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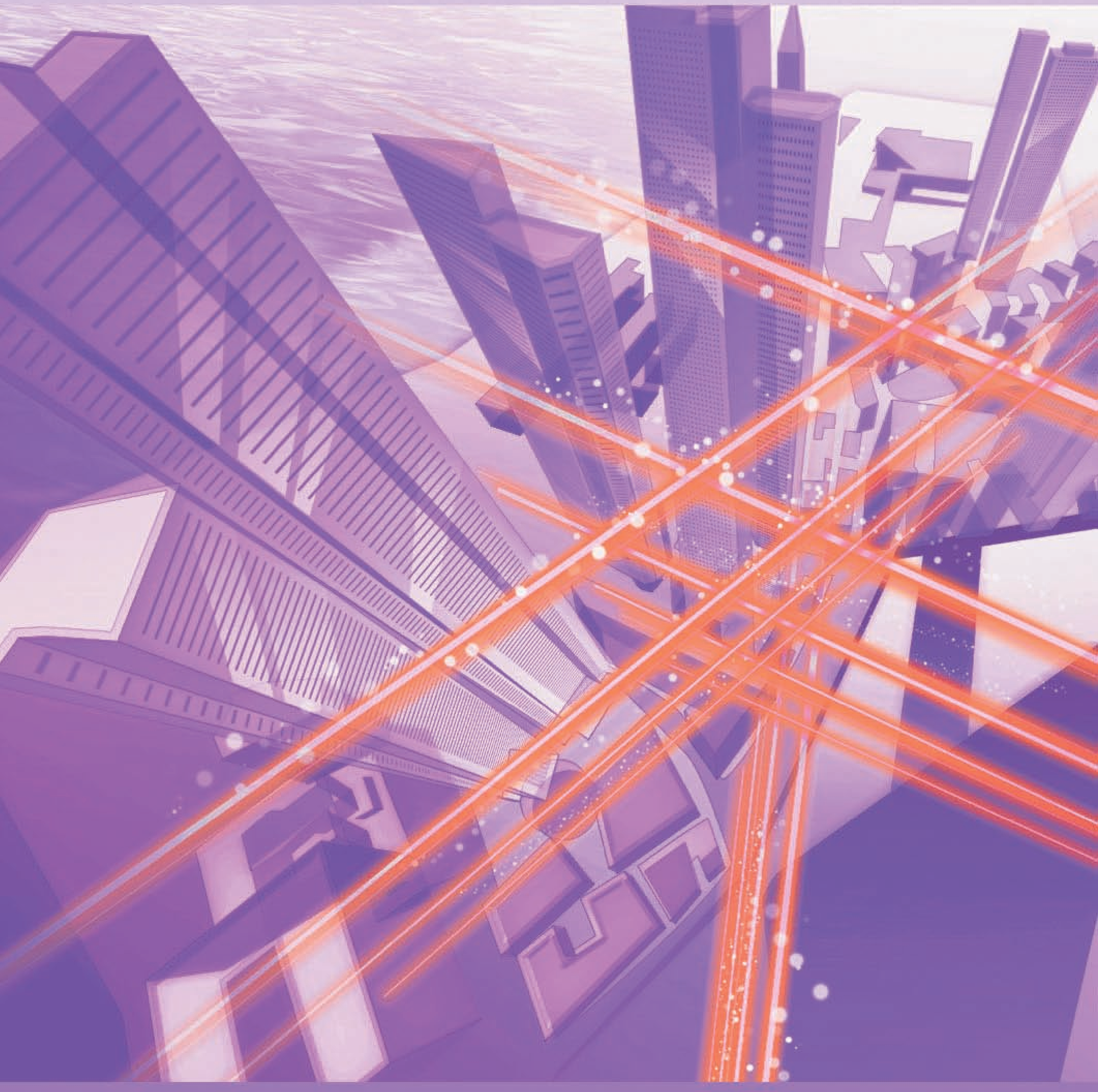

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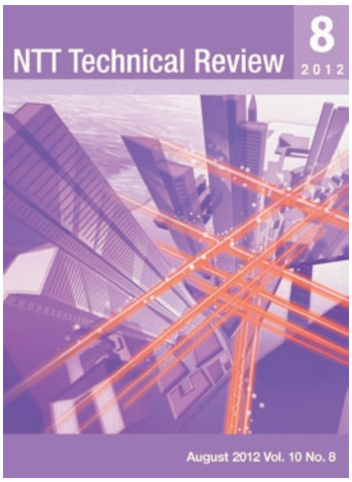

Flexible Networking Technologies for Future Networks

Atsushi Hiramatsu† *and Ryutaro Kawamura*

Abstract

In recent years, many researchers around the world have been tackling the Future Network, which should supplant the current Next Generation Network (NGN) and the Internet. This article issue describes some examples of research activities on flexible networking in NTT's laboratories; these examples have been selected because they involve important issues with future networks. Flexible networking aims to meet the changes in users' demands, permit easy development of new services, and reduce the capital and operating expenditure costs of existing services.

1. Introduction

In the last decade, the continuous stream of innovations in networking technologies, such as optical, wireless, the Internet, and the Next Generation Network (NGN), has had a huge impact on us and has significantly enhanced social value in combination with information-processing technologies. As a result, the purposes for which networks are being used have become diversified, and networks have become one of the key social infrastructures.

Based on the evolution of networking and information technologies, many studies on the design of the next-generation network, which they call the Future Network, New Generation Network, or Future Internet, have started. This includes the Network of the Future and Internet of Things (IoT) projects in FP7/EU, FIA (Future Internet Architecture) projects funded by the National Science Foundation (NSF) in the USA, and next-generation network research centered on the NWGN (New Generation Network Promotion) Forum Japan.

2. Key changes in network environments

When we attempt to create a new network concept, one of the important viewpoints must be the changes in the environment-hosting networks. This year is the 50th anniversary of the birth of the Internet. Over that period, the situation surrounding networks has dramatically changed. The main changes are listed in **Table 1**.

For example, the main purpose of network users has changed from peer-to-peer connection between two sites to data access to obtain information. The diversity of appliances, such as smartphones and tablets, is increasing rapidly, so the IoT and M2M (machine-to-machine) world will emerge in the near future. From the viewpoint of network traffic, data traffic from/to mobile appliances is increasing very quickly. Moreover, the energy consumed by information and communications technology (ICT) equipment is becoming a major problem. This problem is especially important for NTT because the massive earthquake in 2011 triggered serious energy shortages.

3. Four key flexibilities

Since networks are a social infrastructure, stability has been one of the most important requirements for them. However, to this we must add the ability to respond to the abovementioned changes. We think that *flexibility* is another key goal when developing future networks. Flexibility is enabled by virtualizing the networking and computing resources, such as bandwidth, routing functions, servers, and storage, and combining them dynamically in order to create new services, balance loads, recover from failures, and so on. Our proposed flexible networking

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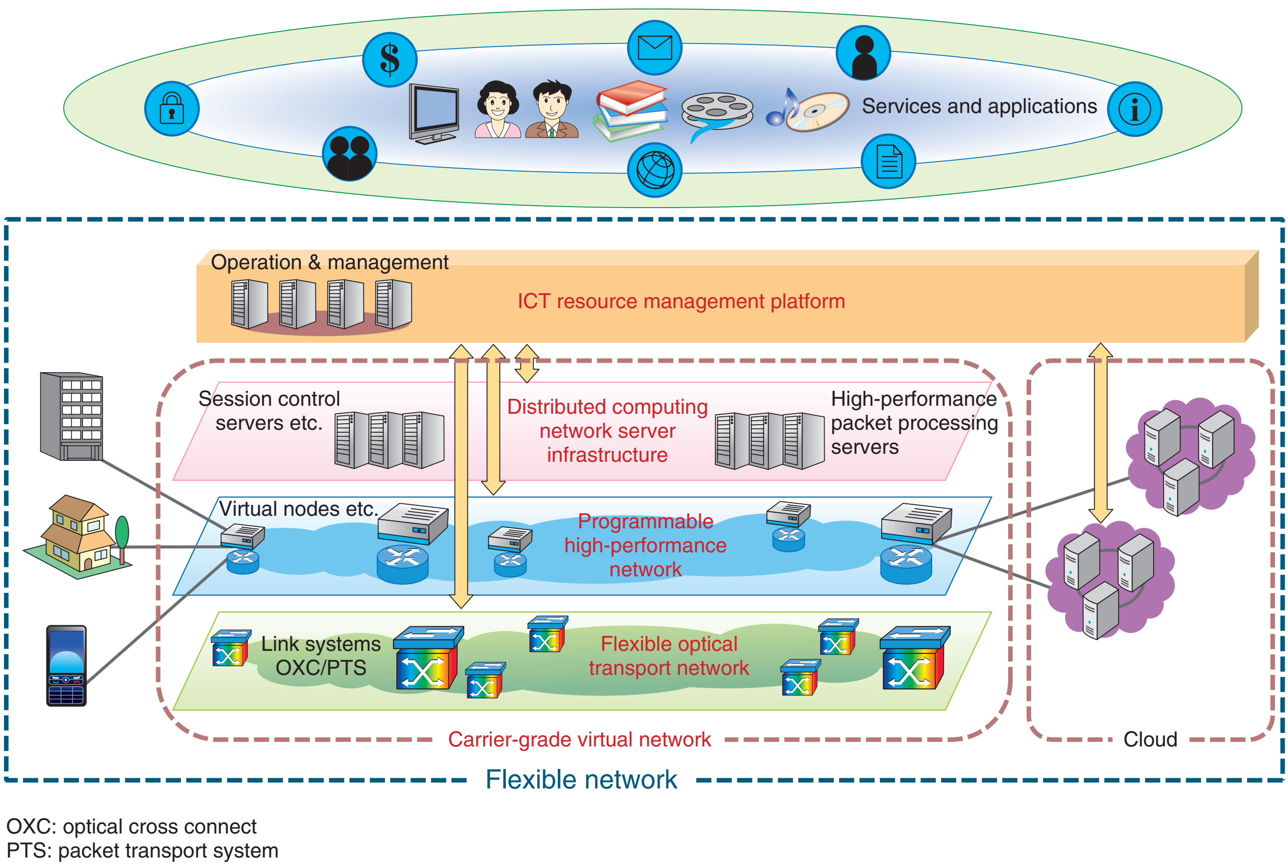
Table 1. Key changes in networking environment.

1. Traffic generated by information access is overwhelming 1-to-1 communication traffic.
2. Variety of appliances and sensors (IoT and M2M)
3. Explosive growth in mobile traffic
4. Problem of power consumed by network equipment
5. Requirements for recovery from disasters and large-scale failures



OXC: optical cross connect
PTS: packet transport system

Fig. 1. Flexible networking architecture.

architecture has four layers providing four types of flexibility (**Fig. 1**). These layers are outlined below and described in more detail in the other Feature Articles in this issue.

The lowest layer holds the flexible optical transport network [1]. This layer virtualizes the resources of the physical network layer and provides them to the higher layers. The network in this layer can dynamically change its topology and bandwidth to suit traffic changes, disasters, and so on.

The second layer is the programmable high-performance network [2], [3]. This is a virtualized network layer that uses the resources provided by the layer below. The virtual nodes include computing resources and combine them with network resources. A virtual node can be altered by software in order to implement new network functions, e.g., protocols.

The third layer is the distributed computing network server infrastructure [4]. This layer provides service functions such as the SIP (session initiation protocol) server in the NGN. The servers are distributed over the virtual networks and collaborate with each other to provide cloud computing. As such, this architecture can dynamically alter the server resources to meet changes such as the adoption of new services and a rapid change in service traffic due to a disaster. Moreover, some data-handling functions such as high-performance packet processing could be performed utilizing this architecture.

These three network layers aim to virtualize and abstract the resources in each layer. Of course, some of them are used together with existing network systems, but the architecture works well when all layers collaborate to combine the various resources available.

The top layer, the ICT resource management platform [2], serves the role of an orchestrator of network resources. This layer also coordinates with computing (information technology (IT)) resources in the cloud. As a result, the Flexible Network accelerates the creation of new network services in combination with IT resources.

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Flexible Virtualized Optical Transport Networking Technology

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Abstract

Network and computing resource sharing technology, such as network virtualization and cloud computing, is becoming more important for further reductions in capital and operating expenditures or further improvement in availability. We are researching a flexible mechanism for partitioning optical transport network resources and dynamically allocating them to diversified services or applications with isolated controllability. This article introduces the basic concept and research status of flexible virtualized transport networking technology, which enables service and application layers to control the network topology or path bandwidths in response to environmental changes such as disasters or unexpected traffic fluctuations.

1. Introduction

As communication services tend to become more diversified and require more bandwidth, the amount of traffic and its variation in time and space are increasing continuously. The amount of traffic that the carrier networks receive from Internet access services, video-on-demand services, and datacenter clouds has reached 100 Gbit/s per point of interface and may fluctuate enormously depending on social conditions or human behavior. Meanwhile carrier networks are required to be more sustainable against large-scale network failures or disasters because they act as lifelines; in other words, they must have a mechanism for rapidly recovering by reconfiguring residual resources in the event of large-scale failures as well as a hitless protection scheme against small failures or system maintenance. So future networks should handle unexpected traffic fluctuations or failures. One of the key schemes for this purpose is network resource virtualization, which shares network resources among multiple services or users and flexibly allocates them in the event of environmental changes. As for computing resources, flexible resource sharing and control technologies, such as server virtualization and cloud computing, have already been developed. Now flexible resource sharing and dynamic control schemes, including the optical transport or packet forwarding layer, are expected for the purpose of rapid adaptation to huge traffic fluctuations or disasters. This article introduces basic concepts and technical issues of the flexible, virtualized transport networking technology that NTT Network Service Systems Laboratories is researching.

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2. Technology trends for flexible network resource operation

Carrier service networks are generally composed of multilayer network resources, as shown in **Fig. 1**, such as the optical transport layer (fibers and cross connects (XCs), which may be optical XCs (OXCs), time division multiplexing (TDM) XCs, or multiprotocol label switching transport profile (MPLS-TP) XCs), the address or flow-based routing layer (Internet protocol (IP) routers, flow routers, and Ethernet switches), the session control layer (computing resources), and the application cloud layer (also computing resources). Each user session goes through the resources from the optical transport layer to the session control layer and finally reaches the application

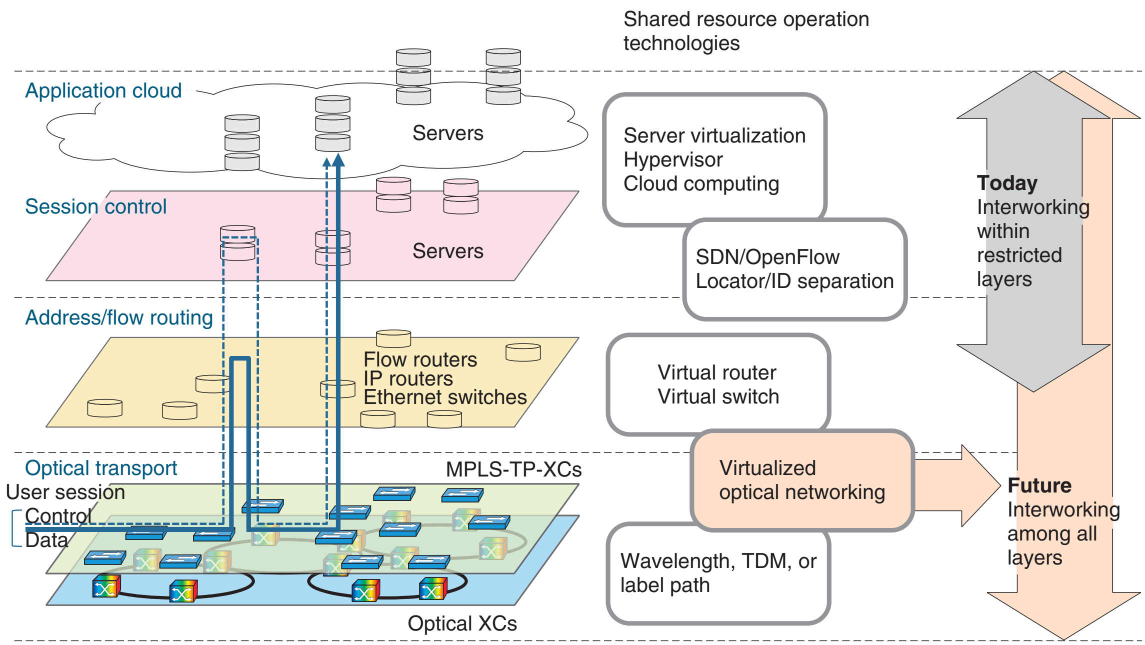

Fig. 1. Overview of virtualization technologies.

cloud in the case of server-client applications. In many cases, the resources of each layer are operated independently on the basis of the resource operator's policy, and multiple upper-layer resource operators utilize different elements of common lower-layer resources, or an upper-layer resource operator integrates multiple lower-layer resources managed by different resource operators. When the scale of traffic fluctuation or assumed failure is relatively small, it is sufficient for each operator to increase or decrease its own resources according to its long-term traffic forecast and request and get fixed-sized resources statically from the lower layer resource operators.

To handle large environmental changes, however, dynamic resource reallocation or exchange within each layer and coordinated resource control across multiple layers will be necessary. Network virtualization can be understood as a technology that enhances the controllability or operational flexibility of those multilayer common resources. Recently, many technologies related to network virtualization have been proposed or developed. Their basic functions can be categorized into three groups.

(1) Physical resource partition, isolation, and flexible allocation: server virtualization, hypervisor, virtual router/switch, virtual path/channel, and wavelength/timeslot path
(2) Simple unified operation for diversified resource elements: cloud computing [1] and virtual chassis
(3) Flexible, coordinated control for logically defined resources: software defined network (SDN) [2] and locator/identifier separation (LISP).

Network virtualization integrates these three functional aspects for the purpose of resource utilization efficiency promotion, simplified network design and operation, rapid new service delivery, and enhanced network service sustainability and availability.

ITU-T SG13 (International Telecommunication Union, Telecommunication Standardization Sector, Study Group 13) has discussed basic concepts for future networks since 2009. It regards network virtualization as the most important issue and has standardized a basic framework recommendation ITU-T Y.3011 [3].

An overview of current virtualization technologies in terms of network layers is shown in Fig. 1. (1) Partitioning technologies and (2) unified-operation technologies in each network layer are being improved continuously. Recently, studies of integrated operation of various layer resources and cross-layer networking have increased. Some examples are SDN, OpenStack, or OpenFlow, where applications or computing resources control packet switching functions actively and operate multilayer resources

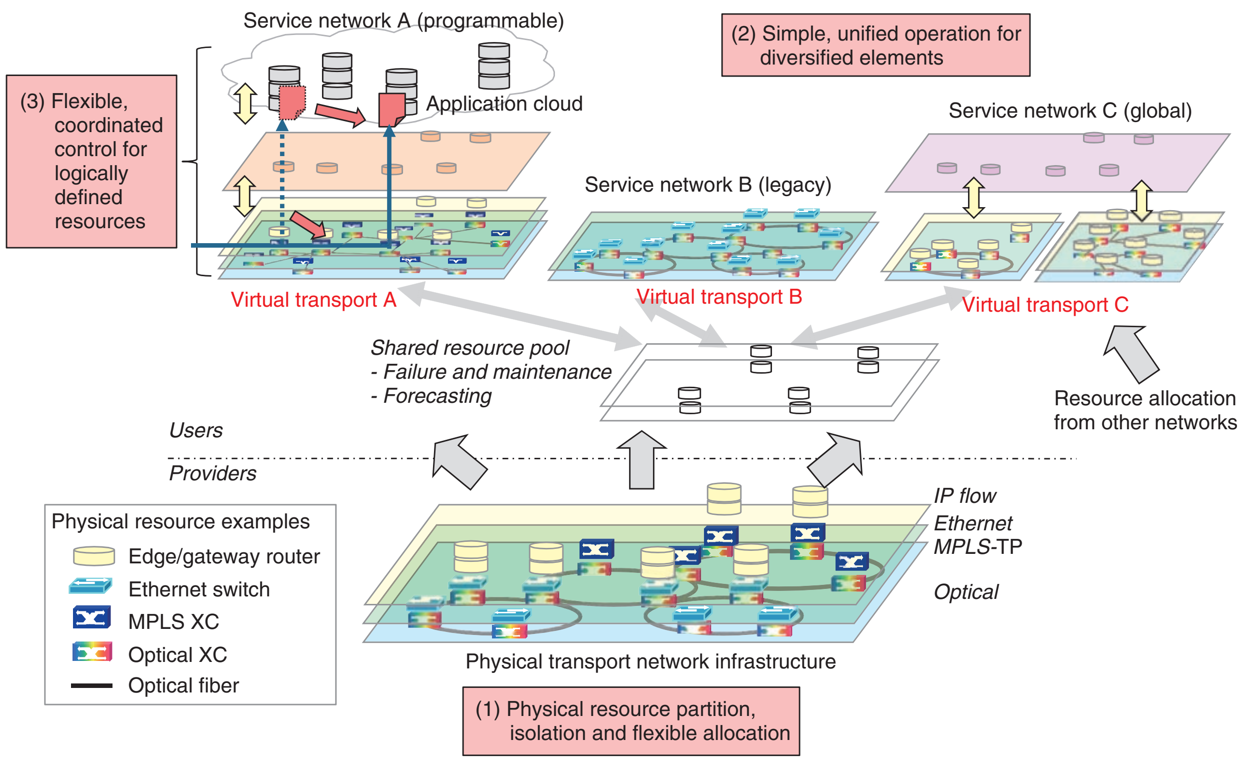

Fig. 2. Basic concept of virtualized transport networking.

flexibly. But current proposals are restricted to controlling traffic locally within datacenters or between datacenter locations. When software migration between datacenters causes a large variation in traffic amount or when the amount of traffic exceeds the thresholds in some core network parts, then wider cross-layer networking, such as dynamic reallocation of transport layer resources or rapid rerouting in the IP/Ethernet networking layer, is necessary for network service sustainability.

Therefore, future networks must be able to handle unexpected traffic variation, disasters, or rapid service creation by using cross-layer network resource control. One of the key schemes is to make overall network resources into a resource pool shared by multiple users and to optimize the amount of resources allocated to each user flexibly according to environmental changes, so that each user reconfigures its own network to retain optimal connectivity or service quality. It is also important for the lower-layer resources to provide controllability or programmability for the service or application layers, which integrate and control all of the allocated resources according to their unified operation policies. SDN concepts should be extended in terms of overall network layer interworking.

3. Flexible, virtualized transport networking

3.1 Fundamental concepts

To date, the optical transport infrastructure has had little relationship with IP routers, Ethernet switches, and computing resources. The former (the infrastructure) sets up and provides each wavelength path or MPLS path to the latter (routers, switches, and computing resources), from which service networks are formed. In the future, the former is expected to provide a virtual transport network comprising a logical system and logical link resources to the latter, and the latter are expected to control the transport network according to their own schemes for flexible adaptation to environmental changes. The basic concepts of flexible, virtualized transport networking [4] are shown in **Fig. 2**. Fibers, wavelengths, network systems, and related control functions are logically partitioned to generate a shared resource pool commonly available to users, and they are allocated to users as virtual transport resources. Each user integrates the virtual transport resources with its own resources and operates the overall service network according to its own networking policies and schemes. This dynamic, optimized resource allocation via the shared resource pool enhances the following network performance attributes.

- sustainability against unexpected traffic fluctuations or large-scale network failures
- rapid delivery of new advanced services
- cost reduction by optimization of the overall resource deployment including standby or forecast resources
- enhanced availability through additional shared standby resources

Appropriate resource abstraction capability, controllability, and programmability via various kinds of resource control interfaces enhances the following usabilities for virtual transport users.

- high value-added transport service creation and lineup
- simple and efficient network design and operation on the users' own networking policy
- integrated, flow-through operation for virtual transport resources and users' specific functions

To achieve the above concepts, we are now researching two technical issues to enhance the flexibility of optical transport networking: (1) shared resource management and an isolated control mechanism and (2) controllability and programmability for computing or packet processing layers. These are explained in sections 3.2 and 3.3.

3.2 Shared resource management and isolated control mechanism

To achieve both dynamic resource allocation via the shared resource pool and isolated resource control, which enables each user to access only allocated resources and prohibits users from accessing non-allocated resources, it is necessary to establish a model for managing partitioned logical resources and a mechanism for controlling resource access rights. The resource management model that we are proposing for both transport system resources (OXCs, MPLS-XCs, Ethernet-switches, and IP routers) and transport media resources (fibers, wavelengths, and packet labels) [5] is shown in **Fig. 3**. Both system and media resources are logically partitioned and each logical resource has an attribute indicating the users permitted to use it. Basic resource isolation can be achieved by a network virtualization platform that verifies the consistency between users' control commands and logical resource access rights. Dynamic resource allocation among users via the shared resource pool can also be achieved by controlling logical resource access right properly.

3.3 Controllability and programmability for computing or packet processing layers

The network virtualization platform aggregates logical resources assigned to each user and presents them to users as a virtual transport network at an appropriate level of abstraction. Since each user will operate the virtual transport network according to its own scheme, each virtual transport network should provide conformity and controllability to the user's operating environment. The ranges of virtual network topologies and operating schemes are also shown in Fig. 3. Virtual transport network A is used as sets of fixed paths connecting user systems, and B acts as one large virtual switch, communicating with user systems via some control-plane protocols. C acts as a switch network, supervised and controlled via some management-plane protocols. The network virtualization platform understands the correspondence between virtual transport resources and logical resources, and it optimizes the abstraction level according to the users' specifications. The platform also supports users' graphical user interfaces and application programming interfaces, which enable them to request additional virtual resources or virtual topology reconfiguration, and it emulates a virtual control & management plane to provide conformity to each user operating environment.

4. Proof of concept

4.1 Network virtualization platform prototyping

To confirm the feasibility of flexible resource allocation and controllability of the optical transport infrastructure, we implemented prototype software for the network virtualization platform [6]. We chose to use a platform architecture with a physical network manager separated from each virtual network manager on the following basis.

- centralized resource management and configuration to isolate physical system control efficiently
- abstraction of detailed network information at the physical network manager for each user to manage virtual transport easily
- independent functional extensibility and programmability for each user to develop virtual transport control applications that support new traffic engineering technologies.

For functional extensibility and programmability,

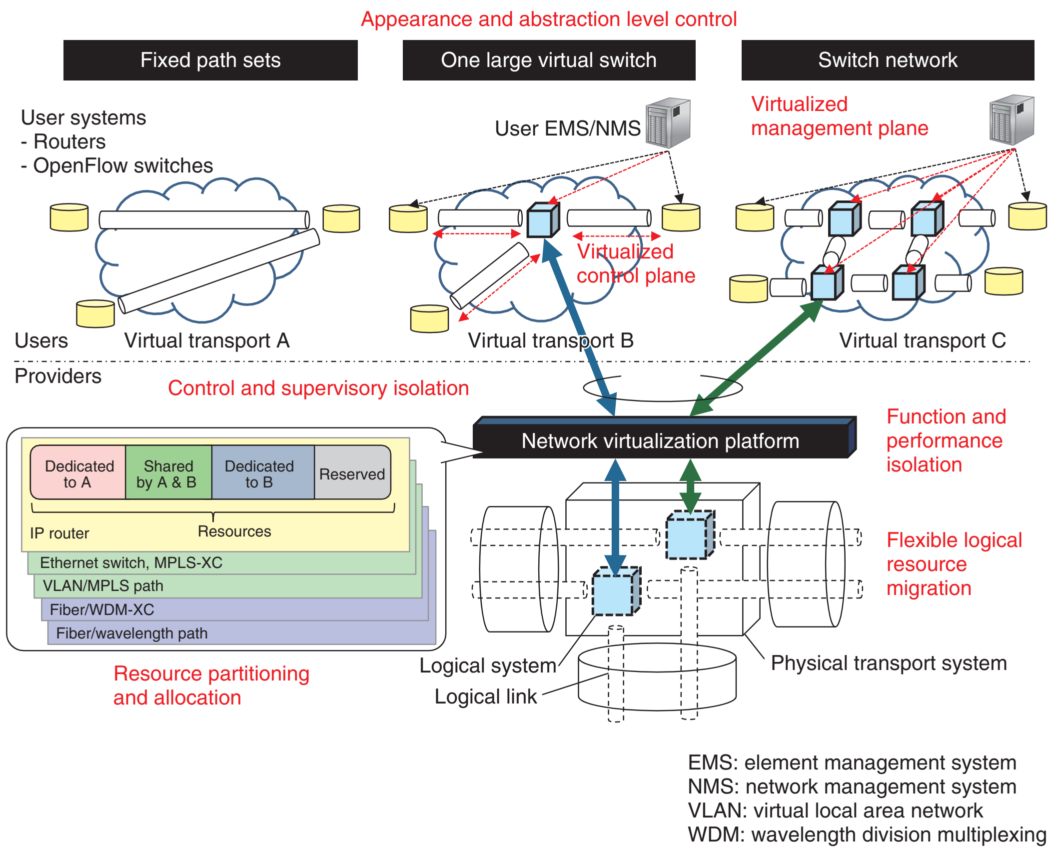

Fig. 3. Resource management, isolation, and controllability.

the virtual network manager has fundamental automatic network operation functions and can be easily connected to upper-layer functions. For example, it has a network reconfiguration function that optimizes the virtual transport topology and performs routing according to traffic demand and minimizes the amount of resources while keeping the communication quality and reliability [7]. Cross-layer and flow-through operation can be easily demonstrated by simple software modification, which directly reconfigures the topology or bandwidth of the virtual transport network when triggered by services or applications for example [8].

4.2 Proof-of-concept on national testbeds

With the abovementioned prototype software, we have been demonstrating shared resource networking and cross-layer operation with applications of the optical transport network on national testbeds, such as JGN (Japan Gigabit Network) [9], [10]. An experimental setup for global-scale virtual transport networking at SC11 (Supercomputing 2011), held in Seattle in November 2011, is shown in **Fig. 4**. The prototype software partitioned JGN-X (X: extreme) and provided virtual transport networks for multiple experimental groups, each of which successfully configured its virtual transport network independently. We also demonstrated global transport path networking technology across Japanese, American, and European testbeds for the first time in the world and showed the feasibility of global-scale virtual transport networks. The prototype software established bandwidth-guaranteed paths across multiple testbeds via the network service interface protocol, which is currently undergoing standardization, and constructed a global-scale virtual transport network. Using broadband video streams transmitted from Osaka to Seattle and London to Seattle, we also demonstrated the transmission performance attributes for actual application traffic and the feasibility of flexible path route selection according to the transmission quality of each testbed and available time zones.

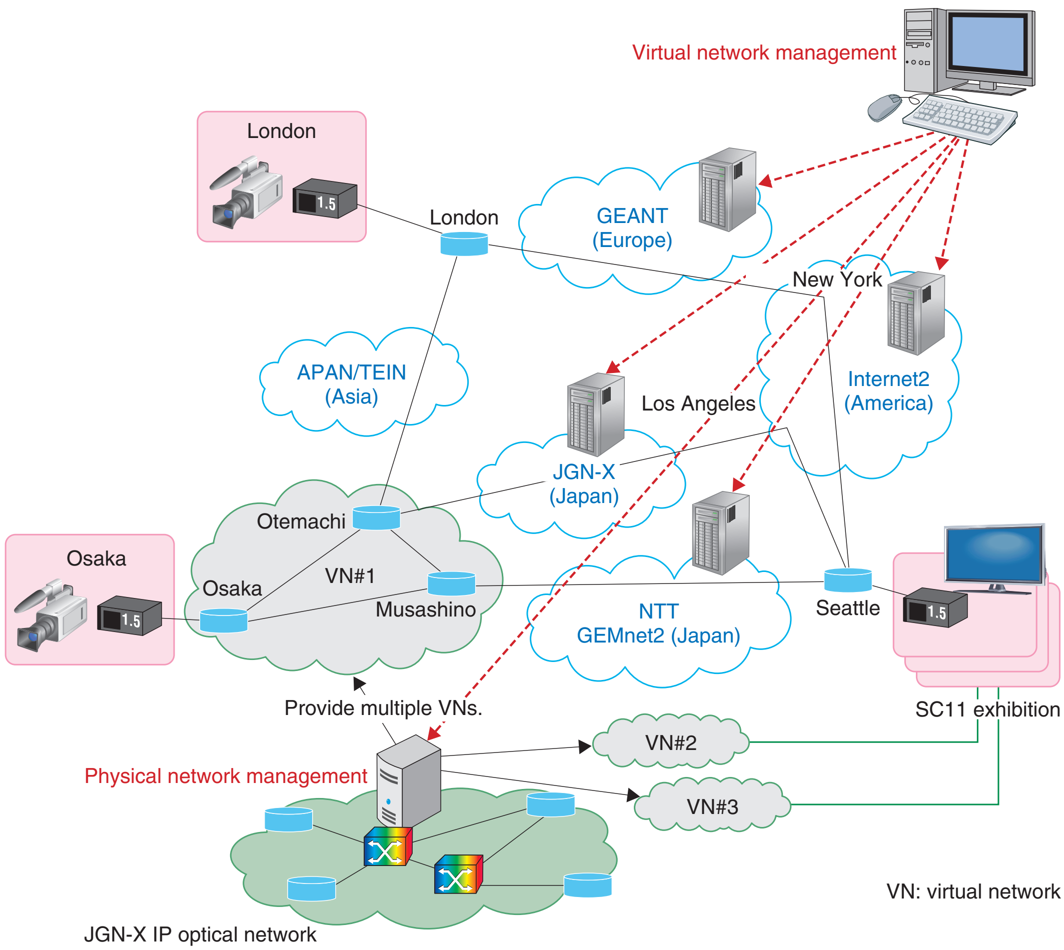

Fig. 4. Proof of concept on national testbed.

We have submitted reports of these JGN experiments to ITU-T SG13 Q.21 as use-case contributions and we are contributing to agreement on the basic framework recommendation Y.3011.

5. Conclusion

We introduced the basic concepts and technical issues of flexible, virtualized transport networking technology and also mentioned our network virtualization platform prototyping and proof-of-concept activities on national testbeds. In the future, we will promote research and development of the technical issues mentioned in section 3, establish and spread the network virtualization concepts by demonstrations on national testbeds, and continue contributing to standardization.

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Integrated Management of Networks and Information Processing for Future Networks

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Abstract

This article introduces two research initiatives in NTT Network Innovation Laboratories aimed at giving future networks functionalities that proactively facilitate novel information and communications technology services; namely, architectural design of deeply programmable networks and integrated management of networks and information processing. They will bring great value to society and people.

1. Introduction

This article introduces research on the fusion of novel network and information technologies being undertaken by NTT Network Innovation Laboratories. We aim to design a network infrastructure that fosters service creation of great value to society and people by effectively combining virtualized network resources and information technology (IT) equipment resources (NW/IT resources). The key concepts in this research are deeply programmable networks and integrated management of networks and information processing.

2. Structure of future networks

The logical structure of future networks that we are promoting is shown in **Fig. 1**. The networks consist of four layers. The lower three layers correspond to the flexible networks discussed in the first of these Feature Articles [1] on flexible networking technologies for future networks. Among them, we are paying special attention to two functional layers, namely, the ICT resource virtualization layer and the NW/IT integration layer (ICT: information and communications technologies). The bottom layer is a flexible ICT substrate composed of network and IT equipment, which is rapidly increasing in flexibility and becoming ready to be utilized as resources that can be composed through virtualization and abstraction.

The ICT resource virtualization layer virtualizes ICT resources and acts as a provider of the ICT resources to its upper-layer user and applications. The layer above is the NW/IT integration layer. The combination of networks and information processing has recently given rise to several valuable services, in areas such as information retrieval and social networking. We believe that the integration layer will play an important role in promoting the combination on the full scale in future networks.

An important viewpoint of future networks is that they bring a human-centric concept to ICT services. The seamless combination of NW/IT resources and processing lets users be unaware of NW/IT resource mechanisms and frees them from troublesome setup work; the situation and context of each user is handled by the layers so that users can enjoy rich services more readily, easily, and safely.

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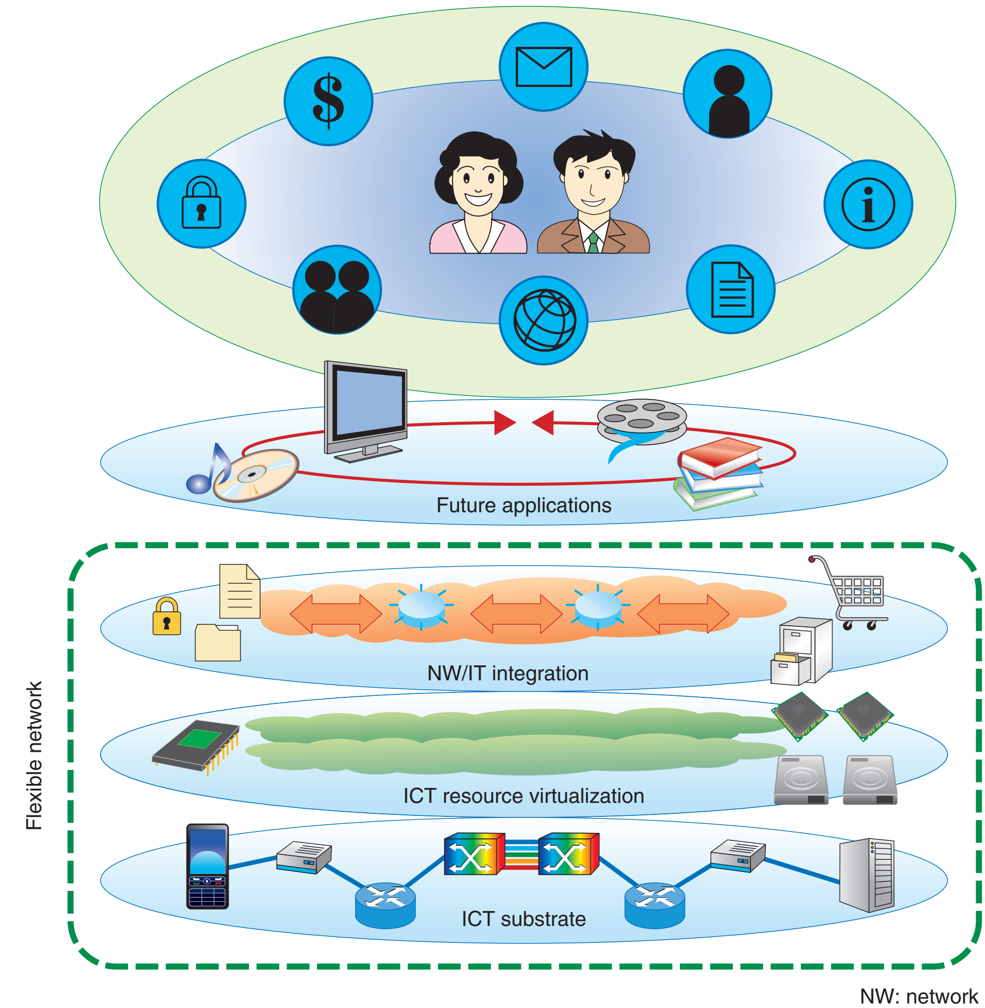

Fig. 1. Structure of future network.

3. Virtualization and abstraction of NW/IT resources

It is of the utmost importance that the physical NW/IT resources, such as bandwidth and computing functions, are skillfully abstracted and virtualized and that unnecessary details about physical implementations are hidden in order to leave room for further improvement through the deployment of new technologies. Inventions in applied physics and materials engineering can produce more useful lower-layer devices that replace conventional ones; meanwhile, in the upper-layer, original applications come and go, resulting in ever increasing diversity in the usage of the infrastructure. Through resource abstraction and virtualization, we can retain room for further and continuous development to incorporate new technologies and accommodate new applications.

The concept of abstraction and virtualization has been a tradition in the telecommunications industry; notions of layering and interfaces, for example, are based on this concept. However, it is acquiring more importance nowadays because 1) the flexibility of resources is vastly increasing and 2) some techniques for combining various NW/IT resources are becoming mature; particular examples are cloud computing technologies and OpenFlow networking.

An example of the abstraction/virtualization of NW/IT resources is shown in **Fig. 2**. Suppose that a user wants to connect among multiple sites and some servers; a conventional way is to purchase several circuits that have a low level of abstraction such as conventional leased lines, combine them into a network, and connect to the server at one point. By

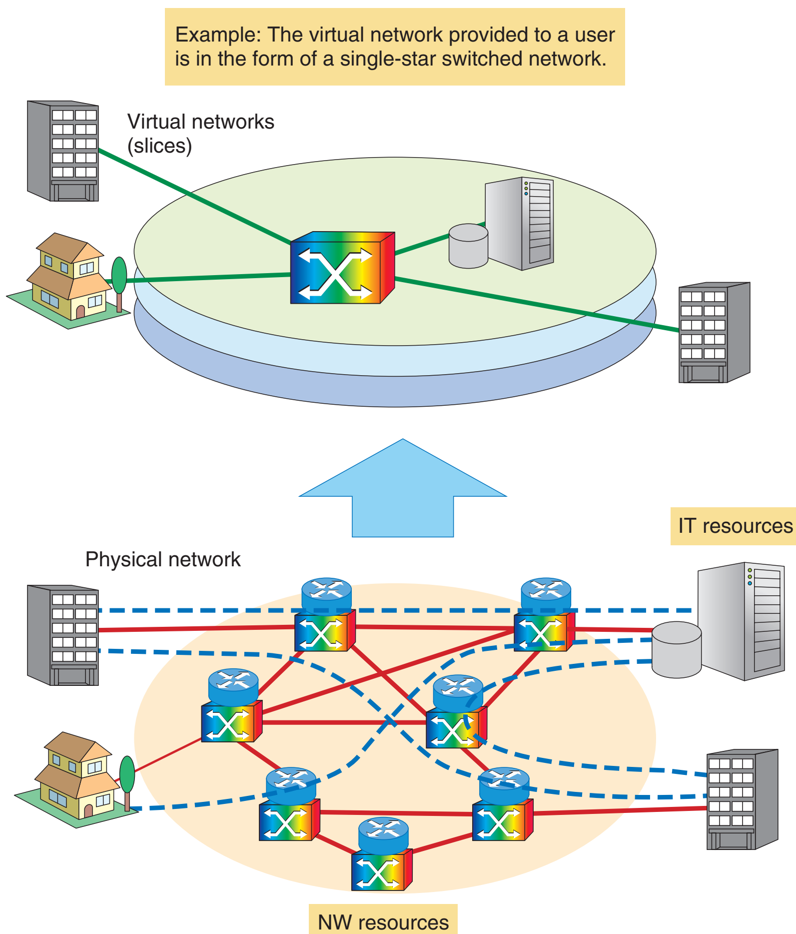

Fig. 2. Virtualization and abstraction of NW/IT resources.

contrast, in the virtualized case, depicted in the upper half of Fig. 2, a single-star virtual topology is tailored and provided to the user, and the user does not have to be bothered by the actual physical layout (i.e., the layout in the physical layer). Computational resources can be prepared by the carrier so that the NW/IT resource combination gives good performance and they can be provided to the user as a seamless customized service. The main feature of NW/IT resource abstraction and virtualization is that it can offer multiple virtual networks simultaneously: each virtual network is called a slice.

4. Integration of networks and information processing

As a means of integrating networks and information processing, the concept of programmable high-performance networks is attracting attention. In this concept, in addition to communication functions, network nodes have information processing functions provided by central processing units (CPUs), memory, and storage. These various NW/IT resources in the nodes are flexibly combined to provide integrated services. NTT Network Innovation Laboratories has been promoting this concept through an industry-academia collaborative project with the University of Tokyo, NEC, Fujitsu, and Hitachi since 2008.

In this project, we are studying three components for programmable high-performance networks: virtual nodes, the access gateway, and a virtual network management system. The structure of the virtual node is shown in **Fig. 3**. It consists of a networking function block and a programmable processing block. The latter includes network processors to provide hardware-assisted high-performance processing and virtual machines to provide more flexible software-based processing using generic CPUs and memory.

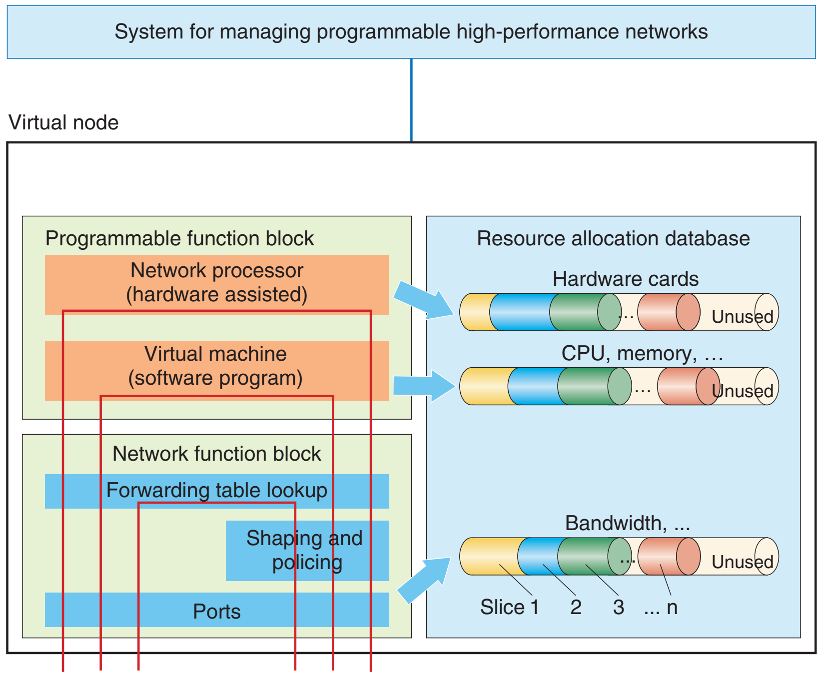

Fig. 3. Structure of virtual node.

Virtual nodes provide their networking and processing resources to slices according to their demand under the supervision of the virtual network management system. The management system takes care of resource requests from users and resource usage in nodes, and it commands the nodes to allocate, adjust, and release appropriate resources according to the user's request for slice generation, modification, or deletion.

The project has developed prototypes of the virtual nodes, access gateway, and management system and has deployed them in the national networking testbed, JGN-X [2], for verification and demonstration. The prototypes are also actively utilized for studies of applications utilizing NW/IT resource combination.

We are also studying coarser-grained NW/IT resource integration. The aim is to establish techniques for coordinating IT servers and networks (rather than embedding server functions in networks). With the recent development of cloud computing, the flexibilities of IT resources such as servers, storage equipment, CPUs, and memory are ever increasing, so there are high expectations for sophisticated combinations of these NW/IT resources. NTT Network Innovation Laboratories has been studying this issue in another industry-government-academia project called VICTORIES (for Vertically Integrated Center for Technologies of Optical Routing toward Ideal Energy Savings) [3] with the National Institute of Advanced Industrial Science and Technology (AIST) and other companies. In that project, we have developed a resource management system that controls resource usages of contents servers and high-capacity optical path networks, and we successfully demonstrated its usability through experiments on ultrahigh-definition video distribution in August 2010. The experimental setup is shown in **Fig. 4**. Upon receiving a viewing request from a user, the management system searches for the necessary resources, i.e., traffic transmission capacity of video servers residing outside the network and bandwidth for the links that can provide a path between the server and the users (viewers). The management system determines a desirable combination of resources and allocates them for the video distribution session.

5. Integrated management of NW/IT resources

As described above, the management functionality is vital for an integrated service composed of network resources and computation resources. We are focusing especially on this among technologies for flexible networking.

The proposed architecture for integrated NW/IT

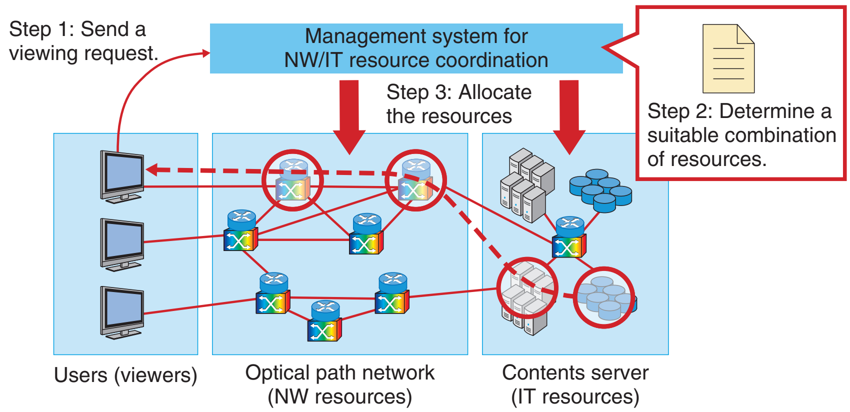

Fig. 4. Experimental setup of NW/IT resource coordination.

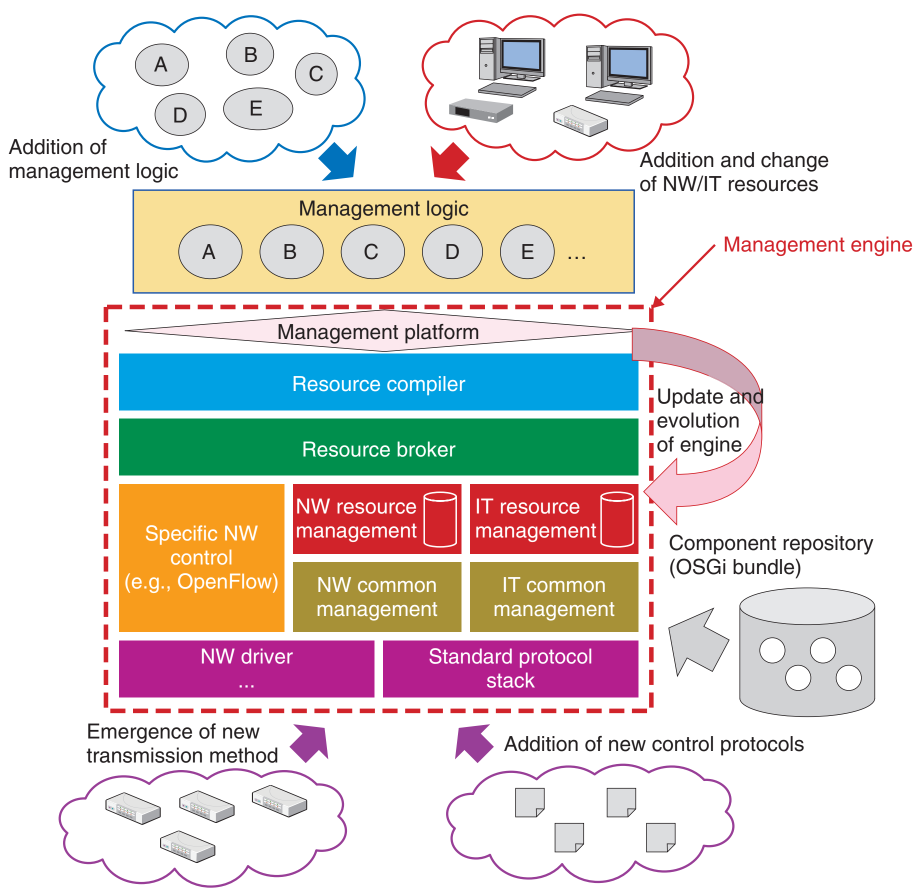

Fig. 5. Management Engine, an architecture for integrated NW/IT resource management.

resource management is shown in **Fig. 5**. Called the Management Engine, it is designed in a hierarchical manner with the upper layer being the most abstract while the lowest layer is the least abstract to provide an interface with physical equipment.

The management logic is a platform that allows network users (including service providers of various kinds such as Internet service providers and application service providers) to describe their requests to network operators in a highly abstract manner. By defining new management logic, it is easy and straightforward to add an operation policy, change an existing one, or combine new NW/IT resources. A service request is issued by management logic, which is translated in the management engine's resource compiler. The resource broker, working in association with the network resource manager and IT resource manager, searches for and determines the optimal combination of various resources that fulfills the service request. If the network includes a subdomain with specific control interfaces and protocols, such as an OpenFlow subdomain, these interfaces are utilized by the resource broker. The resource broker issues requests for the selected resources, which are translated by network drivers and a standard protocol stack into appropriate sequences of commands for corresponding equipment, so that the equipment is set up to accommodate the service. In addition to the resource management, common management modules for NW/IT resources in the engine will offer functions for failure management, performance management, etc. The engine is being implemented using the OSGi [4] framework, which is a modular software component platform and an international standard promoted by NTT and other companies, so that it can swiftly and flexibly deal with new protocols in various layers and the rapid emergence of novel transmission methods and equipment.

6. Concluding remarks

The integration of networks and information processing in future networks is expected to lead to a rich set of novel valuable services. We will continue our research on NW/IT resource abstraction & virtualization and the component-oriented management engine toward a flexible management engine that can be extended in line with innovations in networking and information technologies.

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Toward Future Network Control Nodes

Takeshi Fukumoto†, *Masami Iio, and Kiyoshi Ueda*

Abstract

As a step toward reducing the cost of carrier networks, centralized adjustment and maintenance of various server systems is being studied. In this article, we describe a shared platform for network control nodes that NTT Network Service Systems Laboratories is studying as part of that cost reduction effort.

1. Introduction

There have been great changes in the environment of carrier networks over recent years, and network control nodes have also diversified. Because the degree of diversification varies with the required levels of performance, cost, quality, etc., control nodes are developed on their respective platforms. One result, however, is that maintenance procedures vary from system to system and there are restrictions on the range within which development expertise can be acquired. That creates circumstances that hinder plans for overall optimization. To break out of these constraints, we are investigating a shared platform for NTT network control nodes.

2. Shared platform and its architecture

In systems for which high reliability is required, one approach is to use a single server that has a high failure tolerance and to have a backup server to enable service provision to continue if a failure does occur (active-standby (ACT-SBY) architecture). In the case of session control servers for the Next Generation Network (NGN), it is expensive to use hardware that conforms to the Advanced-TCA (Telecom Computing Architecture) standard to ensure reliability and expensive to use the ACT-SBY architecture to ensure reliability. On the other hand, there are also systems for which cost reduction is desired, even if some degree of reliability must be sacrificed. Therefore, we chose to use the N-ACT (n active servers) architecture (**Fig. 1**), which provides functions for flexibly changing the degree of redundancy in backup systems. The N-ACT architecture features a high facility utilization rate because servers provide backup for other servers at the same time as performing their own processing. By contrast, the ACT-SBY architecture has dedicated backup servers, which are idle when on standby.

Furthermore, because the system scale (processing capability) is determined by the functions and services, there is great variation in size from small to large. Accordingly, a future network platform must be applicable to both large systems and small systems. With the consideration that “large is the sum of many smalls”, there is also the approach of unifying on large systems, but if a large-scale platform is applied to small systems, the cost and energy consumption required for adjustment become problematic. Accordingly, our platform offers a way to provide performance, reliability, and scale according to demand by grouping small, low-cost servers. If this platform is shared by multiple systems, resources can be allocated among the systems. Specifically, as shown in **Fig. 2**, servers that do not have any application software installed are managed as a resource pool. The loads of the systems are monitored and high-load systems are given a capacity boost by installing application software on servers in the resource pool. For low-load systems, some servers are returned to the resource pool. This server adjustment is done automatically, without any interruption of services.

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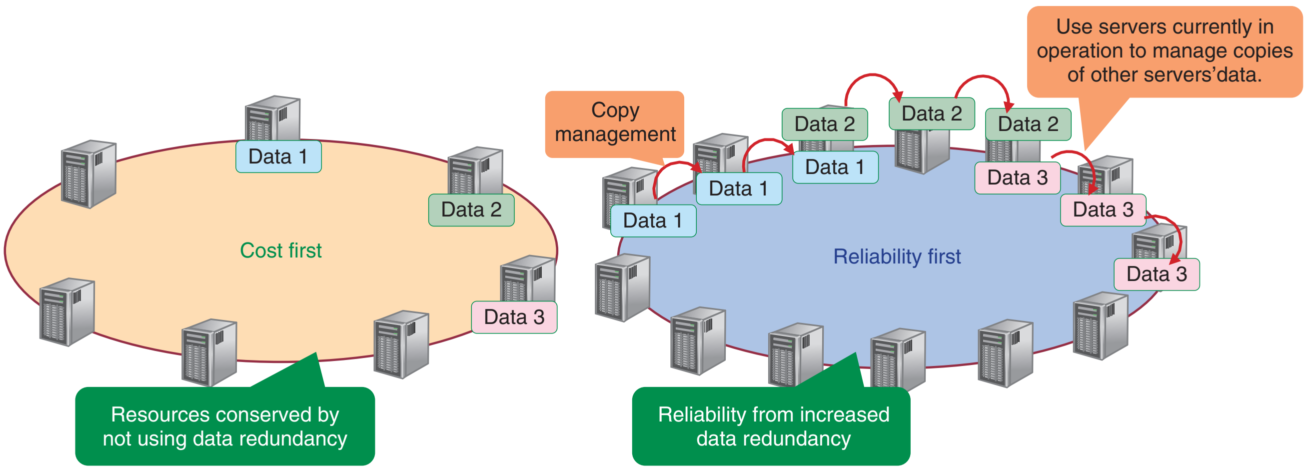

Fig. 1. Maintaining reliability in an N-ACT architecture.

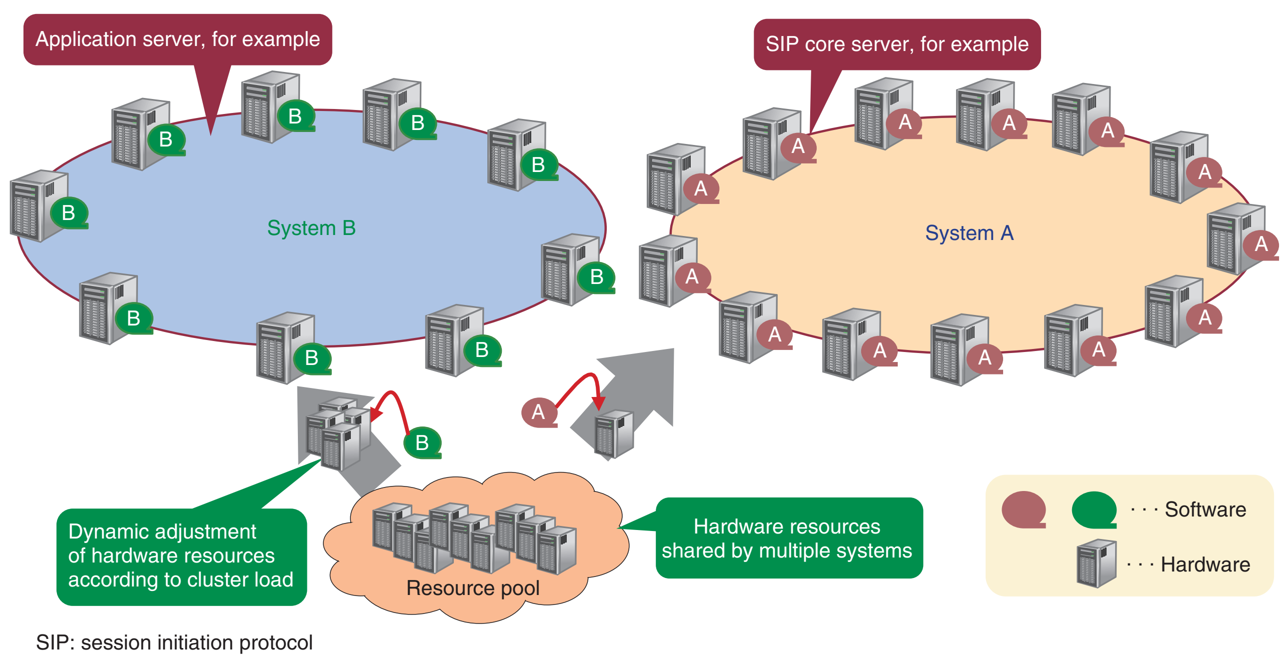

Fig. 2. Dynamic resource control.

3. Reduction of maintenance cost

As mentioned above, the need to reduce costs is increasing, and for future networks, there is a demand to reduce maintenance to the maximum extent possible. Our objective is to reduce maintenance costs by unifying the maintenance system applicable to a platform shared by multiple systems.

There is concern that many of the systems currently in operation may be incapable of providing services in a normal way if the load exceeds their processing capability, so the trend is toward autonomous invocation of system regulation. The system is given some degree of surplus capability at the capacity design stage so that services can be provided in the unregulated range. However, if the possibility of the load surpassing that assumed during the design arises, a switching of accommodation, which is referred to as location division, is done. Location division involves momentary halting of services during the night when there are fewer users so that various types of data can be moved. High-risk tasks such as location division involve the temporary stoppage of service, and the effects of this task failing are great. Therefore, the work is done only after verification by multiple prior tests conducted in a testing environment to minimize the risk of failure from bugs or operational errors. However, such a cautious procedure increases costs, so to address that problem we have implemented a mechanism for flexibly changing capacity to provide automatic server recovery. That mechanism can dynamically increase or decrease server capacity by adding servers automatically when the processing load becomes large or by removing servers when the processing load becomes small.

4. Tolerance of severe disasters and congestion

Last year's major earthquake in eastern Japan caused serious damage to NTT buildings. If a similar disaster were to damage entire buildings, it would become impossible to provide services because most of the current systems have the online and backup servers located in the same building. Although there are some systems with remote backup servers to avert that problem, the switchover is done manually, so restoration after a severe disaster takes from a few hours to several days.

Our objectives are to minimize the effects of regional damage such as that as caused by the 2011 Great East Japan Earthquake by distributing servers over a wide area and to enable rapid restoration of services in undamaged areas. Moreover, because the effects of that earthquake extended over a wide range, phone calls made by people to check on the safety of their family and friends were concentrated: as a result, servers entered a regulated state that extended over a long period of time. For that problem, too, we would like to use the dynamic server addition mechanism described above to prevent prolonged service regulation due to load concentration.

5. Modeling approach

Next, we describe the technologies used. A distributed system is a group of multiple servers regarded as a single virtual server. This group of servers is referred to as a cluster. The individual servers in a cluster cooperate to perform processing, but the volume of signals that must be exchanged among the servers generally increases with the number of servers. That prevents the abovementioned scalability. We chose to use a method [1] in which the signals for cooperation between servers are regularly distributed in advance, and signals received from outside are divided up among the servers that hold the data. The processing that determines the location of the data required at a particular time uses a consistent hash algorithm, which is explained below.

6. Consistent hash algorithm

The function that distributes received signals to the servers must satisfy the following conditions.

(1) The request signals shall be distributed evenly over multiple servers.

(2) Multiple related request signals shall be assigned to the same server.

To satisfy these two conditions, we use a hash function, which is a computational method for generating a pseudorandom number of fixed length from given variable-length data (key information). By using a hash function to compute the parameters that relate the requests contained in the received signals in order to determine the processing server, we can satisfy the two conditions.

However, the platform that we aim for requires dynamic adjustment of the number of servers to which the request signals are distributed. When a simple hash function is used, changing the number of destination servers also changes all of the request distribution conditions. Because the number of servers is expected to change frequently, the cost of data reorganization processing when conditions are changed cannot be neglected. One technique for minimizing that cost is to use a consistent hash algorithm (**Fig. 3**).

Using a consistent hash algorithm [2] enables the effects of an increase or decrease in the number of destination servers to be limited to the adjacent servers. This method is also effective for determining the backup servers in an N-ACT architecture such as shown in Fig. 3. With this method, the mechanism for implementing the processing for signal distribution to the backup system servers when a failure occurs can be simpler than that in the conventional ACT-SBY configuration, which does it by changing the IP (Internet protocol) addresses.

7. Separation of logic and data

Having explained a method for maintaining

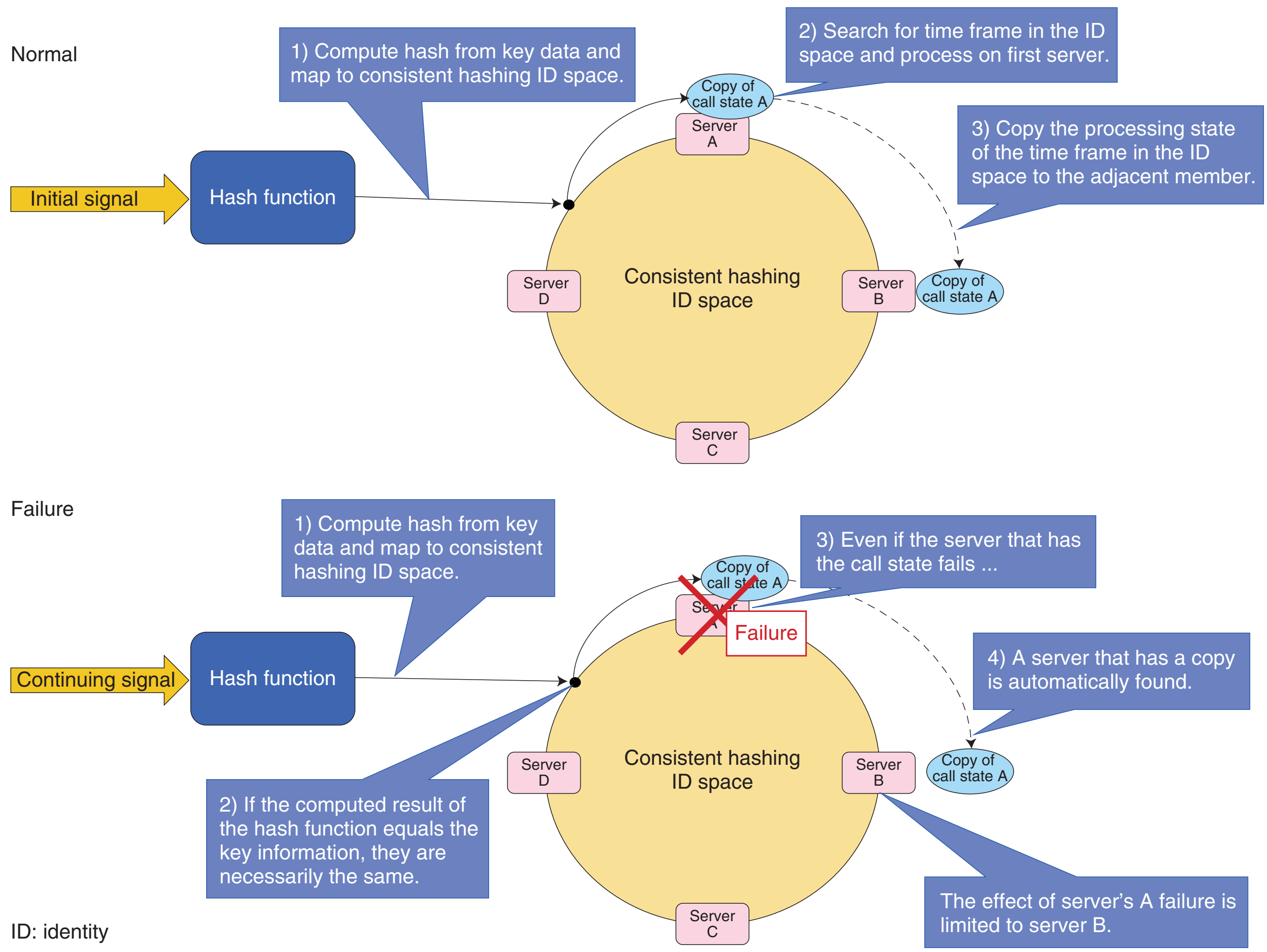

Fig. 3. Using a consistent hash algorithm to determine the server.

organization and reliability of the dynamic data generated by the request processing, we now explain the handling of static data stored on the servers in advance, such as service conditions and user contract information.

Our platform is not of the distributed capacity type: the requests sent by a particular user do not necessarily all arrive at the same server. Therefore, it is assumed that static data can be stored on all servers. If the amount of data is small, it is not a problem for the same data to be stored on all of the servers; however, for a large amount of data, the data distribution is an important issue. Therefore, we have proposed a split configuration that involves a cluster for performing services (logic cluster) and a cluster for the management of static data (data cluster) (**Fig. 4**). The logic cluster retrieves the data required for processing from the data cluster each time it is needed, which allows the use of a distributed load architecture. However, with this method, there is concern about the delay until data is retrieved. To address that concern, the data cluster uses the hypertext transfer protocol (HTTP), which has a relatively light processing overhead, and a key-value data store, which permits high-speed retrieval. Although their roles differ, any of the clusters described so far can be configured on the basis of the new network control node configuration technology. Concerning the processing delay in data clusters, we are currently constructing prototypes for the purpose of investigating the issue.

8. Concluding remarks

Many technical problems remain regarding commercial introduction of the new network control node configuration technology. Work to characterize the

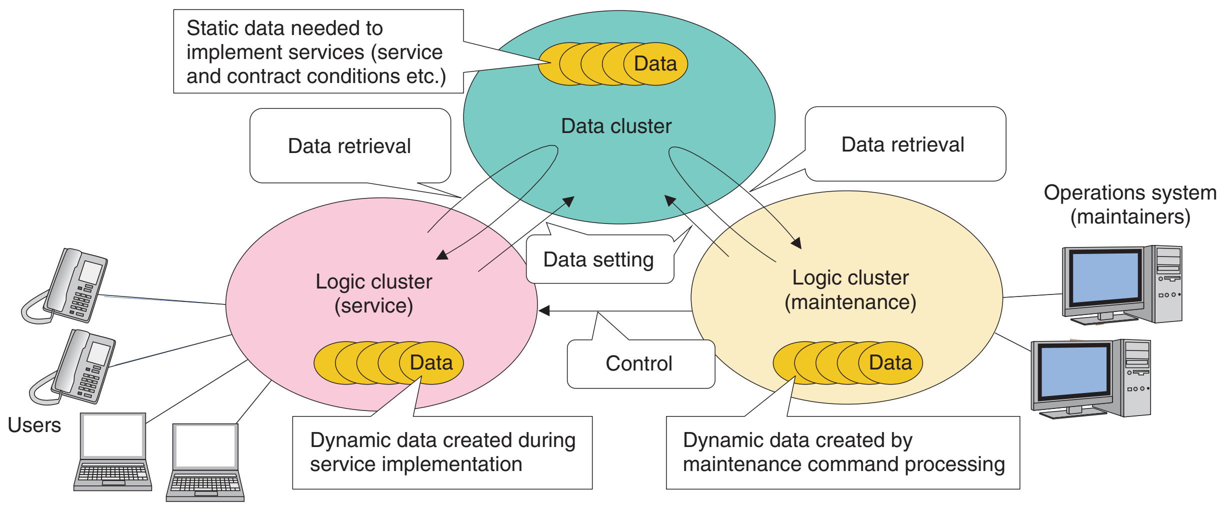

Fig. 4. Logic and data clusters.

delay in static data retrieval is in progress, but revision according to circumstances and additional study are required. It is also necessary to investigate methods for implementing file updating, failure detection, analytical methods, and other functions available in current systems. Furthermore, advanced control technology based on automatic control theory for dynamic control of servers has also become necessary.

We will continue to investigate the feasibility of various application-dependent requirements, including the extent to which implementation is possible, and continue with technical studies of application to commercial networks.

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Monitoring Technology for Programmable Highly Functional Networks

Seiki Kuwabara†

Abstract

This article introduces technology for monitoring network quality, which is one of the most basic parameters for network management. NTT's high-precision network monitoring system, PRESTA 10G, which is compatible with perfSONAR (performance service oriented network monitoring architecture), can monitor network quality with high time resolution. It will enable the provision of higher service quality over a highly functional future network.

1. Introduction

In future networks, network resources will be virtualized and assigned flexibly in order for users to enjoy high-quality services. To maximize the user's quality of experience (QoE) and optimize resource assignment, we need to provide monitoring technology that can grasp every external factor directly. Future network services are expected to be used as lifelines for daily living by providing remote collaboration through broadband video applications, electronic government, and telemedicine services. Therefore, it is important to program the network flexibly while being aware of the QoE for users.

2. Background

2.1 QoE factors

The QoE is determined by the combination of complex user needs and the surrounding environment (**Fig. 1**). For example, the network condition for user needs, such as many file transfers just before a deadline or live streaming of high-definition video ((a) in Fig. 1), is affected by sudden events (b), application specifications (c), and network status (d). NTT Network Innovation Laboratories is conducting a study of QoE enhancement by monitoring user needs and all of the parameters changing in space and time and by feeding the results back to network management and control.

2.2 Network quality and QoE

To meet user needs, it is necessary to monitor various parameters correctly. Network quality is considered to be one of the leading indicators. For example, if we can get network traffic behavior more accurately, we can detect the cause of an unknown reduction in QoE and we can improve the QoE by eliminating the cause. Namely, there is a deep connection between advances in network monitoring technology and complete understanding of QoE. Moreover, to understand application behavior and environmental changes in the network, it is necessary to perform a lot of packet processing and log analysis. Network monitoring, which analyzes network delay and congestion at the packet level, is a critical technology.

2.3 Need for high-precision network monitoring

Several network monitoring technologies have already been deployed in order to achieve a stable network. For example, routers and switches record the number of input packets and output packets on each management information base (MIB) interface, and we can understand network utilization if the monitoring system gathers this data for a short period

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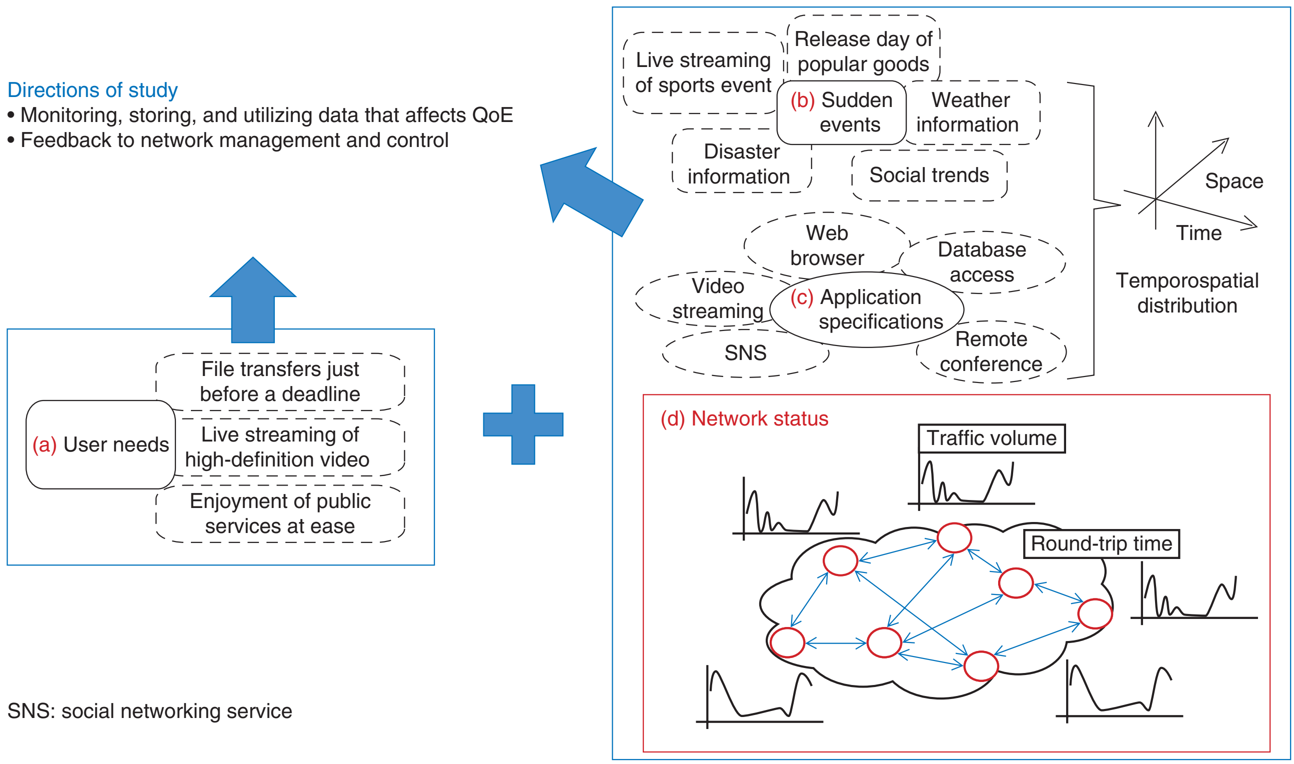


Fig. 1. Surrounding environments for network quality monitoring technology.

of only a few minutes and processes the traffic volume. The routers and switches send and receive monitoring packets among different items of equipment and control the equipment's vital processes. This data is used to operate the network such as eliminating bandwidth shortages or avoiding trouble. However, recent network services are sensitive to delay or consume bandwidth in a bursty manner, so we need more detailed monitoring data than the conventional network monitoring system can provide.

The need for high-resolution network monitoring is demonstrated by the example shown in **Fig. 2**. Results for processing the bitrate changes observed on a monitoring scale of 5 mins are shown in Fig. 2(a) and those on a scale of 10 ms are shown in Fig. 2(b). When the scale used for monitoring the traffic volume is coarse, the network bandwidth seems to be sufficient because bursty traffic is averaged. On the other hand, when the monitoring scale is fine, it is clear that traffic is bursty and sometimes briefly exceeds the available bandwidth, enabling us to detect potential packet loss or speed deterioration.

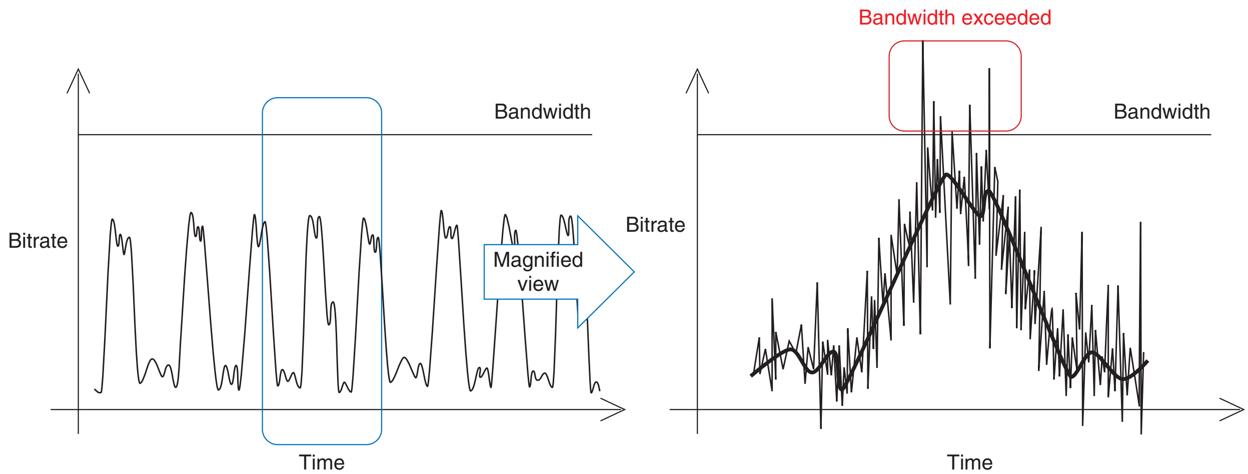
In practice, network bandwidth is designed with a safety margin, and momentary bandwidth shortages occur only infrequently. However, considering the management of several network qualities, e.g., not only bandwidth but also delay and jitter, it is important to grasp the network situation accurately.

3. New monitoring system: PRESTA 10G

3.1 Overview

My colleagues and I have developed a high-precision network monitoring system called PRESTA 10G. It consists of a general-purpose personal computer equipped with a network interface card (NIC) with network measurement extensions, device drivers, dedicated API (application programming interface) libraries, and general-purpose packet capture libraries [1].

The NIC supports three protocols—10GbE-LAN PHY, WAN PHY, and OC-192c POS—for a 10-Gbit/s network and has two main functions, which achieve high-accuracy, high-resolution network monitoring (10GbE: 10-Gbit/s Ethernet, LAN: local area network, PHY: physical layer, WAN: wide area network, POS: packet over SONET, SONET: synchronous optical network).



(a) Bitrate changes observed by the existing monitoring system (on the scale of 5 mins)

(b) Bitrate changes observed by the high-precision monitoring system (on the scale of 10 ms)

Fig. 2. Comparison of existing and high-precision monitoring.

(1) 10-Gbit/s wire-rate packet capture and generation
(2) Externally synchronized precise timestamping based on timing signals using GPS (global positioning system)

These hardware functions make it easy to develop a network monitoring system that can monitor several network quality parameters precisely. For example, we can detect bursty traffic with microsecond-order time resolution of the traffic volume processing or we can measure one-way delay and jitter with microsecond time resolution by using synchronized timestamps.

3.2 Multilayer and multipoint monitoring

By using PRESTA 10G for monitoring, we can determine the network quality in detail. It is important to detect any network quality deterioration or failure occurrence promptly and to identify the location and cause of the failure in order to provide stable network service. In particular, once we know the location of the failure, we can quickly take the measures necessary for service restoration.

3.2.1 Analysis using multilayer monitoring

As an example, I introduce the workflow of troubleshooting in the case of multilayer monitoring of a video service. To detect video disturbances, which are easy for the user to notice, we check for the presence of packet loss in each video frame by analyzing the header of the video transfer stream such as the RTP (Real Time Protocol) header in the application layer. When packet loss occurs, we perform a flow analysis in layers 3 and 4 to determine the traffic volume of each flow and identify the cause of packet loss. For example, we can identify the flow causing the trouble when there is a momentary shortage of network bandwidth caused by another bursty flow on the same line. We characterize jitter and delay in the lower layers and analyze the packet loss cause in detail. Serious jitter triggers a buffer overflow in a switch or router leading to packet loss.

We have developed software that monitors individual layers and designed all of it to run on PRESTA 10G (**Fig. 3**). In particular, PRESTA 10G can monitor multiple layers at the same time under a low load on a 10-Gbit/s broadband network by means of hardware functions.

3.2.2 Analysis by multipoint monitoring

To identify the location of a failure, it is important to determine where the packet loss occurs and the jitter worsens by monitoring multiple layers at multiple points. We have applied perfSONAR (performance service oriented network monitoring architecture) [2], which is an infrastructure for network performance monitoring and its standardization is being promoted by the Open Grid Forum. By utilizing the SOAP/XML-based data transmission protocol defined by perfSONAR and the middleware in which it is implemented, it is possible to share remote data in a common format by conforming to various

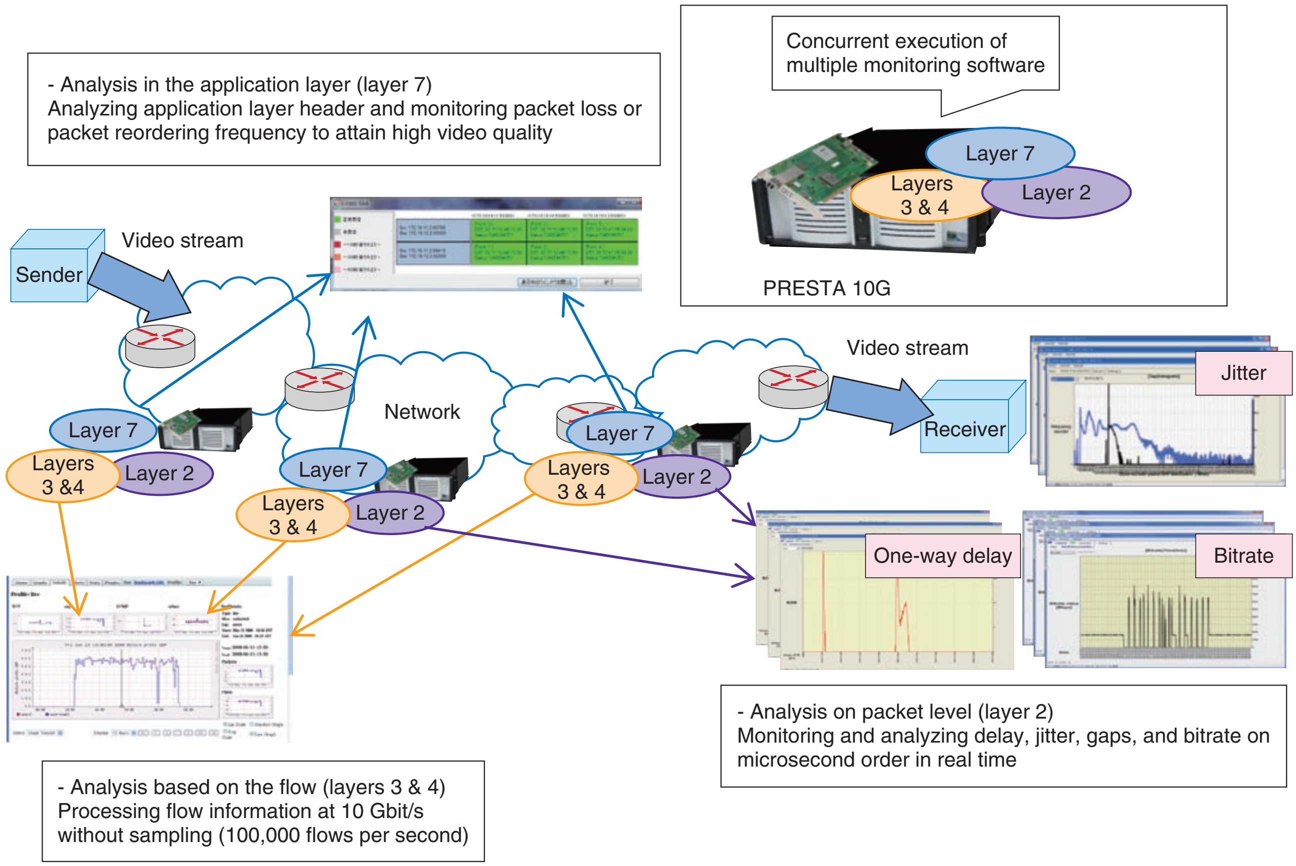


Fig. 3. Multilayer and multipoint network monitoring technologies.

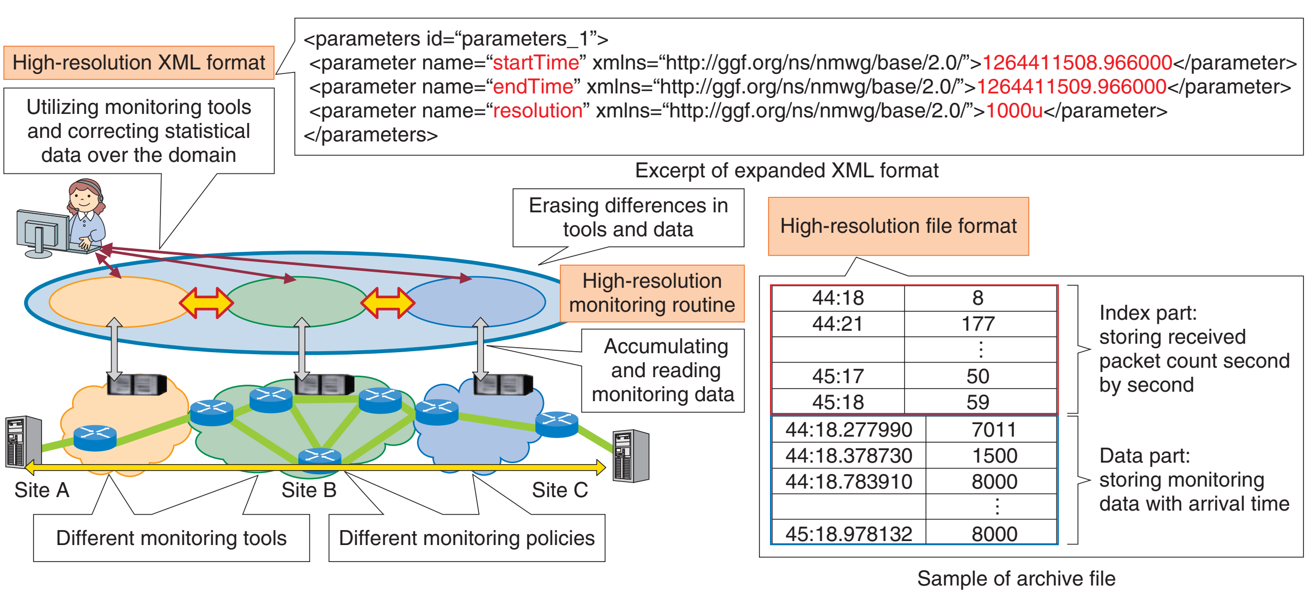


Fig. 4. Enhancements to perfSONAR.

published policies (SOAP: simple object access protocol, XML: extensible markup language). Moreover, perfSONAR provides a lookup service that reports where and what kind of data or monitoring function is being used; this makes network quality easier to manage over the domain.

However, the current perfSONAR handles monitoring data at a resolution of more than 1 s, so we have enhanced it by adding three new functions to enable perfSONAR to process data at a microsecond rate (**Fig. 4**).

(1) High-resolution monitoring routine

We have implemented a monitoring routine that stores monitoring data at a microsecond rate and processes it at a resolution higher than 1 s. We suppress further increases in the amount of data to be processed and in the required processing time in the case of high-resolution monitoring by using the existing routine when the requested resolution is more than 1 s and using our routine when requested resolution is less than 1 s.

(2) High-resolution file format

Our file format has an index part that stores the received packet count in units of seconds and a data part that stores monitoring data together with its arrival time. This format enables fast data extraction because the necessary number of packets can be determined by searching by only the time.

(3) High-resolution XML format

We have expanded the XML format to enable an XML message to handle the start and end times and a microsecond resolution. As a result, it is now possible to request data by the microsecond with the perfSONAR protocol.

4. Conclusion

Our high-precision network monitoring system, PRESTA 10G, can monitor network quality, which is the key factor for network management, with high precision. We are planning to develop technology for monitoring the factors that affect QoE, such as environmental changes and application behavior, and a technology for stabilizing the network through the use of monitoring data.

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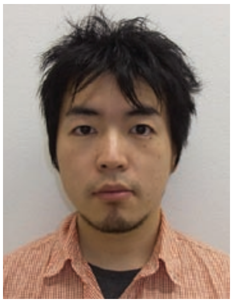

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Leveraging Semantic Web Technologies for Enterprise Information Integration

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Abstract

We describe a data-oriented architecture for exploiting integrated enterprise data as knowledge by using Semantic Web technologies. It features an extensible schema design for storing integrated enterprise data including historical data. This architecture will meet the rising demand for enterprise data integration, which is currently difficult because enterprise information is stored in different formats or has different meanings in different systems.

1. Introduction

In companies, different departments and divisions operate their own information systems. Each system obtains various information (also interchangeably called data in this field) in a suitable format, so it is difficult for systems to use data in other systems. However, the demand for enterprise information integration is increasing because it is useful for business intelligence, which supports better business decision-making. Moreover, the resource description framework (RDF) [1], which expresses the relationship between things in three sentence parts—subject, object, and predicate—is becoming widely used. There are several methods [2], [3] of converting data in a relational database (RDB) into RDF format. Enterprise information is often stored in an RDB, so its conversion into machine-readable RDF format lets us find useful relations among it with the help of Semantic Web technologies.

In this article, we describe a data-oriented architecture for using integrated enterprise information in RDF format.

2. Enterprise information integration

Attention is being paid to technologies such as Enterprise Search for searching enterprise data and websites [4], enterprise application integration for integrating information systems [5], and knowledge management and business intelligence for searching and analyzing enterprise information for decision-making purposes [6]. To meet these needs, enterprise information integration is crucial.

However, information systems and their data schemas change over time, and these changes make it difficult to integrate enterprise data. Moreover, we need to integrate different enterprise data for different purposes, and such integrations are expensive. To manage enterprise data from different information systems and reuse it, we require a data sharing platform that does not need to modify the original data. This is the target of the study reported in this article.

Enterprise data integration enables desired information stored on different systems to be obtained in an integrated manner. Moreover, it might lead to new knowledge that we could not find when the information is used separately.

3. Data sharing platform based on data-oriented architecture

To tackle the problem mentioned in section 2, we have studied a data sharing platform based on a data-oriented architecture. The aim of this architecture is to organize integrated enterprise data in order to promote effective use of it.

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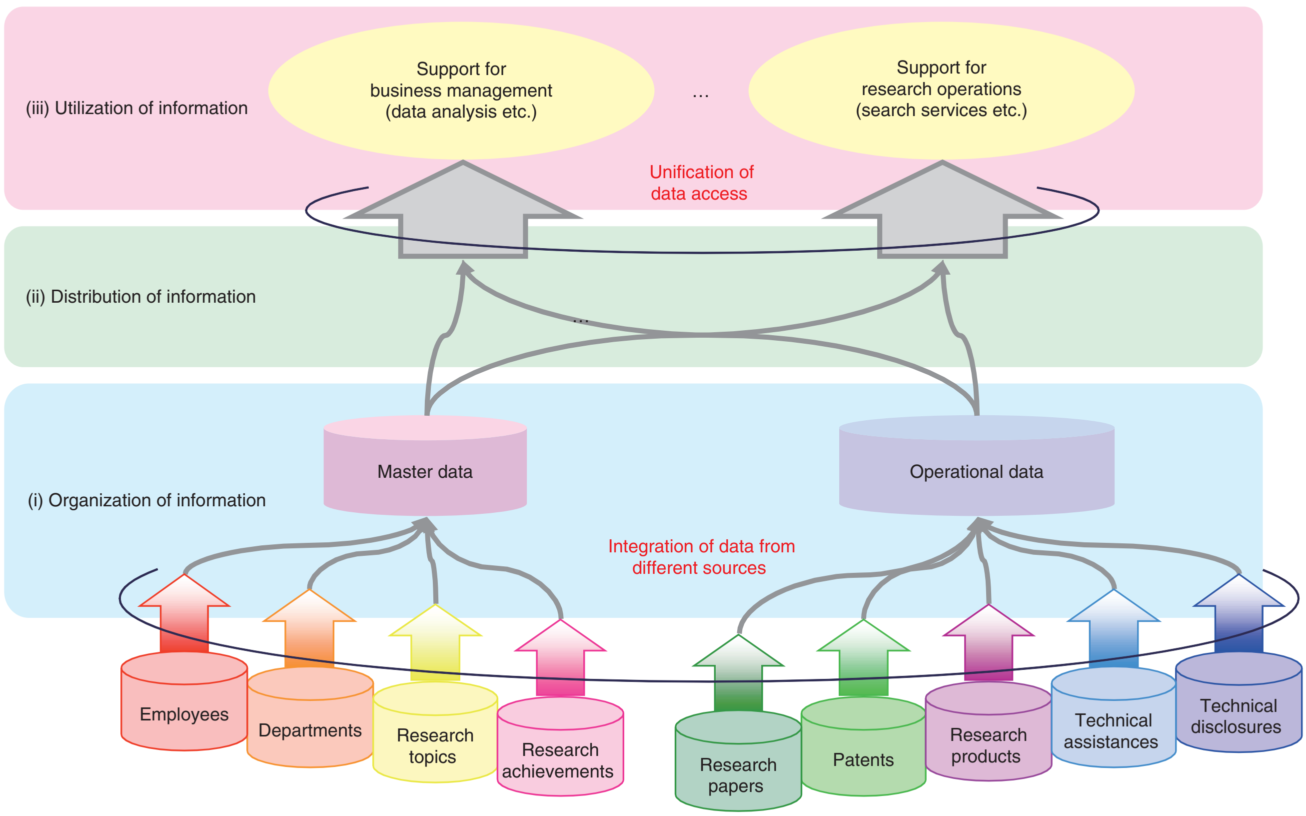

Fig. 1. Data-oriented architecture.

As shown in **Fig. 1**, a data-oriented architecture consists of three layers: (i) organization of information, (ii) distribution of information, and (iii) utilization of information. We define these layers as follows:

(i) The organization of information layer (OI layer) makes data available.

(ii) The distribution of information layer (DI layer) supplies information in an expected way.

(iii) The utilization of information layer (UI layer) supports the extraction of knowledge.

Why introduce two different layers for information retrieval? The OI layer is intended to store all of the data including historical data with timestamps while the DI layer is intended to deliver desired data by processing and editing data from the OI layer.

In addition, just like *services* in the service oriented architecture (SOA), we treat *data/information* as a unit of common use across different systems. This architecture does not contradict the SOA [7].

All the data used in services in SOA is managed in an integrated fashion in the OI layer as master data. Each service accesses this master data via the data bus in the DI layer on the basis of metadata that indicates access histories, data meaning, and so on.

In sections 3.1 and 3.2, we discuss the mechanisms of the OI and DI layers. In section 3.3, we present an example of a service based on this architecture.

3.1 Organization of information

The OI layer needs to manage all data, including historical data, and changes in the data structure. To make this possible, we categorize enterprise data according to its characteristics and define guidelines for the data schema for each category.

3.1.1 Categories and characteristics of enterprise data

There are five categories of enterprise data according to [8]: (1) master data, (2) operational data, (3) unstructured data, (4) analytical data, and (5) metadata. Master data represents essential business entities and is used in many different information services. Operational data has two types: transactions and inventory. Both are generated in the daily operations of a business, but the former is normally described as an add operation while the latter is described as an update operation [9]. Typical examples of unstructured data are text data, portable document format files (PDFs) and other documents, and data for websites. Analytical data and metadata is derived from the other types of data and is highly reusable.

In this article, we focus on master data, the core data in business. Master data in our laboratory is employees, departments, research topics, and research achievements. Operational data associated with this master data is research papers, patents, research products, technical assistance, and technical disclosures.

3.1.2 Master data with historical data

Each information service has its own *dialect*. Integrating data in different information services requires some data processing such as merging data with the same meaning and eliminating inconsistencies. A typical master data management (MDM) [10] method for integrating data at a point adds a unique identifier (ID) (primary key (PK)) to each record and uses this PK as a reference from records of other tables. Data in one system might have been consistent with data in other systems at some point in the history (but may not be now); however, historical data is deleted if it is not used. Changes to data schemas and a lack of historical data make it difficult to integrate enterprise information.

3.1.3 Master data schema design

We describe a master data schema for integrated master data, including historical data. In addition to the requirements of MDM, this schema should:

(1) manage historical data in a simple manner and
(2) handle schema changes such as attribute addition and deletion easily.

Historical data can be managed by storing all of the data either periodically or when any changes occur. The drawbacks of this method are storing redundant data and needing to have extra free space for attributes that might be added in the future.

We classify attributes into two types—(1) ones that are necessary to identify a particular instance of each entity and (2) the rest—and store them separately: attributes in category (1) are stored in a main table and those in category (2) are stored in separate sub-tables (one sub-table for each attribute) [11]. In this way, when attribute values have changed, we only need to add a record to the sub-tables; and when an attribute is added or changed, we only need to create a new sub-table and do not need to change the main table.

Here, we give an example of employees' master data. It is possible to treat only the employee ID as the main attribute, but attributes such as department ID and title also need to be treated as main attributes to identify a particular employee with his or her associated time. Therefore, we decided to manage employee ID, department ID, and job title in the main table and all the other attributes such as telephone number, fax number, and email address in its corresponding sub-tables.

An example of a master table of employees with historical data is shown in **Fig. 2**, which shows the main table and other sub-tables with PKs of the main table for reference. The main table consists of ID as a PK, the expiry date of each record (start and end dates), and the values of other attributes needed to identify a particular record. In the main table, we also include attributes that will not change before the ID expiry dates. Each sub-table contains ID (a PK of the main table), the value of the corresponding attribute, and its expiry date (start and end dates).

To update the value of an attribute, one must change the end date of its previous record and add a new record of a new value and a new expiry date. Since sub-tables exist for each attribute other than the ones in the main table, a new attribute could be added to the master data by just adding a new sub-table, and an attribute could be deleted by just changing the end date values of the corresponding sub-table if necessary.

Therefore, this master data schema will make it possible to handle attribute changes with historical data easily.

3.2 Distribution of information

3.2.1 Background

The DI layer processes and edits data from the OI layer to provide desired data to the UI layer in a desired format. As mentioned in section 2, the UI layer should be able to retrieve data without knowing its structure in the OI layer. Therefore, the requirements of the DI layer are as follows:

(1) hide the data structure in the OI layer from the UI layer
(2) reach the desired data easily
(3) retrieve the attributes of an entity easily.

We convert data in the RDB to the RDF format, which is free from the RDB schema. RDF is a metadata data model defined by the World Wide Web Consortium (W3C), and one possible query language for RDF, is SPARQL [12], which is also defined by W3C. When we use RDF, naming the uniform resource identifier (URI) is a known problem like

Main table

empID	name	deptID	title	startDate	endDate
1234111	Taro Suzuki	111	Senior research engineer	2008-5-1	
3399003	Jiro Sato	003	Research engineer	2000-2-1	2002-1-31

Sub-table of rooms

ID	room	startDate	endDate
1234111	MH9F	2008-5-1	2010-6-30
1234111	MH5F	2010-7-1	
3399003	MH8F	2000-4-1	2002-1-31

Sub-table of phone numbers

ID	phone	startDate	endDate
1234111	0422-xxxx	2008-5-1	2010-6-30
1234111	0422-yyyy	2010-7-1	
3399003	0422-zzzz	2006-2-1	2009-1-31

Sub-table of email addresses

ID	e-mail	startDate	endDate
1234111	taro@ntt	2008-5-1	2009-3-31
1234111	t.suzuki@ntt	2009-4-1	

Fig. 2. Example of employees' master table with historical data.

choosing the proper vocabulary. However, we do not have to worry about this problem because the data in the OI layer always has unique IDs, which can be used as URIs.

Using RDF changes the second and third requirements above into:

(2') express attributes of an entity simply

(3') express relations between entities simply

We discuss how to fulfill these requirements in section 3.2.2 and show an example of the utilization of information in section 3.3.

3.2.2 Information model for distribution

It is easy to express an RDB schema that changes over time (i.e., through column addition and deletion) in RDF format because properties in RDF format represent columns (attributes) in an RDB [13]. By using the RDF format, we aim to represent changes in RDB schemas as simply as possible. To do so, we define both *columns* (attributes) and *relationships between tables* in an RDB as *properties* between resources in RDF format, and the only information that we disclose to users is the properties to represent the relationship between tables. In this way, we can represent RDB schemas using properties of each resources even if RDB schemas have been changed.

An example of data in RDF format that is equivalent to the RDB data in Fig. 2 is shown in **Fig. 3**. In our model, we define our own vocabulary because it is for enterprise use. The properties representing relationships between tables in the RDB include *emp:org*, *emp:log*, *emp:currentLog*, and *emp:prevLog*, and the other properties representing RDB columns include *emp:name*, *emp:title*, *emp:room*, *emp:phone*, and *emp:mail*. Regardless of changes in the RDB schemas with time, the resources connected with *emp:log*, *emp:currentLog*, or *emp:prevLog* properties maintain their RDB schemas at that point and have an expiry date as a property.

The three abovementioned requirements ((1), (2'), and (3')) are fulfilled through the introduction of a simple hierarchical expression like this. For example, a query for selecting all attributes of a particular

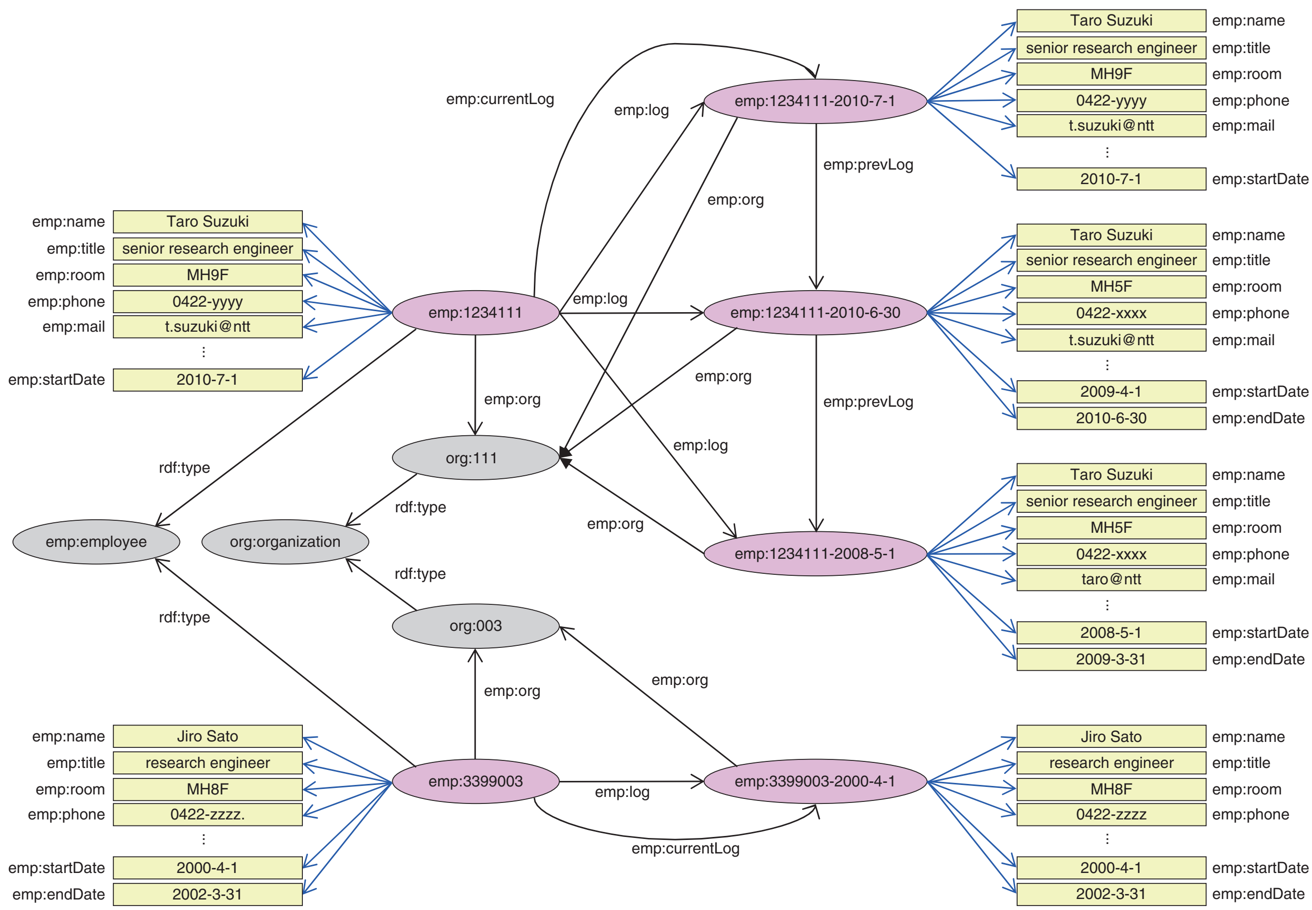

Fig. 3. RDF data representing employees.

```
PRELIX emp: <http://foo.bar/employee#>
SELECT *
WHERE {
   ?emp emp:name “Taro Suzuki”.
   ?emp emp:startDate ?start .
   ?emp emp:endDate ?end.
   FILTER (?start <= “2008-5-1” && ?end >= “2008-5-1”)
   ?emp ?property ?object .
}
```

Fig. 4. Query to retrieve all properties of specified employee.

employee at a given point in time is as simple as the one in **Fig. 4**.

3.3 Utilization of information

As knowledge management services, there are some services like ResearchMap [14] which allow researchers to introduce their skills and research outcomes in a cross-sectional manner. However, using knowledge management services in the style of a social network system (SNS) in companies is usually problematic. Motivating employees to update their profiles is as difficult as searching for and comparing information objectively. Therefore, we developed a way to find employees with a specified condition objectively by using integrated enterprise data. A screen image of our KnowWho service is shown in **Fig. 5**.

All the data in the screen image in Fig. 5 was retrieved from the DI layer by using the SPARQL endpoint. In Fig. 5, the employee's master data shown at the top resulted from a query that searched for an entity using a given employee's name as a search keyword, and retrieved its properties to represent attributes and their values. Similarly, KnowWho retrieved related keywords—search entities for a given employee's name and their values of the

Fig. 5. Screen image of KnowWho.

keyword property. In order to retrieve research papers, KnowWho searches research paper entities using a given employee's name. Only the paper titles are shown in Fig. 5, but it is possible to show other related information about the research papers as well. The historical data can be retrieved by searching for entities using a given employee's name, tracing *emp:prevLog* properties, and getting the values by using *emp:org* properties.

By using a simple hierarchical model, such as the one described in section 3.2, we can establish services without knowing the RDB schema. Changing the RDB schema over time causes conditional branching in search operations. Therefore, search operations are simpler when data is in RDF format, which can represent RDB columns as properties.

4. Conclusion

In this article, we described a data-oriented architecture for using integrated enterprise data. This architecture lets us retrieve all necessary data for any purposes. We no longer need to integrate data for different purposes, so it lowers the cost significantly.

We also categorized enterprise data and described a master data schema with historical data that can handle changes in schemas easily. To reuse integrated data, we introduced Semantic Web technologies to hide the original data schemas and retrieve information easily. We introduced the KnowWho service as an application of this architecture to evaluate its effectiveness. Although we focused on enterprise data in this article, RDF has endless possibilities because of its simple structure; we are planning to apply this architecture to other types of data such as linked open data [15].

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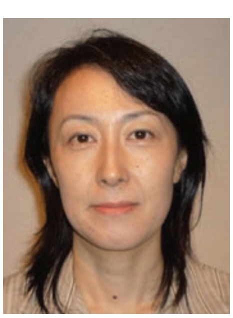

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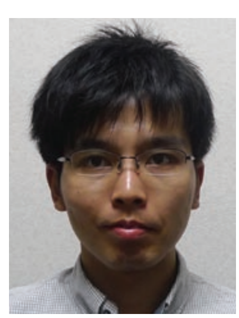

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Value-centric Information and Intelligence Sharing Scheme

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Abstract

The amount of information in the network has been increasing, and it is dominated by a few heavy users. Unfortunately, because the available resources are not infinite, we must consider resource starvation when we develop a future network architecture. We present value-centric networking (VCN), which is based on *information value*. The main purpose of VCN is to maximize information value in the network, and thus support the entire society. We report our implementation of an architecture for the VCN concept in the form of a proxy server and confirmation that VCN operation forwarded the high-information-value streams passing through the proxy server faster than ordinary first-in first-out (FIFO) operation. In addition, we discuss the controversial issues of VCN: value definition and feasibility.

1. Introduction

The Internet's rapid development is triggering an information deluge. Annualized average traffic growth is estimated to be about 30–40% [1], [2]. If this trend continues, the traffic volume will reach 600 Tbit/s in 2025. Moreover, the traffic imbalance among users will remain unchanged. Traffic forecasts for the Internet given in Cisco's white paper [3] are plotted in **Fig. 1**. It shows that the top 1% users will generate over 1 Tbit/s per month in 2015. That paper contains descriptions such as "the top 10% generate over 60% of the traffic". Previously, users who consumed enormous network resources tended to download and upload illegal data. In the future, ordinary household usage will trigger the traffic imbalance. These forecasts show that this imbalance trend is likely to continue to 2015 at least.

However, the available resources are not infinite. From the environmental and economic aspects, networking cannot use an infinite amount of electricity. Moreover, network technologies cannot keep advancing forever. For example, the growth of optical fiber technology development, which is the basis of current network technology, might slow down at around 100 Tbit/s per fiber. One of the technical difficulties is that the power level of laser light becomes too high for optical fiber.

Although a few heavy users are draining networking resources, there has been little consideration of how to solve this problem in the Future Network. The most straightforward approach is to decrease resource consumption without decreasing the information value interchanged among network users. Furthermore, the network should maximize the information value conveyed using the restricted resources.

One of the future network visions, Content-Centric Networking [4], could decrease the total network traffic, but its use of content caching will result in other resources being consumed in greater amounts. On the other hand, Network Virtualization [5], [6] will require more networking and computing resources. Therefore, we must assume that such resource starvation will be a life-and-death issue in the Future Network.

In this article, we introduce a novel concept for the future network. Called Value-centric Networking (VCN), its main purpose is to maximize the value of information in networks and the value of the intelligence contained in that information and to maximize the contribution of networks to human society.

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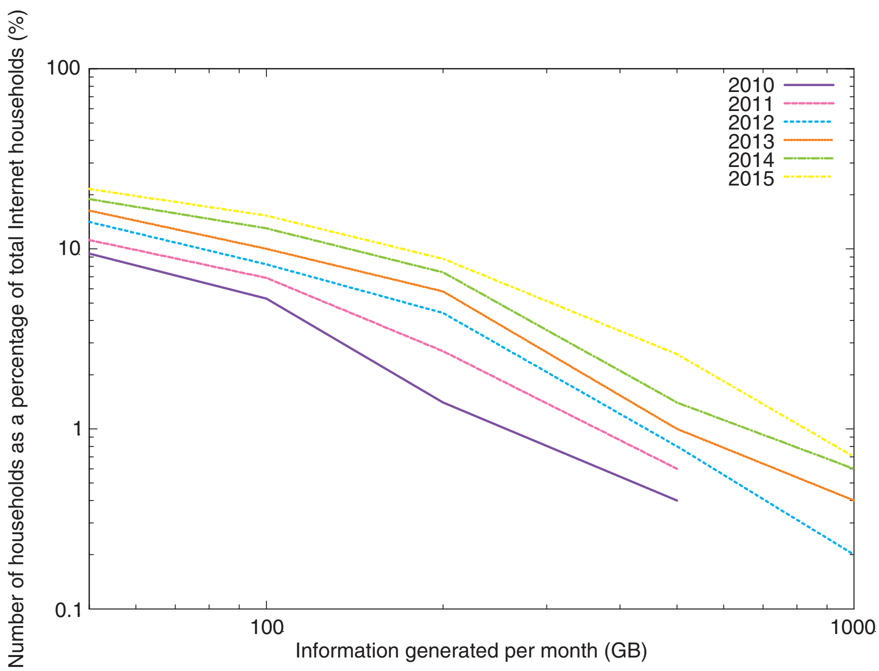


Fig. 1. Trend of Internet household traffic per month.

2. Value-centric Networking

In this section, we describe the concept of VCN and present a simple example of it.

2.1 Main objective

Here, we define the main objective of VCN. First, we define the network components as follows. We denote a piece of information by I_i, where i is the identifier of the information in the network system. Its value is denoted by v_i. The simplest objective of VCN is to maximize the sum of v_i in the network system. We assume that v_i is composed of multidimensional attributes because information has various value aspects.

Furthermore, the network must use some resources, e.g., bandwidth and electricity, when transmitting and receiving information. Let r_i denote resources that I_i uses, and let R denote all of the resources available for use. Like v_i, r_i can consist of multidimensional attributes. We assume that there are n pieces of information in the network system and define the VCN objective by the following formula.

$$\text{Maximize} \sum_{i=1}^{n} v_i I_i$$

$$\text{subject to } \textstyle\sum_{i=1}^{n} r_i I_i \leq R,\ Ii \in 0,1.$$

This is a well-known NP-hard problem called the knapsack problem. Although no algorithm is known to be the fastest for knapsack problems, Dynamic Programming (DP) can solve them quickly in practice. A greedy algorithm can give a suboptimal solution to this problem in the practical way.

2.2 Architecture

An overview of the architecture for the VCN concept is shown in **Fig. 2**. There are three domains: users, networks, and services. All layers have resource restrictions. In the user layer, a user's device has resource restrictions such as the device's battery power, central processing unit (CPU) performance, or network bandwidth. With these resources, users get information of value V_U. When users get information, networks must consume resources—mainly bandwidth and electricity. Networks convey information of value V_N, which is distributed without exceeding the resource restrictions. Services also consume resources to provide information. In doing so, services send information of value V_S and consume resources, such as bandwidth, electricity, and computing capacity.

VCN is intended to maximize all three values V_U, V_N, and V_S. However, there may be conflicts where different behaviors maximize different values. For

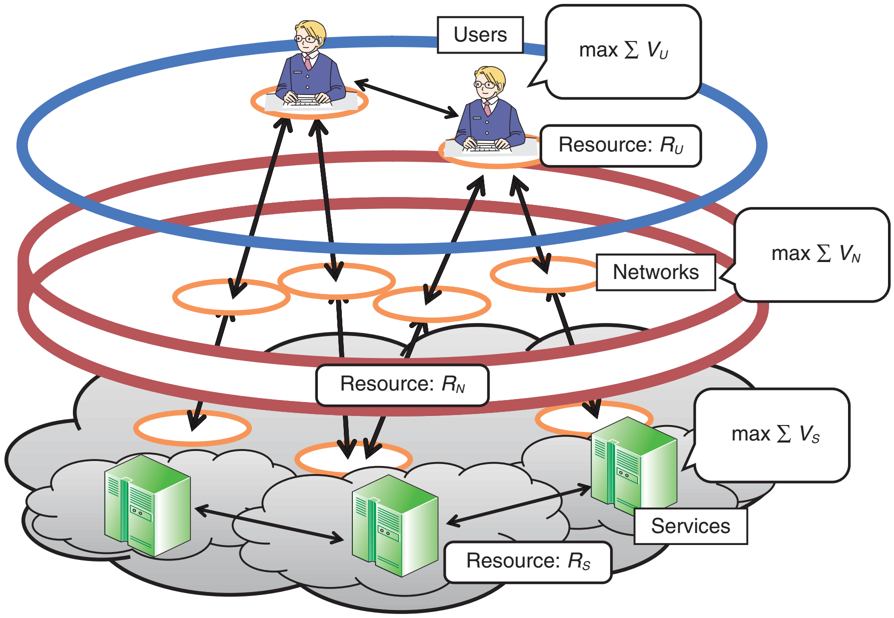


Fig. 2. Overview of VCN architecture. Big ovals represent layers requiring value maximization. Small ovals represent maximizing interfaces.

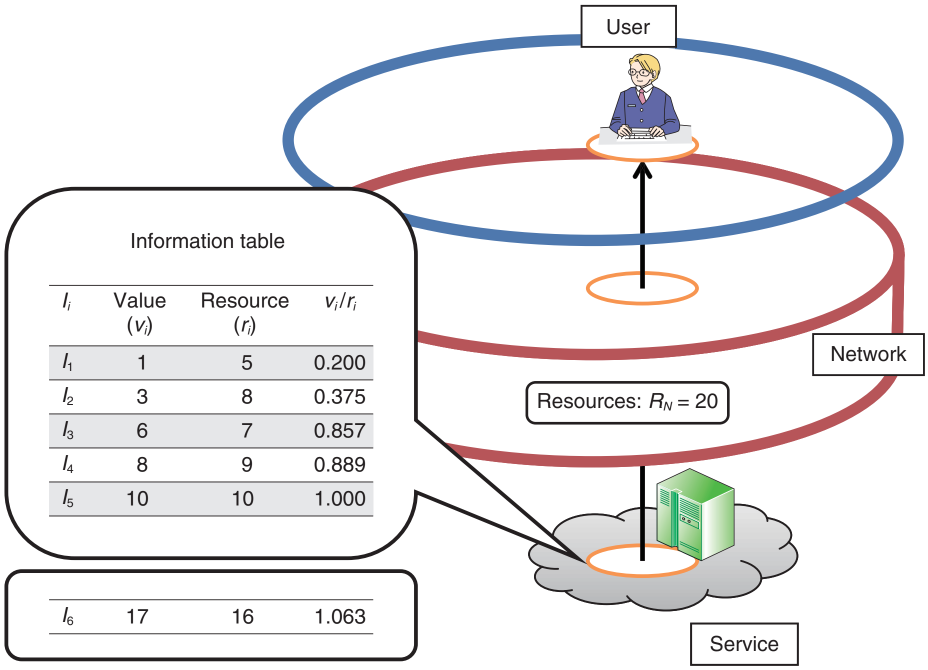
example, when there are two users, A and B, V_U is represented by A's max value (ΣV_{UA}) plus B's max value (ΣV_{UB}). However, if the network resources are insufficient to satisfy the requests of both users, then the information requested by one of the user's, either A or B, is not forwarded; this behavior maximizes V_N but not V_U.

2.3 Maximization methods

In this subsection, we describe how to get the optimal combination of information transferred. As previously mentioned, we assume that v is one of the information metrics (e.g., the popularity of the information) and is a cardinal number and that r is one of the resources, e.g., bandwidth. One of the simplest approaches is to use a greedy algorithm. The greedy algorithm for knapsack problems selects the information combinations sorted by v_i/r_i. We show one of the simplest examples in **Fig. 3**. This example shows the user getting some information, which is shown in the information table, from a service via the network. The network has restricted resources represented by $R_N = 20$. Examples of this restriction include bandwidth. First, we use the information set $\{I_1, I_2, I_3, I_4, I_5\}$. With this information set, the combination that maximizes the utilization of resources is $\{I_1, I_2, I_3\}$. On the other hand, the combination that maximizes the network value is $\{I_4, I_5\}$. These results are obviously different.

The greedy algorithm sorts the information set by v_i/r_i and returns its answer $\{I_4, I_5\}$ as a solution. The procedure for obtaining this solution is similar to quality-of-service (QoS) classification: QoS uses priority, and we can use v/r priority here for the greedy algorithm. However, it is not always true that the greedy algorithm can get the optimal solution.

If we add information I_6 to the above information set, the greedy algorithm selects only $\{I_6\}$ because its v_i/r_i is higher than those of others; this is not an optimal solution. As previously mentioned, DP is well known as one method for solving knapsack problems. DP selects $\{I_4, I_5\}$ as the optimal solution. However, its calculation cost is high because it uses a matrix table having n rows and R columns. If the number of information bits is n, then the order of the greedy algorithm is $O(n)$, while the order of DP is $O(n \times \frac{R_N}{g})$, where g is resource granularity. For VCN, this cost might be excessive. R_N, which may be bandwidth, might be a big value, such as 100 Gbit/s or 1 Tbit/s. In addition, the amount of information ranges from several bytes to several gigabytes. This indicates that if we use DP to get the optimal solution, g must be small and the DP table must be extremely large.



I_i	Value (v_i)	Resource (r_i)	v_i/r_i
I_1	1	5	0.200
I_2	3	8	0.375
I_3	6	7	0.857
I_4	8	9	0.889
I_5	10	10	1.000
I_6	17	16	1.063

Fig. 3. One of the simplest examples of VCN. A user is receiving several information streams from a service, and network resources are restricted to R_N =20.

3. Evaluation

In this section, we describe our preliminary results for evaluating VCN, which was using our prototype proxy server.

3.1 Overview

In order to evaluate the VCN concept and conduct a practical experiment, we implemented a VCN proxy server (VPS) in a system. With this system, we assumed that all connections are controlled by VPS at the network entrance. We assumed that VPS has information about the network's available resources. VPS controls the hypertext transfer protocol (HTTP) connections by assessing their values and resource consumption. Below, we describe VPS and the experimental results.

3.2 Implementation of VCN proxy server (VPS)

We implemented VPS as a Java program. VPS maximizes the value of information passing through it. We used a greedy algorithm to maximize information value because DP's calculation cost is too high. VPS behaves as follows.

When a user sends an HTTP request to VPS, VPS accepts the connection and creates a proxy connection instance. The proxy connection instance includes two connections: Client Side and Server Side. The user's HTTP request is read by Client Side. If it contains a host entry, Server Side tries to connect to the server identified in the host entry. If the connection is successful, Server Side writes the user's HTTP request to the server and reads the server's HTTP response. However, that read operation is restricted by the bandwidth controller. If the read size exceeds the restriction set by the bandwidth controller, Server Side suspends the read operation. Under the restriction, Server Side forwards the HTTP response to Client Side, and Client Side sends the HTTP response to the user. Server Side and Client Side have trash queues for storing packets forwarded from the server. A connection manager analyzes packets in the trash queue and controls the bandwidth according to the connection's value (v) and the resource (r) using each connection's bandwidth controller. Value v is defined in a value table, which stores tuples of a regular expression for the universal resource locator (URL) and value v. Each connection is evaluated against the value table by using its content's URL. Resource r is defined by its content length, and the connection manager sorts the connections by v/r. The top P_v% of all connections at a given moment are allocated R_v%

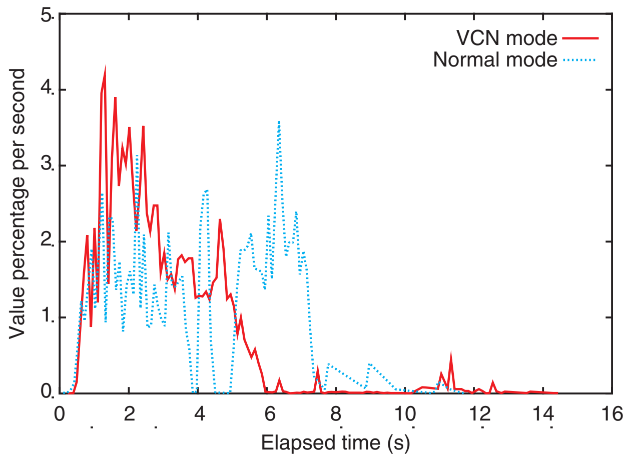


Fig. 4. Experimental results for value percentage per second.

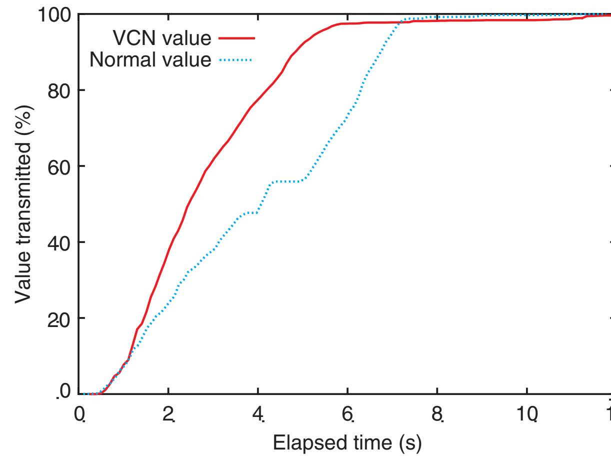


Fig. 5. Experimental results for cumulative value.

of the bandwidth. P_v and R_v can be set independently to any value. For example, setting $P_v = 50$ and $R_v = 50$ yields normal proxy server usage.

4. Evaluation results

We evaluated the effect of VCN as follows. A user browsed a web page containing many pictures via VPS. The storage size was used as the metric for resources and content. Most web browsers use several HTTP connections in rendering a web page that has many pictures. Accordingly, VPS maximized the value of information passing through itself. That is, the user received the more valuable pictures rapidly.

VPS and the Apache server providing web content were instantiated on the same server computer. The web page requested includes 64 pictures (in JPEG format) whose values ranged from low to high at random. Because the browser made one connection for each JPEG picture, this web page can emulate 64 users each getting a JPEG picture. The server computer and the user's terminal (a laptop personal computer) were linked by Ethernet via the same network switch. The total size of all 64 JPEG images was 44 Mbytes, and the bandwidth limitation of VPS was set to 24 Mbit/s, i.e., the performance limit of VPS.

We ran two trials: VCN mode and normal mode. In VCN mode, the VPS settings were $P_v = 30$ and $R_v = 90$, which means that the top of 30% of connections were able to use 90% of the bandwidth. In normal mode, VPS was configured with $P_v = 50$ and $R_v = 50$.

The value per byte of information passing through VPS is shown in **Fig. 4**, where value percentage means the percentage of the value transmitted (i.e., 100% means that all of the value is transmitted). We confirmed that high-value information was forwarded more rapidly in VCN mode than in normal mode. The cumulative value of information passing through VPS is shown in **Fig. 5**. Although both modes completed page loading at the same time, VCN mode forwarded high-value information more rapidly. This means that the user could get more valuable information before less valuable information. These results show that VCN enables users who request valuable information to get it faster than other users.

5. Discussion

In this section, we discuss two remaining issues with VCN.

5.1 Value definition

In this article, we used the term *information value* many times. However, we avoided the fundamental question of "What is the information metric?" Defining the information metric is a difficult and controversial problem. We think that there is no universal solution that will suit everyone. Our assumption is that the definition will be grounded in two fundamental principles: objectivity and cardinal number. From this standpoint, some examples of information metrics are given below.

Objectivity: The information metric should be based on engineering factors and thus not be subject to the feelings or opinions of individuals. We assume that there are two aspects: objectivity and subjectivity. Using measures associated with subjectivity prevents comparisons because they are deeply related to individual feelings. For example, subjective metrics include the beauty of movies and photos, the appeal of music, and human interest in information. By contrast, the resolution or bitrate of movies, photos, or music and the popularity of content based on the number of requests for it are objective metrics.

Cardinal number: The information value should be a quantity, i.e., a numerical value. When characterizing information by a number, we need to consider two types of number: cardinal numbers and ordinal numbers. A cardinal number expresses a numerical quantity (count) while an ordinal number indicates a ranking. An example of a cardinal value is information popularity. Popularity can be expressed by the number of people who like it, and this is a cardinal number.

5.2 Feasibility

In achieving the VCN concept, there are two main difficulties. One is the technical problems posed by VCN's need for deep packet inspection and by solutions to the knapsack problem. The calculation costs might be high enough to cause network services to suffer delay. Actually, the network performance of VPS is only 24 Mbit/s, despite its fully asynchronous operations. We believe that higher-grade computers and more sophisticated programs will run VCN at wire speed; nevertheless, electricity consumption will still be problematic.

The remaining difficult issue is "Who decides the information metric and how?" Because numerical information values are essential in VCN, the metric should be decided carefully. For example, if only the network provider determines the metric, the result may not be acceptable to users and service providers. For this issue, we think that it is important to have transparency in the valuation process. For example, users and services might request the network to provide their own values, and networks would run the value-maximizing process on the basis of those values.

6. Conclusion

Today's network allows access to rich information resources, but it is unaware of the value of the information. One of the main objectives of VCN is to make a value-aware network and maximize the value of information conveyed in the network system given the limited resources available. We assume that in VCN there are three domains requiring value maximization: users, networks, and services. Each has its own resource restrictions and information metrics. In order to evaluate VCN, we implemented it in the form of proxy server, VPS. An experiment conducted in a practical environment showed that VPS could maximize information value. This experiment used an existing browser, web server, and typical web page. Thus, it showed the practicality of VCN. Finally, we discussed two remaining issues: value definition and feasibility. We think that they should be discussed in far more detail.

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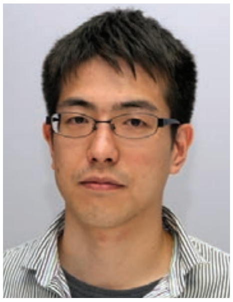

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NTT's Activities in the GreenTouch Consortium

Keiichi Saito†

Abstract

This article describes NTT's activities in GreenTouch, a consortium that is examining how to achieve a 1000-fold improvement in the per-bit energy efficiency of communications. The consortium's discussions cover a wide range from materials to methodologies. NTT, which had been an observer at GreenTouch Members Meetings, has joined in the consortium's activities by officially becoming a member in May 2012.

1. GreenTouch: mission and organization

With network traffic growing exponentially, communication networks are expected to deliver greater efficiencies and lower power consumptions in concert with worldwide energy conservation trends. GreenTouch [1] is a consortium with the mission of demonstrating and delivering by 2015 a new low-energy network that achieves a 1000-fold improvement in per-bit energy efficiency. The consortium is examining many energy reduction and elimination technologies that are needed to fulfill this mission.

GreenTouch, which has 61 members (as of June 2012), was founded in January 2010 by 13 members, led by Bell Labs and joined by network operators, university research organizations, governmental and non-profit research institutes, and equipment manufacturers (**Fig. 1**). Major network operator members include AT&T, France Telecom, China Mobile, and KT Corporation, and equipment manufacturer members include Alcatel-Lucent, Samsung, and Huawei. About half of the members are located in Europe and about a quarter come from Asia.

The organizational structure of the consortium's Technical Committee is shown in **Fig. 2**. Working groups (WGs) and study groups (SGs) are formed in response to proposals from members after approval by the overseeing committee.

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2. NTT's involvement

NTT formulated an environmental vision, THE GREEN VISION 2020 [2], as an initiative to further cut CO_2 emissions associated with communication networks by a target date of 2020. Before this vision was drawn up, the Green R&D Committee, consisting of members of laboratories spanning many research and development (R&D) disciplines, had since August 2009 been exploring the technical development side of CO_2 emission reductions and resource conservation in the areas of communication equipment, datacenters, offices, and homes (**Fig. 3**).

NTT Energy and Environment Systems Laboratories, the secretariat of the Green R&D Committee, and global production managers from NTT's research planning departments have been attending GreenTouch Members Meetings as observers since the consortium's founding in 2010 to monitor the direction of its technical discussions. NTT officially joined GreenTouch as a full member in May 2012. The Green R&D Committee secretariat selects representatives from NTT's laboratories with close links to the technical discussions in GreenTouch WGs and SGs. These representatives examine approaches toward future energy efficiency improvements and application technologies along with energy efficiency studies done at their home laboratories, and they present NTT's positions at the WGs and SGs.

61 members (as of June 2012)
9 network operators, including AT&T, France Telecom, Swisscom, China Mobile, KT Corporation, and Vodafone Group
5 equipment manufacturers: Alcatel-Lucent, ZTE, Samsung, Huawei, and Fujitsu

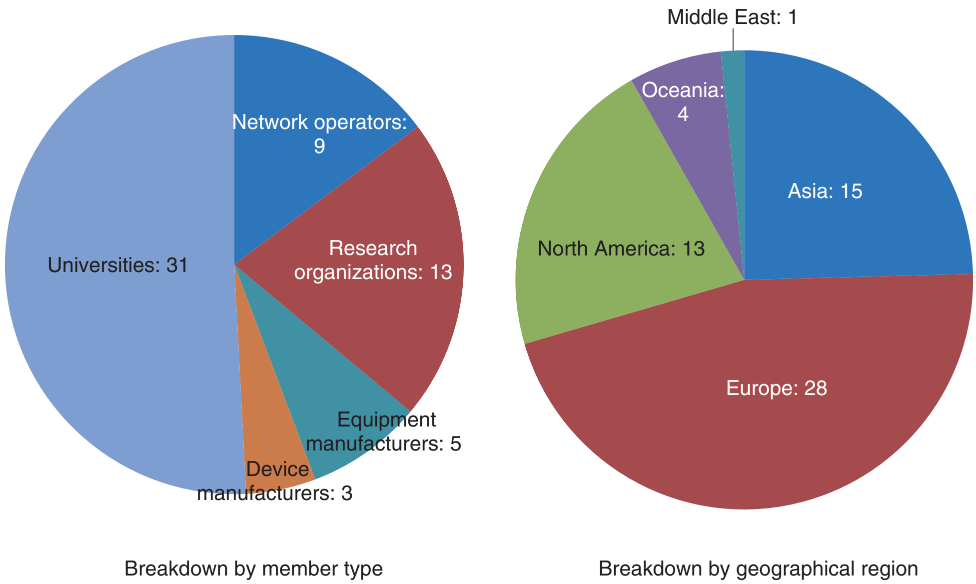

Fig. 1. Current membership of GreenTouch.

Technical Committee

- **Network Committee**
  - Core Networks
    - Core Optical Networking and Transmission WG
    - Core Switching and Routing WG
  - Access Networks
    - Mobile Communications WG
    - Wireline Access WG
    - Network Energy Modelling SG
- **Services, Applications and Trends Committee**
    - Pre-standardization WG

Fig. 2. Organizational structure of GreenTouch Technical Committee.

3. Fourth GreenTouch Members Meeting in Seattle

The fourth GreenTouch Members Meeting and Open Forum were held in Seattle, Washington, USA, on November 14–17, 2011 (**Photos 1 and 2**). This was NTT's first Members Meeting as an official member, and its representatives took part in discussions at three WG sessions closely related to technologies being studied by NTT. The topics discussed in the WGs and the committee in which NTT participated are briefly described below.

• Core Optical Networking and Transmission WG

This WG discussed energy consumption models that account for node devices and link devices in wavelength-division-multiplexing (WDM) networks as well as setting targets and technical approaches in consideration of 2015 traffic volumes with respect to the energy consumed by transponders, cross-connect devices, and optical fiber amplifiers.

• Core Switching & Routing WG

This WG has launched a university-led study that includes improving the materials and components used in devices as an energy-conservation project for communication devices. There are also plans for a demonstration proof-of-concept project based primarily in Europe that will make use of all of this

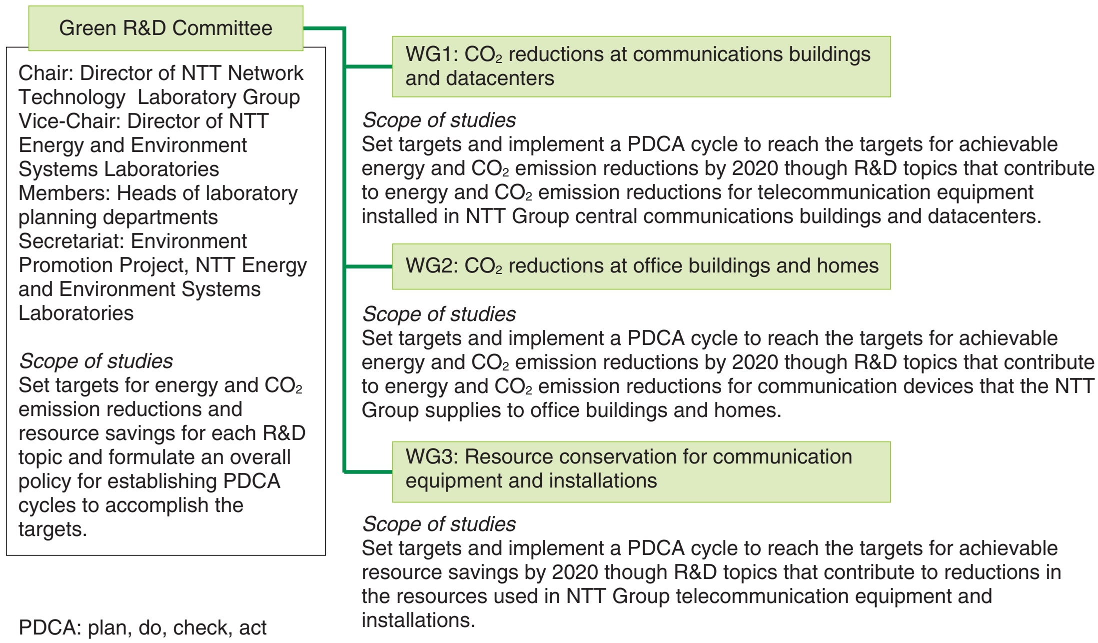

Fig. 3. Structure of NTT's Green R&D Committee.

WG's technologies.

- Wireline Access WG

This WG discussed future WDM passive optical networks (WDM-PONs) and other schemes based on current energy analyses of bit-interleaved PONs and Gigabit-capable PONs (GPONs) with respect to access networks from edge nodes to optical network units (ONUs).

- Services, Applications and Trends Committee

To better understand global traffic volumes in 2020, this committee held discussions about service categories and traffic forecasts in each service category with reference to publically available materials and testimonials from participating companies. The conclusions from these discussions are disseminated as needed to the WGs and used as inputs by the WGs for their technical discussions.

Photo 1. A meeting in progress.

Photo 2. View of the meeting venue.

4. Concluding remarks

GreenTouch is a highly influential consortium concerning the advancement of energy efficiency in the communications field, and its membership is growing amid the global trend toward reducing the burden we impose on the natural environment. The meetings are also expected to be highly significant in terms of preparation for standardization.

NTT will press forward to improve future communication energy efficiencies in conjunction with its contributions to GreenTouch, by referring to and examining the positions in each WG, with respect to the R&D and technologies that it has accumulated to ensure high-quality communications.

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Simple Tool for Inspecting Cleaved Optical Fiber Ends and Optical Fiber Connector End Surfaces

Abstract

This article introduces a tool for inspecting cleaved fiber ends and connector end surfaces. The tool's main components are a microscope, cell phone, and special holders for the fiber or connector being inspected. It does not require focal adjustment and it can be used to inspect and clearly distinguish whether a fiber has been cleaved correctly and whether there are any scratches or contamination on the connector end surfaces. This tool provides a simple and cost-effective way to inspect cleaved fiber ends and connector end surfaces in the field. It is the twelfth in a bimonthly series on the theme of practical field information about telecommunication technologies. This month's contribution is from the Access Engineering Group, Technical Assistance and Support Center, Maintenance and Service Operations Department, Network Business Headquarters.

1. Introduction

In recent years, broadband services delivered via fiber to the home (FTTH) have expanded rapidly and optical facilities are being constructed in vast numbers. As a result, the need to reduce capital expenditure and achieve efficient operation of a large number of optical facilities has increased. The importance of maintenance and management has also increased, and reducing operating expenditure has become a major issue. An effective way to reduce operating expenditure is to reduce facility faults. At the Technical Assistance and Support Center, we have targeted faults of the optical connectors used to connect optical fibers for detailed investigation and study.

In this article, we describe the functions of a support tool that allows simple on-site inspection to evaluate the quality of connection work in order to reduce the number of optical connector faults.

2. Development background

A typical configuration of facilities for providing FTTH is illustrated in **Fig. 1**. From the optical line terminal (OLT) located in the central office, underground cables and aerial cables transmit signals to optical network units (ONU) located in customers' homes. That configuration requires many connection points. Optical connectors are used in the central office, outdoors, and in customers' homes. For each connection point, either a connector produced in a factory (manufactured connector) or a connector assembled in the field (field assembly connector [1]) is chosen and used as appropriate.

2.1 Faults of field assembly connectors

In our investigation of fault causes, we collected actual defective field assembly connectors from an area of Japan and checked their optical characteristics and dismantled them to identify the cause of the fault [2] (**Fig. 2**). 12% of the faults were caused by increased optical loss due to incorrect cleaving of the optical fiber. An incorrectly cleaved fiber end is shown in **Fig. 3**.

2.2 Faults of manufactured connectors

Investigating the causes of faults of manufactured connectors, we found that contamination of the connector end surface by dust or finger oil or damage

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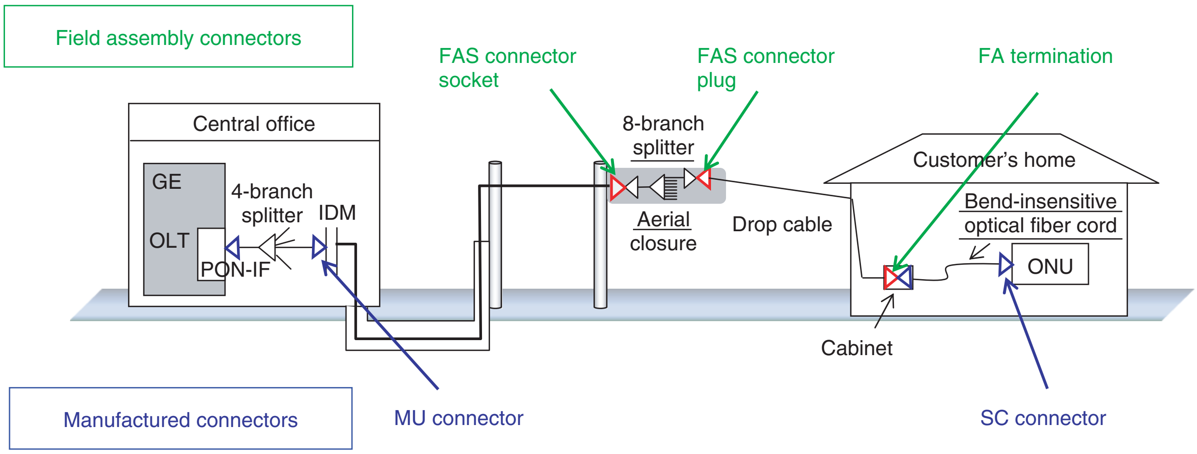

FA: field assembly
FAS: field assembly small-sized
GE: Gigabit Ethernet

IDM: integrated distribution module
FAS, MU, SC: various types of connectors
PON-IF: passive optical network interface

Fig. 1. Use of optical connectors in FTTH.

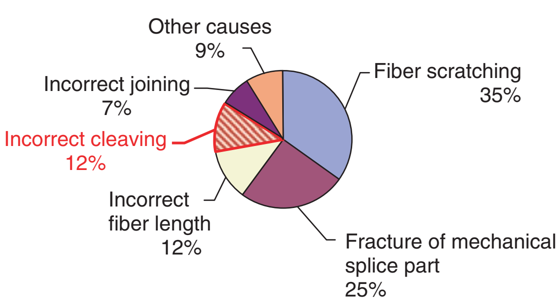

Fig. 2. Causes of field assembly connector faults.

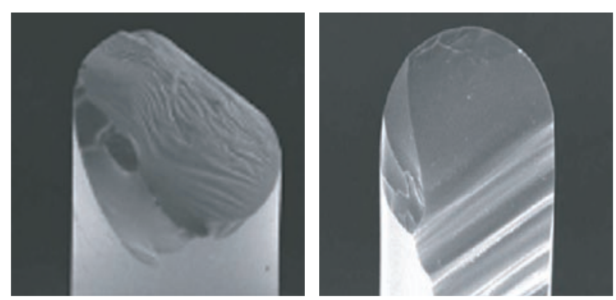

Fig. 3. Cleaved fiber ends.

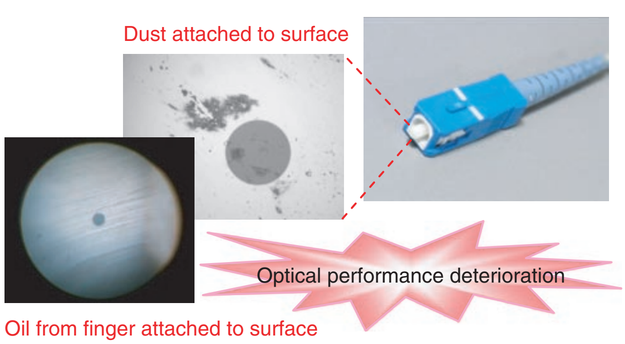

Fig. 4. Causes of manufactured connector faults.

from scratching deteriorated the optical performance and resulted in a fault (**Fig. 4**).

3. Overview of new tool

In order to reduce the two types of faults described above, it is effective to inspect optical fiber ends during field assembly procedures and during connection procedures. However, such work is usually performed outdoors and often in aerial closures high off the ground. At present, there is no suitable equipment for inspecting cleaved fiber ends and connector end surfaces at such work sites, so we developed a new, simple inspection tool for that purpose.

3.1 Design specifications

The design specifications of the tool are listed in **Table 1**. The tool should be small enough to be handled with one hand and weigh less than 500 g. Its built-in microscope should provide magnification of about ×200. It is designed to inspect the cleaved ends of optical fibers attached to field assembly holders (FA holders) and mechanical splicing holders and the end surfaces of SC, MU, FA, and FAS connectors. A cell phone display should serve as the observation screen (direct visual inspection should also be possible). The tool should be equipped with light emitting diodes (LEDs) powered by rechargeable batteries to enable inspection in dark environments.

Table 1. Design specifications of developed tool.

Size	Small enough to be handled with one hand
Weight	Less than 500 g
Magnification	About ×200
Inspection objects	0.25-mm core (FA holder, mechanical splicing holder), SC, MU, and field assembly connectors
Viewing screen	Cell phone display
Light	LEDs × 2
Power	Rechargeable batteries

3.2 Configuration and structure

The configuration of the inspection tool is shown in **Fig. 5**. For low cost and high generality, the tool is composed of three main parts: a body that includes a microscope, a cell phone and its attachment, and special holders for cleaved fiber ends or connector end surfaces.

The tool body is 157 mm high, 72 mm wide, and 57 mm deep and its weight is 250 g, so it is easy to use with one hand.

The holder for cleaved fiber ends is used to install the FA holder used in field assembly procedures. It can be used to check the cleaved optical fiber ends from four directions (0°, 90°, 180°, and 270°), so incorrect cleaving can be easily identified (**Fig. 6**).

The cell phone attachment has a horizontal adjustment slide that we developed to cope with different types of cell phones having cameras in different locations. It ensures that the cell phone's camera lens can be aligned with the tool's microscope regardless of the type of cell phone being used (**Fig. 7**).

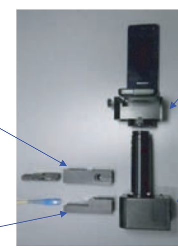

Fig. 5. Configuration of the developed tool.

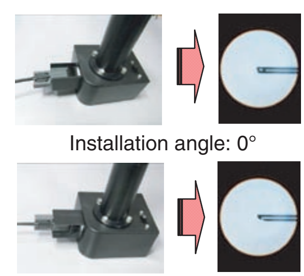

Fig. 6. Holder for FA holder.

Fig. 7. Cell phone attachment.

4. Evaluation results

The developed inspection tool and the results of checking cleaved optical fiber ends and connector end surfaces with the cell phone display are shown in **Fig. 8**. We can clearly see whether there are any defects in the cleaved fiber ends or any contamination on the connector end surfaces, confirming that it is possible to check the quality of the work visually.

Evaluation of the time required for the inspection of the cleaved fiber ends revealed that preparing the optical fiber end accounted for 72% of the task time and assembling the connector accounted for 28% of the time before the introduction of the cleaved-fiber-ends inspection. Adding the cleaved-fiber-ends

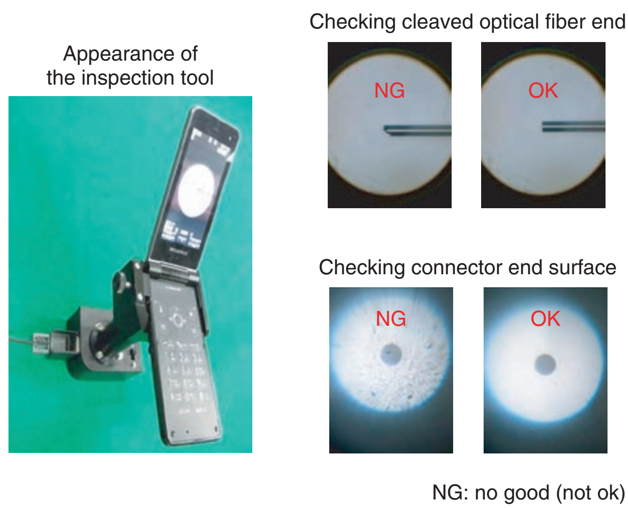

Fig. 8. Results of visibility evaluation.

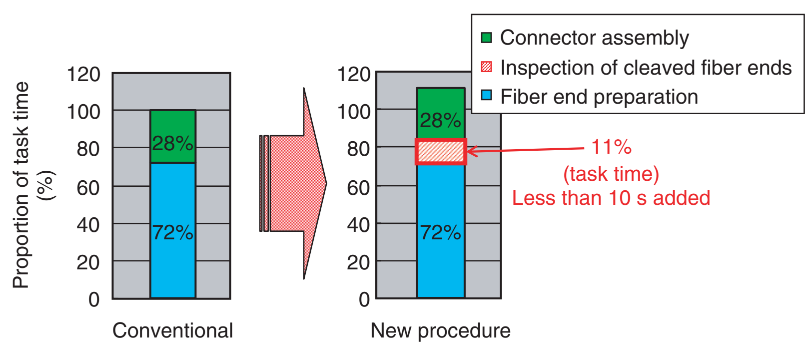

Fig. 9. Results of work evaluation.

inspection task extended the time by 10 s, taking 11% of the entire work time. This result confirms the workability of the inspection (**Fig. 9**).

5. Conclusion

The tool for inspecting cleaved optical fiber ends and connector end surfaces developed by the Technical Assistance and Support Center has good visual clarity and ease of use with good performance for field inspection of cleaved optical fiber ends and connector end surfaces. As the number of FTTH subscribers increases in the future, we can expect an increase in the use of optical connectors. Therefore, reducing connector faults will be an urgent goal, and we believe that this tool will be an effective measure for that purpose. We will continue to develop various kinds of products and support tools to contribute to efforts to reduce faults in the access network even further.

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IEEE Milestone Commemorative Lecture Report

Atsushi Oikawa† *and Norihisa Hatakeyama*

Abstract

This article reports on the IEEE Milestone Commemorative Lecture held on April 5, 2012 after a ceremony dedicating the international standardization of G3 facsimile (fax) as an IEEE Milestone. The lecture session included an overview of the IEEE Milestones Program and interesting stories about the difficult standardization process related by key personnel involved in the research and development of G3 fax at that time.

1. Introduction

A ceremony dedicating the international standardization of G3 facsimile (Group 3 fax) as an IEEE Milestone was held on April 5, 2012 at the Imperial Hotel in Tokyo, Japan. It was followed by an IEEE Milestone Commemorative Lecture consisting of three key talks. The first talk entitled "IEEE Milestones" by Dr. Eiichi Ohno, IEEE Japan Council History Committee Chair, provided an overview of the IEEE Milestones Program. This presentation was followed by a talk entitled "Redundancy Reduction Coding Methods of G3FAX for International Standardization" given by Dr. Toyomichi Yamada, Professor Emeritus of Musashi Institute of Technology (now Tokyo City University) and formerly a Senior Research Engineer at NTT Electrical Communication Laboratories. The lecture session was then concluded with a talk entitled "Role and Effectiveness of International Standardization in G3FAX" given by Dr. Yasuhiro Yamazaki, formerly a Professor at Tokai University and a Senior Research Engineer at KDD R&D Laboratories.

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2. Lecture session

2.1 Talk 1: "IEEE Milestones"

2.1.1 Introduction

Dr. Eiichi Ohno began the commemorative lecture with an explanation of the IEEE Milestones Program (**Photo 1**).

IEEE is the world's largest association of professional engineers in the electrical, electronic,

Photo 1. Dr. Eiichi Ohno, IEEE Japan Council History Committee Chair.

information, and communications fields. It was founded in 1963 out of a merger between the American Institute of Electrical Engineers founded in 1884 and the Institute of Radio Engineers founded in 1912. From the start, IEEE recognized the historical value of achievements made in the fields that it covered, and the History Committee was established as a standing committee to promote such historical information. The History Center was later established in 1980 as a specialized organization working in cooperation with the History Committee, and its base was moved to Rutgers University in New Jersey ten years later. Its activities include the preservation, research, and dissemination of historical assets in the fields covered by IEEE (**Photo 2**).

Dr. Ohno explained that, in addition to the work of preserving records and running a virtual museum, an important activity of the History Center is the IEEE Milestones Program. He described this as a program created in 1983 to provide a system for commending historic achievements that, from among epoch-making innovation in the electrical, electronic, and information fields covered by IEEE, are recognized as having occurred at least 25 years ago and having had a significant regional impact on society or industry.

2.1.2 History of IEEE Milestones

Dr. Ohno introduced key examples of IEEE Milestones from the past. These included Benjamin Franklin's work on electricity and Volta's electrical battery in the 18th century; Thomas Edison's research laboratory, Marconi's work in wireless communications, and Maxwell's equations in the 19th century; and the Fleming valve and other inventions such as radio, television (TV), the transistor, and the Internet in the 20th century. He then mentioned the IEEE Milestones dedicated in Japan—such as the Yagi/Uda antenna, Mount Fuji radar system, Tokaido Shinkansen (bullet train), and the first Japanese-language word processor—distributed in the Milestone Triangle whose vertexes indicate the three fields of seminal papers/patents in science and technology, new products and services, and industrial heritages and social infrastructures (**Fig. 1**). This diagram highlighted the fact that innovations in Japan have generally shown a good balance among these three fields.

2.1.3 Social significance of G3 fax international standardization

Dr. Ohno then turned to the Modified Relative Element Address Designate (Modified READ or MR) two-dimensional coding method developed through close collaboration between NTT and KDDI. He stressed that MR, as the most innovative and efficient

Photo 2. IEEE History Center at Rutgers University.

method for achieving G3 fax, played a major role in its international standardization and that this dedication of the international standardization of G3 fax as an IEEE Milestone explicitly recognized that role. He then pointed out that Japan's strong leadership here contributed strongly to the international penetration of G3 fax in the 1980s and its subsequent development into a well-established standard.

To conclude his talk, Dr. Ohno stressed that IEEE Milestones can be used to (1) learn from the past and blaze a trail into the future, (2) reassess technologies and engineers, and (3) preserve and share achievements.

2.2 Talk 2: "Redundancy Reduction Coding Methods of G3FAX for International Standardization"

2.2.1 Introduction

The facsimile machine was invented by Alexander Bain in the UK in 1843 some 33 years before the invention of the telephone by Alexander Graham Bell.

Dr. Toyomichi Yamada began his talk by saying the following about it: "From the beginning, fax presented a wide variety of possibilities owing to the convenience it provided in transmitting graphic information in its original form to remote locations. In practice, however, fax integrates a variety of technologies, so it is a more complicated system than TV. This complexity proved to be a drag on its development, and it took many years before fax achieved widespread use. As a result, fax was sometimes called

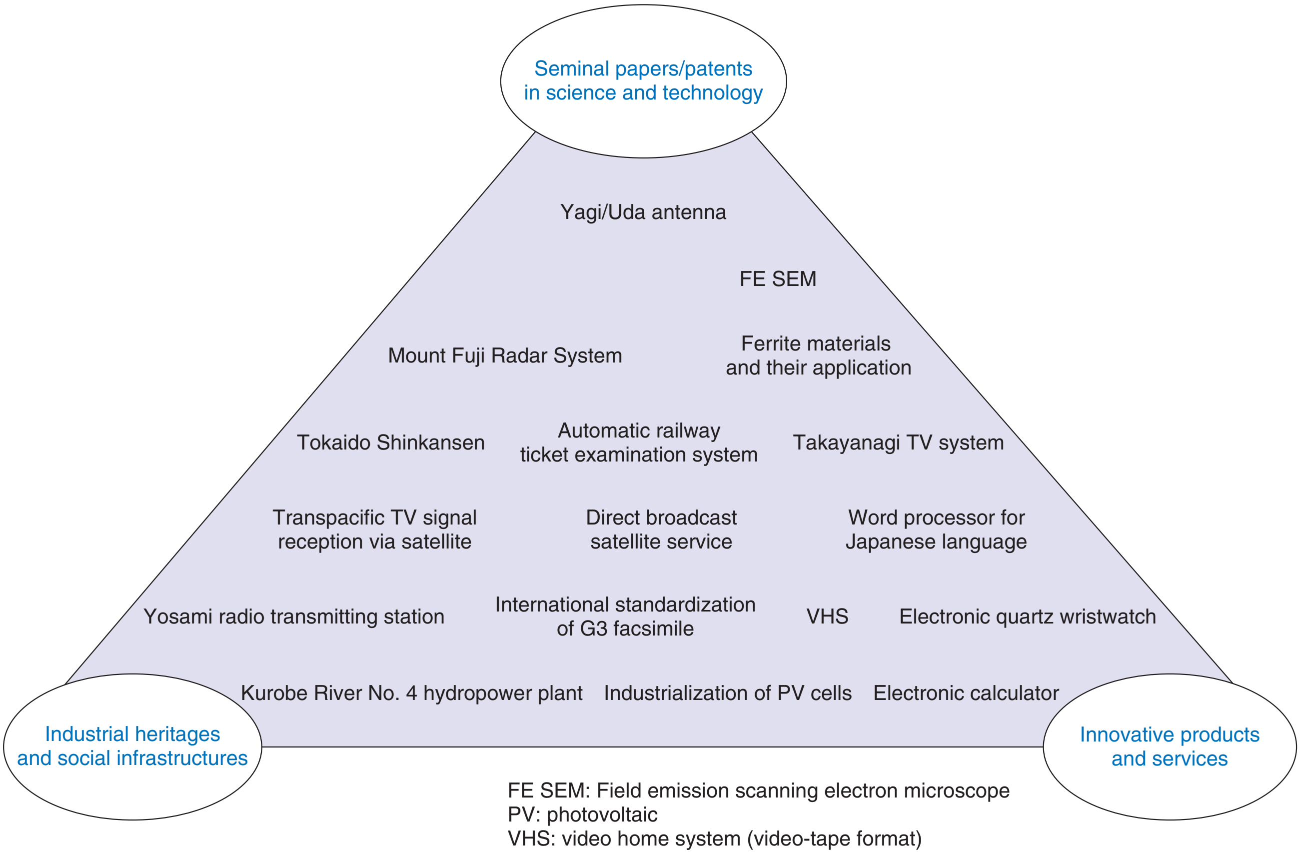


Fig. 1. Milestone triangle with dedicated milestones in Japan.

Photo 3. Dr. Toyomichi Yamada, Professor Emeritus of Musashi Institute of Technology.

a sleeping giant (**Photo 3**).

Next, he explained the principle of fax operation: the transmitter side performs a photoelectric conversion of the graphic information making up the original document and transmits the result over a communications line, and the receiver side synchronizes with the transmitter side to receive, demodulate, and record that information (**Fig. 2**).

In comparing fax with TV, a similar technology, Dr. Yamada explained that—at four million pixels—one frame of a fax transmission represents a high-resolution image having twice as many pixels as a high-definition television (HDTV) image. Moreover, a TV set has no need for recording and fixing technologies, while a fax machine not only requires them, but also needs a motorized paper-feed mechanism for auxiliary scanning. He emphasized that it was for reasons such as these that widespread use of fax in society had to wait for the appearance of semiconductor technologies in the 1970s.

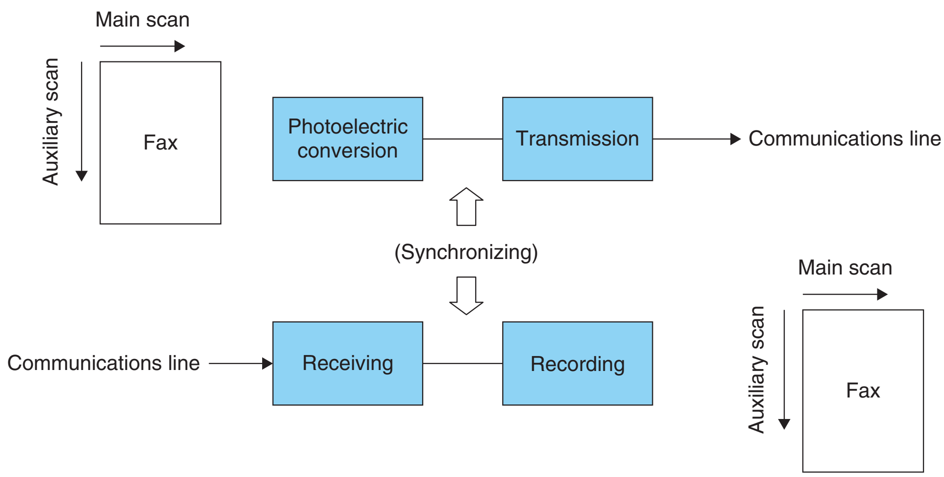


Fig. 2. Principle of fax operation.

2.2.2 Sowing the seeds of development to meet the growing need for G3 fax

The 1970s saw progress in developing a new fax system that could be used at high speed over the telephone network. Dr. Yamada provided some background about the growing need for such a new system at that time.

“Fax machines were actively used even before the 1970s as specialized equipment for specific types of businesses using leased lines, such as for the transmission of telegrams, meteorological charts, and news photographs. However, as the move toward internationalization in business progressed, the need grew for a fax system that could be used over the telephone network as an alternative to the telex machine, which required a specialized operator. Such a system would have to be capable of making international connections in a more convenient manner and of transmitting faxes at high speed with high quality.”

He then pointed out that the conditions for making such a system possible were coming to fruition in Japan as it headed into the 1980s. In short, the progress made in transistor-transistor logic, large-scale integrated circuits, and other semiconductor technologies in the 1970s, the opening up of the telephone network in 1972, the deployment of high-quality telephone circuits at data rates ranging from 4800 bit/s to 9600 bit/s, and the evolution of the information society (shift toward office automation) provided conditions in which needs and seeds finally matched, thereby awakening the sleeping giant. Furthermore, based on the “100,000-yen fax initiative” promoted by then NTT Vice President Yasusada Kitahara, work began on the development of an easy-to-operate, low-cost, compact terminal (Mini Fax) and a fax communications network service (F-Net) while the introduction of solid-state devices in photoelectric conversion technology and recording technology accelerated. These developments, as Dr. Yamada explained, provided a boost to the practical application of G3 fax, for which a compact configuration, high transmission speeds, and digital processing are essential.

2.2.3 READ method: Japan’s unified proposal for 2D sequential coding

Dr. Yamada also said that the G3 fax system was expected to be capable of transmitting one page of a standard A4-size document within one minute and that a redundancy reduction coding method was essential to achieve that. He explained that technology for suppressing picture quality deterioration was needed to achieve sharp faxes with no transmission errors and that maintaining mutual communication between two parties by an international standard was also an important issue.

A redundancy reduction coding method compresses the amount of data to be transmitted from the original document by using entropy coding (allocating a smaller number of codewords to a state having a high frequency of occurrence), as shown in **Fig. 3**. As Dr. Yamada recounted, the major problem here was finding a method to discern states with low entropy, that is, states with a high frequency of occurrence.

Dr. Yamada also explained that redundancy reduction coding methods for G3 fax can be divided into three types—one-dimensional (1D) coding, two-

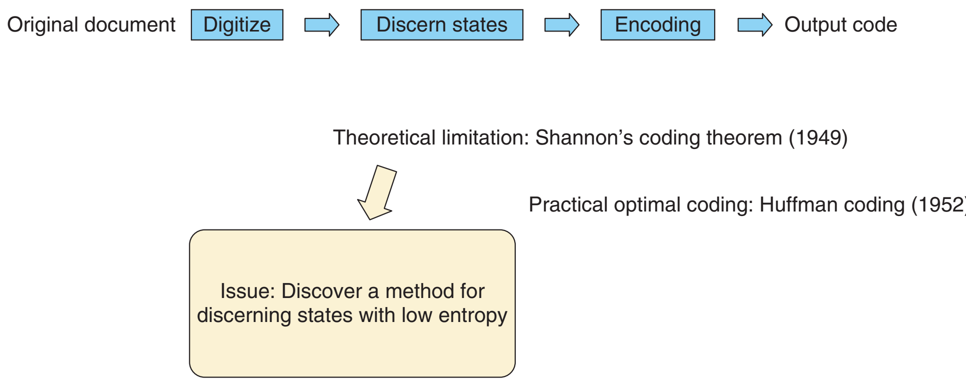


Fig. 3. Redundancy reduction coding method.

dimensional (2D) multi-line coding, and 2D sequential coding—according to the way in which the correlation between scan lines is used. 1D coding does not make use of the correlation between adjacent scan lines. Rather, it performs run-length (RL) coding for each scan line, where RL is the number of pixels of the same color occurring consecutively. A 1D RL coding method using Modified Huffman (MH) coding was later recommended as a basic method for G3 fax. 2D multi-line coding performs coding for each pair of adjacent scan lines. This form of coding was chosen for government use in Japan in 1975 by the Ministry of Posts and Telecommunications (now Ministry of Internal Affairs and Communications). Finally, 2D sequential coding performs sequential-type coding using correlation with the previous scan line.

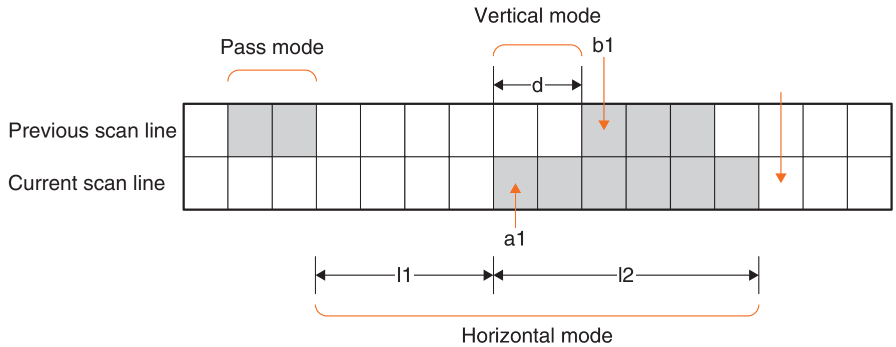
Both KDDI and NTT proposed redundancy reduction coding methods for G3 fax to the International Telegraph and Telephone Consultative Committee (CCITT, now ITU-T (International Telecommunication Union, Telecommunication Standardization Sector)). KDDI proposed the Relative Address Coding (RAC) method, which is a 2D sequential coding method, while NTT proposed the Edge-Difference Coding (EDIC) method. However, as Dr. Yamada explained, it was essential to have a single standard so that fax equipment throughout the world could communicate. Thus, to begin with, the need was felt for a unified standardization effort in Japan, and April 1977 saw the beginning of all-Japan studies bringing together industry, government, and academia in a fax-communications-method sectional meeting established by the Ministry of Posts and Telecommunications toward the international standardization of G3 fax. As a result of these studies, it was agreed that a 2D sequential coding method would be Japan's unified proposal for a redundancy reduction coding method, and that NTT and KDDI would be entrusted with drafting this unified proposal.

Against this background, NTT and KDDI went on to invent the Relative Element Address Designate (READ) method as a unified Japanese proposal integrating the RAC and EDIC methods (**Fig. 4**) and to formally propose it to CCITT. Consequently, as Dr. Yamada related, agreement was reached at the November 1979 CCITT SGXIV Kyoto meeting to adopt an enhanced READ method called Modified READ (MR), which facilitates the development of G3 fax equipment, as the single international 2D coding standard and G3 fax option that would prevent severe international competition among proprietary systems. This method was formally recommended by CCITT in 1980.

2.2.4 Rapid international penetration

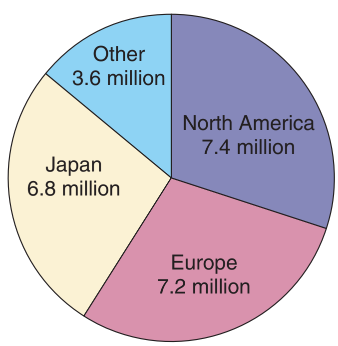
Dr. Yamada talked further about the birth of the MR method: "The READ method was designed to perform coding in either the vertical mode or horizontal mode, whichever needed the least amount of coding bits. By contrast, the MR method, which was adopted as the international standard, simplifies the READ method by performing coding in the vertical mode only for $|d| \leq 3$ and in the horizontal mode otherwise, where $|d|$ is the relative distance between transition points a1 and b1. This simplification to the original READ algorithm was submitted as a request, which Japan accepted."

The number of fax machines installed throughout the world increased dramatically following the international standardization of the MR method in 1980.



a1: the current transition pixel
b1: a transition pixel on the previous scan line
d: relative distance between transition points a1 and b1
l1: RL1 on the current scan line
l2: RL2 on the current scan line

Fig. 4. READ method integrating the RAC and EDIC methods.



Source: "History of the Facsimile," Institute of Image Electronics Engineers of Japan.

Fig. 5. Number of fax machines installed throughout the world (March 1996).

Photo 4. Dr. Yasuhiro Yamazaki, former Professor of Tokai University.

The number broke through the 25 million level in 1996 (**Fig. 5**). Dr. Yamada spoke passionately about the penetration of G3 fax machines: "It was once said that fax penetrated Japan because of the country's use of kanji (Chinese characters) but that it was not that much of a necessity in countries using alphabets. However, upon examining the ratios of installed units by region, one can see that the majority of fax machines are actually installed in North America and Europe, which indicates that fax has truly taken root in international society."

2.3 Talk 3: "Role and Effectiveness of International Standardization in G3 Fax"

2.3.1 Introduction

In the third talk, Dr. Yasuhiro Yamazaki began by looking back at the history of fax, which, though invented in 1843, took a long time to penetrate society. He talked about the problems affecting fax technology in the 1970s, when the G1 and G2 analog machines needed six minutes and three minutes, respectively, to transmit an A4-size document (**Photo 4** and **Fig. 6**).

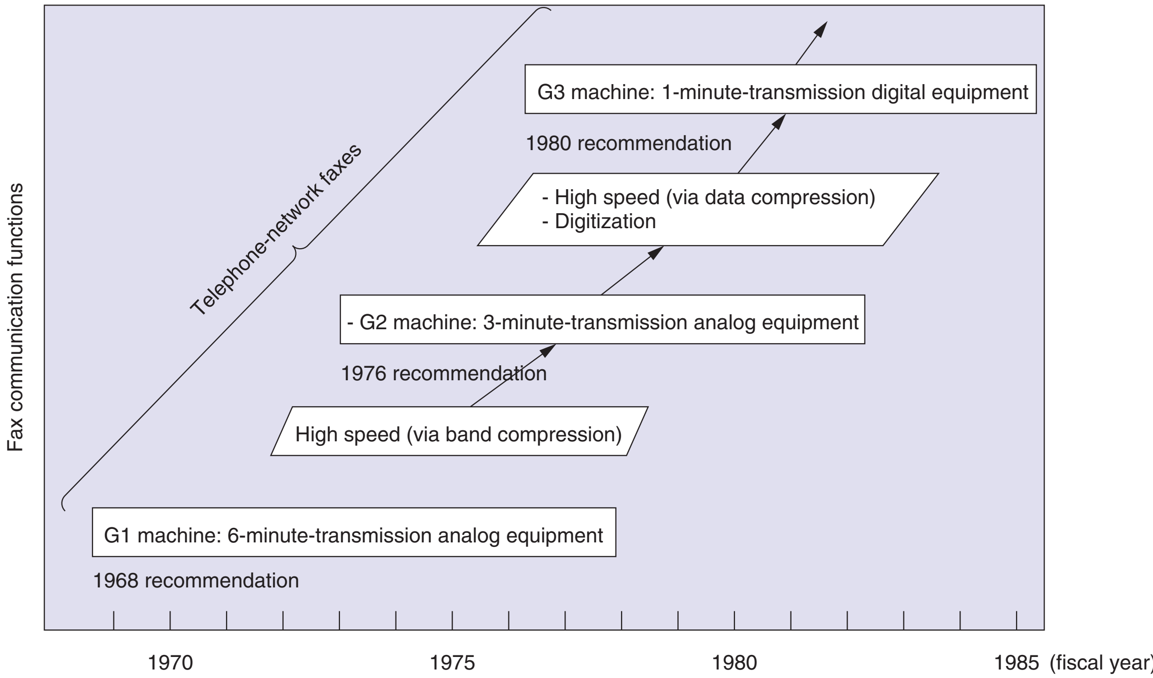


Fig. 6. Transition of telephone-network fax machines from G1 and G2 to G3 machines.

The development target set in the 1970s was a system that, through data compression and digitization, would feature 1) high speeds (where a higher compression rate reduces the communication cost), 2) high reliability (vivid, undistorted image quality), and 3) interconnectability (communication with terminals throughout the world). However, as Dr. Yamazaki pointed out, analog fax communications had been unable to satisfy such requirements, so the problem at that time was to come up with a highly efficient coding method that could enable a one-minute fax machine; that is, a machine that could transmit an A4-size document within one minute. In short, the task was to raise the accuracy of reception, maintain the reliability of fax communications so as not to distort image quality, and achieve a level of interconnectability that would enable free exchanges of documents on a global basis independent of machine model or manufacturer. Dr. Yamazaki stressed that international standardization was indispensible to meeting these goals.

The CCITT study group working on the international standardization of G3 fax met yearly in the late 1970s, holding meetings in Geneva in 1977 and 1978, in Kyoto in 1979 (**Photo 5**), and in Geneva again in 1980. Looking back at that time, Dr. Yamazaki said that "The international competition at the meetings was fierce. In addition, the official languages at the meetings were English, French, Russian, Chinese, and Spanish, so the Japanese camp had to promote the advantages of its system while trying to overcome a language handicap."

2.3.2 NTT and KDDI collaboration bears fruit.

In Japan, NTT and KDDI each developed an original coding method. However, if the ultimate goal was to achieve an international standard, Japan itself would have to create a single, unified standard in some way.

Regarding the situation at that time, Dr. Yamazaki said that "Both companies came together in a collaborative spirit under the leadership of the Ministry of Posts and Telecommunications. In the end, they came up with the READ method as a unified proposal incorporating the best points of the RAC and EDIC methods developed by KDDI and NTT, respectively; it even surpassed the compression rate of either individual method." Furthermore, concerning the naming of this coding scheme, he related that, while the name READ was originally simply a merging of the characters making up the RAC and EDIC names, the new method was later released as the Relative Element Address Designate coding scheme.

Photo 5. Kyoto international conference hall.

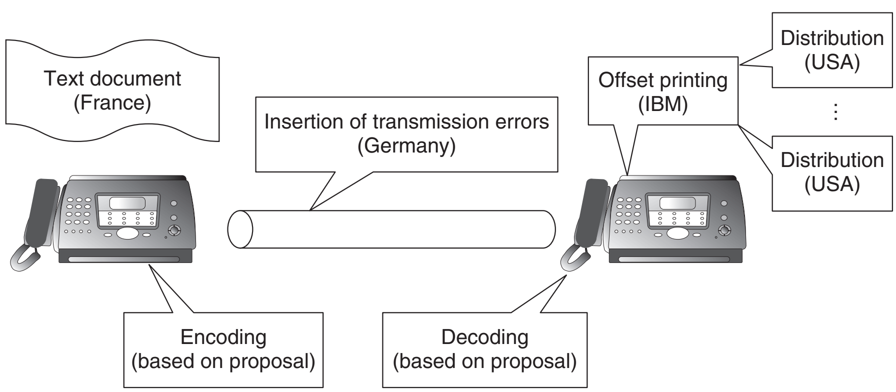


Fig. 7. International evaluation experiment performed in 1979.

Dr. Yamazaki also described how an image in a digital fax system is read from left to right (main scan) and from top to bottom (auxiliary scan) and how eight white or black pixels per millimeter are obtained in this way. He explained that there are two million pixels per A4 page even at standard resolution and four million pixels at high resolution, and that the technology for such scanning is complex.

Looking back at that time, Dr. Yamazaki said that "Countries in Europe and North America had adopted 1D coding methods that read in run lengths one line at a time on the main scan and had unified those methods as an MH scheme. By contrast, the READ method proposed by Japan was a 2D coding method that references the previous line while coding the current line focusing on the differences in elements that changed between the two lines."

2.3.3 Laying the groundwork for global connections

After it was decided at CCITT that the 1D coding standard would be the MH scheme, countries in Europe and North America gradually began to turn their attention to the effectiveness of 2D coding. Dr. Yamazaki reminisced about the time when specific 2D methods were proposed and described how each country had high expectations for such a 2D method. Consequently, when it came time for the final evaluation in 1979, an international transmission experiment by computer simulation was performed. He described how, in this experiment, France provided a

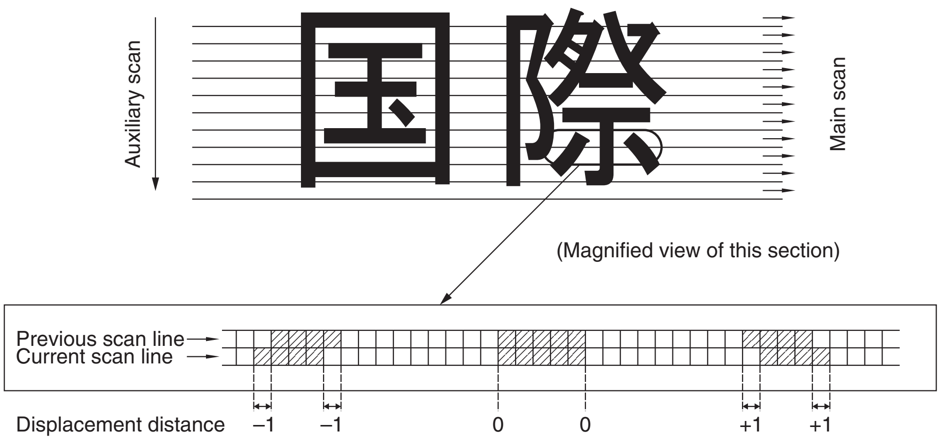


Fig. 8. Principle of the MR method.

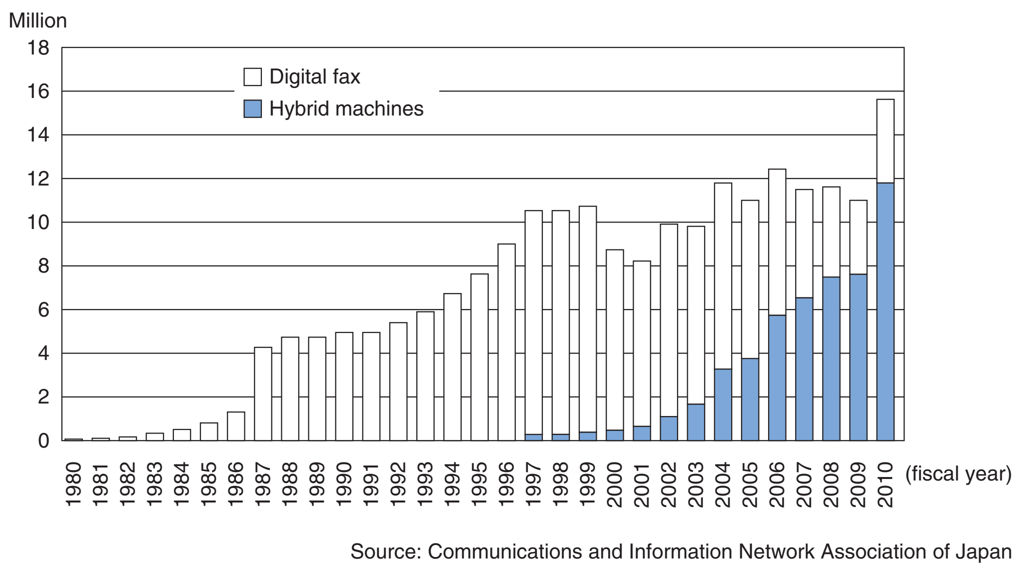


Fig. 9. Number of digital fax and multifunction machines shipped (including those for export).

standard text document on magnetic tape, Germany provided an actual error pattern collected from telephone lines, and the USA provided a means for distributing the transmitted document by offset printing (**Fig. 7**).

Here, as Dr. Yamazaki explained, the evaluation items targeted for standardization were 1) compression rate (rate of reduction in the amount of information to be transmitted by encoding), 2) image quality (reduction in picture degradation caused by transmission errors), 3) complexity (ease of equipment development), and other factors (patents etc.)

Dr. Yamazaki went on to say that “Seven coding methods including the READ method were eventually proposed by a number of countries for standardization. The results of the international evaluation experiment revealed that the READ method had the highest compression rate while no significant difference in image quality could be observed between READ and the other methods. Considering that the READ method had already achieved commercial results, its value was recognized and discussions began to take place around this method.”

He then described how, since its algorithm was somewhat complex, the READ method was revised to create the MR method and simplify the development of fax equipment.

2.3.4 Rapid penetration through a single international standard

As a result of the above efforts, the MR method was finally approved as an international standard for G3 fax (**Fig. 8**).

In 1978, there were only about 65,000 fax machines in Japan. However, following the international standardization of G3 fax in 1980, the number rose greatly. In fiscal year 2010, the number of shipped units exceeding 15 million (**Fig. 9**) with the home penetration rate reaching about 60% (including fax units in multifunction devices, personal computers, etc.). Dr. Yamazaki said that “The 2D coding method finally saw the light of day as an alternative to the 1D coding method. But in later fax equipment, the 2D coding method became mainstream and its rate of penetration accelerated on a global scale.” Such was the achievement of G3 fax standardization.

In this way, a single international standard was achieved for G3 fax resulting in a society that could exchange documents quickly by simply connecting a fax terminal to a telephone line. Dr. Yamazaki concluded his talk by saying “It was exactly this standard that achieved the interconnectability originally set as a target by CCITT. Moreover, because patent usage rights were offered free of charge, a high-reliability fax culture unrestricted by country, area, or manufacturer could grow, enabling fax connections to be made with any fax terminal in the world. Furthermore, by promoting lower prices through mass production, the G3 fax international standard created an opportunity for fax machines to rapidly penetrate not only worldwide business but also general households.”

NOTE: The affiliation of the attendees are those at the time of the report.

IEEE Milestone Dedication Ceremony for International Standardization of G3 Facsimile

Yoshihito Sakurai, Atsushi Oikawa†*, and Norihisa Hatakeyama*

Abstract

A ceremony dedicating the international standardization of G3 facsimile (fax) as an IEEE Milestone was held on April 5, 2012 at the Imperial Hotel in Tokyo, Japan. This article examines the international penetration of G3 fax and the innovation it brought to information transmission and reports on the ceremony in which commemorative plaques were presented and on the celebration that followed.

1. Introduction

Although the facsimile (fax) was invented[*1] earlier than the telephone and was expected to offer many possibilities as a new means of communication, the complexity of the constituent technologies made it difficult to achieve compact and high-speed equipment. As a result, the worldwide development and penetration of fax systems remained at a standstill for many years. In Japan, however, where ideograms in the form of kanji (Chinese characters) are extensively used, it was considered that a fax system that could transmit a written document in its original form would be highly useful. Consequently, with the opening up of Japan's telephone network in the early 1970s, the Ministry of Posts and Telecommunications (now Ministry of Internal Affairs and Communications: MIC) joined forces with academic societies, telecommunications carriers, and communications equipment makers to promote the development and penetration of a fax system for office use.

As part of this effort, NTT (then Nippon Telegraph and Telephone Public Corporation) and KDDI (then Kokusai Denshin Denwa Co. Ltd.) developed a coding method called READ[*2] that combined the best features of each newly developed coding method. This method was submitted to the International Telegraph and Telephone Consultative Committee (CCITT, now ITU-T (International Telecommunication Union, Telecommunication Standardization Sector)) as a unified Japanese proposal.

Then, on the basis of this proposal, the Modified READ (MR) method, which incorporates a few revisions to READ as requested by a number of countries to simplify the design of new facsimile equipment, became an international standard for G3 fax[*3] in 1980. This elevation to an international standard gave a tremendous boost to the international penetration of fax, resulting in a giant step forward in the way that information is transmitted in both office- and home-use scenarios.

On the basis of this worldwide penetration and innovation in information transmission, the

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*1 The fax was invented by Alexander Bain in the UK in 1843, 33 years before Alexander Graham Bell invented the telephone in 1876.

*2 READ: A coding method incorporating the features of the Relative Address Coding (RAC) method developed by KDDI and the Edge-Difference Coding (EDIC) method developed by NTT. The name READ, which was obtained by alternating the first two characters of each of these methods, stands for Relative Element Address Designate.

*3 G3 fax: A fax system for use on the telephone network that can transmit a standard A4-size document in about one minute by digitizing the graphical information and compressing the digital data. G3 stands for Group 3.

international standardization of G3 fax was approved as an IEEE Milestone, which is known throughout the worldwide engineering community as a prestigious designation. An IEEE Milestone is an award presented by IEEE*4 to recognize the historical achievement of a technical innovation in the electrical, electronic, information, and communication fields. A technology recognized in this manner must have been developed at least 25 years ago and built up significant results from an international perspective. Both NTT and KDDI were presented with plaques from IEEE commemorating this approval of the international standardization of G3 fax as an IEEE Milestone (**Fig. 1** and **Photo 1**).

Fig. 1. Plaque with inscription commemorating the international standardization of G3 fax.

2. IEEE Milestone presentation ceremony

2.1 Greetings from hosts

Representing the hosts of this presentation ceremony, Professor Tomonori Aoyama, IEEE Tokyo Section Chair, began the ceremony with an opening message (**Photo 2**). After providing some background about IEEE, which has more than 400,000 members worldwide and nine sections in Japan, he commented that 120 IEEE Milestones had been dedicated beginning with Benjamin Franklin's book entitled "Experiments and Observations on Electricity". He went on to say that the international standardization of G3 fax was the 17th IEEE Milestone dedicated to Japanese achievements, that Japan's dedications accounted for nearly 15% of all IEEE Milestones, and that Japan is the only country in Asia to have received IEEE Milestone approvals.

Professor Aoyama also said the following: "This approval of the international standardization of G3 fax as an IEEE Milestone was a result not only of the research and development efforts of NTT and KDDI but also of the support system provided by the Ministry of Posts and Telecommunications and academic societies at that time toward international standardization as well as of the efforts of various makers in advancing the development of actual hardware."

Photo 1. IEEE Milestone presentation ceremony.

2.2 Presentation of plaques to NTT and KDDI by IEEE president

Next, Dr. Gordon Day, President and CEO of IEEE, addressed the assembly (**Photo 3**). The appearance of

Photo 2. Professor Tomonori Aoyama, IEEE Tokyo Section Chair.

*4 IEEE: The world's largest professional association consisting of more than 400,000 members from more than 160 countries. It plays a leading role in a variety of technical fields including computing, biotechnology, communications, electric power, aviation, and electronics.

Photo 3. Dr. Gordon Day, IEEE President and CEO.

Photo 4. Satoshi Miura, President and CEO, NTT.

the IEEE president at an IEEE Milestone dedication ceremony is rare, so Dr. Day's attendance here reminded all present of the importance IEEE placed on this dedication.

Dr. Day talked with great admiration about how collaboration between two leading telecommunications carriers (NTT and KDDI) led to the international standardization of G3 fax. Furthermore, from a personal standpoint, he looked back with fond memory at his surprise when first using a G3 fax machine, at which time he said, "I didn't know that such an amazing piece of equipment like this actually existed!" He went on to say, "A standard format that can bring about so much innovation in society can hardly be achieved by a single technology or single company." He praised the way that multiple technologies and resources were mobilized *en masse* to give birth to G3 fax. He also commented on the efforts that were made to maintain technological transparency and to achieve a degree of openness in the process of establishing this standard. He stressed that intense intercorporate competition, instead of becoming an obstacle to mutual cooperation, actually promoted it because this standard was expected to lead to the formation of new markets. He concluded by saying, "I would like to express my deep respect to all who were involved in this great undertaking."

After his talk, Dr. Day presented IEEE Milestone commemorative plaques to Satoshi Miura, President and CEO of NTT, and Takashi Tanaka, President of KDDI Corporation. There was much applause.

2.3 Greetings from NTT President and CEO

Satoshi Miura, President and CEO of NTT, talked about the work that was undertaken to achieve high-speed, low-cost, and compact features to promote the penetration of fax communications after the opening up of the telephone network in 1971 and the efforts made toward standardization of G3 fax (**Photo 4**).

Mr. Miura also talked about the road to widespread fax use. He said, "The launching of the F-Net Service that provided flat-rate communications throughout Japan and the birth of fax machines with a market price under 100,000 yen accelerated the penetration of fax machines after the international standardization of G3 fax."

In addition, he expressed his deep gratitude to the all-Japan effort of the Ministry of Posts and Telecommunications, academic societies, communications equipment makers, and other parties, since their efforts in forming an international market and expanding the spread of fax was directly related to this IEEE Milestone approval.

Mr. Miura concluded his talk by saying, "The social mission of communications is becoming all the more important in the light of the Great East Japan Earthquake of 2011. Looking forward, we at NTT will continue our efforts in research and development toward the creation and penetration of new services with the aim of contributing to the advancement of global society."

2.4 Greetings from KDDI President

Takashi Tanaka, President of KDDI Corporation, began by expressing his gratitude to the Ministry of Posts and Telecommunications, academic societies, and various communications equipment makers. He then talked about the situation before G3 fax, when

Photo 5. Takashi Tanaka, President, KDDI Corporation.

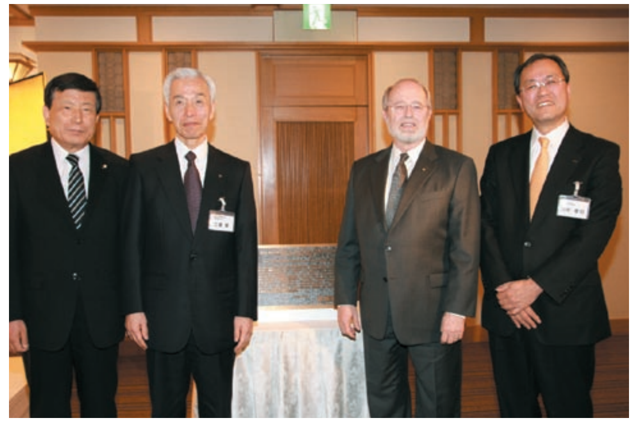

Photo 6. IEEE Milestone celebration.

international business was dominated by the alphabet-based telex machine, and the inconvenience and time delays involved in sending pictures, photographs, and other types of graphical information separately by airmail (**Photo 5**).

He said, "The appearance of G3 fax completely eliminated the frustration of using telex machines—which cannot really express Japanese—and waiting for the arrival of airmail carrying drawings and other types of graphics. Not only did G3 fax contribute to the internationalization of Japanese business, it also promoted innovation through the creation of international markets for fax machines." In short, G3 fax helped to speed up and facilitate international business dealings and communications.

Mr. Tanaka concluded his talk by saying, "At KDDI, we seek to contribute to the further advancement and internationalization of Japan with the conviction that innovation drives business."

3. IEEE Milestone celebration

3.1 Celebration

Following the IEEE Milestone presentation ceremony, more than 130 individuals from NTT, KDDI, and IEEE as well as the Ministry of Posts and Telecommunications, academic societies, and various communications equipment makers gathered together to celebrate the dedication of the international standardization of G3 fax as an IEEE Milestone (**Photo 6**).

At the beginning of the party, Mr. Miura expressed his gratitude to all concerned, saying, "This dedication commends not just those of us present here today but also the many individuals making up the all-Japan effort from the Ministry of Posts and Telecommunications and makers, academic societies, and universities who worked hard for the international standardization of G3 fax and its penetration in society."

He said, "NTT shares everyone's joy in this prestigious IEEE Milestone dedication. We hope to use this commendation as a seed of further research and development efforts with the aim of contributing to a resurgence of Japanese industry in the world."

3.2 Congratulatory messages from the Vice-Minister of MIC and other guests

Congratulatory messages were also received from various guests who honored the celebration with their presence. First to speak was Kimiaki Matsuzaki, Vice-Minister of MIC (**Photo 7**). He said, "As a representative of the Ministry of Internal Affairs and Communications, I would like to express my sincere gratitude to those of you who have said that the support system provided by the Ministry of Posts and Telecommunications at that time played a big role in getting Japan's two-dimensional MR coding method approved as the G3 fax international standard."

Mr. Matsuzaki stressed that information and communications technology (ICT) is Japan's major industry and that its further expansion holds the key to Japan's future growth. In this regard, he said, "I encourage all concerned to double your efforts as leaders in this industry to drive the expansion of Japan's technologies and products in world markets."

Congratulatory messages were also received from Professor Hideki Imai, IEEE Japan Council Chair,

Photo 7. Kimiaki Matsuzaki, Vice-Minister, Ministry of Internal Affairs and Communications.

Dr. Mitsutoshi Hatori, Chairman of The Telecommunication Technology Committee (TTC), and Yoshiyuki Sukemune, President of the Communications and Information network Association of Japan (CIAJ). A toast was then proposed by Mr. Tanaka of KDDI after which everyone began to socialize and engage in casual conversation. The hall was filled with anecdotes and stories from the past and friendships were renewed or fostered.

Finally, after much conversation, Noritaka Uji, NTT Representative Director and Senior Executive Vice President, and Yoshiharu Shimatani, KDDI Senior Vice President and Member of the Board, each gave congratulatory messages to conclude the celebration on a high note.

4. Commemorative lecture

The celebration party was followed by an IEEE Milestone Commemorative Lecture consisting of three talks. The first talk entitled "IEEE Milestones" by Dr. Eiichi Ohno, IEEE Japan Council History Committee Chair, described the IEEE Milestones Program. The second talk entitled "Redundancy Reduction Coding Methods of G3FAX for International Standardization" by Dr. Toyomichi Yamada, presently Professor Emeritus of Musashi Institute of Technology and formerly a Senior Research Engineer at NTT Electrical Communication Laboratories, described the development of G3 fax coding techniques. Finally, the third talk entitled "Role and Effectiveness of International Standardization in G3FAX" by Dr. Yasuhiro Yamazaki, formerly a Professor at Tokai University and Senior Research Engineer at KDD R&D Laboratories, featured interesting stories about the difficulties endured during the G3 fax standardization process. This commemorative lecture is described in more detail in the first Information article this issue [1].

5. Conclusion

The G3 fax system is still being used today in many businesses and homes throughout the world. By promoting global penetration, its international standardization has helped to change the way in which society transmits information and has made a great contribution to the expansion of various industries and the development of culture. Looking to the future, NTT wishes to use world-leading technologies to contribute to the further development of society, industry, and science and the creation of a safe, secure, and prosperous society.

NOTE: The affiliations of the attendees are those at the time of the ceremony.

Reference

[1] A. Oikawa and N. Hatakeyama, "IEEE Milestone Commemorative Lecture Report," NTT Technical Review, Vol. 10, No. 8, 2012. https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201208in1.html

NTT Received the Prize of the Commissioner of the Japan Patent Office at the 2012 National Commendation for Invention

A patented invention, "Efficient Mapping and Time Division Multiplexing for Large Capacity Optical Transport Networks (OTNs)" (PAT. No. 3529713), developed by Nippon Telegraph and Telephone Corporation (NTT, Tokyo), received the Prize of the Commissioner of the Japan Patent Office, which was presented at the 2012 National Commendation for Invention by the Japan Institute of Invention and Innovation [1]. In connection with this Prize, NTT also received the Invention Practice Service Prize, for which a commendation ceremony was held at Hotel Okura Tokyo.

This invention is related to technology for providing a new digital frame format, which is suitable for high-speed optical transmission at the rate of 40 Gbits per second per channel or higher. Having been selected for ITU-T (International Telecommunication Union, Telecommunication Standardization Sector) Recommendation G.709, this technology is being used in commercial telecommunication services and is contributing to the growth of social infrastructure on a global scale.

Mr. Noritaka Uji (center), Senior Executive Vice President, NTT, and the creators of the invention accompanied by their wives.

The National Commendation for Invention is an annual competition designed to contribute to the development and advancement of science and technology by formally recognizing creators of particularly outstanding inventions as well as persons highly notable in their ability to exploit and promote inventions. Each year, the Imperial Household extends its special consideration to encourage inventions and graciously provides funding for the Imperial Invention prize, in line with the above mission, to inventors who have made distinguished achievements. The commendation ceremony was held in the presence of their Imperial Highnesses Prince and Princess Hitachi. The inventors together with Noritaka Uji, Senior Executive Vice President, representing NTT, participated in the ceremony and received the certificates of merit and the medals.

NTT will make every effort to create outstanding technologies and intellectual properties that contribute to the development of social infrastructure.

The Prize of the Commissioner of the Japan Patent Office:
Masahito Tomizawa[†1], Yoshiaki Kisaka[†1], Yutaka Miyamoto[†1], Takashi Ono[†1], and Hiromu Toba[†2]
†1 NTT Network Innovation Laboratories
†2 NTT Electronics Corporation

The Invention Practice Service Prize:
Satoshi Miura, Representative Director and President, Chief Executive Officer, NTT

NOTE: The affiliations of the award winners are those at the time of the ceremony.

Reference

[1] Japan Institute of Invention and Innovation (in Japanese). http://koueki.jiii.or.jp/hyosho/zenkoku/2012/zenkoku_jusho_ichiran.html

External Awards

IEEE Communications Society, 2012 International Communications Quality and Reliability (CQR) Workshop Best Paper Award

Winners: Daisuke Murayama, Noriyuki Oota, Ken-Ichi Suzuki, and Naoto Yoshimoto, NTT Access Network Service Systems Laboratories
Date: May 16, 2012
Organization: IEEE Communications Society Communications Quality and Reliability (CQR) Workshop

For "Low Latency Dynamic Bandwidth Allocation for 100km Long Reach 10G-EPON".

We propose a new dynamic bandwidth allocation (DBA) method for long-reach passive optical networks (PONs) that can shorten upstream latency. In this method, the optical line terminal (OLT) allocates bandwidth to long-distance (up to 100 km) optical network units (ONUs) preliminarily and shortens the latency of long-distance ONUs. We confirmed the effects experimentally.
Published as: D. Murayama, N. Oota, K-I. Suzuki, and N. Yoshimoto, "Low Latency Dynamic Bandwidth Allocation for 100km Long Reach 10G-EPON," Proc. of 2012 International Communications Quality and Reliability Workshop (CQR2012), San Diego, USA, 2012.

ITU Certificate of Appreciation

Winner: Yoshinori Goto, NTT Service Integration Laboratories
Date: June, 2012
Organization: International Telecommunication Union (ITU)

In recognition of the contribution to ITU-T Study Group 13 standardization activities and the excellent work performed by Yoshinori Goto as Associate Rapporteur for Question 1/13 during 2011, Associate Rapporteur for Question 5/13 during 2009–2010, Rapporteur for Question 5/13 during 2011–2012 and Rapporteur for Question 25/13 during 2011–2012.

Fifth International Conference on Optical, Optoelectronic and Photonic Materials and Applications Poster Paper Award

Winners: Hiroshi Kudo†1, Yohei Ogawa†1, Takasumi Tanabe†1, and Atsushi Yokoo†2
†1 Keio University
†2 NTT Basic Research Laboratories
Date: June 3, 2012
Organization: International Conference on Optical, Optoelectronic and Photonic Materials and Applications

For "Fabrication of whispering gallery mode cavities using crystal growth".

Laser-heated pedestal growth (LHPG) was applied for the first time ever to form whispering gallery mode (WGM) microcavities on a sapphire rod. By controlling the feeding and pulling speed during the seeded crystal growth method, we could obtain a WGM cavity configuration with a smooth surface on the sapphire rod. Optical measurement revealed that the cavity has a Q-factor of 350.

IEEE Communications Society, 2012 IEEE International Conference on Communications (ICC) Symposium Best Paper Award

Winners: Ryogo Kubo†1, Masashi Tadokoro†2, Hiroko Nomura†2, Hirotaka Ujikawa†2, Susumu Nishihara†2, Ken-Ichi Suzuki†2, and Naoto Yoshimoto†2
†1 Department of Electronics and Electrical Engineering, Keio University
†2 NTT Access Network Service Systems Laboratories
Date: June 13, 2012
Organization: IEEE International Conference on Communications (ICC)

For "Bandwidth Scheduling Techniques in TDM-PON Supporting Inter-ONU Communication with Network Coding for Smart Grid Applications".

Applying network coding (NC) techniques to the traffic between optical network units (ONUs) will improve throughput, security, and reliability. This paper proposes a novel bandwidth scheduling technique to reduce the additional queuing delay at the optical line terminal (OLT).
Published as: R. Kubo, M. Tadokoro, H. Nomura, H. Ujikawa, S. Nishihara, K-I. Suzuki, and N. Yoshimoto, "Bandwidth Scheduling Techniques in TDM-PON Supporting Inter-ONU Communication with Network Coding for Smart Grid Applications," Proc. of the 2012 International Conference on Communications Symposium (ICC2012), Ottawa, Canada, 2012.

Prize of the Commissioner of the Japan Patent Office at the 2012 National Commendation for Invention

Winners: Masahito Tomizawa†1, Yoshiaki Kisaka†1, Yutaka Miyamoto†1, Takashi Ono†1, and Hiromu Toba†2
†1 NTT Network Innovation Laboratories
†2 NTT Electronics Corporation
Date: June 19, 2012
Organization: The Japan Institute of Invention and Innovation

For "Efficient Mapping and Time Division Multiplexing for Large Capacity Optical Transport Networks (OTNs)".

Research Award

Winners: Tatsuya Mori, Kazumichi Sato, Yosuke Takahashi, Tatsuaki Kimura, and Keisuke Ishibashi, NTT Service Integration Laboratories
Date: June 19, 2012
Organization: IEICE Internet Architecture Research Committee

For "Combining the outcomes of IP reputation services".

Internet protocol (IP) reputation systems establish a service that provides us with the "reputation" of IP addresses, primarily on the basis of past measurement. For instance, several domain name system block list (DNSBL) services provide a list of IP addresses published through the DNS; i.e., they return the negative reputation for IP addresses as potential origins of e-mail spam messages. As there are a lot of independent DNSBL services available on the Internet, it is crucial to combine the outcomes of those reputation systems. This paper provides simple methods that attempt to extract accurate decisions based on multiple outcomes of IP reputation systems. Using e-mail delivery logs collected at an medium-scale enterprise network, we evaluate the effectiveness of the approaches and compare their advantages and disadvantages.
Published as: T. Mori, K. Sato, Y. Takahashi, T. Kimura, and K. Ishibashi, "Combining the outcomes of IP reputation services," IEICE Tech. Rep., Vol. 111, No. 81, IA2011-1, pp. 1–6, 2011.