of your moments of joy?

Four years ago at an image encoding symposium in Japan, I gave the first presentation on evolutionary video encoding—the topic I am working on now. At an informal get-together after the presentation, a number of people who had heard my talk came up to me and made laudatory comments, such as saying that my talk was interesting or gave them a strong impression. I was also delighted to receive the highest award of that symposium for my talk.

At the same time, I received encouragement for my idea. There was one thing unrelated to evolutionary video encoding that stimulated their interest greatly. It was the idea of how the difficulty of highly efficient encoding of normally distributed data could be overcome by arranging the data in a two-dimensional



A signal source having a normal distribution is difficult to encode as it is. However, for pairs of signal sources (upper right), assigning numbers (corresponding to z in the graph in the lower left) around the center in a spiral path (lower right) allows a reversible conversion to an exponential distribution, which is suitable for data compression by Golomb encoding (lower left).

Fig. 4. Highly efficient encoding of the signal source according to a normal distribution.

lattice and taking values in a spiral shape beginning at the center. Doing that converted a normal distribution, for which highly efficient encoding is possible but difficult, into an exponential distribution, for which efficient encoding is easier (**Fig. 4**). That idea was praised as beautiful by Professor Bernd Girod, an authority on media coding at Stanford University, and others. It also led to a Yamashita Memorial Research Award from the Information Processing Society of Japan.

I've also heard the words, "This is great." many times coming out of nowhere.

While I am very happy to receive praise directly in this way, when I hear of a good evaluation second-hand, from an unexpected source, it is truly pleasant and encouraging.

—My impression is that you find joy rather than worry to be more of a stimulation in life. From your experience, what advice do you have for the young researchers.

I believe that young researchers pass their days being too busy. When one thinks about it later, the younger you are, the more time you have to spend for your research. For example, I am now often away from home on business, either in Japan or abroad, so on days off I spend my time going out with my family and enjoying being with them. Also, to be with my three children while they are small, I usually leave work at 6:30 pm. Even if I'm not able to have dinner with them, I still put priority on time shared with them in other ways. Looking at this as a common thing, I think that you have more time to spend for pursuing your own research when you are in your youth.

Although I, too, may fail to recognize when there is time to use for research, I will try to describe my

ideas of how to be a researcher.

- Aim for the highest: Always target the optimum, the theoretical best. Even though it is often not actually attainable, we can set that as our goal.
- Value the fundamentals: As I mentioned before, make it a policy to do careful thought experiments before trying to implement an idea. Build a foundation of knowledge that allows you to do that by reading many technical papers and books.
- Develop the ability to implement programs: For most things, we do not know until we try. In such cases, I think it is most effective to implement them in your own mind, and I am sure no one else can do that more effectively.
- Understand your own motivations: In my case, being able to do research is my motivation, not money. The expression, "researcher is not an occupation, but a kind of person", is one for which I have a lot of sympathy. In any research, no matter how much time you spend, there is no limit to what can be produced. We should probably not think of research in terms of cost or time effectiveness.
- Extend your strong points: It is good to overcome our weaknesses to a certain extent, but I have come to understand from my experience that to bring about the only one, the only path to follow is to extend our strengths. So, please have confidence in yourself. Good results come from tackling problems with the attitude that "I know I can do it!"

I will use these tips as the basis for my own ongoing endeavor to master encoding research. I would like to continue to help more young people enter the world of research and develop into mature researchers. Leadership is not one of my strengths, but I believe that helping and showing how I, as a researcher, grapple with my own research is something that I can do.

Seishi Takamura

Distinguished Technical Member, Senior Research Engineer, Supervisor in the Video Coding Group of NTT Media Intelligence Laboratories.

He received the B.E., M.E., and Ph.D. degrees from the Department of Electronic Engineering, Faculty of Engineering, the University of Tokyo in 1991, 1993, and 1996, respectively. His current research interests include efficient video coding and ultrahigh quality video coding. He has fulfilled various duties towards the research and academic community in current and prior roles such as: Associate Editor of IEEE Transactions on Circuits and Systems for Video Technology, Technical Program Committee Chair of the IEEE Tokyo Section, the Institute of Electronics, Information and Communication Engineers (IEICE) Image Engineering SIG Secretary and Director—Technical Relations of the Institute of Image Information and Television Engineers (ITE). From 2005 to 2006, he was a visiting scientist at Stanford University, California. He has received 21 academic awards including the ITE Niwa-Takayanagi Best Paper Award in 2002, Information Processing Society of Japan (IPSJ) Nagao Special Researcher Award in 2006, and PCSJ Frontier Awards in 2004 and 2008. He is a senior member of IEEE and IEICE and a member of MENSA, IPSJ, the Institute of Image Electronics Engineers of Japan, and ITE.

IEEE802.11n Wireless Local Area Network Troubleshooting Tool with Electromagnetic-environment Monitoring Function

Abstract

NTT EAST Technical Assistance and Support Center has developed a wireless local area network (WLAN) troubleshooting tool equipped with an electromagnetic-environment monitoring function that can visualize the signal strength and electromagnetic interference conditions of IEEE802.11n WLANs.

1. Introduction

Each revision of the IEEE802.11 wireless local area network (WLAN) standard has provided expanded functions in addition to higher communication speeds. It is implemented not only in personal computers but also in smartphones and other types of personal digital assistants. A tool for visualizing problems with IEEE802.11a/b/g WLANs has already been reported [1]. With the growing demand for higher WLAN speeds in both office and home environments, IEEE802.11n has become mainstream owing to its use of multiple-input and multiple-output (MIMO) technology and higher speeds achieved by expanding the channel bandwidth. The home gateway supporting the HIKARI DENWA function of the FLET'S HIKARI optical IP telephony service provided by NTT EAST and NTT WEST also supports IEEE802.11n (IP: Internet protocol).

IEEE802.11n achieves high speeds by using MIMO spatial multiplexing technology and by expanding the channel bandwidth by utilizing the 2.4-GHz and 5-GHz bands. The 2.4-GHz frequency band, which is also called the industrial, scientific and medical (ISM) band, is used for communication systems such as Bluetooth and ISM equipment such as microwave ovens and microwave medical treatment devices. Electromagnetic waves emitted from such communication systems and ISM equipment have the potential to affect WLAN communications using the 2.4-GHz band. Therefore, a channel free from electromagnetic interference should be selected so that the high-speed performance of an IEEE802.11n WLAN can be used to the maximum.

Furthermore, in addition to 20-MHz-bandwidth communications, the same as in the IEEE802.11a/b/g standard, IEEE802.11n supports 40-MHz-bandwidth high-speed communications by bundling two 20-MHz IEEE802.11a/b/g channels. However, 40-MHz-bandwidth communications—especially in the 2.4-GHz band—can easily encounter interference from electromagnetic waves emitted by other communication systems or ISM equipment as well as interference from IEEE802.11b/g WLAN signals on adjacent channels.

Against this background, NTT EAST Technical Assistance and Support Center developed an IEEE802.11n WLAN troubleshooting tool in fiscal year 2010. This tool is equipped with an electromagnetic-environment monitoring function for visualizing IEEE802.11n WLAN signal strength and electromagnetic interference conditions. This article describes the IEEE802.11n channel configuration and the electromagnetic-environment monitoring function of this WLAN troubleshooting tool.

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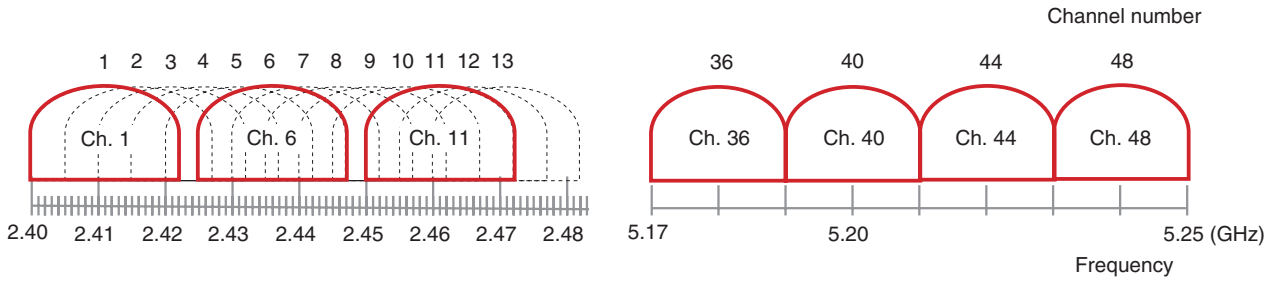


Fig. 1. Channel configuration (20-MHz bandwidth).

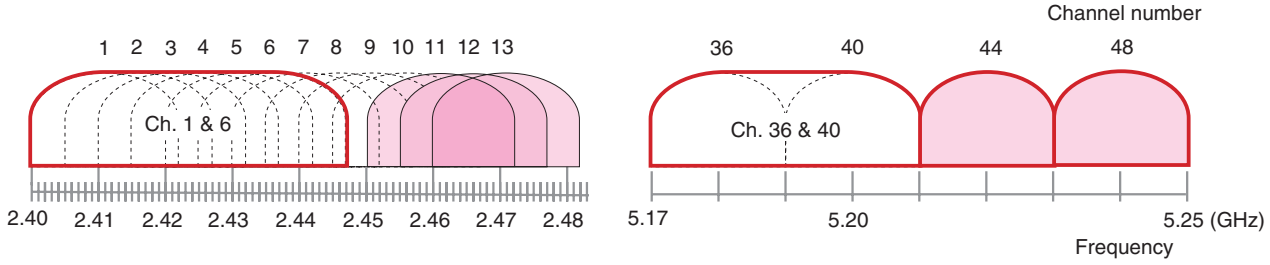


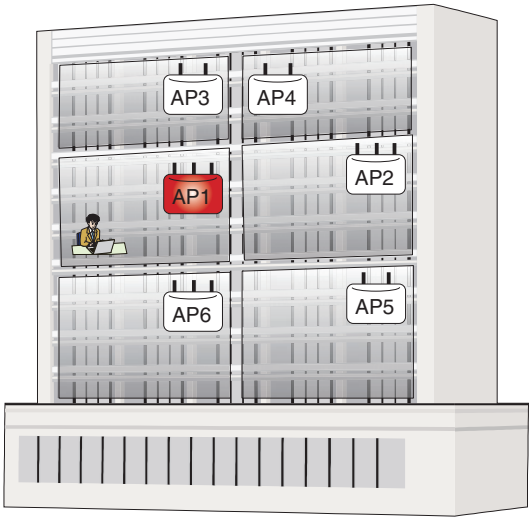
Fig. 2. Channel configuration (40-MHz bandwidth).

2. IEEE802.11n channel configuration

The channels allocated to IEEE802.11n WLANs consist of 13 channels in the 2.4-GHz band and 19 channels in the 5-GHz band. Each channel has a bandwidth of 20 MHz (strictly speaking, 22 MHz in the 2.4-GHz band). As shown in **Fig. 1**, the configuration of the 2.4-GHz band differs from that of the 5-GHz band in that adjacent channels overlap at 5-MHz intervals in the former while channels are independent of each other at 20-MHz intervals in the latter. Thus, when the 2.4-GHz band is used, the channels being used should be separated by at least five channels, as in channels 1, 6, and 11. Failure to do so could result in inter-channel interference.

Furthermore, interference can also occur as a result of IEEE802.11n 40-MHz-bandwidth high-speed communications using two bundled 20-MHz-bandwidth channels. For example, when channels 1 and 6 are bundled, interference can occur from 20-MHz-bandwidth communications using channels 1–10 (no interference occurs with channels 11–13), as shown in **Fig. 2**. Similarly, when the 5-GHz band is used and channels 36 and 40 are bundled, interference can occur from 20-MHz-bandwidth communications using either channel 36 or 40.

Therefore, to make best use of the performance available with IEEE802.11n, there is a need to understand three types of interference conditions and to set channels accordingly to prevent such interference from occurring as much as possible. To begin with, just as in the case with IEEE802.11a/b/g, measures must be taken against (1) same-channel interference caused by signals from another WLAN system using the same channel and (2) adjacent-channel interference caused by signals from another WLAN system using adjacent, overlapping channels. In addition, measures must also be taken against (3) channel interference unique to 40-MHz-bandwidth high-speed communications caused by signals from 20-MHz-bandwidth WLAN signals. Incidentally, the maximum transmission speed in 40-MHz-bandwidth communications is 300 Mbit/s, but that could drop to 144.4 Mbit/s because the occurrence of this third type of channel interference would lead to a reversion to 20-MHz-bandwidth communications.



AP: access point

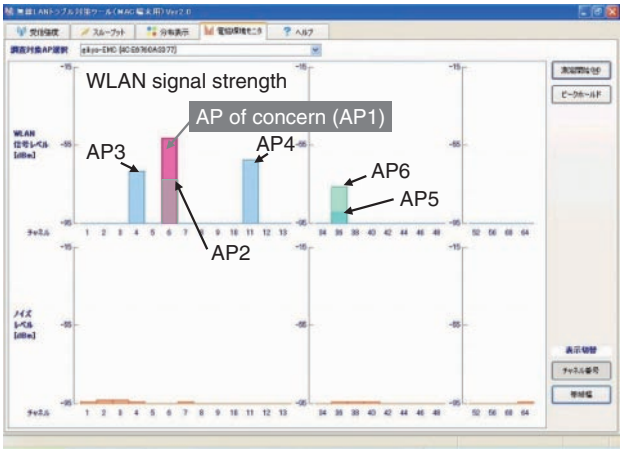
Fig. 3. WLAN access point environment.

3. IEEE802.11n electromagnetic-environment monitoring function

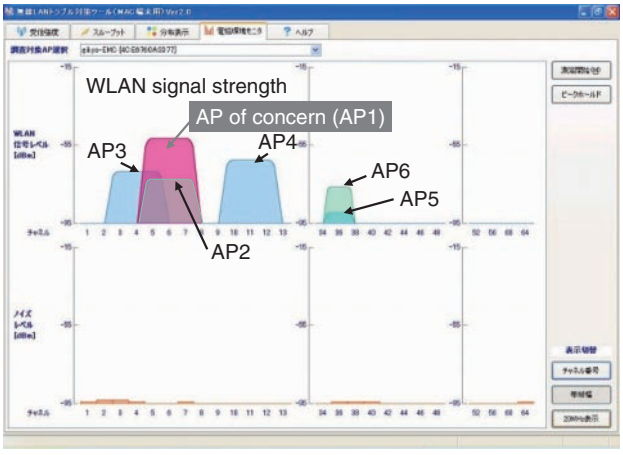
This section describes the electromagnetic-environment monitoring function incorporated into the WLAN troubleshooting tool. The purpose of this function is to visualize the state of interference of the abovementioned three types. This section presents some results of monitoring conditions in an environment containing six WLAN access points (**Fig. 3**).

The electromagnetic-environment monitoring function can display results by channel number or by bandwidth (**Fig. 4**). As shown in Fig. 4(a), the channel-number display mode shows the signal strength of access points AP1–AP6 for each channel. Here, the access point signal strengths are shown in a stacked manner if more than one access point is using the same channel. These results reveal that AP1 is receiving same-channel interference from AP2.

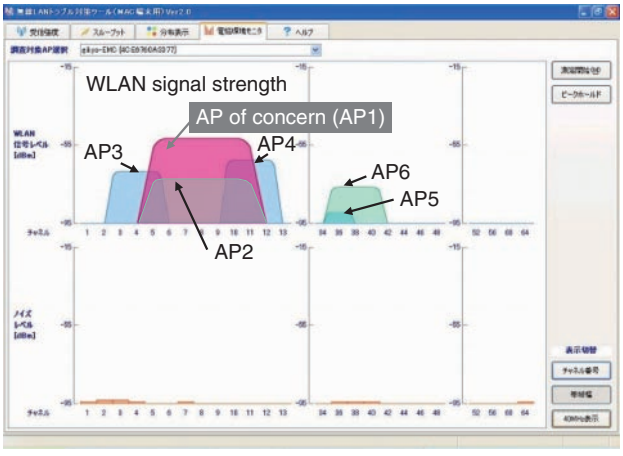
By contrast, the bandwidth-display mode shows WLAN signal strength according to bandwidth. Figure 4(b) shows the results of monitoring conditions for 20-MHz-bandwidth communications. This display mode can visualize adjacent-channel interference and shows, specifically, that AP1 signals are being affected by those of nearby access point AP3. Figure 4(c), on the other hand, shows the results of monitoring conditions for 40-MHz-bandwidth high-speed communications. AP1 signals are being affected by AP4 signals using channel 11.



(a) Display by channel number



(b) Display by bandwidth (20 MHz)



(c) Display by bandwidth (40 MHz)

Fig. 4. Screenshots of the electromagnetic-environment monitor.

4. Conclusion

The WLAN troubleshooting tool presented here makes it easy to determine the presence of interference that can affect WLAN signals, including those of the IEEE802.11n standard. This tool is expected to shorten the time taken to troubleshoot WLAN problems.

Reference

[1] "Visualization of Problems with Wireless Local Area Networks," NTT Technical Review, Vol. 9, No. 12, 2011. https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201112pf1.html

Case Studies of Faults and Countermeasures in a Passive Optical Network System

Abstract

This article reports faults unique to an optical access system based on passive optical networks (PONs). It presents (1) communication trouble caused by abnormal signal light emission from an uncontrolled optical network unit (ONU) and (2) facility trouble involving fatal damage to an optical fiber end surface of the connector used for video delivery services over a transmission line. It also describes appropriate countermeasures for these faults.

1. Introduction

The demand for three kinds of service (Internet service, Internet telephone service, and video delivery service) is growing and the number of network facilities is increasing rapidly as the penetration of optical broadband services accelerates. NTT supplies these services, which are called FLET'S HIKARI, to customers via passive optical networks (PONs). A typical configuration of access network facilities from the central office to a customer's house is shown in **Fig. 1**.

Today's optical access facilities provide ultrahigh-speed communication services and video delivery services to multiple customers over one optical fiber. Gigabit Ethernet PON (GE-PON) is a technology that provides ultrahigh-speed communications at 1 Gbit/s in the access segment. The GE-PON is capable of communicating using the Internet protocol (IP) data method. A GE-PON optical line terminal (GE-PON OLT) in the central office provides Internet connection services and IP telephone services through IP data communications to the GE-PON optical network unit (GE-PON ONU) in the customer's house. The GE-PON communication uses two wavelengths: 1.49 μm and 1.31 μm in the downstream and upstream directions, respectively. In addition, a visual-OLT (V-OLT) transmits video delivery services (called FLET'S TV by NTT) using the 1.55-μm wavelength band in the downstream direction. Optical signals from both the GE-PON OLT and the V-OLT are multiplexed in a splitter that has a function for wavelength division multiplexing (WDM) and delivered to customers via a single optical fiber and those signals are demultiplexed with a wavelength-division demultiplexer (labeled WDM in Fig. 1) in the customer's house.

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2. Case studies

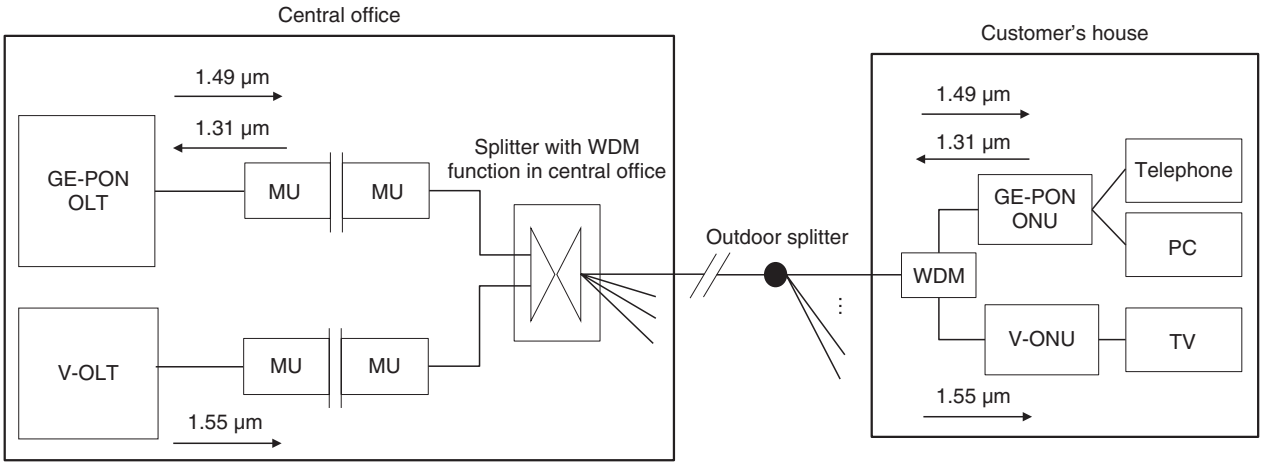
2.1 Case 1: Fault caused by abnormal light-wave emission from uncontrolled ONU

2.1.1 Fault description

There was an unique fault in the GE-PON system, which was reported at the same time by a number of customers. The NTT fault reception department checked facility information and alarm conditions on the operations system and discovered "upstream-error-rate deterioration" and "service immobilization" alarms for multiple ONUs. During trouble-shooting, it was found that disconnecting a certain ONU from the system (such as by turning off its power or unplugging its optical cord) would restore the other ONUs where faults had occurred.

2.1.2 Cause of fault

An investigation of this disconnected ONU revealed that when power was applied to it, it generated a steady output of a continuous wave (CW) signal at a wavelength of 1.31 μm with a power level of +2 dBm. It was inferred that this CW signal affected the other ONUs administered by the same PON OLT interface



MU: miniature universal coupling optical connector
PC: personal computer
TV: television set

Fig. 1. Typical configuration of access network facility.

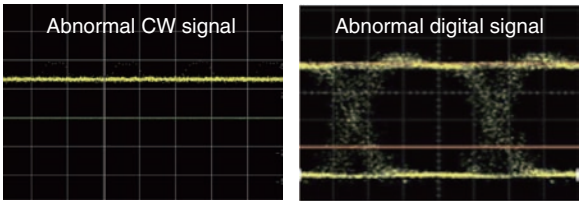


Fig. 2. Abnormal CW signal and abnormal digital signal waveforms output from faulty ONUs.

package.

In another similar fault case, we also discovered abnormal optical digital signal emission from an uncontrolled ONU, which incessantly output a 1.31-μm optical digital signal. Examples of the waveforms of the abnormal CW signal and the abnormal digital signal of faulty ONUs are shown in **Fig. 2**.

The cause of this particular fault can be explained as follows. Ignoring OLT control because of faulty operation, the faulty ONU output a continuous upstream signal (CW signal) that was overlaid on the upstream signals from other ONUs allocated by the same PON-OLT interface package (**Fig. 3**). This prevented the OLT from identifying all of the ONUs and resulted in the generation of upstream-error-rate-deterioration and service-immobilization alarms.

2.1.3 Countermeasure

The generation of upstream-error-rate-deterioration and service-immobilization alarms in multiple ONUs allocated by the same PON-OLT interface package suggested that the fault might have been caused by an ONU with abnormal light-wave emission. In this case, simply arranging to exchange the ONUs reported to be experiencing problems would not have resulted in their restoration and might only have prolonged the situation. To troubleshoot such a problem as quickly as possible, one must begin troubleshooting at the OLT-side 4-branch splitter in the central office. Specifically, the optical fiber connectors for the four paths at the integrated distribution module (IDM) must be physically disconnected in turn, power from the connector must be detected using a power meter, and the connector where the faulty ONU is connected must be identified (**Fig. 4**).

Under these circumstances, a normally operating ONU cannot launch signal light if it is disconnected

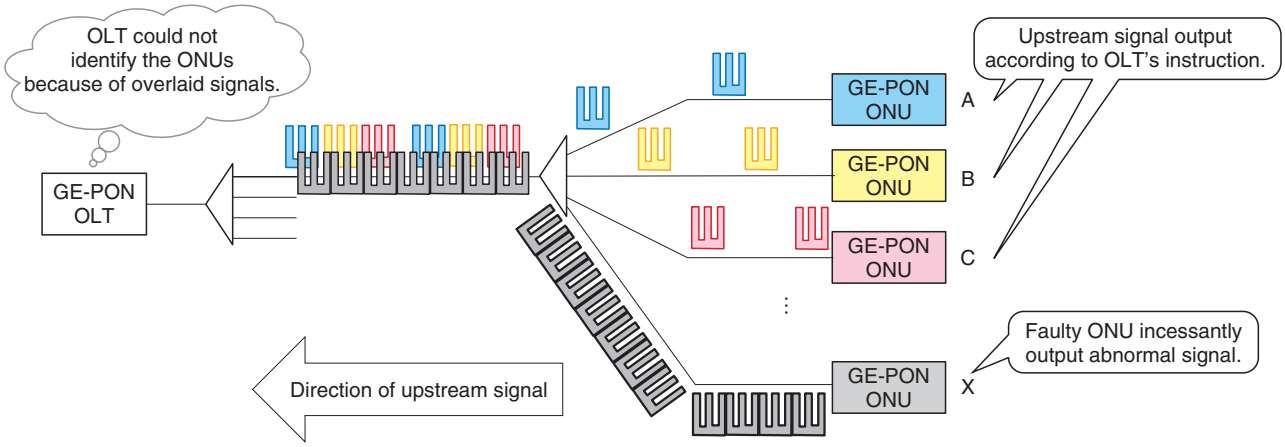


Fig. 3. Upstream signal from faulty ONU.

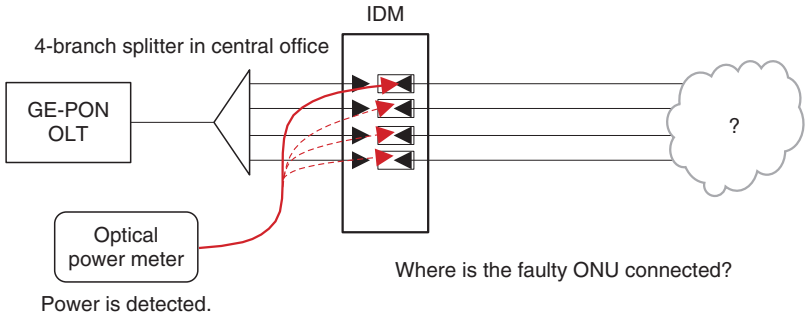


Fig. 4. Troubleshooting procedure at an IDM in the central office.

from the OLT. The absence of received optical power here would therefore indicate normal ONU operation. By contrast, the presence of received optical power would indicate that the faulty ONU with abnormal signal light is connected to the optical fiber connector. Next, on the OLT-side of the outside 8-branch splitter, one must disconnect the eight optical fiber connectors in turn and identify as described above and check each connector for received optical power from that ONU using an optical power meter. Finally, once the faulty ONU has been located, it can be exchanged with a normal one to complete the repair procedure (**Fig. 5**).

Before an optical fiber connector at the IDM or outside 8-branch splitter is reconnected, its optical connector plug or adaptor must be cleaned.

2.2 Case 2: Fatal damage to optical fiber end surface of the connector

2.2.1 Fault description

This case study involved a miniature universal coupling (MU) connector on an IDM-B used for video delivery services (FLET'S TV). At the beginning of installation of intra-office equipment (V-OLT), the received power level at the MU connector was found to be +17 dBm. After a while, when it was re-measured upon connection. it was found to be +12 dBm. The insertion loss at the MU connector increased to about 5 dB. The facility configuration in which this fault occurred is shown in **Fig. 6**. The insertion loss did not improve even after the optical fiber end surface of the MU connector had been carefully cleaned, so an investigation into the cause of the fault was conducted.

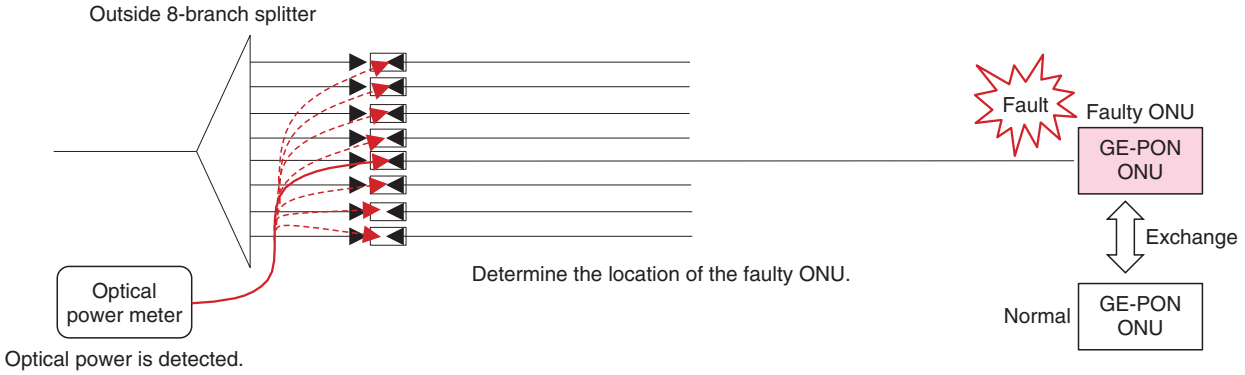


Fig. 5. Troubleshooting procedure at an outside 8-branch splitter.

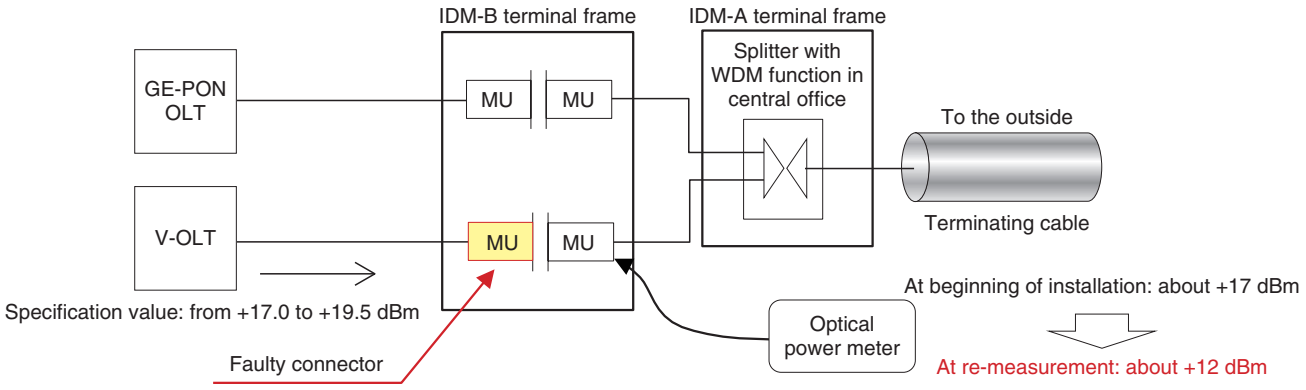


Fig. 6. Facility configuration for case 2.

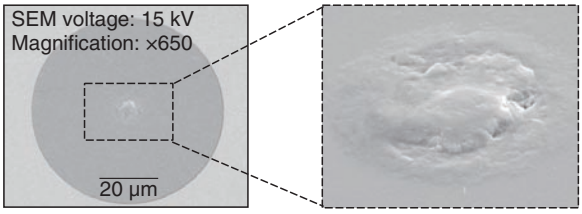


Fig. 7. Results of SEM inspection.

2.2.2 Cause of fault

The investigation began with optical characteristics. The return loss at the end of the faulty connector in air was found to be abnormal at about 39 dB compared with about 14 dB for a normal connector; moreover, the loss when connected was also large at about 5 dB, as mentioned above. Next, the connector was dismantled and the connector ferrule end surface was inspected using a scanning electron microscope (SEM). This revealed signs of fatal damage caused by silica-melting in the core section (**Fig. 7**).

An experiment was conducted to reproduce the fault: light from the V-OLT was injected into the connector and the tip of the MU connector was exposed to various types of contamination from oily hands, clothes (work shirts), dust, etc. It was found that fatal damage caused by silica-melting occurred in the core section and that the loss increased in the case of all of these types of contamination, but that the signs of damage observed for contamination by oily hands and clothes most closely resembled the characteristics seen in this case study. It was therefore inferred that the high optical power of the V-OLT equipment was converted into heat by the contamination on the optical fiber end surface of the connector and that this led to the silica-melting in the core section.

Fig. 8. Examples of cleaning with specialized cleaners.

2.2.3 Countermeasure

It is important to eliminate contamination from a connector end surface by using a cleaner. Specifically, it is essential to clean an optical connector plug and adaptor using specialized cleaners before connecting them (**Fig. 8**).

3. Conclusion

This article presented case studies of faults and countermeasures in a PON system. The Technical Assistance and Support Center, NTT EAST Corporation will continue in its efforts at technical consulting and fault analysis with the aim of maintaining a safe and secure network for its customers.

Gigabit-compatible Protocol Checker

Abstract

NTT EAST Technical Assistance and Support Center has developed a protocol checker that has gigabit-per-second ports as a tool for troubleshooting IP-related faults within a customer's residence (IP: Internet protocol). This protocol checker, which can be easily installed inside the residence by a simple procedure, features remote login and straightforward protocol checking functions. It is a promising device for investigating the causes of IP-related phenomena that have low reproducibility.

1. Introduction

Home networks are reaching the gigabit-per-second level as in NTT's FLET'S HIKARI NEXT broadband access service [1], and the ways that customers use Internet protocol (IP) services are going beyond triple-play services to include network-based games, multipoint connections via a virtual private network (VPN), and other formats. As a consequence, a greater variety of IP-related faults is occurring. In particular, the following types of faults are showing a noticeable increase.

- Faults caused by devices installed by the customer (network equipment not installed by NTT)
- Nonrecurring or infrequently occurring faults.

To research the causes of these two types of faults, we developed a gigabit-compatible protocol checker (**Fig. 1**), which has gigabit-per-second ports. It can be easily installed inside a residence to perform packet capture and remote maintenance. Moreover, its packet capture function can handle the high-speed version of FLET'S HIKARI NEXT [2].

2. Functions

This protocol checker is a piece of hardware equipped with two gigabit-per-second ports for mirroring purposes and one local area network port for remote access. Equipment specifications are listed in **Table 1**.

In addition to a packet capture function, the protocol checker includes several functions that facilitate troubleshooting within a residence and simplify long-term monitoring. These functions are summarized below and shown in **Fig. 2**.

(1) Packet capture function: Packet capture can be performed by simply pressing the Start button on the top panel of the protocol checker. A hold function is also provided to prevent erroneous operation during the capture process and for reassurance to any customers concerned about installing the protocol checker.

(2) Remote connection/maintenance function: This function enables the protocol checker to be remotely controlled from the maintenance center via a preset connection to a remote server after the protocol checker has been installed at the site having the fault to be repaired. It automatically establishes a VPN with the server at the maintenance center by using point-to-point tunneling protocol (PPTP).

(3) Automatic transfer function: This function automatically transfers packet-capture files to the maintenance center, thereby eliminating any

Fig. 1. External view of gigabit-compatible protocol checker.

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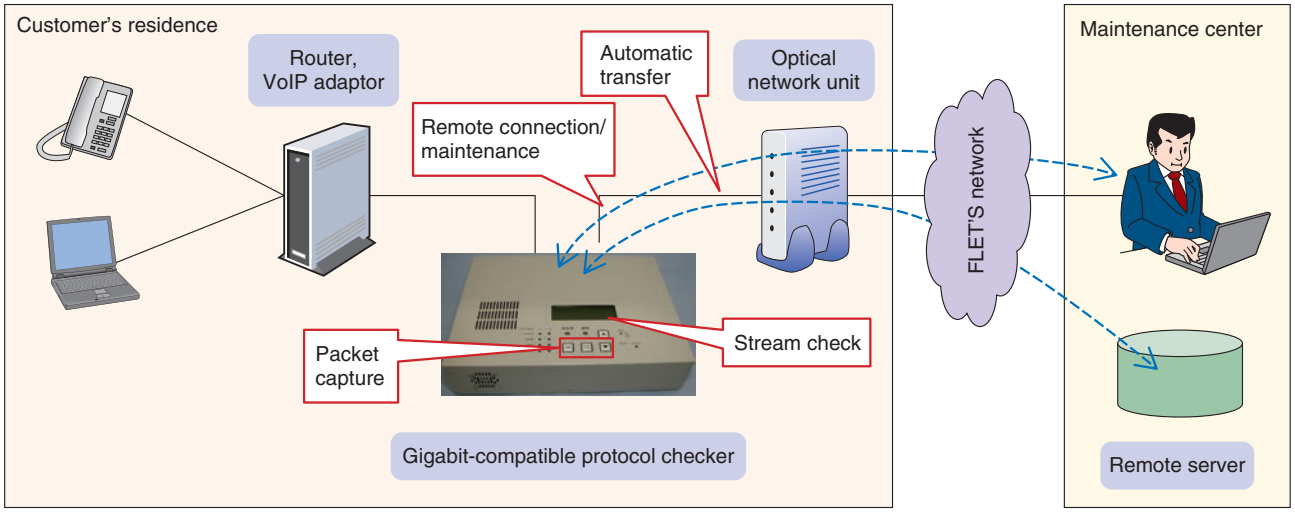
Table 1. Specifications of gigabit-compatible protocol checker.

		Specifications	
Interface	Ethernet	Quantity	Ports for circuit measurement: 2 (Port A, Port B) Ports for management purposes: 1
		Standards	1000BASE-T, 100BASE-TX, 10BASE-T (conforms to IEEE802.3ab, IEEE802.3u, IEEE802.3), RJ-45 (8-pole modular)
	USB	Quantity	1 port
		Standard	USB 2.0 (standard A receptacle)
Data storage function		128-GB SSD memory (packet capture area: about 100 GB)	
Packet capture performance		200 Mbit/s	
Setting functions		Buttons (Up/Down keys, Start/Stop keys, Ok key, Reset key) Dip switches (Hold switch, setting switches for circuit-measuring ports)	
Display functions		Liquid-crystal panel	Monochrome (4 rows × 20 characters)
		LED lamps	Link lamp, access lamp, judgement lamp
Power supply (power consumption)		DC 12 V (about 30 W max.)	
External dimensions (weight)		W 265 mm × D 195 mm × H 55 mm (about 1.7 kg)	

Dip: dual-inline package
LED: light emitting diode
SSD: solid-state drive
USB: universal serial bus



VoIP: voice over IP

Fig. 2. Usage scenario of gigabit-compatible protocol checker.

fears of exceeding the SSD capacity during long-term monitoring.

(4) Stream check function: For audio and video services, this function stores packet loss counts and detects jitter that exceeds user-defined threshold values without accumulating captured data. It can also illuminate red lamps on the protocol checker unit and output a log.

The protocol checker's circuit-measurement ports can also detect frame check sequence (FCS) error frames.

3. Performance

Packet capture in a gigabit (gigabit-per-second) environment is commonly carried out using a gigabit

switching hub set to mirroring and a notebook personal computer (PC) equipped with a gigabit port. However, an increase in the amount of traffic may cause some packets to be missed depending on the performance of the PC's central processing unit (CPU), memory, and network interface card (NIC). These missed packets may be erroneously construed as packet loss due to an equipment fault. The gigabit-compatible protocol checker exhibits sufficient packet-capture performance compared with a PC.

The results of a test comparing the packet-capture performances of an ordinary commercial PC and the gigabit-compatible protocol checker are shown in **Fig. 3**. The horizontal axis shows the distribution band and the vertical axis shows the capture rate (number of captured packets ÷ number of distributed packets). The number of packets per second corresponding to the distribution band is shown along the top of the graph. The distribution band was increased from 10 Mbit/s to 1000 Mbit/s (1 Gbit/s). An example of test conditions is given in **Table 2**.

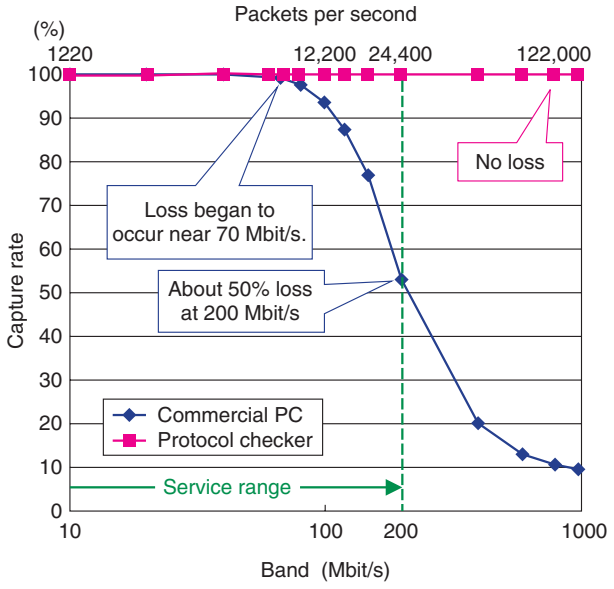


Fig. 3. Test results (under test conditions of Table 2).

For a packet size of 1024 bytes, these results show that the gigabit-compatible protocol checker could perform loss-free packet capture up to 1000 Mbit/s (upper limit)*. By contrast, packet loss on the commercial Windows PC caused a dramatic drop in the capture rate to begin at around 70 Mbit/s and eventually resulted in a capture rate of about 50% at 200 Mbit/s (the upper limit of service provided to each home in the high-speed version of FLET'S HIKARI NEXT).

The test also revealed that packet loss occasionally occurred even in the 10- and 20-Mbit/s bands when packet capture was performed using the Windows PC. Accordingly, the specifications of a PC used for packet capture at a customer's residence should be examined in detail. Moreover, it is recommended that the gigabit-compatible protocol checker introduced here be used in the case of a customer environment with heavy network usage as in the case of multipoint VPN connections or the HIKARI DENWA OFFICE A (ACE) telephone service.

4. Concluding remarks

The ongoing diversification of services is being

* This test was performed when attempting to verify that its performance was sufficient to perform loss-free packet capture at 200 Mbit/s.

Table 2. Example of test conditions.

	Conditions
Packet size	1024 bytes
No. of packets distributed	1 million
PC specifications for comparison	Commercial PC Windows XP SP3 32-bit (on market from 2010) CPU: Core 2 Duo P8700 2.53 GHz Memory: 3.4 GB NIC: Intel 82567LM Gigabit Network Connection
Capture software	Wireshark Ver. 1.4.7, WinPcap Ver. 4.1.2 Realtime display: performs capture in mode that divides data into 100-MB files
Distribution bands (Mbit/s)	10, 20, 40, 60, 80, 100, 120, 150, 200, 400, 600, 800, 1000
Packets per second	1220, 2440, 4880, 7320, 9770, 12,200, 14,700, 18,300, 24,400, 48,800, 73,200, 97,800, 122,000

accompanied by an increase in IP-related faults occurring within customer residences. To enable us to better understand a fault that has low reproducibility, affected customers must allow us to install packet capture equipment inside their residences over the long term so that the data-capture file can be analyzed when the fault reappears. The gigabit-compatible protocol checker is a tool designed for long-term monitoring: it is easy to operate, can perform remote maintenance, has a small, space-saving footprint, and features key lock protection. Its packet capture performance is high enough to handle the high-speed version of FLET'S HIKARI NEXT. It was released in September 2011. NTT EAST is currently conducting public relations activities in the form of product introductions, how-to-use seminars, and equipment rentals with the aim of having the gigabit-compatible protocol checker used in all prefectures and regions of Japan.

References

[1] NTT EAST FLET'S. http://flets.com/english/
[2] FLET'S HIKARI NEXT. http://flets.com/english/next/

Case Study of Printed Circuit Board Corrosion and Countermeasures

Abstract

This article presents a case study of corrosion on a printed circuit board in an optical network unit operating in a hot-spring area and the results of investigating countermeasures to that corrosion.

1. Introduction

Optical network units (ONUs) are telecommunications devices installed in customers' homes to receive optical broadband services. ONU failure is frequently reported by customers living in hot-spring areas. Photographs of a printed circuit board (PCB) in a failed ONU are shown in **Figs. 1** and **2**. Figure 1 shows thruholes (gold-plated copper) that have been corroded: a gray-colored corrosion product is visible. Figure 2 shows a place where the corrosion product has made contact with a neighboring wiring pattern (indicated by the arrow), creating a short circuit. It was inferred that this short was the cause of the ONU failure. The results of an X-ray analysis of the corrosion product are shown in **Table 1**. The corrosion products were mainly composed of copper, oxygen, and sulfur. This result suggests that copper on the board reacted with moisture and hydrogen sulfide in the atmosphere to form an oxide (copper oxide) and sulfide (copper sulfide). The hydrogen sulfide concentration in the user's home ranged between 0.05 ppm and 0.45 ppm (parts per million), which is a high concentration several tens to several hundreds times that of a normal environment.

2. Morphology of corrosion

The morphology of the corrosion is shown in Figs. 1 and 2. Corrosion of this type is called sulfide creep. In this phenomenon, a corrosion product (sulfide) of metals such as copper or silver spreads over the surfaces of metals that do not form sulfides, such as tin and gold. Sulfide creep is known as a major factor in

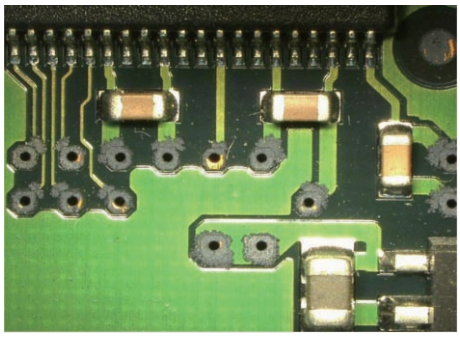


Fig. 1. Image of PCB in the failed ONU.

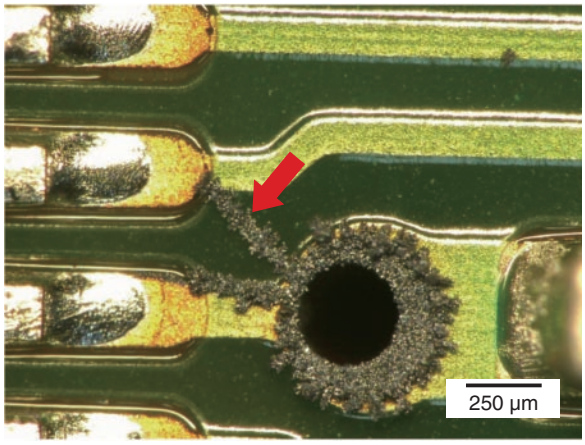


Fig. 2. Another image of PCB in the failed ONU.

Table 1. Composition of the corrosion product.

	Copper	Oxygen	Sulfur	Chlorine
Composition (wt%)	49	35	15	0.2

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Table 2. Type, applications, and thickness of coating materials studied.

Coating material	Type	Applications	Thickness (this study)
A	Polyvinyl	Power meters, traffic lights, PCBs in vehicles, etc.	20–35 μm
B	Fluorine resin	Mobile phones etc.	60–150 μm
C	Polyurethane	Automobile control boards	40–90 μm

Table 3. Change in insulation resistance of interdigitated array electrodes treated with coating material (before and after exposure test).

Coating material	Insulation resistance before exposure (average value)	Insulation resistance after exposure (average value)
A	2.5×10^{11} Ω	2.6×10^{11} Ω
B	4.5×10^{12} Ω	2.6×10^{12} Ω
C	3.3×10^{12} Ω	1.6×10^{12} Ω

the deterioration of small, gold- or tin-plated contact points or terminals. It can easily occur in environments in which there is a high concentration of hydrogen sulfide, such as regions having sulfurous hot-springs, and it has been implicated in reduced lifespans of not only telecommunications equipment but also electrical products such as home appliances used in hot-spring areas.

3. Investigation of countermeasures

Various measures can be considered to tackle corrosion caused by hydrogen sulfide such as improving the environment by installing desulfurizing equipment or relocating vulnerable equipment to a location having a low concentration of hydrogen sulfide. In the case study presented here, the installation environment was not a room but an open area, and equipment relocation would have been difficult. For these reasons, a study was performed to prevent the corrosion on PCBs by applying a coating material.

4. Study of coating materials

Three types of coating materials for application to PCBs were studied taking into account their previous use in industry, as summarized in **Table 2**. The anti-corrosive properties of these materials were tested by fabricating copper interdigitated array electrodes, preparing samples by coating those electrodes with the three types of coating materials, and exposing the samples to hydrogen sulfide. This exposure test was performed for 260 hours in an environment having a hydrogen-sulfide concentration of 10 ppm, temperature of 40ºC, and relative humidity of 70%. The samples were then visually inspected and the electrodes were checked for changes in their insulation resistance. The visual inspection did not reveal any corrosion for any of the coating materials, indicating that each had good anti-corrosive properties. In addition, no significant changes in the insulation resistance of the electrodes were found in any case (**Table 3**).

5. Concluding remarks

A study was performed on coating materials to prevent corrosion on PCBs caused by hydrogen sulfide in the atmosphere. Accelerated testing in a laboratory environment revealed that the coating materials studied had good anti-corrosive properties. We are planning to test these materials under actual field conditions. NTT telecommunications equipment is installed in a wide variety of environments, and the electronic components and devices used in it are increasingly being made smaller and more compact. This trend indicates a rising risk of equipment failure, which necessitates appropriate corrosion-protection measures. NTT EAST will continue to investigate countermeasures to corrosion to achieve higher levels of reliability in information and communications technology services.

Discriminative Training for Language Models

Takanobu Oba†

Abstract

After reviewing the discriminative approach to training language models in natural language processing and describing an example of its use in automatic speech recognition (ASR), this article introduces two techniques that overcome the problems with the conventional discriminative approach. One is to introduce a novel discriminative criterion; in short, a novel learning machine is presented and its relationship to and advantages over conventional learning machines for training a language model based on a discriminative criterion are described. The other is a model pruning method, which makes a model compact with less degradation of accuracy. This article also reports ASR experimental results that reveal the effectiveness of these two techniques.

1. Introduction

Recent advances in natural language processing technology have led to the development of many convenient applications, which not only enable us to communicate with computers in a human-like manner using natural language but also aid our conversation, work, and thinking. They include automatic speech recognition (ASR), machine translation, information retrieval from texts, dialogue systems, and applications combining them.

One of the key techniques for achieving these applications is language modeling. Language models (LMs) are basically used to measure the appropriateness of a sentence as natural language. For example, they can be used to choose the best sentence from multiple sentences by measuring their appropriateness. While many kinds of LMs exist, back-off n-gram modeling is one of the most basic and important techniques. This technique is very simple and its model is powerful despite being easily obtained by counting the number of occurrences of each n-gram (an n-tuple of consecutive words) in training data.

Other LM techniques measure the appropriateness of a sentence taking account of factors such as syntax, the dependencies between words and topics. They commonly train a model by estimating distributions of words and symbols of syntax. In short, these techniques generate a model that gives a high score to high-frequency words, as with back-off n-gram LM techniques. However, when an LM is used for ranking sentences or estimating the class of a sentence, it should be trained so that reference sentences are distinguished from the other sentences. For example, in the case of ASR, reference sentences should be distinguished from the other possibly misrecognized sentences. As a method that meets this requirement, discriminative training has been attracting increasing attention in the natural language processing community [1]–[4]. In the discriminative training framework for ASR, speeches in a training set are recognized by using a speech recognizer. Then, the sentences of the recognition result, together with their reference sentences, are used for training the language model. The model is trained so that the references are distinguished from the misrecognized sentences [5], [6].

Discriminative language models (DLMs) are effective, but problems to be solved remain. This article mentions two problems with DLMs. The first is that the best learning machine for DLM training depends on datasets even with the same task (application) [7]. This requires a DLM specialist to carefully choose a learning machine before training starts. A novel learning machine to overcome this problem [8] is described in section 3.1, which also describes its

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relationship to and advantages over conventional learning machines. Experimental ASR results that reveal the effectiveness of the novel learning machine are presented in section 4.

The other problem relates to the number of parameters. DLM training requires improper (possibly misrecognized) sentences and proper reference sentences and then obtains features from both types of sentence, whereas conventional back-off n-gram LMs obtain features from only reference sentences. Hence, DLMs tend to have a much larger number of features, which means they have more parameters than conventional LMs. Thus, a large process memory is usually required when a DLM is used. One method for overcoming this problem is the pruning approach, which makes a model compact by removing redundant parameters (features). This is basically easy to use even for application developers without special knowledge of the target task, and it is very effective in expanding the availability of LMs to a variety of devices. Pruning methods have already been proposed for back-off n-gram LMs but not for DLMs [9]. A pruning method for DLMs [10] is described in section 3.2 and experimentally evaluated in section 4.

2. Discriminative language models (DLMs)

This section reviews the fundamental features of DLMs and how they are used in ASR, assuming this to be one of the most typical usages. DLMs are generally designed on the linear model, i.e., $\mathbf{a}^{\mathsf{T}}\mathbf{f}(s)$, where $\mathbf{a}$ is a parameter vector, $\mathbf{f}$ is a feature vector of a sentence s, and $^{\mathsf{T}}$ is a transpose. Usually, n-gram Booleans are used as features. Where $f_k(s)$ represents the k-th element of the feature vector $\mathbf{f}(s)$, they are defined as $f_k(s) = 1$ when s contains the k-th n-gram and 0 otherwise. For example, if a bigram '*yeah I*' corresponds to the k-th element, $f_k(s)$ is 1 when s contains '*yeah I*' and 0 otherwise.

The problem of finding the best sentence from a sentence set using a DLM can be formulated as

$$s^* = \arg\max_{s \in L} \{a_0 f_0(s) + \mathbf{a}^{\mathsf{T}}\mathbf{f}(s)\}, \qquad (1)$$

where $L = \{s_j | j = 1, 2, \ldots, \mathrm{N}\}$ denotes a set of sentences, $f_0(s)$ denotes the initial score of sentence s, and a_0 is a scaling constant, which can be decided using a development set. In ASR, L is a recognized sentence set, i.e., a hypothesis set, which is generated from each utterance using a baseline speech recognition system, and f_0 is the recognition score. In short, DLMs perform as rerankers, whose purpose is to locate the reference sentence at the top of the list of hypotheses [5], [11], [12].

The value of parameter vector $\mathbf{a}$ is decided using a training set, which comprises lists of hypotheses and their references. All the hypotheses in the lists and the reference sentences are converted into feature vectors before training; they are denoted by $\mathbf{f}_{i,j}$ and $\mathbf{f}_{i,r}$, where i and j represent the indexes of utterance and hypothesis, respectively. In addition, some learning machines use weight $e_{i,j}$, which indicates the incorrectness of a sentence. Typically, the word error rate (WER), which is the ratio of the number of misrecognized words to the number of reference words, is used for DLM training [8], [13].

The purpose of training a DLM is to find value $\mathbf{a}$ that minimizes an objective function. Each learning machine is characterized by a specific objective function. Given an objective function, the minimization problem can be solved using general parameter estimation methods such as the gradient descent method and the quasi-Newton method. The objective functions of conventional learning machines, i.e., the weighted global conditional log-linear model (WGCLM) [5], [7] and minimum error rate training (MERT) [13], are given by

$$\mathcal{O}^{\mathrm{WGCLM}} = \sum_{i=1}^{I} \log \sum_{j=1}^{N_i} \left\{ \frac{e_{i,j} \exp(\mathbf{a}^{\mathsf{T}}\mathbf{f}_{i,j})}{\exp(\mathbf{a}^{\mathsf{T}}\mathbf{f}_{i,r})} \right\} \qquad (2)$$

$$\mathcal{O}^{\mathrm{MERT}} = \sum_{i=1}^{I} \sum_{j=1}^{N_i} \left\{ \frac{e_{i,j} \exp(\mathbf{a}^{\mathsf{T}}\mathbf{f}_{i,j})^a}{\sum_{j=1}^{N_i} \exp(\mathbf{a}^{\mathsf{T}}\mathbf{f}_{i,j})^a} \right\}, \qquad (3)$$

respectively.

3. New techniques

3.1 Discrimination in round-robin fashion

3.1.1 Background

Objective functions are typically formed of an accumulation of loss functions. The definition of loss greatly affects the behavior of the model. The loss functions of WGCLM and MERT correspond to the terms in brackets { } in the equations of their objective functions.

The WGCLM loss function is designed only to distinguish a reference from a hypothesis. In other words, where two hypotheses are given, WGCLM does not distinguish which is the better hypothesis. Hence, a model trained using WGCLM will not perform properly when a list consists of erroneous

sentences. By contrast, MERT trains a model so as to distinguish hypotheses having a relatively low error rate from the other hypotheses, without directly distinguishing references from the hypotheses. Therefore, a MERT-trained model will not be able to find the reference when the list contains many low-error-rate sentences together with the reference.

As a result, when a list contains a non-erroneous sentence that is identical to the reference, WGCLM performs more properly than MERT; otherwise, MERT is better than WGCLM. One way to avoid the problem of the best learning machine depending on datasets is to design a loss function that incorporates the characteristics of both WGCLM and MERT.

3.1.2 New technique: round-robin duel discrimination (R2D2)

This section introduces a novel learning machine that possesses the abovementioned characteristics of both WGCLM and MERT. It consists of the loss function

$$l_a(i, j, j') = \frac{e_{i,j} \exp(\mathbf{a}^\top \mathbf{f}_{i,j})}{e_{i,j} \exp(\mathbf{a}^\top \mathbf{f}_{i,j'})}. \quad (4)$$

In this loss, a reference (zero error rate hypothesis) is distinguished from another hypothesis, and a hypothesis is distinguished from a higher-error-rate hypothesis. Since an objective function is an accumulation of loss functions, the objective function of the new learning machine is given by

$$\mathcal{O}^{\mathrm{R2D2}} = \sum_{i=1}^{I} \log \sum_{j'=1}^{N_i} \sum_{j=1}^{N_i} l_a(i, j, j'). \quad (5)$$

In this objective function, the hypotheses in a list are distinguished from each other in round-robin fashion. Hence, this new learning machine is called round-robin duel discrimination (R2D2) [8].

R2D2 requires a heuristic for avoiding a zero denominator. For this purpose, $\exp(\sigma e_{i,j})$ is used instead of $e_{i,j}$, where σ is a hyperparameter. In this case, the loss function of R2D2 is the same as the WGCLM loss function when σ in the denominator is $-\infty$. In other words, R2D2 is an expansion of WGCLM; hence, R2D2 can perform at least as well as, and potentially better than, WGCLM.

R2D2 also has other advantageous characteristics. One is the concavity of the objective function, which means that convergence to the global optimal solution is promised. In addition, there is an efficient method for calculating the term of double summations over j and j'. This term can be calculated in $\mathbf{O}(N)$, although the direct calculation takes $\mathbf{O}(N^2)$. As a result, R2D2 can train a model in almost the same computation time as WGCLM and MERT.

3.2 Pruning method for DLMs

This section describes a pruning method developed for DLMs [10]. This method can be applied to linear models. It assumes that model parameter vector $\mathbf{a}$ is pruned to $\hat{\mathbf{a}}_m = R_m^\top \mathbf{a}$, where $R_m = [\mathbf{r}_1, \mathbf{r}_2, \ldots, \mathbf{r}_m]$ is a matrix consisting of m-tuple n-dimensional orthogonal bases, i.e., $\mathbf{r}_k^\top \mathbf{r}_{k'} = \delta_{k.k'}$ ($\delta_{k.k'}$ is a Kronecker's delta). Therefore, the score of the pruned linear model is given by $\hat{\mathbf{a}}_m^\top R_m^\top \mathbf{f}$. For simplicity, only one of the elements of $\mathbf{r}_k$ is 1 and all the other elements are zero. Hence, R_m can be regarded as a matrix that removes $n - m$ elements of $\mathbf{a}$ and permutes the remaining elements.

The permutation of the parameter elements is decided on the basis of square error metric

$$E_m = \sum_{\mathbf{f} \in S} \| F\mathbf{a} - FR_m R_m^\top B\mathbf{a} \|^2, \quad (6)$$

where S is a dataset and F is a diagonal matrix whose diagonal elements are $\mathbf{f}$. E_m is an approximation of $\sum_{\mathbf{f} \in S} \| \mathbf{a}^\top \mathbf{f} - \hat{\mathbf{a}}_m^\top R_m^\top \mathbf{f} \|^2$ and can be obtained by assuming that $\mathbf{f}$ is sparse, i.e., $f_k f_{k'} = 0$ for $k \neq k'$. Considering that $R_m R_m^\top = R_{m+1} R_{m+1}^\top - \boldsymbol{r}_{m+1} \boldsymbol{r}_{m+1}^\top$, E_m can be written in a recurrence formula as

$$E_m = E_{m+1} - a_K^2 \sum_{\mathbf{f} \in S} f_K^2, \quad (7)$$

where K denotes the index of the element whose value is 1 in $\mathbf{r}_{m+1}$. The second term $\eta_K = a_K^2 \sum_{\mathbf{f} \in S} f_K^2$ represents the impact of removing the K-th dimension in the total error. Namely, the elements of $\mathbf{a}$ must be permuted to satisfy $\eta_{K1} \geq \eta_{K2} \cdots \geq \eta_{Kn}$.

In summary, this pruning method simply calculates η_k for all the elements and sorts in order of η_k. Then, the top m elements of the sorted parameter are retained and the others are discarded.

4. Experiments

In this section, the two techniques introduced in this article are evaluated through ASR experiments. First, using a baseline ASR system, which is a state-of-the-art system, 5000 hypotheses were generated from each utterance in three different corpora—CSJ-A, CSJ-O, and MITLC—for both training and evaluation. Then, for each corpus, three DLMs were trained, i.e., one each by using WGCLM, MERT, and R2D2. The DLMs were evaluated by WER for the hypothesis

Table 1. WERs before and after reranking the 5000-best hypotheses using DLMs.

Corpus	CSJ-A	CSJ-O	MITLC
w/o DLM	18.0	34.5	37.0
WGCLM	17.1	32.6	35.6
MERT	17.6	32.9	35.3
R2D2	**16.9**	**32.4**	**35.2**

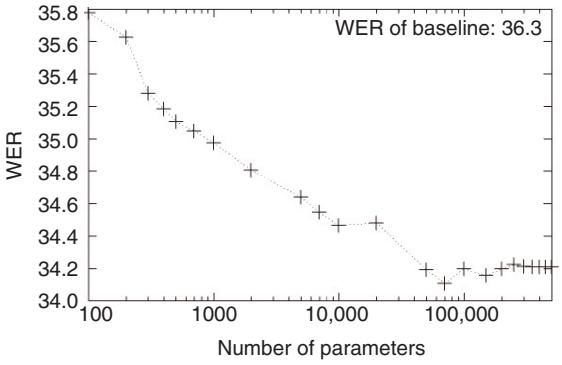

Fig. 1. Effectiveness of pruning. Pruned model size and WER.

with the highest score among the 5000 hypotheses, which were reranked by each of them. Features used here were uni-, bi-, and trigrams of words and parts of speech. **Table 1** shows the WERs for the three DLMs (WGCLM, MERT, and R2D2) and for no DLM (w/o DLM). R2D2 provided the best performance with all of the corpora, while WGCLM outperformed MERT with CSJ-A and CSJ-O, but not with MITLC.

Next, the pruning method was evaluated. The training set in CSJ-A was used for both training a DLM and obtaining statistics for pruning, and the pruned models were then evaluated with the CSJ-O evaluation set. This simulated a cross condition. The learning machine used here was R2D2. The initial model, which was the model before pruning, consisted of more than 10 mega-parameters. The WER of the baseline system, i.e., the WER before reranking, was 36.3. The relationship between WER and model size, i.e., the number of parameters, is shown in **Fig. 1**. Results for pruned models with over 500,000 parameters are omitted from the figure because the WER differences were very small. This means that the original DLM contains many redundant parameters, and they can be removed effectively by using the pruning method. Even when a 10,000-parameter model was used, the WER degradation was only 0.3.

5. Conclusion

After reviewing the fundamental features of DLMs and an example of their use in ASR, this article introduced a novel learning machine and a pruning method for DLMs. The novel learning machine is very effective for generating an accurate model and performs well under various conditions; the pruning method enables us to use a DLM on a variety of devices. They can expand the availability of DLMs, so they will contribute to the development of many kinds of intelligence applications.

References

[1] J. Lafferty, A. McCallum, and F. Pereira, "Conditional Random Fields: Probabilistic Models for Segmenting and Labeling Sequence Data," Proc. of Machine Learning, pp. 282–289, Freiburg, Germany, 2001.

[2] R. McDonald, K. Crammer, and F. Pereira, "Online Large-margin Training of Dependency Parsers," Proc. of the 42nd Annual Meeting of the Association for Computational Linguistics (ACL 2004), pp. 91–98, Barcelona, Spain.

[3] M. Collins and T. Koo, "Discriminative Reranking for Natural Language Parsing," Computational Linguistic," MIT Press Journals, Vol. 31, No. 1, pp. 25–70, 2005.

[4] D. Okanohara and J. Tsujii, "A Discriminative Language Model with Pseudonegative Samples," Proc. of 45th Annual Meeting of the Association for Computational Linguistics (ACL 2007), pp. 73–80, Prague, Czech Republic.

[5] B. Roark, M. Saraclar, and M. Collins, "Discriminative n-gram Language Modeling," Computer Speech & Language, Vol. 21, No. 2, pp. 373–392, 2007.

[6] Z. Zhou, J. Gao, F. K. Soong, and H. Meng, "A Comparative Study of Discriminative Methods for Reranking LVCSR n-best Hypotheses in Domain Adaptation and Generalization," Proc. of the 31st International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2006), pp. 141–144, Toulouse, France.

[7] T. Oba, T. Hori, and A. Nakamura, "A Comparative Study on Methods of Weighted Language Model Training for Reranking LVCSR n-best Hypotheses," Proc. of the 35th International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2010), pp. 5126–5129, Dallas, TX, USA.

[8] T. Oba, T. Hori, A. Nakamura, and A. Ito, "Round-robin Duel Discriminative Language Models," IEEE Trans. on Audio, Speech and Language Processing, Vol. 20, No. 4, pp. 1244–1255, 2012.

[9] A. Stolcke, "Entropy-based Pruning of Backoff Language Models," Proc. of DARPA News Transcription and Understanding Workshop, pp. 270–274, Lansdowne, VA, USA, 1998.

[10] T. Oba, T. Hori, A. Nakamura, and A. Ito, "Model Shrinkage for Discriminative Language Models," IEICE Trans. on Information and Systems, Vol. E95-D, No. 5, pp. 1465–1474, 2012.

[11] E. Arisoy, M. Saraclar, and I. Shafran, "Syntactic and Sub-lexical Features for Turkish Discriminative Language Models," Proc. of the 35th International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2010), pp. 5538–5541, Dallas, TX, USA.

[12] T. Oba, T. Hori, and A. Nakamura, "Efficient Training of Discriminative Language Models by Sample Selection," Speech Communication, Vol. 54, No. 6, pp. 791–800, 2012.

[13] F. J. Och, "Minimum Error Rate Training in Statistical Machine Translation," Proc. of the 41st Annual Meeting of the Association for

Computational Linguistics (ACL 2003), pp. 160–167, Sapporo, Japan.
[14] K. Maekawa, H. Koiso, S. Furui, and H. Isahara, "Spontaneous Speech Corpus of Japanese," Proc. of the 2nd International Conference on Language Resources and Evaluation (LREC 2000), pp. 947–952, Athens, Greece.
[15] J. Glass, T. J. Hazen, S. Cyphers, I. Malioutov, D. Huynh, and R. Barzilay, "Recent Progress in the MIT Spoken Lecture Processing Project," Proc. of Interspeech 2007, pp. 2553–2556, Antwerp, Belgium.

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Small Satellite Earth Stations for Disaster Recover Operations

Yutaka Imaizumi†, *Takashi Hirose, and Hidekuni Yoshida*

Abstract

NTT Access Network Service Systems Laboratories has developed small satellite earth stations for satellite communications to provide communication links for specially installed public phones and Internet connection in evacuation and disaster response centers in the event of communications being disrupted by disasters and other emergencies. These earth stations are compact and lightweight and use antenna reflectors that can be dismantled and reassembled, so that they can be packed inside carrying cases. They are equipped with automatic satellite-capture and -tracking functions and with functions for remotely conducting uplink access tests, which enable rapid link provisioning and reduce the setup operations that must be done by field workers.

1. Introduction

Because of the wide coverage and ease with which link provisioning can be carried out with satellite communication systems, they are useful in serving as communications systems for disaster recovery operations. As part of the NTT Group's protocols for restoring the communications infrastructure in the event of a disaster, temporary communication links are initially secured in evacuation and disaster response centers through satellite communications systems while efforts to restore optical fiber and other transmission lines are underway.

The satellite earth station systems currently used by NTT EAST and NTT WEST for disaster response operations [1] are shown in **Fig. 1**. The Ku-band Ultra Small Earth Station System provides one audio line per channel, while the Portable Earth Station System utilizes voice over Internet protocol (VoIP) for voice communications, simultaneously providing multiple lines for both voice and IP data transmission.

However, since these systems were built more than fifteen years ago, they are now showing signs of deterioration, and it has become difficult to purchase brand new equipment and repair damaged equipment. Moreover, their setup involves manual tasks such as manual alignment of the antenna to the satellite direction, so installation takes at least one hour even when performed by experienced engineers. Furthermore, since they are not very easy to transport, they offer poor mobility and setup speed, which are essential factors in disaster recovery operations.

To overcome these problems, NTT Access Network Service Systems Laboratories has developed the Small Satellite Earth Station [2], [3].

2. Summary of development process

The goal of the development was to make use of current portable satellite systems without making any major changes to them. To achieve this, we developed three new devices for the earth station terminal and a new program for the control station.

Two kinds of antennas were developed to provide a choice of two terminal compositions according to the situation of a stricken area, i.e., a flyaway type station and a vehicle-mounted type station. The flyaway type is easy to carry to a disaster area because it can be broken down and packed into four separate carrying cases. On the other hand, the vehicle type can be installed on a normal-sized car, so it can reach a stricken area quickly to help restore communications. Both terminals can start performing their mission in

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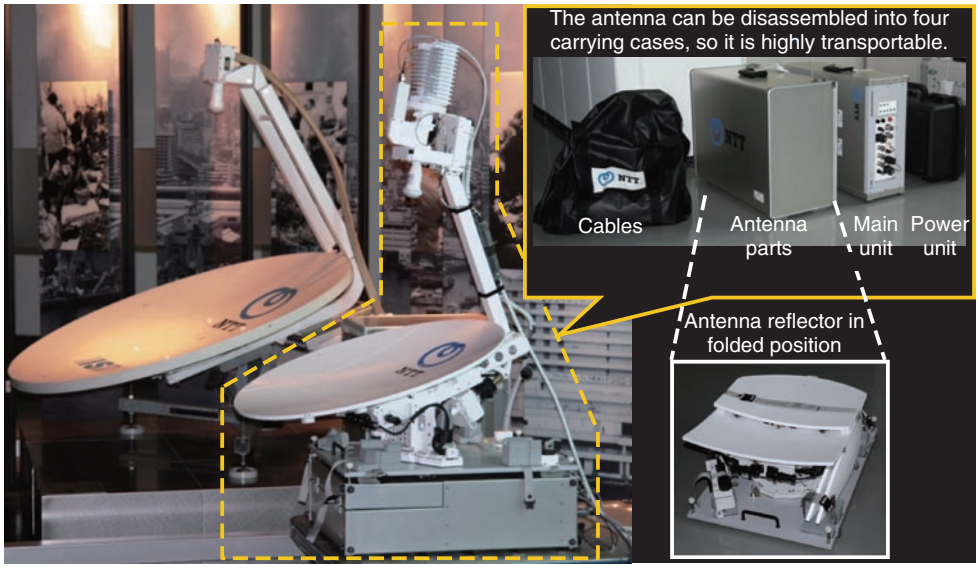
Ku-band Ultra Small Earth Station System		Portable Earth Station System	
Fixed type	Portable type	Portable type	Vehicle-mounted type
			
Aperture: 75 cm Weight: 100 kg	Aperture: 55 cm × 55 cm Weight: 30 kg	Aperture: 120 cm Weight: 150 kg	

Fig. 1. Existing satellite earth stations for disaster recovery operations used by NTT.



(The antenna of the existing Portable Earth Station System is shown on the far left.)

Fig. 2. Flyaway antenna.

less than approximately 15 minutes owing to the satellite auto-tracking function compared with 60 minutes at present. These stations ensure a transmission speed of up to 384 kbits/s for the return link, which can carry ten VoIP channels, simultaneously.

The technologies that we developed are summarized in sections 2.1–2.4.

2.1 Flyaway antenna

The flyaway antenna that we have developed for the earth station is shown in **Fig. 2**. This antenna can be readily carried by hand to disaster areas that are inaccessible by car or other means of transportation. We chose to use a 75-cm-aperture reflector antenna that can be dismantled and reassembled to enable transportation inside a carrying case. Other parts can also fit into cases, which greatly increases the portability compared with the existing device. Moreover, no tools are needed for disassembly, packing, and reassembly and the automatic satellite-capture function removes the need for operators to have special skills to set it up: setup can be finished within approximately 15 minutes.

Fig. 3. Vehicle-mounted antenna.

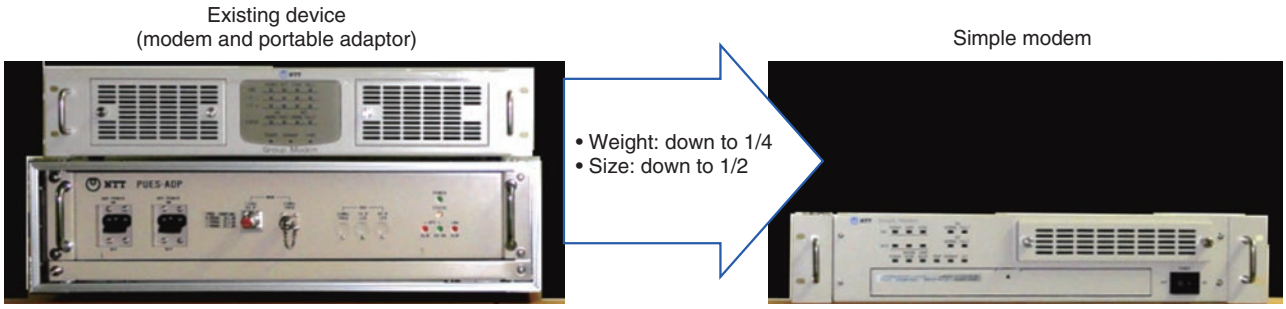


Fig. 4. Simple modem.

2.2 Vehicle-mounted antenna

The vehicle-mounted antenna that we have developed for the earth station is shown in **Fig. 3**. This antenna is mounted on the roof of a vehicle and is suitable for use in disaster areas that are still accessible by vehicles. The antenna aperture was reduced to approximately 60 cm to enable mounting on even ordinary cars. In addition to an automatic satellite-capture function, it also has a function for automatically tracking satellites while the vehicle is moving. Antennas of this type are widely used in ships, but ours is considerably simplified, making it lighter in weight, lower in height, and less costly.

2.3 Simple modem

The simple modem that we have developed for the earth station is shown in **Fig. 4**. If a disaster affects a wide area, a large number of earth stations will need to be installed. However, there is a limit to the frequency range that can be used for satellite communications. Thus, to enable simultaneous use in as many places as possible, we have developed a modem with limited communication speed and frequency band for each earth station. In addition, using the same transmission system as that of existing portable satellite communication systems enables operations with only minimal changes to the current configuration and settings of base stations of existing portable satellite systems. By removing unnecessary functions and reducing the capacity to the minimum necessary, we were able to reduce the weight to one-fourth and the size to one-half of the current modem.

2.4 Remote uplink access test program

In existing systems, an uplink access test is carried out after the earth stations have been installed but

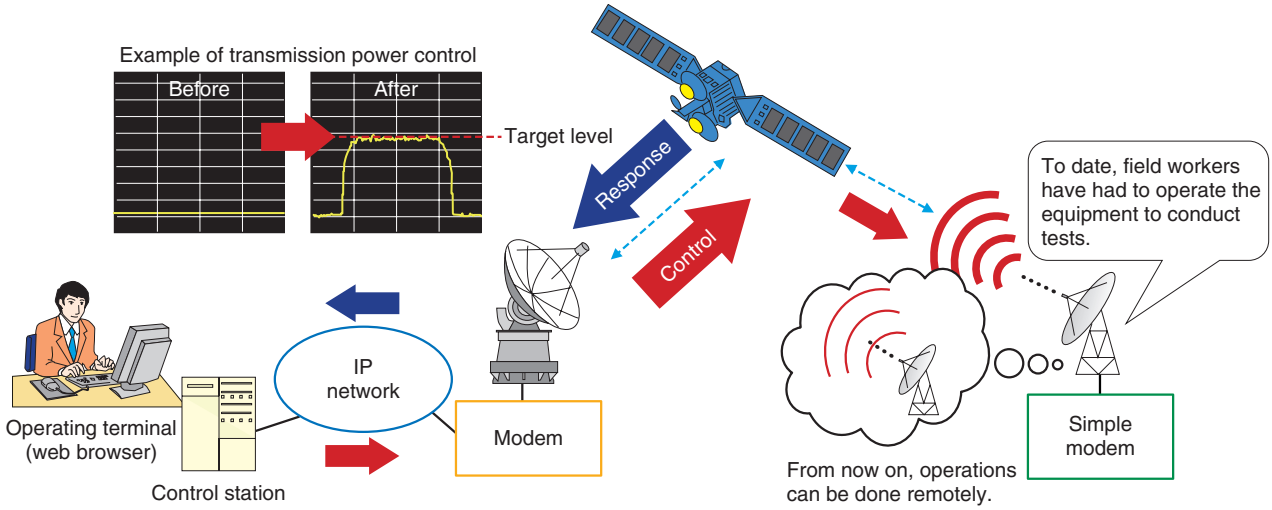


Fig. 5. Procedure for remote operation of uplink access test.

before they begin operations. This test is conducted through phone conversations between technicians of SKY Perfect JSAT Corporation, the owner and operator of the satellites, and field workers to check that the antenna direction and power transmission levels are correct. Thus, in order to conduct these tests, the field workers require knowledge and skills of radio communication systems. However, during widespread disasters, such as the Great East Japan Earthquake of 2011, it is difficult to easily gather many field workers who have such knowledge. To enable field workers who do not have such knowledge to easily set up earth stations in the field, NTT Access Network Service Systems Laboratories has developed an uplink access test program that can be operated remotely from a control station. The procedure for conducting this test remotely using this program is shown in **Fig. 5**.

3. Conclusion

The small satellite earth stations can provide a communications infrastructure quickly in the event of a disaster-induced communications disruption. These systems are scheduled for deployment in NTT EAST and NTT WEST during the current fiscal year (FY2012). NTT Access Network Service Systems Laboratories will continue to conduct research and development of technologies that can compensate for the speed and performance limitations arising from the conversion of earth stations into small lightweight systems. To enable a faster disaster response and improved user-friendliness, we will continue to improve the functionality and performance of these systems through a flexible combination of such technologies according to experience gained during disasters.

References

[1] T. Hirose, K. Ohta, Y. Imaizumi, and H. Yoshida, "Satellite Communication Systems Used in Disaster Recovery Operations," IEICE Technical Report, SAT2011-57, Vol. 111, No. 336, pp. 109–113, 2011.

[2] T. Manabe, "Trends in Wireless Access Technologies toward Expansion of Broadband and Ubiquitous Services," NTT Technical Review, Vol. 9, No 5, 2011.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201105fa4.html

[3] "Small Satellite Earth Stations for Disaster Recovery Operations," NTT R&D Forum Panels 2012, NTT Technical Review Archive (registered members only).
https://www.ntt-review.jp/library/ntttechnical.php?contents=ti1202rdfpa21e.pdf

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Movement Toward Medical Information Standardization and NTT's Efforts Toward Integrating the Healthcare Enterprise (IHE)

Kazuo Morimura†

Abstract

Integrating the Healthcare Enterprise (IHE) is an initiative begun in the USA that has evolved as a guideline for sharing information systems within medical institutions. It is being further expanded to encompass sharing among different medical institutions as electronic health records are implemented at the national level in Europe and in western countries. IHE defines guidelines for efficiently dealing with a variety of standards for health information systems. In recent years, as standard guidelines for cooperation in information exchange between medical institutions of information, awareness of IHE has been increasing. This article describes IHE and NTT's own IHE initiative.

1. Introduction

Integrating the Healthcare Enterprise (IHE) is an initiative for sharing medical information systems that was created in the USA in 1999 [1], sponsored mainly by the Radiological Society of North America (RSNA) [2] and the Healthcare Information and Management Systems Society (HIMSS) [3]. It initially served mainly as a guideline for the sharing of multiple information systems within individual medical institutions (e.g., radiology information and ordering systems). Since the emergence of electronic health records at the national level in European and western countries such as France and the USA, the application of IHE has been further expanded to facilitating sharing among different medical institutions (**Fig. 1**).

2. Initiative in Japan

IHE-J (Integrating the Healthcare Enterprise Japan), which is separate from the American initiative, was established in Japan in 2001 [4] with the initial aim of solving problems related to the transfer of medical images. Japan applied IHE to facilitate connections within medical institutions under the "Project of standardization and verification of regional medical information systems", a project run by the Ministry of Economy, Trade and Industry from 2006 for three years [5]. In this project, multiple IHE integration profiles such as Cross-Enterprise Document Sharing (XDS) and Patient Identifier Cross-referencing/Patient Demographics Query (PIX/PDQ) in particular were utilized to create critical paths for a regional health information exchange system for stroke care among multiple health enterprises.

3. National-level initiatives

Several national projects have recently been started in Japan, including the "Every hospital is my hospital plan" and "Seamless regional medical coordination". The aims of such initiatives are to promote coordination between hospitals and clinics and coordination between hospitals by sharing diagnoses and laboratory results among multiple medical institutions and

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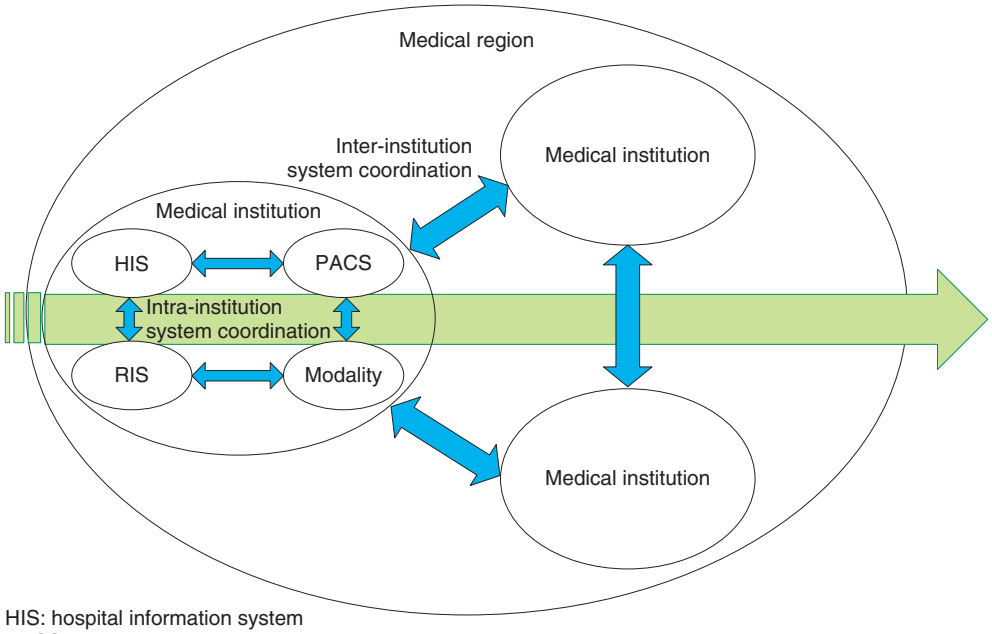

Fig. 1. Expansion of IHE's application.

ultimately to improve the quality of medical treatment while reducing total costs. For these aims to be accomplished, it is essential to have effective and smooth coordination for information exchange among the medical information systems of multiple medical institutions. The project report for the "Health Information Application Foundation-Building Project", in which technical requirements and technical specifications for such coordination among multiple medical institutions are defined, includes the proposal to base the foundation on XDS and PIX/PDQ in the IHE integration profile [6].

4. IHE integration profile used for regional medical coordination

This section briefly describes the IHE integration profile used in regional medical coordination.

4.1 XDS

XDS is an integration profile used to share medical documents among medical institutions [7]. It consists of a document registry and document repository, which store original documents and index information from them, respectively.

4.1.1 Procedural flow of XDS

The procedural flow of cross-enterprise document sharing from a private physician's office to regional hospitals is as follows (**Fig. 2**).

(1) Document submission and registration: The original document is registered in the repository of the private physician's office.

(2) Document index registration: The document index is then registered in the registry. The following index information can be registered.

- Regional patient ID (individual patient identifier (ID) common to the whole of the region concerned)
- Date and time of document creation
- Class code and item description (prescription, summary at discharge, report, and other information)
- Code for diagnostic background and description
- Code for medical enterprise type and name
- Availability for use (available or unavailable)
- Unique document ID

Since the registry must be shared by regional health enterprises, there is one registry for each region.

4.1.2 Procedural flow for document browsing

The procedural flow for inter-medical-institution browsing of registered documents consists of

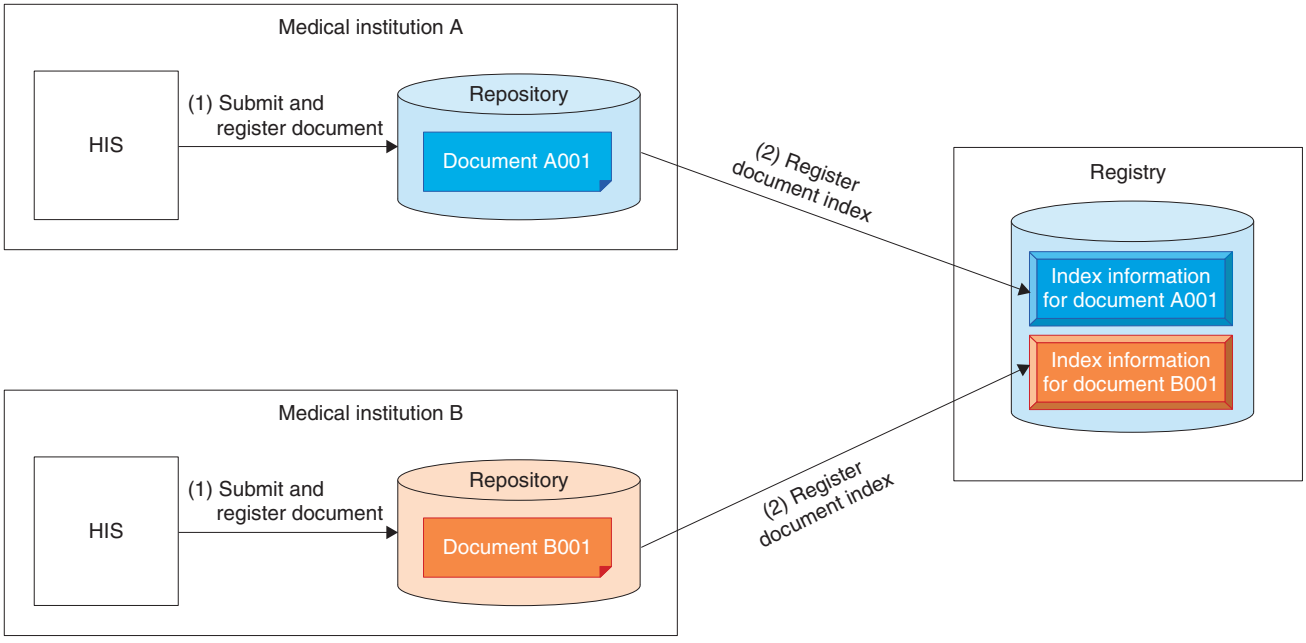

Fig. 2. Procedural flow of XDS.

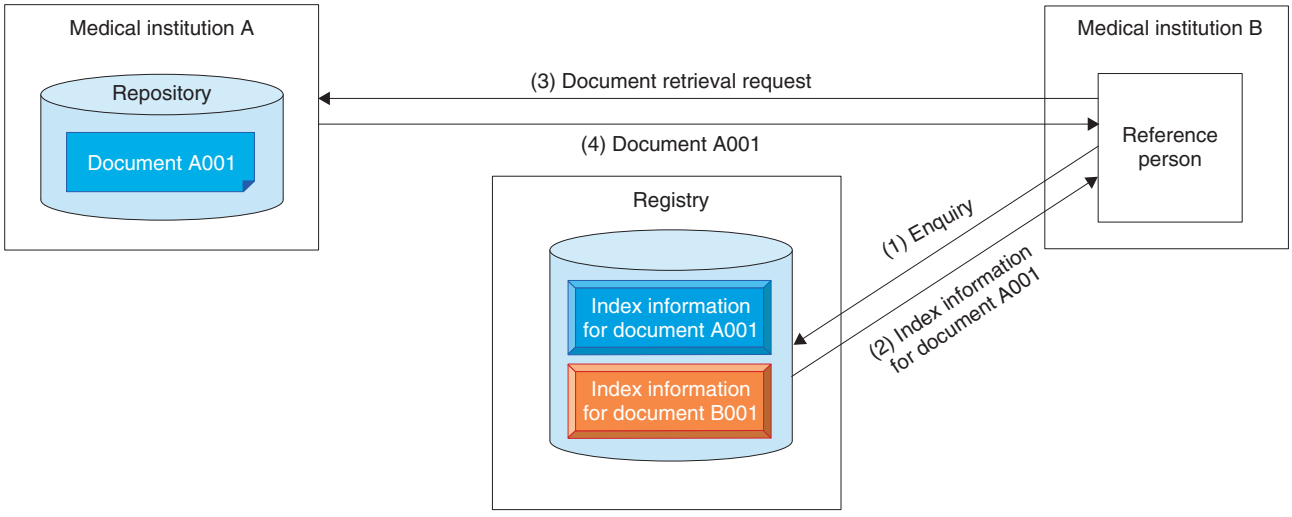

Fig. 3. Procedural flow for browsing a document in XDS.

document enquiry and retrieval (**Fig. 3**).

- Document enquiry: A medical institution wishing to browse a particular document sends an enquiry to the registry (1). The registry returns the document's storage location (2).
- Document retrieval: Next, the medical institution sends a document retrieval request to the repository holding the document (3), and the document is obtained (4).

4.2 PIX/PDQ

When XDS is performed as described above, the integration profile for sharing patient information among regional medical institutions is PIX/PDQ [8].

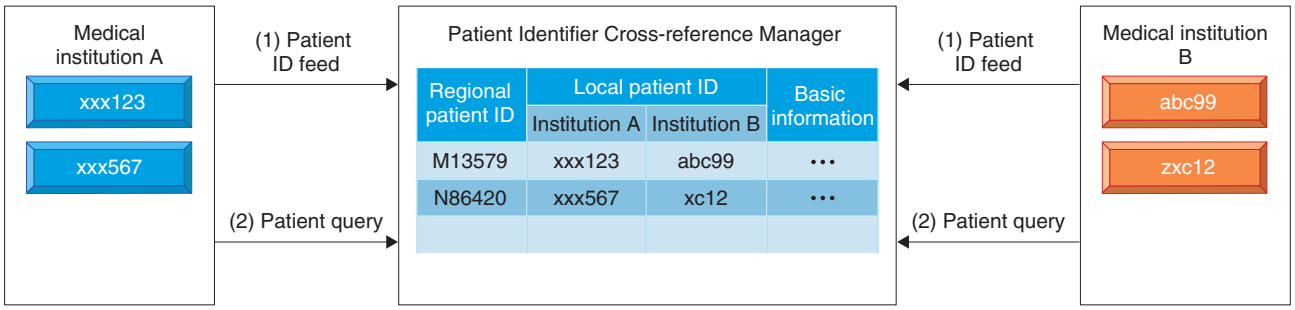

Fig. 4. Procedural flow for sharing patient information in PIX/PDQ.

The sharing of patient information is done in the manner described below (**Fig. 4**).

(1) Registration and renewal of patients' basic information: Patients' basic information (regional patient ID, hospital patient ID, patient name, and other information).

(2) Enquiry about patients' basic information: A search of registered patients' basic information is conducted. As search criteria, the regional patient ID or the patient's name and date of birth can be entered.

5. NTT's initiative

Since 2008, NTT has been developing a foundation for information sharing with the purpose of circulating medical information safely and faithfully and has applied it through a company to a project verifying the application of this health information foundation. In 2011, on the basis of the abovementioned circumstances regarding IHE, NTT implemented integration profiles such as XDS and PIX/PDQ in this foundation. Integration profiles such as XDR (Cross-Enterprise Document Reliable) and XDM (Cross-Enterprise Media Interchange) are designated as systems for information sharing among medical institutions and industries [9]. These systems are used to perform information sharing safely even in environments in which registry and repository (explained above as infrastructures for inter-enterprise information sharing) cannot be implemented. XDR is a system used to conduct one-on-one document sharing online, while XDM is a system that uses various media for document sharing.

We are actively implementing these systems and additionally verifying connectivity with other companies.

6. Future directions

NTT will closely monitor the movement towards medical information standardization, as with IHE, and continue research and development for promoting regional medical treatments and improving medical treatment quality.

References

[1] Integrating the Healthcare Enterprise. http://www.ihe.net
[2] Radiological Society of North America. http://www.rsna.org
[3] Healthcare Information and Management Systems Society. http://www.himss.org
[4] IHE-J. http://www.ihe-j.org/en
[5] Report (in Japanese). http://www.medinet-tokai.com/npo/katudou/parts/061214.pdf
[6] "Ministry of Economy, Trade and Industry: 2011 Research Project for Environmental Improvement of Service Industry Activity (Health Information Application Foundation-building Project) Report," 2011 (in Japanese).
[7] Japanese Association of Healthcare Information Systems Industry: IHE XDS Application Guide for "Regional Medical Information Coordination System, IHE PIX/PDQ Application Guide for Medical Information Sharing," JAHIS Technical Document, 09-101, 2009 (in Japanese).
[8] Japanese Association of Healthcare Information Systems Industry: "Regional Medical Information Coordination System, IHE PIX/PDQ Application Guide for Patient Information Management," JAHIS Technical Document, 09-102, 2009 (in Japanese).
[9] ePHDS committee/Japan PACS study group: "Handbook for Development of Regional Medical Coordination Information System, 2011," A Separate Volume; Recent Movement Regarding IHE-XDS—Political Movement in Japan and the USA, Cloud Technology and Broad Coordination," 2011 (in Japanese).

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NTT DATA Global Technology Services Private Limited Company

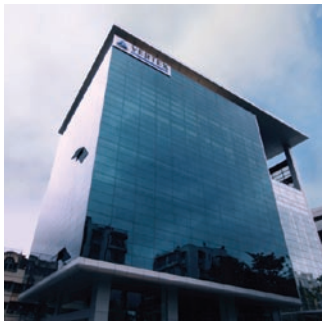
Ajit Patil, CEO†

Abstract

NTT DATA Global Technology Services Private Limited Company (formerly Vertex Software) is an information technology (IT) services company based in Pune, India. It has over 15 years of experience servicing customers across diverse geographical regions and over 650 employees spread across India, Japan, and the North America region. With a strong Japanese business association, it has invested in building a technically efficient bilingual (English & Japanese) resource pool that currently accounts for 33% of its overall employee strength. As part of the recent integration with NTT DATA, Vertex Software has officially become NTT DATA Global Technology Services Private Limited Company for better alignment with the global business.

1. Introduction

NTT DATA Global Technology Services Private Limited Company (formerly Vertex Software) [1] is an information technology (IT) services company based in Pune, India, with offices also located in Tokyo, Japan; Chicago and New York, USA; and Toronto, Canada. It was founded in 1996 as Vertex Software, and a majority stake was acquired by NTT DATA in 2007 [2], [3]. It has been serving customers across Japan and the North America region (which includes Canada) for 15 years. With over 650 employees spread across three geographical regions, the company has a special focus on the Japanese market, which generates 61% of its sales revenues (FY2011). With its strong Japanese business association, it has invested in building a technically strong bilingual (English & Japanese) resource pool that currently accounts for 33% of its overall employee strength. As part of the recent integration with NTT DATA, it has become NTT DATA Global Technology Services for better alignment with the global business.



Office building in Pune.

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ITI Road, Aundh, Pune-411007, India

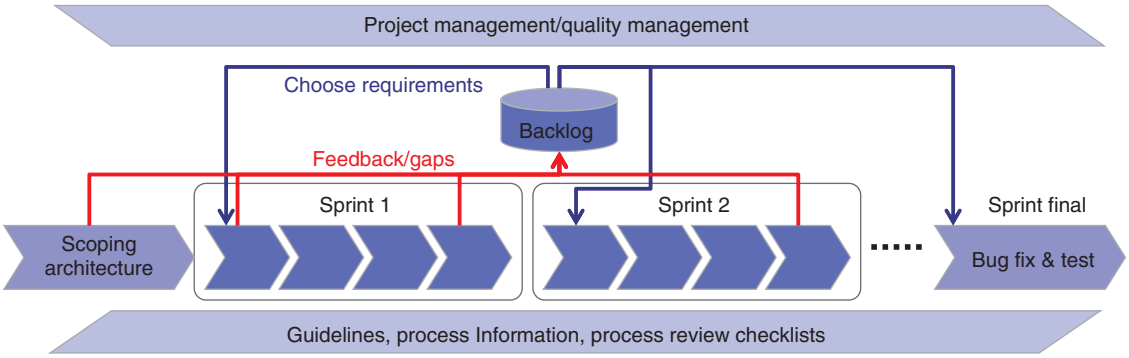

Fig. 1. Standard Agile/iterative development process.

2. Business offerings

Business offerings are split into software development and academy services.

2.1 Software development services

We help our customers develop and maintain software solutions in a cost-effective way by using a global delivery model. We have over a decade of experience of serving customers in Japan, North America, and Europe. Our services are focused around three key areas:

- Outsourced product development and research & development (R&D)
- e-Business application development
- Quality assurance and software testing

2.1.1 Outsourced product development and R&D services

Ensuring speedy time to market and delivering high productivity and innovation through the use of cutting-edge technology are major priorities for software product companies and R&D centers. Over the last decade, we have been serving such customers and have evolved a fine understanding of their requirements. Our customers in this field constitute a mix of large blue-chip software product companies, startup companies, and R&D centers of large organizations. To address their needs, we focus on developing resources with a high-technology skills set and through the use of Agile/iterative methodologies (**Fig. 1**).

We have a strong background in the area of mobile technologies, which helps us create more value for our customers. Our mobile expertise encompasses understanding both Japanese and international mobile eco-systems and technologies.

We entered the R&D field with the launch of the Global R&D Lab. At present, the Global R&D Lab is serving as the offshore arm for NTT DATA's R&D, but the aim is to eventually extend its focus towards high-end R&D requirements of the NTT DATA Group companies across Japan, the USA, and Europe. It focuses on specialty work and cutting-edge technologies such as cloud computing with a dedicated open source software laboratory. Amongst other things, we have been involved in supporting development, maintenance, and global promotion of NTT DATA's TERASOLUNA platform [4], [5].

2.1.2 E-Business application development services

More and more Japanese companies are extending their business worldwide. Our global delivery frameworks of e-business, ranging from business consultation to technical implementation, expedite and ease the globalization process of Japanese corporations.

We have three major strengths.

- We have domain experts who can work from high-level requirement definitions to identify the key features along with the strategic product roadmap to optimize the development process and to project the return on investment through consultation.
- We understand Japanese culture and methodology as well as the US-European way of doing business. This makes us unique and proficient at supporting the global e-business systems of Japanese companies.
- We have a large development center in India and our experts are spread across the globe.

One of our key customers is a large Japanese apparel retailer with global operations. We support the development and maintenance of its e-commerce

system. The system manages multiple countries, stores, currencies, taxes, and languages as well as a wide range of client devices from personal computers to the latest smartphones.

In addition to the retail industry, we have experience in the fields of foreign exchange trading, digital advertising, on-board retailing, and, recently, the educational industry.

2.1.3 Quality assurance and software testing

Our quality assurance and testing (QAT) business unit operates at the enterprise level, continually identifying opportunities to optimize a customer's IT investment. Our application testing approach gives each customer the advantage of going beyond its own scale and resources to support the required testing volume; this provides more effective solutions to business problems.

We typically achieve a 30–50% overall cost reduction for clients over multi-year contracts. Our testing of software includes test management, automation, performance testing, and software load testing & mobile application testing.

Our QAT procedure supports all phases of the development lifecycle and is renowned for its program/project management approach and track record. We can reduce application development and integration costs by as much as 30% while lowering risk, enhancing product quality, and improving the time to market. We accomplish this by taking advantage of our disciplined project execution approach, multidisciplinary teams, and seamless ability to blend the right mix of onsite, offshore, and near-shore resources to meet and adapt to a customer's specific needs. Our responsive, vendor-agnostic approach ensures flexibility, utilizes open source software where feasible, and maximizes the customer's return on investment.

The salient features are as follows:

- We provide excellent solutions in the quality assurance field through the Global One Team of NTT DATA that we provide.
- Our solutions are being effectively implemented across the world's largest banks in the North America region and at NTT DATA.

2.2 Academy services

A focused team at NTT DATA Global Technology Services is working to build a strong capability in both Japanese and Indian resources to support global project requirements. In India, the Japanese Learning Center (JLC) supports many Japan-related projects by offering several kinds of Japanese language training courses.

2.2.1 Japanese Learning Center

This center was launched ten years ago with the mission of creating a sustainable bilingual resource pool, which is critical for us to serve the Japanese market. We made a significant investment in this initiative in order to support its Japan-related projects. JLC is now an evolved model with its own course curriculum and the appropriate training infrastructure to create the much-needed resources. The training is designed to accelerate learning to make participants productive and mature developers for Japan delivery business in only six months. This training has also been made available to our Japanese customers who have global plans.

2.2.2 Globalization training program in India (Japan 2 Pune Program)

The Japan 2 Pune (J2P) program, which was launched in 2008, is based on business needs in Japan, which faces factors such as declining cost margins, an aging population, and a possible shortfall in resources capable of handling IT projects. Japanese IT organizations now feel the need for global collaboration and they are working in global delivery models for their imminent future growth.

The J2P program addresses the need to orient Japanese resources to work in the global IT environment. The training encompasses conceptual-level inputs about a global delivery framework and IT project management styles coupled with hands-on training to help Japanese executives experience the training inputs and get better exposure of working on outsourced projects.

The program is customized to organizational needs and is a residential program in India lasting from 3 to 8 weeks depending on the customer's requirements.

Participants are executives from NTT Group companies and other Japanese companies who have a technical background and have worked on IT projects in the past. They are selected by their employing companies through a nomination process and on the basis of their English ability as measured by their TOEIC (Test of English for International Communication) score.

References

[1] NTT DATA Global Technology Services Private Limited Company (site still under construction as of June 2012). http://gts.jp.nttdata.com/
[2] NTT DATA. http://www.nttdata.com/global/en/
[3] NTT DATA Americas. www.nttdata.com/americas
[4] TERASOLUNA website (in Japanese). http://www.terasoluna.jp/
[5] Press release about TERASOLUNA. http://www.nttdata.com/global/en/news-center/global/2008/012901.html

NTT DATA Global Technology Services—short column

Employee engagement initiatives

NTT DATA Global Technology Services has several initiatives aimed at engaging employees.

Zelus

Zelus started with the mission of creating energy and passion in the company's early days. It comprises members from different peer groups who plan interesting events with the objective of easing the work pressure on employees. It aims to give employees every opportunity to enjoy working for the company and to have as much fun as possible in their hectic schedules.

Envision

This group was formed with the philosophy of aligning perspectives shared by employees and management to help us get the right mix of values, culture, and direction. It aims to build an environment that is conducive to the creation of passionate engaged employees and also to develop a responsive, integrated internal communication system that will facilitate a trust environment.

Environment Protection Initiative:

As part of this initiative, we initiated Go Green, which has a multipronged approach to preserving the local environment. The objective was to create awareness and build a sustainable program towards this cause. It covers initiatives ranging from saving electricity, promoting car-pooling, planting trees, and promoting the use of public transport.