NTT Technical Review

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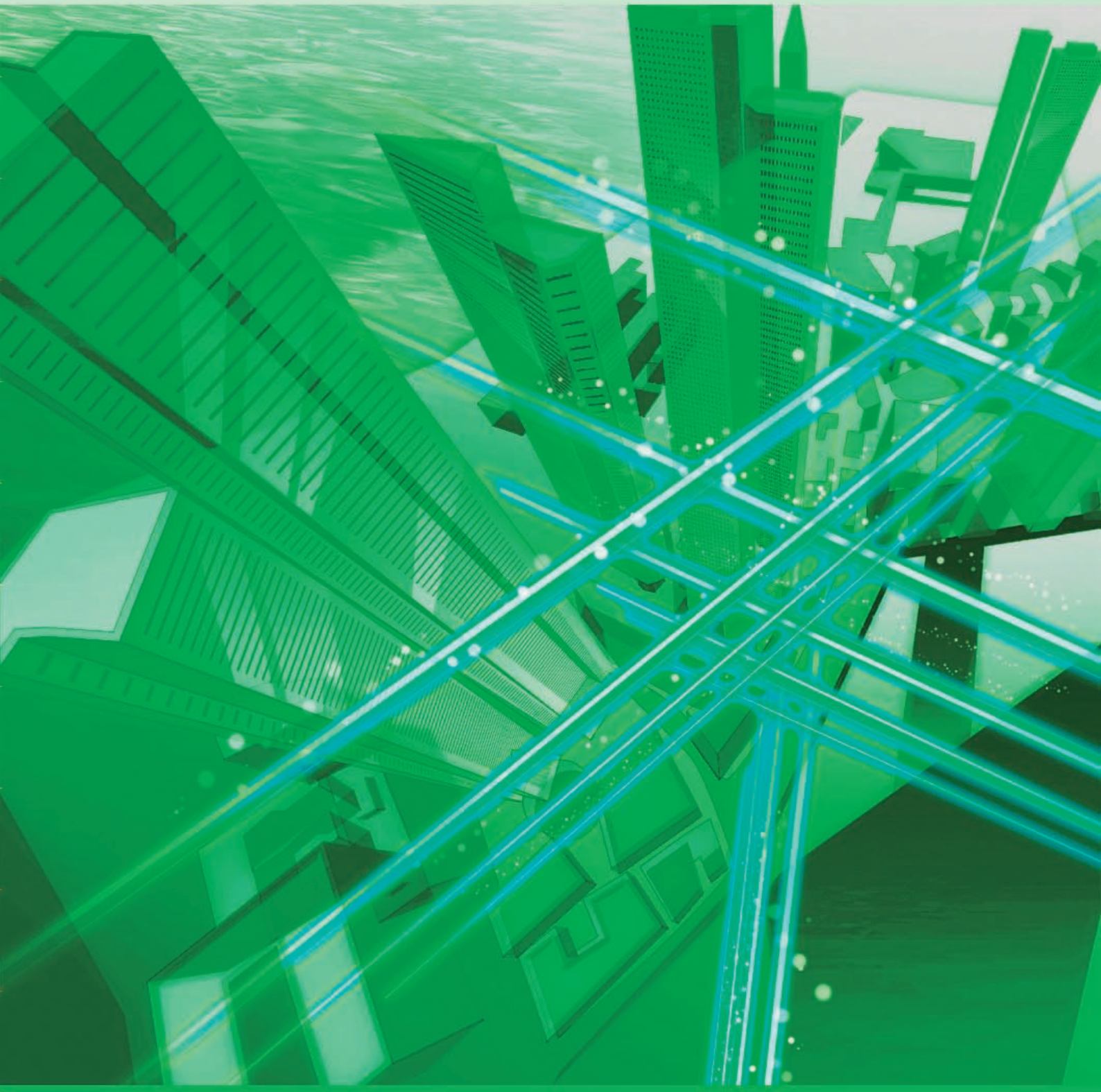

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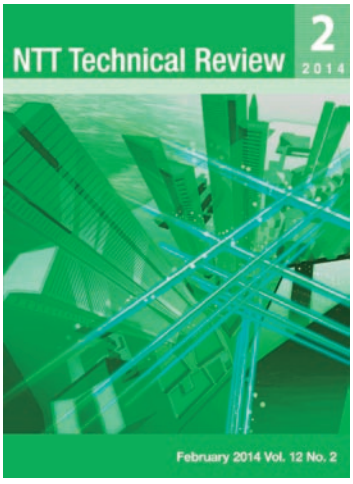

Practical Field Information about Telecommunication Technologies

Lightning Damage and Mitigation in Telecommunication Access Installations

External Awards/Papers Published in Technical Journals and Conference Proceedings

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Information Gathering as the Key to Good Decision Making—Creating New Value for a Smart Life

Fumio Iwasaki
Senior Executive Vice President
NTT DOCOMO

Overview

Today, the mobile phone is becoming a central part of everyone's life, and NTT DOCOMO, a pioneer and innovator in mobile communications, seeks to become a *Smart Life Partner* to customers and create new value for their benefit. We asked Fumio Iwasaki, NTT DOCOMO Senior Executive Vice President, to tell us where the key to a successful growth strategy can be found.

Keywords: new value, ICT market, smart life

NTT DOCOMO: Becoming a Smart Life Partner to customers in 2014

—Mr. Iwasaki, from a position at the core of NTT DOCOMO management, how do you see the current ICT market?

It's been about four years since I first took on management responsibilities covering the whole of NTT DOCOMO. As you know, technical innovation in the mobile-communications-related market is very intense. The latent business value in this market is very high, and like other companies, we are always looking to enter new business areas. It's a market that makes my work very enjoyable and that also makes me stay sharp.

On returning to the NTT DOCOMO head office in 2010, my first task was to oversee the launch of Long Term Evolution (LTE) services. Given that we were the first in Japan—and one of the leading groups in the world—to introduce LTE, there were many things that we had to overcome. Frankly speaking, the conditions were such that we could not foresee the growth in the smartphone market and did not think that the LTE penetration rate would rise to what it is now in such a short time. Nevertheless, looking at today's figures of 18 million LTE subscribers (as of the end of November 2013), I feel that our decisions in that period about three years ago were the right ones.

—Smartphones and mobile phones have certainly become a big part of our lives.

That's right. Several years ago, the mobile phone was a product that everyone had to have, but the widespread penetration of the smartphone has made mobile devices an even bigger part of our everyday lives. Up to now, however, we have been focused on voice and packet communications, and we have come to see that growth in these areas has its limits. Consequently, on considering how we could increase our revenues as a mobile operator, we examined what our strong features were, and we came up with our

terminals, networks, a very high quality customer base that includes customer names, addresses, paying accounts, and other useful information, and our docomo shops throughout Japan that provide many opportunities for face-to-face contact with customers.

We therefore decided to leverage this core competence with the aim of creating and providing safe and secure and highly convenient services in areas that we expect to have a high level of innovation geared to mobile communications.

By the way, have you seen the NTT DOCOMO commercials with Ken Watanabe? In these commercials, he is made to personify a smartphone that the user can go to for help similar to the way that one would use Aladdin's magic lamp to make a wish. NTT DOCOMO wants to become the customer's partner via the smartphone in turning one's life into a "smart life."

Winning trust in existing business is a stepping stone to entering new areas.

—What does NTT DOCOMO have to do to become a Smart Life Partner? And what areas are you setting your sights on?

To enter new business areas, we must first win a high level of trust in the mobile area that lies at the core of NTT DOCOMO business. Mobile communications and new business areas are like a pair of wheels—I want both of them to move together, in unison.

Specifically, we can divide new business areas into eight types of business: media content, commerce, finance and payments, medical and healthcare, environment and ecology, machine-to-machine (M2M), aggregation and platforms, and safety and security. Of these, it is in the media content business that we have so far poured much effort since the beginning of the i-mode era. Now, with the coming of smartphones, screens have become larger and network speeds higher, which bodes well for growth in the video, animation, and music markets. In fact, *dvideo*, NTT DOCOMO's fee-based video delivery service, is now commanding a leading position in this area. It is extremely important to form partnerships with outside companies upon entering new business areas. In this regard, it is hardly our desire to be viewed as a company that wrestles one existing business area from another. What we want to do is to create a synergetic effect with our mobile technologies to open up

new business areas in a win-win manner.

In the media content business, I believe we have a fairly good selection of content covering video, books, and other media, but going forward, we need to increase the number of content offerings even further and get more people to use our content.

Another field that we are in the process of developing is commerce. Our aim here is to generate purchases of real-to-life products in the manner of *dfashion* and *dtravel*, which are different from conventional digital content. I would like to see NTT DOCOMO's *dmarket* become a smartphone-centered shopping mall with products ranging from media content to real commercial products.

—Could this undertaking be reflected in the "Big Event" of 2020?

I think that we can contribute in some way to the Big Event. In particular, the fact that we have our own research and development department is unique among mobile operators, and I would like to make the most of this advantage.

As you know, trends in society move fast, and it is essential that we create and provide services just as quickly. NTT DOCOMO's voice-agent application called *Shabette Concier* (Talking Concierge) is a good example of a service that was developed and provided very quickly.

At the same time, it is also important to look a bit forward and to develop services with a medium- and long-term point of view. In anticipation of an increasing demand for data communications, we are working on the next generation of LTE-Advanced, or 5G, as a new wireless communication system, with the aim of providing 5G services around 2020.

Information originates from people. It is important to grasp not just the data but the originator too.

—You must be making management- and business-related decisions all the time. As Vice President, what kind of materials do you base your decisions on?

In making decisions, it is essential that I gather a great deal of accurate information in some way, and it is important that I obtain some information during my daily work routine, which includes communicating with employees. However, it often happens that I have to make a decision based on limited information. In such cases, I may not be sure how to proceed, but depending on the product or area of business, I choose to execute some plan of action.

This may result in a trial and error scenario, but I believe that the corporate culture of NTT DOCOMO is to overcome such errors and succeed in the end.

Of course, some information that I obtain will be on paper, but even information of this type will at some point originate from human beings. It's important here to determine who is behind this information and why that person has issued it. The same applies to even dry numerical data; who issued it and how enthusiastic that person is about it can add nuance to that information.

Communication is a baton pass.

—You are part of the top management supporting the president. What is it like to be in a position to know what goes on above and below you?

To begin with, part of my job is to communicate with many employees, and I welcome that. But I'm always struggling on how to allocate the 24 hours of each day for that purpose. I feel that I am not scoring as high as I could in this regard.

NTT DOCOMO has a system in which each senior executive oversees a regional office, and I follow a tight schedule for visiting my regional office, as I believe that it takes priority. On the other hand, I try to make enough time for walking through different sections in the home office so that employees can talk to me freely. Additionally, in a place like the employee cafeteria, which is also known as the "communication lounge," I can talk freely with anyone regardless of our job titles or affiliations, and I try to attend year-end and New Year parties as much as possible to increase my opportunities to talk with employees. I also enjoy "non-shop-talk" with my colleagues and employees "after five."

In short, I endeavor to create an atmosphere in which any employee can have the opportunity to talk with me freely.

In addition, I have lunch with the company president and other vice presidents several times a month to talk business and, time permitting, to have some light conversation too. In this type of setting, it is essential to talk about things that may be uncomfortable to hear so that problems can be dealt with before they get out of hand. But I also think it is important to use this time in creating a good relationship by exchanging jokes and just having a good laugh.

By the way, if I were to speak for more than half of the time during a conversation with someone, I don't think that could really be called "communication." I try to avoid one-way conversations as much as possible so that employees feel like they really can talk to me.

When I was young, I had the unfortunate experience of leaving a conversation with a superior without understanding what was said to me. If a superior and subordinate cannot communicate to the point that the superior's advice can be understood, it is a sad result for both.

Communication can be likened to a baton pass,

where there is a limited amount of time in which both the passing hand and receiving hand are holding on to the baton. When communicating with someone, I want to exchange information in much the same way that a baton is passed between two runners.

—What do you think the role of NTT DOCOMO is as an NTT Group company?

It's been more than 20 years since NTT DOCOMO was spun off from NTT, and I think that the role of the company has changed since then.

In fact, I believe that we are entering a period that demands the unified power of the entire NTT Group including NTT DOCOMO. We touched upon the role of NTT DOCOMO in our talk about the Big Event of 2020, but I am keenly aware that mobile services are built upon a variety of NTT networks.

I have recently come to feel that the business of NTT DOCOMO will come to be supported by the NTT Group in a behind-the-scenes manner. I would like to make our connection with the NTT Group even more important going forward.

—Mr. Iwasaki, please leave us with a few words for researchers in the R&D department.

Of course. In an era that demands speed, we need you to create compelling products that "shake up" the world. Please create an atmosphere conducive to innovation—and lots of it—by launching joint ventures using NTT DOCOMO technology and incorporating ideas from the outside.

Interviewee profile

■ Career highlights

Fumio Iwasaki joined Nippon Telegraph and Telephone Public Corporation (now NTT) in 1977. He served as a Senior Vice President of NTT DOCOMO and Managing Director of its Kyushu Regional Office from 2008. He became an Executive Vice President responsible for Networks and a member of the Board of Directors of NTT DOCOMO in 2010. He took up his present position in June 2012.

UMS: Software for Automating Operators' Actions to Rapidly Improve Operational Efficiency at Low Cost

Hiroyuki Adachi, Kentaro Hotta, Fumihiro Yokose, Takahiro Toyoda, and Akira Inoue

Abstract

Operational efficiency is a universal theme required in every business domain. In this article, we introduce our product called UMS (unified management support system), which enables anyone to easily automate terminal operations in office work and to thus improve operational efficiency.

Keywords: UMS, automation, operational efficiency

1. Introduction

Companies use various operation support systems (OSSs) to improve operational efficiency and ultimately reduce costs. The OSSs need to be modified in accordance with changes in operational flow caused by, for example, the launch of a new service. However, such modification typically involves very high costs and considerable time, so it is therefore difficult to modify OSSs in a timely manner. In some cases, companies abandon the idea of modifying OSSs at all. In such cases, operators have to add operations that the OSSs cannot handle, resulting in complicated, lengthy, or repetitive operations. This leads to heavy workloads and lengthy operation time. Moreover, it frequently leads to human errors.

To address this issue, we have developed the unified management support system (UMS) [1], which is software that automates users' terminal operations.

2. Features of UMS

UMS has three main features (**Fig. 1**), which are described in the following subsections.

2.1 Automation of operations

UMS is able to automate complicated user terminal operations on various applications (APs) that run on the environment indicated in **Table 1**. UMS provides various functions for automation, as shown in **Fig. 2**. A typical function is an operation to the graphical user interface (GUI)[*1] components of an AP, such as clicking on a button or inputting a string into a textbox. In addition, UMS provides functions that adapt to various behaviors of an AP such as waiting for a window to appear, image recognition on the window, conditional branches, iteration, cooperation with external commands, and interactive processing. Furthermore, UMS can acquire a string from a textbox or a list box on an AP and store it as data.

Since UMS identifies target AP windows and GUI components, it can fully operate even with GUI components arranged outside of the screen if the AP is running on Internet Explorer or comprises Windows standard components.

*1 GUI: A type of user interface that allows users to interact with electronic devices such as a mouse through graphical icons and visual indicators.

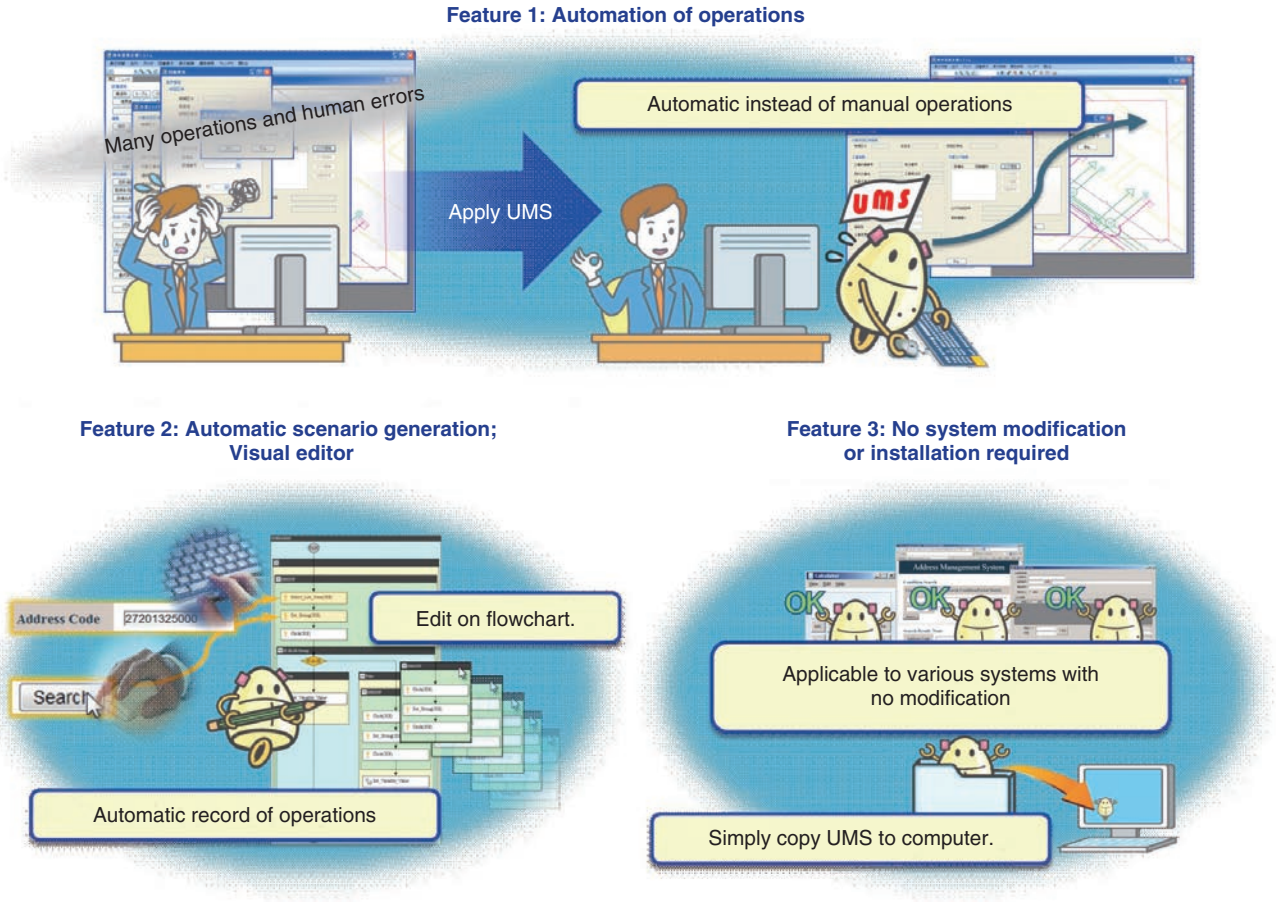


Fig. 1. Main features of UMS.

Table 1. System requirements.

Requirement	Class	Description
Hardware requirements	CPU	Intel Pentium 4, 2.5 GHz or greater
	HDD	Over 500 MB
	Memory	Over 1 GB (over 1.5 GB in Windows 7)
Software requirements	OS	Windows XP SP2/SP3 (32 bits) Windows 7 (32 bits)
	Others	Internet Explorer 6–9 if UMS is applied to web browser. .NET Framework Ver. 2.0 or greater if UMS is applied to application on .Net Framework.

CPU: central processing unit
HDD: hard disk drive
OS: operating system

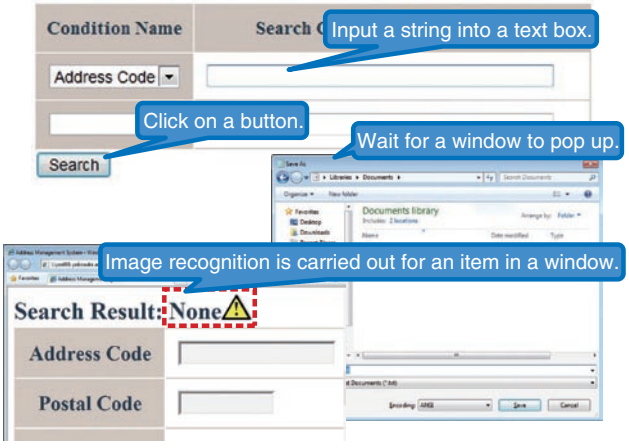


Fig. 2. Applicable operation examples.

Table 2. Comparison with other similar software.

	UMS	UWSC*1	Test automation software*2
Features	UMS is mainly for field operators and enables the operator to automate an operation intuitively.	UWSC has general versatility because it is based on replaying mouse and keyboard actions. It has good flexibility due to its high-level script functionality.	Software specialized for developing software. It has many test automation functions.
Required skill	Operator can create a scenario intuitively without coding by using automatic scenario generation, the visual editor, and other features.	Operator must create/edit text-based scripts. This requires considerable coding skill.	A visual editor is available, but it is aimed at software developers.
Data handling	Operator can easily input/output data to/from operations by using a CSV or Excel file.	Operator writes scripts to input and output data.	Operator writes scripts to input and output data.

CSV: comma-separated values

*1: http://www.uwsc.info/
*2: Micro Focus TestPartner, HP WinRunner/QuickTest Professional, IBM Rational Functional Tester Plus, etc.

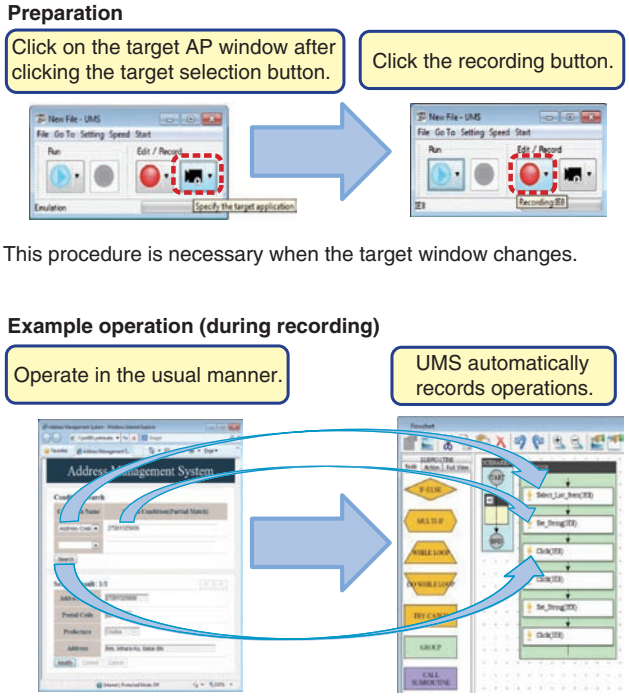


Fig. 3. Automatic scenario generation procedure via operator example.

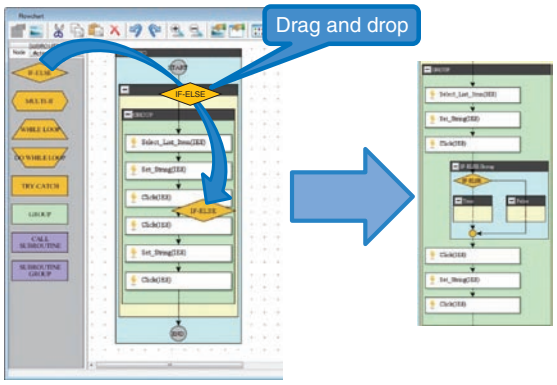


Fig. 4. Creating a branch flow.

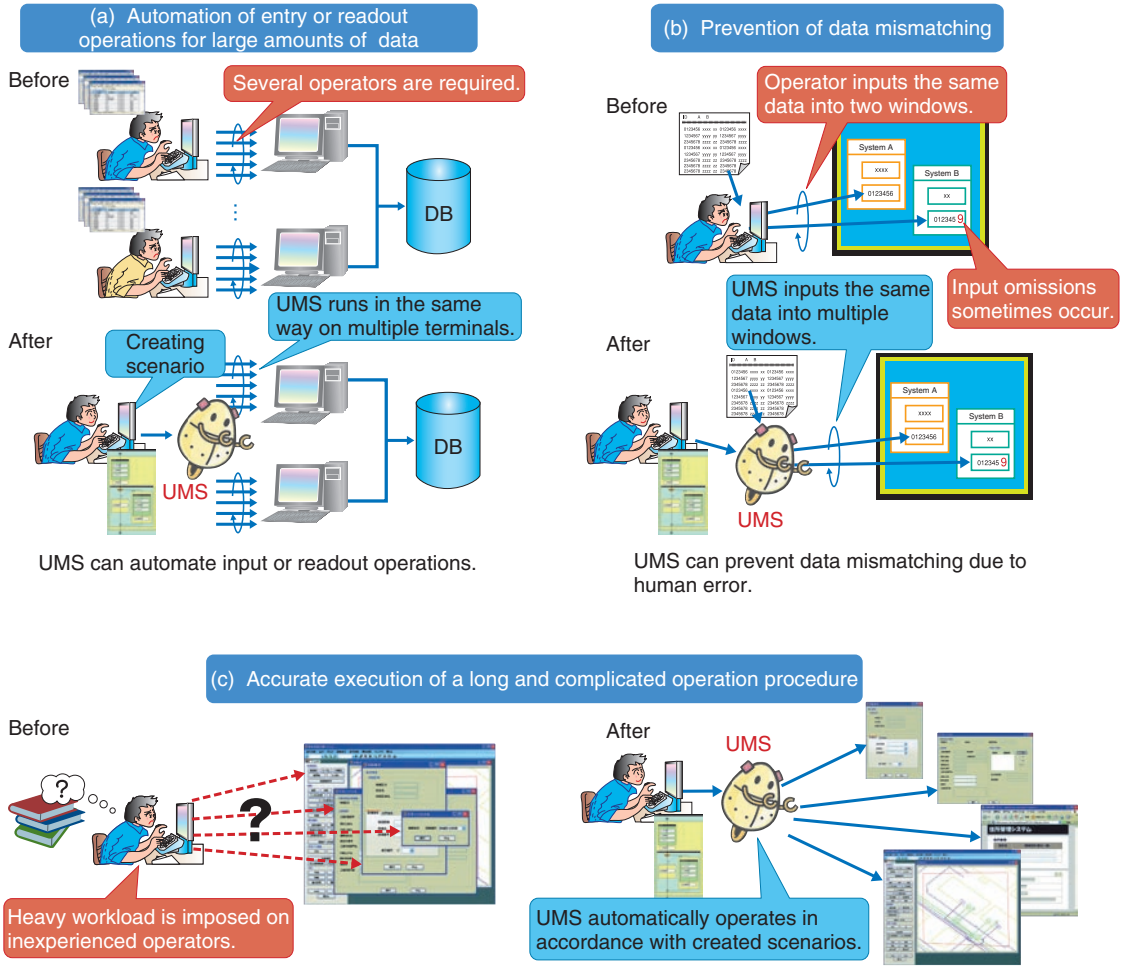
2.2 Automatic scenario generation and visual editor technology

There are a number of software programs to automate user operations; a few are listed in **Table 2**. However, they are often difficult to use because considerable programming skill is required to create the *scenario*, or automation program. UMS solves this problem by providing automatic recording via operator examples and a visual editor on a GUI. Thus, any user, even a personal computer (PC) novice, can use UMS. The procedure for creating a scenario via an operator example is shown in **Fig. 3**. If the user manipulates the target AP in the usual manner, UMS automatically records the operation on a flowchart as a node whose granularity is easy to understand, for example, *Click* or *Set String*. A user can freely edit the scenario merely by manipulating the mouse to copy and paste, delete, or rearrange nodes.

Furthermore, if an operation diverges because of various conditions, the user can describe the branch process merely by manipulating the mouse to drag and drop the IF-ELSE node from the left-hand node palette to the flowchart (**Fig. 4**).

2.3 No modification of target OSS required

The target OSS does not need to be modified because UMS operates the target AP in the same way as a user operating it manually. Thus, UMS can be



UMS can automate input or readout operations.

UMS can prevent data mismatching due to human error.

UMS accurately executes complicated operations across multiple windows.

DB: database

Fig. 5. UMS application examples.

applied to various systems at low cost and in a short time. Additionally, since UMS can be used merely by copying a few associated files to the PC, it can minimize the negative effects on the terminal environment.

3. Application examples

UMS works most powerfully in the case of repetitive entry operations involving data prepared for an AP. Typical application examples are shown in **Fig. 5**.

The first example involves entry or readout operations that are performed for a large amount of data and that require many operators. UMS can dramatically reduce the operators' workload by automatically processing the data (Fig. 5(a)).

The second example involves entry operations for inputting the same data into several OSSs, which might occur when OSSs cannot share data with each other. In this case, the operations are likely to yield data mismatches due to entry errors. However, UMS can prevent data mismatches caused by human error by accurately performing entry operations to the OSSs (Fig. 5(b)).

The third example is of a time-consuming and complex operation procedure. As operation procedures become longer and more complicated, inexperienced users require more operation time and make more mistakes. However, UMS solves this problem by enabling even long and complicated operations to be

performed smoothly (Fig. 5(c)).

In these three cases, the more data that are prepared, the more effectively UMS works.

4. New features of UMS

Currently, UMS is being applied to various operations in different fields within the NTT Group. A few functional problems have been revealed as the system's usage has become more widespread.

We have been working to expand UMS's application range, and in October 2013, we developed the latest version of the system (Ver. 3). This new version is equipped with new functions that can overcome these problems.

The major functions are described in the following subsections.

4.1 Automatic prevention of malfunctions caused by user operations

(1) Background

If the user unintentionally inputs information to the target AP through mouse or keyboard operation while UMS is operating automatically, malfunctions such as input errors or inadvertent deletions may occur.

(2) New functions

- If unintentional mouse or keyboard operations are detected, this function suspends the scenario and displays a message to the user.
- Automatic confirmation of input strings' correctness is provided.

4.2 Response to unexpected errors

(1) Background

Because UMS works in accordance with a created scenario, the user should take every possible behavior of the target AP into consideration when creating the scenario. However, since it is quite difficult to foresee every possible behavior and error, the scenario is suspended with an error message if UMS encounters an unexpected event on the AP during automatic operation.

The problem, therefore, is responding to unexpected events.

(2) New function

- The scenario continues to be executed even when an unexpected error occurs.

4.3 Expansion of applicable scope

(1) Background

UMS provides fundamental functions required for automatically creating scenarios. Users can utilize combinations of these functions to create scenarios. However, automation is difficult with some operations merely by using these fundamental functions. Certain operations are needed in specified cases, including handling complicated files, processing data formats, processing data strings, and operating with highly functional APs such as Microsoft Office and its macro programs.

(2) New functions

- VBScript[*2] can be used to freely define new UMS functions.
- A library is provided that makes it possible to reuse a group of nodes created on other scenarios.

5. Summary and future plans

We have developed UMS, which enables anyone to easily automate terminal operations. UMS is a versatile system and is now being applied to various operations in NTT EAST, NTT WEST, NTT Communications, and NTT DOCOMO [2]–[5]. In December 2013, we transferred the UMS technology to NTT Advanced Technology Corporation, and they intend to further develop and commercialize it.

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*2 VBScript (Microsoft Visual Basic Scripting Edition): A scripting language that runs on Microsoft Windows. It can automate external applications such as Microsoft Office.

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Implementing UMS to Improve Efficiency of Optical Fiber Path Testing

Shigeru Numahata, Hidemitsu Yamazaki, and Kiyoharu Sasaki

Abstract

NTT EAST routinely carries out testing of optical fibers as part of maintenance efforts to ensure that optical fiber cables are sound. Equipment for testing optical fiber paths is installed in all telecommunication buildings; if this equipment is fully utilized, testing with high efficiency and precision can be put into practice because it will be unnecessary for network technicians to go to the actual locations of the cables. However, although this testing procedure is more efficient, improvement is still required because some of the procedural operations need to be repeated. In this article, we explain how our unified management support system can be applied to solve certain problems.

Keywords: UMS, testing of optical fibers, optical fiber path testing

1. Introduction

NTT EAST periodically tests core fibers in order to determine the condition of optical fiber cables and to properly maintain them to prevent malfunctions. Optical fiber cables in telecommunication buildings are mechanically terminated in racks. Therefore, one testing method requires a tester to go on site and measure each fiber one by one with portable testing equipment. Another method involves using optical-path testing equipment installed in each telecommunication building to do these measurements automatically (see **Fig. 1**). This testing equipment can be controlled remotely, so optical fiber cables can be tested without the tester having to leave the maintenance base. The Great East Japan Earthquake of 2011 prompted a review of procedures, and consequently, application of the unified management support system (UMS) for emergency testing during times of natural disasters is under consideration. That is, the implementation of UMS is gradually being expanded starting with major telecommunication buildings.

One concern with performing emergency testing in practice, however, is that the testing work done by operators takes too much time. This is because optical-path testing equipment is optimized for performing automatic testing on a routine basis under predetermined test conditions and time intervals (usually ten days). Consequently, when testing is attempted over a wide area immediately after a disaster has occurred, it is necessary to reset the test conditions. In other words, if a large quantity of optical fiber cable is targeted for testing, operators must repeat the setting operation until they have set the test conditions for the core fibers of all optical cables and all telecommunication buildings. This kind of methodical and tedious work often results in human error, which can lead to test-target oversights or other problems as a result of the incorrect operations.

In considering how to investigate these problems and solve them somehow, we focused our attention on UMS. In particular, we thought that if UMS could be applied to automate these repeated setting operations, optical fiber cables could be tested automatically in an error-free manner without having to carry out a costly upgrade of programs (**Fig. 2**).

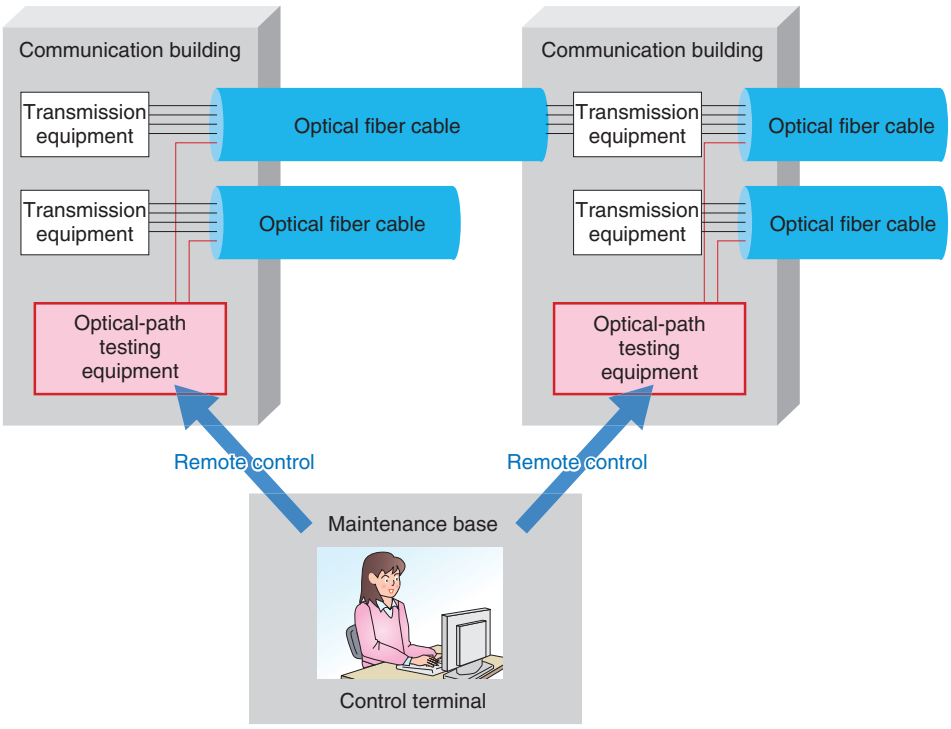

Fig. 1. Image of optical paths testing.

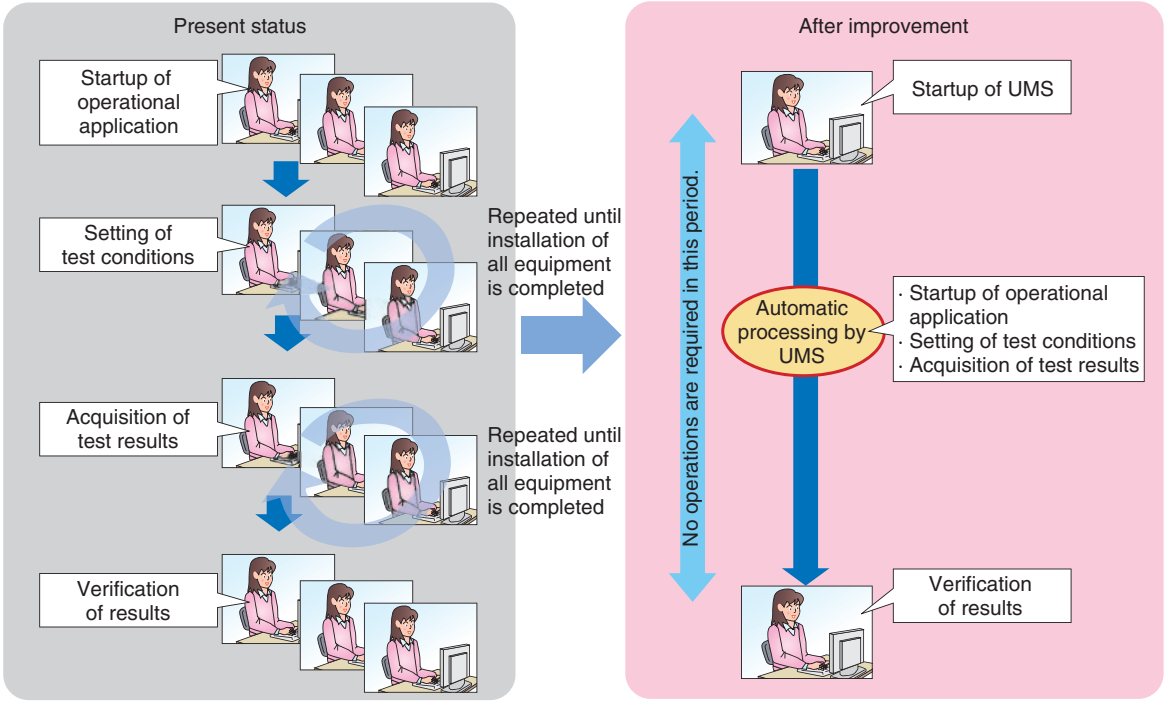

Fig. 2. Improvement in testing process achieved by implementing UMS.

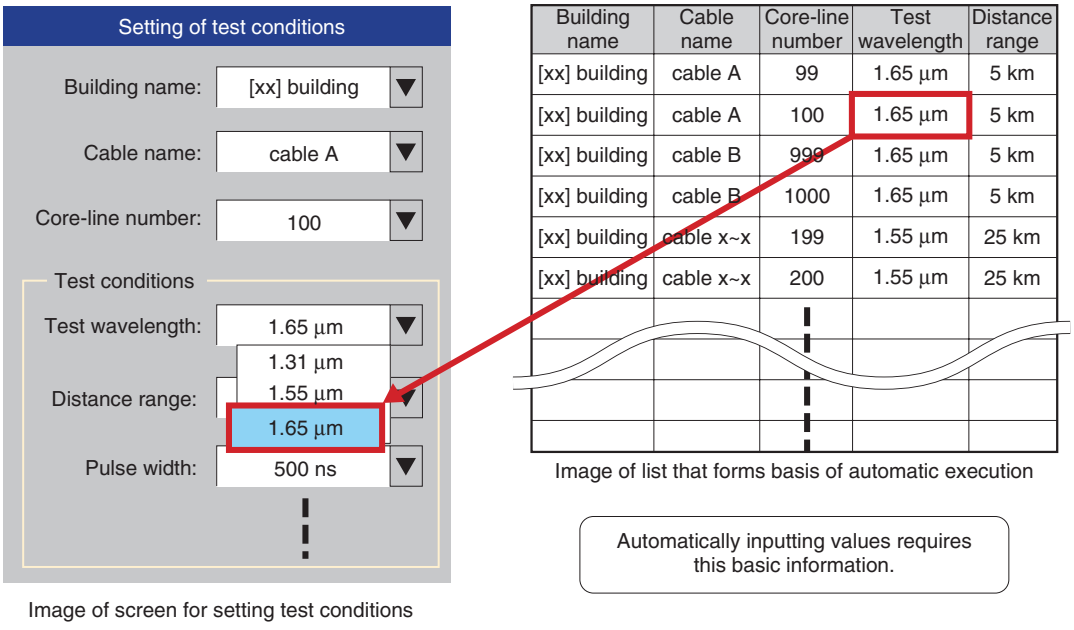

Fig. 3. Image of list forming the basis of automatic execution.

2. Activities targeting routine testing work

The momentum generated by investigating applications of UMS has improved the efficiency of emergency testing of optical fiber cable after disasters. However, while our investigation on applying UMS was underway, we became aware of the struggles of operators who were performing the repetitive operations during the ordinary periodic testing that still had to be done. If the efficiency of such regularly generated periodic-testing work could be improved in conjunction with that of emergency testing, it would be possible to achieve greater improvements, and UMS could be applied without hesitation in times of emergency by operators who had become familiar with it on a routine basis. Given these considerations, we have been making efforts to make this automation possible in regard to periodic testing as well.

3. Targets for automation

We initially chose only the repetitive operations concerning optical-path testing equipment as targets for automation. However, as we continued our investigation, we realized that true improvements in efficiency would not come from targeting only those operations, and therefore identified some other targets.

3.1 Automatic creation of list forming the basis of automatic processing

An example of such an improvement concerns creation of the list that forms the basis of automatic execution. Before UMS can be run, it is necessary to create a list that defines the data and all input details of the target processing operations as well as to create a scenario defining a sequence of operations. In this example, that creation process involves information including the telecommunication building name, optical fiber cable name, core-line number, and test conditions. Creating that list requires either inputting all data by hand from scratch or downloading information registered in optical-path testing equipment as comma-separated values (CSV) data and processing that information using a spreadsheet such as Excel. Acquiring the CSV data is also a repetitive operation, and therefore, if many targets exist, a considerable amount of time and effort is used up on those repeated operations. Moreover, once the list is created, the work is not complete; that is, the list must be updated for testing at times of emergency. However, in preparing for times of emergency, we want to avoid imposing extra burdens on operators. Accordingly, we thought it was necessary to automate the creation of the list (which forms the basis of automatic execution) itself (see **Fig. 3**).

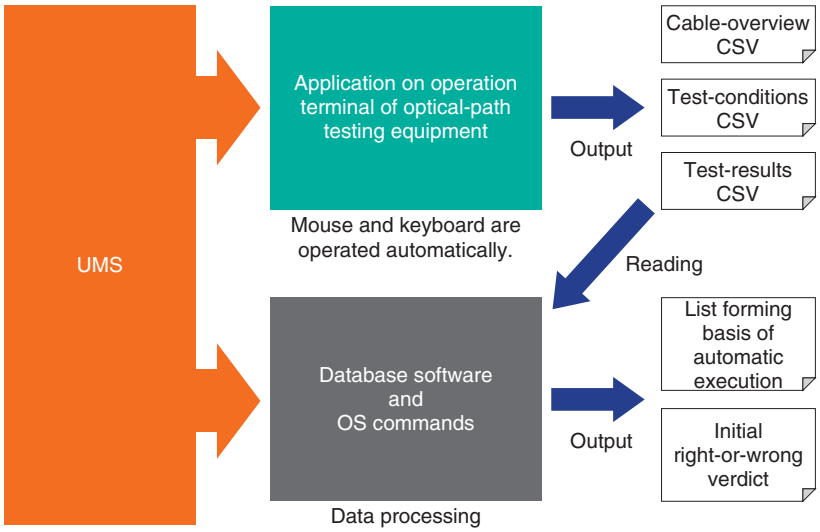

Fig. 4. Schematic image of linkage of UMS with other programs.

3.2 Automation of initial judgment of rightness/wrongness

We realized that in addition to automatically creating the base list described above, being able to simply acquire the results of emergency testing and regular testing automatically was insufficient in regard to improving efficiency. In other words, when the amount of data becomes excessive, analyzing right-or-wrong judgments requires a lot of work. To solve that problem, we added a function for simply judging variations beyond a predefined value (by comparing past and present test results) as a target of automation. This function makes it possible to narrow down all targets for detailed verification.

3.3 Method for solving problems

The above-described problems cannot be solved by only automating the operation of the optical-path testing equipment. That is to say, it was necessary to first import each CSV file that is output from each piece of optical-path testing equipment into a commercial relational database and process it there and then to match it with execution of OS (operating system) commands. UMS has a function for calling up other programs and consecutively executing them in order, and applying that function made it possible to automate all processing sequences (**Fig. 4**). This function makes it possible to flexibly handle complex processing, and it indicates that UMS is an effective tool for covering a wide range of operations.

4. Future initiatives

At present, we are conducting trials of UMS in cooperation with the Saitama branch office of NTT EAST. These trials have demonstrated that UMS improves the efficiency of periodic-testing work. From now onward, we plan to continue the horizontal expansion of UMS to all branches in cooperation with operations management.

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Expanded Use of UMS in the Tokai Area

Kumi Nakayama

Abstract

NTT WEST has been promoting the introduction of a unified management support system (UMS) since fiscal year 2011 to improve the efficiency of its optical circuit activation operations. In Japan's Tokai area, the Optical Circuit Activation Departments have been playing a leading role in promoting UMS in each of the four Tokai prefectures. This article introduces a UMS promotion project that has been launched to expand the application of UMS to other business tasks in the Tokai area with the aim of achieving highly efficient and standard operations.

Keywords: UMS, promotion project, UMS summit

1. Introduction

At NTT WEST, the introduction of unified management support system (UMS) tools began in fiscal year (FY) 2011 under the guidance of the Service Management Department with the aim of improving the efficiency of optical circuit activation operations. The plan was to make business operations more efficient by providing a core system for optical circuit activation operations in the plant system. It was found, however, that there were many operations that required manual entry of large amounts of data. The number of lines to be activated was also increasing annually, so UMS tools were introduced to automate terminal operations in optical circuit activation to make this task more efficient. These tools took on groundbreaking significance, as they were able to greatly reduce the time required for those terminal operations. About the time of the FY2012 Kaizen Promotion Conference in Fukuoka, promoted by NTT WEST Group every year, personnel at each optical circuit activation center began to adopt these UMS tools, commenting that, "These tools make work easier!" and "They make work practically error-free!" The use of UMS tools exploded as a result. This development also had a supplementary effect in that skilled personnel at the various centers began to hold energetic exchanges on successful case studies in their prefectural areas and to brainstorm on how they could further improve the efficiency of their work through UMS.

2. Independent efforts at Tokai branches to expand UMS

To further stimulate the NTT WEST movement described above, each of the four Tokai prefectural branches began implementing their own UMS efforts in the first half of 2013. Specifically, the Optical Circuit Activation Department at each of these branches took on a leadership role by holding study sessions and presentations on expanding the use of UMS to other business tasks. The following projects were launched at these branches.

(1) UMS48: Launched in March 2013 by the Mie-branch business department with the aim of creating 48 UMS scenarios and expanding the number of UMS tool engineers (Team UMS48 members).

(2) Toko-Ton (Thoroughly) UMS: Launched in May 2013 by the Shizuoka-branch business department with the aim of further utilizing UMS by increasing the rate of UMS usage as well as securing UMS engineers.

(3) Gifu-Ai UMS★106 Project: Launched in May 2013 by the Gifu-branch business department to develop UMS engineers (106 individuals) and formulate UMS scenarios (106 measures).

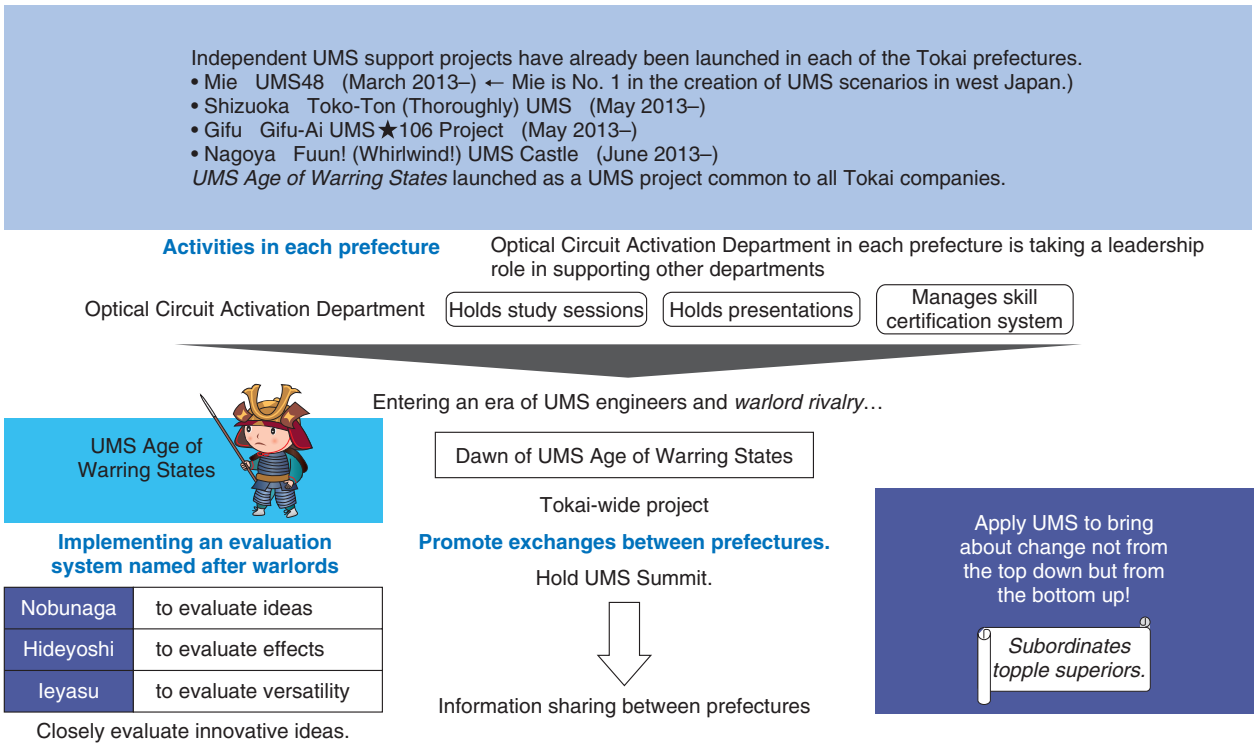

Fig. 1. Dawn of *UMS Age of Warring States.*

(4) Fuun! (Whirlwind!) UMS Castle: Launched in June 2013 by the Nagoya-branch business department in collaboration with NTT Access Network Service Systems Laboratories to raise UMS awareness in other business operations and to develop UMS engineers.

3. Launch of *UMS Age of Warring States* as a Tokai area UMS promotion project

While the independent UMS expansion efforts at each Tokai prefectural branch were underway, a UMS promotion project named *UMS Age of Warring States* was launched in July 2013 with the aim of expanding the application of UMS throughout the Tokai area. The naming of this project is based on the fact that the Tokai area is now entering a period in which the number of UMS engineers is increasing, which is similar to the rise of warlords during Japan's civil war period and in which the driving ideology behind UMS is not a top-down approach but rather a bottom-up one in which *subordinates topple superiors* (**Fig. 1**).

A project system was constructed under the guidance of a project leader, namely, the plant department manager of the Nagoya branch. In this system, various types of business operations (concerning the plant, sales, the corporate office, and common planning) are laid out along a vertical axis, while the four prefectural areas and their respective systems, which are based on efforts and activities to date, are laid out along the horizontal axis. The elements of the horizontal and vertical axes are systematically connected to construct a system that takes expandability into account.

The system includes project-promotion and technical-support roles such as:

- Formulation of plans such as UMS-promotion measures
- UMS technical support and help desk

It also includes news-provision and progress-management roles such as:

- Providing news on proposed business measures and support for managing them
- Assessing UMS progress and effectiveness

Furthermore, as business managers are actively recruited to be UMS promoters, they can continue to improve based on their knowledge and daily work experience in applying UMS in order to utilize UMS thoroughly in any field in the early stages of tasks (**Fig. 2**).

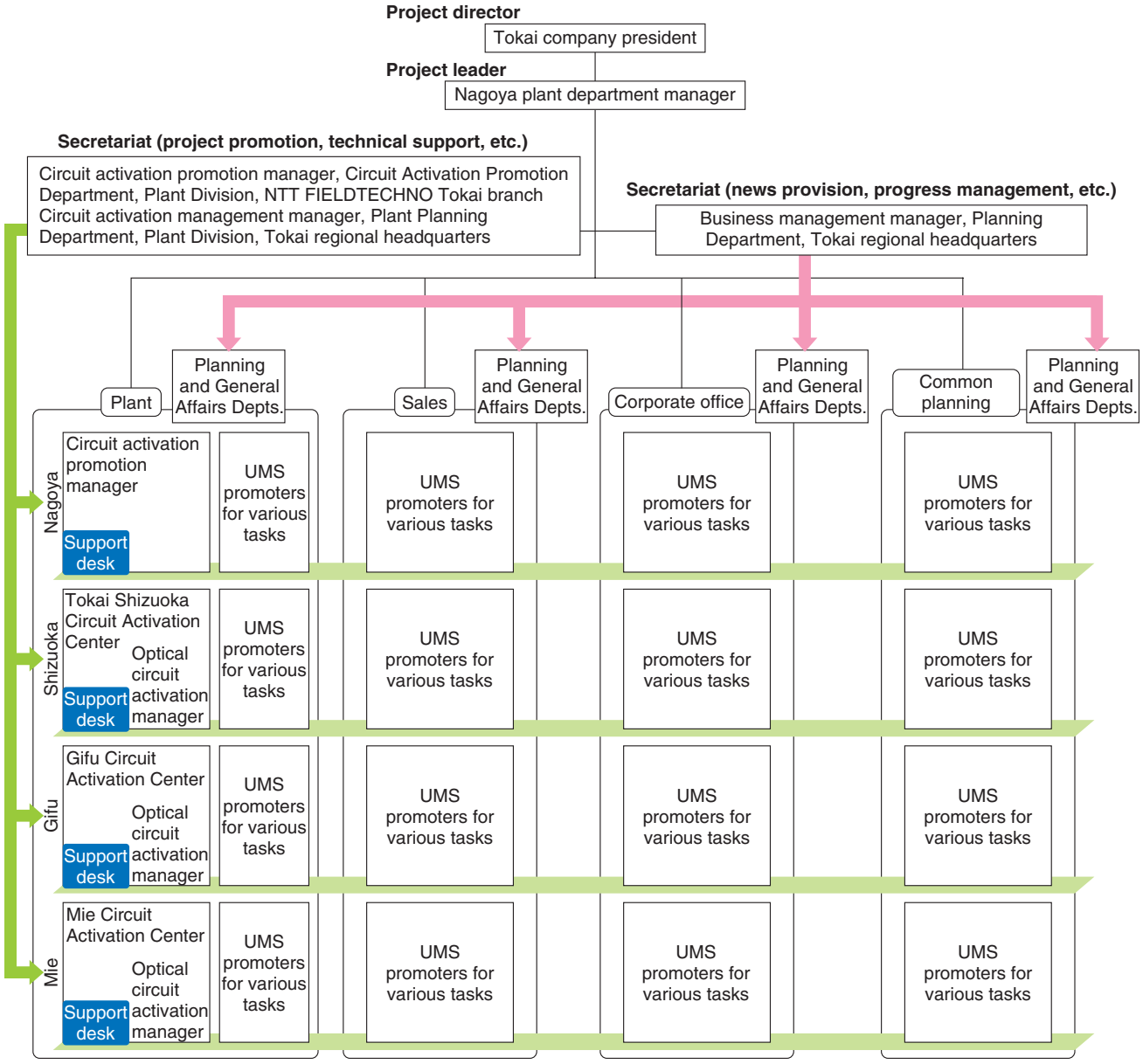

Fig. 2. UMS introduction/promotion project system.

4. UMS Summit

For this project, plans were made to hold a UMS Summit every quarter as a forum for presenting achievements and promoting horizontal development, and on the basis of these plans, the 1st UMS Summit was held in Nagoya City on September 20, 2013. About 80 employees participated from the four Tokai prefectures, and presentations were made on ten measures.

This 1st UMS Summit included presentations on measures to be implemented in business operations other than those in optical circuit activation, for which UMS has already been adopted. These include utility-pole test data preparation (Optos) and FLETS TV terminal management (Optos) in the plant system, service order submission (ARENA/IP-OPS) in the sales system, work table preparation (e-Human II: human resource and salary integrated core operation system) and payment of external expenses (N-

ACTIVE: a bookkeeping system commonly used in the NTT Group) in the common-planning system. Since UMS-applicable operations and systems are quite diverse, it had been thought that the adoption of UMS was simply in its initial stage, but this summit was proof that UMS was definitely beginning to spread to a variety of areas. The versatility of UMS is extremely high in operations such as work management and payment of expenses that are not specific to any one area of business, and the plan within the project is to support the expansion of UMS to such operations in conjunction with the 2nd UMS Summit in Shizuoka (held December 20, 2013).

5. Future developments

A key issue in expanding the use of UMS is the creation of a mechanism that would enable personnel skilled in UMS to exchange their opinions and provide mutual technical support, thereby facilitating the rapid horizontal development of UMS measures. The ultimate goal here is to unify and refine UMS scenarios and achieve a smooth transition from *quantity* to *quality*. NTT WEST plans to continue its efforts in promoting this project with the aim of producing maximum results in the Tokai area.

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Improving Efficiency of Company-wide Operational Work by Applying UMS

Kazuaki Uchiyama, Kazuyuki Senba, and Yuki Tsunashima

Abstract

Companies are routinely encumbered by numerous labor-intensive tasks that take much time and effort to complete. By autonomously handling labor-intensive operations (primarily human resources related tasks) through application of our unified management support system (UMS), operators are improving efficiency and quality in a wide range of business areas. This article reports on the effects of implementing UMS at work sites across NTT Communications on a company-wide basis and explains our efforts to further expand UMS throughout the company.

Keywords: UMS, operational work, efficiency

1. Introduction

The Process and Knowledge Management Department at NTT Communications is the driving force behind improving operations throughout the company. This department is therefore visualizing operational processes that are duplicated or overly complex and reforming them by applying the latest information and communication technologies in areas where elements of the company value chain intersect.

1.1 Current status of operational work

Efforts are often made to systematize operations to improve efficiency. However, a lot of systematization work only covers certain parts of processes. Other process tasks still remain after the systematization is implemented. For example, information inquiries and information distribution between multiple systems have always been done manually by employees, and they involve labor-intensive operations such as carrying out *bucket relays* of information between operators and visually cross-checking the results.

1.2 Background to implementation of UMS

Cutting the workload of staff performing operations at facilities on-site requires heavy investments and long development periods spent in reviewing the specifications of large-scale systems. Consequently, the increases in efficiency achieved by staff having certain skills using applications such as Excel and Access are limited.

In view of this, NTT Communications began discussions on applying the unified management support system (UMS) on a company-wide basis in July 2012. UMS can automatically record the actions of operators at their computer terminals and automate the work of staff (such as implementing conditional branching on flowcharts) without requiring programming. Consequently, the efficiency of operations has been steadily improving as a result of operators autonomously applying UMS. Moreover, UMS is being extended for use across the entire company under the name *manual-procedures warp tool*, by familiarizing operators with it and making its adoption easier.

Number of UMS implementations: about 130 per year (as of July 2013)

Operational segment	Activities concerning main automation target (Blue highlights indicate operations involving large amounts of work, where the implementation of UMS is highly effective.)	No. of scenario implementations	Savings achieved through reduced work (100 m yen/year)
Sales/ service orders	- Drafting approvals of quotations and customer proposals (about 90,000 cases/year) - Issuing orders for various requested services and options - Surveys of service-provision areas - Coordinating relative prices and construction costs - Appraisals of many global locations (supplementary system function for appraisals) - Progress reports on service orders for agencies - Creating alarm lists for discount systems	40	▲1.0
Facility design	- Designing transmission systems/paths/circuits (about 100,000 cases/year) - Configuring parameters - Designing facility units and panel expansion - Designing wiring of intra-office optical cables - Supervising work to remove obstacles Managing relocation of communication equipment (cables or poles) due to external factors such as road construction	40	▲1.2
Fees	- Billing-itemization inquiries/job-invoice reissuing (about 40,000 cases/year) - Operations for revising information concerning billing addresses etc. - Registration of information concerning campaign discounts	30	▲0.5
Shared	- Conference costs/overseas business trips/ordering services/drafting goods approvals (about 50,000 cases/year) - Registration and stock-taking of system accounts - Processing due-payment requests (end of month) - Appropriation of arrears (last month of the quarter) - Registering information about staff salaries - Processing requests at help desks	20	▲0.3
Total		130	▲3.0+α

Fig. 1. Current status of implementation of UMS at NTT Communications.

2. Result of implementing UMS

We made an effort to get operators to willingly apply UMS while carrying out their daily work, and as a result, we successfully improved the efficiency of operations in areas such as service ordering, design, billing, maintenance and repair, and system development. The results of implementing UMS at NTT Communications are explained in **Fig. 1**.

We found that a great number of manual operations are performed across the entire company; in other words, they are not limited to operation systems. Moreover, we demonstrated that in addition to improving the efficiency of operations, UMS reduces the amount of checking work required (by improving accuracy and quality) as well as the amount of investment in system development. Furthermore, we demonstrated that standardization work along with UMS implementation is an effective approach that helps in creating flow-through processes and in optimizing the creation of scenarios.

Example 1: Improving efficiency of operations for configuring parameters

Operations for configuring parameters must be carried out manually circuit by circuit, and the operators who do that configuration work must be continuously stationed at operation systems. Consequently, UMS is applied so as to automate those network-opening operations (see **Fig. 2**). In concrete terms, the conventional configuration time required per circuit has been reduced from 10 minutes to 2 minutes by implementing UMS.

Example 2: Improving efficiency of making final decision about customer proposals, estimates, etc.

Final decisions on proposals and estimates given to customers must be manually drafted on electronic decision-making systems on a daily basis. Applying UMS improves the efficiency of drafting final decisions and correcting technical flaws by conducting checking, reworking, and other such tasks. In concrete terms, the time spent on these operations has been reduced from the conventional 60 hours per item

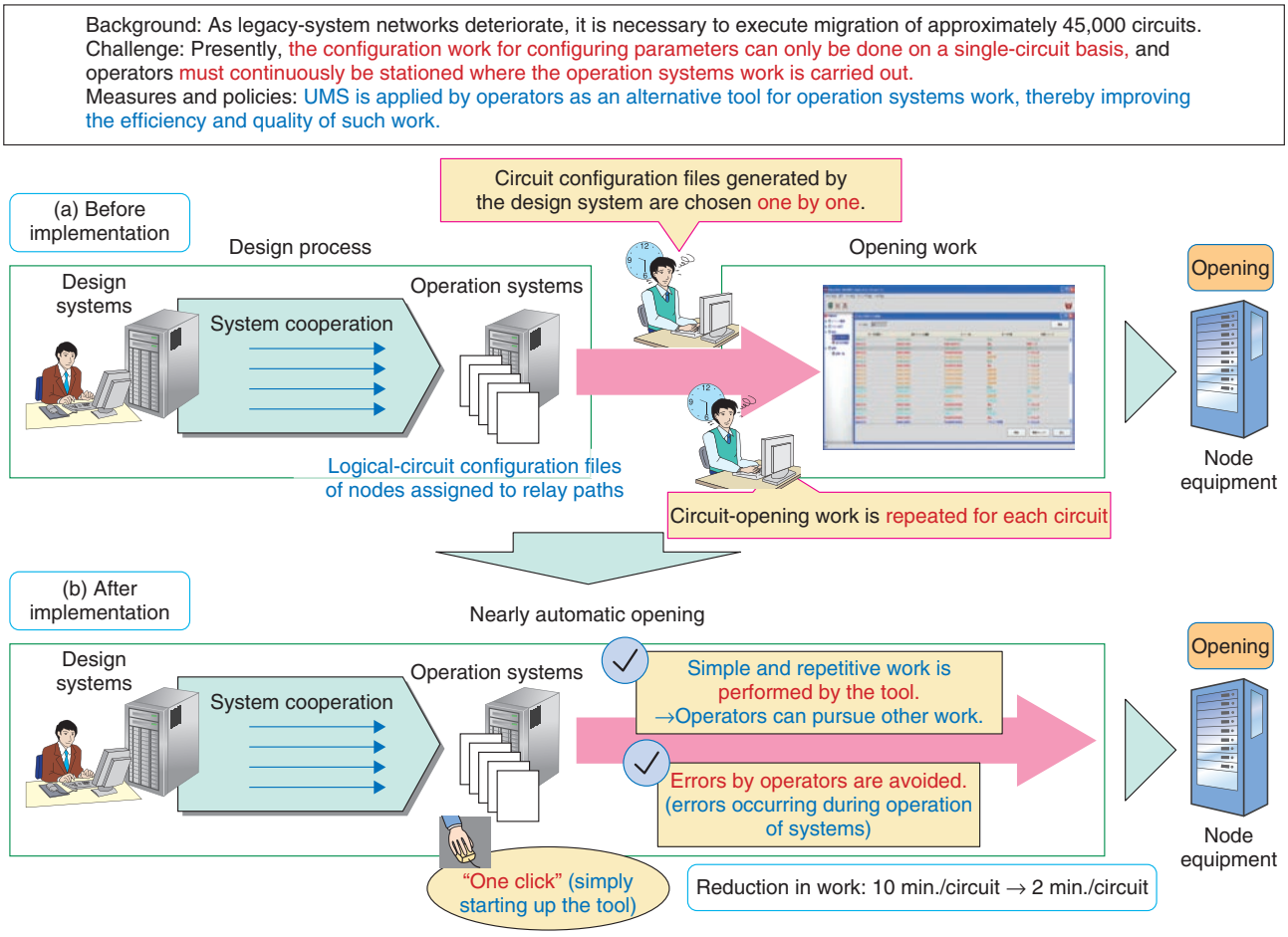


Fig. 2. Improving efficiency of configuring parameters.

to only 30 minutes per item.

Example 3: Improving efficiency of updating customer information

When customers notify NTT Communications with information concerning changes to contract names or the names of places of business, etc., those changes must be confirmed, copied and pasted one by one, and then input into customer-management systems (while care is taken to avoid selection oversights and input errors). Implementing UMS makes it possible to improve the efficiency of updating customers' information, conducting identity checks, etc., while creating a paperless process. Specifically, time spent on such application work has been cut from 20 minutes per order to 10 minutes per order, and the amount of paper consumed has been reduced by about 10,000 pieces per month.

3. Activities for supporting expansion of UMS

As part of our aim to get the entire company involved in applying UMS to improve efficiency, we have introduced various activities to support the expansion of UMS. These include increasing in-house visibility, applying human resources, giving commendations to staff working on automation, promoting recognition of UMS, and so on; they are explained schematically in **Fig. 3**. A questionnaire was given to more than 400 students attending a course on UMS, and the responses indicated that 30% of students said they would "immediately try" it, while 50% said they would "look into work applicable to UMS". Moreover, many answers mentioned the ease of use of UMS, its effectiveness in regard to on-site work, and the students' willingness to adopt UMS. Some of the responses are summarized below:

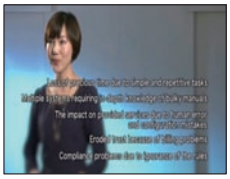
(a) One-day training course (AM: classroom lectures; PM: trying out posting automation adapted to work of class members)

⇒ Expandable to cover NTT Group companies

By attending one-day training course, students acquire UMS skills and put UMS into practice.

On-the-job training to improve skills/class achievements
- Number of times held: 30
- Number of attendees: 400 (including center operators)

(b) Lateral expansion
- Extension to group companies: UMS is especially effective for group companies involved in labor-intensive work.
- Global extension: English version of UMS tool will be provided at each overseas site; UMS is currently being used for making estimates. Remote support is provided in addition to explanatory videos and manuals.



(c) Commending persons making superior efforts—through presidential awards, online journals, dedicated websites, etc.—enhances motivation of workers.

Fig. 3. Activities for supporting implementation of UMS.

- "I now understand that automation (which I have come to accept as inevitable) can be accomplished simply by using UMS".
- "Great precision is required in avoiding input errors during copying and pasting etc., so I will definitely give UMS a try".
- "I want to apply UMS to system-verification work. If we implement it successfully, it will be possible to perform validation work on the weekend without the need for any staff".

4. Future expansion of UMS

From now onwards, while continuing to help improve the efficiency of operations across the entire company by applying UMS, we will focus our attention on expanding the application of UMS on a global basis to our overseas branches. At the same time, we will do our utmost to put the accomplishments of our research laboratories (starting with UMS) to practical use. Moreover, we presume that work-intensive operations are challenges faced by many kinds of businesses—both domestic and overseas. We believe that UMS can help solve problems that our customers may face, and we therefore want to expand application of UMS in a strategic manner to the general marketplace.

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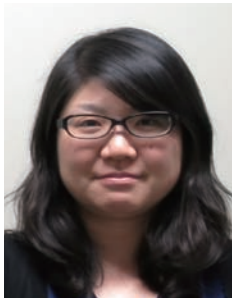

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A UMS-based Default-setting Tool for Smartphones and Tablets

Toshiaki Daido, Kazuaki Ichihashi, and Takashi Nonobe

Abstract

At NTT DOCOMO, we have applied our UMS (unified management support system) to develop and test a tool for efficiently setting defaults when corporate customers adopt smartphones and tablets. Utilizing this tool makes it possible to quickly adopt smartphones and tablets, which typically require many setup operations at first use, and is expected to help streamline operations in the early stages.

Keywords: UMS, default-setting, smartphone

1. Introduction

Adoption of smart devices such as smartphones and tablets by businesses is steadily progressing. Some widely reported examples of the way businesses use these devices include providing solutions befitting various businesses and device lineups, enhancing application service provider services, and introducing information related to application of smart devices. However, businesses desiring to utilize smartphones and tablets as mobile phones for business use must first perform many operations for the numerous default settings in order to optimize the devices for their purposes. Such operations include pre-installing business-use applications, configuring networks, and setting security levels, and the burden imposed by the cost of carrying out these operations is often a barrier to adopting smart devices. At NTT DOCOMO, we have addressed this issue by greatly improving the efficiency of operations concerned with default setting by establishing various tools, in particular, a tool utilizing a unified management support system (UMS) for speeding up the adoption of smart devices in the offices of our customers. We evaluated this tool in utilization trials.

2. Current situation regarding default settings

The five operations normally performed at NTT DOCOMO to set defaults on smartphones and tablets are listed as follows. (Note that each operation takes about 30 minutes per device.)

(1) Basic device settings: homepage; security; sound and screen options
(2) Network settings: APN (access point name); VPN (virtual private network); Wi-Fi
(3) Application setting: installing applications for each customer
(4) Device-account setting: acquiring accounts of businesses such as service providers (or setting existing accounts)
(5) Verification of setting details: final confirmation of detailed default settings.

Operations (1) to (3) are taken care of at device sales agencies, system integrators, and NTT DOCOMO (for specified devices only) using the dedicated tools provided. Accordingly, operation (4)—work on which has yet to be started—was chosen as the target for streamlining by applying UMS.

3. Effect of implementing the default-setting tool

The results of surveying examples of adoption of smartphones and tablets by corporate customers indicated that device accounts are acquired in batches beforehand (via Windows personal computers (PCs)) by information system departments or general affairs departments for user management). Moreover, it was ascertained that when the accounts are being acquired, much time and effort is required to input numerous

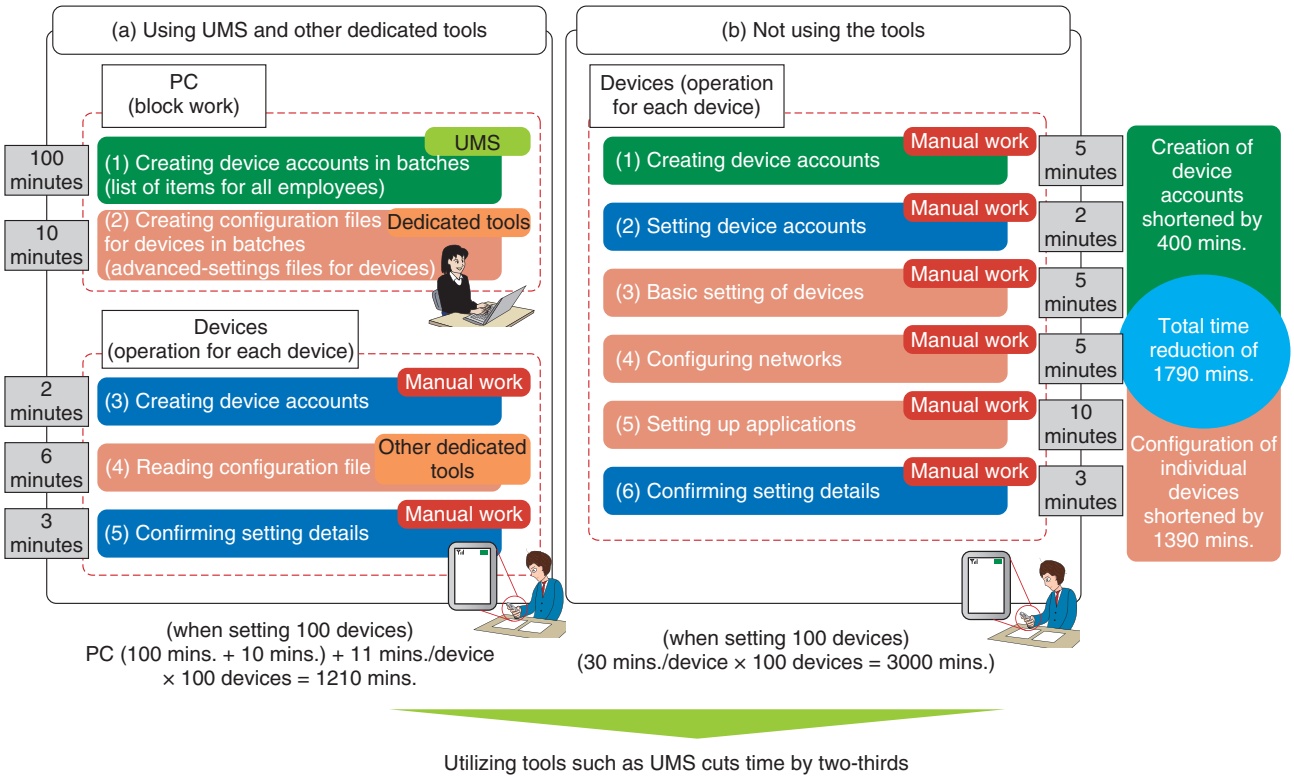
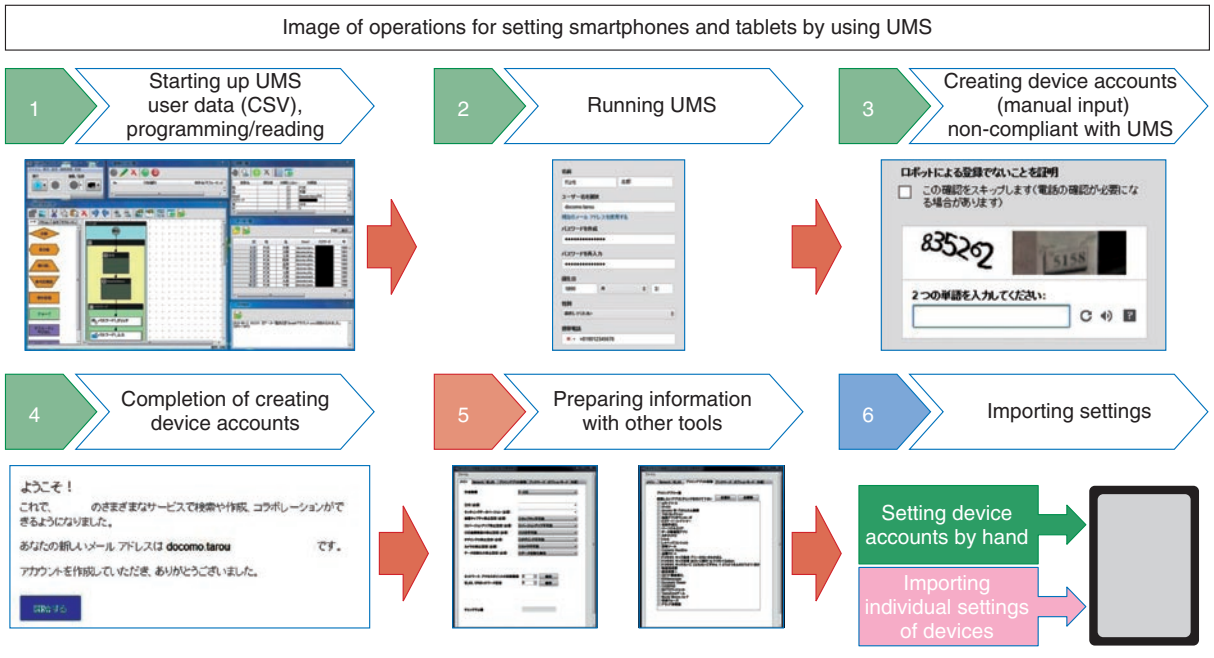


Fig. 1. Effect of introducing tools such as UMS.



Automating setting operations leads to reductions in input errors (due to manual setting) and number of workers.

Notes: Steps 1 to 4 are where creation of device accounts [by using UMS shown in Fig. 1(a) step (1)] is automated.
Step 5 is where settings of individual devices using other dedicated tools [shown in Fig. 1(a) steps (2) and (4)] are automated.

Fig. 2. Complete image of default setting after introducing tools such as UMS.

items for each account (which must be individually created), or a great deal of time is wasted because of input errors resulting from manual work. In light of these issues, we thought we could effectively apply UMS under the assumption that Windows PCs would be the operational platform, and we therefore developed a tool for acquiring device accounts in batches as a function of using the UMS. The main points concerning operation of the developed tool are listed below:

(1) Existing user lists (CSV (comma separated values) type) are applied for batch acquisition of a large number of device accounts.
(2) Fields that must be confirmed manually (such as security items) are not automated.
(3) Not all processes are supported by UMS, and combinations with existing tools are considered.

The effect of introducing the developed tool (on a test basis) for default setting is explained in **Fig. 1**.

Compared to setting all default items in a manual fashion, setting them by utilizing the UMS-based tool improves the efficiency of operations; that is, the number of setting errors is reduced, and less manpower is required for the setting operations. In fact, the number of working hours is cut by two-thirds (see **Fig. 2**).

4. Future developments

With device accounts, it is sometimes difficult to acquire a large number of accounts in accordance with the specifications of the sites provided by service operators. The developed tool is currently being retained at NTT DOCOMO for test applications. From now onwards, while affirming trends concerning service providers, we will investigate introducing the developed tool at each service point as soon as circumstances are clarified. Furthermore, we have confirmed that UMS is applicable to various operations; accordingly, we will also extensively study applications of the tool for purposes other than default setting and will strive to bring even more added value to the tool to appeal to corporate customers.

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Creation of Wide Business Domain Using Visual Communication Services

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Abstract

Visual communication is one of the many promising applications of an optical broadband network. These Feature Articles provide an overview of services and report on the business research and development underway at NTT EAST and NTT WEST as part of the NTT Group's efforts to develop and expand services that help to create a rich lifestyle by connecting people to each other and to society via video services.

Keywords: videophone, space sharing, content sharing

1. Introduction

Visual communication services are known as tools for transmitting information using audiovisual technologies. However, we also define them as a means to more naturally and smoothly achieve *mutual understanding* and *affinity* between people by adding video to voice, under the concept of connecting people to people, and people to society. That results in something that makes our customers' lives more comfortable and fulfilling.

At NTT, we have been working on developing visual communication services such as videophones since the 1960s, when we were known as the Nippon Telegraph and Telephone Public Corporation. However, the use of videophones did not spread initially. The main reason for this is thought to be that the network had a low-quality narrow bandwidth and a relatively higher cost of use compared to now. Nowadays, most of the quality issues have been solved, although efforts are always ongoing to improve the network infrastructure and devices, and the business applications are expanding. A recent survey [1] found that the combined market of video-conferencing, web-conferencing, and audio-conferencing was valued at 42 billion yen in 2012 and is expected to expand in the future.

By contrast, personal use of these services has not expanded yet, although users have come to have a positive idea of such services because of the attractive promotion of videophone functions on smartphones and tablets.

2. Toward expansion of personal visual communication

The NTT Group provides personal videophone services such as FOMA and HIKARI FLET'S Phone. We conducted a questionnaire survey and found that people had various reasons for not using videophone services. Some of the reasons they gave are as follows:

- Fundamental obstacles: "the voice phone is good enough", "had no one to call on the videophone",
- Psychological factors: "resistance to put pressure on others to use the videophone", "need to care about my personal appearance and the surrounding environment", "cannot talk while doing other things",
- Functional factors: "no feeling of space-sharing and no sense of reality due to the small screen and insufficient video quality", "complicated operation", "difficult settings",
- Economic factors: "high price of videophone devices", "telecommunication cost",

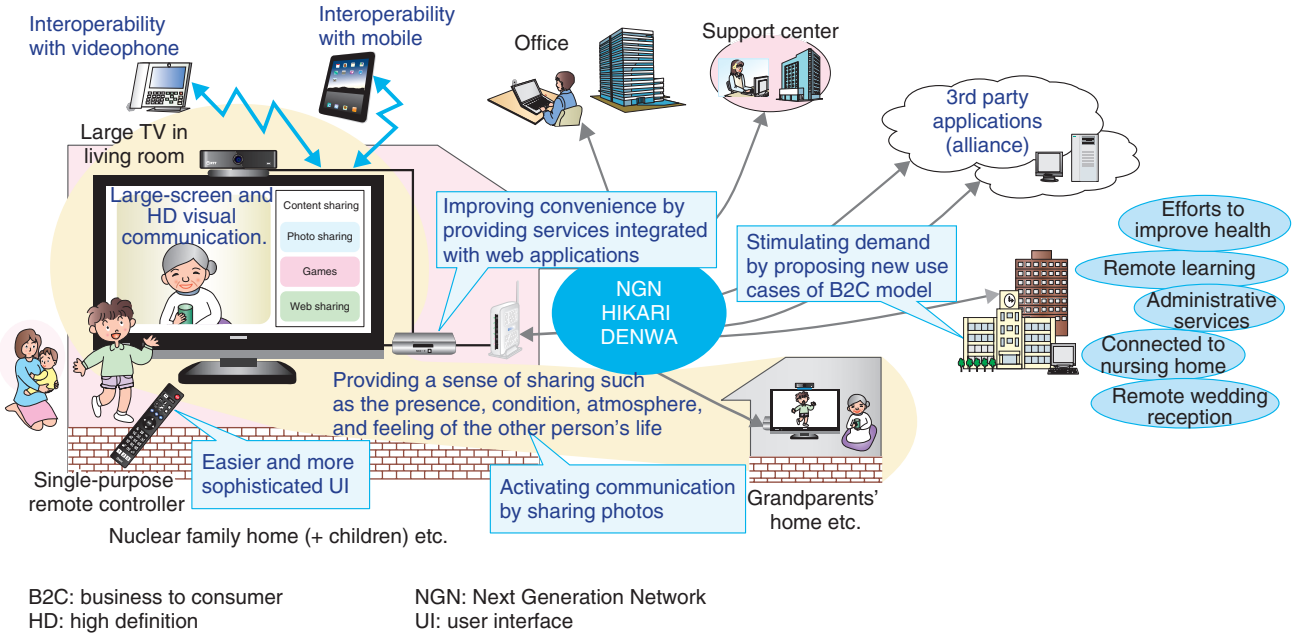

Fig. 1. Conceptual image of Hikari Living project.

- Environmental factors: "few other people have videophone devices".

Moreover, many of these problematic factors occur simultaneously, which makes the situation even more complex.

Of these problems, however, the functional factor of "a small screen" in particular was solvable. The eco-point system for home electronics initiated in Japan in May 2009 had induced consumers to purchase large screen televisions (TVs) that could receive digital terrestrial TV broadcasting. Consequently, by using these TVs as videophone screens, we are now able to have a large screen without worrying about the price of videophone devices.

This provided a good opportunity to tackle the issue of expanding the personal use of visual communication. We conducted a survey on general consumers' intended uses of videophones. The persona model of the survey was family communication, in which there seemed to be less resistance to using a videophone and frequent opportunities to use a telephone. Then, on the basis of the results, we set our initial target user as businessmen posted to remote locations and living away from their family and elderly people living alone. We also created a new concept of services, as follows:

- New *HIKARI visual communication* using a large screen TV in living room,
- Casual and effortless communication,
- Sense of unity and space-sharing feeling, to convey atmosphere and emotions.

This concept was named *Hikari Living*.

By specifying a target user and a use case of the service, we gain the possibility to solve the fundamental obstacles and the psychological factors in the five problem areas described above. We can also achieve preferentially functional improvement, reduced cost, and widespread use of videophones.

Through these efforts, we are creating a service to communicate seamlessly, in order to connect separated family members in the comfort of their living room, and in a lifestyle suitable for each family.

In addition, we are developing a new use case, which involves establishing a connection environment that is not limited to the living room only, but includes any place inside or outside the home, for example, between the office and the home. We also aim to realize an environment in which social services (medical care, education, long-term care, and community services, etc.) can be accessed conveniently inside the home. We are stimulating demand for Hikari Living by proposing these capabilities (**Fig. 1**).

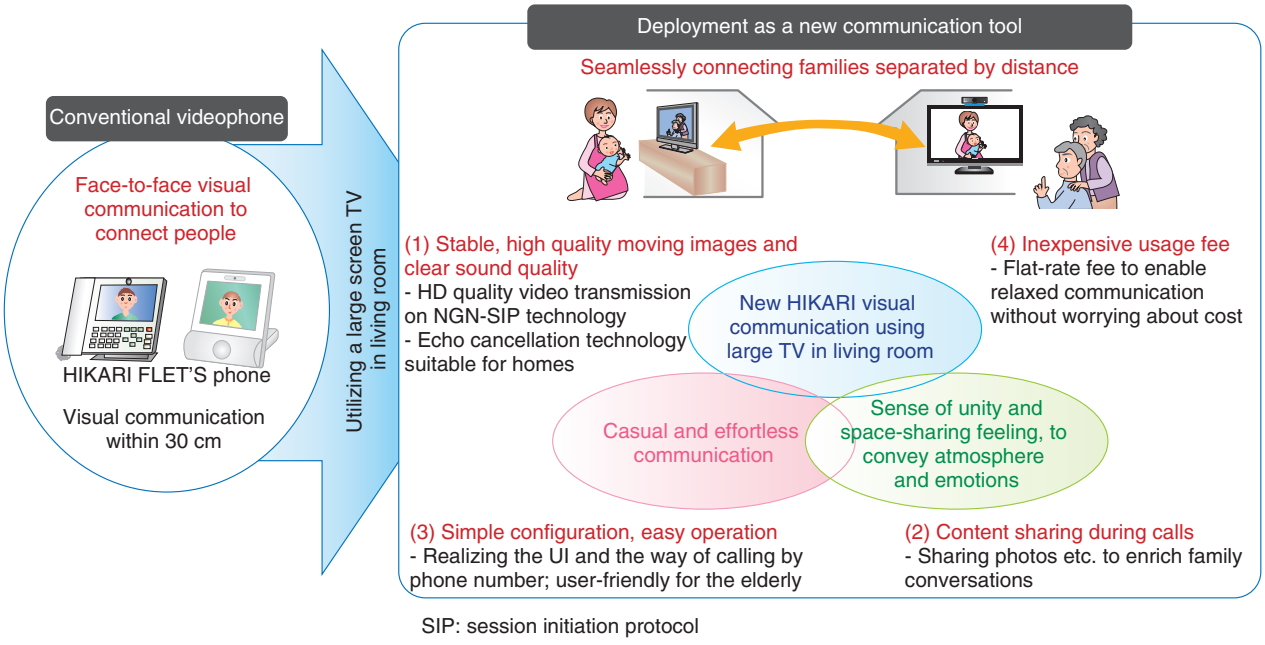

Fig. 2. Primary features of Hikari Living concept.

3. Concrete plan for attaining Hikari Living

To meet the requirements of the Hikari Living concept, we set the goal to achieve the following features (**Fig. 2**).

(1) Stable and high quality moving images, and clear sound quality (functional factor),
(2) Content sharing during calls (functional factor),
(3) Simple configuration, easy operation (functional factor),
(4) Inexpensive usage fee (economic factor).

We first discuss the feeling of space-sharing and a sense of reality. To achieve this, it is necessary to ensure that the HD (high definition) quality video transmission has been adjusted for large screen TVs. Also, in environments where various life sounds exist, the application of acoustic echo cancellation technology with noise suppression developed by NTT Media Intelligence Laboratories ((1) in Fig. 2) helps to achieve natural and clear communication with no howling or acoustic echo.

Here, we discuss the idea of casual and effortless communication. When people are in the same place, they often enjoy looking at photos and videos together while carrying on a conversation. We considered it important to be able to perform such typical activities with our service. Utilizing the content-sharing technology of NTT Service Evolution Laboratories ((2) in Fig. 2) enabled us to achieve this capability.

In addition, it is necessary to be able to set up the device easily even by people who have never used a personal computer. It should also be as easy to operate as watching TV and making phone calls. Therefore, a simple setup guide was drawn up based on knowledge of user experience and a universal design that was studied at the NTT Service Evolution Laboratories ICT (Information and Communications Technology) Design Center ((3) in Fig. 2).

Finally, to enable users to communicate in a relaxed way without worrying about the cost, we discussed with NTT EAST and NTT WEST the possibility of providing the service at a flat-rate fee. As a result, we have introduced a new videophone service at a flat-rate fee ((4) in Fig. 2).

We provide the videophone service with these features using a set-top box that is connected to the TV, so that it can be used widely with TVs from any manufacturer.

In these Feature Articles, we describe an overview and the business development of NTT EAST's Hikari Share Place and NTT WEST's Hikari Danran TV as services that embody the concept of Hikari Living. We also explain the technologies that support Hikari Living, specifically, how we achieve stable and high quality moving images and clear sound quality, and

the technology that allows content sharing during calls.

4. Future prospects

The aim of Hikari Living is to provide communication services to people separated by distance that allow them to feel like they are in the same place. This concept is becoming more common for various purposes such as remote learning and remote viewing of events such as wedding receptions.

Hikari Living provides visual communication via the TV, which is indispensable to the lives of elderly people. Consideration is being given to provide this service in senior housing as part of efforts to improve the health of the elderly. It may take a little longer for personal use of videophones to become standard in people's lives, but it will most likely happen eventually, since visual images have the power to convey ideas that cannot be expressed in words only.

We would like to prompt many people to take notice of this power and to help them construct a rich lifestyle. We will therefore continue to promote efforts to expand our visual communication services.

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Space-sharing Communication by Hikari Share Place and Hikari Danran TV and Future Business Development

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Abstract

December 2012 marked the launch of Hikari Share Place (NTT EAST) and Hikari Danran TV (NTT WEST) as two products that enable high-quality, real-time visual communication using a home television (TV). These products were enhanced in August 2013 with a *content sharing during calls* function that allows the sharing of data such as photos and videos and the sharing of web content while the user is conversing with another party. With the addition of this function, Hikari Share Place and Hikari Danran TV will help make space-sharing communication a reality among family members, friends, and acquaintances living far apart from each other. New ways of using these products can also be expected through alliances with other operators.

Keywords: space sharing, visual communication, content sharing

1. Introduction

Recent years have seen a rapid increase in the number of households consisting of elderly persons living by themselves in addition to those made up of nuclear families and individuals living away from home for work. Against this background, NTT EAST and NTT WEST sought a means by which people with close ties but living apart from each other could use the television (TV) in their living rooms to easily create a shared space for relaxation and communication at any time, thereby overcoming the limitations of time and distance. To this end, they developed Hikari Share Place (NTT EAST) and Hikari Danran TV (NTT WEST)[*1] in collaboration with NTT laboratories and launched these products in December 2012 [1]–[3].

2. Service overview

This service constitutes an information device that enables high-quality visual communication and content sharing during calls by connecting the product to a home TV supporting the HDMI (High-Definition Multimedia Interface) and using that TV's screen (**Fig. 1**). Because the other party's surroundings can be shown on the TV's large screen, this service goes beyond the face-centered communication of past systems by sharing the atmosphere of the other party's location in such a way that the user feels as if he or she is also there. This capability makes for enjoyable visual communication.

3. Main features

3.1 Communication by stable, high-quality video and clear audio

Visual communication provided by this service

*1 Both Hikari Share Place and Hikari Danran TV require paid subscriptions to FLET'S HIKARI NEXT or FLET'S HIKARI LIGHT and HIKARI DENWA.

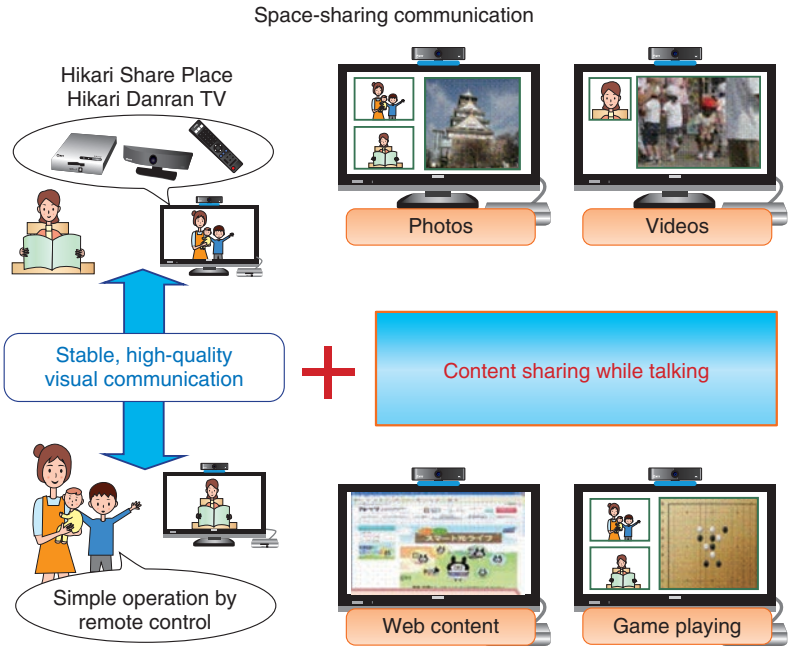

Fig. 1. Service overview.

makes uses of NTT's HIKARI DENWA optical fiber IP (Internet protocol) telephony service, which, in turn, uses the Next Generation Network (NGN) developed by the NTT Group. In contrast to best-effort type videophones that use the Internet, this service enables extremely stable visual communication through connections that secure sufficient bandwidth.

The high-definition quality video and clear audio provided by this service will enable users to enjoy space-sharing communication with a high sense of presence. The product is equipped with echo cancellation technology incorporating noise suppression, which was developed by NTT Media Intelligence Laboratories to enable stress-free and enjoyable video calls using one's own TV in one's own living space.

3.2 Sharing diverse content while talking with the other party

We can all imagine a scene in which a family reminisces about the past while viewing photographs of a family outing or a video of a sports day at school. This service has made such activity possible even for family members living far apart by providing a content-sharing function that can be used even while a call is in progress. This *content sharing during calls* function incorporates the content-sharing technology of NTT Service Evolution Laboratories that enables the bidirectional transmission of data while users talk, based on NGN SIP (session initiation protocol). As a result, users can share and save various types of content including photos, videos, and website URLs while a video or audio call is in progress.

With this technology, a user sends content to the other party by bandwidth-guaranteed data communication (data connect) over HIKARI DENWA, thereby enabling stable and secure transmission of content to another party with operations as simple as making a call.

3.3 Simple setup and operation and reasonable usage fee

All devices and cables necessary to use this service—including the main unit, remote control, and microphone/camera—are bundled with the product. As a result, all the user needs to do to start using the service immediately is to unpack and connect those components (**Fig. 2**). The service is designed with a user interface and screen transitions that even users who are apt to say "I don't know how to proceed!" or "I can't operate this!" will find straightforward and easy to understand.

Furthermore, to make the service easy to operate

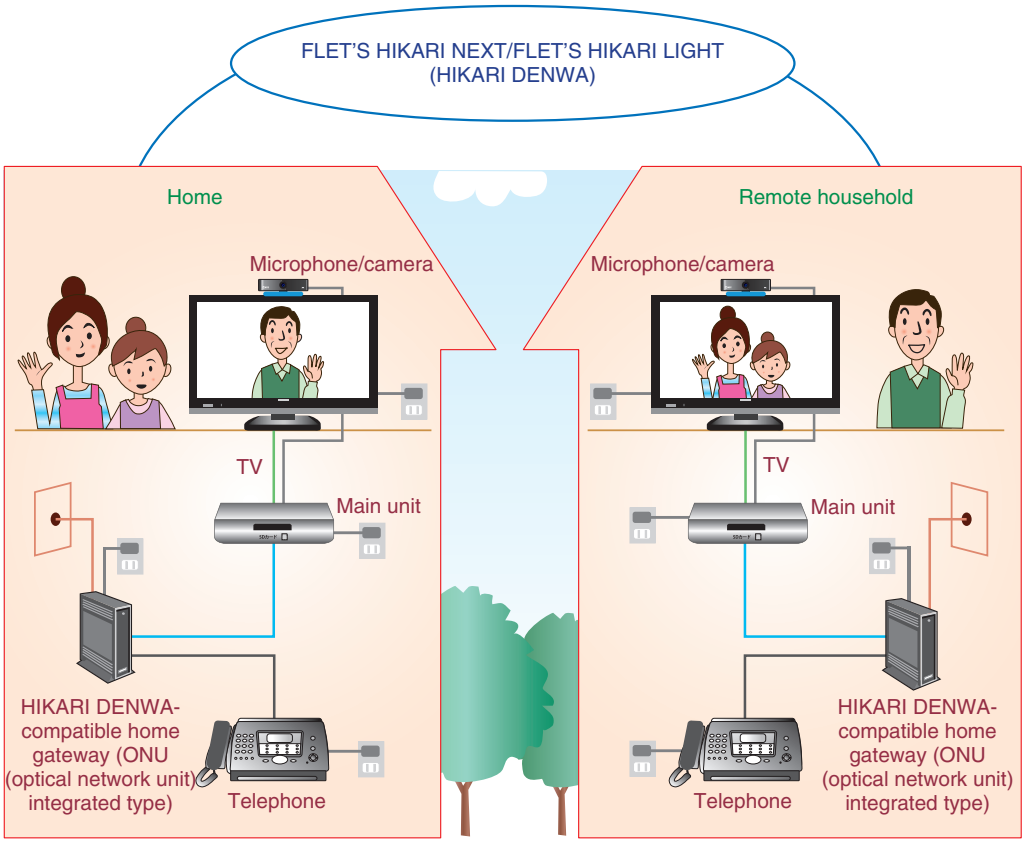

Fig. 2. Connection scenario.

even for small children and the elderly, the service incorporates features that enhance the usability of both hardware and software components.

For example, the functions that can be used with this service are listed on the home screen when the device starts up so that the desired function can be selected in an intuitive manner. In addition, photos or videos received through the content-sharing function are displayed as thumbnails at the bottom of the home screen that can act as a stimulus to conversation with the other party.

NTT EAST and NTT WEST also provide a flat-rate plan for this service called *Terebidenwa Choisu Teigaku* (Videophone Choice Flat Rate)[*2] so that users can enjoy talking as much as they like without worry.

The Videophone Choice Flat Rate plan is a service that allows video calling to a previously designated telephone number at a flat rate. In the NTT EAST area, the customer may designate up to two telephone numbers and make as many video calls to each number as desired at a flat rate under the condition that each call is less than 30 minutes. In the NTT WEST area, the number of telephone numbers that can be designated and the maximum calling time per call under the flat-rate plan have been extended to five numbers and three hours, respectively, to make it easy to use the service under a variety of usage scenarios. The fee for Videophone Choice Flat Rate is 525 yen (tax included) per month at both NTT EAST and NTT WEST.

NTT WEST also provides all necessary equipment under a rental plan to reduce the customer's initial expenses for this service.

4. Future business development

Under the basic concept of space-sharing communication with cherished family members or people we hold dear living far away, we can envision a variety of

*2 Use of the *Terebidenwa Choisu Teigaku* (Videophone Choice Flat Rate) plan requires paid subscriptions to FLET'S HIKARI NEXT or FLET'S HIKARI LIGHT and HIKARI DENWA.

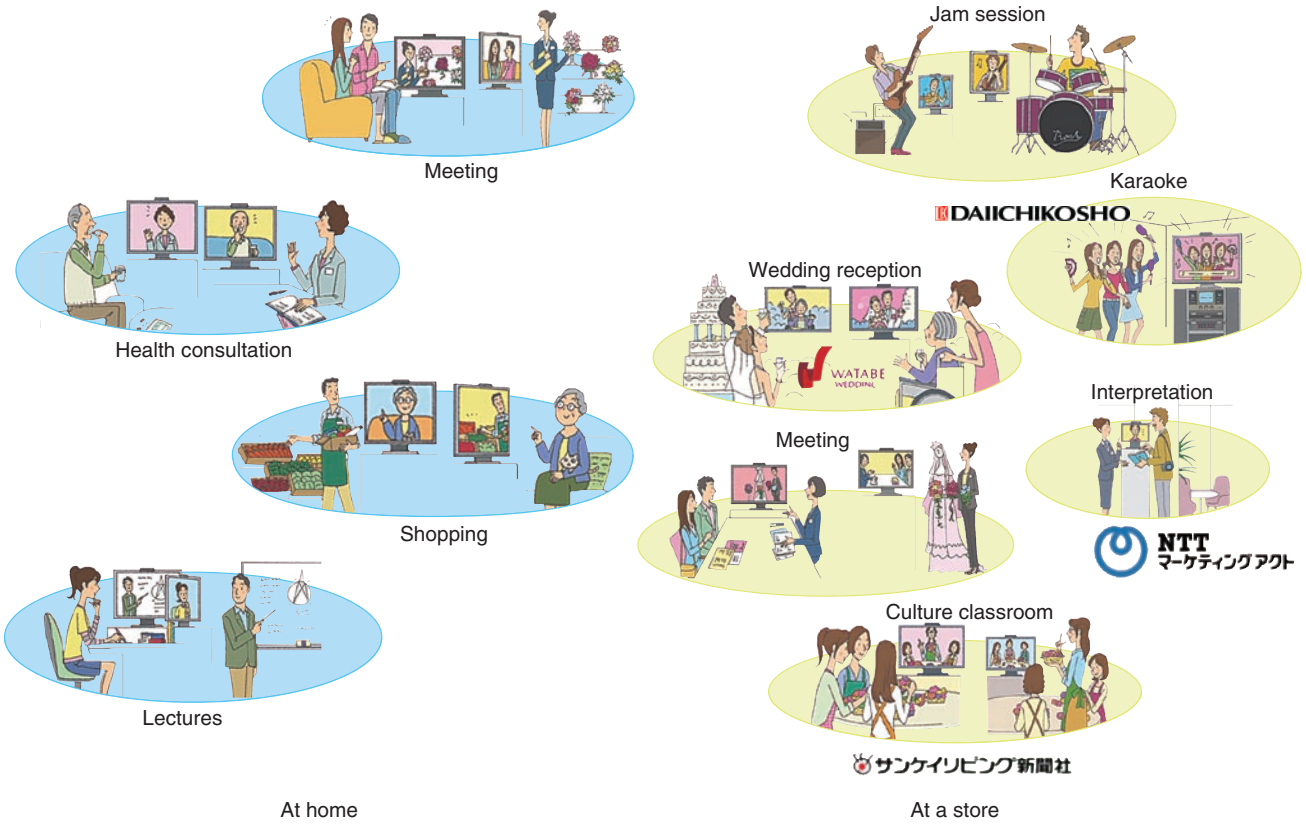

Fig. 3. Examples of usage scenarios through alliances.

usage scenarios for this service including daily use. The service could be used, for example, to hold events such as birthday parties, to share dinner with a father living away from home for work—just as if the whole family were gathered around their dining table, and to check on the condition of one's elderly mother who lives by herself.

Furthermore, in the area of visual communication, this service is applicable to a variety of fields including education, caregiving and medical care, commerce, and entertainment. The plan is to develop this service through alliances with other business operators.

Some current examples include Watabe Wedding, a wedding service company using visual communication to provide a service called *Tsunagaru* (Connect) *Wedding—Hello Celebration* that enables relatives and friends who cannot attend the customer's wedding to participate remotely in the wedding reception, and Sankei Living Shimbun Inc., which is currently experimenting with a *culture classroom* service that connects its main venue with satellite venues via a video link.

We are also holding joint studies on service creation with many other operators. Our goal here is to form alliances that will facilitate the use of visual communication in a wide range of everyday applications. These could be home schooling to receive lessons from school or cram school while at home, or simply remote personal instruction; shopping support for individuals who have trouble getting out for physical reasons; exercise lessons for the elderly living in sparsely populated areas to improve their health; and a department store concierge service in which users can receive general advice from staff on clothes coordination and dressing (**Fig. 3**).

Going forward, NTT EAST and NTT WEST seek to spread the use of space-sharing communication via the service introduced here by creating a variety of usage scenarios that can add convenience and pleasure to everyday life.

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Supporting Technologies for Hikari Living

Akira Nakagawa, Mushin Nakamura, Suehiro Shimauchi, Kiyoshi Nakahama, Takeshi Matsumoto, Ryuichi Tanida, Kazunori Kobayashi, and Koichi Sugiura

Abstract

Hikari Living is not only a means for visual communication but also a tool that includes a function for sharing content during visual communication. This tool enables family members separated by distance to visually share content from their living rooms. In this paper, we explain supporting technologies that enable Hikari Living to provide comfortable visual communication.

Keywords: content sharing, media tuning, echo canceller

1. Introduction

The Hikari Living concept includes the following features:

- New type of *Hikari* visual communication via a large television (TV) screen in the living room
- Easy and relaxed communication
- Shared atmosphere providing a feeling of togetherness

These features were achieved by using the four technologies below, which are explained in detail in the subsequent sections.

(1) Content sharing technology on the *data connect* service provided in the Next Generation Network (NGN) Hikari telephone
(2) Speech delay reduction technology to minimize speech delay, which is a requirement for fixed telephones
(3) Video quality tuning technology to stream high definition video via the NGN Hikari telephone (about 1.8 Mbit/s)
(4) Acoustic echo cancellation technology to stably reduce echo in the living environment of general households

2. Content sharing technology

Hikari Living enables users to share digital content such as pictures taken with a digital camera during audio communication and visual communication. Steps for sharing pictures while carrying out visual communication are as follows (**Fig. 1**):

Step 1: The users establish visual communication.

Step 2: The sender chooses one photo from a selection of photos and sends the data to the receiver.

Step 3: When all of the data has been captured by the receiver, the screens of both the sender and receiver are automatically divided into right and left panes. The left side displays the visual communication image and the right side displays the shared data.

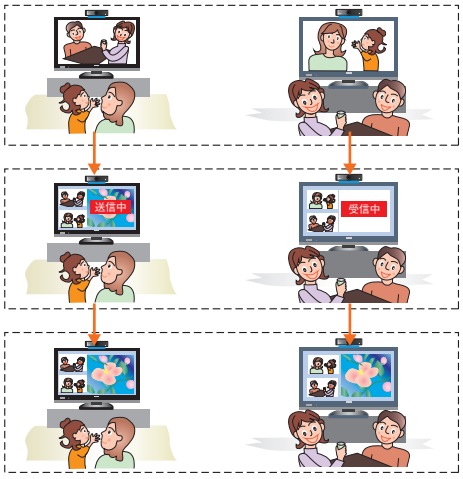
As described above, you can share digital content with the person you are speaking to. To realize this function, we used our new *Content Sharing During Communication Protocol*.

This protocol works are shown in **Fig. 2**. The protocol enables either the caller or callee (receiver) to send digital content. Only two requirements are set for the devices used.

Requirement 1: Both devices must be able to support incoming/outgoing communications (audio or audio/visual) and be capable of sharing digital content from either side.

Requirement 2: Both devices must be capable of determining the types of content the other side can process, for example, by previewing it.

To confirm that these requirements can be met, this



Step 1: Establish visual communication.

Step 2: Send digital content during visual communication.

Step 3: Share digital content during visual communication.

Fig. 1. Function to share pictures during visual communication.

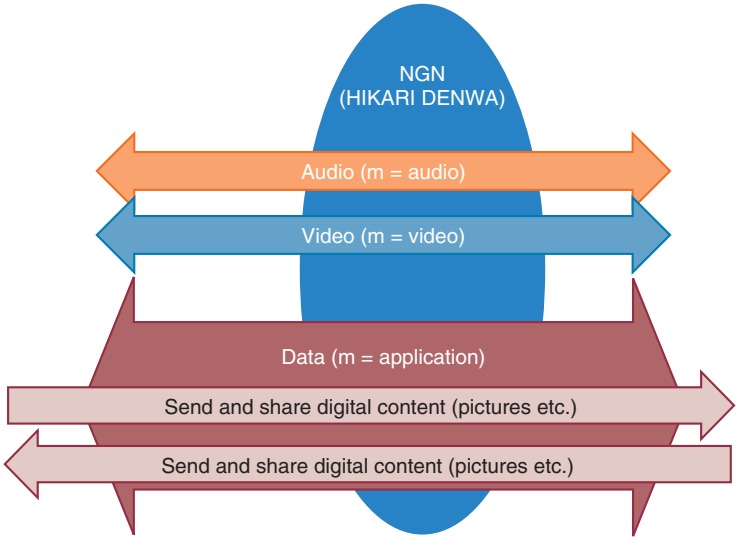


Fig. 2. Content sharing during communication protocol.

protocol enforces the following rules:

Rule 1: Establish transmission path in a TCP (transmission control protocol) session in order to share content multiple times with two-way commands (**Fig. 3**).

Rule 2: Exchange device capabilities such as what kinds of previewable content will be allowed after the path is established.

When we were designing the Content Sharing During Communication Protocol, the protocol design for normal state operation went smoothly, but of course, we also had to consider all abnormal states.

Specifically, we considered all situations (especially the collision of processes and collision between manipulation commands from the sender and receiver), in designing the protocol so that it could recover from all eventualities.

Consequently, designing the Content Sharing during Communication Protocol was rather a challenge given the complexity and frequency of abnormal states, as opposed to designing completely new services such as Hikari Living.

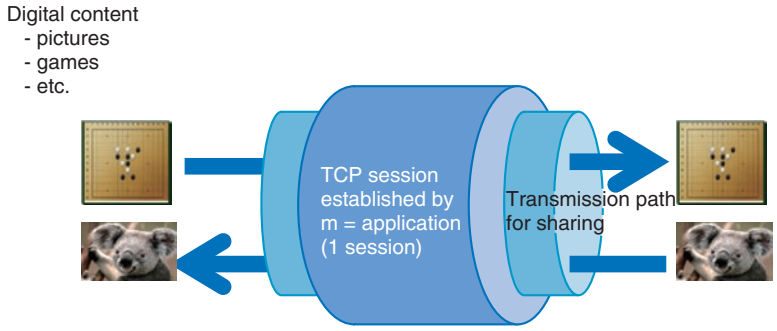


Fig. 3. Establishment of transmission path for digital content.

3. Speech delay reduction technology

In Hikari Living, the target for one-way speech delay is less than 150 ms. The assumed maximum network delay is 30 ms, so the upper limit of delay for the Hikari Living terminal is 120 ms. Furthermore, because the packet size of the Hikari telephone is 20 ms, 60 ms is required for the transmission of voice packets. This 60 ms comprises 20 ms each for capture delay, playback delay, and synchronization delay. The processing delay in the speech codec and echo canceller is also 20 ms. The remaining delay is 40 ms (= 120 ms – 60 ms – 20 ms). Therefore, it was necessary to implement a jitter buffer and synchronization buffer with delay of less than 40 ms. To achieve a small delay, it is necessary to reduce the buffer size. However, a shorter buffer size makes it easy for sound interruptions to occur as a result of external disturbances, e.g., if the CPU (central processing unit) load is too high. Accordingly, we attempted to determine the minimum buffer size that would not generate sound interruptions under various conditions. By controlling the read and write buffer sizes, we were able to control the accumulated amount of audio data to the minimum buffer size. With this control, the target for the one-way speech delay (less than 150 ms) was achieved.

4. Video quality tuning technology

We adjusted the configuration of the camera, encoder, and decoder units to improve video quality, while satisfying not only related standards but also the limitations for both bandwidth and delay time (**Fig. 4**).

First, the camera and its preprocessing section were tuned in order to capture clear and easily recognizable images under low bitrate conditions. The light-receiving sensitivity of an image sensor in the camera was increased so as to obtain an easily viewable picture under dark conditions. In addition, a function to correct peripheral darkening, which is a typical characteristic of wide lenses, was added. It works by brightening the edges of problematic pictures. Furthermore, we developed a new adaptive noise reduction filter that maintains edge information in order to get a well-modulated picture.

Second, we focused on the encoder. For practical use of the limited bandwidth, we changed the rate of bit allocation for each picture because it greatly affects video quality. However, we checked the peak rate and delay time simultaneously because these factors are also affected by it.

The last adjustment involved the decoder. Because there is a tradeoff between latency and playout smoothness, we adjusted the buffer size in order to smooth out the network jitter and bit-rate fluctuations. Bit-rate fluctuations are the result of biased bit allocation by the encoder.

These tests were repeated under various illumination conditions to ensure stable operation.

5. Acoustic echo cancellation technology

When visual communication (or audio communication) is initiated on Hikari Living, you can hear the other person's voice from the TV's built-in loudspeakers connected to the Hikari Living terminal, as if you were listening to the sound of a TV program. You can talk to the other person without being aware of the microphone, since the small microphone is built into the Hikari Living camera device set on the TV. Natural hands-free visual communication is achieved even in such audio setup conditions through

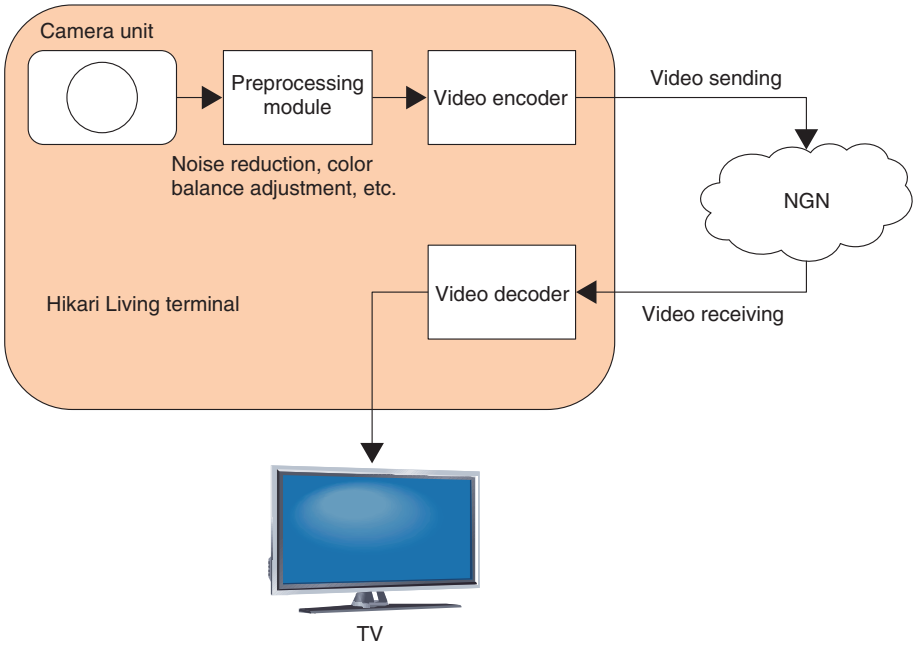


Fig. 4. Configuration of video transmission.

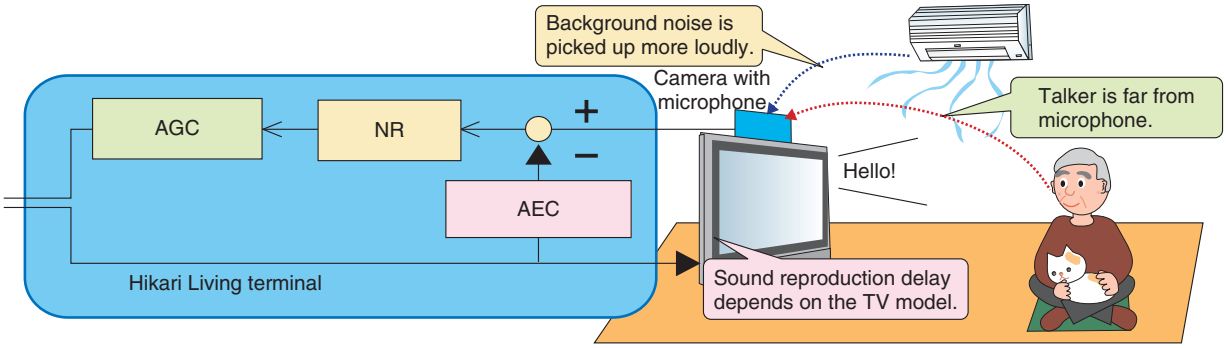


Fig. 5. Acoustic echo cancellation technology used with Hikari Living.

the implementation of newly developed audio processing functions, i.e., acoustic echo cancellation (AEC), noise reduction (NR) and automatic gain control (AGC), in the Hikari Living terminal (**Fig. 5**).

Acoustic echo caused by acoustic coupling between the loudspeaker and the microphone seriously disturbs visual communication. Therefore, AEC is necessary to cancel the annoying echo; it works by predicting the echo signal and subtracting the predicted signal from the microphone signal. Digital TVs usually reproduce sound with a relatively long delay after inputting the sound signal to the TV due to the synchronization of the video processing. The length of the delay varies depending on the TV model or manufacturer. The AEC can automatically adapt to the delay differences of most TV models and can subtract the predicted echo in the proper timing so that a TV can be used as-is for Hikari Living.

Another problem can occur when the talker is too distant from the microphone on the TV. When the distance between the microphone and the talker increases, the talker's voice that is picked up is quieter and the background noise is picked up louder. We have addressed this issue by incorporating NR to

reduce the background noise and AGC to amplify the talker's voice with the AEC function.

6. Conclusion

Hikari Living utilizes many technologies and much knowhow to provide convenience and ease of use to users. Moreover, tuning operations were performed repeatedly to improve convenience and service quality. We believe that Hikari Living has many benefits and will provide a lot of enjoyment to users.

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Three-dimensional Nanofabrication in Si Using Electron Beam Lithography

Kenji Yamazaki and Hiroshi Yamaguchi

Abstract

A new technique for fabricating three-dimensional (3D) nanostructures enables us to create various 3D nanodevices. The technique involves using electron beam (EB) writing from various directions on microstructures. New methods of resist coating on microstructures and etching parallel to the substrate surface make it possible to apply the 3D-EB writing to 3D nanofabrication in various materials, including Si and hard materials. This technique was used to create 3D Si nanostructures at high resolution and with a high fabrication speed and large arbitrariness in the types of 3D structures that can be created. The technique is therefore promising for creating 3D nanodevices in various nanotechnology fields such as nanomechanics and metamaterials.

Keywords: EB writing, nanomechanical device, 3D nanostructure

1. Introduction

Nanofabrication technologies such as those used in semiconductor manufacturing now have resolutions on the order of 10 nm. Because these technologies are generally based on layer-by-layer or planar techniques, we cannot use them to freely create real three-dimensional (3D) structures with such resolutions. However, we can create various items or machines using real 3D components on a macroscopic scale. An ability to freely create real 3D components and handle them on a microscopic scale will lead to the development of highly functional high-performance micro/nanoscale devices and equipment. In fact, various 3D micro/nanofabrication techniques based on concepts that differ from those in planar technologies have been reported for creating 3D nanodevices in various nanotechnology fields such as photonic crystals [1], [2], nanomechanical systems [3], [4], nanorobotics [5], [6], and metamaterials [7], [8]. However, each of the reported 3D techniques seems to have drawbacks such as poor resolution, time-consuming fabrication, or lack of arbitrariness in the applicable materials or the types of 3D structures that can be created. For example, techniques using ion beams [9], [10] or multiphoton absorption [8], [11] are limited to certain applicable materials, and the layer-by-layer [1] and thin-plate assembly [2] techniques are time-consuming or have low resolution in the vertical direction, depending on the number of layers. A versatile technique that could be used to create various 3D nanodevices would accelerate innovation in such nanotechnology fields. Such a technique should satisfy four major requirements: high resolution, high fabrication speed, applicability to various materials, and a large degree of freedom, that is, arbitrariness, in the types of structures that can be created. To realize such a technique, we have devised and improved 3D electron beam (EB) writing, which can delineate arbitrary patterns on microstructures [12]–[15]. By combining the writing with two newly devised methods—resist coating on vertical side faces of micrometer-order blocks on a substrate and ion etching parallel to the substrate surface—we have obtained a new 3D nanofabrication technique that achieves vastly superior total performance with respect to the four requirements mentioned above, compared to the conventional 3D techniques [16]. We describe here some demonstrations of the technique that confirmed its high level of performance and present some results for the two new methods. In addition, we propose a measure (quantitative index) of 3D nanofabrication speed. Application of this new technique to create 3D nanodevices in various nanotechnology fields will

open up new avenues in 3D nanotechnology.

2. 3D fabrication process and experimental

Our 3D nanofabrication process is simply illustrated in **Fig. 1**. First, 2D EB writing and ion etching of a Si substrate are applied from the top to create microblocks on the substrate (steps 1 and 2). In these two steps, we use poly(methyl methacrylate) (PMMA) resist film about 500 nm thick and then apply EB writing at 100 kV (Vistec, VB-6UHR) on the film. Then, we use a lift-off technique with 300-nm-thick Ni film, and reactive ion etching (RIE) of about 4 μm using $CF_4/CHF_3/O_2$ gases. Then, a resist film is spin-coated on the vertical side faces of the microblocks. PMMA resist film (70–100 nm thick) and an additional electroconductive polymer film (Showa Denko, Espacer®) are used. The method for coating these films on the side faces with good uniformity is described in subsection 4.1. Next, EB writing on the two opposite side faces of a microblock is performed (steps 3 and 4). The acceleration voltage, beam current, and beam diameter are 70 kV, about 50 pA, and about 7 nm. Details of this 3D-EB writing are described in literature [12]–[15], [17], [18]. Then, patterned masks are formed on the side faces. We use 30–60-nm-thick Ni films deposited with an EB evaporator; the unneeded films are then lifted off. Finally, RIE is carried out parallel to the substrate surface from the same side directions. This process etches through the microblocks and creates 3D nanostructures in single-crystal Si (steps 5 and 6). This RIE is performed in a 1.2-Pa vacuum with radio frequency power of 40 W using a RIE-10NR apparatus (SAMCO) and $CF_4/CHF_3/O_2$ gases. The method of using RIE parallel to the substrate surface is described in detail in subsection 4.2. Baking before and after EB writing and photolithographic development after it were performed under conventional conditions. The substrate material used has little effect on the processing steps. Moreover, as also described in detail in subsection 4.1, coating the resist on the vertical side faces of a block is possible with various substrate materials as long as the resist solution wets the substrate. RIE can also be used with various materials, as it is often used in planar technology, although the mask material, gases, and other conditions may have to be carefully chosen depending on the materials. Therefore, in principle, materials do not impose limitations on this process.

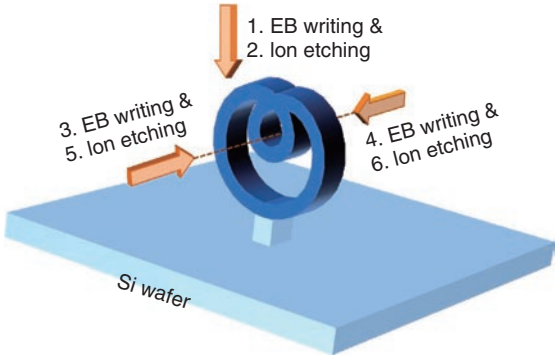


Fig. 1. Simplified schematic showing the steps of 3D nanofabrication.

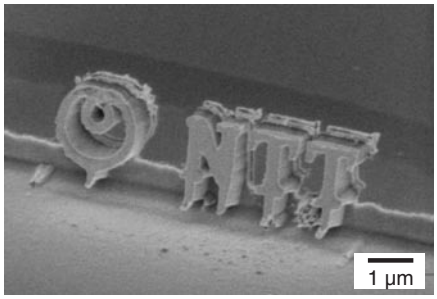
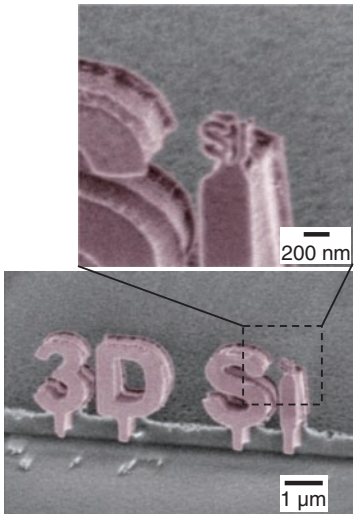


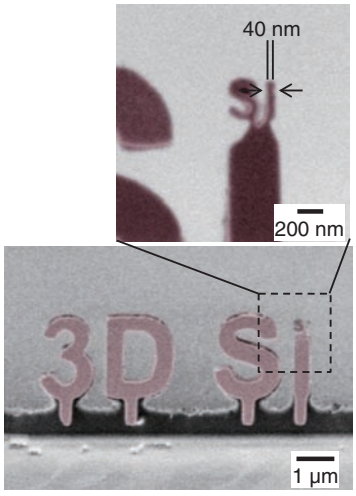
Fig. 2. SEM image of a 3D Si nanostructure of NTT's logo. The total EB writing time needed to create this structure was about 1 s.

3. Demonstrations of technique

Scanning electron microscopy (SEM) images of 3D Si nanostructures that we created to demonstrate our technique are shown in **Figs. 2, 3**, and **4**. It is clear from these images that our technique is effective for creating various 3D nanostructures in Si. The total EB writing times needed to create the structures in Figs. 2 and 3 were only about 1 and 2 s, respectively. Thus, the fabrication speed of our 3D technique is high. (A quantitative measure of fabrication speed is discussed in section 5.) The enlarged image in Fig. 3(b) shows that the minimum feature size is 40 nm, which means that our technique has a spatial resolution of 40 nm or less. The structure shown in Fig. 4 was designed and created as a nanomechanical cantilever. You can see that it is much more complicated than the nanostructures in Figs. 2 and 3. A cantilever about 40 μm long is attached to the base only through two nanobeams with sizes on the order of 100 nm, and



(a)



(b)

Fig. 3. SEM images of a 3D Si nanostructure: (a) bird's eye view, (b) front view, and their close-ups in the insets. The dot of the "i" on the right consists of a much smaller "Si". The minimum feature size is 40 nm.

there is a continuous change in thickness along the length of the cantilever. Note that if we had used conventional wet etching for a sacrificial layer, such fragile structures would have been broken by surface tension or by the flow of the etchant. The main difference in the fabrication process from that used for the simpler structures is that a complicated pattern shown as the inset of Fig. 4 (lower) is used in the first step of EB writing from the top instead of a simple rectangle. Even with this complicated pattern, all of the steps that follow can be performed in the same way, and

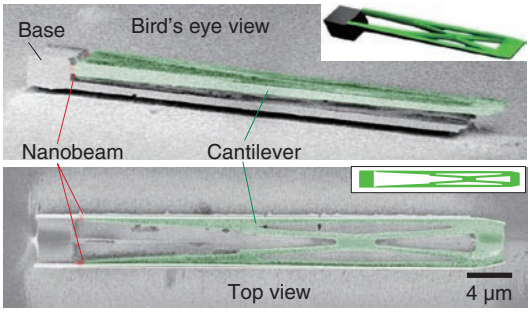


Fig. 4. SEM images of a 3D nanomechanical resonator: (upper) bird's eye view, (lower) top view, and their designs in the insets. Complicated 3D nanostructures like this can be created using our 3D technique.

such complicated structures can be created. Because we can, in principle, use arbitrary patterns in EB writing, this 3D technique allows us to create 3D nanostructures with great flexibility in the types of structures that can be created.

4. Key processing steps

4.1 Coating resist on side faces

Coating resist on the vertical side faces of microblocks with good uniformity is the first key to applying 3D-EB writing to various materials. Several methods for coating resist on non-flat surfaces with good uniformity have been reported. However, methods involving spraying resist solution [19], dipping a sample in solution [20], or keeping the sample in a mist of resist solution [21] are thought to be unsuitable for achieving good uniformity in the resist coating on the side faces of micrometer-order blocks. Evaporating resist with durability against high temperatures [22] is possible with certain resist materials, although they are severely limited. We recently discovered that high-speed spin-coating of a low-viscosity resist solution results in good uniformity in the thickness of the resist film coated on the side faces.

When we spin-coat PMMA resist on micrometer-order blocks on a substrate using the conventional solution, we cannot obtain good uniformity on the side faces. As shown in the cross-sectional SEM image for typical PMMA (OEBR-1000, Tokyo Ohka Kogyo) (**Fig. 5(a)**), the resist becomes thicker at the lower (inner) edges and thinner around the upper (outer) ones. This is most likely because the surface tension of the solution reduces the surface area during coating. This solution uses 2-ethoxyethyl acetate as a

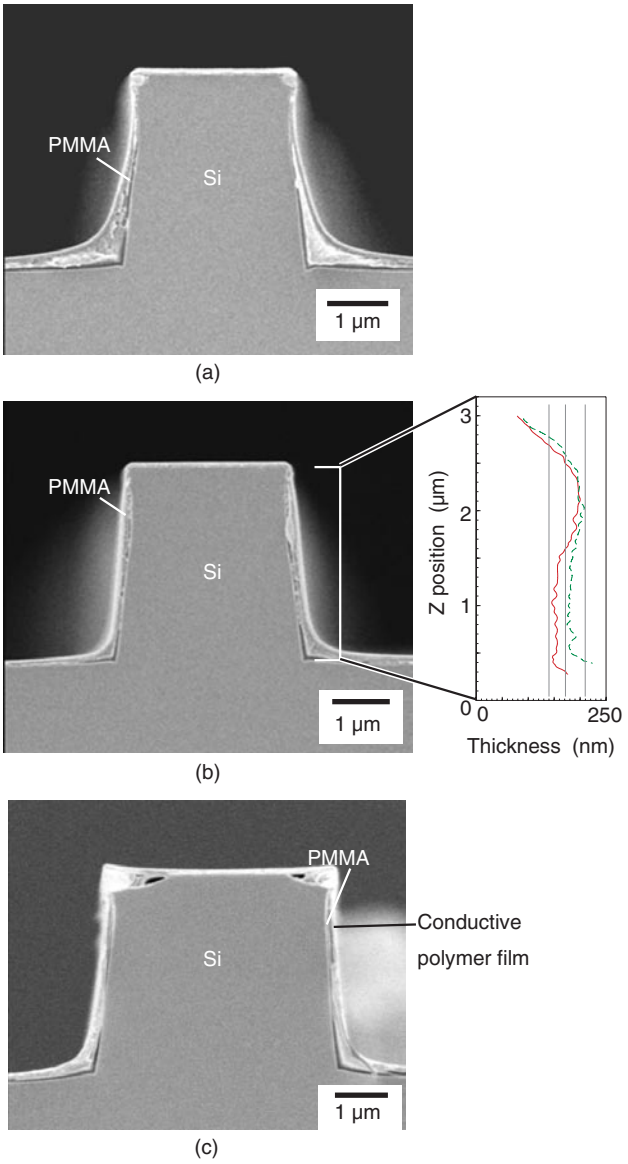


Fig. 5. Cross-sectional SEM images of resist-coated microblocks using (a) conventional resist solution and (b) low-viscosity solution, and (c) with additional coating of electroconductive polymer film.

solvent, which, in addition to the contribution from PMMA polymers, increases the viscosity. We found that when we coat our original solution (made by dissolving PMMA powder into a mixture of methyl ethyl ketone and hexane) at a spin speed as high as 6000 rpm, we can obtain good uniformity in the resist thickness on the vertical side faces (**Fig. 5(b)**). The viscosity of this solution is one to two orders of magnitude lower than the conventional solution. Therefore, since it flows faster during spin-coating, the force making it thinner at the inner edges, which is caused by its spinning-out, is thought to be larger than the force in the opposite direction due to its surface tension, and thus, uniform films on the side faces are obtained.

We propose a model to quantitatively understand this phenomenon as follows [17].

$$U << \begin{matrix} \Delta E < \Delta S\gamma \\ \Delta S\gamma < \Delta E \end{matrix} << \Delta W \qquad \begin{matrix} \text{poor uniformity} \\ \text{good uniformity} \end{matrix} \qquad (1)$$

$$\Delta E \propto F_C^2 / \eta \qquad (2)$$

where U is the potential energy due to gravity, ΔS is the increase in surface area, γ is the surface tension ($\Delta S\gamma$ is the increase in surface energy due to the increase in surface area), ΔE is the decrease in energy due to spinning out of the solution, ΔW is the decrease in free energy due to wetting, F_C is centrifugal force (per unit volume), and η is viscosity. When a solution flows along the side of a long microblock, it may be easier to consider Eqs. (1) and (2) per unit length along the side. Even if the block is as high as 1 mm, the increase in potential energy U for a solution to climb the block is much smaller than the other terms in inequality (1). Most resist solutions thoroughly wet substrates of various materials even during spin-coating at high speeds. This means that the decrease in free energy due to wetting, ΔW, is much larger than the other terms. The relationship between remaining terms ΔE and $\Delta S\gamma$ is thought to determine whether the uniformity of the resist on the side faces is good or poor. As expressed in Eq. (2), ΔE is proportional to the square of centrifugal force and inversely proportional to viscosity; that is, ΔE can be increased by increasing the spin speed and using a low-viscosity solution. Smaller surface tension, γ, is preferable for obtaining the lower relationship of inequality (1), but the difference is not large between the conventional solution and our solution. Actually, the estimated ΔE and $\Delta S\gamma$ under the conditions used for the resist coating in Figs. 5(a) and (b) are consistent with the relationship of inequality (1) [17]. This model indicates that we will be able to coat resist with good uniformity no matter what substrate material is used by preparing a resist solution with low viscosity and using a high spin speed so as to obtain the lower relationship of inequality (1).

We also coated electroconductive polymer films on the side faces, as described in section 2. The default solvent for this is water, and it therefore has high surface tension and viscosity. We were not able to obtain good uniformity with the solution. By partly replacing

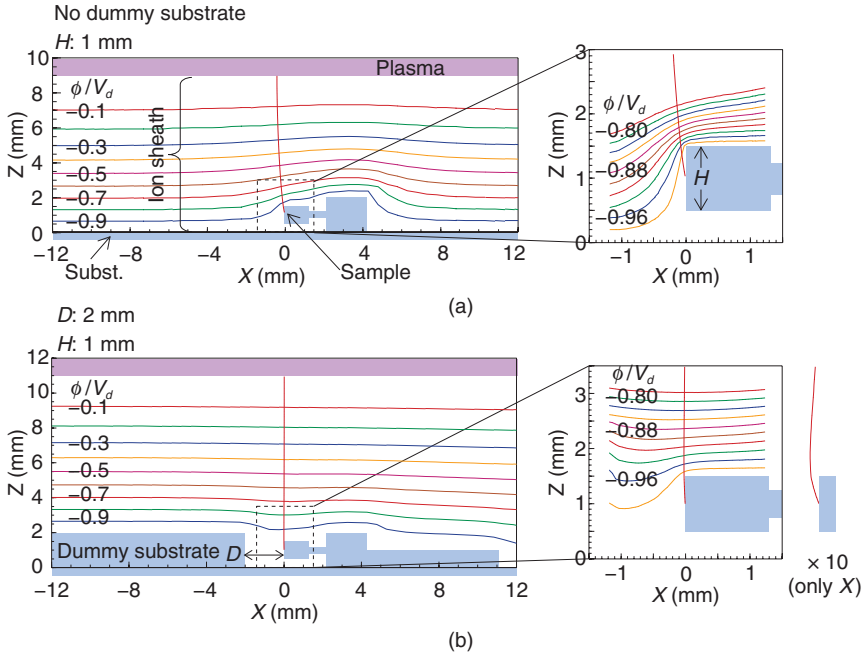


Fig. 6. Calculated potential distributions (ϕ normalized by potential difference V_d between plasma and gray regions including the sample) and ion trajectories in reactive ion etching (a) without and (b) with dummy substrates around the sample. The conditions were the same as those used in the experiments.

the solvent and diluting it with ethanol, we were able to prepare a solution with low surface tension and viscosity. The resulting uniformity using the solution is good, as shown in **Fig. 5(c)**. This supports our model in inequality (1) and suggests the wide applicability of our technique to various resist (and other film) materials in addition to various substrate materials.

4.2 Etching parallel to substrate surface

The other key step in our 3D nanofabrication is the method for etching microblocks from the side, that is, etching parallel to the substrate surface. We found that this becomes possible by keeping the sample height as low as 1 mm and by placing dummy substrates around the sample in the etching chamber. Many reports have been published on angled etching since the 1970s, but the reported etching angles range from approximately 40 to 75 degrees [23]–[25]. That is, no studies on etching parallel to the substrate surface have been reported. For example, setting a chip sample so it is vertically standing on edge in the chamber does not result in etching parallel to the substrate surface because the sample itself distorts the potential distribution around it, and thus, the ion trajectories bend near the sample, as shown in **Fig. 6(a)**.

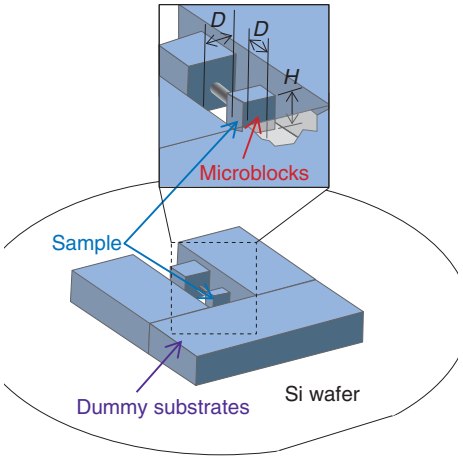


Fig. 7. Schematic showing the configuration of etching parallel to the substrate surface.

We extended the method reported by Takamori *et al.* [24] by surrounding the small sample vertically aligned in the chamber with dummy substrates (**Fig. 7**). The key parameters in the configuration are the height of the sample, H, and the distance between the sample and dummy substrates, D. When both H and D are 1 mm, which were the minimum in our

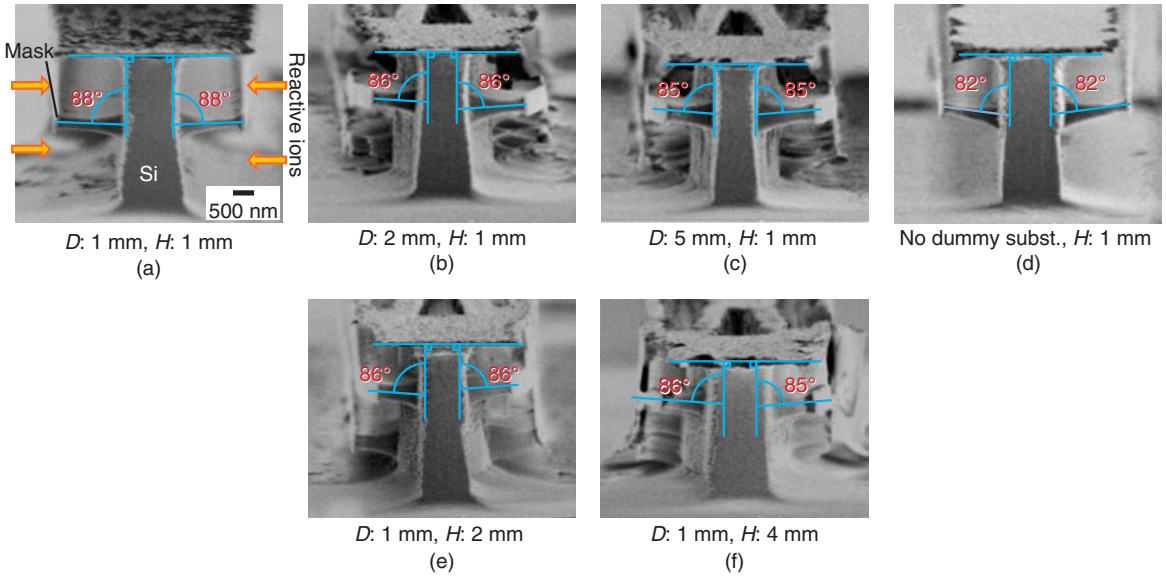


Fig. 8. Cross-sectional SEM images of microblocks (partly) etched with various D and H values. Etching at 88 degrees (parallel to substrate surface with an error of 2 degrees) was achieved with 1-mm D and 1-mm H (a).

experiments, the maximum etching angle of 88 degrees is obtained. The cross-sectional SEM images in **Fig. 8** show the etching angles with various H and D values.

We also performed theoretical calculations of etching angles and rates using the configuration shown in Fig. 7. The procedures consist of calculating 1) the spatial distribution of ion density in the ion sheath, 2) the potential distribution using the finite element method, and 3) the ion trajectories considering variations of the initial ion velocities. The calculation results agreed well with the experimental results derived from SEM images such as those in Fig. 8 [16]. Two of the calculation results are shown in Fig. 6 and clearly indicate that the ion trajectory without dummy substrates largely bends, resulting in a smaller etching angle (Fig. 6(a)), and that dummy substrates reduce the potential distortion, resulting in a straight ion trajectory and an etching angle very close to a right angle (**Fig. 6(b)**). The obtained maximum etching angle of 88 degrees is sufficient for our purpose, but a larger angle (closer to a right angle) should be obtainable by further reducing distance D between the sample and dummy substrates.

5. Index of 3D fabrication speed

As mentioned in section 1, several 3D fabrication techniques exist, and they all have certain advantages and disadvantages. This may make it a little difficult to fairly compare their fabrication speeds. A quantitative comparison is very useful, however, so we propose a measure (quantitative index) j of fabrication speed to make it possible to compare the 3D micro/nanofabrication speeds of various techniques:

$$j = 1/(\text{time needed to fabricate a resolution volume})$$
$$= \frac{(\text{volume that can be fabricated within unit time})}{(\text{resolution volume})}$$
$$= \frac{\min(V_C, V_S)}{(\text{resolution volume})\,(\text{fabrication time})}$$

where (resolution volume) = (resolution)^3 or, more strictly, (resolution along X) (resolution along Y) (resolution along Z) when resolution depends on direction, and V_C and V_S are the volume of the fabricated structure and the volume removed to make the structure, respectively. Resolution is defined by the minimum size of the feature/gap that is three-dimensionally fabricated.

The fabrication speed of our technique is calculated from the structure shown in Fig. 3 to be about 80,000 resolution-volume units/s, where the total EB writing time (2 s) was used as the fabrication time. This speed should be in the top group among the 3D techniques described in section 1. Although the fabrication time does not include the time of other steps such as etching, it is appropriate because EB writing is the rate-determining step in the process. This concept—the

use of the time of the rate-determining step as the fabrication time—is very common in planar fabrication technology because the time is directly related to throughput. For example, when a huge number of microstructures are etched at the same time in an etching chamber, the etching time per structure becomes negligible even if the total etching time is on the order of hours. On the contrary, an EB can write on only one microstructure at a time, so the EB writing becomes the rate-determining step.

6. Conclusion

We have devised a 3D nanofabrication technique that has high resolution (40 nm or better), high fabrication speed (80,000 resolution-volume units/s at least), wide applicability to various materials, and a large degree of freedom in the types of structures that can be created. The technique was realized by using our new methods of spin-coating resist with good uniformity on vertical side faces and etching parallel to the substrate surface. The technique is promising for developing 3D nanodevices in various fields such as nanomechanics and metamaterials.

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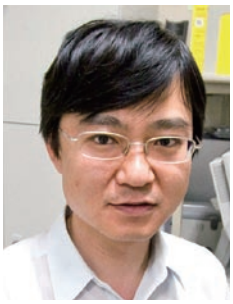

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Standardization Trends for the HEVC Next-generation Video Coding Standard

Shohei Matsuo and Seishi Takamura

Abstract

Ten years have passed since the H.264/MPEG-4 (Motion Picture Experts Group) AVC (Advanced Video Coding) standard was established in 2003. With the recent explosive increase in high-resolution video such as 8K Super Hi-Vision (SHV) video, there is worldwide demand for a video coding standard with higher quality compression. The international standards organizations, ITU-T (International Telecommunications Union, Telecommunication Standardization Sector) and ISO/IEC (International Organization for Standardization/International Electrotechnical Commission), have been collaborating on a next-generation video coding standard called High Efficiency Video Coding (HEVC). The basic standard has been completed, and work is proceeding on an extended standard. In this article, we describe the state of HEVC standardization and give a simplified technical description.

Keywords: HEVC, ITU-T, ISO/IEC

1. Introduction

In multimedia, video contains more information than other media, so efficient video compression methods are vital. Existing international video coding standards were created as a result of collaboration between two standardization organizations: the International Telecommunication Union, Telecommunication Standardization Sector (ITU-T), and the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC). The MPEG-2 (Motion Picture Experts Group) standard is the most well-known and widespread standard among them. MPEG-2 was completed in 1995 and is used in a wide range of fields including DVDs (digital versatile disks), hard-disk recorders, and digital broadcasting. MPEG-2 brought efficient video compression, enabling video services to spread around the world, which brought recognition to the importance of video coding standards. After the MPEG-2 standard was completed, work proceeded on the newer H.264/MPEG-4 AVC (Advanced Video Coding) standard (H.264/AVC), which achieves approximately double the coding efficiency of MPEG-2, and this standard was completed in 2003. After that, the H.264/AVC FRExt extension (Fidelity Range Extension) was standardized in 2007, which included support for various input video formats and a High Profile, or HP, with higher compression rates. H.264/AVC has received much industry attention and has been adopted in a wide range of video-related applications such as Blu-ray Discs, One-Seg and HDTV (high-definition television) broadcasting, digital cameras and handy cams, video capture devices, video conferencing, and video upload sites. It is widely used in the communications, broadcasting, and storage fields, and has become one of the foundational technologies used for video services.

2. Standardization activities for next-generation video coding

2.1 Trends with the HEVC basic standard

The Joint Collaborative Team on Video Coding (JCT-VC) was inaugurated in January 2010 with members from the ISO/IEC MPEG and the ITU-T

Table 1. HEVC standardization schedule and JCT-VC meetings.

Meeting date and location			Topic	No. of participants	Approx. no. of docs contributed
1	2010/04	Dresden (Germany)	TMuC decided	188	40
2	2010/07	Geneva (Switzerland)	–	221	120
3	2010/10	Guangzhou (China)	HM1 decided	244	300
4	2011/01	Daegu (South Korea)	HM2 decided	248	400
5	2011/03	Geneva (Switzerland)	HM3 decided	226	500
6	2011/07	Torino (Italy)	HM4 decided	254	700
7	2011/11-12	Geneva (Switzerland)	HM5 decided	284	1000
8	2012/02	San Jose (USA)	HM6 decided, CD issued	255	700
9	2012/04-05	Geneva (Switzerland)	HM7 decided	241	550
10	2012/07	Stockholm (Sweden)	HM8 decided, DIS issued	214	550
11	2012/10	Shanghai (China)	HM9 decided	235	350
12	2013/01	Geneva (Switzerland)	HM10 decided, FDIS/PDAM issued	262	450
13	2013/04	Incheon (South Korea)	HM11 decided, IS issued	183	450
14	2013/07	Vienna (Austria)	HM12 decided, DAM issued	161	350

DAM: Draft Amendment PDAM: Proposed Draft Amendment
IS: international standard

VCEG (Video Coding Experts Group), to begin serious work on the High Efficiency Video Coding (HEVC) standard as the next-generation video coding standard. First, a call for proposals of new coding methods satisfying specified requirements (bit rates, latency, etc.) was issued [1], and 27 proposals were received by the February deadline. In March, a focused, quantitative evaluation was done on the subjective quality of decoded video achieved using these methods [2]. In April 2010, the first meeting of the JCT-VC was held in Dresden, and a Test Model under Consideration (TMuC) was settled on, with algorithms in the proposals that ranked highest in the results of the evaluations described above considered as provisional HEVC reference software. Improvements were subsequently added, and official reference software—HEVC Test Model 1 (HM1)—was decided in October of that year. Ongoing technical improvements were made in subsequent JCT-VC meetings every three to four months. Specifically, coding methods proposed within particular domains were gathered, and core testing groups were organized to deliberate on them. Each proposed method was selected or rejected by evaluating them overall using various indices such as: (1) the BD-rate (Bjontegaard Distortion rate), which indicates the amount of improvement in coding efficiency; (2) the processing time for coding and decoding; (3) the memory bandwidth for hardware implementation; and (4) changes in the software source code. As the core test groups were newly established, succeeded in carrying out their tasks, and were disbanded with each meeting, technologies were selected from the various proposals to improve the performance of HEVC. The HEVC standardization process and the topics focused on at each meeting are listed in **Table 1**.

There are three main steps in establishing a standard: developing the Committee Draft (CD), the Draft International Standard (DIS), and the Final Draft of International Standard (FDIS), in that order. The CD of the HEVC standardization process was issued at the San Jose meeting in February 2012, where most of the technical specifications were decided. The DIS was issued at the Stockholm meeting in July 2012, where most of the specification details were completed. The FDIS was issued at the Geneva meeting in January 2013; it included some minor bug fixes and the completed final basic HEVC specification. The FDIS was approved through a ballot distributed to participating countries and was issued as an international standard in April 2013. As can be seen from Table 1, most of the technical specifications were decided with the CD, so just prior to this at the 7th meeting in Geneva in November/December 2011, there was very high participation from members, and many contributions were added. It is quite rare to have over 1000 contributions for a single meeting, and this indicates the unprecedented scale and amount of activity related to HEVC standardization.

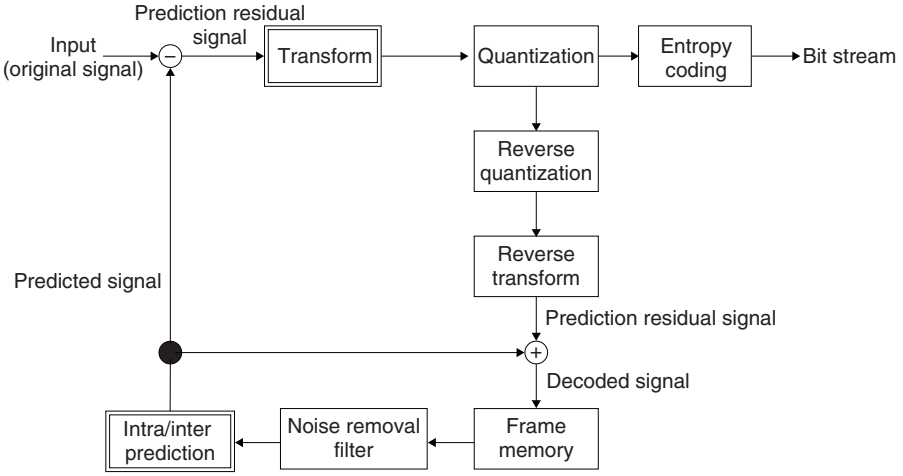

Fig. 1. Basic video coding process.

2.2 Standardization activity for HEVC extensions

The basic HEVC standard discussed in the previous section is limited to input video with a 4:2:0 color format* and does not support 4:2:2 or 4:4:4 color formats. It also supports bit depths of eight and ten bits to express each pixel, but higher bit depths are not anticipated. There is a need to handle video formats that are not supported by the basic HEVC standard, particularly in professional video recording and playback devices and in medical imaging devices, so the standardization of extended standards to support such color formats and bit depths is in progress. These extended standards go through stages corresponding to CD, DIS, and FDIS, which are called the international standard Proposed Draft Amendment (PDAM), Draft Amendment (DAM), and Final Draft Amendment (FDAM), respectively. This standardization is proceeding on a schedule delayed six months from the basic standard, as shown in Table 1. At the Vienna meeting in July 2013, the extended standard DAM was issued, and the FDAM is expected to be issued at the 16th meeting in San Jose, in January 2014.

3. Technical description of HEVC

3.1 Basic video coding framework

The basic process of video coding for H.264/AVC and HEVC is shown in **Fig. 1**. The input video is partitioned into square blocks of $n \times n$ pixels, and coding is performed in units of these blocks. These blocks are the input in Fig. 1, and are encoded into a bit stream—a binary signal array of 0's and 1's—through processes including prediction and orthogonal transformation.

Prediction is a core technique in coding. Consider the example in **Fig. 2**. In the process of encoding the frame at time t, if the frame at time t-1 has a similar pattern, then only the difference (the prediction residual) between that pattern (the prediction signal) and the source signal, is sent. This concept of using information that is already at the decoder to efficiently compress information is called prediction. Between t-1 and t, the character shown in Fig. 2 moved one block position to the left. When an object moves during the time between one image and the next, a motion vector indicating the amount of movement is sent to the decoder, indicating its predicted position. For objects that do not move, like the cloud shown in the figure, no motion vector needs to be sent. Prediction that spans images in this way is called *inter prediction* (prediction between images). In contrast, prediction done within an image is called *intra prediction* (within an image). For example, as shown by the red box enclosing the cloud in Fig. 2, the block to the left is already present at the decoder, so coding is performed using a copy of the pixels on the left as the prediction signal and taking the difference between those values and the source signal. The

* Color format: Video can be separated into a luminance signal component and chrominance signal components. If the image size for the luminance signal is $m \times n$ (where m is the number of pixels horizontally and n vertically), then the format in which the chrominance signals are half the size in the horizontal and vertical directions, or $m/2 \times n/2$, is referred to as 4:2:0; that with only the horizontal direction halved, or $m/2 \times n$, is 4:2:2, and that with neither halved, or $m \times n$ chrominance signals, is 4:4:4.

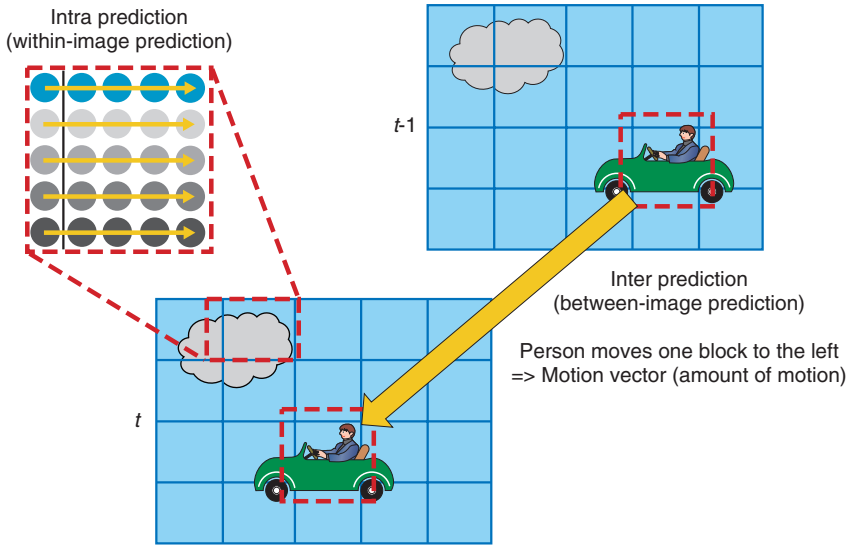

Fig. 2. Prediction overview.

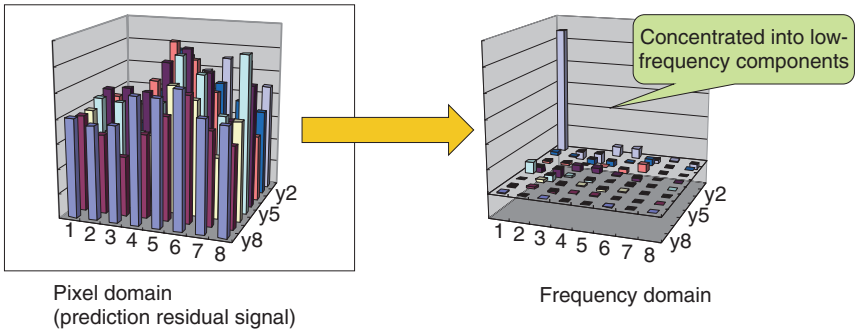

Fig. 3. Orthogonal transform overview.

intra/inter prediction in Fig. 1 is able to significantly reduce the amount of information using these processes, so it has become a core coding technology.

After the prediction process, an orthogonal transform is performed on the prediction residual signal, which converts it to a signal that can be compressed still further. When the signal is transformed into a different signal space called the frequency domain, efficient compression can be achieved by preserving the low frequency components, which express the basic structure of the pattern, and dropping the high-frequency components (**Fig. 3**).

3.2 New features of HEVC

The differences between HEVC and conventional H.264/AVC are summarized in **Table 2** [3]. H.264/AVC performs coding in units of 16 × 16 pixel blocks called macro-blocks, while HEVC does so in blocks of up to 64 × 64 pixels called coding units (CUs). CUs are partitioned into a quad-tree structure, with the leaf elements independently partitioned into prediction units (PUs), which are the unit for prediction, and transform units (TUs), which are the unit for orthogonal transforms. Processing in large units such as the 32 × 32 transforms or 64 × 64 predictions was not possible with H.264/AVC. These large units enable efficient compression, particularly for high-resolution images ((1)–(5) in Table 2 and **Fig. 4**).

For inter prediction, a scheme has been introduced that enables more accurate prediction signals to be generated. The process of creating signals for objects whose movement cannot be expressed in integer pixel

Table 2. Comparison of H.264/AVC and HEVC coding technologies.

	H.264/AVC	HEVC
(1) Coding units (CU)	16 × 16 only	8 × 8 to 64 × 64, tree structure
(2) Prediction units (PU)	4 × 4 to 16 × 16 (7 types, including rectangular)	4 × 4 to 64 × 64 (28 types, including rectangular)
(3) Transform units (TU)	4 × 4 or 8 × 8	4 × 4, 8 × 8, 16 × 16, 32 × 32
(4) Transform unit tree structure	No	Yes
(5) Transform types	DCT	DCT, DST (4 × 4, only intra), transform skipping
(6) Fractional pixel precision interpolation filter	2 or 6-tap	4-, 7-, or 8-tap
(7) Motion vector estimation	Spatial median estimation	Improved version, including time-space median
(8) Intra prediction	4 or 9 modes	35 modes, adaptive reference pixel smoothing
(9) Entropy coding	CABAC or CAVLC	CABAC
(10) Bit-depth extension	No	Internal bit-depth extension (+2 bits)
(11) Block noise removal filter	Yes	Yes (parallelizable simplified version)
(12) Coding noise removal filter	No	Yes (SAO)
(13) Parallel processing structure	Slice	Slice, WPP, tile

CABAC: Context-based Adaptive Binary Arithmetic Coding
CAVLC: Context Adaptive Variable Length Coding
DCT: discrete cosine transform
DST: discrete sine transform
SAO: sample adaptive offset
WPP: wavefront parallel processing

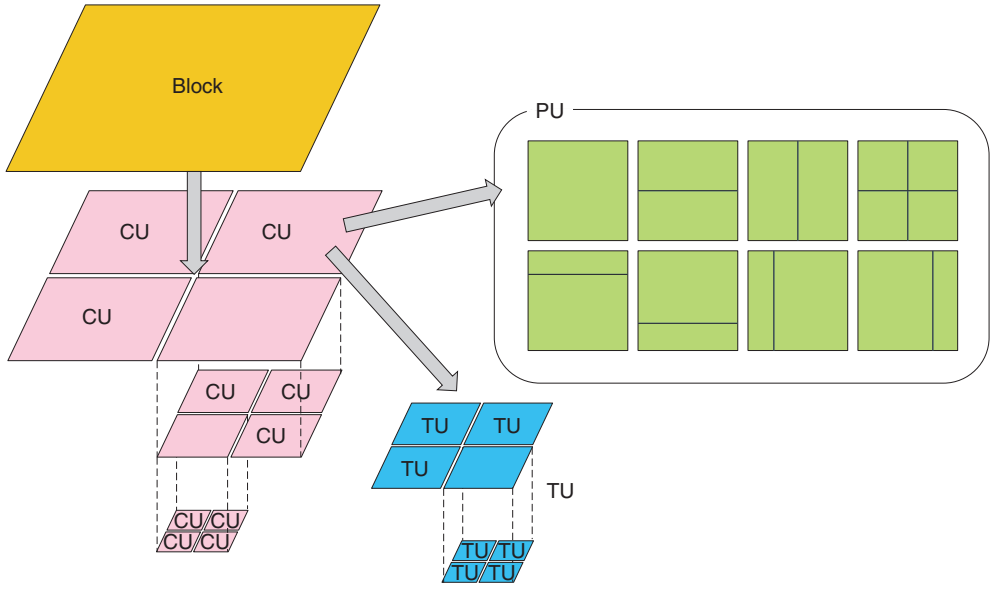

Fig. 4. HEVC flexible processing structure.

motions is called interpolation, and prediction performance was improved by increasing the number of taps on the interpolation filter to express the motion more accurately ((6) in Table 2), and by improving the prediction methods for the motion vectors themselves ((7) in Table 2). For intra prediction, performance was improved by using approaches such as greatly increasing the number of prediction directions and by applying smoothing filters adaptively when copying the source pixels, depending on the block size or direction ((8) in Table 2).

Context-based Adaptive Binary Arithmetic Coding (CABAC) is used uniformly ((9) in Table 2) as entropy coding to binary-encode the information. Also, the bit depth of the input video is increased by bit-shifting it to the left, and this value is used in the coding

Table 3. Coding performance improvement of HEVC compared to H.264/AVC, BD-rate.

	Y	U	V	YUV
Intra prediction set	–23.0%	–22.0%	–22.0%	–23.0%
Inter prediction set (for random access)	–33.5%	–34.1%	–35.0%	–33.8%
Inter prediction set (for low-delay communications)	–36.4%	–34.3%	–35.4%	–36.3%

- H.264/AVC reference software: JM18.4
- HEVC reference software: HM10.0,
Results of performance comparison are given. (e.g.: A result of –23% indicates HEVC provided a 23% improvement in coding efficiency over H.264/AVC.)

loop and in orthogonal transform processing. This reduces rounding errors in orthogonal transformation and increases coding efficiency for intra and inter prediction ((10) in Table 2).

The source for the predicted signal is called the reference signal. This refers to the *t*-1 frame in Fig. 2 for inter prediction, and the set of pixels at the left-most edge of the enlarged red frame at time *t* for intra prediction. These reference signals are from the decoded signal, so they also have distortion known as block noise superimposed on them. With HEVC, the filters for removing this distortion have been improved ((11) in Table 2). New filters that are not in H.264/AVC have also been introduced. These filters bring the reference signal closer to the original signal, which reduces the prediction residual signal components that need to be transmitted and increases the coding efficiently significantly ((12) in Table 2). A mechanism for efficiently controlling partitioning losses and supporting parallel processing was also introduced ((13) in Table 2), in response to the need to support recent multi-core environments.

3.3 Comparison of coding performance

A comparison of HEVC and H.264/AVC performance using reference software [4], [5] and JCT-VC standard test images is presented in **Table 3** [6]. Common conditions were used for the tests, and the results are an average of BD-rates indicating the coding efficiency improvements for a total of 20 images ranging from a 2560 × 1600 pixel high-resolution image down to a 416 × 240 low-resolution image. Y is the luminance signal, U and V are chrominance signals, and YUV is a weighted average of the three. An improvement of approximately 23% was achieved with intra prediction, and approximately 35% with inter prediction (for both random access and low delay communications settings). Looking at the image quality objectively, we found that we did not double the coding efficiency, which would be an approximately 50% improvement comparing BD-rates. However, it was confirmed that when the subjective quality was the same, HEVC achieved approximately twice the coding efficiency of H.264/AVC.

4. Future developments

We have described standardization activities and given a simple technical explanation of HEVC, the next-generation video coding standard. Extensions to the HEVC standard will be completed in January 2014, and six months later, HEVC scalability extension standards should be completed. Work on extensions for 3D video is also proceeding steadily. There is strong demand for these technologies in society, so we can expect further developments in the future as well.

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Lightning Damage and Mitigation in Telecommunication Access Installations

Abstract

In this article, we introduce case studies of lightning damage in telecommunication access installations and a countermeasure against it. This is the twenty-first in a bimonthly series on the theme of practical field information on telecommunication technologies. This month's contribution is from the EMC Engineering Group, Technical Assistance and Support Center, Maintenance and Service Operations Department, Network Business Headquarters, NTT EAST.

Keywords: countermeasures, lightning damage, telecommunication access installations

1. Introduction

Lightning that directly strikes high-rise buildings and structures such as wind turbines or antenna towers usually causes lightning damage to telecommunication access installations adjacent to such structures. Particular cases include damage to messenger wires [1], discharge damage to telecommunication cable connections in splicing closures [2], and delamination of the surface of concrete poles (CPs) [3]. Damage to telecommunication installations due to lightning strikes may lead to interruptions in telecommunication services; accordingly, developing countermeasures against that possibility is an important challenge that requires further study. This article introduces examples of damage to telecommunication installations due to lightning strikes and explains the mechanism generating that damage. In addition, a construction method for improving robustness against lightning strikes (namely, configuring messenger wires in a particular way) is proposed, and the results of an experimental evaluation of the effectiveness of the proposed method are presented.

2. Cases of lightning damage to access installations

A direct lightning strike on a high-rise structure such as an antenna tower is accompanied by lightning damage to nearby telecommunication access installations. An example of damage caused by a lightning strike to the messenger wire used for fixing the telecommunication cable is shown in **Fig. 1**. Under the assumption that a large current flows as a result of such a lightning strike, it is expected that significant damage to the messenger wire will remain and that the messenger wire will degrade faster than usual.

One phenomenon, namely, damage to a connection between a cable sheath and a ground wire bonded by aluminium tape (hereafter called an A-tape bond) in the splicing closure that connects telecommunication cables, is shown in **Fig. 2**. This phenomenon may potentially cause failure of the insulation between the core wires in the cable. Another phenomenon, that is, the surface damage of a CP, is shown in **Fig. 3**. This

Fig. 1. Damage to messenger wire.

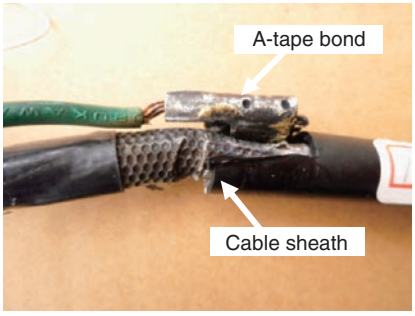


Fig. 2. Damage to connection between cable sheath and A-tape bond.

Fig. 3. Damage to CP (detachment of concrete from surface of CP).

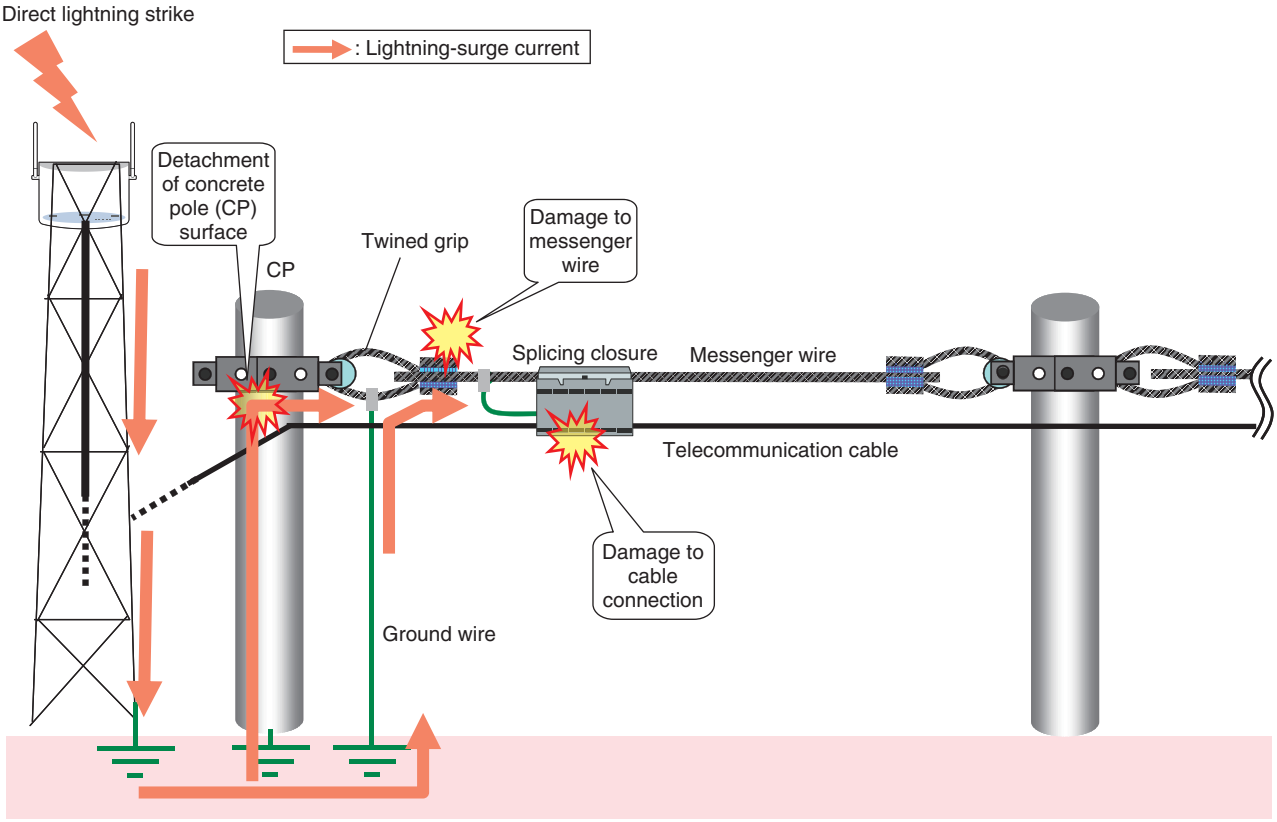


Fig. 4. Configuration of telecommunication access installation and presumed routes of lightning-surge current.

phenomenon makes it necessary to erect a new CP sometime in the future. Damage presumed to be caused by these phenomena related to lightning strikes often occurs on the telecommunication access installations located near high-rise buildings. Accordingly, understanding the mechanism that causes lightning damage to such installations and devising countermeasures against such damage are important targets of study.

3. Mechanism of lightning damage

The configuration of a damaged telecommunication access installation and its surroundings is shown

in **Fig. 4**. It comprises CPs, telecommunication cables, messenger wires, twined grips, support bands, and ground wires. The twined grips are generally used to connect the messenger wires to the CPs. Each twined grip is connected to a ground wire to ensure electrical-power safety and lightning protection. Moreover, as a safety measure, an aluminium-sheathed cable is used for the telecommunication cable, which is configured in such a manner that it is connected to ground at the point of connection with the cable inside the splicing closure.

The mechanism of the lightning damage that occurs in the above-described configuration is explained as follows. When the lightning directly strikes a high-rise building, a lightning-surge current is propagated through the building and flows to ground. Part of the surge current flowing to ground flows in the opposite direction, namely, up the ground line, as a backflow current. The surge current that flows into the ground wire then flows into the messenger wire via the twined grip. The energy generated by this surge current exceeds the surge capacity of the messenger wire, which is thereby damaged [1]. Furthermore, if the energy of the surge current flowing in the messenger wire exceeds the surge capacity of the A-tape bond, the connection of the cable sheath and the A-tape bond heats up and becomes damaged [2]. In addition, the flow of the lightning-surge current to ground raises the electrical potential of the ground. As a result, an overvoltage is applied to the concrete medium between the support bands and reinforcing bars of the CPs. As a result of this overvoltage, the insulation provided by the concrete breaks down, and the concrete surface of the CPs detaches in places [3].

4. Experiment to evaluate lightning-surge capacity of messenger wire

We verified the damage mechanism of the messenger wire by applying lightning-surge current simulating a direct lightning strike to the messenger wire and then evaluated the result [1]. The configuration of the experimental facility is shown in **Fig. 5**. The messenger wire in this figure is made of high-corrosion-resistance steel (18CR) with a diameter of approximately 5 mm. The lightning surge is applied by an impulse generator (IG). The output and return terminal of the IG are respectively connected to the twined grip and the messenger wire via a ground wire. A 10/350-μs current waveform regulated as a direct lightning strike was used in accordance with lightning-surge experiment standard IEC 61312-3 [4].

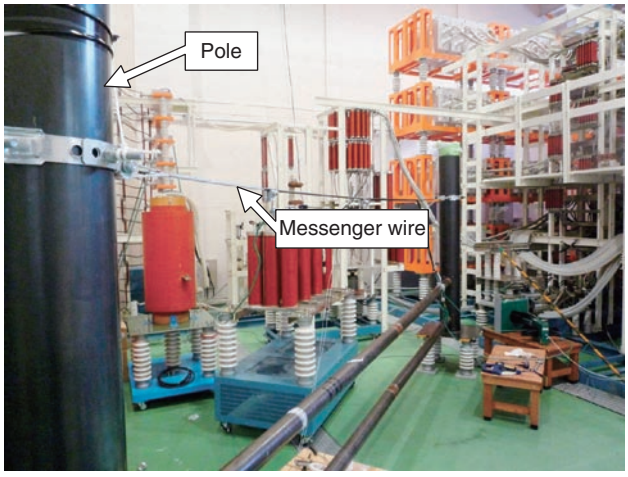


Fig. 5. Configuration of experimental installation.

Fig. 6. Spark discharge at the time of lightning surge application.

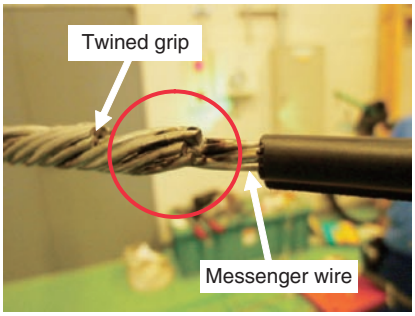


Fig. 7. Result of reproducing degradation of messenger wire.

Examples of the experimental results are shown in **Figs. 6** and **7**. A spark discharge is shown in Fig. 6,

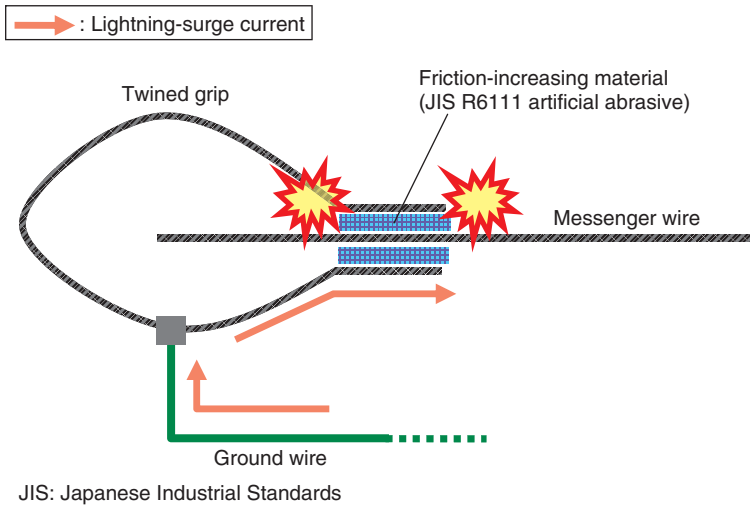
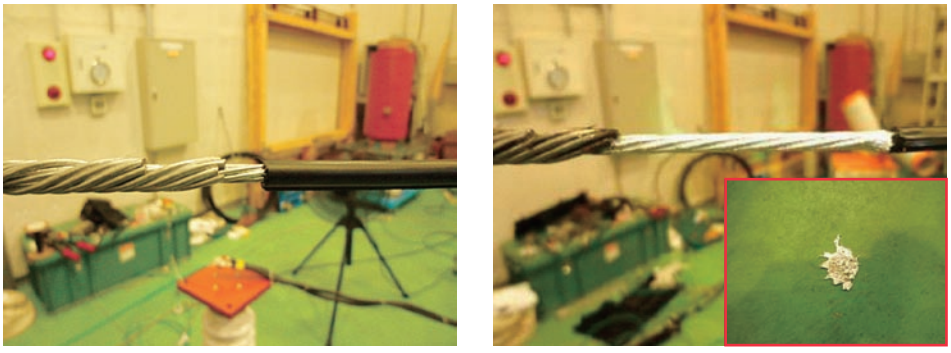


Fig. 8. Electrical discharge in the vicinity of the connection of the messenger wire and the twined grip (enlarged).



(a) Normal condition (b) Melting and dripping of zinc plating

Fig. 9. Example of experimental result.

and traces of the electrical discharge remain on the messenger wire as shown in Fig. 7. The electrical discharge occurs near the connection between the messenger wire and the twined grip, and the peak value of the current wave at the time of discharge is 23.8 kA.

In order to prevent a disconnection at the twined grip and the messenger wire, friction-increasing material (artificial abrasive JIS R 6111) is coated on the internal surface of the spiral part of the connection (**Fig. 8**). Because of that coating, a gap is formed in the connection, and that gap is thought to make it easier for spark discharge to be generated by the surge current. Consequently, it is thought that damage to the messenger wire such as corrosion of the wire itself and degradation of the zinc coating will remain, and the messenger wire will deteriorate faster than normally expected.

The peak current value of the direct lightning strike is generally several dozen kiloamperes (kA). During the winter in the regions along the Sea of Japan, however, on rare occasions, lightning strikes with current-wave peaks exceeding 100 kA have been measured. When such a large current flows in the messenger wire, the kind of damage that occurs also depends on the duration of the current flow. In this experiment, we confirmed the phenomenon in which the zinc-aluminium-alloy coating on the messenger wire melted and dripped onto the ground (**see Fig. 9.**).

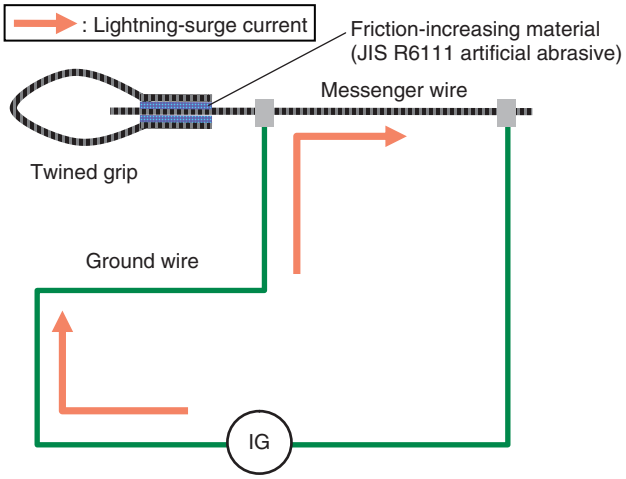


Fig. 10. Configuration to prevent lightning damage.

5. Study of countermeasures against lightning damage

Much research on lightning damage has been done in order to develop countermeasures to it [5], [6]. The results of the evaluation of the lightning strike capacity described above were used to determine a configuration method that mitigates the deterioration of the messenger wire. In particular, a method of connecting the ground wire to the main messenger wire on the external side of the twined grip was devised, as shown in **Fig. 10**, and its effectiveness was evaluated experimentally.

Constructing the connection in this way causes the surge current flowing in from the ground wire to flow into the messenger wire without passing through the connection between the messenger wire and the twined grip. As a result, it is possible to avoid the discharge phenomenon that occurs near the connection between the messenger wire and the twined grip. The experimental results indicated that the peak value of the current wave during the spark discharge was 36 kA. This result confirms the effectiveness of the configuration method; that is, applying this method increases the surge capacity by approximately 1.5 times (spark discharge occurs at 23.8 kA) at little extra cost.

6. Conclusion

This article described cases of lightning damage occurring in telecommunication access installations located near high-rise structures. Additionally, a countermeasure to the lightning damage occurring at the messenger wire was proposed based on the results of an evaluation experiment. The results of this study are summarized as follows. A spark discharge due to the lightning surge is generated near the connection between the messenger wire and the twined grip. To alleviate deterioration of the messenger wire, a method of connecting the connection point of the ground wire with the main messenger wire was proposed as a countermeasure and confirmed to be effective. From now on, we plan to follow the proposed procedure in the design and installations maintenance departments.

Lightning damage occurs at various points in telecommunication installations. At the NTT Technical Assistance and Support Center, we aim to provide trouble-free communication services and to reduce maintenance work that results from lightning damage. We are therefore actively proposing effective and economic lightning-damage countermeasures based on on-the-spot investigations, developing lightning-resistant products for telecommunication installations (including telecommunication equipment), and promoting activities to popularize technologies through technical seminars.

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External Awards

Prize for Science and Technology, Research Category, The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology
Winner: Hiroshi Yamaguchi, NTT Basic Research Laboratories
Date: April 16, 2013
Organization: Ministry of Education, Culture, Sports, Science and Technology

For "Optoelectromechanical Hybrid Devices Using Compound Semiconductor Heterostructures".

A new research field is being developed by integrating conventional optoelectronic and electromechanical devices using compound semiconductor heterostructures.

The Young Scientists' Prize, The Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology
Winner: Katsuhiko Nishiguchi, NTT Basic Research Laboratories
Date: April 16, 2013
Organization: Ministry of Education, Culture, Sports, Science and Technology

For "Nanometer-scale Semiconductor Devices with High Functionality".

Single-electron-based electric circuits and sensors by using nanometer-scale transistors play an important role in research on low-power-consumption circuits and other fields.

2013 JSAP Fellow Award
Winner: Hiroshi Yamaguchi, NTT Basic Research Laboratories
Date: September 16, 2013
Organization: The Japan Society of Applied Physics (JSAP)

For "Pioneering Contributions to the Application of Compound Semiconductor Heterostructures to Mechanical Devices".

Novel functional devices have been developed by applying compound semiconductor heterostructures to mechanical structures.
http://journals.jsap.or.jp/english/awards/jsap-fellow-2013.html

JSAP Outstanding Paper Award
Winners: Katsuhiko Nishiguchi and Akira Fujiwara, NTT Basic Research Laboratories
Date: September 16, 2013
Organization: JSAP

For "Single-electron Stochastic Resonance Using Si Nanowire Transistors".

We demonstrate stochastic resonance (SR) with single electrons (SEs) using nanoscale metal-oxide-semiconductor field-effect transistors (MOSFETs). An input signal applied to a MOSFET modulates SE transport in an average manner based on nonlinear characteristics. On the other hand, an individual SE goes through the MOSFET in a completely random manner, which corresponds to shot noise. SEs transferred to a storage node are counted precisely by the other MOSFET and used as an output signal. The correlation between the input and output signals is improved by taking advantage of extrinsic noise as well as the intrinsic shot noise composed of SEs. It is confirmed that the shot-noise-assisted SR allows fast operation with a simple system. Pattern perception utilizing SR is also demonstrated.
Published as: K. Nishiguchi and A. Fujiwara, "Single-electron Stochastic Resonance Using Si Nanowire Transistors," Jpn. J. Appl. Phys. Vol. 50, 06GF04, 2011.

IEICE Human Communication Award
Winner: Masumi Yamaguchi, NTT Basic Research Laboratories
Date: December 19, 2013
Organization: The Human Communication Group, the Institute of Electronics, Information and Communication Engineers (IEICE)

For "A Case Study of the Communication between Families Living in Remote Locations: Report of the Communication Style Using "Denwa-channel" for Five Years".

Important elements for family-use video communication system were proposed, and a case study of communication between families living in remote location was performed. A lot of benefits of video communication were revealed through this study.
Published as: M. Yamaguchi, "A Case Study of the Communication between Families Living in Remote Locations: Report of the Communication Style Using "Denwa-channel" for Five Years," IEICE Tech. Rep., Vol. 112, No. 455, HCS2012-91, pp. 73–78, 2013.

Papers Published in Technical Journals and Conference Proceedings

Cortical Stimulation Consolidates and Reactivates Visual Experience: Neural Plasticity from Magnetic Entrainment of Visual Activity

Hsin-I Liao, Daw-An Wu, N. Halelamien, and S. Shimojo
Scientific Reports, Nature Publishing Group, Vol. 3, p. 2228, 2013.

Delivering transcranial magnetic stimulation (TMS) shortly after the end of a visual stimulus can cause a TMS-induced 'replay' or 'visual echo' of the visual percept. In the current study, we find an entrainment effect that occurs after repeated elicitations of TMS-induced replay with the same visual stimulus. The replay can be induced by TMS alone, without the need for the physical visual stimulus. In Experiment 1, we used a subjective rating task to examine the phenomenal aspects of TMS-entrained replays. In Experiment 2, we used an objective masking paradigm to quantitatively validate the phenomenon and to examine the involvement of low-level mechanisms. Results showed that the TMS-entrained replay was not only phenomenally experienced (Exp. 1), but was also able to hamper letter identification (Exp. 2). The findings have implications in several directions: (1) the visual cortical representation and iconic memory, (2) experience-based plasticity in the visual cortex, and (3) their relationship to visual awareness.

Wavelength Path Reconfiguration Design in Transparent Optical WDM Networks

A. Kadohata, A. Hirano, F. Inuzuka, A. Watanabe, and O. Ishida

Journal of Optical Communications and Networking, IEEE/OSA, Vol. 5, No. 7, pp. 751–761, 2013.

This paper studies the reconfiguration design and migration from an old path set to a new path set in multifiber wavelength-division-multiplexing networks. For the reconfiguration design phase, we introduce the functions of wavelength fragmentation cost and reconfiguration cost, and we propose a reconfiguration design that minimizes both wavelength fragmentation and the number of changed wavelengths. For the migration phase, we propose a migrating sequence algorithm that uses spare wavelengths to break the dependency cycle between before and after reconfiguration design sets and thus prevent service disruption. A numerical evaluation shows that the number of fibers is suppressed 4%–15% compared to the design without employing fragmentation cost and that the number of changed wavelengths is reduced by approximately 50%–90%.

Model-based Noise Suppression Using Unsupervised Estimation of Hidden Markov Model for Non-stationary Noise

M. Fujimoto and T. Nakatani

Proc. of the 14th Annual Conference of the International Speech Communication Association (Interspeech 2013), pp. 2982–2986, Lyon, France.

Although typical model-based noise suppression including the vector Taylor series-based approach employs a single Gaussian distribution for the noise model, it is insufficient for non-stationary noise which has a complex structured distribution. As a solution to this problem, we have already proposed a method for estimating a Gaussian mixture model (GMM)-based noise model by using a minimum mean squared error estimate of the noise. However, the state transition process of the non-stationary noise is not modeled in the noise GMM. In this paper, we propose a way of modeling the noise with a hidden Markov model (HMM) as an extension of our previous method. The proposed method proves that the HMM-based noise model outperforms a GMM-based noise model composed of the same number of Gaussian components. In addition, we discuss the appropriate topology for the noise HMM, i.e., a left-to-right HMM and an ergodic HMM.

Video-based Tracking, Learning, and Recognition Method for Multiple Moving Objects

H. Sakaino

IEEE Trans. on Circuits and Systems for Video Technology, Vol. 23, No. 10, pp. 1661–1674, 2013.

This paper presents an extended Markov chain Monte Carlo (MCMC) method for tracking and an extended hidden Markov model (HMM) method for learning/recognizing multiple moving objects in videos with jittering backgrounds. A graphical user interface (GUI) with enhanced usability is also proposed. Previous MCMC and HMM-based methods are known to suffer performance impairments, degraded tracking and recognition accuracy, and higher computation costs when challenged with appearance and trajectory changes such as occlusion, interaction, and varying numbers of moving objects. This paper proposes a cost reduction method for the MCMC approach by taking moves, i.e., birth and death, out of the iteration loop of the Markov chain when different moving objects interact. For stable and robust tracking, an ellipse model with stochastic model parameters is used. Moreover, our HMM method integrates several different modules in order to cope with multiple discontinuous trajectories. The GUI proposed herein offers an auto-allocation module of symbols from images and a hand-drawing module for efficient trajectory learning and for interest trajectory addition. Experiments demonstrate the advantages of our method and GUI in tracking, learning, and recognizing spatiotemporal smooth and discontinuous trajectories.

An Exploratory Study of Proxemics and Impression Formation among Video Communication Users

M. Matsuda, I. Daibo, S. Kumano, K. Otsuka, and J. Yamato

The Transactions of Human Interface Society, Vol. 15, No. 4, pp. 433–442, 2013 (in Japanese).

This article aims to examine how proxemics affects interpersonal impression formation among video communication systems users. Ordinary video chat systems abstract each user's physical location when more than three users are involved. Therefore, it is difficult to use directional non-verbal cues to control their conversation, and the users tend to compensate directional information with verbal cues. Such an unnatural way of communicating might affect the speaker's impression. Our experimental results confirmed this phenomenon that interpersonal impressions could be different between the party and the bystanders. We propose a future design and usage of video communication systems based on our findings.

Insensitivity to the Coherence of Interaural-time-difference Modulation across Frequency Channels

S. Furukawa, T. Nishida, T. Kondo, and K. Kakehi

Acoust. Sci. & Tech., Vol. 34, No. 6, pp. 397–403, 2013.

The present study examined the dynamic properties of the across-frequency integration mechanism, specifically the extent to which the information about the direction of changes in the interaural-time difference (ITD) is integrated or compared across frequencies. The stimulus was a complex tone consisting of two sinusoidal carriers, one at 400 and the other at 700 Hz. A sinusoidal modulation in the ITD was imposed on one carrier alone or the two carriers simultaneously. The ITD of each carrier was centered at 0 ms, and the modulation started and ended with the zero phase. ITD modulations, when imposed on the two carriers simultaneously, were in-phase or anti-phase between them. Experiment 1 measured the threshold modulation depth for detecting the modulation with an adaptive method. The

thresholds were generally lower when both carriers were modulated than when only one was, indicating across-frequency integration of the information about the presence of modulation. The threshold, however, was not significantly different between the in-phase and anti-phase conditions, even when the modulation rate was as low as 1 Hz. Experiment 2 measured the discriminability between in-phase and anti-phase modulations. Modulation depth was fixed at a supra-threshold value (600 ms). The performance varied largely among the listeners, and it was near the chance level for half of listeners even for a 1-Hz rate. The study failed to present compelling evidence that the auditory system is sensitive to the relative phase of ITD modulations for the conditions tested. This suggests that the directional information of even slow (approx. 1 Hz) ITD modulation is not combined effectively across frequencies, at least for the conditions tested.

Advantages of IP over Elastic Optical Networks Using Multi-flow Transponders from Cost and Equipment Count Aspects

T. Tanaka, A. Hirano, and M. Jinno

Optics Express, Vol. 22, No. 1, pp. 62–70, 2014.

To evaluate the cost efficiency of IP over elastic optical network architectures, we use a multi-layer network design scheme that covers the network to node equipment level. An evaluation in a static traffic environment shows that the multi-flow optical transponder-based elastic optical network reduces the total cost as well as the equipment count compared to other elastic network models based on fixed-rate, mixed-line-rate and bandwidth-variable transponders.

Language Runtime Support for Non-volatile Main Memory Management

S. Saito, G. Nakagawa, and S. Oikawa

Proc. of the 8th International Conference on Innovative Computing, Information and Control (ICICIC 2013), Kumamoto, Japan.

The recent performance improvement of non-volatile (NV) memory enables NV memory to be used as the main memory of computer systems. In order to realize such systems, system software needs to manage NV memory in accord with its characteristics, such as slower write speed and limited write durability. In order to cope with these characteristics, it is important to selectively store data in NV memory because there are unsuitable data that should be stored in dynamic random access memory. Such selection can be done by collecting the information about data access tendency. This paper proposes a method that utilizes the write-barrier mechanism supported by language runtime in order to collect the write access tendency. We implemented an access logging system and investigated the effectiveness of utilizing data access tendency for data selection. As a result, we show it is useful to utilize the data access tendency for the efficient selection of data suitable for NV memory.
