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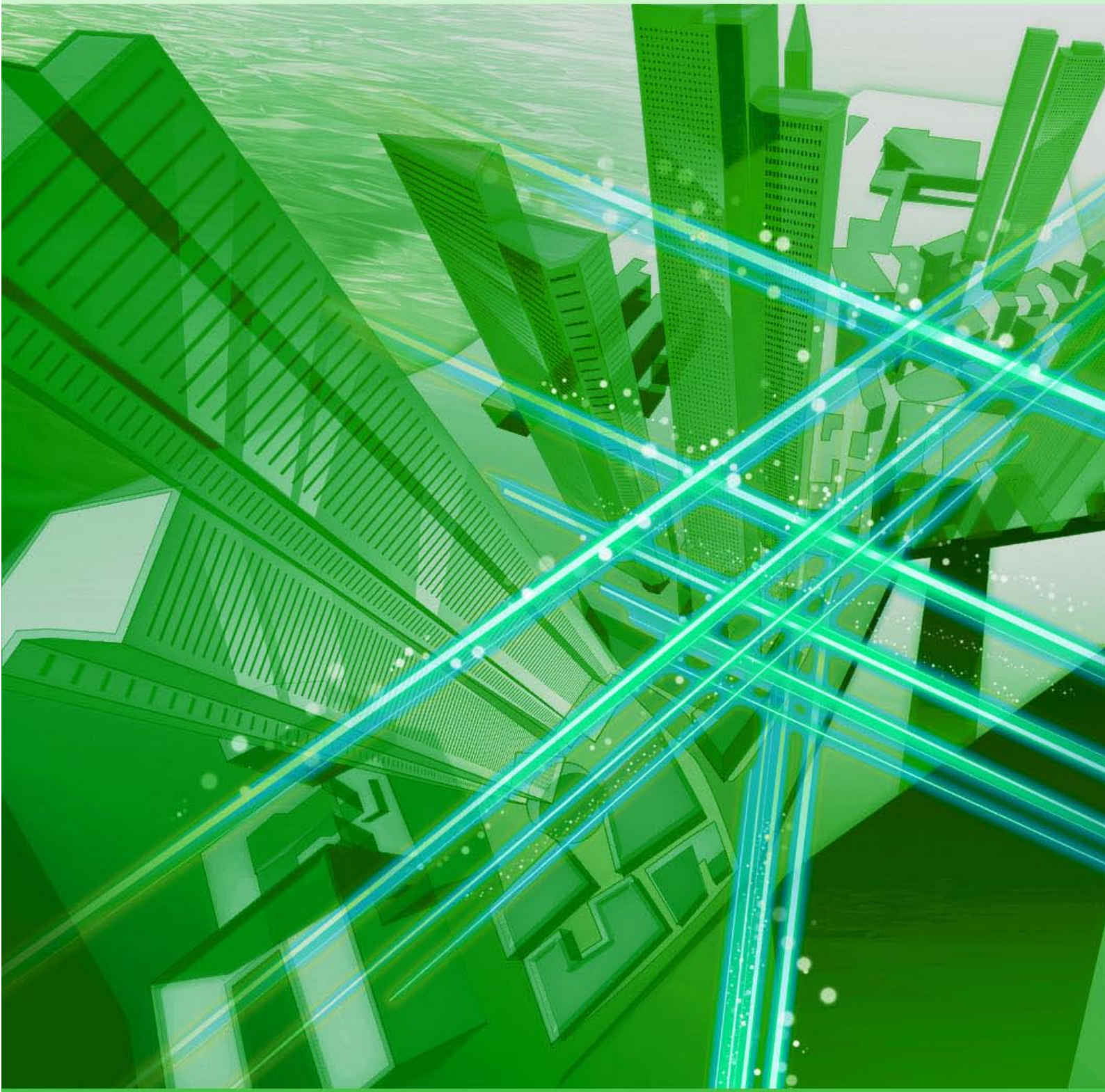

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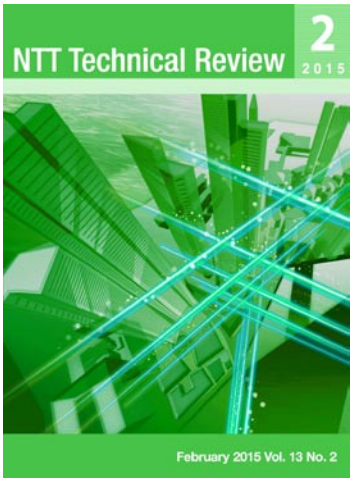

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Build a Feedback Loop for Value Creation—Enriching and Accelerating Open Innovation in 2015

Kazuhiro Yoshizawa
Senior Executive Vice President,
NTT DOCOMO

Overview

Today, feature phones and smartphones have become indispensable in our daily lives, and users are looking for even more convenient mobile devices that provide a greater sense of beneficial value. At the same time, the convergence of mobile and fixed communications has the potential to bring dramatic changes to the way that we communicate with others. We asked Kazuhiro Yoshizawa, NTT DOCOMO Senior Executive Vice President, to tell us about the types of mobile-fixed services that NTT DOCOMO plans to provide and the company's approach to innovation as a foundation of service creation.

Keywords: open innovation, feedback loop, Hikari Collaboration Model

Facing 2015 with a sound attitude: "Of thy sorrow be not too sad, of thy joy be not too glad"

—Mr. Yoshizawa, please tell us about the current state of NTT DOCOMO and the outlook for 2015 from your position as Senior Executive Vice President.

NTT DOCOMO has downwardly revised its forecasts of financial results for the 2014 fiscal year ending in March 2015. The 2015 fiscal year will be a time for us to revitalize our competitive edge. In addition to a new billing plan called "Kake-hodai & Pake-aeru," we are rolling out novel services such as "docomo Hikari" as part of our aggressive approach to further enhancing customer satisfaction. Having said that, we have to bear in mind that the competitive edge should come from our customers' strong need for NTT DOCOMO services and not from the one-sided assumption of what our competitive abilities should be.

Talking of my position at NTT DOCOMO, in contrast to the formulation of company-wide strategies I was engaged in, my current responsibilities involve dealing with specific fields such as technologies, information systems, information security, personal or confidential information, and devices.

In the area of information security, for example, questions were raised last year about the safety of personal information. In the face of such data security concerns, it is my job to increase our awareness that we are entrusted with the huge amount of personal information and to enhance our countermeasures against data leaks. To provide our president with solid support and to fulfill my responsibilities, I need to be calm and collected during difficult times without losing sight of what is really happening, and I must be

careful about being overoptimistic during good times. The words that I like to live by are, "Of thy sorrow be not too sad, of thy joy be not too glad."

—What, then, will be your specific strategies? To begin with, please tell us about the enthusiasm that NTT DOCOMO has for the Hikari Collaboration Model [1].

As you know, we plan to provide our customers with a service called "docomo Hikari" by purchasing FLET'S HIKARI (a high-speed optical fiber Internet connection service) from NTT EAST and NTT WEST on a wholesale basis.

In this move, we are determined to play a B2C (business-to-consumer) role within the entire NTT Group by leveraging our experience in providing customers with feature phones and smartphones. Our key role here is to set up an optimal broadband environment for our customers so that they can seamlessly enjoy mobile and fixed services, rather than just setting new billing plans including package discounts.

For example, this means creating a seamless environment in which customers can continue to enjoy their digital content even away from home as they always do at home. This would be an area where NTT DOCOMO is expected to provide new services by leveraging NTT EAST and NTT WEST services for users including those at home.

Meanwhile, the mobile domain is still our business platform. It goes without saying that it will continue to be an important pillar of NTT DOCOMO business. However, the use of voice services is declining, so we have to take a composite approach of bolstering voice services and improving profitability in data communications.

The new "Kake-hodai & Pake-aeru" billing plan that we announced last year is just part of this initiative. I believe that "voice" lies at the basis of communication. Voice services have traditionally been charged on a volume basis, and as a result, customers have viewed them as being somewhat expensive and have tended to use them sparingly.

I considered that applying a flat rate billing scheme to voice services could change this trend to encourage customers to increase their voice communication. What could be better than being able to enjoy phone calls regardless of whether the other party is on a mobile or fixed phone without having to worry about the fee charged?

Moreover, to further promote the use of voice, we

have developed a high-quality voice service called VoLTE (Voice over Long Term Evolution). Of course, one can convey one's thoughts and intentions through text and graphics using e-mail or social networking services (SNS). Nevertheless, I would like to see our customers deepen exchanges of more subtle and nuanced emotions by using one-to-one, high-quality calls using their own voice—the basis of human communication.

As for data communications, we have prepared plans that offer a variety of benefits for our customers. These include the sharing of packet quotas among family members and the ability to carry forward unused packets to the next month. My goal here is to combine this initiative with business in new areas to bolster revenues in the mobile domain.

Build a feedback loop for value creation

—What areas would you look to first in launching a new business?

As a leading company specializing in the communications business, we will place our primary emphasis on voice, data communications, and e-mail as before.

Now, "service" has been added to the list of important areas where we compete. "Service" can be interpreted as something convenient and enjoyable to use from the viewpoint of the customer. That means we need to identify the applications and content useful for customers' lives as the Internet is playing an indispensable role for them. In this context, we must determine what services to be provided for what types of customers through marketing, which is essential and will become the key element of our

business.

At the same time, we need to be keenly aware of the competition. It's not just other telecommunication carriers in Japan. We are facing the competition from the so-called Over The Top (OTT) global service providers such as Amazon*1 and Facebook*2. So it's important for us to pursue service creation, keeping the competition in mind. To this end, it is essential to enhance our research-and-development and product-planning capabilities so that we can create and provide services as quickly as possible, incorporating the voices of our customers. I always tell the employees, "Look through the eyes of the customer. Then you will see what they really need." Without building a *feedback loop* that promptly reflects the voices of our customers, we cannot win in the service competition.

—Is preparation for a future mobile network steadily underway?

We are building up and expanding the network as we roll out new services.

Data traffic is showing a two-fold increase annually. To accommodate such rapidly growing traffic, we are launching a fourth-generation mobile communication system called LTE-Advanced at the end of this fiscal year. As even this will still not be sufficient to keep up with the traffic growth, we would like to roll out a fifth-generation mobile communication system in time for the "big event" in 2020. To achieve this goal, we have already initiated joint research with six global vendors from Japan and other countries while trying to contribute to the standardization of this fifth-generation mobile communication system as one of the leading companies.

In fact, we already have a track record of contributing to standardization efforts. The mobile industry in Japan has often been referred to as being suffering from the "Galápagos syndrome" due to its development of specialized products that are isolated from the rest of the world, but this is not the case. The Personal Digital Cellular (PDC) network technology running the "i-mode" mobile Internet service is an international standard, which happened to be adopted by few countries. The PDC system, moreover, brought in the largest profits in NTT DOCOMO's history. In addition, the current LTE technology standardized through the leadership of NTT DOCOMO has been adopted in many countries. As for a fifth-generation mobile communication system, the six companies with whom we are conducting joint research toward standardization are all global players, so there is no worry about the Galápagos syndrome. When it comes to commercialization, however, relying solely on Japanese vendors would not be sufficient to achieve global penetration. It is therefore essential that we cooperate and collaborate globally even prior to technology standardization.

Enrich and accelerate open innovation with an eye to the "big event"

—What type of approach do you intend to emphasize this year to expand NTT DOCOMO activities?

As I mentioned earlier, a variety of players are active at the service layer in the global market. As we cannot compete without pursuing development in a more open manner and creating services in a short period of time, I am committed to promoting open innovation in the company.

Although the research and development of core technologies requires a good deal of time, we are now in an era in which speedy commercialization in one or two months is needed for some types of services. To keep pace with such a rapid flow, we established the Innovation Management Department just last

*1 Amazon is a trademark of Amazon.com, Inc.
*2 Facebook is a trademark of Facebook, Inc.

year. Actually, we have already practiced open innovation to create some novel servcies and applications. Among those are a voice agent application called "Shabette Concier," and automatic voice translation service "Shabette Honyaku." We were able to bring them to market in a relatively short period of time by combining technologies from both within and outside the NTT Group.

Furthermore, leveraging the know-how that we accumulated in creating the above-mentioned services, we established a joint venture called "Mirai Translate," which aims to develop high-level machine translation technology and services between Japanese and other languages. The translation accuracy we hope to achieve is comparable to a TOEIC[*3] Test 700-point level for English. We feel that such a translation service should be helpful in creating a hospitable environment for the many international visitors who will be visiting Japan during the 2020 "big event."

Innovation is not only about developing original and revolutionary technologies. It also includes combining existing technologies in original ways to create new products and services. With this in mind, we aim to join forces with people having all sorts of ideas. To this end, we finance venture companies, create funds, and establish support programs through NTT DOCOMO Ventures, Inc. All in all, my aim is to promote short-term open innovation by making effective use of the Innovation Management Department and NTT DOCOMO Ventures.

At the same time, we will be promoting the development of technologies that can contribute to cost reductions. With regard to the network, this means virtualizing network equipment such as servers to cope with the increasing traffic. In addition, we intend to use multi-frequency band antennas, which integrate operations of a variety of frequencies in radio base stations, to help reduce equipment costs.

—Mr. Yoshizawa, could you leave us with a message for all NTT DOCOMO employees?

I would be happy to. During my time in the Corporate Sales and Marketing Division, much of my work was devoted to making apologies, and I came to realize the importance of "listening to what people have to say." This is not limited to customers—lending an ear to your superiors and colleagues can give you marvelous insights. If you feel that someone else's idea is more reasonable compared to yours, you should incorporate that idea.

If you want to grow, start by listening to what other people have to say.

They say that the next-generation of devices will be wearable devices. However, it's not that simple. In the case of the wristwatch, some people have the habit of wearing one while others don't, and among those who do, some will prefer to wear it on their right hand and others on their left. In other words, one set of service specifications will never satisfy all customers. We have to strive to listen to the voice of our customers and find out appropriate combinations of services and functions that can meet the needs of individual customers. I believe that this way of thinking can foster innovation.

Reference

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*3 TOEIC is a registered trademark of Educational Testing Service.

Interviewee profile

■ Career highlights

Kazuhiro Yoshizawa joined Nippon Telegraph and Telephone Public Corporation (now NTT) in 1979. He has been involved in the mobile phone business since the dawn of the industry. He became NTT DOCOMO Senior Vice President and Managing Director of Corporate Sales and Marketing Department II in 2007, Senior Vice President and Managing Director of Human Resources Management Department in 2011, and Executive Vice President, Managing Director of Corporate Strategy & Planning Department in 2012. He assumed his current position in June 2014. Concurrently, he retains his position as a Member of the Board of Directors, which he assumed in 2011.

Cloud Computing Platform Technology Initiatives at NTT Laboratories

Kenichi Ohto, Yuzo Koga, Takeshi Kaji, and Takuji Kishida

Abstract

To realize flexible, agile, low-cost, and safe and secure cloud services, NTT laboratories are involved in various research and development (R&D) initiatives in cloud computing platform technologies through open innovation. This article explains the approach of these R&D initiatives for implementing the NTT laboratories' cloud computing vision, and also gives an overview of our current work on cloud controller and virtualization technologies.

Keywords: cloud, open innovation, virtualization technology

1. Introduction

A cloud provides information and communication technology (ICT) resources such as a central processing unit (CPU) and memory of a server machine, as well as storage promptly through a network in the configuration required by customers. Customers can reduce their capital and operational expenses and increase competitiveness in their various business endeavors by using cloud services. To strengthen the competitiveness of the NTT Group's global cloud businesses, research and development (R&D) is underway at NTT laboratories to realize a world-class cloud computing platform that is flexible, agile, low-cost, safe, and secure (**Fig. 1**).

2. R&D through open innovation

Technologies in the cloud field are advancing rapidly. The lifecycles are getting shorter, and the technologies are becoming more complex. In such conditions, we believe it is important in principle to avoid large-scale, independent product development, and to promote open innovation so as to utilize excellent products and/or open technologies from around the world. This will enable us to shorten the periods of product development, reduce costs and various risks, catch up with the latest technologies, and avoid vendor lock-in. We also believe it is very useful for NTT Group businesses to utilize know-how that is fed back from our activities to verify and/or support both products and technologies. The approach of the NTT Software Innovation Center in these R&D initiatives is summarized in **Fig. 2**.

(1) *Verify and support* involves verifying technologies and supporting customers in adapting them in accordance with their needs and technology trends. (2) *Provide with open source software (OSS)* involves providing products by combining them with existing OSS, contributing to helpful OSS communities, and advancing technical development in cooperation with the communities. (3) *Provide with proprietary products* involves providing products by combining them with excellent new products, which are discovered and verified at an early stage in cooperation with other groups such as NTT Innovation Institute, Inc. (NTT I^3) in the USA. Finally, (4) *Develop in laboratories* involves R&D limited to technologies that promise large growth and are in their early developmental stages. We also take into consideration the

[Flexibility] Realize cloud computing environment that provides ICT resources in the required configuration
- Provide ICT resources divided and deployed centrally in a datacenter

[Agility] Rapidly build new systems as well as migrate existing systems
- Configure and deploy an entire system with multiple servers on an on-demand basis through a user's portal
- Centrally monitor and operate ICT resources deployed in dozens of location

[Low-cost] Improve datacenter utilization
- Eliminate server resource fragmentation in operation
- Actively use open technologies that effectively reduce costs

[Safety and security] Store and process confidential data securely
- Realize system configuration and disaster recovery spanning datacenters by linking with global networks
- Realize confidentiality so that even cloud operators cannot access data, and availability so that the data can be recovered even if some is lost
- Accumulate operational histories on data, enabling verification of whether all operations were legitimate

Fig. 1. NTT laboratories' cloud computing vision.

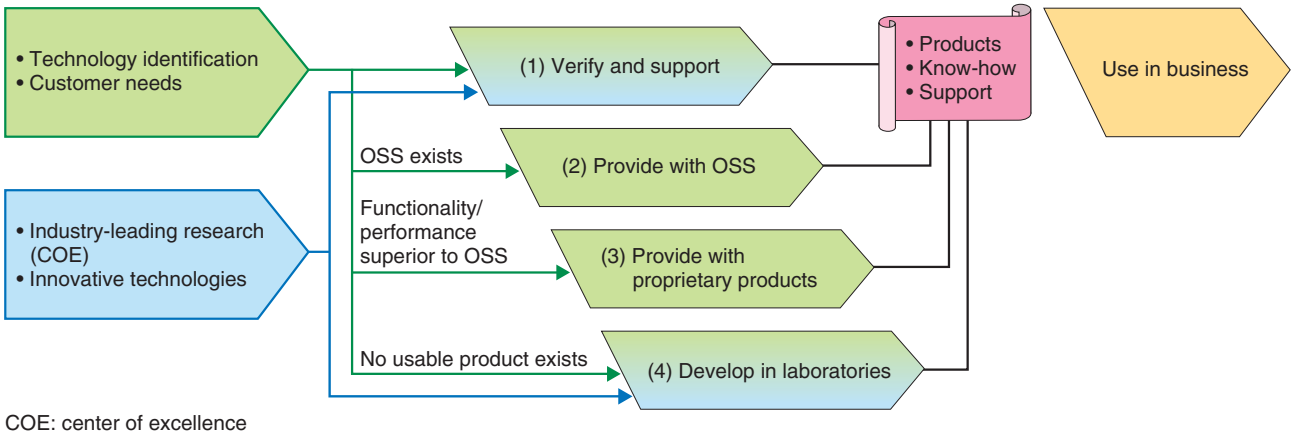

Fig. 2. Approach to R&D initiatives.

publication of our developed products as OSS. NTT laboratories are incorporating the security technologies introduced in the Feature Articles in the July 2014 issue [1] of this journal and are working on the cloud computing platform technologies described in these Feature Articles, based on the R&D initiative approach shown in Fig. 2.

3. Cloud computing platform technology

Cloud computing platform technology consists mainly of *cloud controller* and *virtualization* technologies. Virtualization technology divides and provides ICT resources freely for use, which are centrally deployed in a datacenter. Virtualization technology has expanded from the CPUs and memory of server machines to various ICT resources such as

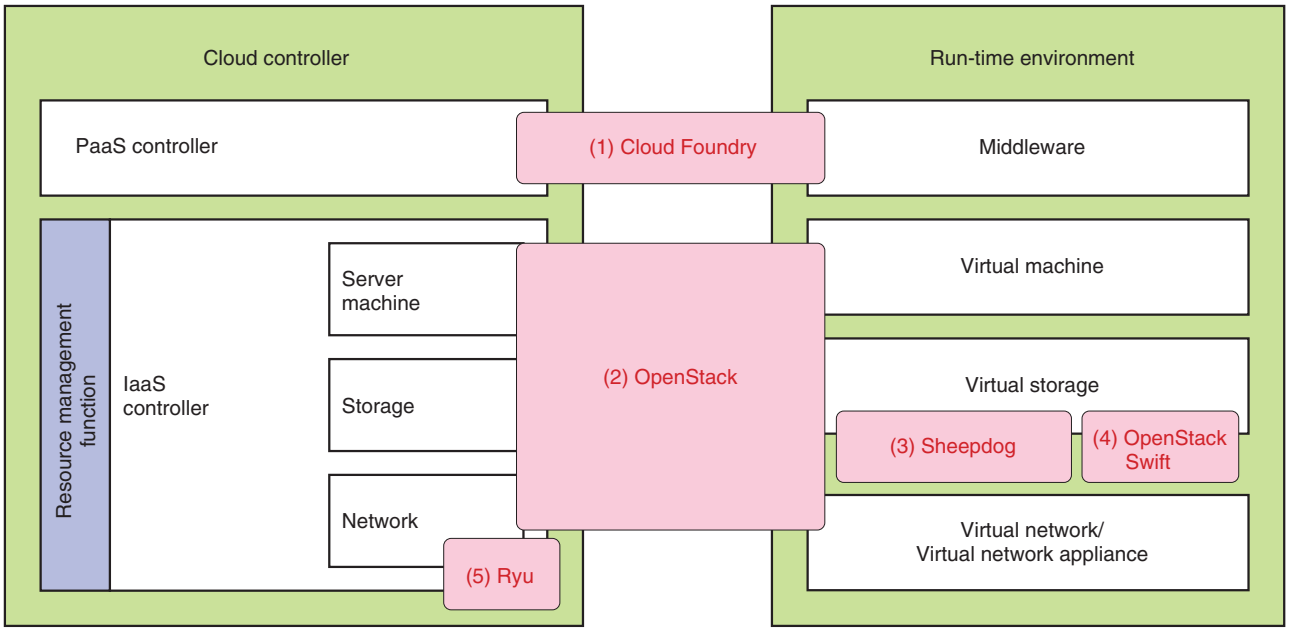

Fig. 3. Cloud computing platform technology initiatives.

networks, storage, and network appliances. Cloud controller technology controls these virtualized ICT resources and makes them available in cloud run-time environments, in accordance with customer requirements. Cloud controllers are used for both private clouds, which use cloud technology on a customer's own information systems, and public clouds, which are operated by cloud service providers. The range of applications has recently expanded to include hybrid clouds, which incorporate a mix of private- and public-cloud services. Cloud service providers are using these cloud computing platform technologies to provide services such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).

4. Open architecture initiatives

NTT laboratories make various ICT resources available through standard interfaces and will continue to incorporate the latest technologies that emerge in the future. To achieve this, we are engaged in R&D on cloud computing platform technologies based on open architectures (**Fig. 3**).

(1) Cloud Foundry is an open PaaS administrative function that provides middleware on a cloud run-time environment. It includes run-time environments for applications programmed in the Ruby or Java languages, and for middleware such as databases. The "PaaS Platform Based on Cloud Foundry" article in these Feature Articles describes Cloud Foundry extensions for application management and operations automation. Additionally, the article describes other improvements for development and operations processes, which are promoted in cooperation with NTT I^3 [2].

(2) OpenStack is an open IaaS management function that controls virtual machines, storage, and networks in a cloud run-time environment. The article on OpenStack activities introduces R&D initiatives on functionality needed to apply OpenStack to public clouds, such as multi-plugin support for virtual networks, transaction functions, and resource management functions. Initiatives for private clouds and to enhance overall enterprise IT infrastructure are also introduced [3].

(3) Sheepdog provides distributed block storage, and (4) OpenStack Swift provides object storage; both are virtualized in a cloud run-time environment. The article entitled "R&D Efforts in Storage Virtualization Technology" introduces efforts to improve the operability and reliability of Sheepdog by implementing multipath features, which enable connection to multiple servers, and by using remote locations, which help prevent service outages and data loss. It also introduces efforts to make OpenStack Swift

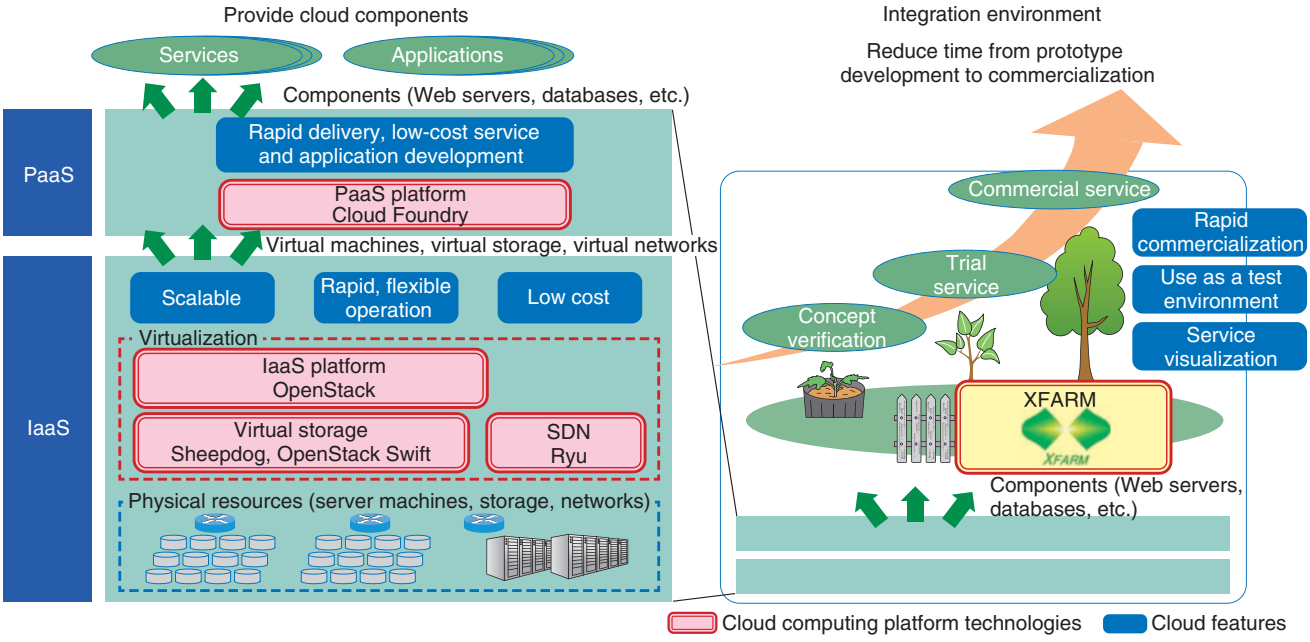

Fig. 4. In-house cloud "XFARM" concept.

operation more efficient and to reduce costs for multiple, large-scale, autonomous and distributed storage servers [4].

(5) Ryu is platform software that implements software-defined networking (SDN) to manage the operation of network devices centrally through software. It provides functions such as network path control and traffic monitoring using the OpenFlow protocol specified by the Open Networking Foundation [5]. Details of Ryu initiatives were introduced in a Feature Article [6] in the August 2014 issue of this journal.

5. XFARM initiatives

We now introduce *XFARM*, an in-house cloud to enable researchers to use and improve R&D results from NTT laboratories for themselves. XFARM provides environments for demonstration or service development, using aggregation technologies such as virtualization, to share servers and other ICT resources, to increase efficiency, and to reduce R&D costs. We have gained know-how in cloud operations ourselves by operating XFARM, and by integrating this know-how with research results regarding various cloud computing platform technologies, services, and applications, we will be able to use it to evaluate usability, visualize services, provide test environments, and develop commercial applications in shorter periods of time. The XFARM concept is shown in **Fig. 4**. An example of a research result incorporating XFARM is the cloud controller described above that links OpenStack and SDN. Using a cloud controller, researchers can secure ICT resource components on demand, and can build separate, independently configured virtual networks per user. This not only increases the efficiency of R&D activities, but also helps in quickly solving problems experienced by researchers such as inadequate performance.

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PaaS Platform Based on Cloud Foundry

Ken Ojiri, Noburou Taniguchi, Takahiko Nagata, Shinichi Nakagawa, and Yudai Iwasaki

Abstract

The NTT Software Innovation Center is working on the development and commercialization of Cloud Foundry, which is open source PaaS (Platform as a Service) platform software. This article introduces the latest trends with Cloud Foundry and our activities related to its expansion to cloud businesses.

Keywords: cloud, open source, PaaS

1. Overview of PaaS

The NTT Software Innovation Center is developing a Platform as a Service (PaaS) platform*1 using Cloud Foundry [1, 2] as part of efforts to build a cloud infrastructure using open source software.

The objective is to provide a platform for an application run-time environment, that is, a software stack that combines the various types of software needed to run applications such as the operating system (OS), various libraries, frameworks, and middleware such as web servers, databases, and load balancers on top of Infrastructure as a Service (IaaS) (**Fig. 1**). A PaaS provider provides PaaS users with a common run-time environment that can be shared among various types of applications, as well as services such as a health monitor for running applications.

The greatest advantage of using PaaS is that it eliminates some of the work involved in building the run-time environment for application development and operations. Application development can be accelerated because test environments can be obtained easily using PaaS. Applications can be operated efficiently because computing resources with a pre-built environment can be procured easily while scaling the applications to a large size.

The need for PaaS has increased recently, and as a result, many commercial PaaS services have appeared on the market, including the Cloud^n PaaS [3] service introduced by NTT Communications in December, 2012, as well as Google App Engine, AWS (Amazon Web Services) Elastic Beanstalk, Microsoft Azure, Heroku, and IBM Bluemix (see **Table 1**).

2. Cloud Foundry: open source software project

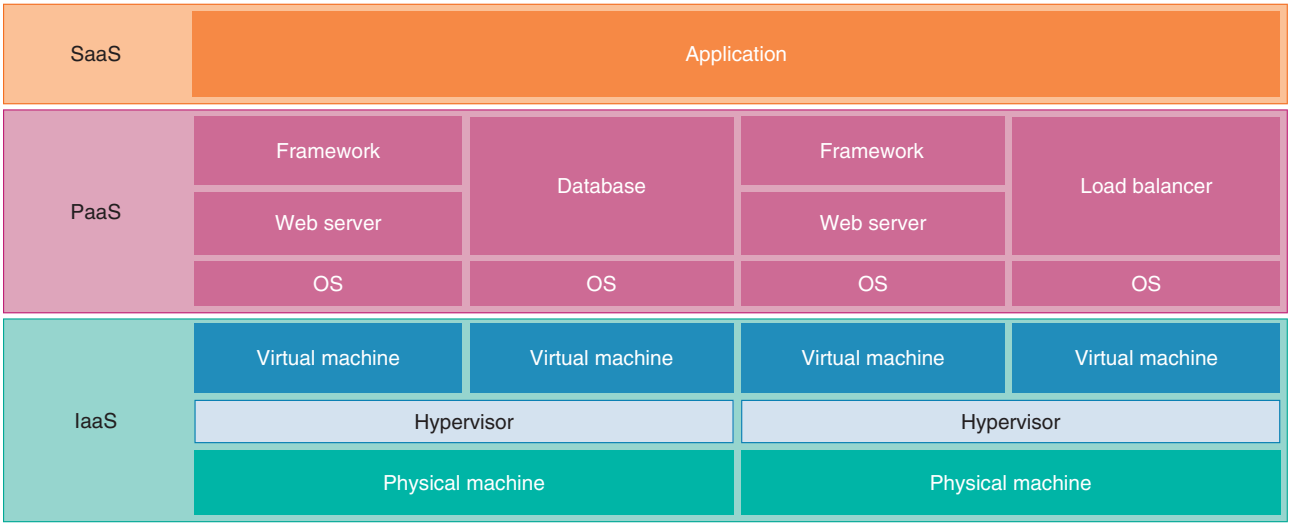
Cloud Foundry is PaaS platform software being developed as open source. In contrast to services such as Microsoft Azure or Heroku, which are built with proprietary, closed-source software, Cloud Foundry uses published source code that anyone can use to build their own PaaS platforms.

The strengths of Cloud Foundry can be summarized in three main points, described below.

(1) No vendor lock-in

Because Cloud Foundry is open source, PaaS users can avoid dependence on a particular PaaS provider (vendor lock-in). Generally, the functions provided by each PaaS and how they are used differ, so there is no compatibility between them. Because of this, migrating an application developed for a particular PaaS to another PaaS requires rewriting the source code and revising operational procedures in most

*1 PaaS platform: In this article, "PaaS" refers to the PaaS service itself, and "PaaS platform" refers to the technology stack used to build the PaaS. "Application" refers to applications (services) running on the PaaS. "PaaS user" refers to users developing and providing applications on the PaaS, while "application user" refers to users of those applications.



SaaS: Software as a Service

Fig. 1. Hierarchical structure of technologies comprising a cloud.

Table 1. List of PaaS services.

Service name	PaaS provider name	Features
Google App Engine	Google	Guarantees high scalability with proprietary APIs, BigTable, and other mechanisms
AWS Elastic Beanstalk	Amazon	Supports linking with other services provided using AWS
Microsoft Azure	Microsoft	Rich linking with Microsoft integrated development environment
Heroku	salesforce.com	Pioneering PaaS service supporting a variety of general programming languages
Force.com	salesforce.com	Rich business application logic
Cloud^n PaaS*2	NTT Communications	Equipped with Cloud^n RDB integration, logging, monitoring, distributed applet functions
Pivotal Web Services*2	Pivotal	Operated by Pivotal, leader of the Cloud Foundry community
IBM Bluemix*2	IBM	Rich applet developer support functions, linked services
anynines*2	anynines	Uses 100% European datacenters
OpenShift	Red Hat	Service using OpenShift Origin from Red Hat

*2 Services using Cloud Foundry

API: application programming interface
RDB: relational database

cases. This makes it difficult to handle conditions such as sudden increases in user fees or the shutdown of a service. These can pose a great risk, particularly for users who operate commercial applications. For PaaS services that use Cloud Foundry, compatibility is guaranteed and there is no vendor lock-in, so these sorts of migration problems are avoided. Users can select a PaaS provider according to conditions, or even build their own private PaaS.

(2) Flexible system configuration

To enable Cloud Foundry to satisfy varying PaaS requirements, the overall system is divided into loosely connected components able to operate in a multiple-active configuration (n-ACT) and designed to be variously combined as needed (**Fig. 2**). This makes it possible to build a PaaS according to the required scale and reliability, from a small-scale, private PaaS with all components running on a single machine, to a large-scale, public PaaS operating on several thousands of machines. Components can also be added or removed afterwards, so it is easy to start by building on a small scale and later scaling out as processing requirements increase.

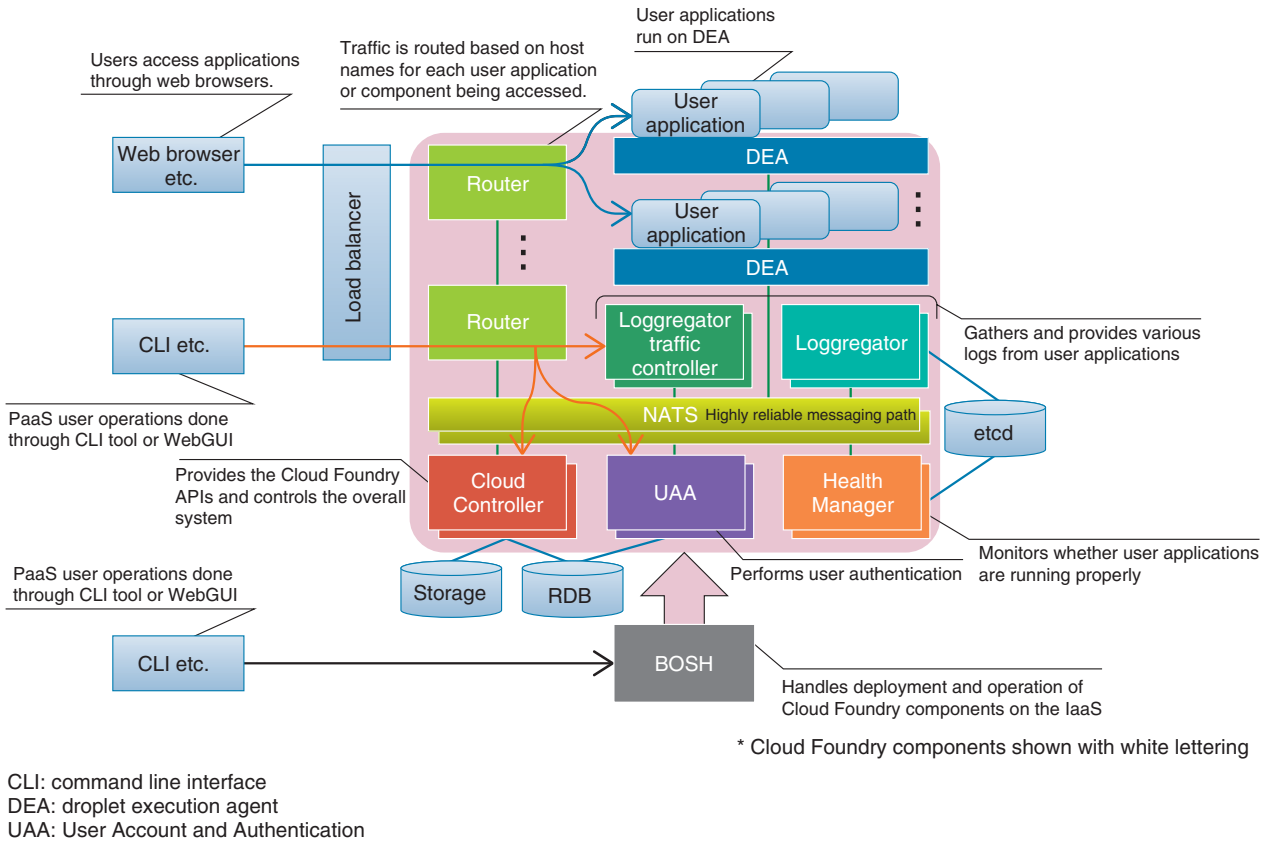


Fig. 2. Cloud Foundry component architecture.

(3) Diversity of development languages and frameworks

Applications developed using a variety of programming languages such as Ruby, Java, JavaScript, and PHP, and web application frameworks such as Ruby on Rails, Sinatra, Spring, and Node.js can run on Cloud Foundry. It also supports the Buildpack concept introduced by Heroku, which can be used to run applications using programming languages and frameworks not supplied by the PaaS platform.

Besides Cloud Foundry, there is another open source PaaS platform called OpenShift Origin, developed mainly by Red Hat Inc. At this point, Cloud Foundry is a step ahead of OpenShift Origin in terms of the number of contributing technologists, the level of activity as an open source community, and adoption by PaaS providers.

3. NTT laboratories initiatives

NTT laboratories have taken the following initiatives concerning the use of PaaS platforms based on Cloud Foundry.

3.1 Feature expansion and verification

3.1.1 Increasing availability of applications running on the PaaS platform

When PaaS users want to ensure availability to run multiple applications, it is desirable to distribute application deployment locations as widely as possible. Therefore, we have extended Cloud Foundry application management features so that application placement can span multiple datacenters and servers.

3.1.2 Automating operations of the PaaS platform

BOSH is software for PaaS platform management. It deploys, launches, and monitors Cloud Foundry components on IaaS platforms. We have developed auto-scaling functions that cooperate with BOSH to automatically adjust the number of virtual machines on IaaS platforms when there are shortages or excesses of necessary resources such as the CPU (central processing unit), memory, and network bandwidth.

3.1.3 Building and operating a PaaS platform spanning multiple IaaS systems

BOSH, as mentioned above, provides a CPI (Cloud Provider Interface) that supports various IaaS platforms, so Cloud Foundry can be installed on various IaaS platforms. Cloud Foundry can also be used to build and operate a single PaaS platform spanning multiple IaaS platforms if IP (Internet protocol) communication is possible between the IaaS platforms. Thus, we have demonstrated the practicality of hybrid clouds built and operated using a PaaS platform that combines multiple public IaaS platforms, or combines a public IaaS platform with a private IaaS platform.

3.2 Improved efficiency of operation processes through link with NTT clouds Develop

NTT laboratories and NTT Innovation Institute, Inc. (NTT I^3) [4] are conducting a collaborative experiment with *NTT clouds Develop*, a service that supports installation of Cloud Foundry and DevOps. NTT clouds Develop is a solution for implementing the service development and operations processes known as DevOps, which have attracted attention as a side effect of the recent spread of agile software development. By combining the improvements in development and operations processes due to DevOps with the operational efficiency of Cloud Foundry, we expect to see substantial improvements in the efficiency of development processes.

The use of DevOps to tightly integrate the development and operations processes, which have previously been separate, means that services can be updated dozens of times per day, much more quickly and frequently than before. Frequent service updates are essential for incorporating end-user needs in a service, so it is a strong competitive advantage in today's market of rapidly changing needs. However, there are barriers to introducing DevOps. A wide range of tools must be mastered in order to implement DevOps effectively. The tools depend on the application, including source code version control and issue ticket tracking, and also continuous integration (CI) and server configuration management automation. However, gaining mastery of all of these tools and the know-how to combine them is not a simple matter. To overcome these difficulties, NTT clouds Develop has been designed to provide services with these various functions already integrated, so that anyone can easily start using DevOps.

Integrating Cloud Foundry into NTT clouds Develop should make service delivery even more efficient. It was already possible to build server environments automatically with NTT clouds Develop, but specialized know-how was necessary to configure features such as those for clustering and monitoring of servers. Also, setting up servers in each environment incurred costs in terms of both time and money, and managing settings in each different environment was a major operational burden.

Introducing NTT clouds Develop greatly improved efficiency in terms of development tasks such as source code and ticket management, although service delivery, which is the final step, still required a great deal of time and effort. Integrating Cloud Foundry as a service delivery platform improved these issues significantly. With Cloud Foundry, service delivery is simplified to just setting parameters and pushing out the source code. This enables not only the dedicated operations team to perform the final updates but the developers themselves to do it, too. The time required for the pushed code to actually run can also be reduced to minutes or even tens of seconds, so time costs are also reduced. Cloud Foundry can also provide multiple environments, namely development and production, so computing resources are used more efficiently, and moving from the development to the production environment is easier. When Cloud Foundry is combined with NTT clouds Develop in this way, the integration of development and operations, which is the key strength of DevOps, can be taken to a higher level.

3.3 Contribution to the community

Having an active open-source community is essential for stability when using an open source product such as Cloud Foundry. Thus, NTT laboratories will participate in the Cloud Foundry Foundation [5] representing the NTT Group, and will work to build the Cloud Foundry community and expand PaaS in Japan. With these two initiatives, we will also actively contribute to the community by sharing information such as publishing source code and making presentations at the Cloud Foundry Summit.

4. Future prospects

Cloud Foundry is excellent open source PaaS platform software with very attractive features. NTT laboratories will continue to contribute to the Cloud Foundry community and work to expand the PaaS market. In the future, in addition to our current initiatives, we will also work to enhance links between Cloud Foundry and OpenStack, which is an influential

open source IaaS platform, and to expand the development of PaaS platforms to include private-cloud use.

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OpenStack Activities

Hirofumi Ichihara, Shintaro Mizuno, Kenichi Sato, Tomoko Inoue, Takashi Natsume, Masahito Muroi, and Masahisa Kawashima

Abstract

In the three years since the founding of OpenStack, numerous companies have joined the community, an ecosystem has been established, and the commercial use of OpenStack has grown. This article describes recent developments in OpenStack, public-cloud and private-cloud efforts at NTT laboratories, research and development of hybrid clouds at NTT Innovation Institute, Inc. (NTT I^3), and NTT activities in the OpenStack community.

Keywords: OpenStack, IaaS, OSS

1. Introduction

OpenStack [1] is an open source software (OSS), Infrastructure as a Service (IaaS) platform project that provides users with infrastructure such as computers and networks as virtual resources. OpenStack functions have increased with every release cycle, as in the Icehouse release of April 2014 (**Fig. 1**). OpenStack Summit Atlanta 2014, which was held in the month following that release, highlighted the maturity of the OpenStack ecosystem[*1].

At this summit, the launch of OpenStack Marketplace was announced as a site for gathering information on products and services using OpenStack. Through Marketplace, 14 companies provide OpenStack distribution and 17 companies provide public-cloud and private-cloud services using OpenStack. In addition to users and cloud service providers, various companies such as vendors, consultants, and integrators participate in the OpenStack community and form an ecosystem. The ecosystem can support multiple use cases at NTT business companies, and it also prevents vendor lock-in. This ecosystem enables NTT services to effectively use OpenStack and facilitates the research and development of cloud services at NTT laboratories through collaboration with domestic and international partners.

2. OpenStack efforts at NTT laboratories

NTT laboratories have been investigating a method for combining OpenStack and a virtual network controller in order to deploy complex networks on virtual environments since 2012 [2]. NTT laboratories have also been testing and developing a public cloud using OpenStack. This testing revealed that the Folsom release targeted for 2012 was deficient in some functions needed for commercial use of OpenStack, so we added a number of functions to OpenStack. We describe here some representative functions developed by NTT laboratories.

2.1 Multi-plugin support for virtual network function

A multi-plugin function (Metaplugin) was added to enable multiple plugins to be simultaneously pluggable with Neutron, the OpenStack network controller. Although Neutron allows a plugin to be selected in accordance with the subordinate network, it has not allowed the simultaneous use of multiple plugins. To support use cases that involve the control of a complex network that might have multiple types of subordinate vendor switches, the Metaplugin function was

*1 Ecosystem: A mechanism for developing collaborative relationships among companies, developers, and users and forming a single environment through mutual cooperation

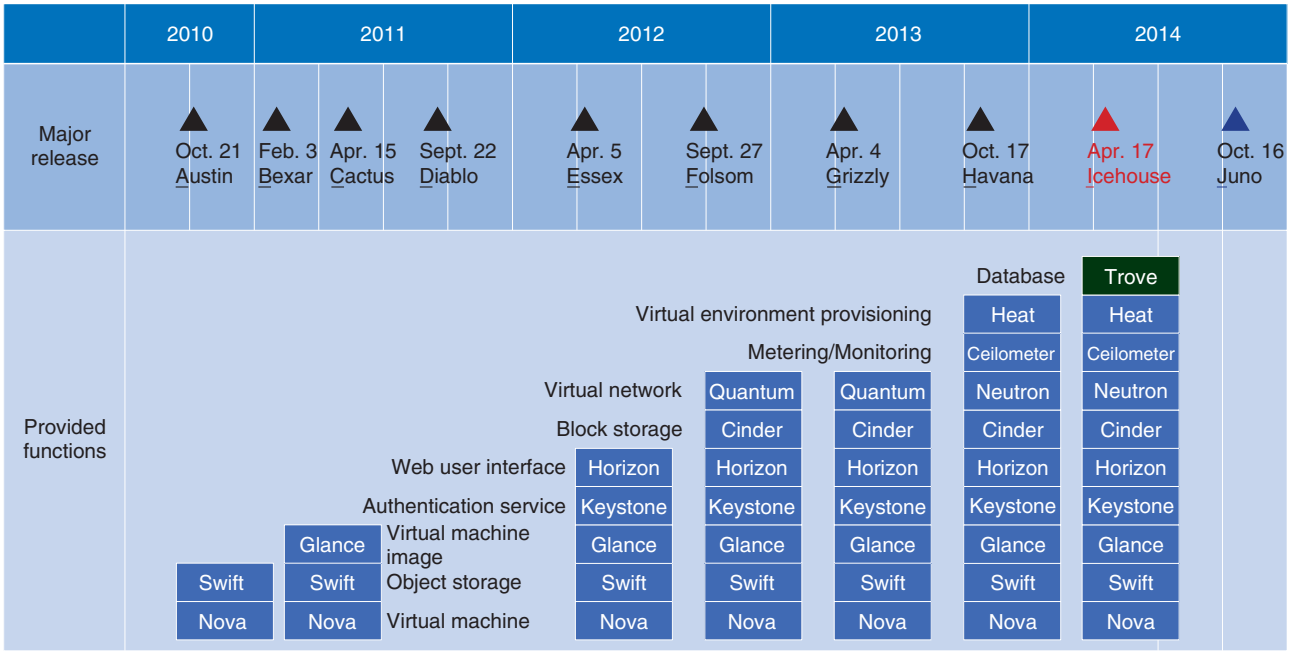


Fig. 1. OpenStack release schedule.

added to enable multiple plugins to be simultaneously pluggable, as shown in **Fig. 2**.

2.2 Transaction function

Transaction processing[*2] appeared to be deficient across the entire OpenStack Folsom release, so NTT laboratories investigated transaction processing in OpenStack. It was found, for example, that a process in which an error occurred during OpenStack operations would often leave behind erroneous settings and unnecessary resources that had been created during the execution process. NTT laboratories added transaction processing across all of OpenStack in order to appropriately delete resources and correct settings after the occurrence of a processing anomaly.

2.3 Resource management function

A variety of issues were revealed in relation to OpenStack resources when using OpenStack in commercial services. For example, while a commercial service would normally initiate billing at the time of resource creation by a user, there was no billing system in OpenStack. We also found that OpenStack did not have a sufficient mechanism for checking whether an operation to OpenStack was valid. NTT laboratories created a resource management function that manages resources from outside OpenStack and supports operations initiated by users (**Fig. 3**).

These functions added by NTT laboratories were provided to the OpenStack community. The Metaplugin function was incorporated in Neutron code. NTT laboratories are also contributing as a community member to the development of the Taskflow library to achieve transaction processing. We have been discussing within the community how to deal with problems solved by the resource management function.

3. NTT laboratories and NTT I^3 efforts going forward

NTT laboratories will continue efforts in developing cloud services using OpenStack based on requirements and use cases of NTT business companies, while NTT Innovation Institute, Inc. (NTT I^3) will survey the North American market and research and develop cloud services as next-generation cloud solutions applicable to the needs of that market. The following describes these activities in more detail.

3.1 Public-cloud efforts

NTT laboratories have adopted the use of unmodified

*2 Transaction processing: Information processing that guarantees the flow of a sequence of indivisible operations

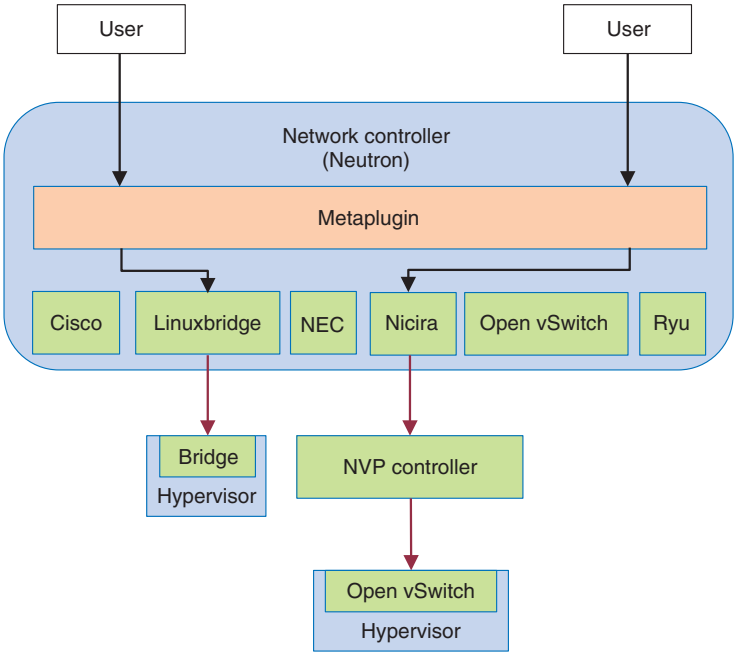
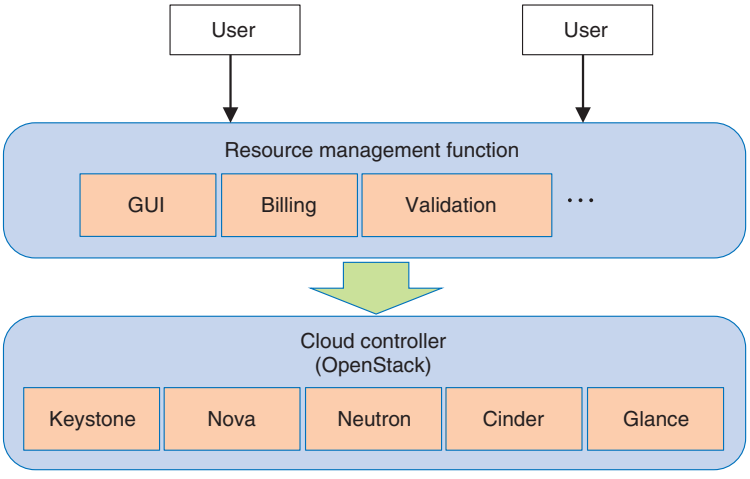


Fig. 2. Example of using Metaplugin.



GUI: graphical user interface

Fig. 3. Example of using the resource management function.

OpenStack community code as a major research policy of public clouds since 2014. The reason for this is that NTT laboratories have added more than 100 of their own software patches to the community code in their development work, and NTT-modified code has been vastly different from the community version. This difference has made it extremely difficult to keep up with updates to the community version of the code. To provide public-cloud services using OpenStack code without internally incorporating our own patches, we will provide our patches to the community. If there are some patches that have not been incorporated into the community code, we will implement alternative functions in an external system managed outside of OpenStack (**Fig. 4**). This approach will make it easier to keep up with updates

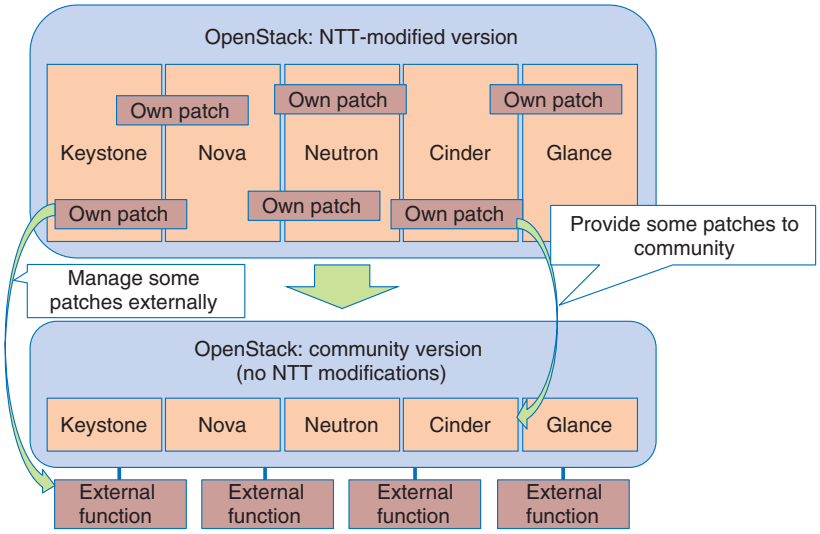


Fig. 4. Configuration using OpenStack community version.

within the OpenStack community.

3.2 Private-cloud efforts

NTT laboratories have been researching and developing public clouds and have been participating in the OpenStack community since the beginning. We regard research on public clouds to be an activity that is important for expanding the provision of the NTT Group's cloud services as a counter to Amazon Web Services (AWS)[*3]. However, we are conscious that the demand for private clouds is increasing rapidly. In researching public clouds, NTT laboratories have mainly been targeting clouds of medium scale or larger that are configured using at least several dozen appliances of various types. We plan to research private clouds that can be completely configured using OSS. We expect that the private clouds will be able to extend their own configurations to the needed scale from an initial small-scale configuration (**Fig. 5**).

3.3 Enhancing a company's entire IT infrastructure

NTT I^3 is engaged in a platform project called Elastic Service Infrastructure (ESI) to enhance the operation of a company's information technology (IT) infrastructure, including datacenters and enterprise WANs (wide area networks) [3]. The NTT Group's main business line for companies consists of virtual private network (VPN) products, hosting, managed IT, and network security, and ESI promotes the strategic evolution of these products and services into the cloud era.

We developed ESI because of the gap between the operational efficiency of the cloud and that of the current corporate IT infrastructure. The advances in cloud computing have substantially raised the efficiency of operating clusters of computers, but this has affected only a portion of the corporate IT infrastructure. A datacenter installed with computers includes network devices such as firewalls and load balancers, and the various bases of corporations connect to the datacenter over an enterprise WAN (VPN). However, the operation of these network devices and the enterprise WAN has been complicated and dependent on manual labor, thereby taking a lot of time and money.

The ESI makes the operation of datacenters and enterprise WANs efficient through cloud-based technologies such as virtualization and software operation. For example, the operation of network devices such as firewalls and load balancers can be made more efficient with a software controller that consolidates the management of those devices as virtual appliances. This approach is called network function virtualization (NFV)[*4] for enterprises.

An important factor in making this approach successful is the construction of an ecosystem consisting of many virtual appliance products and infrastructure-operation products for the virtualization era.

*3 AWS: The general name for cloud services provided by Amazon
*4 NFV: Technology for achieving the functions of network devices using software

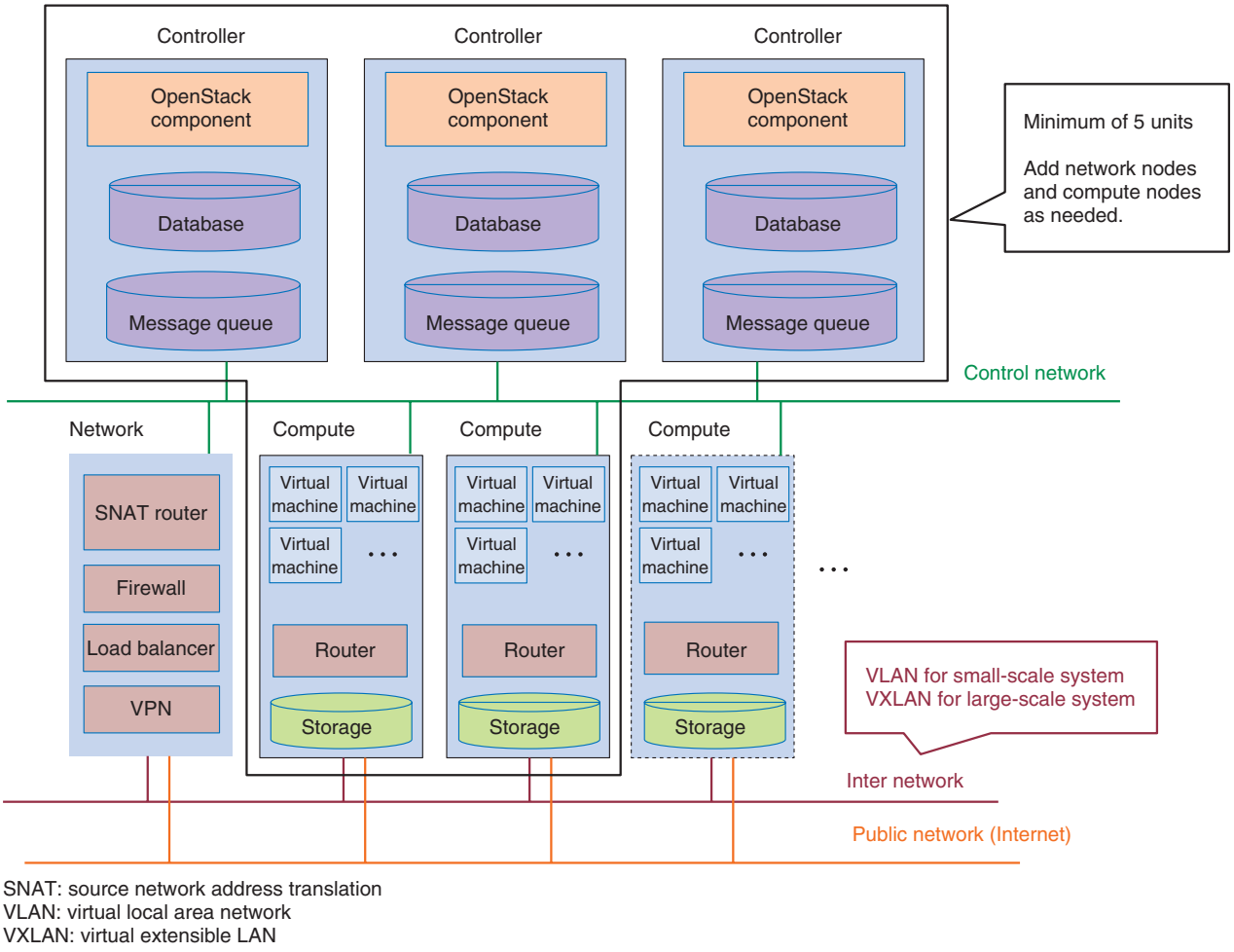


Fig. 5. Proposal for private-cloud configuration.

Therefore, OpenStack API (application programming interface)[*5] was adopted in the ESI project.

4. Community activities

Since 2010, directly after the founding of OpenStack, 21 developers across the entire NTT Group have been contributing to the OpenStack community. These contributions have included reviews of patches proposed to the community, the provision of bug patches to the community, and proposals for new functions.

The contributions that NTT laboratories have made to repair bugs and propose new functions are many and varied (**Fig. 6**). Many of these contributions have involved functions that were deemed necessary for the provision of commercial services by the NTT Group. However, such use cases associated with a single corporate group and approval of related proposals requires long discussions and much time to gain acceptance from the community. An important point is that many other companies have also proposed many patches to satisfy the use cases of their own services. Under these conditions, the shortest way for a company's own patches to be reviewed and approved by developers is to make many contributions to the community. It is important to gain the confidence of others and form new professional relationships by contributing high-quality reviews of patches proposed within the community and by providing patches that have value for the community. NTT laboratories are making more contributions and developing stronger relationships with the aim of improving our standing within the OpenStack

*5 API: Interface for using an application from the outside

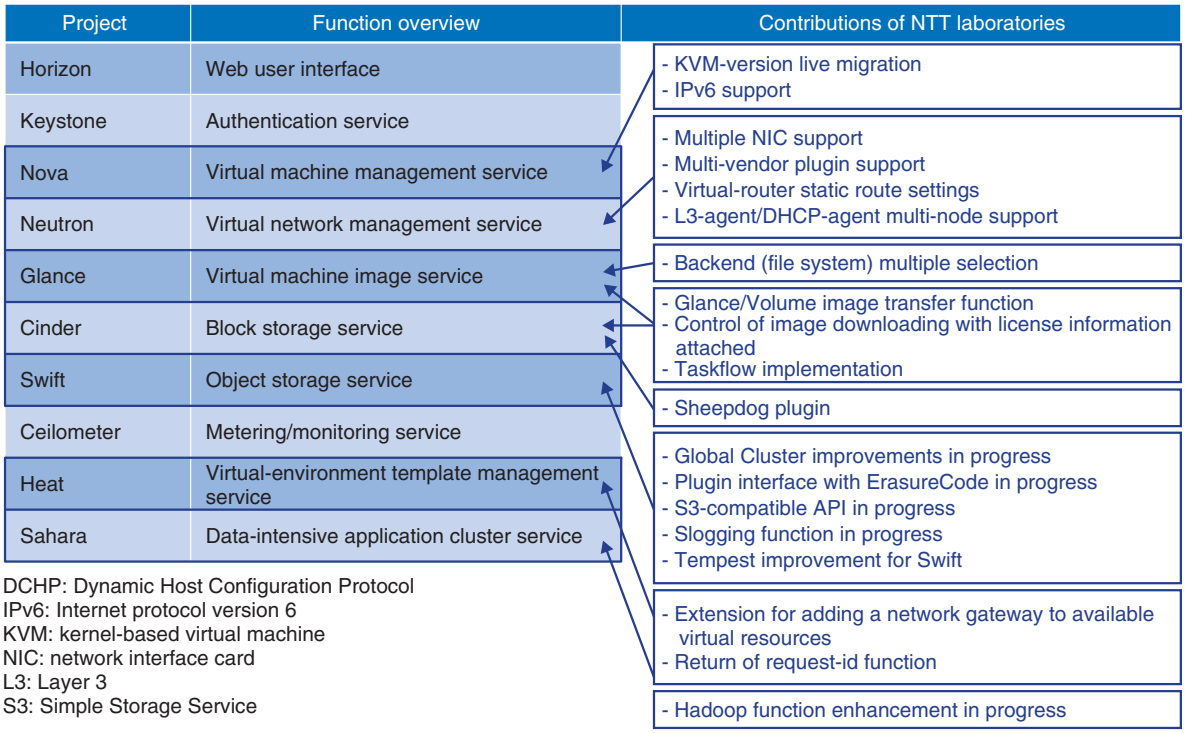


Fig. 6. Contributions to OpenStack community.

community.

5. Concluding remarks

The expansion of the OpenStack ecosystem has enabled cloud providers to provide cloud services with a variety of formats. As part of this ecosystem, NTT laboratories and NTT I^3 are continuing to develop services using OpenStack tailored to use cases and are endeavoring to make substantial contributions to the OpenStack community.

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R&D Efforts in Storage Virtualization Technologies

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Abstract

The NTT Software Innovation Center is active in the research and development (R&D) of storage virtualization technologies. This article introduces its R&D of Sheepdog, a distributed block storage system that can be used from any file system, and OpenStack Swift, a robust distributed object storage system featuring high operability.

Keywords: storage virtualization, distributed system, OSS

1. Introduction

Virtualization is finding widespread use as a technology to achieve flexibility and cost reductions in managing computer resources in a cloud infrastructure. Furthermore, *storage virtualization* technology can make multiple units of storage equipment appear as a single unit and make a single unit of storage appear as if it contains multiple units. It is an important technology that makes it easy to manage virtual machine images and to share application data.

This article introduces Sheepdog and OpenStack Swift, open-source storage virtualization technologies now under development at the NTT Software Innovation Center (SIC). The Sheepdog distributed block storage system is a type of storage that can be used as hard disk drives on personal computers (PCs) or servers via file systems. The OpenStack Swift distributed object storage system, meanwhile, is a type of storage that can read and write files using a REST (representational state transfer) API (application programming interface) and that enables large quantities of data to be stored and shared among applications.

2. Sheepdog distributed block storage system

PCs and servers have become a major part of our daily life. Files in a PC are read from and written to a hard disk via a file system. Here, the hard disk is treated as a type of block device that has the sole function of reading and writing data in block units of fixed size, and the file system has the task of writing and reading files by managing the locations of file data on the block device. Although there are various types of file systems, they all share this basic type of operation with respect to the block device. Block storage, meanwhile, is a type of storage that can provide block devices. It has the basic role of reading/writing and saving data and is considered to be the most versatile storage method.

Virtual block devices are essential in the operation of virtual machines. Therefore, in the construction of a virtual environment, the mainstream approach is to introduce shared storage appliances that can provide virtual block devices (virtual disks) of any size via the network. Shared storage can enhance the operability and reliability of a virtual environment through such virtualization functions as thin provisioning, storage snapshots, and live migration.

Sheepdog is open source software (OSS) that combines multiple commodity servers into a cluster (**Fig. 1**) in order to construct block storage that can be used in the same way as shared storage appliances. It can bundle the internal disks of the servers belonging to the cluster into a single storage pool, and it can provide virtual disks to users from the pool. Sheepdog

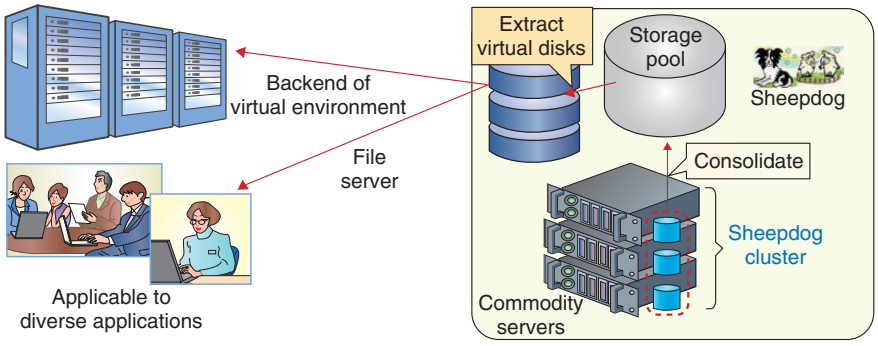


Fig. 1. Sheepdog overview.

can be used in virtualization infrastructure software such as OpenStack and QEMU/KVM (Quick EMUlator/Kernel-based Virtual Machine), and it supports the iSCSI (Internet Small Computer System Interface) general storage interface.

Various issues arise when using ordinary shared storage. These include scalability issues (prior design is needed for extending capacity and performance, degeneration is not possible in principle, and vendor lock-in can occur) and reliability issues (service interruptions, no access to some data because of hardware failures). Sheepdog has been designed to address these issues as a fully symmetric architecture in which the servers making up a cluster all have the same role. This gives Sheepdog three key features: (1) easy addition/removal of cluster servers, enabling flexible capacity scaling and load distribution in accordance with system scale beyond the capabilities of shared storage; (2) high reliability due to no single point of failure and the capability to avoid service interruptions and data loss even if some servers should fail; and (3) high manageability due to the automating of data rebalancing, redundancy restoration, and other processes when adding/removing servers, thereby reducing the number of necessary manual operations.

A virtual disk provided by Sheepdog is divided and multiplexed into objects of fixed size (initial size: 4 MB) that are then distributed among the servers making up the cluster, as shown in **Fig. 2(a)**. The consistent hashing algorithm that is used for determining where exactly to place these objects is depicted in **Fig. 2(b)**. In Sheepdog, a data structure called a *virtual node* is generated with respect to each server (physical node), and these virtual nodes are arranged along a ring in random order. In the process of writing data to a virtual disk, an object is generated or updated with respect to three physical nodes as the destination locations of that object. Specifically, based on the virtual node determined by the object ID, a second and third virtual node along the ring are selected, and the physical nodes corresponding to those virtual nodes are deemed to be that object's destination locations. In this way, Sheepdog can mathematically determine by consistent hashing where to place the data object. This enhances autonomy by eliminating the need for a centralized management server, thereby contributing to features (1) to (3) above.

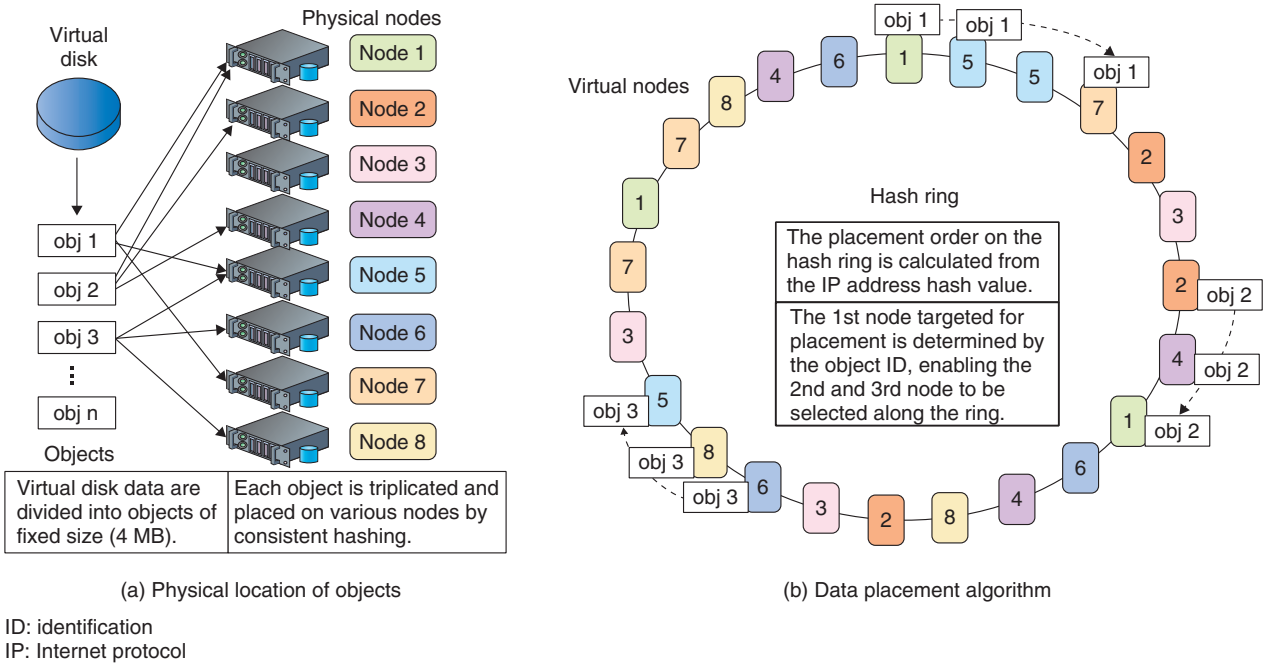
3. Recent activities

SIC is working to improve the operability and reliability of Sheepdog so that it can be used with confidence in commercial services.

Zookeeper, a de facto standard coordination kernel, can be used with Sheepdog to manage the addition and removal of servers belonging to the cluster. SIC has performed exhaustive tests and long-term stability tests on Sheepdog clusters combined with Zookeeper to uncover problems, and has proposed revisions to the Sheepdog community to solve any problems found and improve its quality.

SIC is also working to implement a multipath function that would enable the connection between a client and Sheepdog to be made with more than one server within the cluster to establish redundant paths for reading/writing. This function would enable reading/writing to continue with another server in the event that an existing connection between the client and server within the Sheepdog cluster were severed.

Furthermore, to prevent service disruption and data loss, SIC is developing a function for using a remote site in the event that an entire base fails due to a



(a) Physical location of objects

(b) Data placement algorithm

ID: identification
IP: Internet protocol

Fig. 2. Consistent hashing.

severe disaster or power outage.

The Sheepdog open source community has also implemented a function called *erasure coding*. Rather than simply replicating objects to prevent data loss, erasure coding is a technique that stores both divided data and parity data in the manner of RAID 5 (redundant array of independent disks, level 5). This function can reduce the consumption of disk space and minimize hardware costs.

4. OpenStack Swift, a distributed object storage system

It is now common for photographs taken with a particular smartphone and stored on the cloud to be made available for viewing by other terminals. As a result, the amount of data stored on the cloud has become massive, and the demand for low-cost, high-reliability cloud storage has been growing. To meet this need, the OpenStack community has developed object storage software called OpenStack Swift (referred to below as "Swift"). The NTT Group, Rackspace, and other enterprises have had commercial success with Swift.

Swift has three key features, as summarized below (**Fig. 3**).

(1) File operations by HTTP (REST API)

Data on Swift can be managed by any terminals including smartphones, tablets, and PCs through the use of HTTP (Hypertext Transfer Protocol). Swift is suitable for unstructured data such as backup, photos, and videos.

(2) High reliability

Losing data stored on a storage system is unacceptable. Swift generally creates three replicas of data in a cluster to achieve high reliability. Furthermore, a process called *replicator* regularly runs on each object-server node in the cluster to check whether the data saved on that disk are also stored on two other disks in the cluster. If it is determined that a disk has failed and has been unmounted, a new replica of data will be automatically reproduced.

(3) Scale out

Being a distributed autonomous system, Swift has no single point of failure and is capable of scaling out from a small cluster. A typical example of a Swift cluster configuration is shown in Fig. 3. In this example, the system consists of proxy nodes that receive requests from clients and storage nodes that actually store data. This results in highly extendible cluster architecture since proxy nodes can be added if

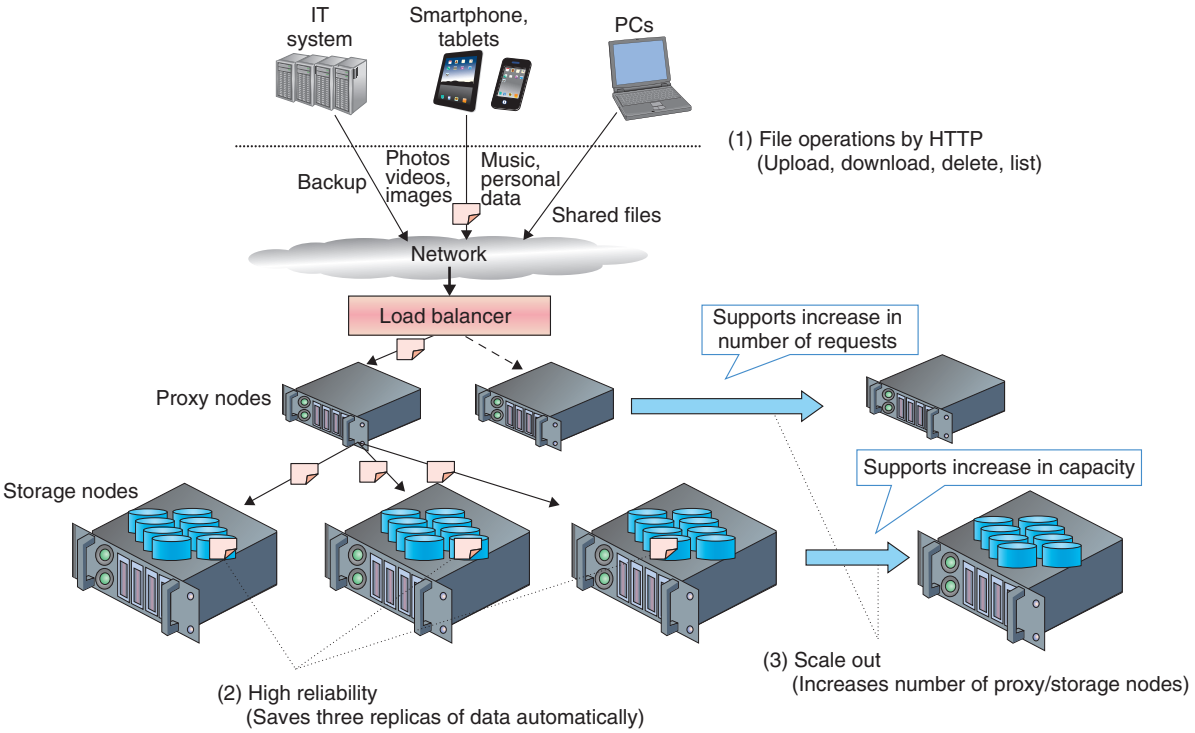


Fig. 3. Features of Swift.

requests become excessive, while storage nodes can be added if storage capacity becomes insufficient.

5. Improvement of Swift operability

SIC seeks to make Swift operation more efficient in order to facilitate the commercial cluster composed of distributed autonomous nodes and to provide services at low cost. To analyze the total operation time for a cluster with a total capacity of one petabyte, researchers at SIC constructed an actual PoC (proof of concept) environment and performed a quantitative evaluation of the time taken up by system configuring, system monitoring, equipment expansion (scale out), troubleshooting and recovery, and software updates. It was found that the time taken up by node addition for scale-out purposes as well as the time spent recovering from a disk failure made up a high percentage of the total operating time, so measures for improving in this regard were investigated.

To reduce the time needed to add nodes, it was decided to automatically install the OS (operating system) and applications using a Preboot Execution Environment (PXE) boot, to automate configuration settings using Chef, a configuration management tool, and to use Tempest, a tool for automating API testing in a pre-release operation check. Adopting these measures made a portion of the node scale-out procedure more efficient, reducing the time by about two-thirds compared to current values (**Fig. 4**). Tempest is a testing tool developed by the OpenStack community, but at SIC, researchers expanded the test items for Swift, which enabled efficient as well as complete testing.

The time from a disk failure to recovery must be minimized to ensure high data reliability. This study at SIC found that the S.M.A.R.T. (Self-Monitoring Analysis and Reporting Technology) system built into hard disk drives could be used to create a tool for automating the detection of a failed disk and for unmounting that disk (**Fig. 5**). This tool was estimated to reduce the time to recovery to one-fifth that of the manual procedure.

6. Future developments

Sheepdog is a fully symmetric distributed block storage system that provides high extendibility,

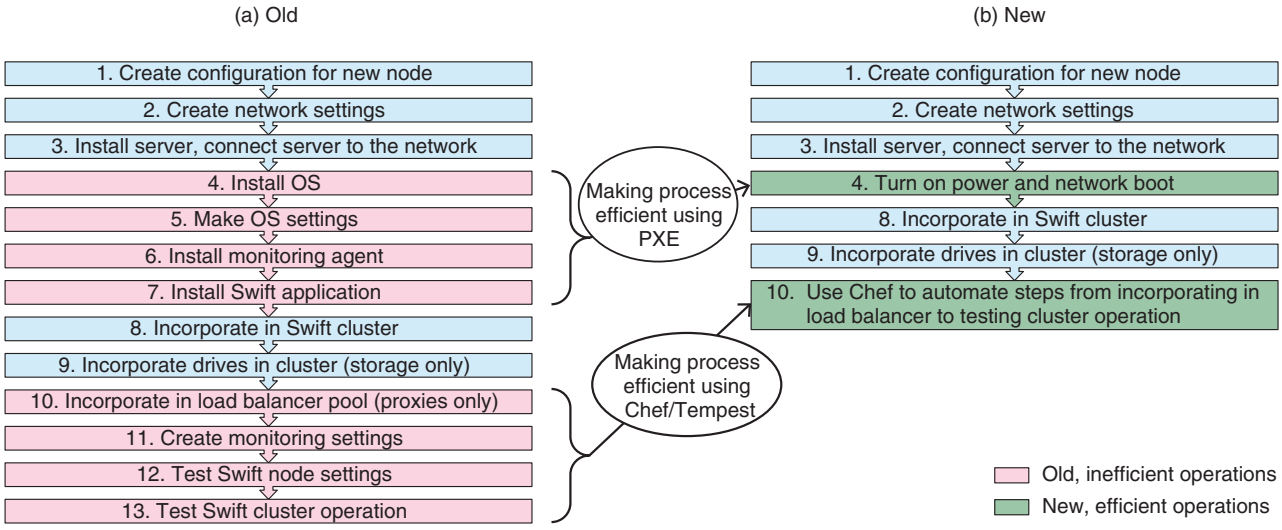


Fig. 4. Raising efficiency at time of node scale out.

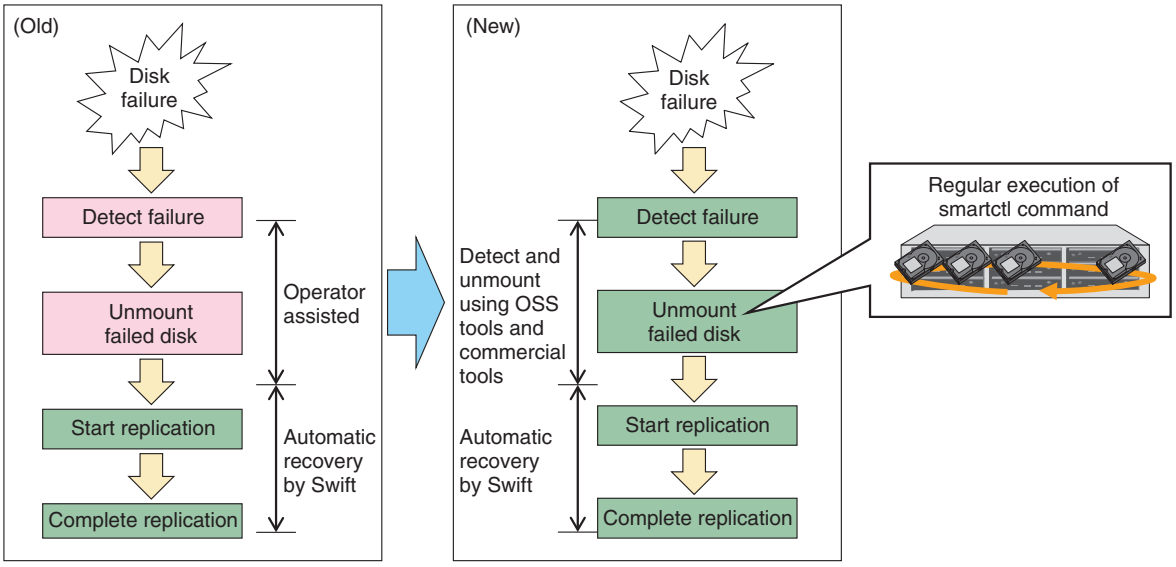


Fig. 5. Raising efficiency at time of disk failure.

reliability, and ease of operation. It is beginning to be introduced into actual services in Japan and in other countries. To help customers feel at ease about introducing Sheepdog in their operations, we plan to continue our efforts to improve quality and reliability while also sharing operating procedures and carrying out tests with users.

Swift is a highly reliable, scalable object storage system. We plan to further develop the operation automation with the operating efficiencies introduced here while also developing erasure coding (a function for raising disk usage efficiency while maintaining robustness), which is being studied as a new function in the Swift community.

Going forward, we plan to pursue quality improvements and function extensions in both Sheepdog and Swift together with major developers and users in those communities with the aim of improving stability, performance, and operability.

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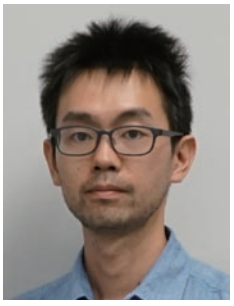

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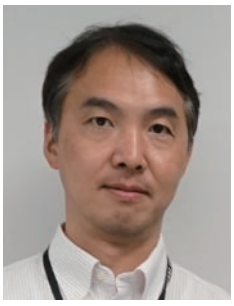

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Wireless Access Point Placement Design Support Tool for Small- and Medium-sized Offices

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Abstract

We have developed a tool that enables the simple design and construction of a wireless local area network (LAN) for small- and medium-sized offices of smaller enterprises. The tool has a function to simulate wireless propagation based on the configuration of the office floor, as well as a function to automatically calculate output strengths and channels from the environment deduced by signals from adjacent wireless access points. This makes it possible for people who are not wireless LAN experts to carry out the design and construction work. This is expected to shorten the work process from 12 hours to 3 hours compared with the previous design and construction process.

Keywords: wireless access point, wireless LAN design and construction, output strengths and channels

1. Introduction

In today's rapidly changing business environment, there is increasing need for wireless local area networks (LANs) that will enable access to important information instantly from anywhere within the office.

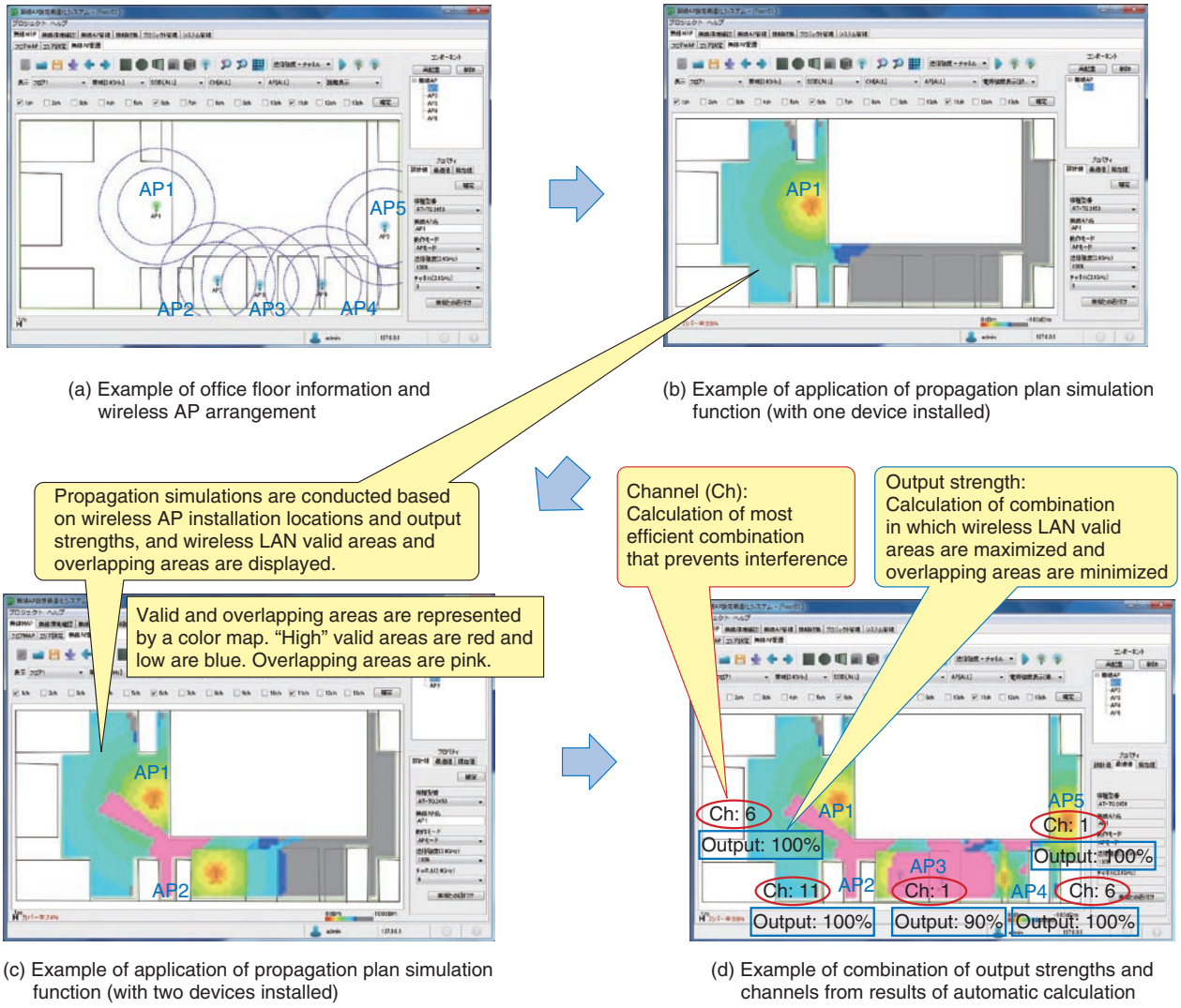
However, the job of designing and constructing a wireless LAN generally necessitates certain work such as a site survey*, which involves provisionally installing wireless access points (APs) temporarily on site and measuring the arrival status of radio waves, as well as planning and adjusting parameters (output strengths and channels). This requires the services of a costly technician with expertise in wireless LANs or the use of an expensive commercial design support tool. It has therefore been more difficult to propose the installation of wireless LANs to small and medium enterprises that have smaller offices than large enterprises.

2. Issues in previous wireless LAN design and construction work

In general, the job of designing and constructing a wireless LAN is done in the following sequence. The LAN designer does a first preliminary on-site examination to determine the office configuration, and then does a trial design of installation locations for the wireless APs after receiving the results. The designer then does a second preliminary on-site examination to conduct a site survey in order to measure whether or not radio waves are arriving within the area.

Next, because of concern that interference might be generated that would cause a drop in throughput if adjacent wireless APs use the same channel (frequency) [1], the designer designs appropriate parameters for the wireless APs that will be installed based on information obtained in the site survey. On the

* Site survey: A test in which wireless APs are brought into the office or other location and installed provisionally. Measurements are then done to check whether or not radio waves are arriving within the area. It involves large loads in terms of personnel and time.



(a) Example of office floor information and wireless AP arrangement

(b) Example of application of propagation plan simulation function (with one device installed)

(c) Example of application of propagation plan simulation function (with two devices installed)

(d) Example of combination of output strengths and channels from results of automatic calculation

Fig. 1. Examples of wireless AP placement design support tool functions.

basis of that design, the designer constructs and installs the wireless APs on site and performs connection trials and parameter adjustments.

This kind of work requires an expert technician who can design and construct the wireless LAN. Consequently, we initiated development of a tool that has a function to simulate a wireless AP propagation plan, which replaces the site survey, and a function to automatically calculate and set output strengths and channels from the signals of adjacent wireless APs, which replaces the design and on-site adjustment of parameters. The purpose of this tool is to enable even someone who is unfamiliar with wireless LANs to do the design and construction work simply and rapidly.

3. Propagation plan simulation function

The wireless AP propagation plan simulation function makes it possible to predict a general outline of the wireless environment by provisionally arranging a number of wireless APs onto previously acquired office floor information and doing a propagation simulation. An example of office floor information and wireless AP arrangement is shown in **Fig. 1(a)**, and an example application of this function is shown in **Figs. 1(b) and (c)**.

Use of this function makes it possible to make a provisional arrangement of wireless APs, then to determine how many wireless APs to install and the installation locations to ensure that the wireless LAN

Table 1. Results of comparing output strength and channel calculations with other companies' systems.

	Our tool		Company X's system		Company Y's system		Company Z's system	
	Channels	Output	Channels	Output	Channels	Output	Channels	Output
AP 1	6	100%	13	100%	11	100%	1	100%
AP 2	11	100%	6	100%	6	100%	6	100%
AP 3	1	90%	13	100%	1	70%	1	100%
AP 4	6	100%	6	100%	1	70%	6	100%
AP 5	1	100%	6	100%	1	70%	6	100%
Number of overlapping areas of wireless LAN	4		9		1		1	
Number of invalid areas of wireless LAN	35		64		72		82	

(Total number of survey areas is 261.)

Allocation of adjacent wireless APs to different channels

Narrowing of invalid areas (= expanding valid areas) while limiting overlapping areas

is effective on that office floor, by reviewing the results of testing that arrangement on a computer without performing a site survey. This enables a visualization of the wireless LAN environment that is scheduled for construction. The visualization enables customers to get an image of the wireless LAN to be constructed and an estimate of the cost of the wireless APs that will be needed. It can also be utilized as an exploratory tool for suggesting a more precise site survey.

4. Automatic output strength and channel calculation and setting function

We have also implemented a function that automatically calculates output strengths and channels from signals between a number of installed wireless APs and sets them for each wireless AP. This shortens the process of designing appropriate parameters and adjusting them on site.

In construction using this tool, the installation work is implemented at the arranged locations of a number of wireless APs that were decided in the computer review using the propagation plan simulation function, without doing any preliminary parameter design. This function deduces the actual wireless environment from the signals of the installed wireless APs and calculates a combination of appropriate parameters for the wireless APs. It sets the calculated parameters in the wireless APs, which completes the construction work.

For output strength, it rapidly calculates one combination from among the parameter combinations at which the valid floor areas of the wireless LANs are at a maximum and also the areas where several wireless LANs overlap are at a minimum. This function calculates the most efficient combination of channels that ensures that adjacent wireless APs use different channels, and it can prevent the generation of interference by using the network-controlled channel allocation scheme for IEEE 802.11 wireless LANs [2] developed by the NTT Access Network Service Systems Laboratories.

An example of a combination obtained by the results of the automatic output strength and channel calculations is shown in **Fig. 1(d)**.

5. Validity verification

We implemented a comparative evaluation between our tool and other companies' systems using five wireless APs each. We concentrated on the automatic output strength and channel calculation and setting function. As a result, we were able to verify that this tool's functions compare favorably with those of other companies' systems, since they ensure that the valid floor area of the wireless LAN is broad while limiting floor areas where two or more wireless LANs overlap, and ensuring that adjacent wireless APs do not occupy the same channel.

The results of comparing our system with other companies' systems under the same environment are listed in **Table 1**.

When we applied the processing capability of this tool to ten wireless APs, we found that the processing of the automatic output strength and channel calculation and setting function was run within 30 minutes. We anticipate that the use of our tool in the work of constructing a wireless LAN environment for ten wireless APs will reduce the time of 8.3 hours that corresponds to a site survey to 1.8 hours and the 3.3 hours that corresponds to the work of designing the parameters and adjusting the setup on site to 1.3 hours; thus, a process that would ordinarily take 12 hours overall can be shortened to 3 hours.

6. Future plans

This tool is designed so that it can expand the types of wireless APs that are covered. It can support users operating in various wireless LAN environments, and it also enables the visualization of wireless LAN environments, so it will therefore be useful in the future for improving maintenance and operability in addition to design and construction.

We can also expect that wireless LAN systems will become simpler to install and that their use in small- and medium-sized offices will increase by expanding the use of the tools reported here in the wireless LAN design and construction work departments.

This tool was initially provided as a tool to support the design and construction work of wireless LANs; we would like to see it used by more people to popularize it further.

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ITU-T SG16 Sapporo Meeting Report

Kiyoshi Tanaka, Shohei Matsuo, Hitoshi Ohmuro, and Seiichi Sakaya

Abstract

The International Telecommunication Union-Telecommunication Standardization Sector Study Group 16 (ITU-T SG16) met from June 30 to July 11, 2014 at the Sapporo Convention Center, Hokkaido, Japan. We report on the results of the SG16 Sapporo meeting and describe some side events held in conjunction with the meeting.

Keywords: ITU-T meeting, multimedia, IPTV, digital signage, accessibility, audio coding, video coding

1. SG16 meeting results

Study Group 16 (SG16) creates ITU-T (International Telecommunication Union-Telecommunication Standardization Sector) recommendations related to multimedia, which become international standards. It is composed of three Working Parties (WPs), which are further divided into Questions for study according to research themes (**Fig. 1**). The Sapporo meeting was the third meeting in the current study period (2013 to 2016), and was held with 232 participants from 24 countries at the Sapporo Convention Center (**Photo 1**). Great progress was made at the meeting, with 67 draft recommendations consented. We report on the state of deliberation for Questions to which NTT contributed below.

1.1 IPTV

Japan took a lead role in work done on recommendations for the basic Internet protocol television (IPTV) specifications, and this work has already been completed; thus, Question 13 regarding IPTV has recently been studying additional issues including smart TV such as services using multiple screens and multiple devices, and enhanced operation interfaces other than a remote control, for example, speech control, gestures, and touchscreens [1]. At this meeting, NTT also proposed a revised text with illustrations to gain a good understanding of the draft recommendation and a draft appendix explaining the use cases in order to facilitate the study of device discovery typically used in second-screen services. The technical paper HSTP.IPTV-Gloss [2], which listed terminology for IP-based TV-related multimedia services including smart TV, was also completed at this meeting and approved for publication.

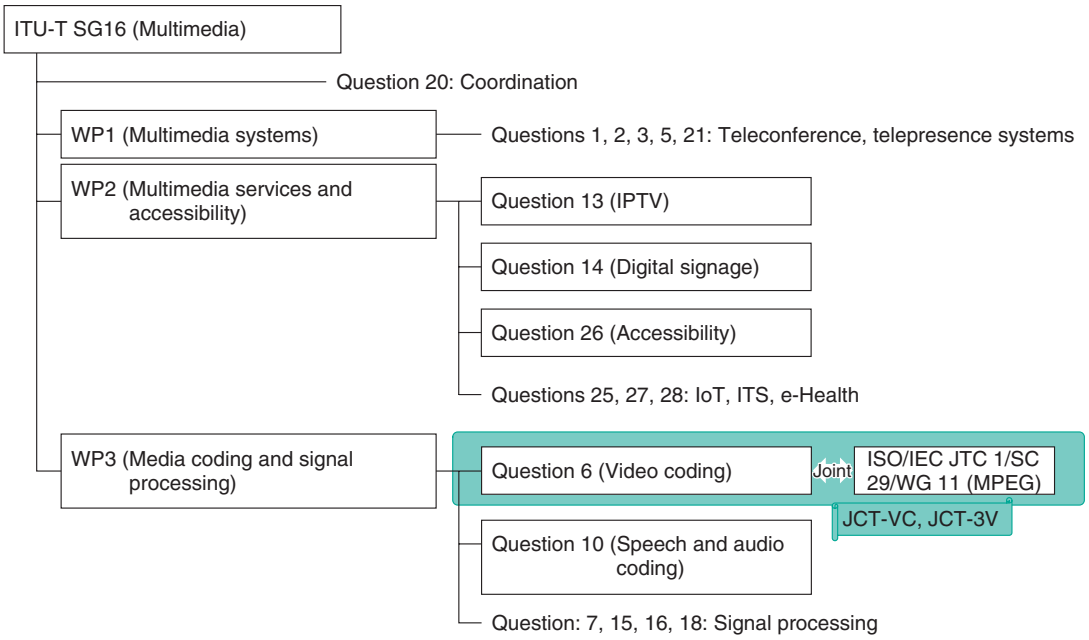
1.2 Digital signage

Digital signage is a new study item in ITU-T, and it was established as the new Question 14 starting with this study period. Recommendation H.780 [3], based on active Japanese contributions, was accepted in the previous study period. It is a basic recommendation for digital signage describing service requirements and IPTV-based architecture, and study on it is now advancing in the area of applied services. At this meeting, the draft recommendation for requirements of disaster information services, which Japanese companies led in proposing work items, was consented as Recommendation H.785.0 [4]. Moreover, approval of the technical paper HSTP.DS-UCIS [5] regarding use cases of interactive services was also achieved.

1.3 Accessibility

Accessibility[*1] of multimedia services and systems is examined in Question 26. In this meeting, NTT collaborated in proposing two contributions regarding systems enabling persons with hearing or speech disabilities to make emergency calls.

*1 Accessibility: The ability for anyone, including the elderly or disabled, to use a service or system without impediment.



IoT: Internet of things
IPTV: Internet protocol television
ISO/IEC: International Organization for Standardization/ International Electrotechnical Commission
ITS: intelligent transport system
JCT: Joint Collaborative Team
JTC: Joint Technical Committee
MPEG: Moving Picture Experts Group
SC: subcommittee
VC: video coding
WG: Working Group

Fig. 1. SG16 organization.

Photo 1. Venue at Sapporo Convention Center.

These proposals are based on the results of a study of emergency calling systems using mobile phones and smartphones for persons with hearing or speech disabilities done by the Emergency Call Accessibility Working Party (Em-Call WP) of the Telecommunication Technology Committee and lead by Emeritus Prof. Sadahiko Kano of Waseda University. The WP held discussions with participation from NTT and other telecommunications carriers as well as vendors and service providers related to emergency calling, the Fire and Disaster Management Agency, and organizations for the disabled. The contributions discussed here include specifications for information (data) required at the application layer and proposals for activities necessary to create recommendations.

As a result of discussion in this meeting, it was agreed to proceed with the creation of a new work item (H.ACC-RDE) based on these proposals so that study of detailed specifications can proceed.

1.4 Speech and audio coding

Question 10 involves the study of speech and audio coding. NTT has been working since 2007 on standardizing a 14-kHz bandwidth, super wideband (SWB) extension of the G.711.1 [6], 7-kHz bandwidth, wideband (WB) scalable audio coding, which is in turn, an extension of the 3.4-kHz bandwidth,

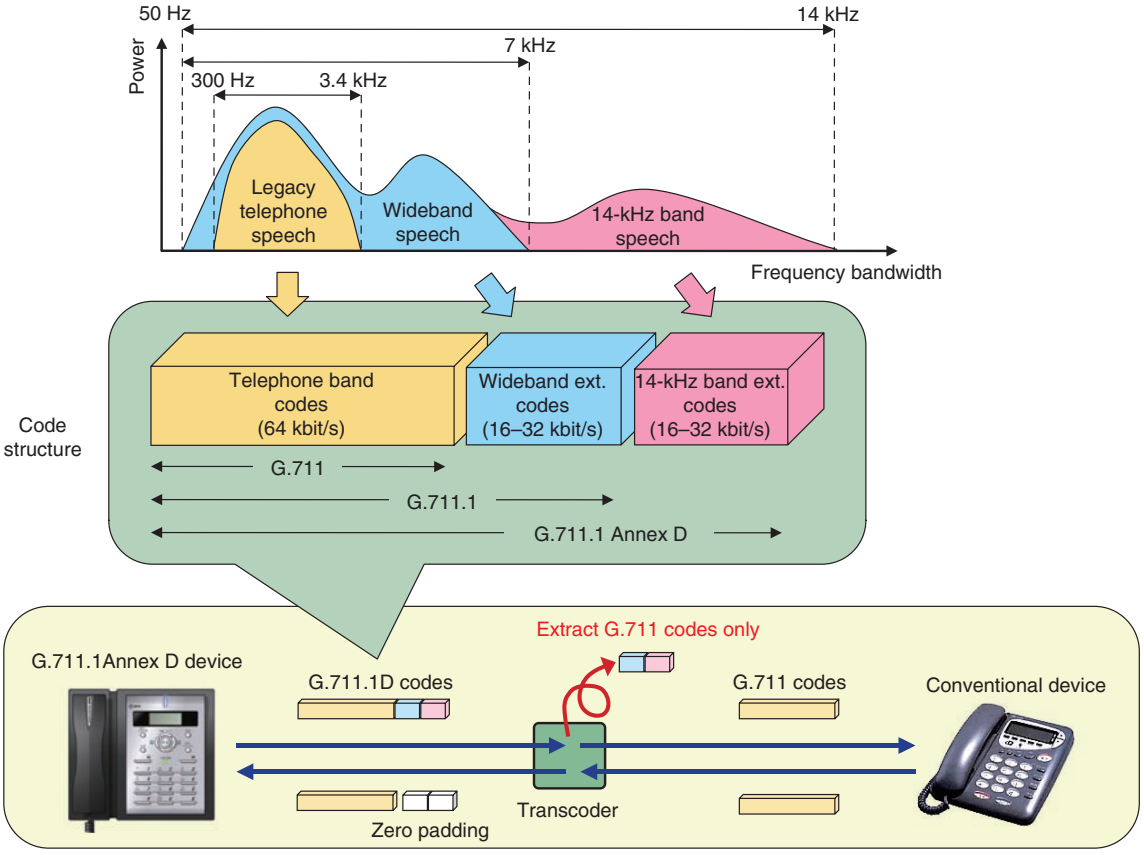


Fig. 2. Scalable bit-stream structure.

Table 1. G.711.1 extensions.

Time frame	Name	Coding details
November 2010	Annex D	14-kHz band extension coding (fixed-point implementation)
September 2012	Annex E	Alternative floating-point implementation to Annex D
September 2012	Annex F	14-kHz band stereo extension coding (fixed-point implementation)
Agreements of this meeting	Annex G	Alternative floating-point implementation to Annex F

G.711 codec used for legacy telephone speech signals. Scalable coding is based on transmission formats that add coded data (bandwidth extension codes) to data coded in an earlier format, in order to expand the audio bandwidth. The advantage of this is that it can interoperate with earlier formats without requiring re-encoding (**Fig. 2**). After the SWB extension was approved as G.711.1 Annex D in November 2010, standardization of a floating-point implementation (Annex E) and a stereo extension (Annex F) advanced (see **Table 1**). In the previous meeting, a new annex was drafted recommending an alternative floating-point implementation to Annex F, and in this meeting, NTT and Huawei Technologies contributed a report on results from an objective evaluation of interoperability between it and the fixed-point implementation. This was reviewed, and it was confirmed that there were no issues with interoperability, so it was agreed for consent. This recommendation is scheduled to be published as G.711.1 Annex G.

1.5 Video coding

The 18th meeting of the Joint Collaborative Team on Video Coding (JCT-VC), formed from the

Question 6 group studying video coding (VCEG) and the ISO/IEC JTC 1/SC 29/WG 11[*2] (also known as the Moving Picture Experts Group or MPEG) group, was held from June 30 to July 9, 2014. Approximately 140 people participated, and 340 contributions were input. Progress was made in deciding extended specifications for the next-generation High Efficiency Video Coding (HEVC), also called H.265 [7], and specifically, the final specification for SHVC, the scalable HEVC extension, was settled. Together with the RExt range-extension specification settled during the April meeting and the MV-HEVC extension for multi-view video settled during the July meeting, the three extension specifications will proceed to the voting stage as HEVC 2nd Edition.

The Screen Content Coding (SCC) extension draft specification for artificial imagery such as PC (personal computer) screen captures was also issued. SCC performance was improved through discussion on refinements of techniques such as efficiently copying block units of images and analyzing color map data and combining colors that appear frequently in order to compress images. Deliberation on SCC will continue at the October meeting and thereafter.

2. Invitation to Japan

On November 6, 2013, the Ministry of Internal Affairs and Communications formally invited ITU-T Director Malcolm Johnson to hold the SG16 meeting in Japan, and this was accepted at the SG16 Plenary Session on the 8th of the same month. A Japanese host committee was established from the sponsoring companies to run and administer the meeting smoothly. A working group was formed to do preparation work and offer on-site support. The NTT Group, as a platinum sponsor, also participated in these committees and supported the running of the meeting.

3. Side events

Various meetings and events were held in conjunction with the SG16 Sapporo meeting. The workshop and exhibition planned by the Japanese host committee are outlined in this section.

3.1 Workshop

A workshop on multimedia technologies was held as a local event in conjunction with the SG16 Sapporo meeting in the afternoon of July 1, 2014. This workshop was held in cooperation with the exhibition described below, and was planned by Japanese companies hosting the SG16 meeting. The workshop consisted of technical sessions, mainly to introduce technologies shown in the exhibition, and keynote sessions by the platinum sponsors. NTT's contribution included a keynote speech from Toshiaki Fujita, Senior Vice President of the NTT Service Innovation Laboratory Group (**Photo 2**), and a technical session on the roadmap for UHDTV (ultrahigh-definition television) services including 8K and H.265/HEVC encoder technology.

Photo 2. Mr. Toshiaki Fujita giving the keynote speech at the workshop.

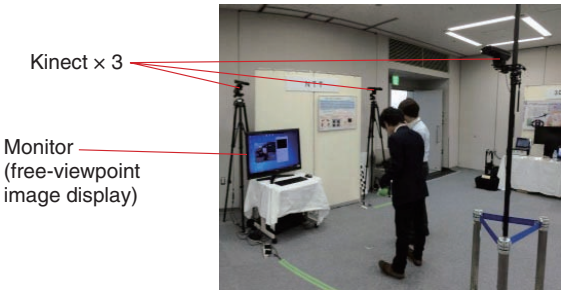
Professor Junichi (Jay) Kishigami from Muroran Institute of Technology, and a senior advisor at NTT, gave an invited speech entitled "Beyond the Content Distribution and Its Technology," in which he discussed the similarities between ITU-T metadata Recommendations F.750 [8] and H.750 [9], the recent importance of metadata, and future directions related to metadata.

Of the 81 participants in the workshop, 56 also participated in the SG16 meeting and the JCT-VC meeting held on the same day.

3.2 Exhibition

An exhibition with the theme of showcasing cutting-edge multimedia technologies was held from July 1 to 4 in order to broadly promote technologies both under study and already standardized. NTT provided two demonstration exhibits entitled "Depth-based Free-viewpoint TV" and "Reliable 4K H.265/HEVC

*2 ISO: International Organization for Standardization, IEC: International Engineering Consortium, JTC: Joint Technical Committee, SC: Subcommittee, WG: Working Group



(a) Depth-based free-viewpoint TV

(b) Reliable 4K H.265/HEVC real-time transmission using MMT-FEC

Fig. 3. Exhibits.

Real-time Transmission by Using MMT-FEC (MPEG media transport forward error correction)" (**Fig. 3**).

The former is a technology for synthesizing free-viewpoint video in real time from multi-point video and a depth map captured using multiple cameras and a depth sensor. Original synthesis technology enables synthesized display of free-viewpoint video from sparse depth data containing sensor noise in real time, without depth defects.

The latter is a robust transmission technology using 4K video HEVC real-time hardware processing technology and MPEG media transport (MMT). 4K video is partitioned into quarters, encoded with four hardware encoders, and transmitted as a highly robust stream using a very robust low-density generator matrix coding provided by NTT.

We received comments from many visitors. Yoko Kamikawa, Vice-Minister of Internal Affairs and Communications (at the time) visited the former exhibit and asked when the technology would be ready for practical use, and noted that it was interesting that the video could be viewed from a position where there was no camera. The latter was recognized for its ability to process 4K video in real time (by the chairman of JCT-VC and other session participants), while others expressed their desire for 8K video support. Each day, many domestic and international participants in the sessions, related technologists, and members of government and the press visited the exhibits, making them a phenomenal success.

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Recent Case Studies of Packet Capture and Analysis —Use of Captured-data Analysis Support Tool—

Abstract

This article introduces case studies involving packet capture and analysis using a support tool. This is the twenty-seventh of a bimonthly series on the theme of practical field information on telecommunication technologies. This month's contribution is from the Network Interface Engineering Group, Technical Assistance and Support Center, Maintenance and Service Operations Department, Network Business Headquarters, NTT EAST.

Keywords: IP-related faults, packet capture, captured-data analysis support tool

1. Introduction

The volume of Internet protocol (IP)-related data communications has been increasing thanks to the recent proliferation and increasing sophistication of IP broadband access services typified by NTT's FLET'S HIKARI NEXT and the rise of social network services and other novel services. The functionality of routers and terminals installed in homes has consequently been advancing, but this has been accompanied by increasingly complicated IP faults. As a result, there has been an increasing number of cases in which the conventional approach of dealing with a fault by simply replacing faulty equipment has not been effective. In response to this situation, techniques for identifying the causes of such faults have been promoted. These techniques obtain (capture) a large volume of packets transmitted between IP devices through the use of our gigabit-compatible protocol checker [1] or a similar tool and analyze the state and content of communications.

However, with popular software for packet analysis such as Wireshark, the operations needed to identify the packets that are causing the fault from a large volume of captured data can be quite complicated and extremely time-consuming. Maintenance personnel must also learn how to use such analysis methods, which means that the analysis results can depend greatly on the maintenance personnel's individual skills.

To address these problems, we have developed and begun using a captured-data analysis support tool equipped with functions for supporting batch input and analysis of a large volume of captured data so that the causes of complicated IP faults can be quickly uncovered. We describe here some recent case studies of packet capture and analysis using this tool.

2. Overview of captured-data analysis support tool

The captured-data analysis support tool consists of software that inputs data captured in the pcap/pcapng packet-capture format and displays the results of analyzing that data. This tool has an analysis section and a display section with a total of five functions, as shown in **Fig. 1**.

(1) Captured-data analysis function

This function analyzes captured data and is the core

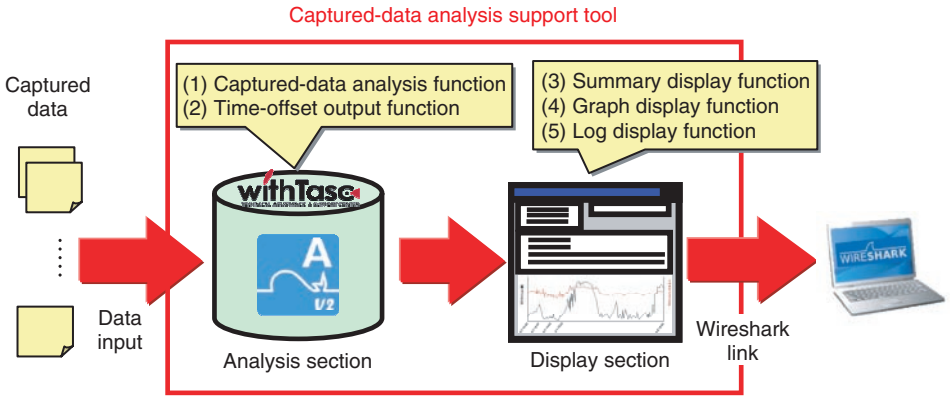

Fig. 1. Configuration of captured-data analysis support tool.

Table 1. Types of summary information.

Hikari-Denwa/050IP-phone information	General information (number of calls, completed calls, uncompleted calls, etc.), call-specific information (call begin/end times, originating/destination phone numbers, packet loss, jitter), etc.
Hikari-TV information	Start/termination times, viewed channel, packet loss, etc.
Internet access information (DNS/HTTP)	Start time, response time, IP address, domain name, download speed (HTTP only), etc.
Video site information	IP address, port number, viewed uniform resource locator (URL), file size, download speed, etc.
TCP information	Session start/end times, IP address, maximum segment size (MSS) value, protocol type (Secure Sockets Layer (SSL), HTTP, etc.), number of TCP errors, response time, etc.
MAC-address/IP-address information	MAC-address/IP-address correspondence table
UPnP information	Universal Plug and Play (UPnP) table inferred from communications (internal IP address/port, external IP address/port)

DNS: domain name system
HTTP: hypertext transfer protocol
MAC: media access control
TCP: transport control protocol
TV: television

of this software. It is capable of analyzing several gigabytes of data divided into multiple files all together.

The display section presents the results of this analysis using the summary display function ((3) in Fig. 1), graph display function (4), and log display function (5). Maintenance personnel can re-examine analysis results for certain data without having to perform the analysis again by simply inputting that data into the display section.

(2) Time-offset output function

This function changes the timestamp given to each captured packet. This is a useful function if the user wishes to correct the timestamps of captured data whose times are offset from the actual time.

(3) Summary display function

This function displays the results of analysis performed by the captured-data analysis function. It can display various types of service- and protocol-related information as listed in **Table 1**. Each type of summary

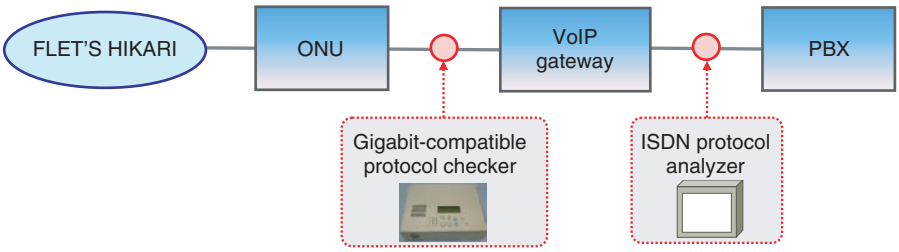

Fig. 2. Configuration of inspection method.

information can be subjected to full-text searches, making it easy to display a portion of the analysis results that are of interest to the maintenance personnel and to check individual packets in unison with Wireshark.

(4) Graph display function

This function can display multiple time series simultaneously. Specifically, it can simultaneously compare multiple time series such as the number of simultaneous IP phone calls, the estimated number of network address and port translation (NAPT) tables, and traffic volume, which is not possible with other types of software such as Wireshark.

(5) Log display function

This function prepares logs from information in communication packets recorded in routers and other communication devices and displays those logs. It can display that information in classes; for example, log data that may indicate the cause of a fault can be labeled as a *warning*, and other data that reflect the process flow needed for analysis can be labeled simply as *information*.

3. Case studies of using the captured-data analysis support tool to identify faults

3.1 Call is suddenly disconnected in IP phone service

3.1.1 Fault description

A customer using an IP phone service at a call center reported that calls would suddenly be disconnected several times a day during peak calling periods. The problem persisted despite replacing the VoIP (voice over IP) gateway.

3.1.2 Inspection method

We installed the gigabit-compatible protocol checker between the ONU (optical network unit) and the VoIP gateway to collect data on call-control and voice packets and installed an ISDN (integrated services digital network) protocol analyzer between the VoIP gateway and the PBX (private branch exchange) to collect data on call control (**Fig. 2**).

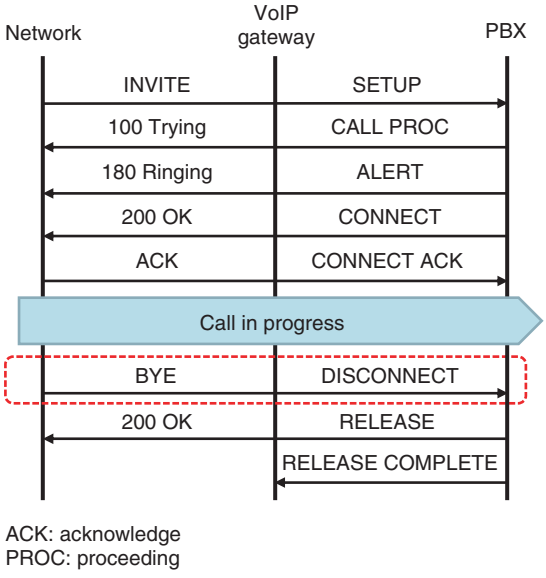

Fig. 3. Call control sequence.

3.1.3 Inspection results

A check of the call control sequence at the time of a cutoff event indicated that the call had been disconnected in a normal manner from the network side (**Fig. 3**). It was also found on checking voice packets (RTP/RTCP: real-time transport protocol/real-time transport control protocol) that the VoIP gateway had transmitted no RTCP packets several tens of seconds before the normal disconnection.

3.1.4 Cause of fault

On the basis of the inspection results described in 3.1.3 above and the customer's report stating that the

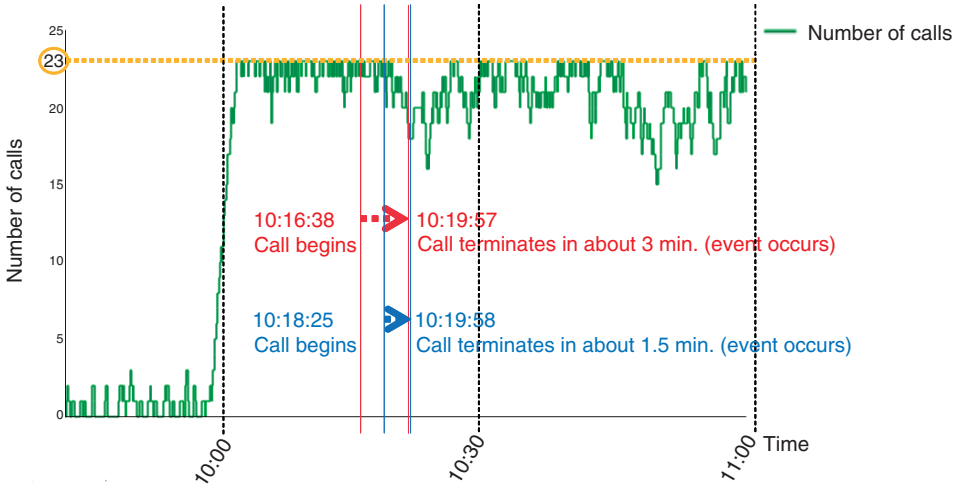

Fig. 4. Calling conditions revealed by captured-data analysis support tool.

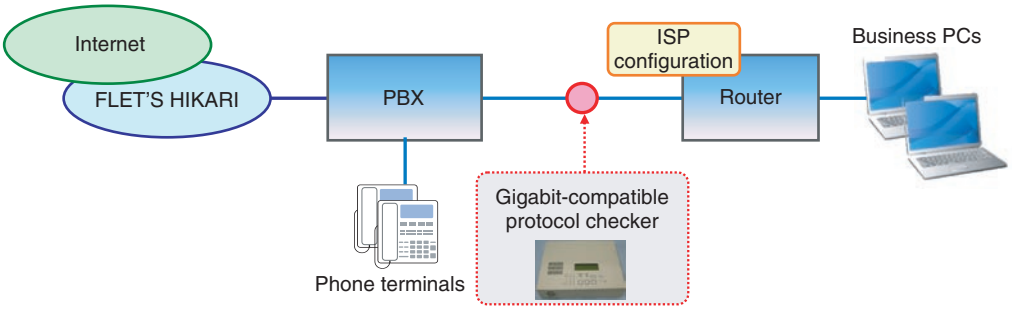

Fig. 5. Configuration of inspection method.

event would occur during peak calling periods, we checked calling conditions using the captured-data analysis support tool (**Fig. 4**) and found that the event would typically occur when the number of calls had risen dramatically, which occurred just after 10:00 AM. We therefore considered the possibility that the non-transmission of RTCP packets from the VoIP gateway was related in some way to the large number of calls.

3.1.5 Countermeasure and effect

We shared this information with the developer of this VoIP gateway, which proposed as a countermeasure that the gateway equipment be replaced with its most recent version that had higher performance. The problem disappeared upon doing so.

3.2 Internet is disconnected

3.2.1 Fault description

A customer reported experiencing trouble connecting to the Internet once or twice a week when starting work in the morning but said that the problem would disappear on its own in about ten minutes. The customer was also a subscriber to an IP phone service that functioned normally at the time of this event.

3.2.2 Inspection method

We installed the gigabit-compatible protocol checker between the PBX and router and captured data for a one-week period (**Fig. 5**).

3.2.3 Inspection results

We analyzed the data captured in this way using the Cascade Pilot software developed by Riverbed Technology and found that the router was attempting to

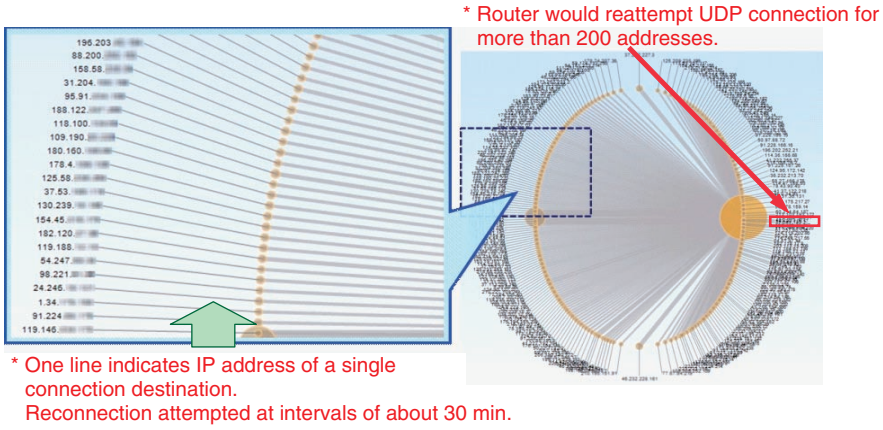

Fig. 6. UDP connection destinations shown by Cascade Pilot.

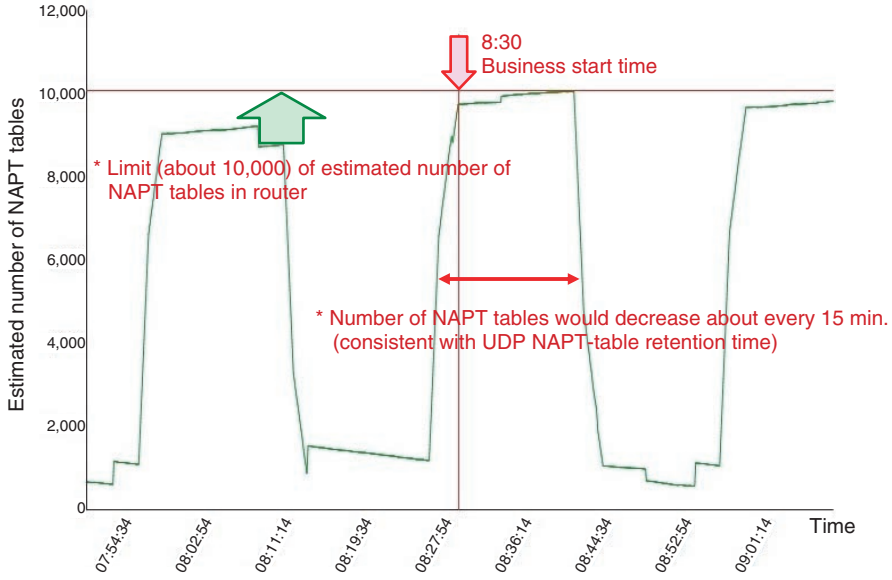

Fig. 7. Estimated number of NAPT tables revealed by captured-data analysis support tool.

make UDP (user datagram protocol) connections for more than 200 IP addresses and was performing unauthorized-access actions (**Fig. 6**). We also checked the number of estimated NAPT tables using the captured-data analysis support tool and found that the number of connections would approach the 10,000 limit of the router about every 15 minutes (**Fig. 7**).

3.2.4 Cause of fault

We speculated that the router's NAPT tables were becoming depleted through unauthorized access from the router's LAN (local area network) side, and that the Internet was inaccessible by computers connected at that time.

3.2.5 Countermeasure and effect

Because we captured data on the WAN (wide area network) side of the router in this inspection, we were not able to isolate the terminal that was generating such a large amount of data traffic. Maintenance personnel explained the analysis results to the customer and requested that any business PCs that were infected by a virus be removed from the LAN. The customer complied with the request, and the fault subsequently disappeared.

4. Conclusion

This article presented recent case studies of packet capture and data analysis using our captured-data analysis support tool. Going forward, the Technical Assistance and Support Center is committed to identifying the causes of faults through packet capture using a variety of tools and to contribute to the early resolution of increasingly complicated IP-related faults.

Reference

[1] "Gigabit-compatible Protocol Checker," NTT Technical Review, Vol. 10, No. 7, July 2012.
https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201207fa3.html

External Awards

RIEC Award
Winner: Haruki Sanada, NTT Basic Research Laboratories
Date: November 28, 2014
Organization: Research Institute of Electrical Communication (RIEC)

For "Electron spin resonance using spin-orbit interaction."

2015 OSA Fellow Member
Winner: William J. Munro, NTT Basic Research Laboratories
Date: December 4, 2014
Organization: Optical Society of America (OSA)

For "Research in quantum optics and quantum information processing."

William J. Munro was elected in the newest class of OSA Fellow Members with the citation saying "for achievements in optics and photonics. He is a key bridge in the optical quantum information field between academia and industry."

SDN/Cloud Program Competition 2014 Special Award
Winner: Tomoya Hibi, NTT Network Innovation Laboratories; Hirofumi Ichihara and Hiroki Kumazaki, NTT Software Innovation Center
Date: December 9, 2014
Organization: Okinawa Open Laboratory

For "Gondola cloud orchestrator."

Papers Published in Technical Journals and Conference Proceedings

High-capacity Scalable Optical Communication for Future Optical Transport Network
Y. Miyamoto
Proc. of the 2014 IEEE International Solid-State Circuits Conference (ISSCC), pp. 118–119, San Francisco, CA, USA, February 2014.

The impact and future scaling of digital signal processing (DSP) on high-capacity optical transport networks are investigated. The developed 100 Gbit/s DSP ASIC (application specific integrated circuit) was recently introduced in a commercial network, where the digital coherent transmission system with the ASIC realized a capacity more than 8 Tbit/s/fiber. The future progress in key DSP areas is discussed toward 1 Pbit/s/fiber capacity in combination with space division multiplexing in an optical transport system.

Petabit/s Transmission Using Multicore Fibers
A. Sano, H. Takara, T. Kobayashi, and Y. Miyamoto
Proc. of the 2014 Optical Fiber Communications Conference and Exposition (OFC), Tu2J. 1, pp. 1–3, San Francisco, CA, USA, March 2014.

Recent developments in high capacity transmission technologies based on multicore fiber (MCF) are reviewed. Propagation-direction interleaving with dual-ring structure 12-core MCF is promising for suppressing inter-core crosstalk and enables spectrally efficient long-haul transmission.

Crosstalk-managed High Capacity Long Haul Multicore Fiber Transmission with Propagation-direction Interleaving
A. Sano, H. Takara, T. Kobayashi, and Y. Miyamoto
IEEE Journal of Lightwave Technology, Vol. 32, No. 16, pp. 2771–2779, April 2014.

This paper describes ultra-high capacity long haul optical transmission technologies based on multicore fibers (MCFs) with space-division multiplexing. First, we discuss the factors limiting the total capacity and the attainable distance of MCF and show that the transmission distances are severely limited by crosstalk (XT) between adjacent cores. Next, we discuss a propagation-direction interleaving (PDI) technique to suppress XT. In PDI, adjacent cores have different propagation directions, and thus, bidirectional transmission is realized by a single MCF. We discuss spectral efficiency and attainable distance of several MCFs and show that threefold reach extension is possible by using PDI in 12-core fiber with a dual-ring structure (DRS). We also describe a long haul transmission experiment on a 12-core DRS fiber with PDI.

Large Capacity Transmission Systems Using Multi-core Fibers
A. Sano, H. Takara, and Y. Miyamoto
Proc. of the OptoElectronics and Communication Conference (OECC), Melbourne, VIC, Australia, July 2014.

This paper describes large capacity long haul transmission technologies based on multi-core fibers. Twelve-core fibers with a dual-ring structure and propagation-direction interleaving are promising in suppressing crosstalk penalty. A large capacity transmission experiment using these techniques is reviewed.

An Overlay-based Data Mining Architecture Tolerant to Physical Network Disruptions

K. Suto, H. Nishiyama, N. Kato, K. Mizutani, O. Akashi, and A. Takahara

IEEE Transactions on Emerging Topics in Computing (TETC), Vol. 2, No. 3, pp. 292–301, September 2014.

This paper proposes an overlay network construction scheme based on node location in a physical network, and a distributed task allocation scheme using overlay network technology. The numerical analysis indicates that the proposed schemes considerably outperform the conventional schemes in terms of service availability against physical network disruption.

Optical Network Optimization Considering Maintenance Cost Related to Operational Expenditures

T. Oda, A. Kadohata, A. Watanabe, and A. Hirano

Proc. of the 40th European Conference on Optical Communications (ECOC 2014), pp. 1–3, Cannes, France, September 2014.

We propose a highly reliable optical network architecture which optimizes the total cost considering maintenance-related operational expenditure (OPEX). Numerical evaluations show that the proposed architecture achieves a lower total cost compared to the conventional one with 1+1 protection.

Maximum Likelihood Demodulators and Their Evaluations on Amplify-and-forward Cooperative OFDM-based Wireless LAN Systems

H. Fukuzono, Y. Asai, R. Kudo, K. Ishihara, and M. Mizoguchi

IEICE Transactions on Communications, Vol. E97-B, No. 11, pp. 2435–2448, November 2014.

In this paper, we propose demodulators for the Alamouti codes in amplify-and-forward (AF) cooperative communication with one relay. The proposed demodulators output exact log likelihood ratios with recursion based on the Jacobian logarithm. The cooperative system with the proposed demodulators offers 1.9 times larger areas in a typical office environment.

Multi-core Multi-mode Dense Space Division Multiplexing for Ultra-high Spectral Efficiency Transmission Systems

T. Mizuno, H. Takara, A. Sano, and Y. Miyamoto

Proc. of Asia Communications and Photonics Conference (ACP) 2014, AFiF. 3, Shanghai, China, November 2014.

This paper describes our recent work on dense space division multiplexing (DSDM) over a multi-core few-mode fiber. We show that using both multi-core and multi-mode is an effective approach towards ultra-high capacity transmission systems.

Advanced Progress in IEEE 802.11 WLAN Standardization

Y. Asai

Proc. of the 2014 Asia-Pacific Microwave Conference (APMC 2014), pp. 911–913, Sendai, Miyagi, Japan, November 2014.

This paper describes recent wireless local area network (WLAN) standardization activities and their specifications. First, the technical overview of the latest "very high throughput" WLAN standard, 802.11ac is introduced. To achieve more than 1 G bit/s of the system throughput, the physical layer parameters are extended for a peer-to-peer bit rate increase. In addition, a downlink (DL) multiuser (MU-) MIMO (multiple-input and multiple-output) technique is supported for more efficient usage of spatial resources. Then, the future forecast of the next generation WLAN standard is presented. The task group (TG) ax in the 802.11 working group was formed in May 2014 and is now working to create the post-802.11ac standard. The most crucial problem that TGax addresses is poor throughput performance of the current WLAN systems in congested environments.

Computational Power of Quantum Circuits with a Small Number of Steps

Y. Takahashi

The Journal of the Institute of Electronics, Information and Communication Engineers, Vol. 97, No. 12, pp. 1110–1114, December 2014.

One of the main problems in realizing quantum computers is that the states of qubits, which represent the status of computation, change into unintended ones in a short time. This prevents us from implementing quantum algorithms correctly. In this paper, we describe techniques that address the problem.

Virtual Scent: Obscuring User Location without Compromising Privacy and Accuracy

H. Sato, T. Inoue, H. Iwamoto, and K. Koyanagi

Journal of Japan Society for Fuzzy Theory and Intelligent Informatics, Vol. 26, No. 5, pp. 820–829, December 2014.

With the spread of mobile devices with positioning systems such as GPS, user locations can be obtained in real time with great accuracy. However, this real-time and accurate location information allows malicious people to identify users in the real space, which causes serious loss of anonymity. Though users can be anonymized by adding noise to their location, the quality of location services would also be degraded. This paper proposes Virtual Scent, which is a novel method to visualize user locations without compromising *k*-anonymity or accuracy. Virtual Scent shows its users as ambiguous *scents* on a map, which can anonymize them. Though each scent has noise in its location, they are positioned so as to be mixed up at a most likely location. We evaluated Virtual Scent with through simulation and experiments, which revealed its accuracy and practicality. This paper is the first work to quantitatively discuss the location accuracy for user anonymity.

Efficient *K*-nearest Neighbor Graph Construction Using MapReduce for Large-scale Data Sets

T. Warashina, K. Aoyama, H. Sawada, and T. Hattori

IEICE Transactions on Information and Systems, Vol. E97-D, No. 12, pp. 3142–3154, December 2014.

This paper presents an efficient method using Hadoop MapReduce for constructing a *K*-nearest neighbor graph (*K*-NNG) from a large-

scale data set. *K*-NNG has been utilized as a data structure for data analysis techniques in various applications. If we are to apply the techniques to a large-scale data set, it is desirable that we develop an efficient *K*-NNG construction method. We focus on *NN-Descent*, which is a recently proposed method that efficiently constructs an approximate *K*-NNG. *NN-Descent* is implemented on a shared-memory system with OpenMP-based parallelization, and its extension for the Hadoop MapReduce framework is implied for a larger data set such that the shared-memory system is difficult to deal with. However, a simple extension for the Hadoop MapReduce framework is impractical since it requires extremely high system performance because of the high memory consumption and the low data transmission efficiency of MapReduce jobs. The proposed method relaxes the requirement by improving the MapReduce jobs, which employs an appropriate key-value pair format and an efficient sampling strategy. Experiments on large-scale data sets demonstrate that the proposed method both works efficiently and is scalable in terms of a data size, the number of machine nodes, and the graph structural parameter *K*.

Simpler Exact Leader Election via Quantum Reduction

H. Kobayashi, K. Matsumoto, and S. Tani

Chicago Journal of Theoretical Computer Science, 2014, Article 10, pp. 1–31, December 2014.

This paper presents a new quantum leader election algorithm that is based on quantum reduction via exact amplitude amplification to a classically solvable problem, computing a certain symmetric function, which provides more intuitive reasoning behind the existence of exact quantum algorithms for leader election. The algorithm first achieves a round complexity that is linear in the number of parties, i.e., the largest possible diameter plus one of the underlying graphs of the network.

Leveraging Dependency Relations and Sentence Examples in Web-scale Corpus for Open-domain Utterance Generation

H. Sugiyama, T. Meguro, R. Higashinaka, and Y. Minami

Transactions of the Japanese Society for Artificial Intelligence, Vol. 30, No. 1, pp. 183–194, January 2015.

The development of open-domain conversational systems is difficult since user utterances are too flexible for such systems to respond properly. To address this flexibility, previous research on conversational systems has selected system utterances from web articles based on word-level similarity with user utterances; however, the generated utterances, which originally appeared in different contexts from the conversation, are likely to contain irrelevant information with respect to the input user utterance. To leverage the variety of web corpora in order to respond to the flexibility and suppress the irrelevant information simultaneously, we propose an approach that generates system utterances with two strongly related phrase pairs: one that composes the user utterance and another that has a dependency relation to the former. Our experiments showed that our proposed approach significantly outperformed other retrieval and rule-based approaches.
