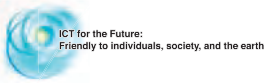
R&D Forum:
A 10-year Retrospective
2005-2014



NTT R&D: Opening up the Future of ICT

Innovative R&D by NTT

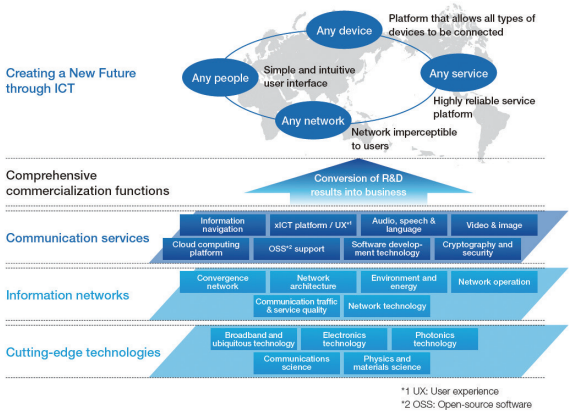
NTT R&D Creating World-Leading Technologies and Creating New Value through Collaborations

Innovative R&D by NTT

NTT R&D Initiatives

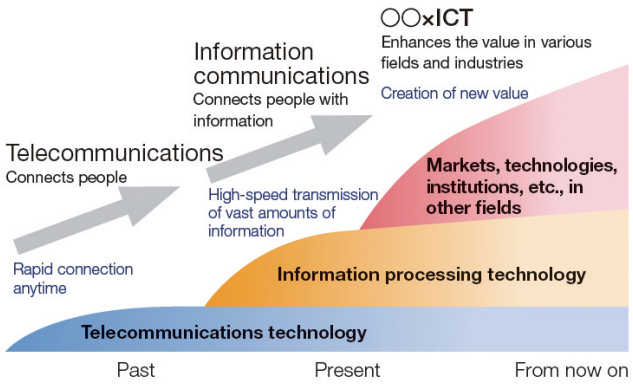
Under the NTT R&D vision of developing cutting-edge technologies that contribute to the advancement of society science and industry, NTT has approximately 2,500 researchers engaging in a wide range of diverse research activities, from basic research to R&D that supports the business development initiatives of operating companies.

R&D is the source of the NTT Group's growth potential. On that basis, the NTT Group creates competitive technologies and engages in open innovation/ collaboration initiatives with a wide range of corporations, universities, and research institutions. In this way, we strive to create new value.



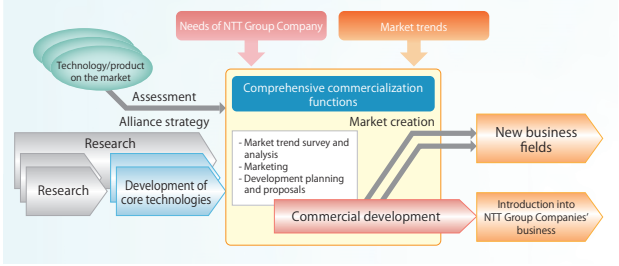
NTT R&D: Increasing Value in a Wide Range of Fields and Industries

The role of a telecommunications operator has evolved from connecting people through "telecommunications" to connecting people and information through "information communications." Moving forward, as a partner that increases value in a wide range of fields and industries, the NTT Group will strive to contribute to the resolution of social issues, such as the decline and aging of Japan's population. In addition, to increase comfort and abundance in society as a whole, we will work to accelerate the creation of new value through the provision of technologies that meet diverse needs.



Capabilities of the Comprehensive Commercialization Functions

A key to ensuring the early application of the technologies developed by the Laboratories to the NTT Group's business is our comprehensive commercialization activity, in which the commercialization team formulates marketing and business plans and forms alliances with relevant parties. As we press ahead with the full-scale deployment of next-generation services, we are creating new services through collaboration within the NTT Group and with other enterprise partners.

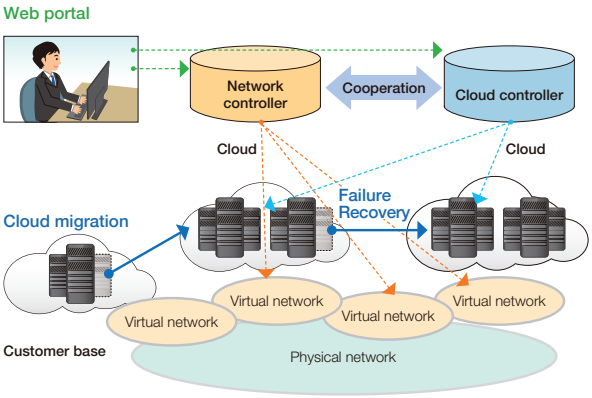


Examples of R&D Initiatives Targeting the Achievement of the Medium-Term Management Strategy

Increasing User Convenience through Cloud / Virtual Network Integrated Management Technologies

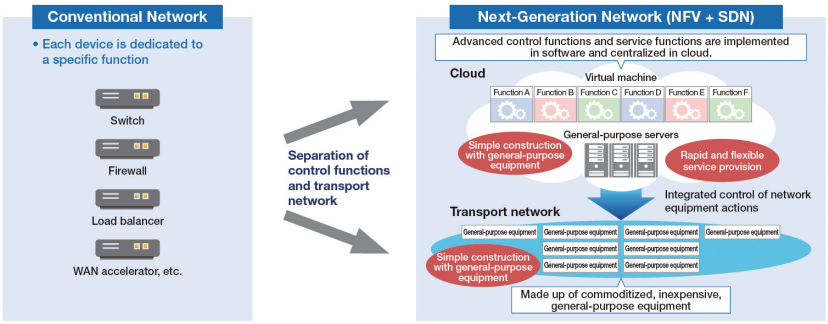
NTT Laboratories are working to add further value to the NTT Group's cloud services. To that end, we are advancing open innovation, which does not rely solely on in-house technologies, and moving ahead with R&D in network virtualization technologies to provide high added value to customers through cloud–network cooperation.

In this way, through the Web portal customers can arrange on-demand deployment of needed virtual equipment and network resources, and we can support a smooth migration from legacy systems to the cloud. Furthermore, we can increase robustness by flexibly changing network configuration and moving virtual equipment used to another data center, when a failure occures .



Strengthening Network Competitiveness

Next-generation carrier networks using virtualization technologies are one focus of our R&D activities. Using virtualization technologies—Network Functions Virtualization (NFV) and Software Defined Networking (SDN)—we have realized highly reliable network services on inexpensive, general-use servers, and have developed technologies for the flexible rapid provision of necessary services. The use of these technologies facilitates efficient network operation, and reductions in CAPEX / OPEX can be anticipated. In addition, it will be possible to flexibly provide network functions to customers and partner companies.



Base for the Development of Technology: NTT I³

In April 2013, we established NTT Innovation Institute, Inc. (NTT I³), as an R&D Base in the North America North American market, where competition is most intense. NTT I³ will advance a market-driven style and cloud computing and security technologies will play the central role in research and development activities as well as reinforce the active development of "Global Cloud Services" that are the driver of the NTT Group's growth. Technologies that meet the needs of NTT Group businesses in the North American market will be modularized as IP (Intellectual Property) and introduced globally, including to Japan and emerging countries.

NTT INNOVATION INSTITUTE, INC.

NTT Receives Top 100 Global Innovators Award for Third Straight Year

NTT has received awards under the Thomson Reuters Top 100 Global Innovators program for four consecutive years, from 2011 to 2014. This program selects innovative companies from around the world. We believe that our receipt of this award is global confirmation of the advanced state of our R&D and of the innovations and results that have been produced by our R&D programs.

2014 THOMSON REUTERS TOP 100 GLOBAL INNOVATORS

2005

NTT Group Communication EXPO

＜Key Technology＞

The Free-bending Optical Fiber Cord that can be freely bent, folded, tied and otherwise handled

In November 2005, NTT R&D developed the world's first Free-bending Optical Fiber Cord that uses "Hall Assisted Fiber (HAF)", an optical fiber with a new composition.

Because it can be used far more easily than any existing optical fiber cord, as long as there is an optical outlet in the user's home, the newly developed optical fiber cord, enables smooth communications not only when bent or tied into a knot, but even when it is folded at a right angle.

So, anybody can easily perform a DIY installation of an optical fiber cable in their room, even if they have no specialized skills or knowledge.

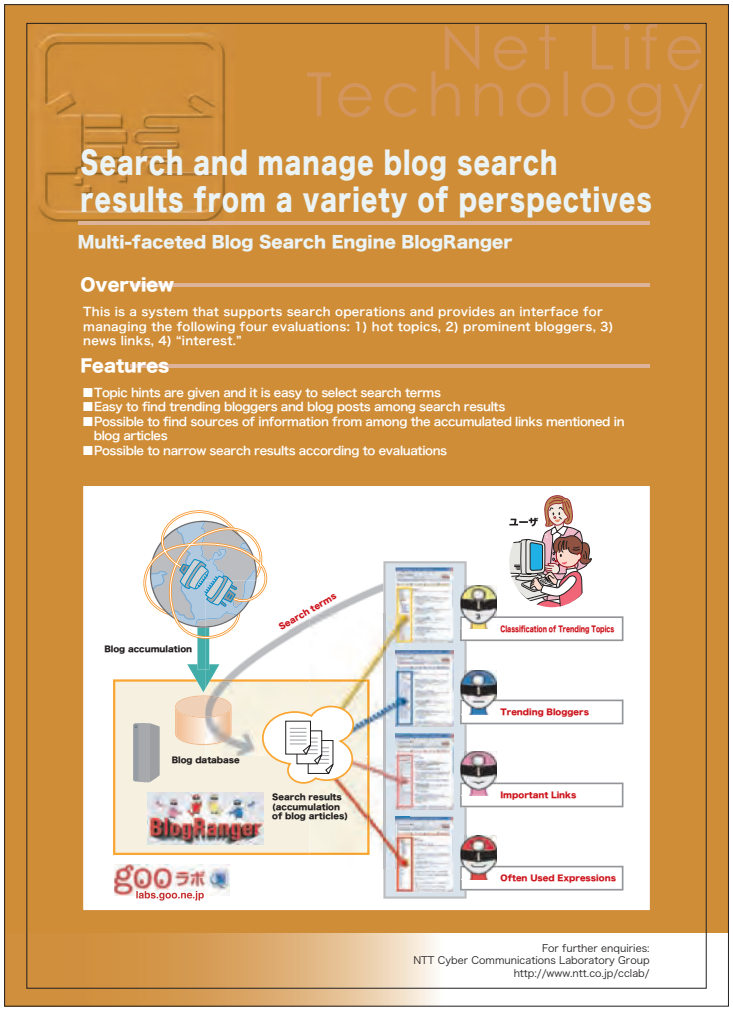
At the "NTT Group Communication EXPO" held in December 2005 to commemorate 20 years since becoming privatized, NTT unveiled/introduced various R&D initiatives for contributing to the establishment of a broadband and ubiquitous society that NTT aims toward.

＜Next Life Technology＞

Multi-faceted Blog Search Engine (BLOGRANGER)

The BLOGRANGER is a multi-faceted classification and organization search technology of keyword based search results that uses filters such as blogger, information source and evaluation to ascertain the most useful information from blogs.

After testing the technical and operational practicality of this system with a public trial service on the "goo" portal site in 2005, the technical components that make up Blogranger were commercialized for "goo" blog searches and a range of other services that use social media.



＜Natural Communication＞

Directional Automatic Gain Control Technology (Directional AGC)

Directional automatic gain control technology (Directional AGC) was planned in relation to the expectation that broadband networks become prevalent in the future, and hands-free communications such as video conferencing or video telephone will likely become widespread. This technology adjusts speech levels making them easy to understand and provides us with a convenient hands-free means of telecommunications using only one small unit even if there are many participants.

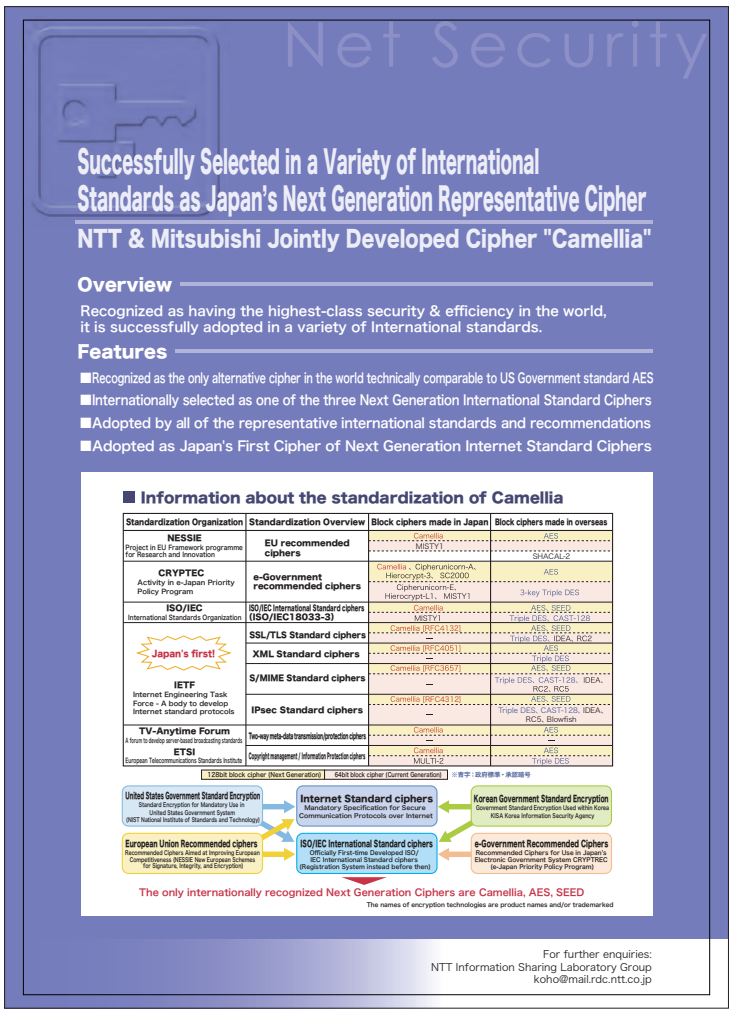
This technology is used widely throughout Group companies, including in the "MeetingBox" IP Voice Conference Terminal that NTT East and NTT West launched in January 2005, the "Real Talk 72" Echo Cancellation Device launched by NTT-AT in September 2006, and the "Real Talk C7" Compact Hands-Free Device launched by NTT-AT in May 2007.

＜Net Security＞

Next Generation International Standard Cipher "Camellia"

Camellia is a block cipher that was jointly developed in 2000 by NTT and Mitsubishi Electric Corporation. Camellia is simultaneously equipped with excellent security and performance and can also be built into high-speed software implementation independent of the platform.

In 2005, it became the first cipher developed in Japan to be adopted by Internet-related standards such as SSL/TLS and IPsec. Then, in 2007, it became the first Japanese developed cipher to be adopted into many major international open source software such as OpenSSL, Linux and Firefox. Furthermore, in 2013 it was selected for adoption in Japan's new e-Government Recommended Ciphers List as the only 128-bit block cipher encryption algorithm developed in Japan along with the Advanced Encryption Standard (AES), the de facto standard 128-bit block Cipher adhering to U.S. government standards. Today Camellia still boasts the highest level of security and performance.



2006

R&D Forum 2007: "Towards a Communication Future Focused on People and the Earth"

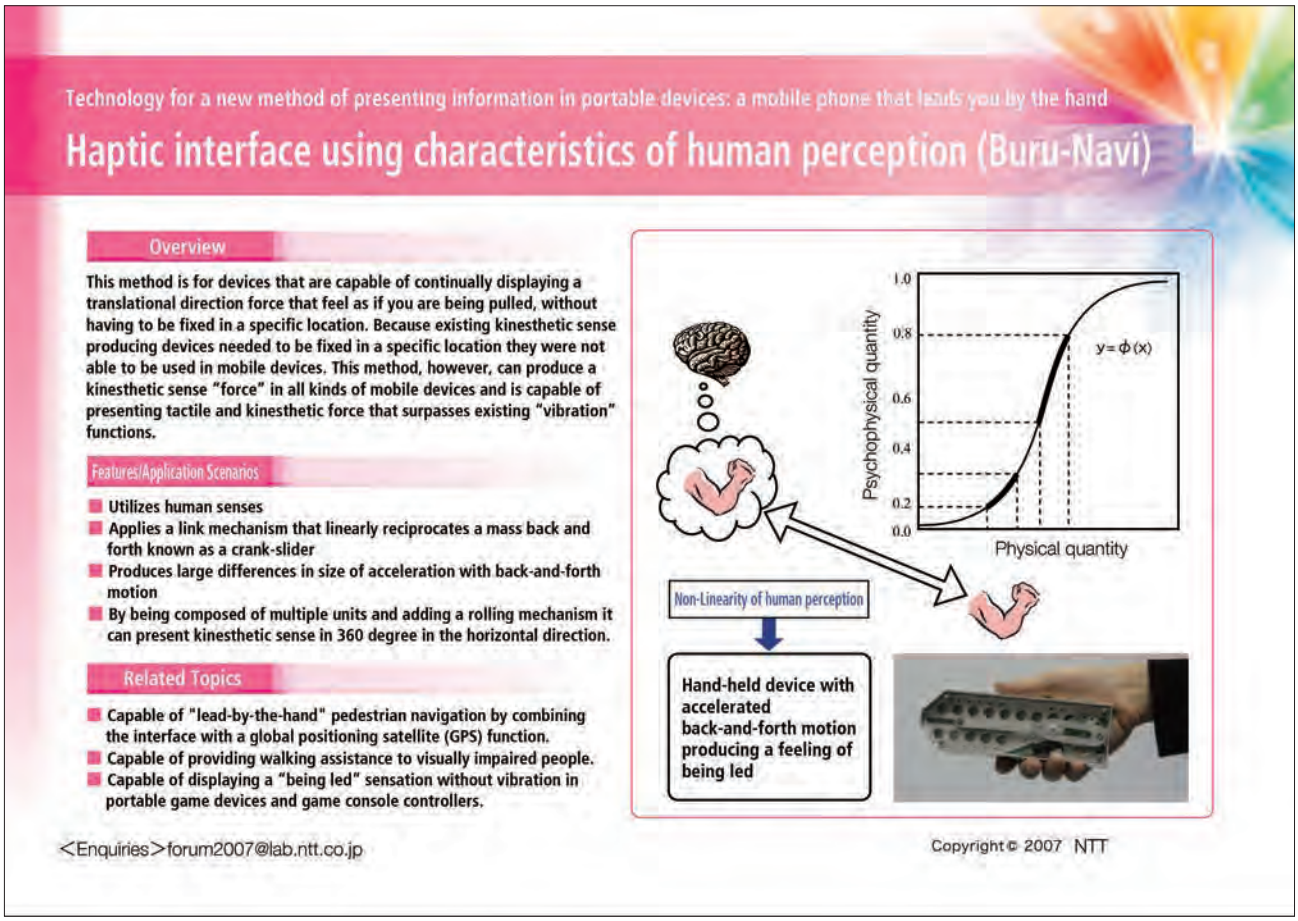
＜New Technology that will Transform the World＞

Haptic interface using characteristics of human perception (Buru-Navi)

"Buru-Navi" is an innovative gadget that stimulates human senses. It brings about an illusion for humans of being led by the hand. Humans hardly perceive a gradually applied small force, but clearly detect a great force. Because of this nature, by our innovative gadget "Buru-Navi", the illusion of being pulled is successfully created by reciprocal application of slow and quick mass-motion in antagonistic directions repetitively. Namely, Buru-Navi makes us feel directional force without any application of real external force.

Since it was first announced in 2004, development has been continuous and the current "Buru-Navi 3" that was developed in 2014 has achieved a "thumb size" device, making it over 90% smaller and lighter than previous devices. The device has gained widespread media attention and acclaim. Development of the device with plans to commercialize it are ongoing.

Buru-Navi 3



Unlike in the past when NTT laboratory groups held separate R&D forums, this year a unified NTT R&D Forum 2007 dedicated to the theme was held which featured the steady progress NTT R&D initiatives are making toward realizing the Medium Term Management Strategy and core technological developments.

＜Contribute to Near-future Lifestyles＞

Sentiment Analyzer "HYOBAN Cloud"

On the Internet nowadays, word-of-mouth information, so-called "opinion information", written on CGM (such as blogs and bulletin boards) is attracting much attention as a factor that strongly influences consumer behavior. This opinion-information indexing technology was developed by NTT R&D to more easily and precisely access such opinion information posted on the Web by performing analysis of text and extraction of opinion information.

This technology was commercialized in May 2007 on NTT Group's comprehensive portal site "goo" as "goo Opinion Analysis service." In July 2011, it began to be provided as a service on NTT Communications' "BuzzFinder," and from April 2014 it was used in NTT Data's service for Twitter data analysis. Furthermore, it is used widely throughout NTT Group Companies.

How is this word being talked about? Blog voices understood at a glance.

Sentiment Analyzer "HYOBAN Cloud"

Overview

Displays automatically extracted and accumulated sentiment (like/unlike/convenient, etc) from blogs when a chosen keyword is searched such as a product name, shop name or service name.

Features / Usage scenes

- Provides timely information on how a new product is being talked about
- Can be linked to unexpected "realizations" and "discovery of new value."
- Can be used for analysis of the products and services provided bv companies and authorities and can be applied to marketing areas

Related Information

- The goo laboratory's "Hyoban Cloud" is now available for public testing (http://labs.goo.ne.jp/rc/)
- By realizing technology for fast indexing of Hyoban (evaluation) information and evaluation search technology for selected keywords, various evaluation information can be quickly searched, including new keywords.

Contact address: forum 2007 @lab.ntt.co.jp

＜Information Sharing Platform Technologies＞

Countermeasure Technologies against "botnets"

NTT has developed technologies that will become indispensable in deterring threats from botnets. These technologies include a decoy terminal called a "honeypot," a bot analysis system for ascertaining bot behavior in a short time, and an integrated management system for presenting information ranging from trends and invasion routes of attacks to bot behavior in an easy-to-understand fashion.

Through being utilized in national projects including the Cyber Clean Center (CCC) Project, PRACTICE Project and ACTIVE Project, and notification of infections for users through ISPs, this technology has helped contribute to reducing the number of bot infections within Japan.

From now onwards, we will continue research and development on collection and analysis technology like client-type honeypots for handling diversified and sophisticated infection routes and other new malware.

Reliable Capture Technology for Bots based on Attack Detection Mechanism and Rapid Bot Active Analysis Technology

Countermeasure Technologies against "botnets"

Overview

Botnets, the infrastructure for internet crime such as DDoS attacks, spam mail and other similar things, are one of the main causes of anxiety about internet usage. As our countermeasure to these botnets, we have put efforts into capture technology for bots which construct botnets and dynamic analysis technology. These technologies are used to identify victims of bots and alert them if they are not already aware, allowing them to make countermeasures. Furthermore, they can quickly analyze the influence the bots have on networks and servers and deploy the necessary countermeasure.

Features/Usage Scenes

- Understand the situation of cyber attacks and bot infections in network operation departments and SOC (Security Operation Centers)
- Use as information sources for alerting bot infected users and leading to quarantine networks
- Utilize collected information to guard against networks damage caused by bots

Related Information

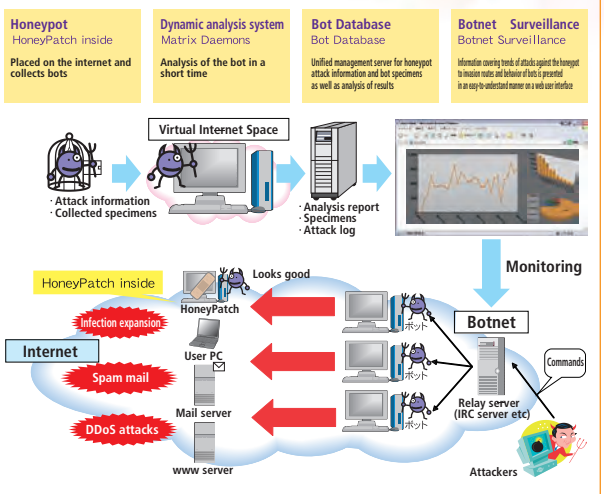
Honeypot Technology

- Accurate detection of security holes open to attack
- Bot collection and identification of infected users

Dynamic Bot Analysis Technology

- Monitoring behavior of bot in virtual internet space
- Automatic judgments of communication protocols sent by bots
- Countermeasures for analysis evasion techniques such as virtual machines detection

Countermeasures against botnet



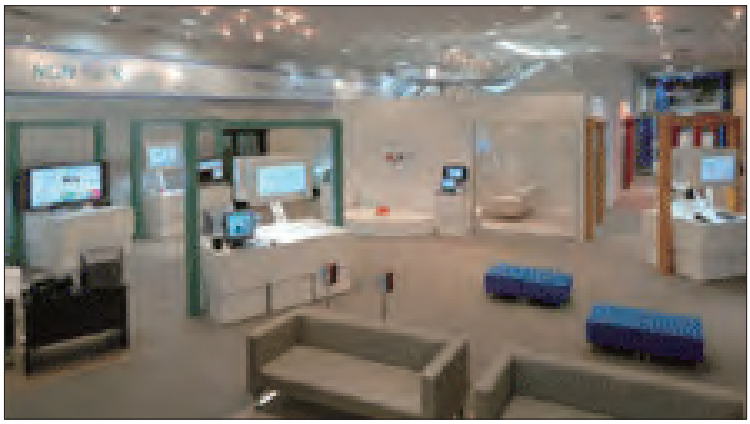
Contact address: forum 2007 @lab.ntt.co.jp

＜Information Sharing Platform Technologies＞

Start of NGN Field Trials

In November 2004, NTT Group had announced in their Medium-Term Management Strategy to lead the industry in launching the Next Generation Network based on fiber access and full IP system. NGN is a new network infrastructure that has both characteristics of legacy telephony systems, such as high-quality, reliability and security, and that of IP networks, such as flexibility and economy. Development of the technologies of NGN was led by the NTT R&D.

In December. 2006, NTT had opened the NGN showroom called "NOTE", while starting the field trials. In the field trials, NTT Group had verified new solutions to achieve scalability and high quality. As a result, "FLET'S Hikari Next Service" was launched in March 2008 as a commercial NGN service in Tokyo and Osaka.



NOTE Otemachi Showroom

Field trial in progress

2007

R&D Forum 2008: "Towards a New World of Communication brought by Sharing of Contextualized Knowledge"

<Life>

An NTT Invention! Wideband Speech Coding Standard Interoperable with Conventional Telephones

With the increasing popularity of broadband access networks, NTT R&D has developed scalable wideband speech coding, UEMCIP, which provides high-quality speech communication on a 7-kHz frequency bandwidth and interoperability with conventional telephones equipped with G.711 codecs, and promoted it for IP-based telephony services. For more deployment of wideband speech communication, NTT has taken the initiative in standardization of a new wideband speech coding based on UEMCLIP in ITU-T. We proposed a coding algorithm in which the technologies from four other organizations are merged. The algorithm was approved as ITU-T standard G.711.1 in March, 2008.

This technology has been used for the high-quality voice service in the Hikari Denwa, or optical subscriber line telephone service, and contributed to the commoditization of high-quality voice telephone and video phone terminals.

NTT R&D: Opening up the Future of ICT

Life

An NTT Invention! Wideband Speech Coding Standard Interoperable with Conventional Telephones

New Global Standard ITU-T G.711WBE

Overview

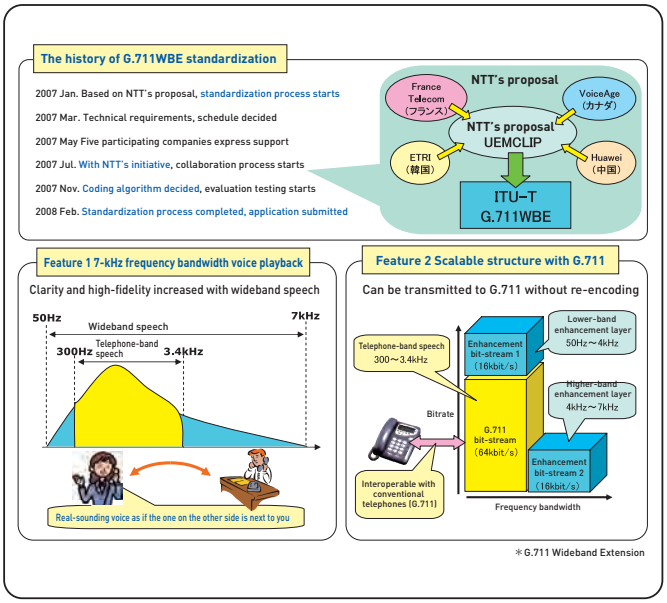
Under NTT's initiative, ITU-T G.711WBE has become a new Wideband Speech Coding Standard. By preserving the interoperability with conventional telephones equipped with G.711, this makes migration to new generation telephones that provide wideband and high-fidelity voice communications easy.

Features

- 7-kHz frequency bandwidth real-sounding voice playback
- Connection to G.711 without re-encoding
- Superior packet loss concealment in VoIP
- Multi-point audio mixing with as low complexity as that of G.711

Areas of Use

- High quality audio phones for NGN
- High quality audio soft phones for PC
- Multi-point audio conference and teleconferences



Enquiries: cc-forum@lab.ntt.co.jp

The future vision for revolutionary new technology that NTT R&D is aiming toward will produce the "Sharing of Contextualized Knowledge" by providing customers with useful information in a natural way and realizing ICT services that bring a new level of efficiency and convenience to daily life and business activities.

＜Business＞

4K Super High-Definition Video Distribution System and Digital Cinema Playback System

In 2001, NTT developed the world's first 4K Digital Cinema playback system, to show the potential of 4K video to the American film industry, and contributed to the standardization of digital cinema required for Hollywood's movies. In October 2005, major movie distributors both in Hollywood and Japan worked together with NTT group to undertake a joint trial called "4K Pure Cinema" with the aim of verifying the technical aspects and establishing new service model using the 4K Digital Cinema standard. First-run movies were successfully distributed via highly secure high-speed networks.

In 2009, the NTT Group enables the first commercial digital cinema distribution in Japan. NTT R&D's technology has been utilized to provide the extremely high security required for distributing first-run movies, movie trailers and other theatrical advertisings in real business.

Business

4K Super High-Definition Video Distribution System and Digital Cinema Playback System

Digital Cinema Delivery and Streaming Service of High Definition Video with Movie-film. Quality

Overview

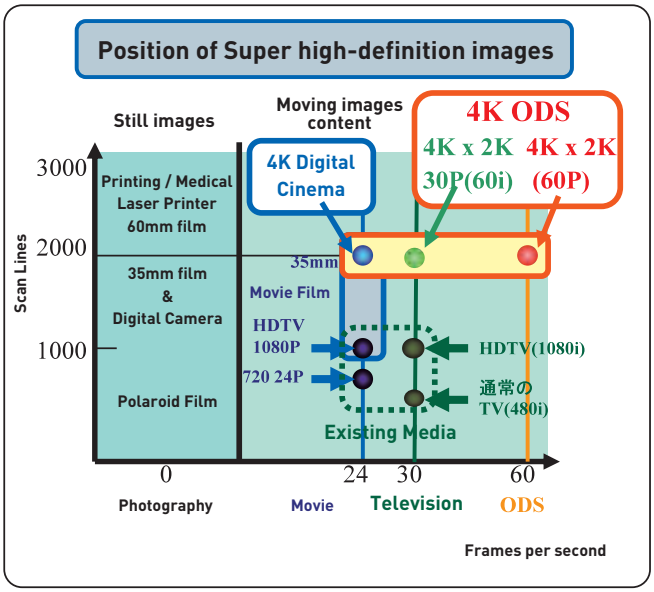
In order to realize a transmission service of high-quality digital contents using the broadband networks, we developed a 4K Video Distribution System and Digital Cinema Playback System that replace high quality movie films.

Features

- 8 million pixel images with 35mm movie film quality
- Real-time JPEG2000 CODEC
- Spatial resolution scalability using JPEG2000 compression.
- Robust image transmission with ultra high-speed error correction technology
- Compatible with Hollywood format (DCI standard) digital cinema

Application Areas

- Live viewing of sports and theatre
- High-realistic distance learning
- Digital Cinema network delivery



Enquiries: a-info@lab.ntt.co.jp

<Business>

t-Room: Telephone of the Future

t-Room is the "telephone of the future" that helps to connect people and overcome time and space. We build rooms with an identical layout, including walls of display screens on which users and objects are all shown at life size. Unlike conventional video conferencing systems, it can support users' mobility within a shared space; and symmetry of awareness and immersion in each other's space. We can meet and talk with someone else that feels just like you are in the same room even if they are far away. Furthermore, by introducing recording and playback capabilities to the activities that occur within the t-Room, we can achieve asynchronous communication that overcomes the temporal barrier.

After we unveiled the t-Room at the 2008 R&D Forum, it was placed in the NTT Group Showroom NOTE and received high praise from visitors from 2008 to 2014.

Business

t-Room : Telephone of the Future

Communication that coalesces time / distance / real / virtual for a feeling of being in the same room

Overview

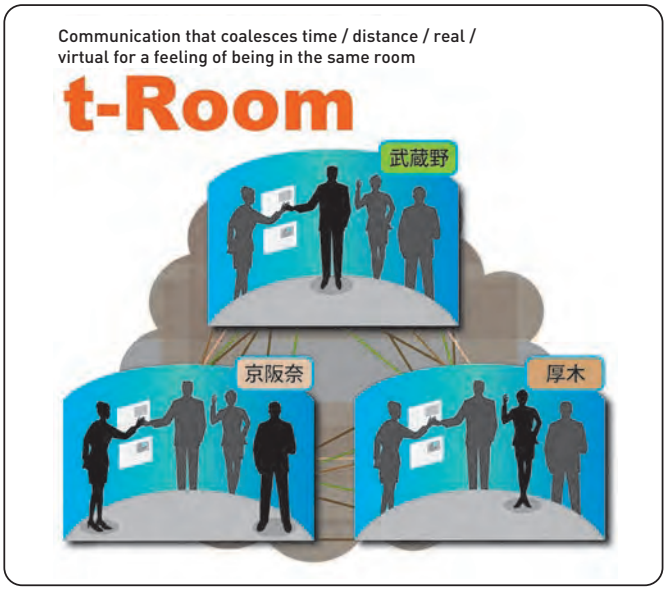
t-Room is a communication system that helps to connect people and overcomes the barriers of time and space. Unlike conventional video conferencing systems, it can support users' mobility within a shared space; and symmetry of awareness and immersion in each other's space. We can meet and talk with someone else that feels just like you are in the same room even if they are far away.

Features

- Real time transmission to remote location of life-size images
- Archiving and play-back past spaces for asynchronous communication that overcomes the temporal barrier
- Connects cyberspace and real space

Areas of use

- Telepresence
- Remote lesson
- Virtual communication tour



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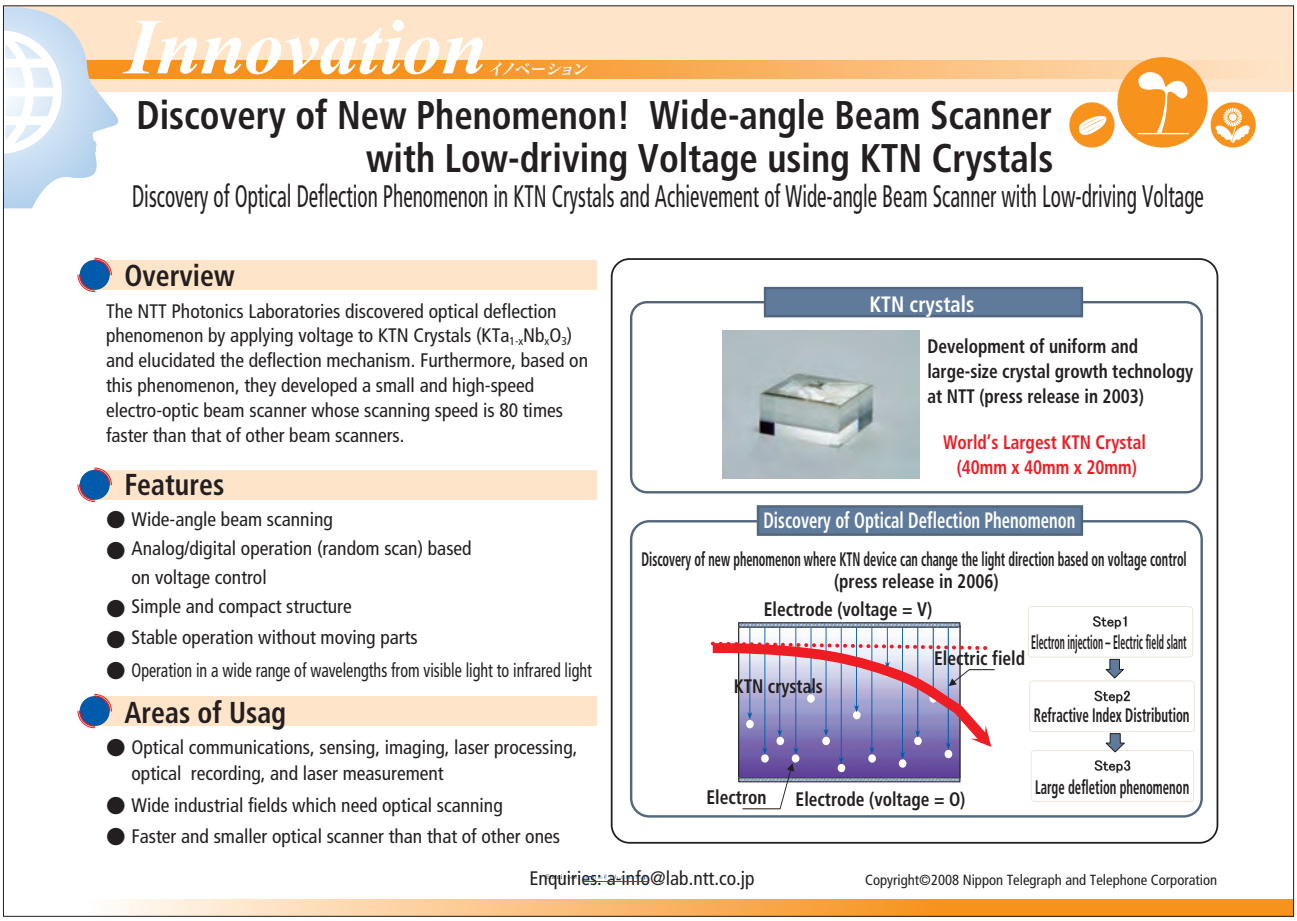
＜Innovation＞

Discovery of New Phenomenon! Wide-angle Beam Scanner with Low-driving Voltage using KTN Crystals

The "KTN-based Scanner" is an optical device which uses an electro-optic oxide crystal consisting of potassium, tantalum and niobium (KTN). This device enables us to arbitrarily deflect the laser beam direction. The deflection principle is based on the refractive index changes in KTN crystals caused by applying voltage. We focused on the fast response of KTN-based scanner which matched the needs to the optical devices for medical applications. We launched the development of the optical coherence tomography (OCT) which was useful for early diagnosis of cancer in 2010.

In 2013, we realized the fastest wavelength swept light source for OCT in the world, based on collaborative research with Hamamatsu Photonics K.K. which is a leading manufacturing company of optical equipment including medical applications.



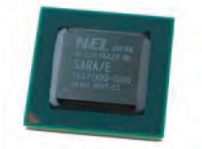
2008

R&D Forum 2009: "The NGN opens up a new chapter of communication service"

＜Themes of NGN services＞

Codec LSI based on H.264 Video Coding Standard and Transcoder

By the background of broadband's popularity and the evolution of large volume content delivery technology, there is a lot of attention and high hopes on the IPTV service that is capable of providing attractive contents and services. Along with promoting the establishment of IPTV standards, NTT R&D is verifying the equipment through a video communications trial directed toward the commencement of NGN service and made a significant contribution to realizing the launch of NTT Plala's "Hikari TV" in March 2008. Hikari TV has continued to grow and at the end of February 2015 had more than 3 million subscribers. Furthermore, based on the H.264/AVC video coding standard, the Codec LSI 'SARA' was developed. The codec is employed in retransmission of digital terrestrial television over IP service that commenced on NGN in May 2008.



CODEC LSI「SARA」

Next-generation IPTV Systems

NTT R&D FORUM 2009

SARA LSI, a codec LSI conforming to H.264 video coding standard, and transcoder systems for achieving IP retransmission services

Codec LSI based on H.264 Video Coding Standard and Transcoder

Overview

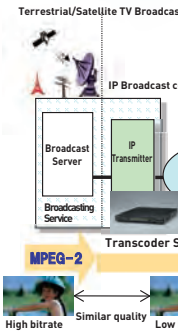
A key device and transcoder system for achieving IP retransmission of live broadcasts. Terrestrial and satellite digital broadcasts in Japan are encoded as international standard MPEG-2 streams. By transcoding these streams to the newer international standard H.264 streams, programming can be retransmitted over an IP network at a lower bitrate than terrestrial digital broadcasts, with similar image quality.

Features

- Compatible with H.264 High 4:2:2 profile for professional use
- Supports both low-latency encoding mode for video transmission, and high-compression encoding mode for broadcasting.
- Supports HDTV real-time encoding with multi-chip configuration
- Supports Highly efficient transcoding functions

Applications

- Distribution services, such as IP retransmission of terrestrial/satellite digital broadcasts
- Contribution services, such as high quality video transmission between broadcasting centers



H.264 Encoder LSI (SARA)

H.264 Decoder LSI (SARA/D)

Specifications

	SARA	SARA/D
Process	90nm CMOS	90nm CMOS
Operating Frequency	200-MHz (Max)	266-MHz (Max)
Power Supply Voltage	1.2V / 1.8V / 2.5V / 3.3V	1.2V / 1.8V / 3.3V
Power Consumption	3.0W	4.0W
Package	625-pin FCBGA (21mm×21mm)	641-pin FCBGA (25mm×25mm)

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■Please visit the website http://www.waza.jp/

Welcoming the first anniversary of the launch of NGN services, "The NGN opens up a new chapter of communication service" was the theme of this year's forum which introduced NTT R&D's various research and development initiatives aimed at full-scale development of NGN in the future.

＜Themes of NGN services＞

"Robust Media Search" Instantaneously Identifies Audio/Video Content

Robust Media Search (RMS) is a basic search technology for audio and video signals that can instantaneously detect and locate the uses of known content. An advantage of RMS is its robustness; it is extremely strong against various signal alterations, such as editing, re-encoding, and mixing with other signals. For this reason, it is currently widely used as a technology supporting the creation, distribution and consumption of media content.

For example, it is used for copyright clearance of music pieces for television and radio broadcasting, internet content monitoring, and precise audience analysis of media content viewing. We expect such media search technology will also play a key role in bridging the gaps between the information world and the real world.

Next-generation Portal Service

NTT R&D FORUM 2009

Identify the sounds and images around you, draw on various information

"Robust Media Search" Instantaneously Identifies Audio/Video Content

Overview

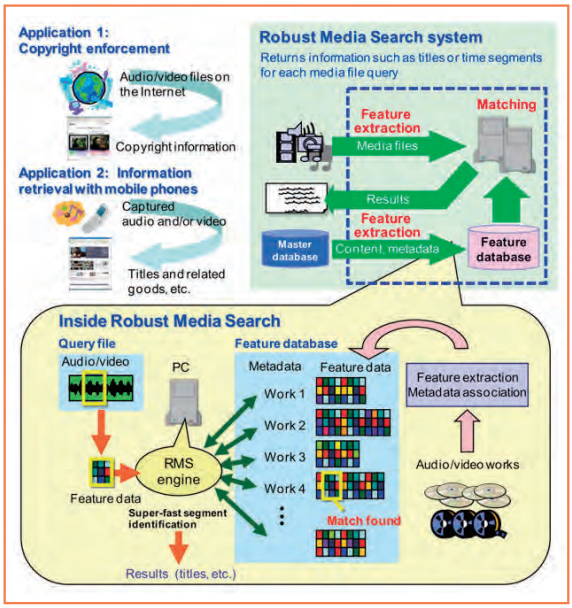
Robust Media Search(RMS) is a basic multipurpose search technology for audio and video signals.it has been used, for example, in copyright monitoring systems for video sharing sites on the Internet that can instantaneously detect the uses of known content. The most recent development not only doubles the search speed and further increases the robustness but also adds a highly distinctive search function that distinguishes very small content differences. It expands the application areas of RMS; for example, it enables version analysis or use generation tracking for audio/video content.

Features

- Fast: Enables a real-time full-scan for all the major video posting sites in the world
- Robust: Strong against noise, signal degradation, occlusion, and even editing
- Flexible: It can be customized to match a purpose or desired conditions
- Scalable: Works at various scales, e.g. on a single personal computer or on hundreds of servers

Application Scenarios

- Copyright management/enforcement on the Internet such as in video sharing sites
- Search the sounds and images around you on an internet search site
- Contents search for images, music and CM in broadcasts
- Distribution of ads that connected to other media information



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＜Themes of NGN services＞

120-GHz-band, 10 Gbit/s Wireless Transmission System

This wireless system had achieved 10-Gbit/s data transmission by using 120-GHz-band millimeter waves that had not yet been used industrially. These features make 6-channel multiplexed wireless transmission of uncompressed High Definition Television (HDTV) signals possible. In 2008, live-video transmission trials using the wireless system were carried out at Beijing Olympics in collaboration with Fuji Television network Ltd., and the practicality of the system was thereby confirmed.

In 2012, NHK Science & Technology Research Laboratories installed a system using this 120-GHz-band wireless link technology and in conjunction with NHK in 2014, a wireless transmission of uncompressed 8K videos over a distance of 1.3km had been achieved.

In the same year, the frequency allocation of 120-GHz band for broadcast service was completed in Japan and it becomes possible for this wireless link technology for 8K program productions.

Innovative technology for the future New Generation Network

NTT R&D FORUM 2009

Success with trial transmission of uncompressed high vision images for live broadcast of Beijing Olympics

120-GHz-band, 10 Gbit/s Wireless Transmission System

Overview

This system utilizes a millimeter band (120-GHz frequency band) not yet used industrially and provides high-speed wireless transmission (10 Gbit/s). These features make wireless transmission of uncompressed High Definition Television (HDTV) images on six-channel possible. In 2008, at live broadcast sites at the Beijing Olympic Games, video material transmission tests using the wireless system were carried out in collaboration with Fuji Television network Ltd., and the practicality of the system was thereby confirmed. From now onwards, this technology can be applied to, for example, large-capacity ad-hoc circuits and wireless communication between buildings equipped with 10G Ethernet.

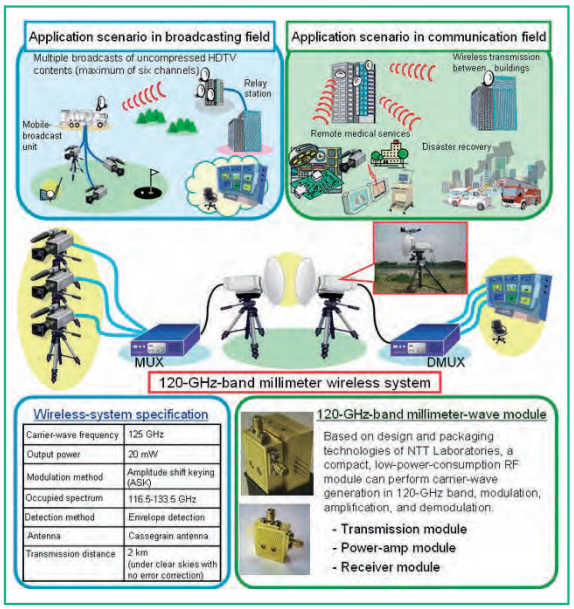
Features

- As a world's first, uncompressed HDTV-image transmission on six channels is possible wirelessly
- Transmission over maximum distance of 3 km is possible (under clear skies with forward-error-correction device used)
- Utilizing MMIC* developed at NTT Laboratories achieves compactness, weight-saving, and low power consumption with equipment of the same size and operability as existing wireless equipment for transmitting broadcasting contents
- Industrially untapped frequency band (120 GHz) is utilized, contributing to expanding radiowave resources

Applications

- Video-content transmission (without delay or picture degradation) from live broadcast sites like golf tournaments
- Large-capacity link-up line for areas where optical fiber is difficult to lay
- Ad-hoc large capacity lines for handling natural disasters, events, etc.
- Part of this research was performed as a research project called "Research and Development for Expanding Radiowave Resources" funded by the Ministry of Internal Affairs and Communications.

* MMIC: Monolithic Microwave Integrated Circuits



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＜Themes of NGN services＞

Ultra-high-capacity Long-haul Optical Transmission of 13.4 Tbit/s over 3,600 km

In order to meet growing demand in data traffic, NTT R&D has researched and developed ultra-high-capacity and long-haul optical transmission technologies. Ultra-high-capacity long-haul optical transmission of 13.4 Tbit/s over 3,600 km was successfully conducted without optical chromatic dispersion compensation at each repeaters by using QPSK digital coherent technique and frequency domain equalization in which the digital signal processing widely used in wireless communications was modified considering features of optical fiber communications.

In March 2009, this techniques were modified, and then 10 Tbit/s-class optical transmission was firstly demonstrated over transatlantic distance (7,200 km). Moreover, 100 Gbit/s multi-carrier digital coherent transmission experiment was also successfully conducted over transpacific distance (10,000 km).

Innovative technology for the future Next Generation Network

NTT R&D FORUM 2009

World record of transmission distance in 100Gbit/s/ch transmission

Ultra-high-capacity long-haul optical transmission of 13.4 Tbit/s over 3,600 km

Overview

NTT has developed an ultra-high-capacity (13.5 Tbits per second) long-haul (3,600 km) optical transmission technology to meet expected increases in data traffic. This corresponds to the transmission of 134 high vision full length feature films in one second. By 134 wavelength multiplexing the 111Gbit/s wavelength channel, it is possible to transmit with high reliability and efficiency a 100G Ethernet signal that is the standard of next generation Ethernet.

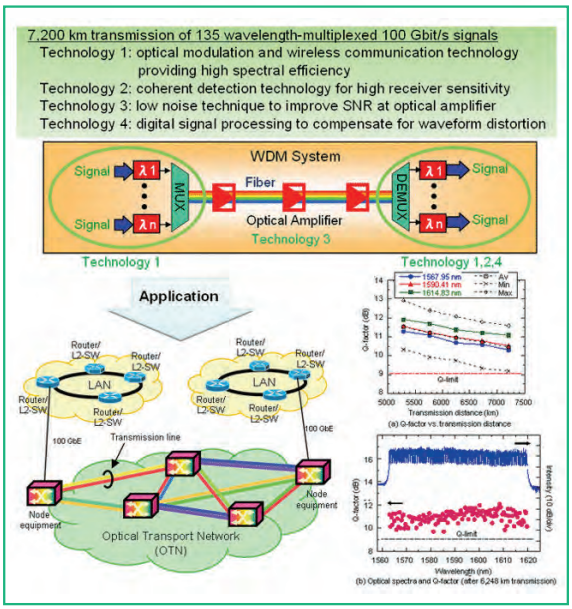
* T: Tera(1012) G: Giga(109)

Features

- Long haul transmission of ultra-high-capacity signal over 13 Tbit/s
- Guaranteed capacity to handle future increases in data traffic
- Line rate supporting 100 GbE signal
- Accommodation of client signal by using OTN technology of ITU-T standard

Application scenarios

- Backbone optical core network of NTT Communications
- Metro optical network of NTT East and NTT West



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2009

R&D Forum 2010: " ICT for the future: friendly to individuals, society, and the earth"

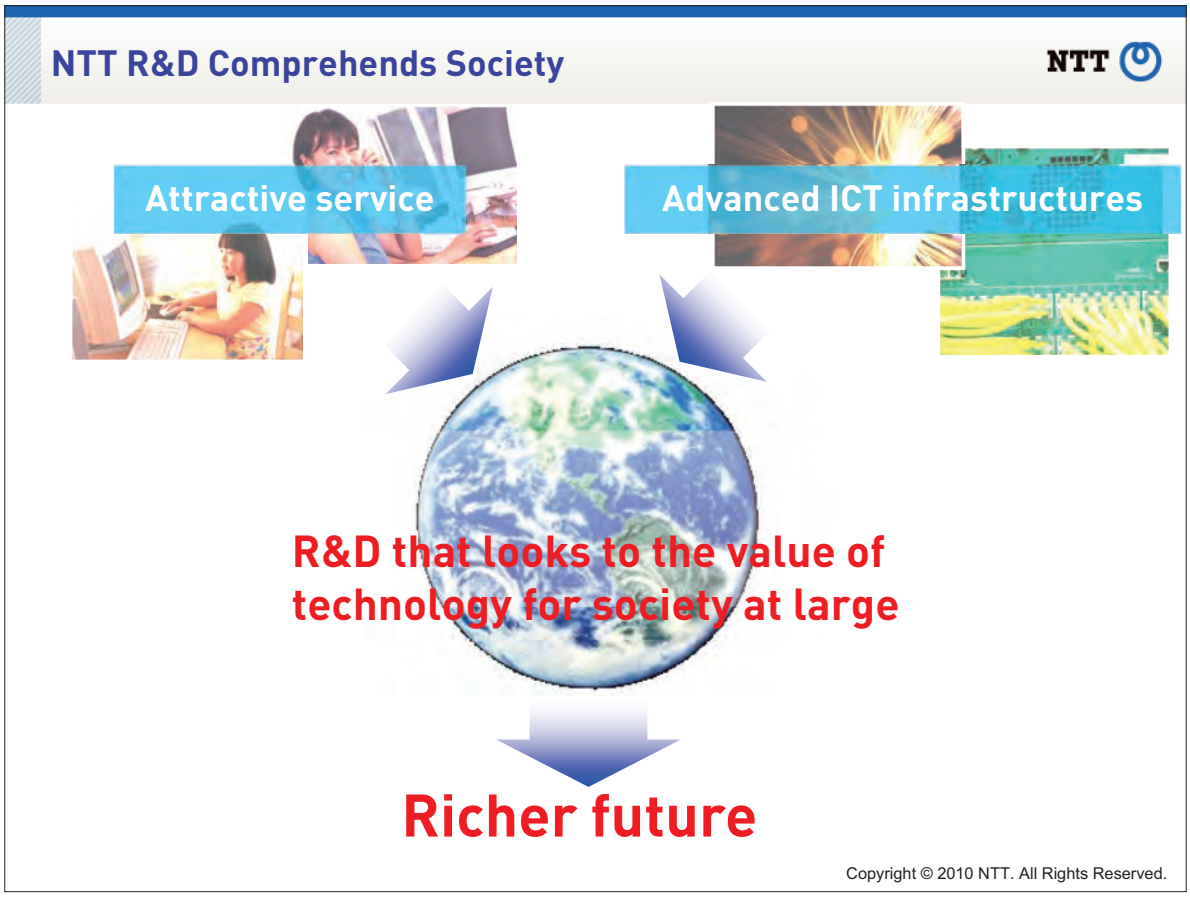
＜NTT R&D Comprehends Society＞

We are pursuing leading-edge technologies that allow "even the heart" of people to be conveyed, creating greater new value than we can imagine.

Recently, there have been increasing manifestations of social issues, such as the aging of society along with a declining birthrate, a decline in children's academic abilities, and global warming. There are high expectations that ICT will play a significant role in helping to solve these issues.

NTT R&D Laboratories not only contributes to the business of the NTT Group by creating attractive services and providing advanced ICT infrastructures, but also undertakes R&D that looks at the value that can be provided to the whole of society in order to achieve a richer future.

NTT aims to achieve a caring heart, caring economy, and caring planet. The vision of the future that we are aiming at is a society of 7 billion people around the world connected and able to communicate with each other: a barrier-free society (caring heart) that enables people to conduct worldwide business at any hour with a high level of confidence in security (caring economy) in which eco- and human-friendly ICT services are readily available (caring planet).



From keynote "Establishing ICT to Create and Support a Richer Future"

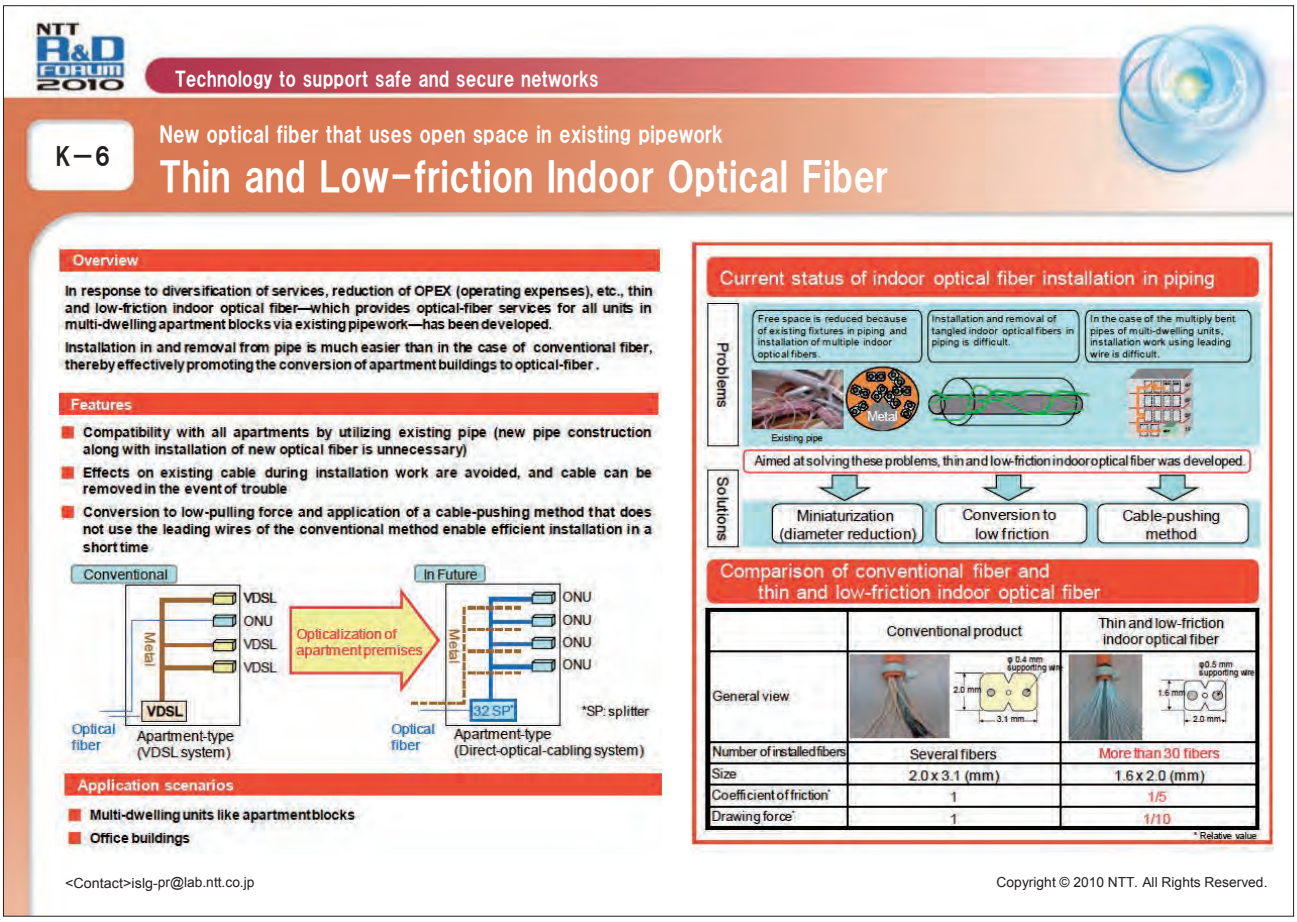
Taking "ICT for the future: friendly to individuals, society, and the earth" as its theme, NTT Laboratories introduced initiatives that will contribute to the future of society with the focus on “responding to social and environmental problems and realizing a safe and secure society.”

＜Technologies that support safe and secure networking＞

Thin and Low-friction Indoor Optical Fiber

New optical fiber cable technology that can be installed in the free space in existing pipework has become necessary in the rollout of optical fiber cable to each dwelling in multi-dwelling apartment blocks. It was for this purpose that we developed thin and low-friction optical fiber.

This optical fiber is much easier to install in multi-dwelling apartment blocks and other similar buildings and is largely contributing to the expansion of fiber to the home (FTTH). Not only is this currently being used as a very important indoor optical cable product, it is also recording impressive sales overseas with 30,000km of it being shipped annually.



＜Services that are friendly to Individuals and Society＞

Toward the Development of Broadband Internet in Train Carriages

NTT R&D along with Industrial Technology Research Institute of Taiwan R.O.C. (ITRI) and NTTBP carried out a technological verification trials (car trials, field surveys, and actual field experiments) to realize a wireless broadband service for Taiwan High Speed Rail that runs at the country's fastest speeds of over 300km/h.

The effectiveness of fundamental technology related to broadband transmission services using WiMAX for train passengers was successfully confirmed through wireless backhaul performance evaluation with WiMAX and wireless LAN transmission test inside train cars as well as a technological verification trial of NTT's unique layer 3 diversity technology that enhances wireless transmission quality.

NTT R&D FORUM 2010

Services that are friendly to Individuals and Society

B−1

Mobile WiMAX Broadband Communication Service Solution For High Speed Rail

Toward the Development of Broadband Internet in Train Carriages

Overview

We are aiming at the development of broadband transmission services inside trains. Using the technological knowhow from the wireless LAN internet service on the "Tsukuba Express" (provided from 2005) provided by NTT along with NTTBP, we participated in trials related to an internet connection service on Taiwan's High Speed Rail that uses WiMAX. Within this, we evaluated the WiMAX system in a high-speed mobile environment and progressed along with ITRI and other in tests related to improving communications technology.

*1 NTTBP: NTT Broadband Platform, Inc.
*2 ITRI: Industrial Technology Research Institute of Taiwan, R.O.C.

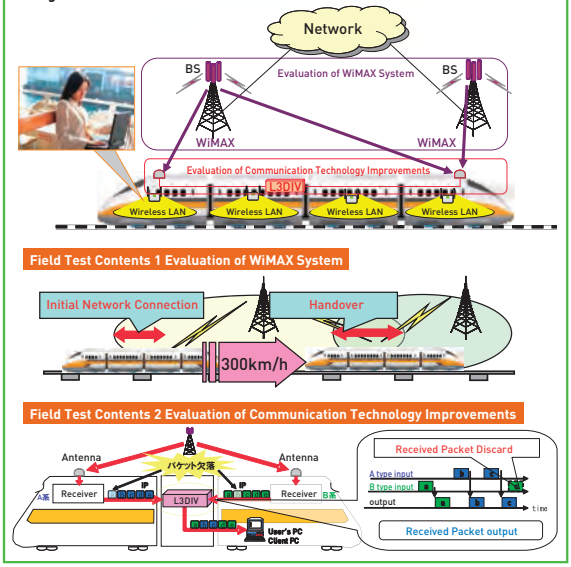
Features

- Because the applicability of WiMAX in a high-speed mobile environment with speeds of over 300km/h is not yet clear, through tests such as verification of basics like initial network connection and handovers, we evaluated the technological applicability.
- With the goal of improving wireless communications in the high-speed mobile environment of Taiwan's High Speed Rail, NTT R&D carried out technological verification tests trial related to the validity of our Layer 3 Diversity technology
- We are progressing with system verification based on the experience of system construction on the Tsukuba Express.

Application scenes

- Contribution to achieving a mobile WiMAX broadband communication transmission service for Taiwan's High Speed Rail.
- Based on the activation of the knowhow gained from the results of the field test trial, it will be possible to achieve a wireless broadband service targeting high-speed mobile entities.

Image of the Broadband Service Inside the Train and the Field Test Contents



〈問い合わせ先〉islg-pr@lab.ntt.co.jp

Attack Information Collection/Analysis Technologies for Websites

Quickly comprehending the trend in the shift of malware paths to the Web, we started research and development into honeypots that are decoy terminals that collect and analyze malware attacks on clients and servers. Various honeypots are used in reputation databases and national projects such as the ACTIVE project.

In 2012, we began providing the blacklist generated from the information gained by various honeypots. Various honeypots and the blacklist are currently used in "WideAngle", the management security service of the NTT Communications Group and commercial services such as large-scale SI and others.

NTT R&D FORUM 2010

Technologies that support safe and secure networking

K−8

Basis for secure Web application service platform

Attack Information Collection/Analysis Technologies for Websites

Overview

Vulnerabilities in Web applications expose computer networks to security threats, and many websites are used by attackers as "hopping" sites through which to attack user websites and terminals. For example, attackers can update the content and databases of websites. Moreover, attackers can operate websites that use the malware which they distribute.

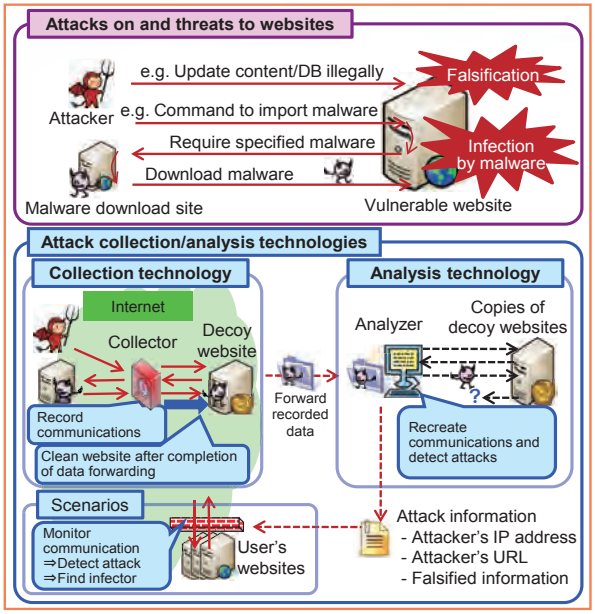
Our technology can safely and economically collect information about many kinds of attacks against websites. It can also automatically generate signatures for filtering attacks. These technologies provide the basis for a secure Web application service platform.

Features

- **Decoy websites which run a number of vulnerable Web applications are used to collect attacks**
- **A collector monitors attacks by access events and records them**
- **The collector cleans the decoy website after recording each attack in order to ensure that malware files are not retained**
- **Using the recorded data, an analyzer recreates the attacks on decoy websites in a closed virtual Internet and specifies the characteristics of the attacks, such as malware actions**
- **The analyzer generates attack data, including characteristics and information, such as the attacker's IP addresses and URLs**

Application scenarios

- **Information resource to assist service providers in detecting attacks on user websites**
- **Discovery of websites under attack and provision of warning notices to website managers whose sites are being attacked or operated by attackers**
- **Investigation and analysis of user websites to check if they are structurally vulnerable**
- **Dataset generation for checking vulnerabilities in Web applications utilized by users**



<Contact>islg-pr@lab.ntt.co.jp

＜Services that are friendly to Individuals and Society＞

Public Health and Medical Care Services

NTT R&D is continuing to make advances with initiatives for realizing Personal Health Records (PHR) that store and manage an individual's health and medical information to improve and enhance the quality of people's lives along with creating a network of medical information and sharing this information in the form of Electronic Health Records (EHR).

As for EHR, based on the knowledge accumulated during the planning of a Japanese EHR system undertaken jointly by the Ministry of Internal Affairs and Communication, Ministry of Economy, Trade and Industry and Ministry of Health, Labour and Welfare from 2008-2010 and using the Unified healthcare/personal health platform built with NTT Laboratories technology, NTT East built Miyagi Prefecture Ishinomaki-Kesennuma Healthcare Area Community Healthcare Integration System aimed both at resolving issues related to the aging population and shortage of healthcare resources, and at ensuring the continuity of medical services even when disasters occur.

NTT R&D FORUM 2010

Services that connect individuals and society in friendly ways - Approach to society -

B−7

Safe and secure platform for sharing of health and medical information

Public Health and Medical Care Services

Overview

To curb rapidly expanding medical costs, it is necessary not only to raise business efficiency and implement preventive care but also to realize high-quality medical services.

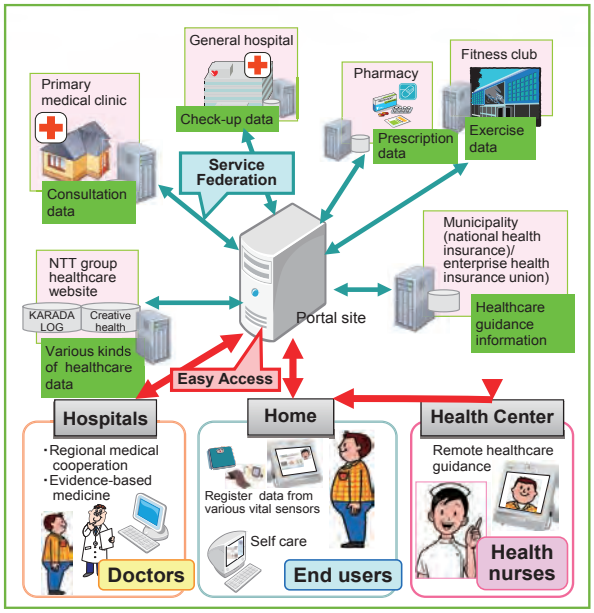
A network-based platform is provided to allow sharing of personal health and medical care data. Remote healthcare guidance can also be provided on this platform.

Features

- **Integrate systems with different interfaces**
- **Easy access to information with SSO (Single Sign On)**
- **Access control in accordance with privacy policy**
- **Data structure which conforms to HL7 standard (medical information standard protocol) and Continua guideline (healthcare data standard protocol)**
- **Secure remote healthcare guidance using video phones**
- **User-friendly collection and registration of healthcare data**

Application scenarios

- **Home healthcare, remote healthcare guidance, remote medical care**
- **EHR (Electronic Health Record)/PHR (Personal Health Record) services**
  - **Integrated management and networking of personal medical and healthcare information**
  - **Shared access to personal medical and healthcare information with medical staff**
  - **Detailed medical and healthcare services based on various data**
  - **Healthcare services with an online portal**
  - **Community healthcare services in which a medical organization cooperates with other organizations**



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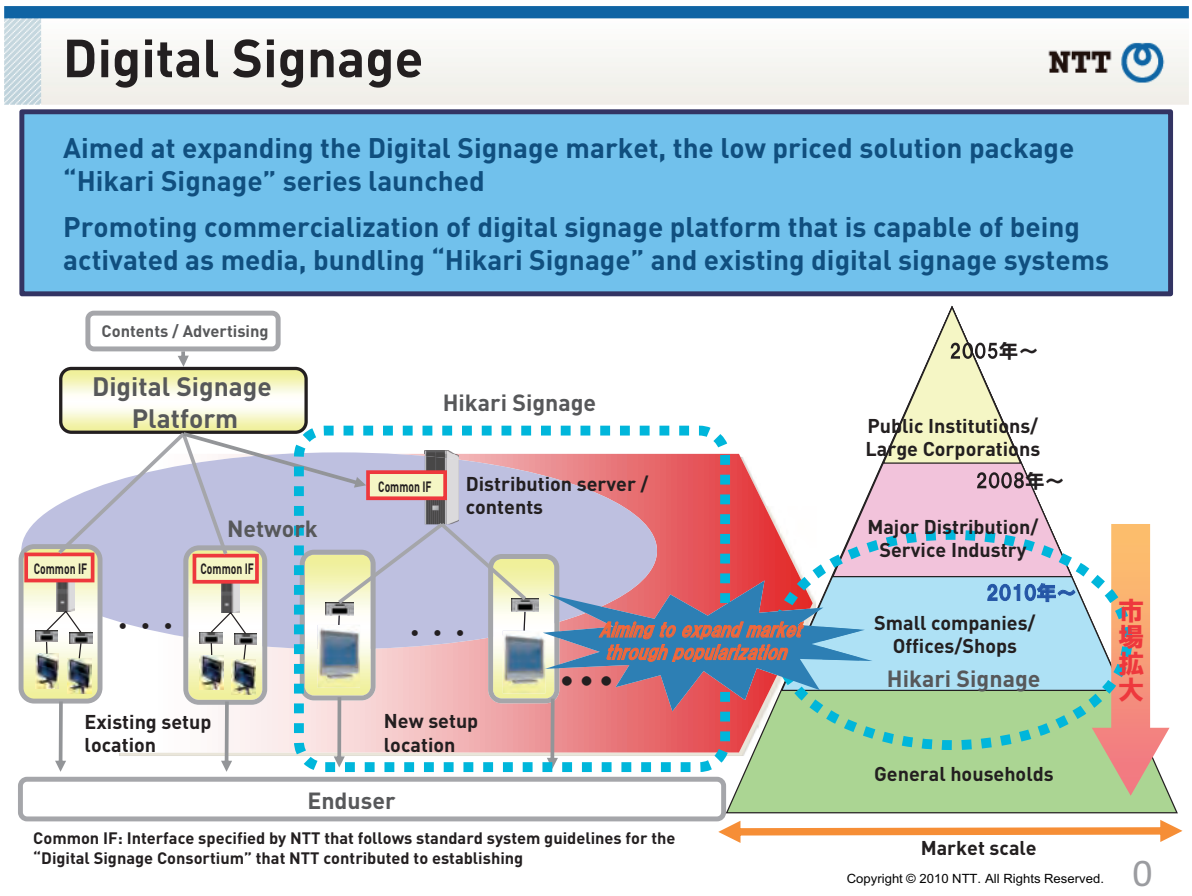
This exhibit contributes to the reduction of environmental load.

＜Creating Attractive Services and Providing Advanced ICT Infrastructures＞

Digital Signage

To realize service creation and sophisticated infrastructure, NTT is continuing with commercialization activities that quickly transform R&D activities into NTT Group's business. Digital Signage is one specific example. Aiming to promote the use of digital signage across fixed and mobile broadband networks, there are initiatives to create a digital signage platform business.

As a result of these initiatives and with the aim of increasing the value of the digital signage market, the "Hikari Signage" series was developed and went on sale in February 2010 as an inexpensive solutions package that can even be used by small companies, offices and shops



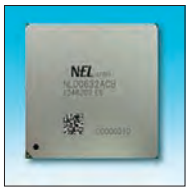
From keynote "Establishing ICT to Create and Support a Richer Future"

＜Innovative technologies that help advance science and engineering＞

Establishing International Standards for Audio Lossless Coding and Packaging Format

Along with the development of networks and digital audio devices, demands for high quality audio (high sampling rate, high resolution frequency and multi-channel) have increased the amount of data for transmission and storage. In order to use these data in a broadband network environment economically, NTT R&D has taken initiatives to develop a lossless compression codec that can reconstruct the original signal without loss or damage and has taken the lead in defining the coding scheme as international standard. As a result, international standard the MPEG-4 ALS (audio lossless coding) has been established in 2005.

MPEG-4 ALS Simple Profile has been recommended for high quality audio services of UHDTV in 4K and 8K television broadcasts by the regulation of Ministry of Internal Affairs and Communication in Japan and ARIB STD-B32 in 2014.



The 100G OTN Framer commercialized by NTT

NTT R&D FORUM 2010

Innovative technologies that help advance science and engineering

M−12

High Quality Audio Transmission and Long Term Storage Service based on MPEG international standards.

Establishing international standards for audio lossless coding and packaging format

Overview

There is increasing demand for transmission and storage of high quality audio content that utilizes broadband. Furthermore, for the long term storage of contents it is necessary to solve a number of issues related to cost, compatibility and maintenance and operation. At NTT R&D, we contributed to establishing standards for lossless audio compression technology, MPEG-4ALS*1and package format MPEG-A PA-AF*. High performance software and libraries which are fully compliant with these standards are available and can be used for a wide area of applications.

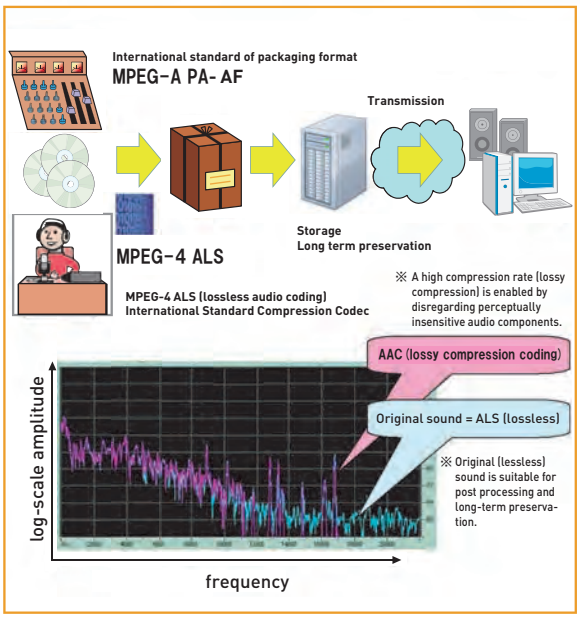
*1 ALS: (Audio Lossless Coding)ISO/IEC 14496-3
*2 PA-AF: (Professional Archival Application Format)ISO/IEC 23000-6

Features

- Compatible with various audio input signals, highest compression level in the world
- Highly flexible and OS independent package format
- Open and long term support are expected due to international standards
- High performance software, library and SDKareavailable for various platforms

Application scenarios

- Service for long term storage of contents (libraries, broadcasters, cloud computing)
- High quality audio music distribution services (mobile phone players, IPTV, fixed network radio cooperation)
- Storage, editing and transmission of music information, medical information, sensor information



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＜Innovative technologies that help advance science and engineering＞

Photonic Network Technologies

Growth of broadband networks are based on high-capacity photonic networks. NTT R&D has contributed to establishing the Optical Transport Network (OTN) international standard ITU-T G.709 for transmitting various client signals over long distances with flexibility and high reliability. Especially NTT R&D made a large contribution to revising ITU-T G.709 in December 2009 in line with the standardization of 40/100G Ethernet. Furthermore, in 2013, NTT Electronics began shipping the industry's first single-chip multi-functional 100G OTN Framer LSI.

Currently R&D initiatives are being undertaken to develop beyond 100G OTN Framer technology in line with the standardization of 400G Ethernet.

NTT R&D FORUM 2010

Innovative technologies for development of science and technology – Photonic Network -

M－10

Ultra long distance and high capacity optical transmission technology, International Standard OTN that efficiently transfers 100G/40G Ethernet

Photonic Network Technologies

Overview

As basic technology that supports high capacity photonic networks, we are progressing with the world's top level of R&D. Ultra high capacity (13.5 Tbit per second) and long distance (7,200km) optical transmission has been successfully achieved by accommodating 100 Gbit/s client signal per wavelength and multiplexing 135 wavelength into one optical fiber.
Efficient high-capacity data signal transmission is realized by directly accommodating the next generation Ethernet standard 100GE/40GE signals into the international standard OTN frame.

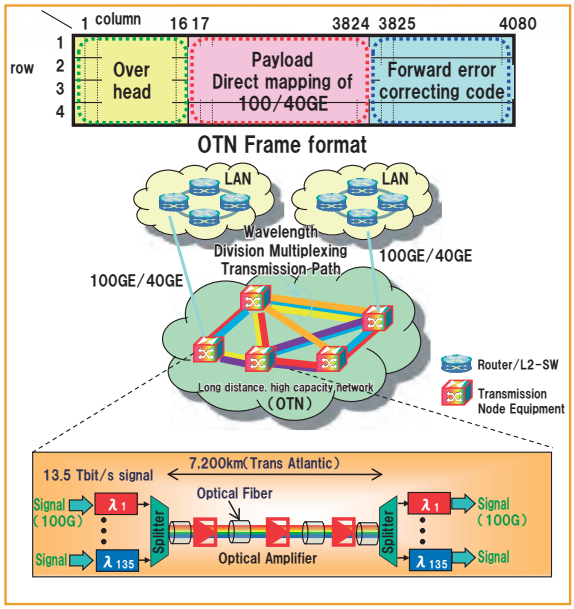
Features

- **The world's top level of transmission capacity-distance product in one optical fiber transmission**
- **135 high vision movies per second can be transferred on one optical fiber**
- **Leading optical modulation format, digital coherent and low-noise optical amplifier technologies**
- **Success in International Standardization of 100GE/40GE over OTN**
  World's first demonstration of transparent 40GE signal transmission with 40G-OTN

Application scenarios

- **Long distance optical network**
- **Metro optical network**

Part of this research related to the international standardization of 100GE/40GE over OTN uses results from the research commissioned by the National Institute of Information and Communications Technology (NICT)



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2010

R&D Forum 2011: "A Vigorous Society and a Richer Future, Created and Empowered by ICT Innovation"

＜New Services and Technologies for the Ubiquitous Broadband Era＞

Home ICT Platform Using OSGi Technology

NTT R&D has worked toward “Home ICT services” which provides more comfortable home and office environments / services by making various devices connected to the home and office networks. In order to realize such services / environments effectively we have developed the “Home ICT Platform” based on the OSGi technology. We adopt OSGi since its functionality of dynamic program modules is indispensable for handling

flexibly various kinds of protocols for home / office devices. Since November 2010, a number of NTT Group companies have been working in alliance with Panasonic Electric Works to carry out field trials aimed at commercialization of “Home ICT Platform”.

Based on the results of these trials, this platform was deployed in August 2011 as FLET’S Joint service by NTT East and NTT West. FLET’S Joint can provide software distribution environments with service providers. This platform was also utilized internally for remote management services to manage home gateways and it leads to reduce operation costs at NTT operating companies.

NTT R&D FORUM 2011

D－10

New Services and Technologies for the Ubiquitous Broadband Era

Home ICT Platform Using OSGi Technology

Platform technology for spreading Home ICT services

Overview

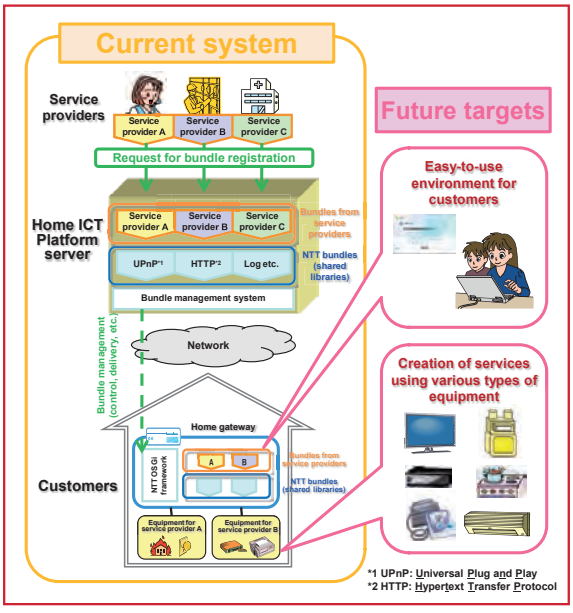
Our Home ICT platform provides essential functions for Home ICT services that enable efficient development and maintenance. To expand the platform’s value, we will continue to develop versions that are easy for customers to use and support various types of equipment for Home ICT services.

Features

- Essential functions for Home ICT service development and management (NTT bundles)
- Flexible and dynamic software management using international standard OSGi technology for Home ICT services

Application scenarios

- Services that use devices in the home (televisions, intercoms, web cameras, printers, weighing scales, etc.)
- Services that use devices in the office (personal computers, printers, security devices, etc.)



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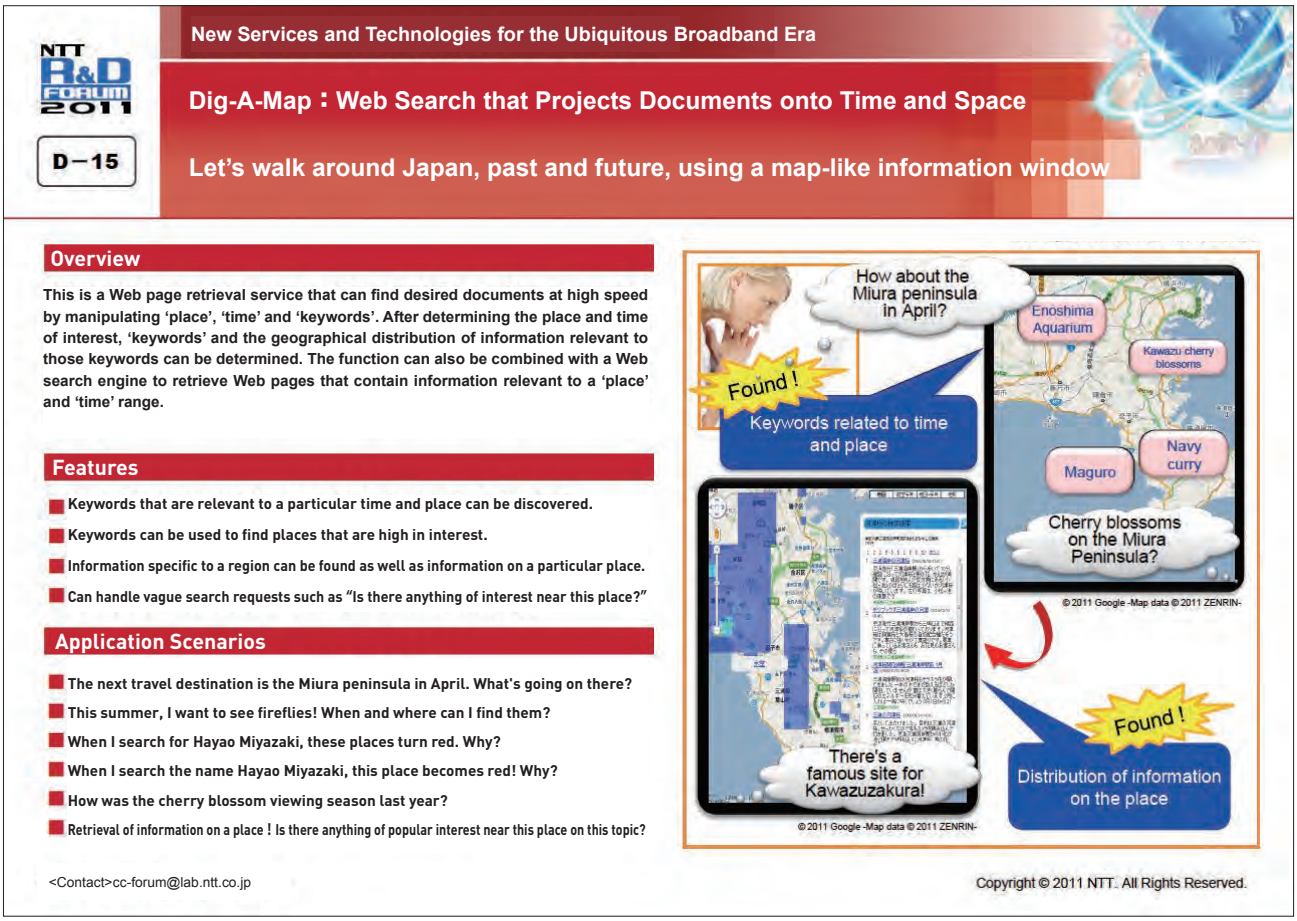
Taking the theme of "A Vigorous Society and a Richer Future, Created and Empowered by ICT Innovation," the forum introduced NTT R&D initiatives that will contribute to the creation of a prosperous society full of vitality by leveraging ICT.

＜New Services and Technologies for the Ubiquitous Broadband Era＞

Dig-A-Map：Web Search that Projects Documents onto Time and Space

By displaying keywords of interest from a specified place and time on a map, Dig-A-Map gives quick and easy access to information and discussions related to keywords. A public trial of the Search-Discover Area DAS application that informs users about trending keywords and related information in a certain place or area was conducted from December 2011 to September 2013 and attracted a lot of media attention as well as users.

Following this, a number of subsequent analytic technologies and technologies related to map display were combined to create Area Information Navigation which is currently still in development with a commercial release date planned during 2015.



＜New Services and Technologies for the Ubiquitous Broadband Era＞

IP Transmission Technology for 8K/Super Hi-Vision (Communications/Broadcasting Cooperation Services)

NTT's highly reliable and high speed IP transmission technology realized the world's first successful live video transmission of 8K / Super Hi-Vision from Tokyo to London utilizing the global shared IP network as a joint initiative with NHK in February 2011. In addition, the technology also largely contributed to making possible the 8K video transmission from London to Tokyo for an international sporting event in 2012, and the completely successful transmission for NHK's 8K public viewing of the 2014 FIFA World Cup Brazil.

This technology is based on the superior forward error correction algorithm FireFort®-LDGM FEC (Low Density Generator Matrix Forward Error Correction) which is quite robust against large size IP packet losses, and in 2015 was adopted as part of MMT(MPEG Media Transport) standard, ISO/IEC23008-10 .

NTT R&D FORUM 2011

D－8

New Services and Technologies for the Ubiquitous Broadband Era

Video

IP Transmission Technology for Super Hi-Vision (Communications/Broadcasting Hybrid Services)

Public viewing of international sports events via the global IP broadband network

Overview

This transmission technology makes it possible to use an IP broadband network for the safe and secure delivery of Super Hi-Vision*1 audio and video, which provides an even greater sense of reality and immersion than regular Hi-Vision. It is destined for use in the next generation broadcasting services to follow Hi-vision to deliver highly realistic video in more familiar forms such as public viewing of events.

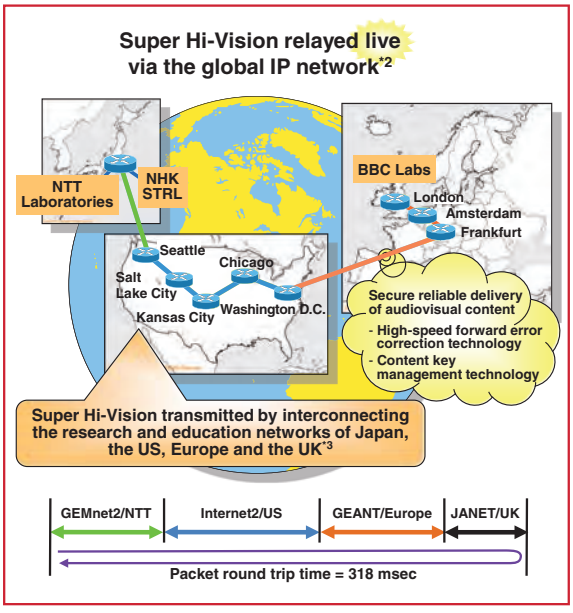
Features

- Can deliver over 300 Mbit/s Super Hi-Vision content (H.264 video and AAC audio) stably over a shared IP network without requiring a leased line.
- High-speed forward error correction technology (LDGM-FEC) facilitates reliable IP transmission.
- The application of encryption (AES/Camellia) and key management technology enables highly secure IP transmission.

Application scenarios

- Public viewing of international sporting events via the global IP network
- Ultra-high resolution audiovisual delivery services including remote medical services, electronic museums, and the screening of ODS (other digital stuff)/Alternative Content such as opera and music concerts in cinemas
- Next-generation communications/broadcasting hybrid services (next-generation IPTV services)

*1 Super Hi-Vision is a next-generation broadcasting service which was researched and developed by NHK Science & Technology Research Laboratories. It features an ultra-high resolution of 7680 x 4320 pixels and 22.2 multi-channel audio.
*2 The shooting, displaying and encoding of Super Hi-Vision content was assigned to NHK, and the transmission experiments were conducted jointly.
*3 L3 connection (19 hops)



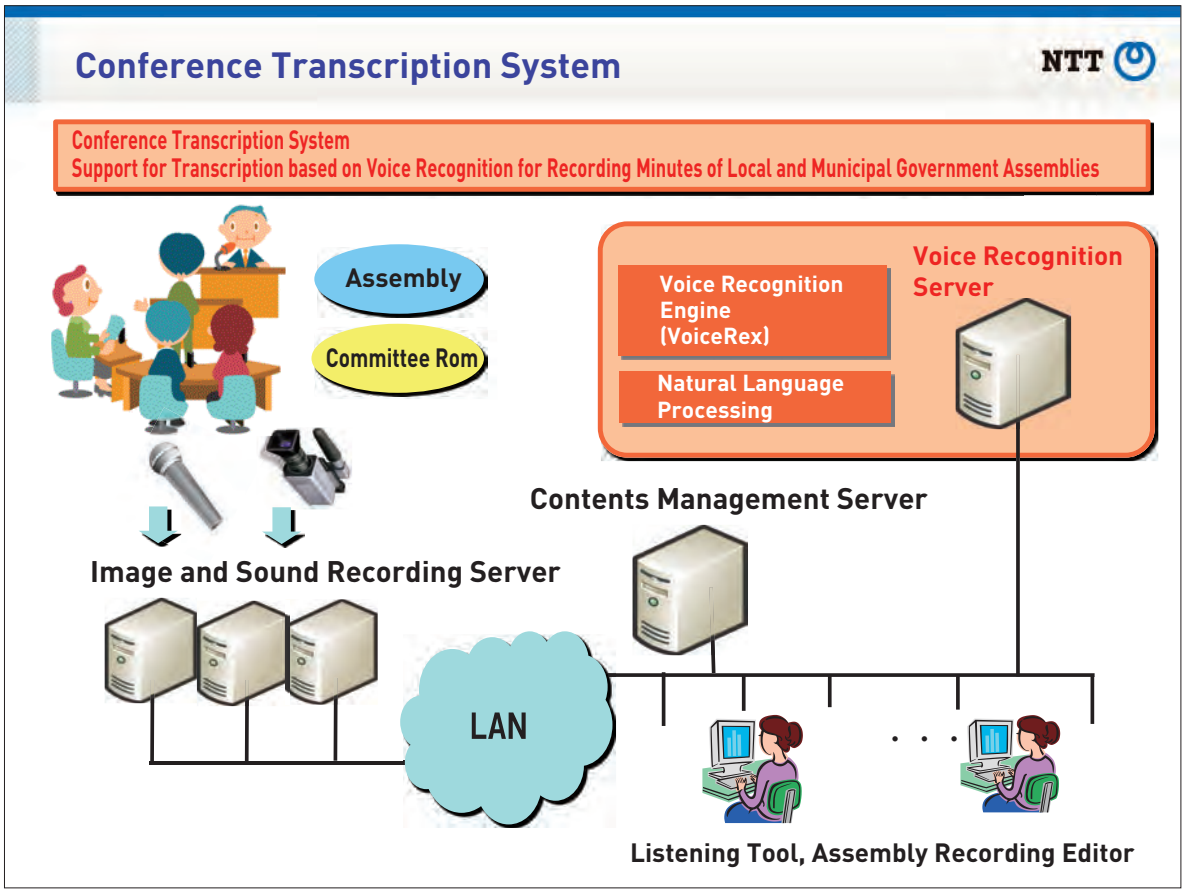
<Contact>a-info@lab.ntt.co.jp

＜Initiatives to Increase the Speed and Efficiency of R&D＞

Conference Transcription System

NTT R&D is speedily and efficiently developing new technologies to meet the ever changing needs of business. From the core research stage, our research reflects the needs of business and we are continuing to undertake joint development initiatives with a range of companies. One of the results from these initiatives is the "Conference Transcription System."

In 2008, using NTT's most advanced speech recognition technology for spoken language, a prototype of the "Voice Recognition New Dictation System," a more efficient system which records speech in conferences and then automatically converts it to text allowing for manual correction of mis-recognized spots. This prototype became the base for "VoiceAir," the conference transcription system that NTT East began providing for Central and Regional Governments from December 2010. This initiative is just one example of how we have been successful from the core stage of research and development to reflect the various needs of business and government, such as the need to record meetings.



From Keynote: "ICT Innovations to Enrich Humanity"

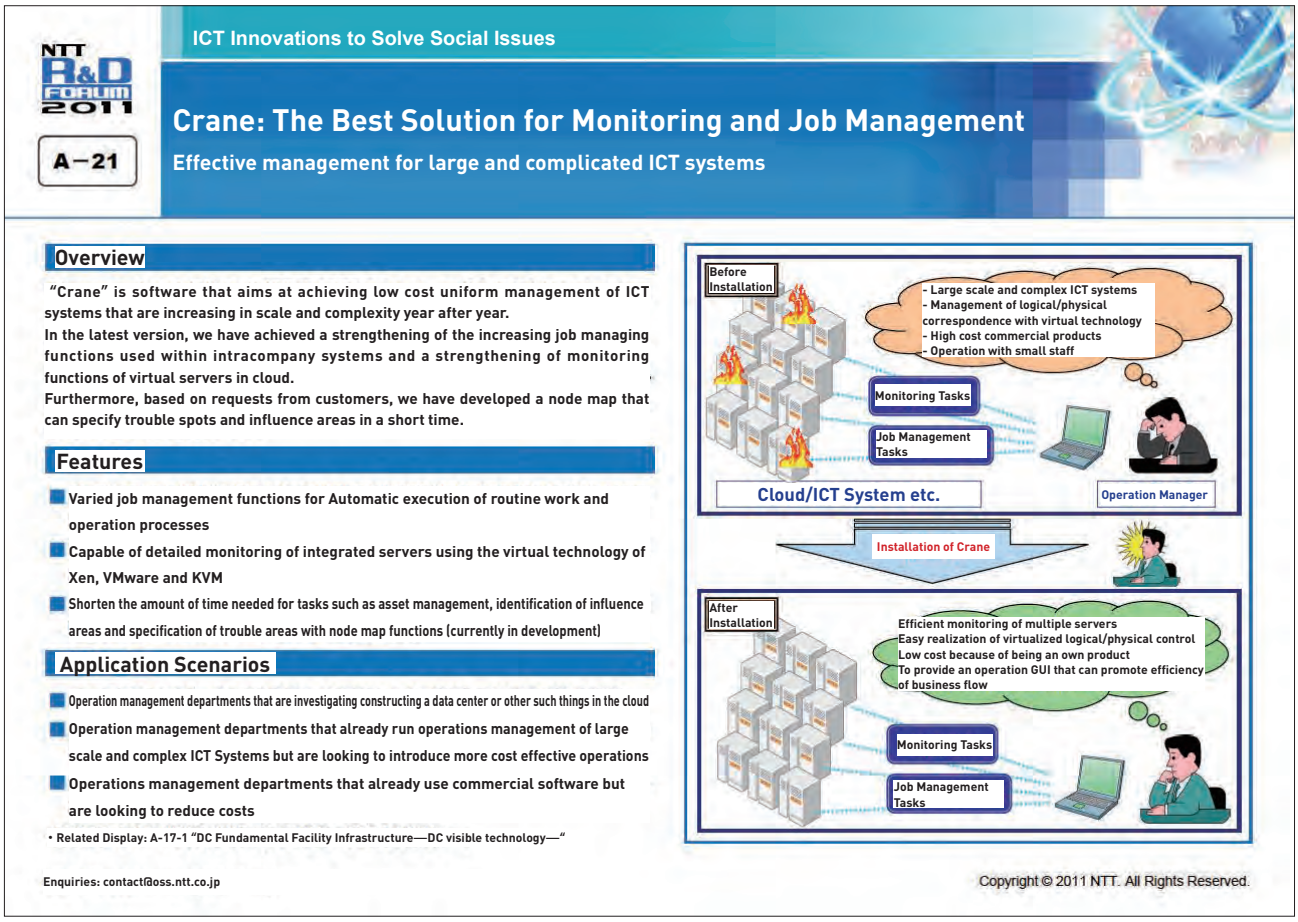
＜ICT Innovations to Solve Social Issues＞

Crane: The Best Solution for Monitoring and Job Management

"Crane" is an Enterprise-level monitoring software developed by NTT R&D. This software makes it possible to uniformly control and integratedly manage all tasks such as monitoring the server and network and managing in an ICT system. The operational status and performance information of the OS, middleware, and network devices as well as user application processes and logs can be monitored and scheduled tasks can be automatically managed.

With the Crane management software's cascades, it is possible to flexibly manage workflows and monitor the systems of any size.

Crane is currently being used as the primary monitoring tool for the NTT East and NTT West ICT systems and there are ongoing efforts to develop it into an ICT management solution for municipalities.



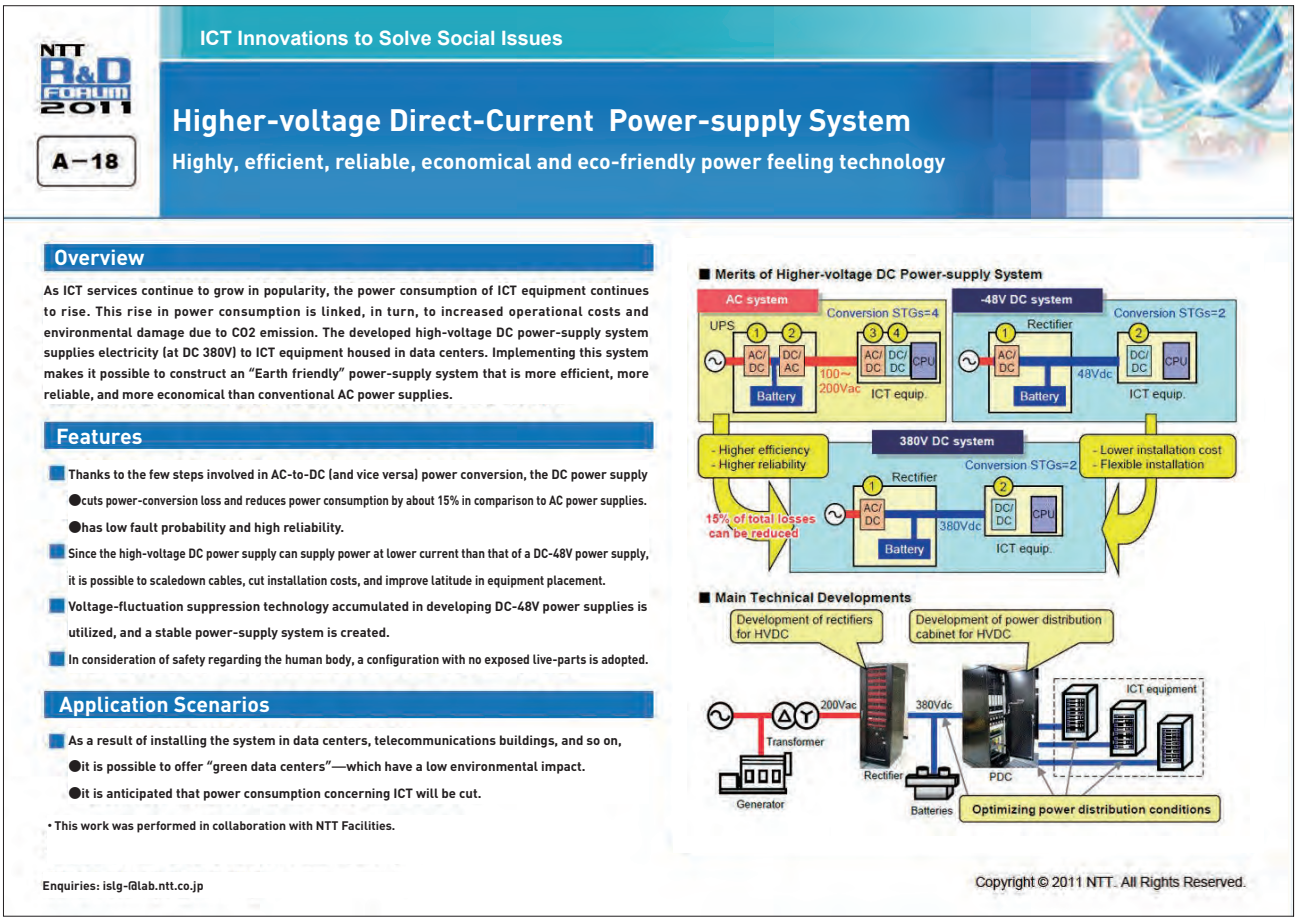
＜ICT Innovations to Solve Social Issues＞

Higher-voltage Direct-Current Power-supply System

As part of activities to prevent global warming and in order to promote measures aimed at increasing the use of power supply systems that can contribute to lowering energy consumption, in 2008 NTT started the way to develop higher-voltage DC Power-supply technology.

Following this, NTT led the way in standardizing activities at ITU-T, resulting in the establishment of two international standards: ITU-T L.1200 "Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment" and ITU-T L.1201 "Architecture of power feeding systems of up to 400 VDC."

In August 2014, NTT published the Technical Requirements for connection of HVDC power supply systems and ICT equipment in telecommunication or data-center buildings and announced NTT will introduce HVDC power supply system to our telecommunication and date center buildings from fiscal year 2016.



＜Innovative Technologies that Contribute to the Development of Science and Technology＞

Broadband Wireless Home Networks

In order to realize a wireless LAN capable of handling a 10-fold increase on current throughput, NTT Laboratories developed a multi-user MIMO transmission prototype that enables simultaneous transmission of data to multiple destination terminals at the same time and over the same radio frequency without cross-interference. In May 2010, NTT Laboratories achieved real-time multi-user MIMO transmission at over 1 Gbit/s for the first time in the world. At present, efforts are underway to quickly establish the next-generation high efficiency wireless LAN (IEEE 802.11ax) standard.

Furthermore, a Millimeter-wave (60-GHz band) high-speed close proximity transmission system has been developed in which large amounts of data containing numerous gigabytes can be downloaded instantaneously just by touching a portable device on the "Kiosk" terminal. This technology is currently being promoted and efforts are underway to have it adopted as an IEEE standard.

NTT R&D FORUM 2011

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Innovative Technologies that Contribute to the Development of Science and Technology

Broadband Wireless Home Networks

Highly convenient home networks composed of broadband wireless systems

Overview

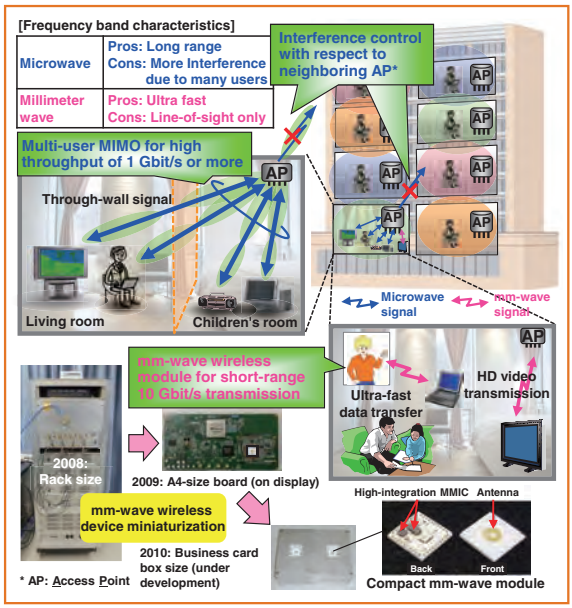
All-wireless home networks are desired for connecting portable terminals to an optical fiber that runs into the subscriber's home. Stable transmission of large amounts of data, such as HD video content, is required for home networks. To meet this requirement, we will develop a highly convenient broadband wireless home network by combining a 1-Gbit/s-class microwave wireless LAN and a 10-Gbit/s-class mm-wave system. The former provides high connectivity between rooms. The latter provides high-speed and short-range transfer of large amounts of data, such as that for long TV programs and future uncompressed or lightly compressed videos.

Features

- Multi-user MIMO with transmission beam-forming in a 5-GHz band wireless LAN can realize high-speed wireless networks whose throughput is at least 1 Gbit/s.
- Suppression of interference from neighboring access points makes the 5-GHz band wireless LAN suitable for use in dense residential areas, such as apartment houses.
- For millimeter-wave communication (60-GHz band), a compact wireless module with integrated antenna can be built into various portable devices, enabling even faster short-range data transmission.
- Parallel wireless transmission via multiple channels in the 60-GHz band achieves 10-Gbit/s-class data transfer and greatly reduces the transfer time of large content.
- Conforms to IEEE 802.15.3c and future IEEE 802.11ac/ad

Application scenarios

- High-resolution video content can be viewed simultaneously in different rooms on large-screen IPTVs and Blu-ray video players connected to the home network by the 5-GHz band wireless LAN.
- Instantaneous transfer of video content to a portable device at speeds of 10 to 100 times as fast as before, (a Blu-ray disc transferred within one minute) for viewing anywhere



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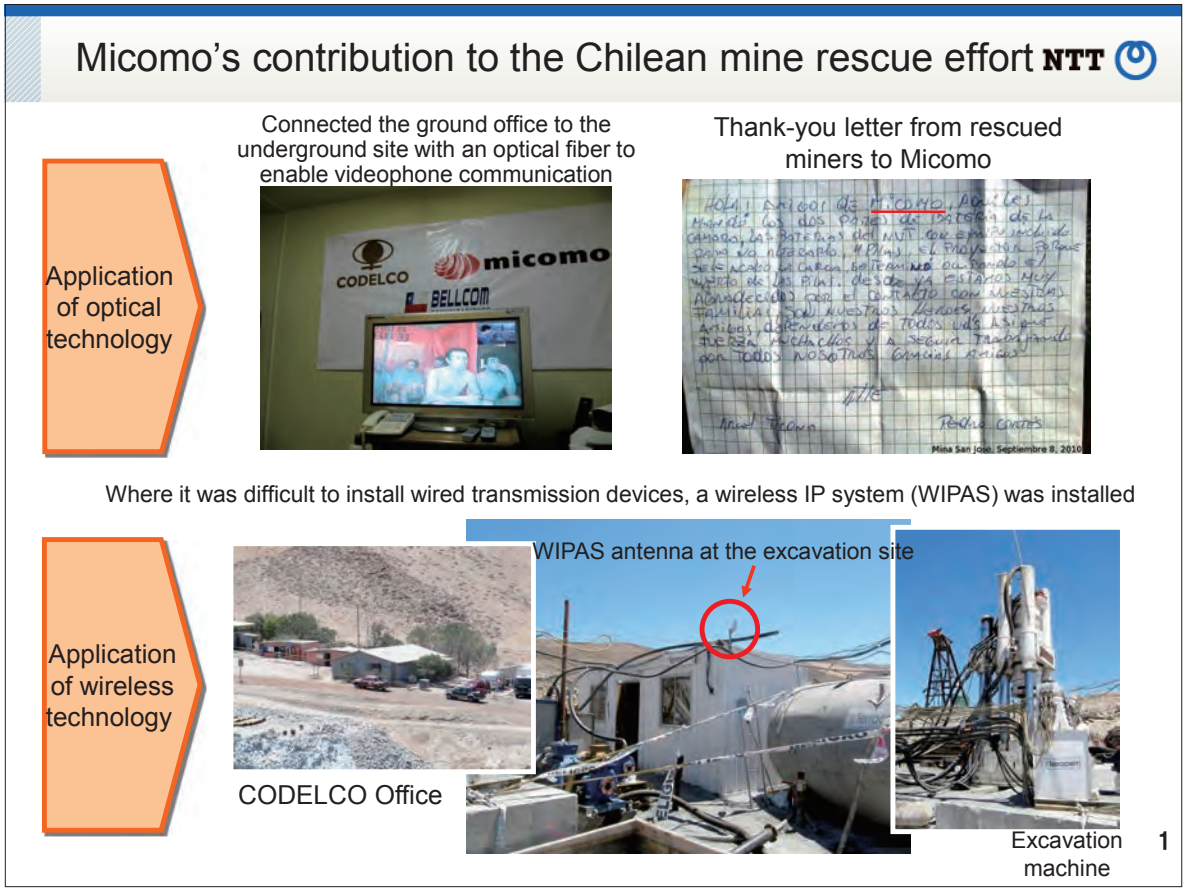
＜R&D for Global Business Expansion＞

Micomo's contribution to the Chilean mine rescue effort

As part of NTT R&D global initiatives, in addition to current collaboration through standardization and the collaborative research that is at the core of our basic research fields, we are also developing new technology and services in different countries and strengthening initiatives to create partnerships with organizations beyond those of communication carriers. For example, in order to develop the mining industry with some of NTT R&D's ICT related products, in April 2006 Codelco (CORPORACIÓN NACIONAL DEL COBRE DE CHILE) and NTT Group Companies established the jointly funded company, Micomo, and installed photonic network (AWG-STAR), wireless IP network (WIPAS), optical fiber sensors and particle emission sensors. In the 2010 mining accident that occurred in Chile, a teleconference system employing optical fiber played a large part in helping to rescue the trapped miners.



From Keynote: "ICT Innovations to Enrich Humanity"

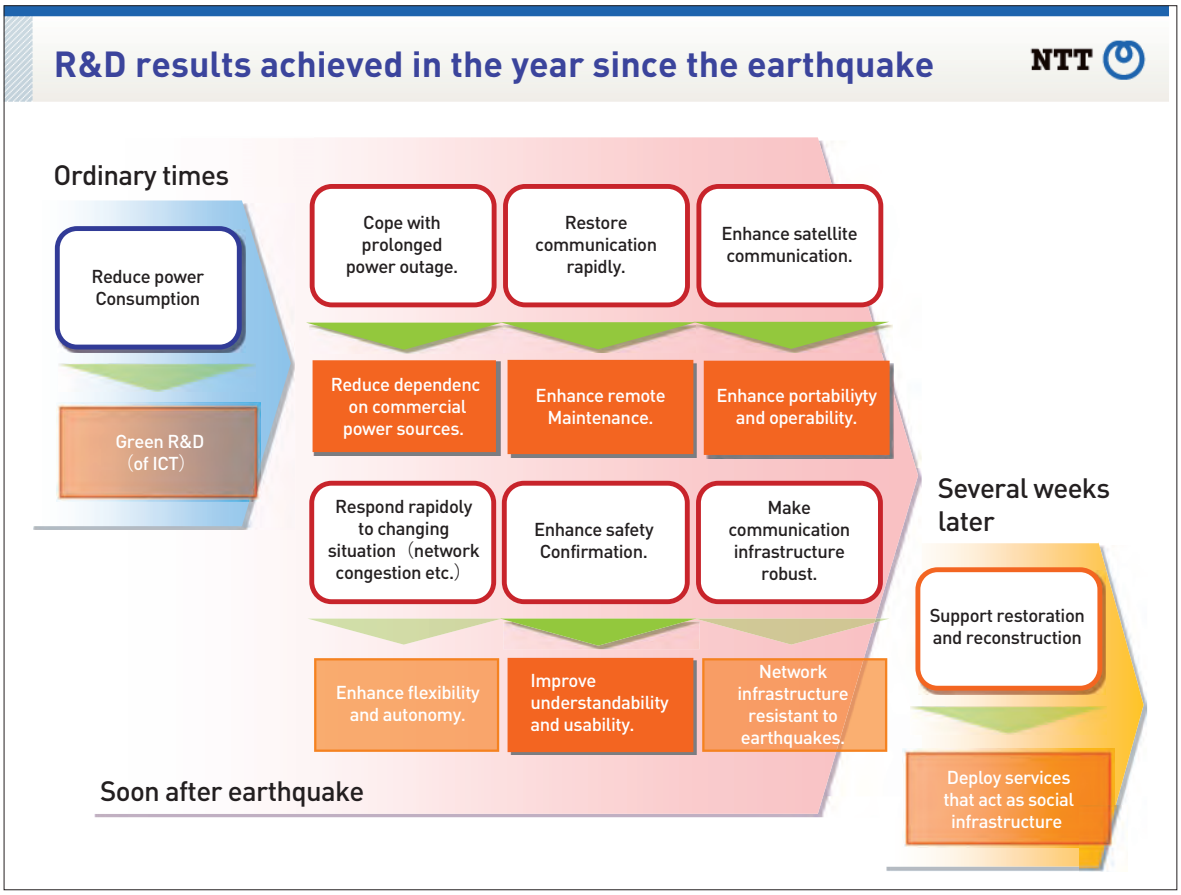
2011

R&D Forum 2012: " ICT that Creates, Supports, and Continues to Evolve"

R&D results achieved in the year since the earthquake

With the Great East Japan Earthquake that occurred on March 11, 2011. NTT R&D focused its research activities in areas such as coping with prolonged power outage, restoring communications rapidly using satellite communications in evacuation areas into three temporal categories: ordinary times, soon after the earthquake and several weeks later.

Within roughly a year of the disaster, NTT R&D developed a new storage battery to be used at NTT buildings during prolonged power outages, and established the aim to achieve an emergency battery power supply for ONU. Furthermore, we also established the aim of developing a remote operating system to quickly restore a ring network. In addition, we also produced steady results in further improving the safety confirmation service by making it easy for anyone to use the service, making a variety of safety information available at one point, and eliminating barriers between text and voice so that people can access the same information from either a telephone or a PC.



From Keynote: "Issues that needed to be addressed by NTT's R&D"

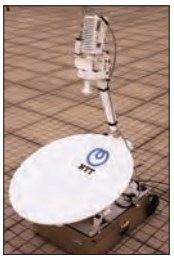
With the unified concept of "ICT that creates, supports, and continues to evolve," introduced NTT's activities to contribute to the creation of a vital society in diverse ways through the use of ICT. Also, in response to the recent Great East Japan Earthquake, we introduced technologies beneficial for disaster management in the "Disaster control and recovery support" exhibit.

＜ICT that Supports＞

Small Satellite Earth Station for Disaster Recovery Operations

We have developed two types (flyaway and vehicle-mounted) of satellite earth stations that can provide temporary communication lines via satellite during communication outage periods caused by disasters. By employing small antennas whose diameters are less than 75cm, the developed satellite earth stations achieve excellent portability as well as lightweight, i.e. the flyaway type can be dismantled and packed into four separate carrying cases while vehicle-mounted type can be installed in a normal-sized car. Moreover, by adopting a new remote uplink access test program and satellite auto-capture function, it can be set up within 15 minutes and quickly establish a communications line.

The developed satellite earth stations are currently being deployed throughout Japan as part of NTT East and NTT West's portable earth station systems. They are contributing to the rapid provision of internet access and public phone services to evacuation areas in disaster affected regions.



Small satellite Earth staion flyaway type

Network services

Disaster control and recovery support

For immediately offering communication services in stricken areas

NTT R&D FORUM 2012

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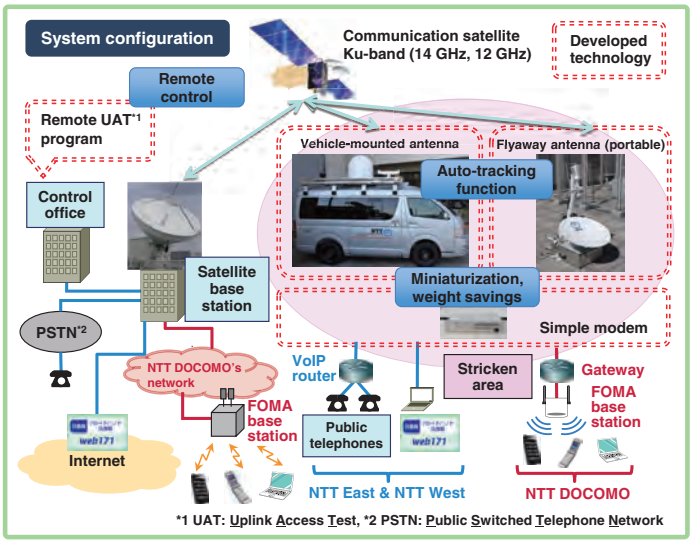
Small Satellite Earth Stations for Disaster Recovery Operations

Our earth stations can be easily set up and can quickly start performing their mission in an area stricken by a disaster. Our terminals ensure a transmission speed of up to 384 kbits/s for the return link, which can carry ten VoIP (voice over Internet protocol) channels, simultaneously. Their transportability has been greatly improved through equipment miniaturization and weight savings. Moreover, our remote uplink access test program and two satellite auto-tracking antennas will dramatically improve the operator's convenience.



Features

- The terminals can be applied to portable earth station systems without concern for network congestion because they use an exclusive frequency band operated by NTT East and NTT West.
- The portability and convenience of our terminals are dramatically improved compared with those of the currently available portable earth station system.
- The equipment composition can be configured to suit the stricken area.
  Vehicle type: Can be installed in a normal-sized car, so it can reach a stricken area quickly to help restore communications.
  Flyaway type: Easy to carry to a disaster area because it can be broken down and packed into four separate carrying cases.
- Our terminals can start performing their mission in less than 15 minutes owing to the satellite auto-tracking function (compared with 60 minutes at present).
- The uplink access test can be executed by remote control.

Application Scenarios

- Free public telephone services and web171 services (Disaster Emergency Broadband Message Board) will be provided to a disaster-stricken area.
- We are now checking whether the system can act as an entrance to the FOMA network.

NTT Group Advantages

NTT has developed new satellite earth stations that have good portability and can quickly start performing their mission with easy operation. In addition to offering free phone services at disaster shelters, they are expected to provide access to the FOMA network.

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NTT docomo

＜ICT that Supports＞

ICT Tool for Special-Needs Schools: Koemiru

"Koemiru" (= visible voice) is a solution developed in January 2012 for special needs students. The system uses speech recognition technology to convert utterances into text and displays them on an interactive whiteboard and portable game terminals.

In 2012, trials were held at various special needs schools by this system at Tottori Prefectural School for the Deaf, Himawari campus, and at Okinawa Prefectural School for the Deaf. In 2013, it has been improved on the basis of these knowledge obtained. The improved system was tested at the Yokosuka School for the Deaf in August 2014. In April 2015, it became a commercial version is provided by NTT software.

Public services

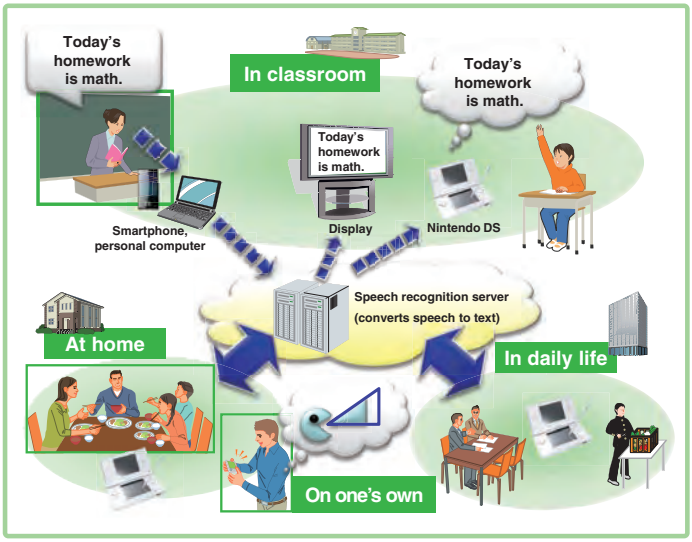
Assisting communication in the education field through visualized speech

NTT R&D FORUM 2012

S−6

ICT Tool for Special-Needs Schools: Koemiru

This solution converts utterances into text and visualizes the speech volume by using speech recognition technology and devices. It supports communication in special-needs schools.



Features

- Converts free utterances into text by using NTT's speech recognition technology.
- Controls access to content by authority category such as teachers only or all students.
- Does not require you to build your own server to access the speech recognition server in the network.
- Displays recognition results on multiple devices simultaneously.

Application Scenarios

- In-classroom assistance: Teacher's spoken remarks can be read as text.
- At-home and in-daily-life communication support: There is support for conversation with families and leaders and for shopping in stores.
- Individual training: Speech volume visualization and utterance checking are available.

NTT Group Advantages

NTT provides NTT Group's first-ever solution for special-needs schools; this is achieved by using R&D technologies, networks, and various devices. We aim to achieve a barrier-free world through ICT.

- This exhibition is a proof-of-concept experiment in Okinawa and Tottori (a cooperative project with Nintendo Co., Ltd., NPO Project UI and NTT CLARUTY).

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＜ICT that Creates＞

Jubatus：Scalable Distributed Computing Framework for Realtime Analysis of Big Data

Jubatus is a processing platform for real-time deep-analysis of flow-type big data. NTT and Preferred Infrastructure, Inc. jointly developed Jubatus as an open-source platform in October 2011.

Jubatus was introduced into the NTT Group's market analysis service, anti-virus software. Jubatus has been adopted in a number of other commercial services and national projects. We are engaged in the experiments of network fault detection, people flow analysis, and so on.

There are also future plans to develop this technology further into new fields under initiatives that include adding feature extraction to realize a greater area of automation, automated machine learning management, and upgrades.

Jubatus

Cloud and Security

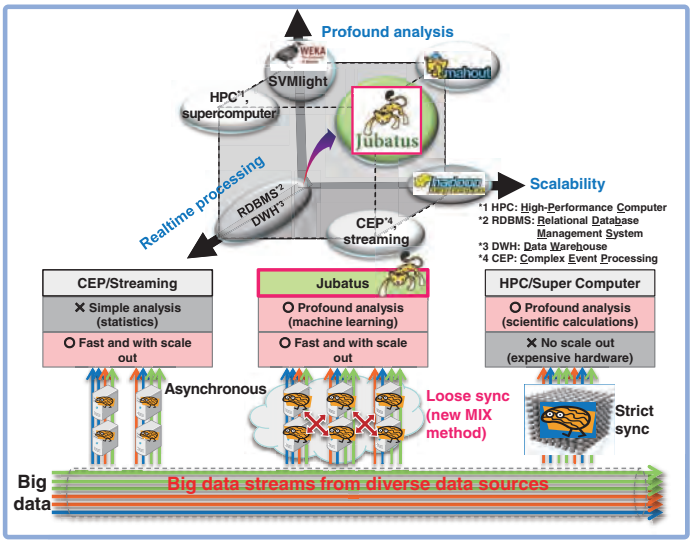
Framework for continuous, high-speed, in-depth analysis of big data

NTT R&D FORUM 2012

C－42

Jubatus: Scalable Distributed Computing Framework for Realtime Analysis of Big Data

Jubatus is a *scalable* distributed framework for *realtime* and *profound* analysis of big data. It improves the availability and reduces the communication overheads by using parallel data processing and by *loosely* sharing intermediate results within the component servers.



Features

- Realtime processing: on-demand processing without data accumulation
  e.g. two servers for worldwide social media data analysis (up to 8,000 messages per second)
- High scalability: scales linearly with the number of commodity servers (up to 100)
  e.g. x 14.9 better performance with 16 servers
- Profound analysis: able to deploy sophisticated algorithms such as machine learning
  e.g. accuracy level comparable with batched machine learning

Application Scenarios

- Realtime analysis
  Examples: Fraud detection; market, economics, and stock prediction; disaster prediction; resource prediction in manufacturing; health management; predictions in the natural sciences

NTT Group Advantages

NTT is undertaking *open* innovations and it is promoting and capitalizing on its realtime distributed framework for big data to contribute to information processing technologies.

- This technology is collaborative work with the company Preferred Infrastructure and with the OSS (Open Source Software) community.

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＜ICT that Creates＞

Secure Computation System

Secure computation technology enables various statistical analyses using encrypted data while it remains encrypted, making computation safer and more efficient. In February 2012, for the first time in the world, it was demonstrated that this secure computation technology could achieve secure statistical analysis of data that needs to be kept confidential, such as clinical research data, with sufficient speed while remaining encrypted.

This processing performance is still the best in the world. At present, development of a commercial system is underway and in 2014 it showed its capabilities with the statistical analysis of a data set with 1 million units. Plans are in progress to continue expanding its operational capabilities and adding functions and performance to establish this as a technology capable of dealing with a 10 million unit data set.

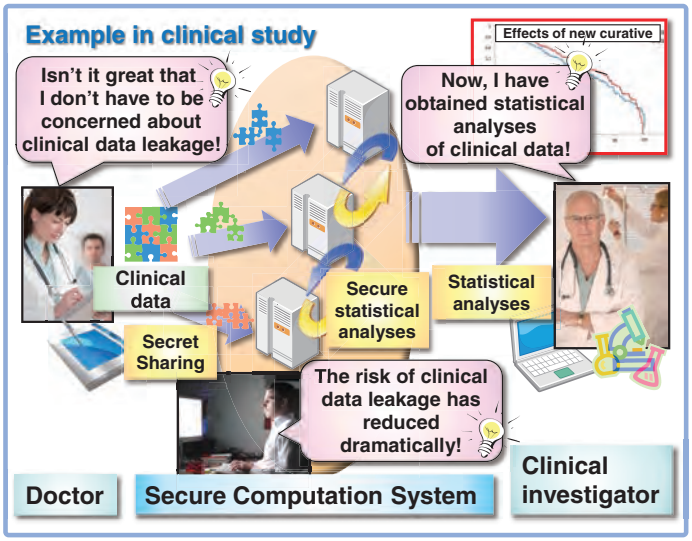
Cloud and Security

Enables safe statistical analysis of confidential data in fields such as medicine

NTT R&D FORUM 2012

C－43 Secure Computation System

Secure computation is a technology that enables one to perform statistical analyses using secretly shared data without reconstructing them. NTT's fast Secure Computation System can perform safely statistical analyses on highly confidential data such as clinical data safely with less information security compromise risk.



Features

- **Security: An operator of statistical analyses can obtain only analytical results, so that he/she need not store confidential data fraught with high risk.**
- **Security: Data provider can post data at ease since even the system administrator cannot view it.**
- **Efficiency: Our Secure Computation System is the fastest in the world (as much as hundreds of times faster than others).**
- **Practicality: Various statistical analyses including medical ones are available.**
- **Usability: An operator of statistical analyses can use our system in Microsoft Excel®.**

Application Scenarios

- **Services: A service provider gathers clinical data from doctors, and provides clinical investigators with statistical analyses.**

NTT Group Advantages

NTT's Secure Computation System has achieved secure clinical statistical analysis functions for the first time in the world due to our inventions of revolutionary algorithms of secure arithmetic operations, secure sorting, etc.

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＜ICT that Creates＞

ICT Design Center (IDeC)

NTT R&D, in aiming to achieve “human-friendly ICT services” is making full use of various techniques in human-centered design and cognitive psychology and promoting the development of support tools and guidelines for design improvement based on user evaluation.

Currently, besides initiatives to construct a service design framework for comprehensively supporting the entire service design process including “market and user understanding,” “creation of service ideas,” and other upstream processes, the NTT Group is aiming toward improving service design and creating attractive services.

Work

Business support to improve the QoE (Quality of Experience) of services and products

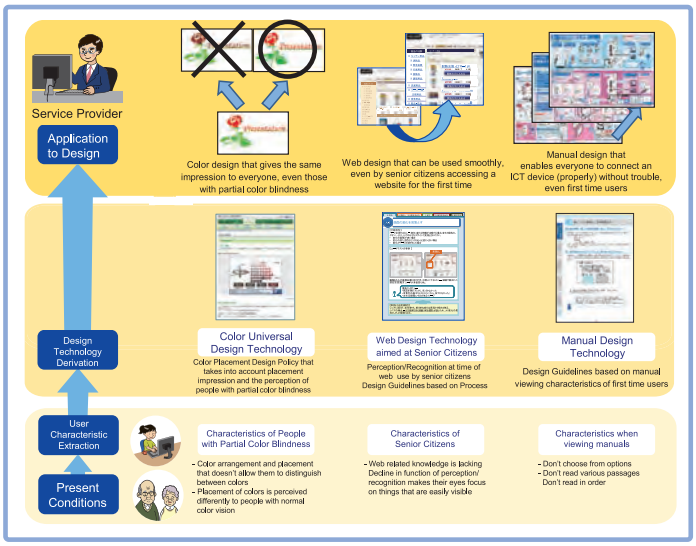
NTT R&D FORUM 2012

C—43

ICT Design Center (IDeC)

ICT Design Center (IDeC)

With a “human centered approach” that thinks about design from a user’s perspective, we are undertaking design support of ICT services that are human friendly. Starting with senior citizens, we are making clear their cognitive and psychological characteristics as users and establishing a design policy based on that. By applying this as the guiding principle to the actual planning, evaluation of ICT services and the support method, we will contribute to the creation of ICT services that are easy for everyone to use.



Features

- Based on humans’ perception of color vision characteristics and color universal design compatibility, establishment of guidelines for color design that are easy for designers to work with
- Based on analysis of cognitive processes of senior citizens web use, establishment of design guidelines that can be used for imagining a user in web creation of upper layer processes and design requirement definitions.
- Based on behavioral characteristics of first time users when looking at manuals, establishment of manual design guidelines that make it possible for users to set up ICT devices on their own.

Application Scenarios

- Design of ICT services targeting consumers (user requirements extraction/formulation of design requirements/user-interface design/manual production)

NTT Group Appeal Point

At NTT, not only are we continuing to provide ICT services that senior citizens can understand and use, we are also establishing color design that pays attention to the way first time senior citizen users psychologically experience colors and persons with partial color blindness and “technology design that is kind to people” that pays attention all the way up to the psychology of users.

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<ICT that Creates>

Wave Field Synthesis for Realtime Sound Field Transmission

In order to create an extremely realistic audio system that gives a sense of sharing a space, we have developed a system for recording wave fronts and physically reconstructing them. In 2011, we derived a digital filter to transform microphone signals into loudspeaker signals based on physical properties for immediate live reproduction. On the basis of this, the world's first realtime sound space transmission with large-scale microphone and loudspeaker arrays was successfully undertaken in 2012.

In 2013, combining this technology with 3D video technology, a 3D audio-visual system that can provide a communication space as if persons in both the local and remote sites were facing each other in the same room was constructed and gained considerable attention.

At home

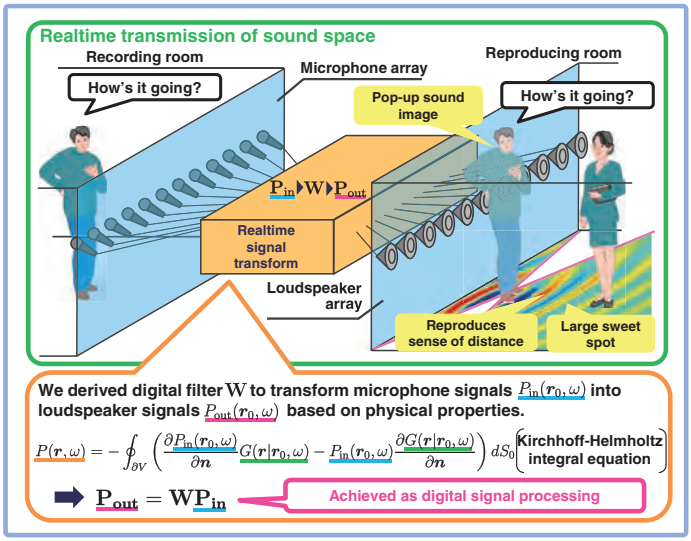
Super-realistic audio system achieved by transmission of spatial sound

NTT R&D FORUM 2012

C–10

Wave Field Synthesis for Realtime Sound Field Transmission

To achieve a super-realistic audio system that gives a sense of sharing space, we have developed a system for recording wave fronts and physically reconstructing them. By applying a new algorithm for preserving the physical properties of sound waves to a large-scale microphone and loudspeaker arrays, we have made possible realtime recording and reproduction of a sound space.



Features

- Spatially recording and reproducing the wave fronts using large-scale arrays enables multiple listeners to sense reality at any location in the reproducing room.
- Conventional stereo panning techniques give a sense of left and right to the sound source position. Our method enables physical reproduction of sound waves; therefore, it gives not only a sense of right and left but also back and forth.
- It is possible to reproduce sound images that pop-up from the sound-wall (loudspeaker array), so listeners in the reproducing room can share the space with people in the recording room.
- It is possible to record and reproduce a sound space in realtime by using our new transform algorithm.

Application Scenarios

- A telepresence system that gives a sense of sharing space and is close to face-to-face communication.
- A super-realistic audio system that is almost the same as live listening.

NTT Group Advantages

NTT has achieved the world's first realtime transmission of a sound space. This technique can be used for super-realistic audio systems that have potential as future telecommunication systems etc.

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＜ICT that Continues to Evolve＞

Next-Generation Photonic Transport System Technologies

Leading the way in digital coherent optical transmission technology which drastically improves optical fiber transmission capabilities by actively using ultra high-speed digital signal processing, NTT R&D successfully conducted an off-line 100 Gbit/s transmission experiment in 2008 and a real-time 100 Gbit/s transmission field trial in 2011. The 100 Gbit/s digital coherent DSP-LSI that was commercialized by NTT Electronics in March 2012 has gained more than a 50% global market share and is widely used in 100G-DWDM systems of world's leading system vendors.

NTT R&D is continuing to research and develop 400 Gbit/s digital coherent transmission technologies, and leading the world.

The 100G Digital Coherent Signal Processor (100G DSP) commercialized by NTT

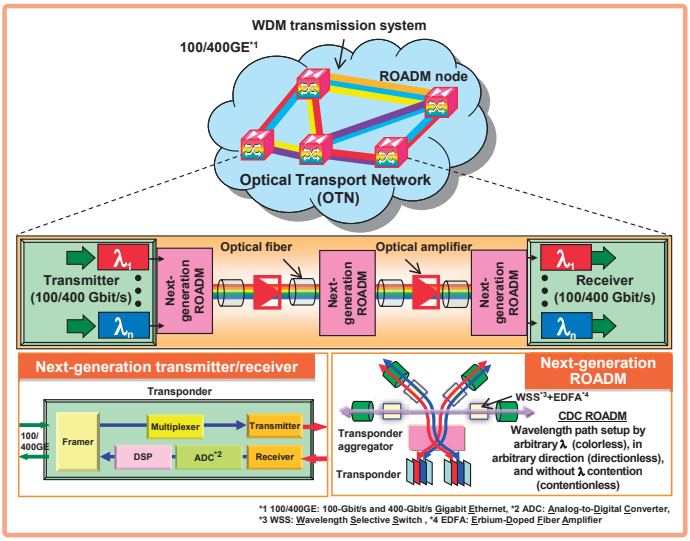
Evolution of networks —High-capacity network—

Key technology supporting future ultrahigh-capacity optical transport networks

NTT R&D FORUM 2012

E—8 Next-Generation Photonic Transport System Technologies

To achieve a long-haul high-capacity optical network, we are conducting R&D of realtime 100-Gbit/s systems based on a digital coherent technique to extend transmission distances and total capacities. We will make network operation efficient by using colorless, directionless, contentionless (CDC) reconfigurable optical add-drop multiplexers (ROADMs). Moreover, we are researching ultrahigh-speed optical transmission at over 400 Gbit/s by using multilevel modulation techniques.



Features

- 100 Gbit/s per channel realtime massive wavelength-division-multiplexing (WDM) transmission by using a polarization-division-modulation quadrature phase shift keying (PDM-QPSK) modulation scheme and large-scale integrated digital signal processing (DSP) technology*1.
- Spectral efficiency of 10 b/s/Hz is achieved by using a PDM-64QAM (64-state quadrature amplitude modulation) format, which is achieved by modulating the amplitude and phase of light into 64 levels.
- Flexible and efficient network operation is possible by using a CDC ROADM, which is expected as a next-generation ROADM.

Application Scenarios

- Next-generation 100-Gbit/s, post-100-Gbit/s backbone optical transport network.
- Future metro optical transport network.

NTT Group Advantages

We have successfully demonstrated 100-Gbit/s and post-100-Gbit/s transmission experimentally for the first time and are leading the world in this R&D. Moreover, we are contributing to standardization activities of 100/400GE over OTN*2.

*1 This work is partly supported by R&D of "High-speed Optical Transport System Technologies" and "High-speed Optical Edge Node Technologies" by the Ministry of Internal Affairs and Communications (MIC) of Japan.
*2 This work is partly supported by the "Lambda Access Project" and "Universal Link Project" of the National Institute of Information and Communications Technology (NICT) of Japan.
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2012

R&D Forum 2013: "Creating the future through innovation"

＜Innovation for Next Value Service＞

Detecting Security Threats and Creating Intelligences

To enhance security operation capability of whole NTT Groups, NTT R&D has developed SIEM analysis engine that is enabled to detect invalid network access of malware-infected hosts, as well as to extract malicious sites as security intelligence. The technology is currently integrated into NTT Communications Group's Manages Security Service "WideAngle".

Continuous research is ongoing to improve detection capability by adding more detection rules and automatically creating detection intelligence. The research scope is further expanded to detection of unauthorized access to web applications.

Cloud/Security

Security infrastructure

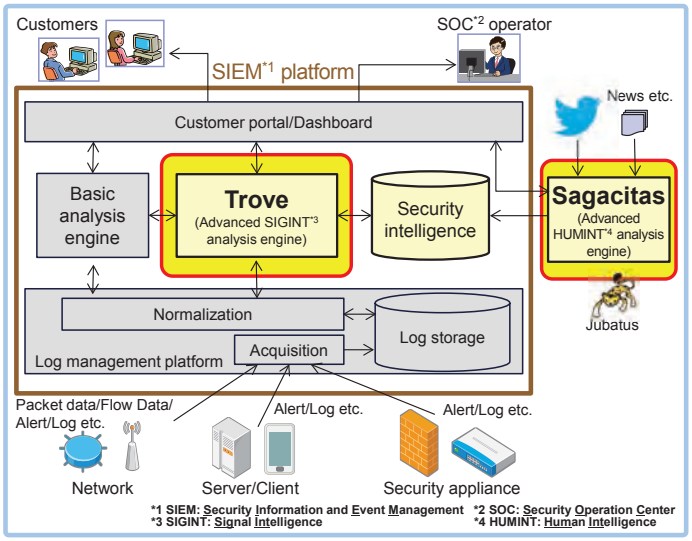
Log analysis engines for global SIEM platforms

S−5

Detecting Security Threats and Creating Intelligences

NTT R&D FORUM 2013

To improve security operations for/by whole NTT Groups, we have developed log analysis engines that can detect evidence of unblocked security threats and provide additional knowledge (e.g., unknown malicious sites and security related information) to an intelligence database. Our engines will be applied in a MSS (Managed Security Service) which uses SIEM platform and in other security operation activities.



Features

- Analyzes long-term time series logs to promptly find evidence of unblocked attacks (e.g., information leakage, targeted attacks, etc.).
- Detects unknown malicious sites by analyzing co-occurrence, which is a characteristic of connecting patterns observed in malware-infected machines. Our engine provides optimized blacklists to individual customers after analyzing their log data.
- Supports security information analysis by automatically extracting security related information from a large amount of social information (e.g., Twitter data, news articles, etc.). The security related information is used to detect evidence of attacks.

Application Scenarios

- Operating in a MSS platform which is developed for global customers.
- Enhancing security operations for enterprise/in-company networks.
- Promoting efficiency of public monitoring operations of CSIRT (Computer Security Incident Response Team) activities.

NTT Group Global Advantage

We plan to deploy our engines in the Global MSS Platform developed by operating company. The platform will provide a managed security service to customers in Asia, Europe, and the US. We will also apply our engines in CSIRT activities.

- This technology is a joint R&D work with NTT Communications Corporation.

<Contact>sv-forum@lab.ntt.co.jp

With the theme “Creating the future through innovation, ”the forum introduced R&D projects focusing on cloud, security, network, and personal services to help achieve NTT's Mid-term Management Plan, “Towards the Next Stage.”

＜Innovation for Next Value Service＞

Low Bitrate Distribution of High Resolution Video

In 2013, based on H.265/HEVC (High Efficiency Video Coding), the most recent international standard for video codecs, NTT R&D developed a software encoding engine with the world’s highest level of video compression. It is commercialized by NTT-AT as HEVC-1000 SDK, the HEVC software codec development kit. With this technology, in 2014 NTT Plala began providing the Hikari TV 4K Service, commercial 4K video streaming service that uses highly compressed, high-resolution 4K stream.

In 2015, NTT successfully developed the world’s first 4K HEVC realtime encoder LSI for professional use.

4K HEVC realtime encoder
LSI for professional use
(developement code name : NARA)

User experience

User interface

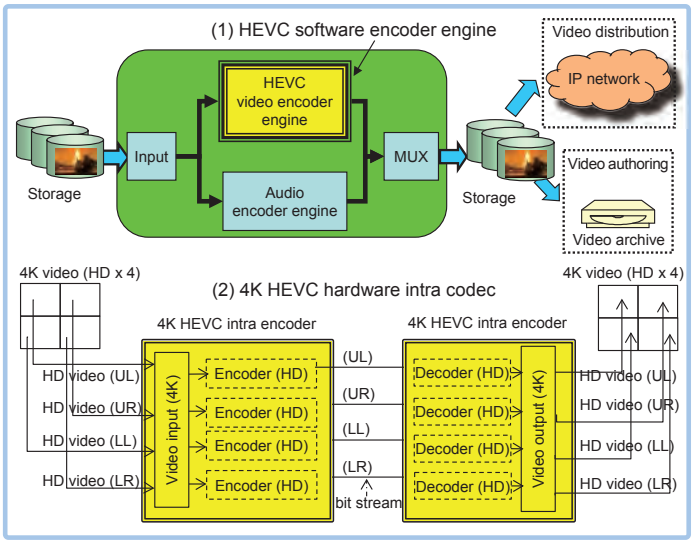
HEVC encoder engine for online video distribution

S−34

Low Bitrate Distribution of High Resolution Video

NTT R&D FORUM 2013

(1) Our software encoder engine conforms to the latest video coding standard HEVC. It’s a software library that can be used in the development of application software such as encoders and transcoders. (2) Our 4K HEVC hardware intra codec uses HEVC intra prediction to achieve real-time encoding and decoding of 4K video having four times the full HD resolution.



Features

- **The encoder engine achieves higher compression performance than MPEG-4 AVC/H.264, thus making it suitable for compression of high resolution video and use in mobile video services.**
- **It encodes software offline to achieve high visual quality, thus making it suitable for use in VOD services.**
- **The intra codec has four HD codecs working in parallel, thus enabling real-time encoding/decoding. It is applicable to transmission or live distribution of TV programs.**

Application Scenarios

- **Video distribution over networks/video broadcast services**
- **Video services for mobile devices**
- **Encoding services for video archives**

NTT Group Global Advantage

This technology is based on the latest international standard, HEVC. The NTT group’s video codec products are known for their high image quality and low latency, and are adopted by broadcasting stations all over the world.

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＜Innovation for Next Value Service＞

Scalable Network for Large-Scale Datacenter with "Ryu"

Ryu SDN Framework is a software platform that provides tools and libraries foragile Software-defined Networking (SDN) development. Since Ryu began being developed as Open Source in 2012, utilizing the strengths of open source. Ryu has been used by many different users including SDN application developers, network device developers, and those involved with maintaining network services.

There are lots of ongoing activities to apply this technology in many different use cases including white box switches.

Cloud/Security

Cloud platform

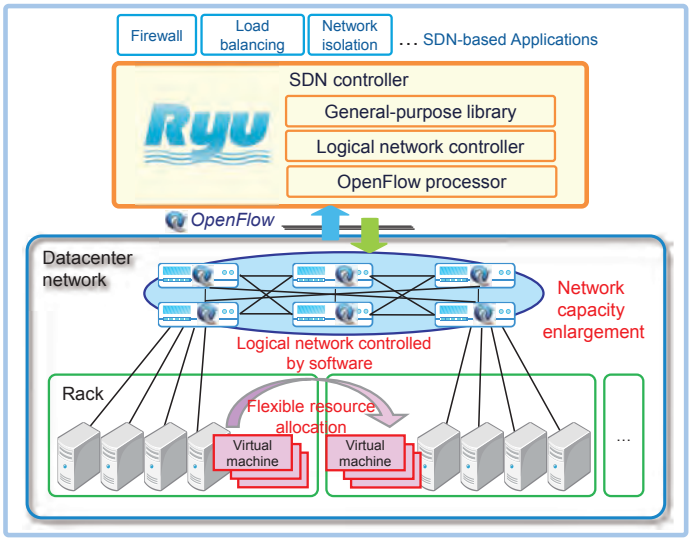
S−1

Open-source development tool set for software-defined networking

Scalable Network for Large-Scale Datacenter with "Ryu"

NTT R&D FORUM 2013

A new network architecture called Software-defined Networking (SDN) enables construction of a scalable network for a large-scale datacenter. The architecture avoids data centralization cased by tree topology and thus achieves high capacity. "Ryu" is a tool set we have developed for such networks in cloud computing that avoids the need to rely on any one particular networking equipment unit.



Features

- Provides open-source software in a quick, flexible, and low-cost way.
- Includes a software development kit for SDN-based application.
- Includes a vendor-free network controller that supports the OpenFlow Protocol. It is a logically centralized controller for managing network devices.
- Includes a development platform for network applications.
- Migrates to an SDN-based network supporting existing network protocols such as BGP.
- Provides developer tools and useful libraries, such as a fault diagnosis library, for its own OpenFlow applications.

Application Scenarios

- Supporting traffic engineering in a datacenter to achieve large-scale cloud service.
- Allocating virtual machines flexibly by network isolation to make the utmost use of the available datacenter resources.

NTT Group Global Advantage

The "Ryu" package is expected to make a significant contribution to worldwide cloud business with its open-source SDN controller, while enhancing partnerships with the Open Networking Foundation (ONF) and network venders supporting OpenFlow.

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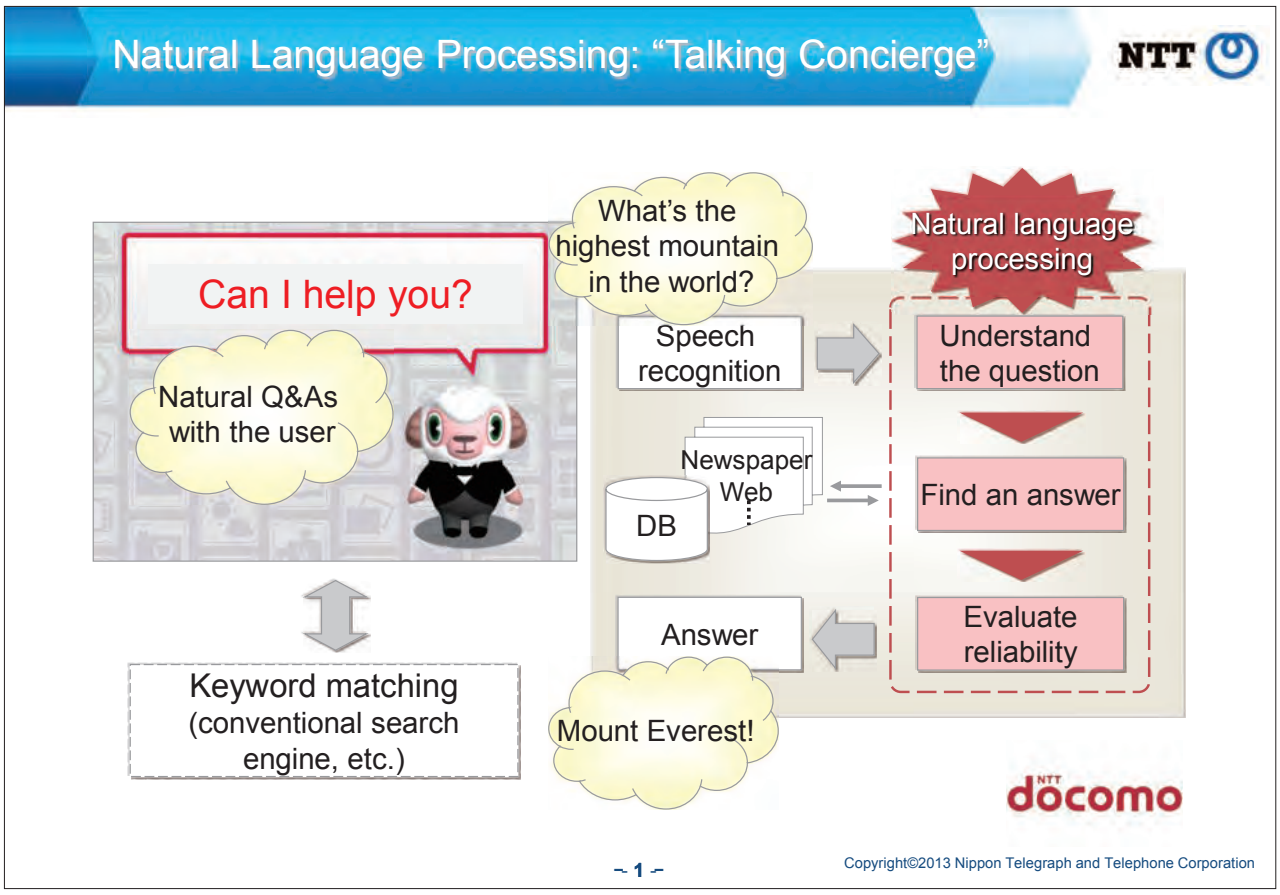
＜Chain Reaction of Innovation＞

Shabette Concierge（Talking concierge）:Natural-Language Processing Technology

Faced with rapid changes in the business environment and the speed of technological trends, as the Group's growth engine, NTT R&D is strengthening its existing innovation framework by the creation of a chain reaction with new innovation and in turn is contributing to transforming the NTT Group into a Value Partner. As part of this, NTT R&D is providing the elemental technology it developed as a service engine and is making efforts to contribute to the company's innovation.

For example, in March 2012, NTT DOCOMO launched the Shabette Concierge service in which NTT R&D provided the technology for answering Japanese language questions and, in June of the same year, greatly contributed to realizing the Shabette Concierge's knowledge Q&A function that makes it possible to directly answer natural-language questions from users.



From Keynote: "Chain Reaction Innovation"

＜Innovation for Network＞

Automatic Manipulation and Navigation Without Renewals

As a technology that has contributed considerably to lowering operating costs across the group, UMS (Unified Management Support System), which helps realize more effective operations by automating the routine manipulations and repetitive operations an operator has to perform and which are not supported on other regular administrative support systems, was developed. It features a "Data Bridge" which securely transfers data between systems and "Annotation Tool," which directly shows navigating information on the Operation System interface. In comparison with similar technology, one of its features is that the operator can easily improve efficiency from their own terminal. The technology is currently used widely and in various ways to improve efficiency throughout the Group's companies.

Currently, UMS is sold by NTT-AT as "WinActor" and "Data Bridge" is sold by NTT Software as "Crossway/Data Bridge".

Operation

Operation

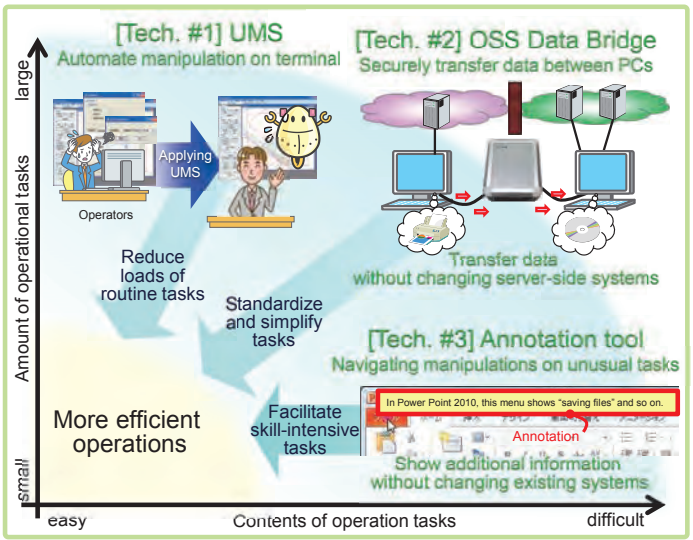
N−3

Operation efficiency technology on client terminal, UMS and related technologies

Automatic Manipulation and Navigation Without Renewals

NTT R&D FORUM 2013

Unified Management Support System (UMS) is agent software that automatically manipulates the Operation System (OpS) interface on behalf of operators. UMS reduces the workload on operators and operating costs. UMS-related technologies are "OSS Data Bridge", which securely transfers data between PCs, and "Annotation tool", which directly shows navigating information on the OpS interface.



Features

- **Tech. #1: UMS helps operators automate operations for simplifying routine manipulations. UMS is especially effective for automating repetitive and stylized operations by functions for editing in visual.**
- **Tech. #2: OSS Data Bridge is a system for easily transferring data between PCs on different policies. For one terminal, another terminal looks like a virtual printer for outputting data; conversely, a virtual CD drive for receiving data. This system transfers only data acceptable to the policies.**
- **Tech. #3: Annotation tool provides additional information that operators should manipulate. This helps operators manipulate without any special skills.**

Application Scenarios

- **Automate repetitive and stylized operation without system modification**
- **Securely transfer data between PCs on different policies**
- **Support and navigate manipulations that are difficult to automate**

NTT Group Global Advantage

For advances in outsourcing human resources and offshoring business, we need to develop systems as a native multi-language environment. "Annotation tool" enables the easy development of an environment without changing existing systems.

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＜Innovation for Network＞

Visualizing Power Consumption of Each Appliance with only Our Sensor installed on a Distribution Board

This is a technology that with one sensor on the distribution board of a home or shop the operational status and power consumption of individual electronic appliances can be analyzed and displayed. This technology realizes a cost-efficient power consumption visualizer for individual appliances and it is expected that it will be operational in other services such as energy saving support services and monitoring of elderly people services.

In addition to household single-phase-three-wire systems, it is also now compliant with commercial three-phase-three-wire systems, meaning that the technology can expand its commercial potential to provide small shops and similar businesses with the ability to visualize their power consumption, monitor for abnormalities and manage their business operations.

This technology was verified in regular households, chain stores and convenience stores to verify the its monitoring capabilities and basic functions in real environments in order to ascertain its practicality.

Energy & Environment

Energy & Environment

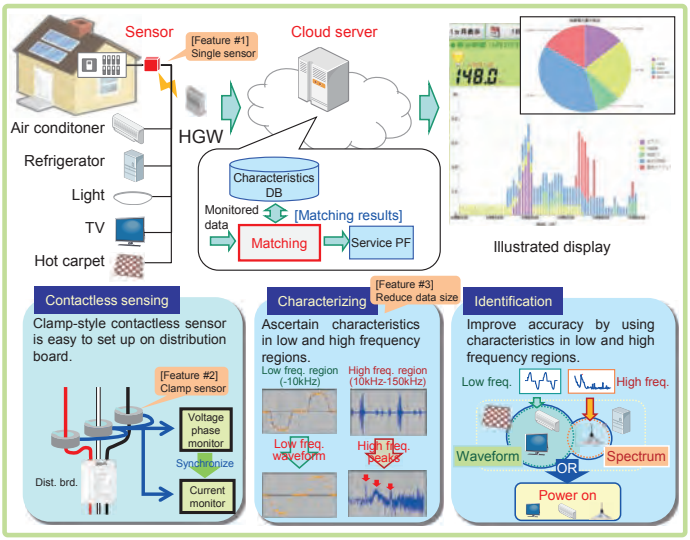
N－29

Appliance load monitoring system

Visualizing Power Consumption of Each Appliance with only One Sensor Installed on a Distribution Board

NTT R&D FORUM 2013

We provide a cost efficient appliance load monitoring system by using a clamp-style contactless sensor attached to a distribution board, and by analyzing measured current data. This is contrary to conventional systems, which require sensors to be attached to every home appliance to visualize power consumption.



Features

- **Feature #1: Appliance load monitoring system with a current sensor attached to a distribution board.**
- **Feature #2: The clamp-style, contactless sensor can be easily attached to the distribution board.**
- **Feature #3: To minimize the data size to transfer, we ascertain the characteristics of monitored current data. This substantially reduces the energy consumption of sensing equipment and the network load.**

Application Scenarios

- **Visualizing home power consumption with low cost.**
- **Applying the system to convenience stores and/or small offices.**

NTT Group Global Advantage

We are considering the idea of applying our system to developing countries, which also need to reduce energy consumption.

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＜Innovation for Network＞

Space-Division-Multiplexing Technologies for 1 Pbit/s Transmission

In order to meet the demand of future ultra-large-capacity optical transmission, NTT R&D is conducting research on space-division-multiplexing and multi-level modulation/demodulation technologies. In September 2012, the world's first ultra-large-capacity optical transmission of 1 Pbit/s over 52.4 km was successfully demonstrated by using 32 QAM digital coherent modulation/demodulation and 12-core fiber with a newly developed structure. Transmission capability of 1 Pbit/s can transfer 5,000 high vision 120-minute long movies in 1 second.

In 2013, NTT R&D also conducted the ultra-high capacity long-haul optical transmission experiment with the capacity-distance product of 1 Ebit/s·km (688 Gbit/s transmission over 1,500 km) by using propagation-direction interleaved transmission technique.

Convergence network

High-capacity networks

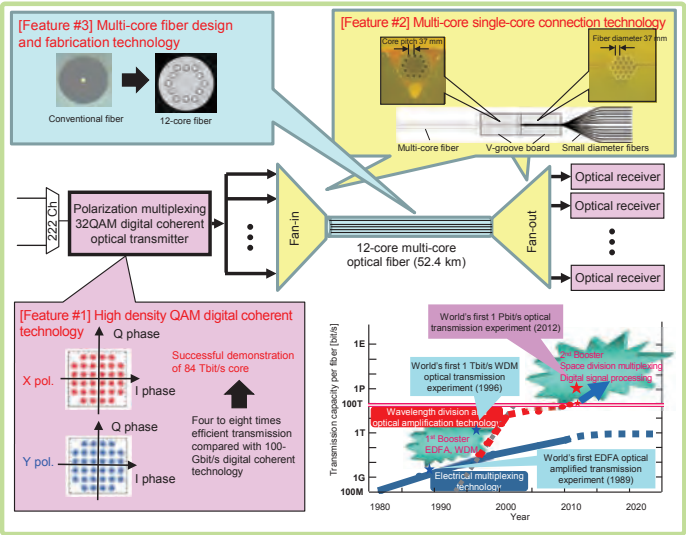
N－10

Ultra-large-capacity multi-core transmission technologies

Space-Division-Multiplexing Technologies for 1 Pbit/s Transmission

NTT R&D FORUM 2013

We are conducting research on innovative space-division-multiplexing technology and multi-level modulation/demodulation technology to meet the demand of future ultra-large-capacity transmission. By combining these innovative technologies, we have made possible the world's first transmission of 1 Pbit/s per fiber.



Features

- **Feature #1: Higher order multi-level signal transmission and digital coherent receiver technology**
- **Feature #2: Low-loss and low-crosstalk fan-in/fan-out device for splitting 12-core fiber into 12 individual fibers**
- **Feature #3: Low-crosstalk 12-core optical fiber with a newly-developed one-ring structure**
- **By combining the above technologies, we have demonstrated the world's first ultra-large-capacity optical transmission of over 1 Pbit/s* per fiber**

* Equivalent to a speed of transmitting 5,000 high-definition two-hour movies in a second

Application Scenarios

- **For future Pbit/s-class long-haul core optical network**

NTT Group Global Advantage

We conducted the world's first EDFA optical amplified transmission experiment (1988), 1Tbit/s WDM optical transmission experiment (1996), and 1Pbit/s optical transmission experiment (2012), and are leading the research and development of large-capacity optical transmission technology.

- Part of this research uses results from research commissioned by the National Institute of Information and Communications Technology (NICT) entitled "Research on innovative optical fiber technology" and "Research on innovative infrastructure of optical communications"

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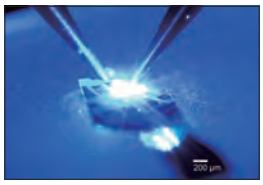
＜Innovation for New Field＞

Detachable GaN-Based Thin-Film Devices

In April 2012, we developed a groundbreaking process for detaching GaN-based thin-film devices (e.g. blue LEDs) from sapphire substrates. The detached thin-film devices will serve a wide range of applications such as ultra-thin LEDs, and transparent and UV-sensitive solar cells. This development has attracted a great attention from both the academic and industrial communities, as evidenced by many invitations to international conferences.

Now, performances of power transistors have been also improved by the detachment and transfer technologies. Combining our thin-film growth and process technologies with device application technologies developed by other institutes may further enhance device performances, leading to development of next generation innovative semiconductor devices.



Blue light emitted from the thin LED

Innovation for New Field

Innovation for New Field

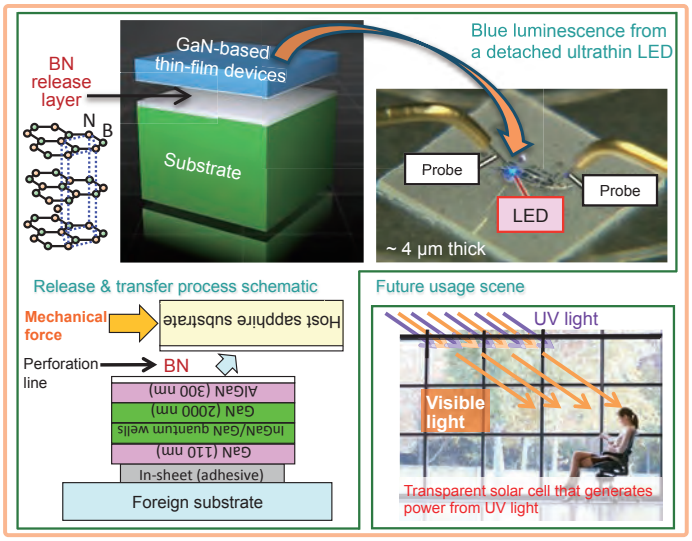
C－2

Advanced thin-film materials technology leading to innovative device designs

NTT R&D FORUM 2013

Detachable GaN-Based Thin-Film Devices

We have recently developed a novel process for detaching GaN-based thin-film devices (e.g., blue LEDs) from substrates. In this process, an extremely thin and cleavable layer that serves as a perforation line is inserted between the substrate and thin-film device. The detached thin-film devices will serve a wide range of applications such as ultra-thin LEDs and transparent solar cells.



Features

- **Detaching GaN-based thin-film devices alone from substrates by utilizing the cleavable nature of the inserted BN (boron nitride), which has a layered structure similar to that of graphite and mica.**
- **Easy and damage-free detachment of thin-film devices by mechanical force without any laser beam machining or chemical treatment, which allows for less expensive yet more scalable processing.**
- **Substrate recyclability further widens the application field of GaN-based devices and provides an environmentally friendly approach.**

Application Scenarios

- **Extremely thin blue LEDs attachable to things such as walls, windows, and vehicles.**
- **A window-attached transparent solar cell that can cut out hazardous UV light while generating power.**
- **High-performance power devices free from heat-induced degradation.**

NTT Group Global Advantage

NTT has developed a groundbreaking process for detaching large-area GaN-based thin-film devices from substrates without using large-scale laser equipment or chemical processing. This achievement has been published in "Nature" magazine and dispatched across the globe.

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2013

R&D Forum 2014: "Co-Innovation-Creating the future with you through R&D"

＜Evolution of Value Services＞

New Shirt for Continuous Monitoring of Vital Data Beneficial for Sports Training and Healthcare

In collaboration with Toray, we have successfully developed a sensing fabric "hitoe" that is capable of continuously vital signs monitoring. The heart rate and heart electric potential can be measured in various situations during daily life just by wearing the shirt composed of "hitoe." And they can be confirmed easily on smartphone or tablet. In December 2014, the "Runtastic for docomo" sports support service from NTT DOCOMO and the "C3fit IN-pulse" wearable measuring device from Goldwin went on sale.

At present, we are investigating the improvement of device design and biological data analysis technologies to launch new services in the sports, health care and medical fields. By these services, we will continuously contribute to solve the social problems and to improve quality of life in various fields.

hitoe

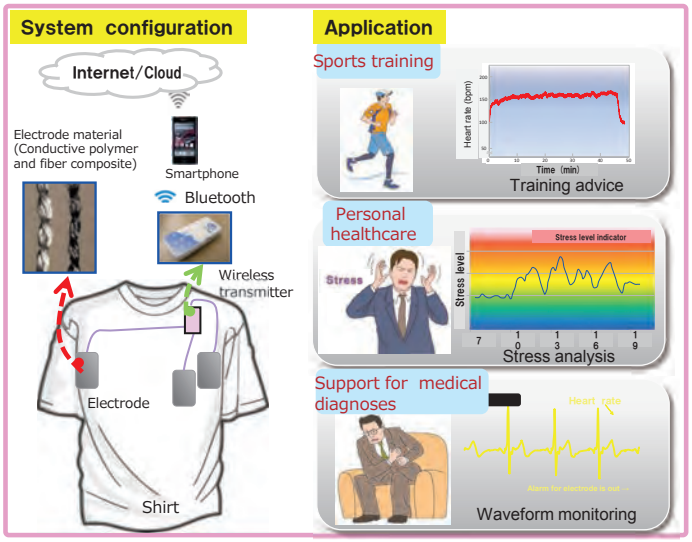
User experiences
User interfaces
V－7

Wearable biological Information system

New Shirt for Continuous Monitoring of Vital Data Beneficial for Sports Training and Healthcare

NTT R&D FORUM 2014

Wearable vital information sensing system is a shirt with a conductive polymer, fiber composite electrodes, and a small wireless transmitter. Athletes and patients wear the shirt and our system continuously monitors vital signs such as heart rate, wave form, and temperature. This technology will support medical diagnosis, personal healthcare, and sports training.



Features

- We fabricated a shirt with a conductive polymer and fiber composite electrodes.
- Long-term acquisition of vital data is possible without disturbing everyday life.
- The system is applicable for both physical and mental analyses.
- Vital data are sent to the smartphone wirelessly for display and also uploaded to the cloud for data analysis.

Application Scenarios

- Application of continuous monitoring of biological signals
  - Sports training advice
  - Healthcare (management of stress, sleep, and heat-related illness)
  - Support for medical diagnosis
- New value creation based on statistical analysis of vital data

Co-Innovation

We will create new services with our partners in the fields of sports and healthcare.

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With the theme of "Co-Innovation," the forum focused on creating Innovation R&D initiatives with partners. NTT Innovation Institute, Inc. (NTT I3), established in April 2013, also exhibited.

＜Evolution of Value Services＞

Predict and Prevent Congestions

Grapon, announced in 2013 as something that brings a new to the area of graph data analysis processing in the analysis of big data, at more than 10 times faster than existing counterparts is the fastest analysis technology in the world. With this technology, analysis of a social graph with the entire population of Japan which used to take a considerable amount of time can now be performed in just 3 minutes.

As the world's fastest graph mining engine, there are efforts underway to develop Grapon for use various fields. Furthermore, based on Grapon's technology, clustering algorithms have been developed for use in the areas of traffic congestion simulation, human logistics and traffic logistics.

Big data

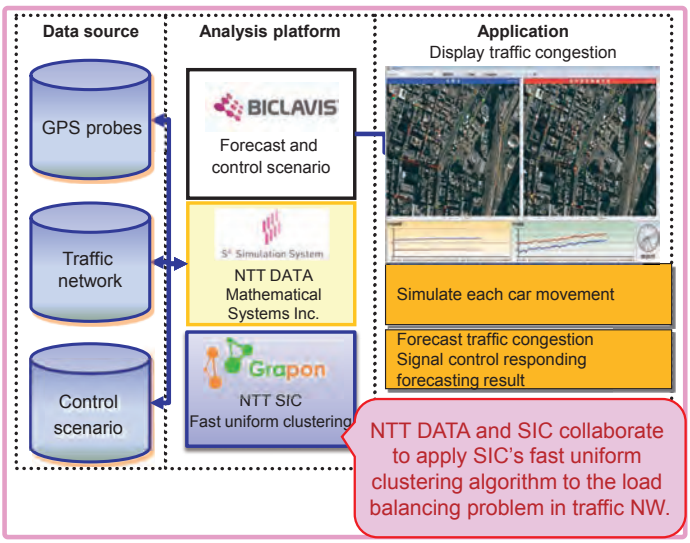
V－29

Traffic congestion forecasting and signal control simulation & Grapon

Predict and Prevent Congestions

NTT R&D FORUM 2014

Our simulation system predicts future traffic congestions from probe data through car navigation systems and smart phones etc. The system avoids traffic congestions in advance with the advanced signal control logic. The system also offers the simulation result at low cost by performing a large-scale distributed simulation using probe data with load balancing technologies.



Features

- Large-scale, highly efficient simulation achieves processing of more than one million data units
  - Distributed processing of HPC base to IA base
  - Highly scalable simulation by real-time load balancing
- Forecast congestions at low cost
  - Forecast congestions by using a lot of GPS probes
- Evaluation that flexibly changed conditions such as signal control etc.
  - Platoon method(Dynamic signal control)
  - Traffic volume
  - Lane closure, approach regulation etc..

Application Scenarios

- Measures against traffic congestions in advanced countries or a developing countries
- Events(Olympic Games etc..) or the design of the regulation part at the time of an important person visit
- Plan of the optimal design in the road building toward traffic mitigation

Co-Innovation

NTT DATA and NTT SIC are collaborating to apply SIC's fast uniform clustering algorithm to the load balancing problem in road traffic simulation. The target of our collaboration is to achieve the scalable, large-scale and highly efficient traffic simulation by using the fast uniform clustering algorithm.

NTT NTT DATA

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＜Evolution of Value Services＞

Dialogue Technique which Enables Natural Conversation between a Computer and Human

We have been developing dialogue technology that can respond to users on the basis of commonsense knowledge and contextual understanding of user utterances. The technology includes the recognition of the current focus of a conversation from users' utterances and utterance generation by using a large knowledge base created from large text data. Using this technology that NTT R&D developed in 2013, NTT DOCOMO developed a chat API and, from November, started providing this API on "DOCOMO Developer support." From December the API was started to be used as part of DOCOMO's car life support service, "DOCOMO Drive Net Info", to provide it with dialogue function.

In 2014, a new version of the dialogue system was developed, and, from this, NTT DOCOMO updated the chat API in February 2015. The updated API enables personalized dialogue.

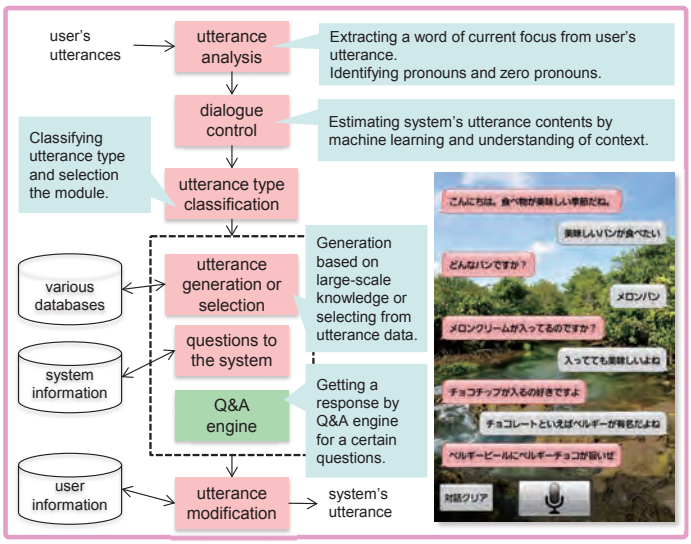
User experiences
Personalized services
V−20

Dialogue engine

Dialogue Technique which Enables Natural Conversation between a Computer and Human

NTT R&D FORUM 2014

This is a dialogue technique that can respond on the basis of commonsense knowledge and an understanding of context after recognizing the current focus of a conversation from user's utterances and context. We realize attractive/useful dialogues by generating utterances from large-scale knowledge and selecting most appropriate module from utterance data.



Features

- Understanding topic transitions by extracting the current focus of conversation from user's or system's utterances.
- Estimating next dialogue acts by machine learning after adding dialogue acts to user's utterances. (e.g., question, propose, empathy, etc.)
- Generating a system utterance from large-scale knowledge or selecting it from utterance data considering the focus and next dialogue acts.
- Expressing the system's personality by changing appearance probability of next dialogue acts and word endings.

Application Scenarios

- Dialogue function of docomo DriveNet Info
- Release API on docomo Developer support
  http://dev.smt.docomo.ne.jp/
- The application of a dialogue game

Co-Innovation

NTT and NTT DOCOMO realized this dialogue system which can respond to a user's utterances flexibly to match the context.

NTT DOCOMO developed the dialogue system based on technology from NTT Media Intelligence Laboratories.

NTT docomo

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NTT I³ : Base for Global R&D

NTT Innovation Institute, Inc. (NTT I³) was established in Silicon Valley in April 2013, with the aim of speedy development and entry to market of the world-leading cloud security technology in the highly competitive North American market, NTT I³ developed the "Automated Advisory Tool(m2cloud)" which establishes comprehensive processes based on cloud related migration know-how of North American companies and in the area of security NTT I³ has been generalizing the activities of the NTT group, helping it to be positioned as a "Challenger" in Gartner Inc.'s Magic Quadrant only one year after the establishment.

From Keynote: "Co-Innovation Challenges"

＜Evolution of Global Cloud Services＞

On-demand System Re-sizing and Upgrade with NFV-enable Hybrid Cloud

Unified Cloud management system for Hybrid Cloud enables enterprise customers to build application systems efficiently with the combination of NTT DC and customer premises.

We developed this technology to operation infrastructure technology applicable to OpenStack and by taking the form of a cooperative coalition with North American network vendors, NTT i3 rapidly integrate the results related to this technology to an infrastructure for NFV-enabled enterprise networking . We announced this topic across a range of media in February 2015 as the start of ESI (Elastic Service Infrastructure).

Cloud

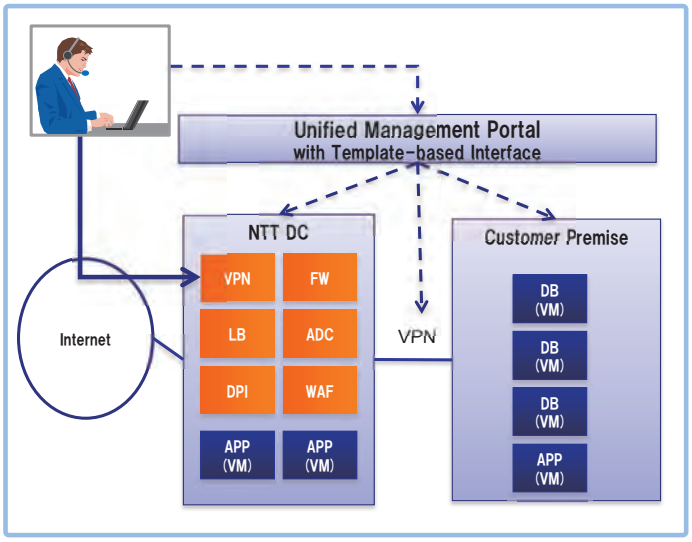
C-11

Unified Cloud management system for Hybrid Cloud

On-demand system re-sizing and upgrade with NFV-enabled Hybrid Cloud

NTT R&D FORUM 2014

Unified Cloud Management System for Hybrid Cloud enables enterprise customers to build application systems with the effective combination of NTT DC and customer premises. By adopting Network Function Virtualization (NFV) technology, it also provides customers with an option of inserting network gateway functions in an on-demand fashion.



Features

- Provides a single point of management for application systems spanning multiple physical sites
- Provides a template-based management interface for the coherent management of multiple cloud resources
- Extensible with a variety of network gateway functions, i.e. VPN, FW, LB, with products supporting OpenStack
- Manage hypervisor products with OpenStack plugins

User Case Examples

- Consumer-facing WEB sites interacting with enterprise's internal systems, i.e. EC sites and CRM portals (myX.com)
- The customer can responsively update the size of the WEB-front tier upon the change of site access traffic.
- The customer can continuously update new network gateway functions as measures against new security threats and device diversification.

Co-Innovation

This technology is the output of a collaborative R&D with NTT Innovation Institute, Inc.

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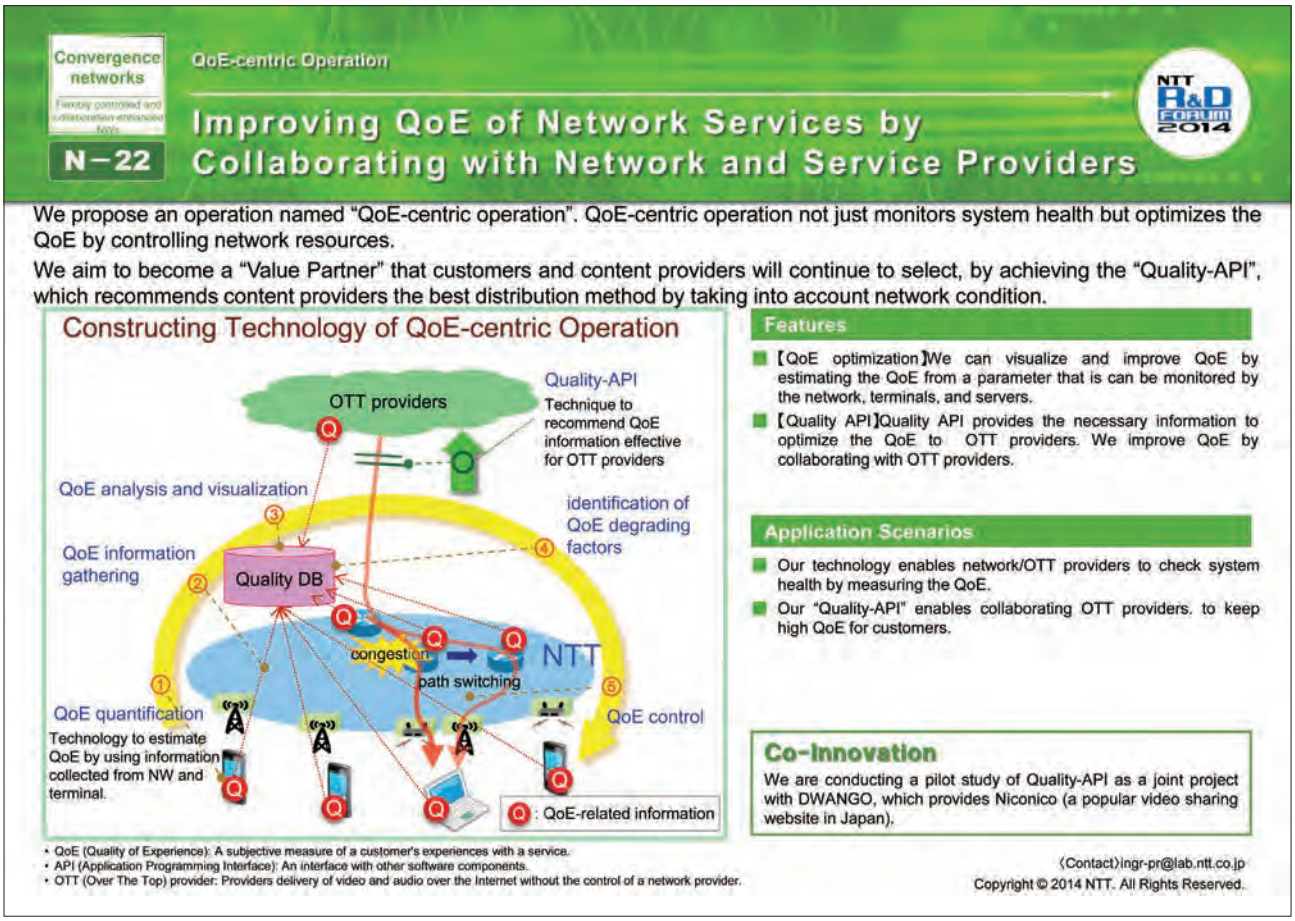
＜Evolution of Network Services＞

Quality API ; Improving QoE of Network Service by Collaborating with Network and Service Providers

In July 2013, NTT and Dwango started promoting technological developments for the advancement of video and social services under a business tie-up agreement. At present, collaborative research and experiments targeting three areas of technology are continuing: “networks,” “media UI/UX,” and “big data.”

Within this, in the area of network technology, NTT developed a prototype of a Quality API that recommends an optimal bit rate that maximizes user’s Quality of experience (QoE) to video distribution companies by considering user’s network quality.

In November 2014, we began conducting a field trial on Niconico, which is a popular video sharing website in Japan with millions of users to evaluate not only QoE changes but also the effect that QoE improvements have on key performance indicators (KPI).



＜Evolution of Global Cloud Services＞

MDRU Offers both the Information Networking and Processing Functions to Meet the Explosive ICT Demand in Various Situations

NTT has proposed a Movable and Deployable ICT Resource Unit (MDRU) which can be stored in a container or a box and is capable of being transported to large-scale disaster areas to provide a transmission/communications system (switching system/network functions) with storage and servers. At present, we are continuing with research and development activities to make this a concrete reality.

In January 2014, we developed an ICT Car, a van-type vehicle in which equipment for providing ICT (Information and Communication Technology) services such as telephone calls and information processing, which gained significant attention.

Following this, in December 2014, we conducted field trials with the MDRU in areas affected by the typhoon in the Philippines.

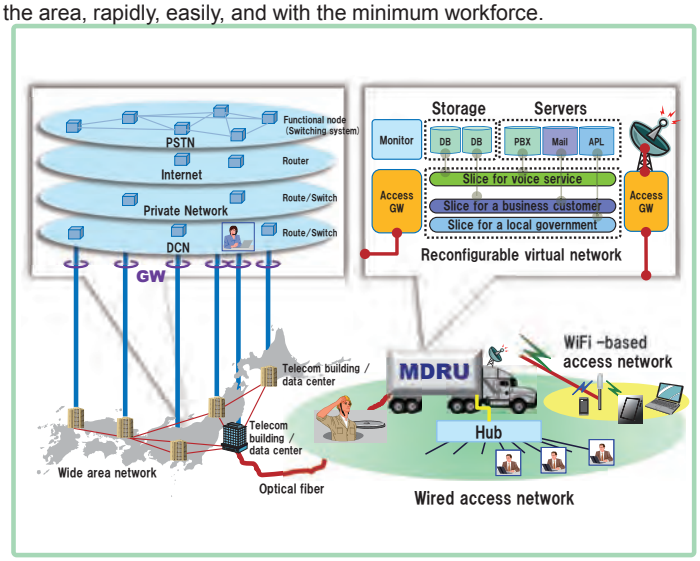
Convergence networks
Large capacity and highly reliable NWs
N–6

Movable and Deployable ICT Resource Unit for instant recovery of ICT services from disasters

MDRU Offers both the Information Networking and Processing Functions to Meet the Explosive ICT Demand in Various Situations.

NTT R&D FORUM 2014

NTT developed an ICT* resource unit which enables us to instantly launch ICT environment under large-scale disasters. The unit called MDRU is a movable container which accommodates both the information networking and processing functionalities. Once a disaster occurs, MDRU is carried to the disaster affected area, forms a Wi-Fi based access network and offers ICT services to the area, rapidly, easily, and with the minimum workforce.



Features

- The rapid restoration of ICT environment in the disaster affected areas.
- Wi-Fi-based wireless access network covering 500m radius area.
- Voice communication service for up to 5,000 users within the area. Users can easily use the service with their smartphones and original phone numbers.
- Hosting service to the organizations such as local governments, hospitals and private companies to support the restoration activities.
- The ICT services can be extended to wide area coverage by connecting the unit to a wide area network with satellite and/or fiber optic links.

Application Scenarios

- Rapid restoration of ICT environment in the disaster situations.
- Timely adaptation to the explosive ICT demand due to various events.
- Construction of ICT environment with short lead time for developing countries.

Co-Innovation

NTT developed a resilient ICT solution using Movable and Deployable ICT Resource Unit (MDRU). It enables us to offer ICT environment with timely manner in various situations such as large-scale disasters and any other events.

* ICT: Information and Communication Technologies.

- A part of this R&D is the collaborative work with Tohoku University, Fujitsu Corp., and NTT Communications Corp. with the support of the Ministry of Internal Affairs and Communications of Japan.

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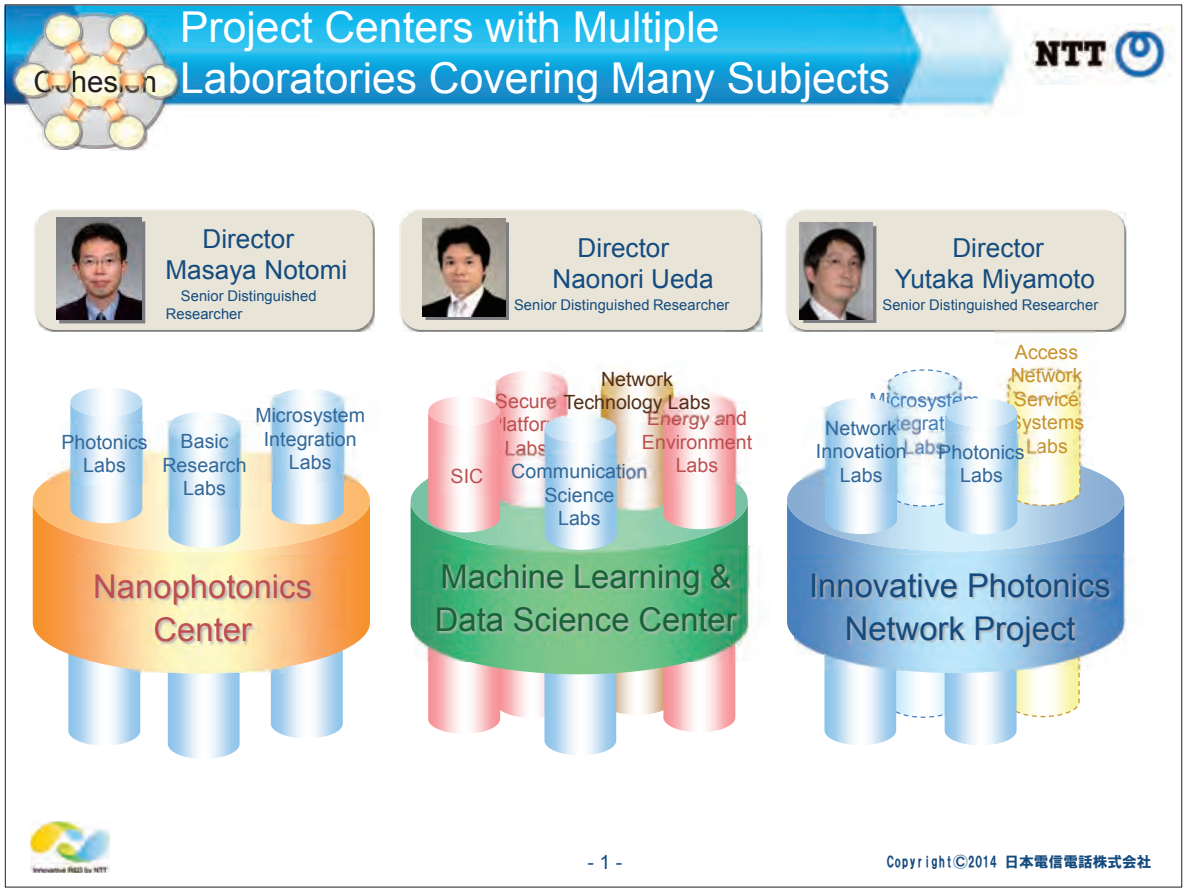
Centers of Excellence (CoE) in Fields of Distinction

From now on, it is necessary that R&D creates innovation through various collaborations. As one of the initiatives in this area, we are creating new value by supporting researchers who have grand visions for the future. For example, we are driving R&D for innovations in future information communication by establishing research centers in the three areas of machine learning, photonic networks, and nano-photonics, directed by distinguished senior scientists who are at the international forefront in their respective fields.



From Keynote: "Co-Innovation Challenges"

2014

R&D Forum 2015: “Co-Innovation—Towards a hospitable and comfortable 2020”

＜Take on Challenges toward 2020＞

“Omotenashi Navigator”: Smart Sightseeing Supporter

We have developed “Smart Sightseeing Supporter”, a system which presents users with appropriate information according to their characteristics and situation on analyzing the view through their smartphone camera or eyeglass-type wearable device and performing highly accurate object recognition.

With “Angle-free object information retrieval technology,” the system can accurately recognize three-dimensional objects in the environment seen from a range of viewing angle, and present users with relevant information.

A number of companies including those in the public transportation and tourism industry are showing interests in the system, and we are preparing for a field trial toward commercialization.

Hospitality

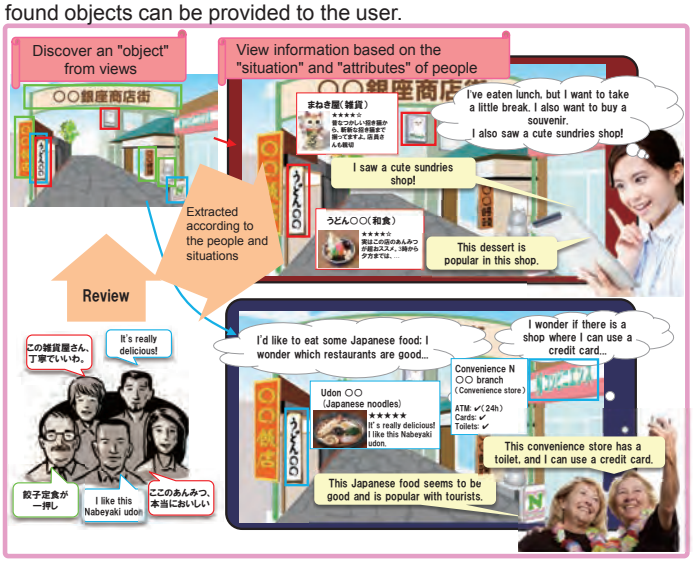
C－5

Sightseeing Navigation System Using Image Recognition Techniques

“Omotenashi Navigator”: Smart Sightseeing Supporter

NTT R&D FORUM 2015

We have developed a system that provides guidance to users according to the person, place, and landscape they are looking at through a smartphone or glass-type device. The system uses "Angle-free object information retrieval" as the subject identification method to discover multiple objects from a landscape image with a high degree of accuracy, and the details on the found objects can be provided to the user.



Features

- This system can detect multiple registered objects from a landscape image from a variety of angles and environments with high accuracy by using Angle-free object information retrieval.
- Only a small number of images need to be registered in "Angle-free object information retrieval" as training data, so service providers or users can register new objects easily.
- The system extracts information about the object and provides a navigation function for tourists depending on the attributes and situation of the user.

Application Scenarios

- Navigation for foreign travelers and tourists with diverse cultural backgrounds in tourist spots.
- Guidance about shops in shopping districts and event guidance aimed at regional activities.
- User support in the form of commentaries of events/exhibitions and navigation based on the interests of participants.
- Venue guidance at sporting and other public events based on the congestion situation and preferences of users.

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Looking toward the year 2020 with the theme of "Co-Innovation—Towards a hospitable and comfortable 2020," the forum introduced technology related to the concept of deeply impressing people providing them with new experiences while also presenting recent research results devoted to helping the NTT Group become a "Value Partner" that continues to be selected by the customers.

＜Take on Challenges toward 2020＞

High-reality Sports Experience from Athlete's View

This system enables users to have a new high-reality experience of sport content as if they were standing on the playing field. In advance, images were captured by a 360-degree omni-directional camera and sounds are captured with shotgun microphone array. Users can select their favorite view video and corresponding binaural sounds with an intuitive HMD/headphone-based user interface.

This is composed of interactive distribution technology for omni-directional video viewing that can transmit highly realistic video through a limited bandwidth, and sound source enhancement technology which is for generating binaural sounds corresponding to user head direction.

In 2014, DWANGO began virtual reality live streaming service using the interactive video distribution part of this technology.

Watch game like an actual spectator

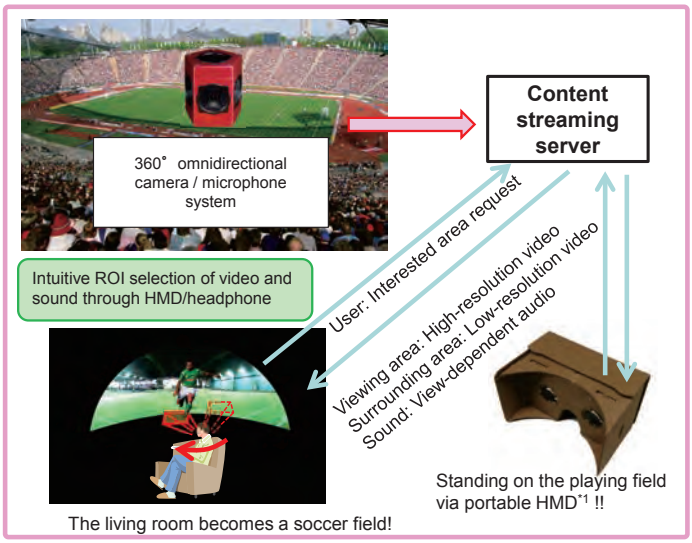
C－16

Omnidirectional Audio-visual Experience

High-reality Sports Experience from Athlete's View

NTT R&D FORUM 2015

This system enables users to have a new high-reality experience of sport content as if they were standing on the playing field. It captures omnidirectional audio and video by a 360-degree omnidirectional camera and microphone. Users can select their favorite view from the audio and video and obtain view-dependent audio with an intuitive HMD/headphone-based user interface.



*1 HMD: Head Mount Display

Features

- Immersive media experience derived from omnidirectional video and sound where users can intuitively access any view angle.
- Our interactive streaming mechanism makes it possible to send audio and video within a limited NW bandwidth without losing user QoE (quality of experience) by streaming at high-/low resolution for the user-viewing/surrounding area.
- Separation of DOA (direction of audio) dependent sounds from omnidirectional audio source captured by the special microphone array. The system enables users to hear view-dependent audio by composing the sounds.
- Our research focus includes synthesis of omnidirectional audio and video viewed from places where a camera/microphone system cannot be placed.

Application Scenarios

- This novel immersive sports experience makes the living room a sports playing field.
- Users can enjoy playbacks from an athlete's view using a portable HMD/headphone system.
- The view from actual referees and/or athletes can be useful for training of junior athletes and referees.

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＜Take on Challenges toward 2020＞

Delivering Sports Games through Realistic Sensations to Worldwide Locations in Real Time

By combining things like High Efficiency Video Coding (HEVC) and "advanced MMT" which synchronizes various media to produce realistic sensations, NTT is going ahead with research and development on the "concept of immersive telepresence "Kirari!"" This technology delivers not only vision/sound of the athlete but also information on the athlete's places and situations and reconstructs this in 3D along with sound at the site to which it is transmitted by using projection mapping technology.

A public demonstration of this technology was given at the R&D Forum 2015. The realistic 3D object images and the sounds that matched them perfectly, along with the lighting and movement, made it seem as if the action was actually taking place right in front of viewers. The technology in this demonstration received a considerable amount of public attention.

Watch game like an actual spectator

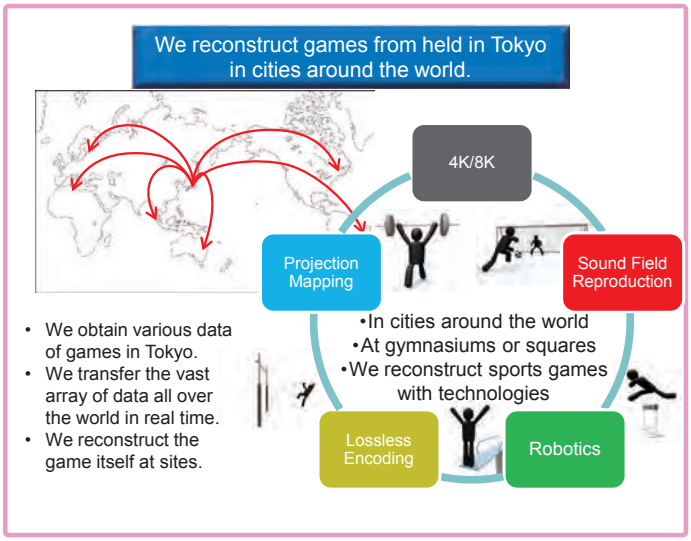
C－18

Concept of Immersive Telepresence "Kirari!"

Delivering Sports Games through Realistic Sensations to Worldwide Locations in Real Time

NTT R&D FORUM 2015

This is the concept of immersive telepresence "Kirari! ", which delivers games held in Tokyo to all over the world. We deliver not only vision/sound but also reconstruct the games with highly realistic sensations at worldwide locations in real time.



Features

- We are going ahead with "advanced MMT", which synchronizes various media to produce realistic sensations. These technologies deliver not only vision/sound but information on subjects, places, and situations all over the world.
- We reconstruct games at real scale without screens or displays, applying projection mapping at 4K/8K resolution.
- We do not deliver a visual of the games but the event sites themselves.
- We reconstruct the sounds of the games and cheers with sound field reproduction.

Application Scenarios

- We can reconstruct games with top athletes in weight lifting or judo at a gymnasium in New York, a square in Beijing, or schools in cities in Japan, providing a new type of public viewing.
- These technologies make it possible for organizers of international sports fests or conferences to provide a new viewing service from outlying regions with B2B2c.

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＜Creating the Future with Value Partners＞

Clear Sound Pickup under Noise Level of 100dB

Intelligent microphone technology makes it possible to have clear, hands-free conversations and pick up voices even in noisy environments such as inside cars moving at high speeds or industrial factories or construction sites. By sound signal processing developed assuming that sounds are captured with a small number of microphones, the noise level is lowered down to 1/10000 and the target voice can be picked up.

In addition, we have also developed "target microphone" that was developed for picking up sport playing sound (e.g. ball kicking sound and player's shout) even when placing microphones in noisy stadium.

Practical example of the headset intelligent microphone embedded in the helmet

Voice collaboration

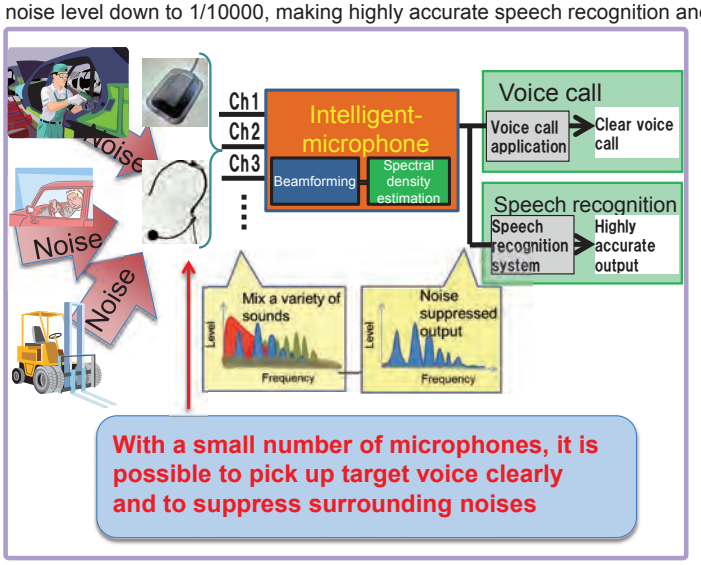
V−13

Intelligent-microphone Technology

Clear Sound Pickup under Noise Level of 100dB

NTT R&D FORUM 2015

We developed a sound signal processing technology to pick up target voices even in noisy environments like cars or industrial factories. In the signal processing, the spectral density of a target voice can be estimated accurately by using the spatial differences between beamformings, the frequency characteristics, and the temporal fluctuation of the sounds. This lowers the noise level down to 1/10000, making highly accurate speech recognition and clear voice calls possible even in a noisy environment.



Features

- The sound signal processing is developed assuming that sounds are captured with a small number of microphones.
- The proposed sound signal processing technology has a hybrid configuration of audio beamformings and spectral density estimation to suppress the noise components in the frequency domain.
- By estimating spectral densities of target and noise sound from multiple beamformings, high quality noise suppression is achieved.
- This newly developed intelligent microphone can be implemented for various terminals and for various situations.

Application Scenarios

- A voice command system using a speech recognition and high quality hands-free intercom that can be used in an environment with a huge noise level like a factory or construction site.
- The voice recognition of a car-navigation system in noisy traffic or when the car stereo is loud.
- A clear hands-free telephone system that can be used even in a noisy car while driving on a highway.

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＜The Future of Network Services＞

Fast and Sustainable Provisioning for Various Service Functions (Multi-Service Fabric)

NTT has launched the "NetroSphere concept" as a new way to form carrier network infrastructures. This enables to build proportional networks that can quickly offer required functionality, capacity, and level of redundancy in accordance to the user's needs. As a result, carrier networks will achieve enhanced flexibility and elasticity while also drastically reducing costs.

In order to realize the concept, NTT is driving the development of "Multi-Service Fabric" (MSF) as one of the key technologies in the transport layer for NetroSphere. MSF will contribute to realize the future network which provides various service functions promptly and economically.

NWs with co-created services
Flexibly controlled and collaboration-enhanced NWs

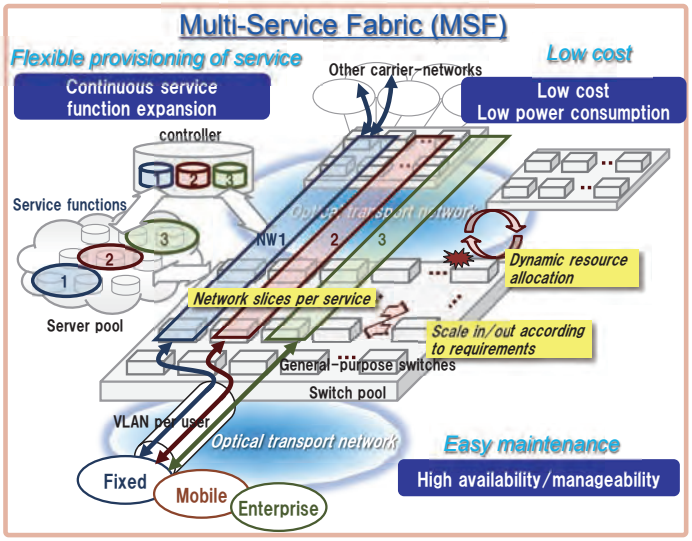
N−19

Network Architecture for Flexibly Controlling General-purpose Switches (Multi-service Fabric)

Fast and Sustainable Provisioning for Various Service Functions

NTT R&D FORUM 2015

Multi-Service Fabric (MSF) enables the development of networks that flexibly deploy service functions and user management functions and quickly provide various sustainable service functions. The new carrier-network architecture that controls general-purpose hardware will result in a drastic reduction in CAPEX/OPEX and the development of highly available networks



Features

- Network functions, which consist of general-purpose switches, are decoupled from the service functions. Switches are managed by external controllers.
- CAPEX and power consumption are drastically reduced using various inexpensive commodity switches.
- Virtual network slices are provided per service or customer.
- General-purpose switches working together with optical transport technology will result in highly reliable networks.

Application Scenarios

- Quick network provision according to various services demand from operators.
- MSF will not require any emergency repairs through the use of network redundancy sustainability when equipment failure occurs.

Taking on challenges toward 2020

We will develop a network that is both reliable and flexible to quickly and precisely meet various demands of partners.

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＜The Future of Network Services＞

High Performance Coding by Integrated Technologies in Global Collaboration for VoLTE

This standard is a superwideband (FM radio band width) speech and audio coding shceme established as EVS in December 2014 by 3GPP. Thanks to collaborative developments by 12 organizations, including NTT and NTT DOCOMO, and huge number of subjective listening tests, all requirements have been met. The standard will be adopted in VoLTE worldwide.

NWs with co-created services
Large capacity and highly reliable NWs
N－8

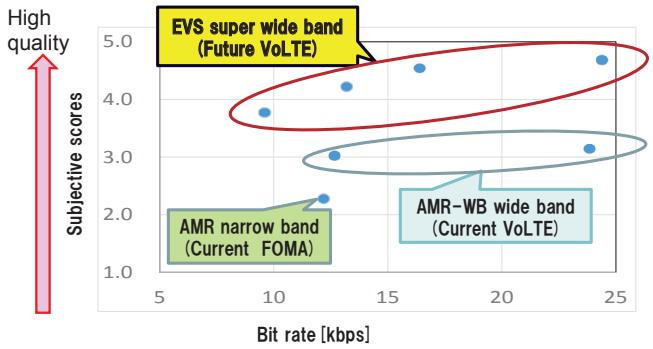
Establishment of Speech and Audio Coding Standard for 3GPP EVS (Enhanced Voice Services)

High Performance Coding by Integrated Technologies in Global Collaboration for VoLTE

NTT R&D FORUM 2015

This standard is a super wide band (FM radio bandwidth) speech and audio coding shceme established as EVS in December 2014 by 3GPP*1. Thanks to collaborative developments by 12 organizations, including NTT and NTT DOCOMO, and huge number of subjective listening tests, all requirements have been met. The standard will be adopted in VoLTE*2 worldwide.

EVS offers more bandwidth and higher quality under the comparable constraints of low bit rates and low delay in conventional schemes.



EVS supports super wide band（32-kHz sampling rate, FM radio bandwidth）
AMR-WB supports wide band（16-kHzs sampling rate, AM radio bandwidth）
AMR support narrow band（8- kHz sampling rate, telephone bandwidth）

Features

- Support for wide range of bandwidths and bit rates, providing best quality for each condition
- Integration of competitive component technologies from 12 organizations, including NTT and NTT DOCOMO
- Enhanced signal analysis and classification
- Enhanced quantization efficiency
- Enhanced bandwidth extension technologies
- Enhanced packet loss concealments optimized for LTE

Application Scenarios

- Global utilization in VoLTE in the future
- Key role in FMC(Fixed Mobile Convergence)

Taking on challenges toward 2020

Bandwidth and quality of telephone conversation in 2020 will be greatly enhanced. R&D will explore new functions beyond the normal concept of telephone.

*1 3GPP: 3rd Generation Partnership Project
*2 VoLTE: Voice over Long Term Evolution

NTT docomo

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＜Basic Research to Realize Visions＞

HenGenTou(Deformation Lamps): Animating a Static Object by Projecting a Motion Flow Field

NTT R&D has developed "HenGenTou(Deformation Lamps)", a light projection technique based on a completely new conception that by projecting a pattern of light produces illusionary movement of static objects.

"HenGenTou", which utilizes the processing characteristics of the human visual system, creates a completely new visual experience that makes it appear as if a still object is actually moving.

The video of this technology uploaded on YouTube for public viewing simultaneously with the R&D Forum 2015 gained more than 60,000 views in three weeks and a press release about the technology was featured on a large number of news sites and portal sites helping attract a considerable public attention.

Ecample of "HenGenTou"

Innovative technology

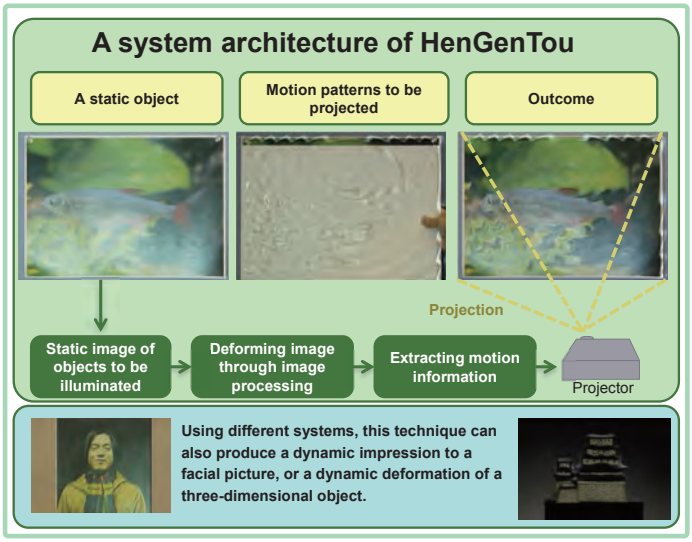
R−7

A Light Projection Technique to Produce Illusory Movements of Static Objects

HenGenTou: Animating a Static Object by Projecting a Motion Flow Field

NTT R&D FORUM 2015

We propose a new light projection technique named 'HenGenTou', which apparently animates, and adds a variety of realistic movement impressions to, a static projection target. By fully utilizing the processing characteristics of the human visual system, a simple algorithm produces novel visual experiences wherein printed pictures appear to move, deform, and flutter.



Features

- Addition of realistic impressions of motion and distortion to 2-D and 3-D static objects.
- An illusory display relying on the basic property of the human vision to separate and integrate color, form, and motion signals.
- Easy computation of projected motion.
- A variety of systems using the same basic principle can produce a a number of astonishing visual effects.
- For example, a printed portrait changing expression; a printed fish staying under moving water; a printed flame fluttering in the wind ; and the wall paper distorting dynamically.

Application Scenarios

- Add impressive expressions to, and increase saliencies of, a variety of static objects in the scene
- New advertisement methodology: e.g., an idle poster smiling at you, bargain goods fluttering on the shelf, a signage on the street that surprises passerby.
- New expression methodology for art and design.
- New illumination system that controls the mood of the room in fancy ways.

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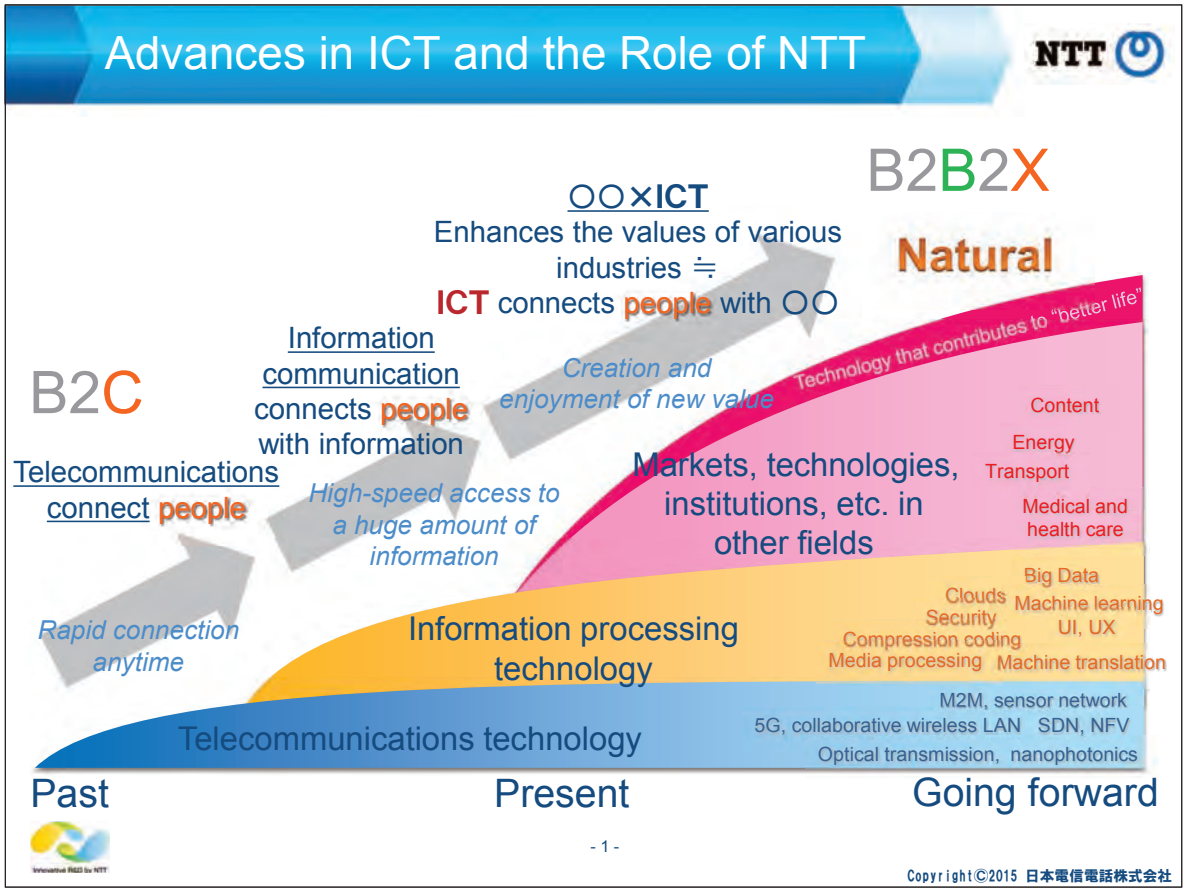
Areas for Further Focus in the Future—in Pursuit of a "Natural" style—

NTT will seek to attain ○○×ICT, a concept that involves enhancing the capabilities of various industries through ICT. In the world of ○○×ICT, it is important to create an environment in which anyone can access various services, not just those who want to.

At NTT R&D, we feel that the gulf between people who can use these forms of communication and those who cannot is gradually widening and that we need to take people to a safe and secure world in which anyone can enjoy new experiences naturally. We believe that we need to strengthen our pursuit of a natural style to resolve the anxiety and the growing gap referred to above.



From keynote "Co-Innovation Leading to the Future"