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FEATURE

Special Issue on Resilient ICT

Interview

Which resilient ICTs should we build to cope with major disasters? In the face of the COVID-19 pandemic, there is a greater need for technologies that are useful in emergencies.

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Cover Photo：Cluster Computers for Resilient ICT Research
Cluster computers are used for accumulating the large amount of text data (corpus) for natural language processing R&D, then they perform massive amounts of calculations on the large amounts of text data, such as for R&D of the various models required to construct artificial intelligence and for the operation of systems that analyze, in real time, the enormous amounts of text data posted on social networking services, etc., to provide easy-to-understand summaries in the event of a disaster. These computers support the various research and development stages, from basic research to social implementation.

Upper Left Photo：Resilient ICT Research Center
The Resilient ICT Research Center was established in April 2012 after the Great East Japan Earthquake. The center's facilities were initially distributed amongst multiple locations inside Tohoku University's Katahira Campus, but in March 2014, these separate facilities were gathered into a newly constructed building directly opposite from the main building of Tohoku University's Research Institute of Electrical Communication, also on the Katahira Campus. The Resilient ICT Research Center has been promoting research and development, social implementation of results, and activities to strengthen the capabilities of collaborative core.

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Interview

Which resilient ICTs should we build to cope with major disasters? In the face of the COVID-19 pandemic, there is a greater need for technologies that are useful in emergencies.

Resilient ICT Research Center

In the last quarter of a century, Japan has been struck by successive major disasters that have left an indelible mark on our memories, such as the Great Hanshin Earthquake, the Great East Japan Earthquake, and the Kumamoto Earthquake. There have also been significant occurrences of meteorological disasters that are suspected to be related to global warming, such as floods and landslides caused by repeated heavy rains. Furthermore, in 2019, the novel coronavirus diseases (COVID-19) emerged and spread globally amid great challenges in grasping and understanding the situation.

Japan is known as a land of disasters. How can we mitigate the risks of disasters and overcome crises? Information and communications technology (ICT) holds the key in responding to various large-scale phenomena ranging from increasingly frequent and severe natural disasters to the threat of new infectious diseases. NICT had established the Resilient ICT Research Center with the aim of applying the lessons learned through the Great East Japan Earthquake. In this interview, we spoke to the Director General of the Center, Dr. SUZUKI Yôiti. (This interview was conducted remotely on January 29, 2021.)

SUZUKI Yôiti

Director General, Resilient ICT Research Center*

He received Dr. degree of engineering in 1981. He had been a Professor with the Research Institute of Electrical Communication, Tohoku University from 1999 to 2019 and joined NICT in 2017. His research interests include psychoacoustics, multimodal perception, signal processing for high-definition acoustic systems, and since 2011 improvement of acoustic mass-notification systems. He is currently R&D advisor of NICT and professor of the faculty of Engineering, Tohoku Bunka Gakuen University.

* Title and Department are as of March 2021

—Could you tell us about the background to the establishment of the Resilient ICT Research Center?

SUZUKI We began to recognize the relationship between major disasters and ICT in the aftermath of the Great Hanshin Earthquake in 1995. At the time, landlines, except for public telephones, could not be connected for days. Coupled with the disruption to transportation systems, the main area affected by the disaster became a donut-shaped information vacuum. Although mobile phones were not yet prevalent at the time, people recognized their usefulness since the PHS and mobile phones could be connected. This was one of the reasons why most people were using mobile phones by the time of the Great East Japan Earthquake in 2011. However, many telephone bureaus and mobile phone base stations were damaged or destroyed in the massive earthquake and tsunami. As a result, service was interrupted for more than two-thirds of the landlines in the Tohoku region, while approximately 29,000 mobile phone base stations stopped working mainly due to the depletion of their electricity storage capacity. Hence, telephone services could not be used in many areas. The optical network also suffered severe damage.

Such serious and extensive damage to the information and communications infrastructure, which is of great importance to society, led to fatal delays in grasping the damage caused by the disaster. This presented a major obstacle to obtaining information about the safety of residents in the affected areas, and to advancing recovery and reconstruction work.

The government responded swiftly to the disaster, and immediately put together a supplementary budget. The Ministry of Internal Affairs and Communications launched many research and development projects with the aim of conducting research and development

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on disaster-resilient ICT and implementing the research outcomes in society. This field of research came to be known as "resilient ICT." NICT also established research projects in three related areas.

The first is related to optical networks, which can also be described as the backbone to information and communications. The second is related to wireless networks, including the use of satellites. The third is on technology that conducts real-time analysis of disaster information by capturing a vast volume of information on the Internet, such as social media, as "social wisdom."

The Resilient ICT Research Center was launched in April 2012, the year after the disaster, to advance research projects on resilient ICT including these three areas.

──Was the Resilient ICT Research Center established in Sendai because it was one of the major cities that had actually suffered severe damage from the earthquake?

SUZUKI I think that was one of the key factors. Furthermore, Tohoku University is very active in ICT research, as demonstrated by the establishment of the Research Institute of Electrical Communication in 1935. Hence, I felt it would be a suitable organization to collaborate with in the research and development of resilient ICT. Tohoku University set up the Research Organization of Electrical Communication in October 2011 to promote resilient ICT research, and we have been promoting research collaboration since. In addition, the Resilient ICT Forum was established in May 2012. The Resilient ICT Research Center is engaged in activities in cooperation and collaboration with Tohoku University, the Ministry of Internal Affairs and Communications, NICT, as well as private corporations and university officials, to advance resilient ICT research with the aim of utilizing the research outcomes in society as much as possible.

Optical networks, wireless networks, and real-time social knowledge

──Could you give us more details about the three pillars of research?

SUZUKI Research in these areas has been promoted by the Infrastructure Laboratory and the Applications Laboratory.

The Infrastructure Laboratory carries out research and development on technologies to ease congestion in communications during a major disaster, and to restore communications as quickly as possible. In an emergency, it is important to ensure that the switching of optical paths and distribution of traffic take place swiftly and automatically. To that end, research has been carried out on core technologies that are able to carry out switching and distribution more quickly and flexibly than with conventional optical switching technology.

The Infrastructure Laboratory also carries out research on technology to realize the quick recovery of optical networks. An example is technology that can put in place provisional recovery measures even in cases where the optical repeater has collapsed by utilizing underground optical fiber cables that are still usable and connecting them with a portable optical amplifier.

In recent years, it has also been engaged in research on technology that enables the constant observation of optical networks even during normal times, detect predictors of trouble quickly, and respond automatically.

The Applications Laboratory pilots two projects. The Wireless Communications Applications project is engaged in research with a focus on construction technologies for networks that are flexible and do not lose connection easily at places that are the closest to users.

A representative example is NerveNet. Conventional access networks that are laid close to users are composed of tree-type branching networks. However, if problems occur in the roots of the branches or the links in the middle, all of the subsequent networks will become unusable. NerveNet is a mesh-type network that has the advantage of being able to stay connected even when a part of the network loses connection. The central nervous system of living things has the plasticity of changing the neural network in response to the environment. NerveNet derives its name from this characteristic. The development of extremely compact systems is also ongoing, and such compact systems will make it possible to construct private communication networks immediately no matter where we are.

The second project is the Real-time Social Wisdom Analysis project. Under this project, a vast volume of posts submitted to social media, such as Twitter, is collected and analyzed immediately to transmit useful information in a few seconds to those who have been affected by the disaster.

The DISAANA*1 is a system that displays the results of the analysis and extraction of posts on social media in the Japanese language when a query is entered, for example, "What supplies is Sendai short of?" This system was actually deployed during the Kumamoto Earthquake in 2016 and was rated highly. Thereafter, research and development has been ongoing on the D-SUMM*2. This system smartly summarizes the results of the analysis of disaster-related information to enable to grasp the overall damage situation, and presents the information in compact form. These have been made available on the NICT website on a trial basis, and results from the large number of demonstration experiments are being utilized in the ongoing research and development work.

However, we have to wait for people to post on social media before the information can be analyzed. In view of that, we are also engaged in collaborative research with private corporations and others on the development of the SOCDA*3. This is a disaster management chatbot that takes the place of human beings to collect and disseminate information between victims and rescuers. Demonstration experiments are already being conducted in places such as Kobe City and Mie Prefecture, and the system has also been used during actual typhoons.

In addition to the above, NICT also has a track record in research and development spanning various areas, with the aim of strengthening the disaster response capability of our society. These include applications such as KoeTra and SpeechCanvas, which provide support to those with hearing difficulties by displaying the spoken words on a smartphone screen, and airborne synthetic aperture radar systems (Pi-SAR2).

"Living with COVID-19" and Resilient ICT

──Remote working has suddenly become a widespread practice as a result of the COVID-19 pandemic. What are your views on this from the standpoint of promoting resilient ICT research?

SUZUKI There is no doubt that this pandemic brings us face to face with the fact that a novel infectious disease may undermines safety and security of a society to the same extent as a disaster. As they emerge in a way that is difficult to predict and are disruptive, society has to respond to sudden events and situations.

The Cabinet Office is now working on drawing up the 6th Science, Technology and Innovation Basic Plan (FY2021-FY2025). This plan captures natural disasters and infectious diseases as social risks that cause disruption to society.

"Resilience" is a concept that is harnessed as one of the perspectives for responding to such social risks. Resilience is a word that expresses elasticity, and could be described as possessing strength, as well as supple restoring force and adaptability. There may be other pandemics of unknown infectious diseases in the future. From this perspective, there is a need to further strengthen the resilience of ICT in the future. For example, IoT is a technology that can gather information continuously and constantly monitor changes in the situation during normal times, and continue to maintain its ICT functions while responding quickly and flexibly during an emergency.

NICT cannot develop such technologies alone. It will be necessary to collaborate with various organizations even more than before.

──What are the types of technologies that you think will emerge in the next 10 or 20 years?

SUZUKI I think that the effective use of AI is a key point. In the society of the near future, it will become common for people and machines to collaborate and work together remotely even during normal times. For example, there are scenarios in which humans work together with a group of robots on rescue and recovery under extremely harsh environments, such as disaster sites. Connections can be maintained somehow, even in places with poor communication environments, through the effective use of AI. Nevertheless, robots (AI) can take appropriate action based on their own judgement in cases of delays in human judgement and response. In these ways, AI, equipped with resilience and flexible response capability, is expected to become an important constituent technology of resilient ICT. Conversely, I believe there will also be a need for resilient thinking in interface technology and interaction technology between humans and machines, which supports the collaboration and division of labor with automated and remotely controlled machines.

The impact of COVID-19 has led to an increase in the number of people working from home. As there is a possibility that young people who have just graduated and started working this year will be working from home right from the start, we will see the emergence of genuine "native" from-home-workers. A facet of resilience is the ability to strike the balance between maintaining interpersonal relations with the physical society, while working through cyberspace. I anticipate that "resilience" will be a key word in promoting the creation of ICT that serves as the foundation for the society of the future.

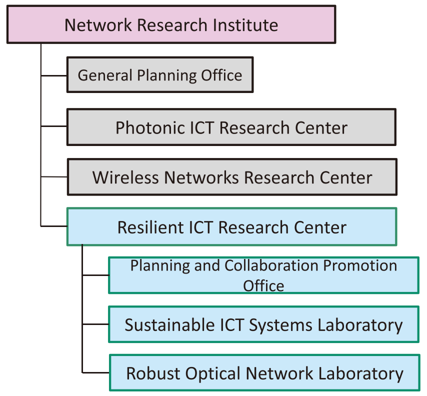

FIGURE Organizational Chart of the Resilient ICT Research Center (From Apr. 1, 2021)

Editorial note:

The "Resilient ICT Research Center, Social Innovation Unit, Open Innovation Promotion Headquarters" was reorganized from April this year as the "Resilient ICT Research Center, Network Research Institute." (See the figure above.)

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*1 DISAANA：DISAster-information ANAlyzer

*2 D-SUMM：Disaster-information SUMMarizer

*3 SOCDA：SOCial-dynamics observation and victims support Dialogue Agent platform for disaster management

Column

Resilient ICT Research Symposium 2021 held on March 24

NICT held the Symposium with the subtitle "For the future development of Resilient ICT," in cooperation with the Ministry of Internal Affairs and Communications, Tohoku University, and the Resilient ICT Forum. Taking advantage of the fact that the Symposium was held online, discussions were held on new research themes by the diverse group of participants (more than 200 participants online) in lectures covering topics ranging from technology and policy trends in recent years surrounding securing communications during emergencies and disasters, to the contribution of ICT, COVID-19 affecting every individual citizen, a network concept of an Open innovation platform of Power and ICT network convergence, and the potential of AI that analyzes SNS by Natural Language Proccessing to support disaster measures.

Discussion with participants from online

Research Activities of the Infrastructure Laboratory
Pursuing enhanced resiliency of the optical fiber network

AWAJI Yoshinari

Director, Infrastructure laboratory, Resilient ICT Research Center

In 1996 he joined the Communications Research Laboratory (CRL: currently NICT). He was engaged in information security strategies at the Cabinet Secretariat from 2004 to 2006. He has been mainly researching optical signal processing, optical amplifiers, optical packet switching, space-division multiplexing and resilient optical network technologies for disaster recovery. He received the Ichimura Academic Award in 2012, Advanced Technology Award (Fuji-Sankei business eye) in 2016, Maejima Hisoka Award in 2020. He is a member of IEEE/Photonics Society and IEICE. Dr. Eng. (Information physics).

* Title and Department are as of March 2021

This article introduces the Infrastructure Laboratory's research activities on pursuing enhanced resiliency for optical fiber networks. Optical networks maintain service with fixed equipment. In order to improve disaster resiliency, we are conducting research on mitigating congestion in wide area networks and on the emergency restoration of optical networks in damaged areas.

Elastic optical switching

In the event of a large-scale disaster, communication failures and congestion are likely to occur due to equipment damage or failure. So, technologies for the early mitigation of such communication failures and congestion are required in optical networks with redundant systems to provide stable communication. Speeding up the switching/setting of optical communication paths (optical path) is one of these necessary technologies. In addition, in order to suppress the fluctuations in optical power that accompany switching/setting optical paths, conventional technologies require a time period of seconds to minutes that is in proportion to the number of optical paths to be switched/set.

In order to enable high-speed switching/setting of optical paths while also suppressing optical power fluctuations, we have been conducting research and development on elastic optical switching technologies (Figure 1) that combine optical amplification for rapid power increases and relaxations, simultaneous switching technology for multi-wavelength signals, and high-speed equalization technology for wavelength-divided multiplexed optical signals. The deletion/setting of 4 wavelengths required 135 seconds with conventional methods. We were able to shorten this to 9 seconds, demonstrating that high-speed optical path switching/setting is possible while suppressing optical power fluctuations. Furthermore, the power equalization of wavelength-divided, multiplexed, optical signals required 200 milliseconds or more with conventional methods, but we sped this up to 2 milliseconds or less (at 8 wavelengths). This demonstrated that high-speed change suppression is possible even when optical power changes unexpectedly.

For the early commercialization of these technologies, we are also researching and developing a high-speed equalization subsystem that can be additionally connected to pre-installed communication devices to speed up the setting of new optical paths. Additionally, using this system, we have confirmed a speed up of 10 seconds or more in client service start time for all cases of 1, 2, or 3 hops when an arbitrary wavelength signal is added to the commercial communication devices at the JGN testbed laid between Otemachi, and Koganei, Tokyo.

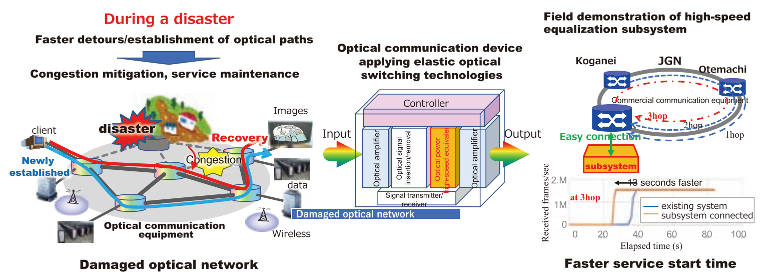


Figure 1 Conceptual diagram of optical communication equipment applying elastic optical switching technologies, the introduction effect, and a field demonstration of a high-speed equalization subsystem.

Interconnections between mixed packet transport networks

Until now, NICT has been researching and developing next-generation, long-distance, and ultra-large capacity optical packet and circuit integrated (OPCI) network technologies. As one area of this developmental research, we are conducting research and development on interconnections between OPCI networks and various types of packet transport networks in order to accommodate year-on-year increases in traffic and to contribute to emergency recovery in the event of a disaster. For existing MPLS networks and wide-area ethernets that are widely constructed and operated, as shown in Figure 2, we are conducting demonstration experiments on interconnection technologies and orchestration control technologies for connecting/relaying divided transport networks for emergency recovery when there is a disaster. Utilizing these technologies, not only does the OPCI network accommodate the traffic of mixed transport networks in normal times, but also in the event of a disaster, the divided/isolated surviving transport network resources and the OPCI network can be interconnected for emergency recovery, and interrupted communications can be quickly restored by rapidly rebuilding the transport function. On the other hand, if the traffic in the OPCI network temporarily increases, then, as a congestion alleviation measure, a portion of the traffic can be diverted/distributed to other available transport communication resources.

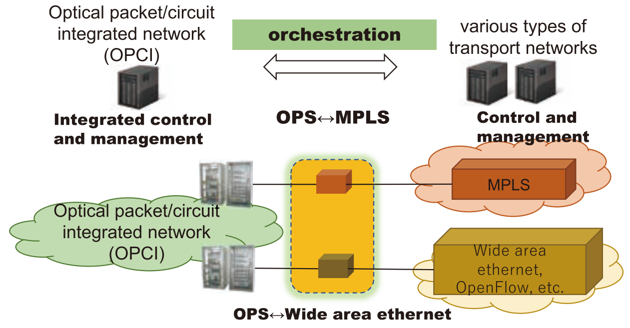


Figure 2 Research and development on interconnection technologies between optical integrated networks and various types of transport networks

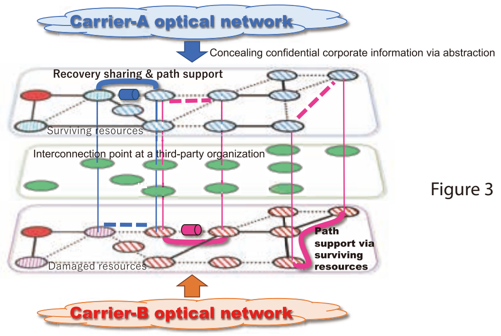


Figure 3 Research and development on technologies promoting mutual support and interconnections between carriers

Promoting inter-carrier cooperation

In the event of a large-scale disaster and after communications infrastructure is widely damaged, a large amount of recovery resources such as communications devices and fiber links will be required, but there is the risk that telecom carriers alone may not be able to procure and recover large amounts of communication resources in a short time. To address this problem, mutual provision/utilization of optical path support, based on surviving resources through the cooperation of multiple telecom carriers within the same disaster area, is thought to greatly contribute to the early restoration of communications. Therefore, in order to contribute to the optimization of information sharing and cooperation strategies, such as supply and demand of optical path support for restoration between different telecom carriers, we proposed a model of third-party mediation, and we are conducting research and development, in cooperation with multiple telecom carriers, on a method for the mutual use of surviving communication resources from different telecom carrier networks. Specifically, as shown in Figure 3, by abstracting each telecom carrier's own physical network topology into a common, logical topology, we have developed technology to formulate an optimal cooperative recovery strategy while also preventing information leakages from within the telecom carriers' networks. It is expected that, with this cooperative strategy, optical path support based on the surviving resources can be efficiently provided/shared between carriers, and additionally, the task of recovering damaged communications infrastructure can be efficiently shared between carriers, thus enabling early recovery after a large-scale disaster. Furthermore, based on the cooperative recovery plan that we formulated, we are proceeding with research and development on interconnection control technologies that mutually provide optical path support based on the surviving resources in different carrier networks and on the preferentially restored resources, and we are conducting demonstration experiments.

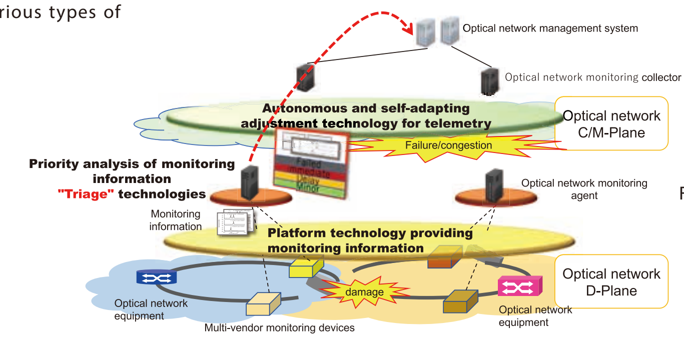


Figure 4 Research and development on robust telemetry framework technology in optical network monitoring

Towards robust telemetry

Monitoring of optical network equipment and optical signals, etc., are indispensable for appropriate control of physical networks in the event of a disaster. As such, we are planning research and development of robust telemetry technologies that quickly reconstruct the lost monitoring functions of damaged optical networks by using temporary C/M-Plane networks constructed via a variety of access means, such as wireless mesh networks, 4G, satellites, and the surviving internet. The performance of the C/M-Plane network for an optical network deteriorates or becomes unstable due to disaster or failure, and in response to the problem of non-functioning conventional optical network monitoring telemetry systems that were developed on the assumption of use of the C/M-Plane network without failure, we have set a variety of questions, such as "Is it possible to achieve robust telemetry that is resistant to deterioration of the C/M-Plane network, especially during a disaster or failure?" and "What kind of related issues will arise, and in particular, what will be the required technology framework?" Also, we are conducting research and development on a trial basis. As shown in Figure 4, we conducted demonstration experiments on a framework that includes technology integrating mixed vendor monitoring devices into a common monitoring information-providing platform with an open application programming API, optical network monitoring agent technology that analyzes and distinguishes the priority of optical monitoring information in order to utilize the unstable and limited C/M-Plane network's bandwidth, "triage" technology for monitoring information, and additionally, technology that autonomously adapts to unstable C/M-Plane networks and automatically adjusts the optimal telemetry system. Through experiments, we validated that it is possible to collect information and analyze the performance of optical networks during failures and disasters, and this has greatly contributed to the development of further research for the next medium to long-term plans. These research activities were implemented as part of the Japan-U.S. JUNO2 collaboration program.

Toward Distributed Edge Cloud Systems for Smart and Resilient Social Infrastructure

OWADA Yasunori

Senior Researcher, Applications Laboratory, Resilient ICT Research Center

OWADA Yasunori received Ph. D. in engineering in 2007. He joined NICT in 2013, and he is now engaged in the research and development of resilient distributed access network systems. Before joining NICT, he worked as associate professor for the Research Institute for Natural Hazards and Disaster Recovery, Niigata University, and then he started Space-Time Engineering Inc. as president. Ph.D. (Engineering).

KURI Toshiaki

Director of Applications Laboratory, Resilient ICT Research Center

KURI Toshiaki joined the Communications Research Laboratory, Ministry of Posts and Telecommunications (currently NICT) in 1996. He has been engaged in research on optical communication systems and resilient ICT systems. Ph. D (Engineering).

* Title and Department are as of March 2021

Unlike during normal times, in the event of a large-scale disaster, public communication systems may become unusable because of congestion due to a temporary surge in communication demand from confirmations for safety or damage status, or because of damage to existing communication infrastructure. For example, in the event of a Nankai Trough earthquake, which is expected to occur in the near future, it has been suggested that public communication networks such as cell phones and landlines, both connected to the internet, are likely to be disrupted for several weeks or more, and it is necessary for social infrastructure as a whole to be prepared for such a situation. On the other hand, in Society 5.0, we aim to realize a smart society through digital twinning technology that collects information in the physical spaces via sensors, etc., and then reproduces physical spaces in cyber space based on the collected data and also through cyber-physical systems that act on physical spaces via actuators, etc.

NerveNet as a resilient ICT platform

Infrastructure for realizing a smart society is not just communications technologies capable of high speed, low latency, and multiple connections, but also requires autonomy and resilience for sudden changes in communications demand and for changes in network configurations due to disasters.

We are conducting research and development on "NerveNet," a network system with built-in, autonomously distributed edge computing capabilities, as one of the ICTs (Information and Communication Technologies) that future social infrastructure should have. NerveNet has a distributed network control structure to overcome the drawbacks of centralized control, which can lead to the shutdown of the entire system due to a single failure, while also configuring a mesh network to realize a network that is difficult to break or sever. It is designed so that applications can also be operated autonomously distributed with the computing resources in their equipment. With these primary capabilities, communication services can continue within an area, even if it becomes isolated and cut off from centralized control devices, and application services can continue while discovering other devices that are connected to each other (Figure 1).

So far, the dedicated NerveNet devices, which have been developed by implementing the primary capabilities in the above paragraph, have been actually used in Shirahama Town (Nishimuro County in Wakayama Prefecture) and in the Tachikawa Wide-area Disaster Management Base, etc. In addition to adding new capabilities to NerveNet, we are also promoting the “softwarization” of capabilities and their separation into minimal configurations so that NerveNet can be freely designed according to a variety of uses and purposes, including the selection of devices and capabilities. By being able to select capabilities themselves according to the use case, users will be able to select appropriate hardware capabilities according to their application and purpose; a hardware switch for Layer 2 switching capabilities can be selected for a use case where high-speed and wideband communication is required, and an inexpensive, single-board computer with the minimum required software configuration, etc., can be selected for an IoT use case. As an example of new capabilities, it has become possible to realize network slicing capabilities that allow a closed Layer 2 network composed from NerveNet to be configured as an overlay on the existing internet. Until now, it was necessary to configure a private network using a fixed wireless access (FWA) or a dedicated physical line, such as optical fiber, but, with this technology, it has become possible to configure a closed Layer 2 network in a mesh shape while using commercial lines and the internet. In addition, we have developed LoRa flooding technology that combines private LoRa, which is one of the LPWA (Low Power Wide Range) technologies, with the data synchronization and sharing services of the service capabilities of the upper layer NerveNet. This technology has also begun to be offered via the Caravan Testbed in NICT's Integrated Testbed, thus expanding the development range for IoT applications.

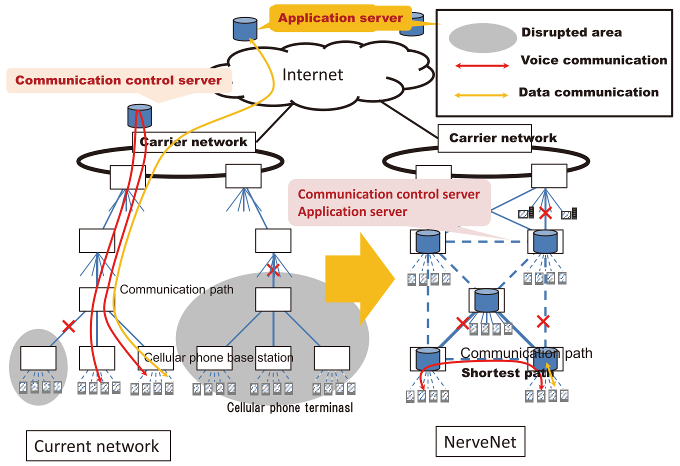


Figure 1 Feature of NerveNet

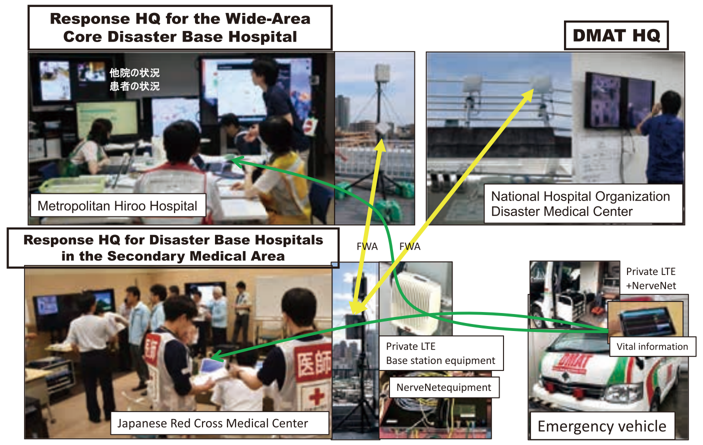


Figure 3 Demonstration of 10,000 attendees at Kobe City

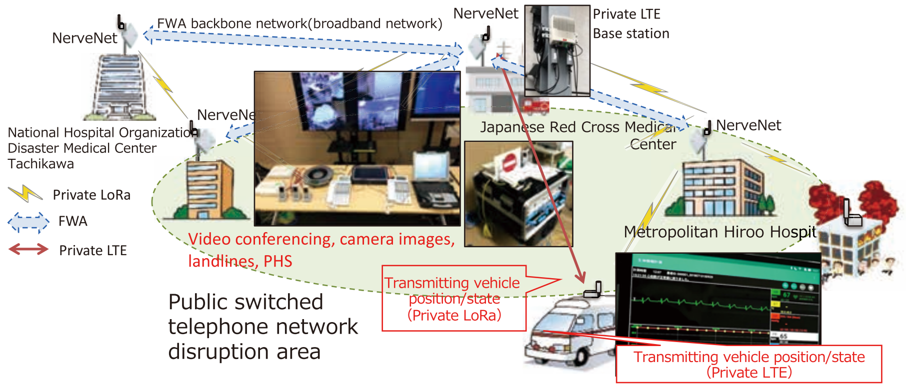


Figure 2 Outline of the system at the drill in Metropolitan Area

Examples of use in disaster medicine

Using a private network connecting disaster base hospitals in Tokyo, we conducted an experiment in which we used it for communication drills/training practice for intra-regional transportation and wide area transportation. Specifically, under the assumption that the internet and cellular phones will not be available within Tokyo due to an earthquake that occurs directly under the Tokyo metropolitan area, using multiple FWAs, we constructed a core private network that connects dedicated NerveNet devices in a mesh topology, and then it was used for drills/training practice to coordinate, via video conferencing or phone calls between multiple disaster base hospitals, the acceptance of transported patients (Figure 2). Additionally, private LTE base stations using public broadband frequencies (195 MHz central frequency and 5 MHz bandwidth) were installed on the roofs of the disaster base hospitals, small general-purpose PCs equipped with private LTE terminals and software-based NerveNet capabilities were mounted on emergency vehicles, and we succeeded in using the private LTE and NerveNet for real-time transmission of vital information, such as images of patients in moving emergency vehicles, electrocardiograms, heart rate, and oxygen saturation (Figure 3). Furthermore, at the same time, we also used a Raspberry Pi equipped with LoRa flooding technology to implement an application to understand information about resources, such as the state and position of emergency vehicles, and we demonstrated that the information can be displayed on tablets at the base hospitals.

Future prospects

The NerveNet technology that we have developed can easily provide a network virtualization environment using small, inexpensive, and general-purpose computers, so, with the recent COVID-19 pandemic, it would be easy to build a logically separated and dedicated network simply by connecting NerveNet equipment to the existing LAN equipment at provisional bases such as temporary medical facilities (hotels). Additionally, in conjunction with using existing LANs, it will become possible to quickly deploy the same network services as in hospitals at these provisional bases. We expect that this will contribute to preventing the spread of diseases, expand medical information networks between existing and provisional medical bases, facilitate online information sharing, and, furthermore, contribute to new lifestyles such as teleworking.

Going forward, we plan to further develop these technologies as platform technologies to realize cyber-physical systems and digital twinning that contribute to Society 5.0, and one such technology is the capability for autonomous distribution and self-organization in terms of operation, including not only network capabilities but also application service capabilities. In the future, while autonomously detecting and sharing a variety of ubiquitous information and communication resources (including not just network and computer resources, but also a variety of resources in the real world) near users and effectively making use of those resources, we aim to realize an information and communications platform that can autonomously reconfigure its capabilities and services in response to changes in environment and demand.

Research and Development on Technologies for Real-time Analysis of Social Wisdom

OHTAKE Kiyonori

Executive Researcher, Applications Laboratory, Resilient ICT Research Center

After finishing a doctoral course in 2001, he joined ATR spoken language communication laboratory. He joined NICT in 2006. He has been engaged in researches on natural language processing and spoken language processing. Dr. of Engineering.

* Title and Department are as of March 2021

The Applications Laboratory, part of the Resilient ICT Research Center, is looking at the possibilities for social media that were shown during the Great East Japan Earthquake, and, in consideration of dealing with false rumors and unverified information, we have been conducting research and development of a system allowing easy access to desired information from an enormous amount of data. This paper introduces the work on real-time analysis of social wisdom that the Applications Laboratory has been advancing.

Background

During the Great East Japan Earthquake that occurred in 2011, it was shown that social media, which was gradually spreading in Japan at the time, could be used for confirming safety, sharing a variety of information on damage, collecting relief information, and more. On the other hand, anyone can easily post information on social media, so it was also recognized that false rumors and unverified information can easily confuse/mislead the real world and that it is not easy to obtain desired information from social media, where an enormous amount of data is exchanged. While addressing these issues, we have begun research and development of technologies that support disaster responses by analyzing disaster-related information on social media.

The DISAANA system for analyzing disaster information on social media

When the Resilient ICT Research Center was first established, we were conducting research and development on WISDOM X, a large-scale web information analysis system that answers questions using the enormous amount of text on the web, and, by applying these technologies to Twitter, we started research and development (in April 2012) of the DISAANA system for analyzing disaster information on social media. In parallel with the development of the prototype system, in areas affected by the Great East Japan Earthquake, we talked to local government officials and volunteer groups about the problem of acquiring information during that time, and we also asked for their impressions of DISAANA's prototype system. DISAANA is a Q&A system that utilizes technologies from WISDOM X. On the other hand, when we were gathering information in the disaster-affected areas, we received responses suggesting that it is difficult to input questions amid strained/difficult situations and that, for quick decision making, it is critical that the damage situation can be compactly summarized to about the size of a single A4 sheet of paper.

We had already begun to consider mechanisms in which an AI reads social media posts on behalf of humans, and then automatically extracts disaster-related information, if there is any, so we implemented capabilities (called an area search function) that automatically extract and output disaster-related information for a specified municipality, and then started a trial release of DISAANA in April 2015 together with the question-answering capabilities. As for dealing with false rumors, we made it so that the system searches for the answer to the question and, at the same time, also searches for content that contradicts the answer, and then provides this as evidence to help determine the information's authenticity. Specifically, if both the answer and information contradicting the answer are found, then one of them may be incorrect, so the system calls attention to this when presenting the answer and includes both possibilities along with the contradictory information.

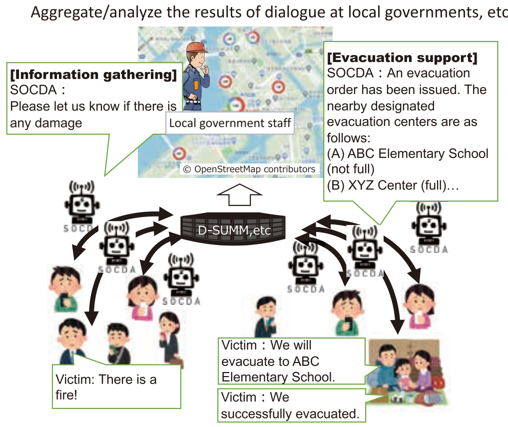


Figure 1 Outline of SOCDA

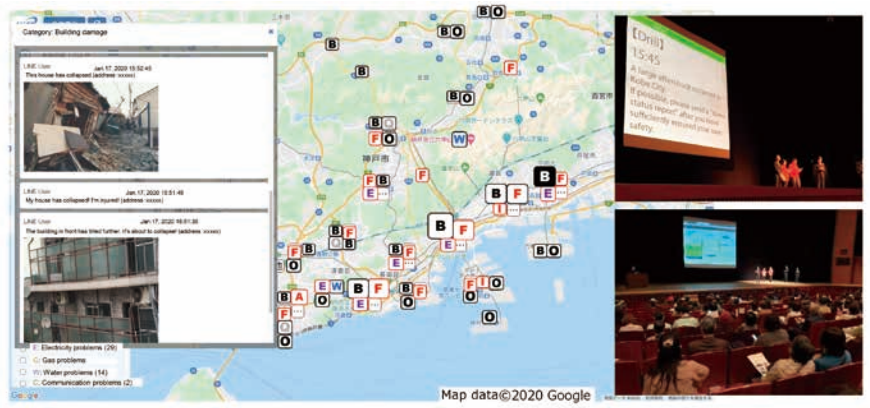


Figure 2

The D-SUMM system for summarizing disaster situations

Research and development on the capability to compactly summarize information, which was suggested during interviews in the disaster-hit areas, was performed under the Cabinet Office's "Cross-ministerial Strategic Innovation Promotion Program," which was launched in 2014. After making it possible to compactly summarize and organize similar expressions, we collected and enhanced AI learning data that automatically extracts disaster-related information, implemented a variety of capabilities such as summarizing data by area and category and displaying the summarized results on a map, and then in October 2016, we began a trial release of D-SUMM.

After the trial release of these systems, DISAANA was used for the Kumamoto earthquake in April 2016, and DISAANA and D-SUMM were used for the torrential rains in the northern Kyushu region in July 2017. They have also been used in disaster prevention drills by local governments, and we have made repeated improvements based on the valuable opinions we received from users, etc.

Additionally, in FY2017, the "IoT/BD/AI Information Communication Platform," a project commissioned by the Ministry of Internal Affairs and Communications to promote research and development for an advanced natural language processing platform, was started. The social implementation of the project was promoted through research and development of a platform with DISAANA/D-SUMM technology as its core, and, since July 2020, a service utilizing both technologies was started by a private company (NEC).

The SOCDA chatbot for disaster management

Even though we confirmed the effectiveness of DISAANA/D-SUMM through their use in disaster management drills and actual disasters, we also become very aware of the limits of handling information that is voluntarily posted on Twitter. Resources on the side of those carrying out disaster responses, such as the disaster response headquarters of a local government, are limited. As such, by having the systems collect comprehensive information and provide detailed information to those who need it, we thought that we could support disaster responses in terms of both collecting and providing information, so we began to consider an AI that could do these tasks. In January 2017, we proposed the concept of a disaster management chatbot to realize this, and, through the 2nd Cabinet Office SIP that started in FY2018 and with the cooperation of LINE Corporation, research and development of the SOCDA disaster management chatbot was started by the National Research Institute for Earth Science and Disaster Resilience (NIED), Weathernews Inc., and NICT.

SOCDA engages in two-way communication with users, but, because it is necessary to communicate with a majority of people during a disaster, we are proceeding with research and development by designing it for lightweight and reliable operation. Damage reports collected by SOCDA are analyzed using D-SUMM technology, and then visualized on a map to enable prompt information sharing (Figure 1).

We were able to carry out SOCDA demonstration experiments immediately after the start of research and development on the project. We quickly realized the information-collecting capability, proceeded to verify it, and, in the lead-up to its social implementation, we have repeatedly had discussions about problems/issues with local governments, etc., that are cooperating with the experiment. In January 2020, a large-scale demonstration experiment with 10,000 people was conducted in Kobe City (Figure 2), and a similar experiment was also conducted in January 2021 with 13,000 people. Additionally, some local governments began paid commercial trials during FY2020, so we are making steady progress from the social implementation perspective. In addition to collecting information, in FY2020, we also implemented capabilities to provide appropriate information to support evacuation, based on the user's position, as an information-providing capability, and a demonstration experiment was conducted in Kanagawa Prefecture on February 26, 2021.

Future prospects

Through social media utilization, it is becoming possible to collect information by regarding people as intelligent sensors, and, by providing appropriate information in the event of a disaster, it is possible to promote evacuations and support people's social activities. Even though we have shown the technology's potential, in order for these systems to be widely accepted and utilized in the world, we recognize that it is not just about the technical systems themselves, but that there are also numerous problems to be addressed, such as usage methods and system design. Going forward, we will continue to take on these challenges and will proceed with research and development to ensure that these technologies can reduce damage during a disaster.

NICT's 5th Mid-to-Long Term Plan has Begun (Overview)

Starting in April 2021, NICT began its new 5-year medium- to long-term plan period. The international situation around information and communication technology (ICT) is dramatically progressing, such as through expectations for socio-economic changes and revolutions in value-creation due to the further development of ICT and the acceleration of digital transformations (DX). In Japan, there is a need to build and promote a powerful and practical ICT strategy that aims to realize Society 5.0 from a global perspective. In August 2020, the Information and Communications Council of the Ministry of Internal Affairs and Communications (MIC), established "five focused areas of research and development (R&D)" and "four strategic research areas"* as a "New ICT Technology Strategy in the Beyond 5G Era." NICT's 5th Mid-to-Long Term Plan will formulate and strongly promote R&D strategies that focus on these areas.

In the realization of Beyond 5G, NICT's 5th Mid-to-Long Term Plan will also accelerate cross-disciplinary and cross-organizational R&D by forming industry-academia collaboration bases that will serve as hubs for creating new value in society, and will aim to maximize R&D results through industry-academia-government collaborations.

Focused areas of research and development, etc.

1. Advanced Electromagnetic Wave Technologies

In the field of advanced electromagnetic wave technologies, NICT will promote the R&D of a variety of technologies to utilize electromagnetic waves, from radio waves to light, for information communications. NICT will carry out R&D to realize remote sensing technologies using electromagnetic waves for acquiring, collecting, and visualizing a variety of target information; to realize space environment technologies that understand and predict the state of the sky through which electromagnetic waves are transmitted from space to the earth; to realize electromagnetic environment technologies to ensure electromagnetic compatibility, in which devices correctly operate when in spaces with mixed electromagnetic waves emitted by a variety of electronic devices; to realize space-time standards technologies for generating, supplying, and utilizing high-quality time and frequencies, which create important societal foundations such as standardized time; and to realize digital optical infrastructure technologies for developing low-cost and highly efficient optical elements by applying electronic holography technologies.

2. Innovative Networks

In order to realize the transformation of social systems via the sophistication of Society 5.0 in the Beyond 5G era, it is necessary to realize advanced information and communication networks that seamlessly connect from the ground to space, and to build revolutionary networks that can respond to rapidly increasing communications traffic, communications quality, and diversifying services. As priority technologies for those purposes, NICT will work on next-generation wireless technologies, photonic network technologies, optical/radio wave fusion technologies, and space communications infrastructure technologies. Additionally, in order to realize information and communications infrastructure for the Beyond 5G era, which is expected to further increase the speed and capacity of communications, NICT will conduct R&D on ICT platform technologies that use terahertz waves, which are expected to see early use and development, and on resilient ICTs that support the sustainable provision of services, even in the event of large-scale disasters or impediments.

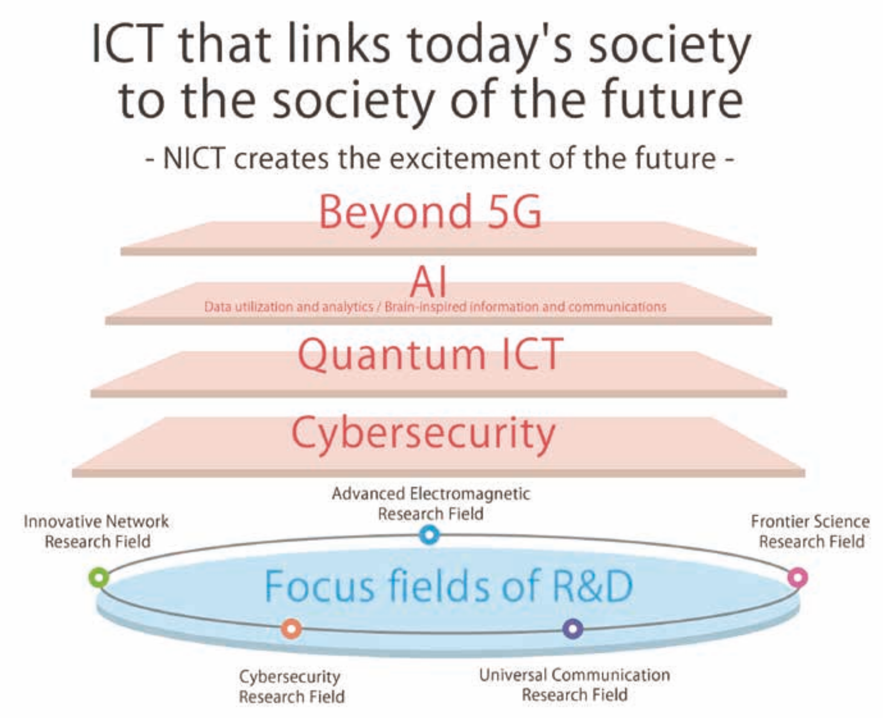
3. Cybersecurity

The sophistication of countermeasure technologies that protect social systems from the rapidly increasing number of cyber-attacks has become an urgent national issue. Therefore, in order to work on the R&D of cybersecurity technologies, cryptographic technologies, and to continuously develop security human resources in society as a whole, NICT will form an industry-academia-government collaboration base for information analysis and human resources development related to cybersecurity.

In addition, as social demands of NICT in the cybersecurity field are increasing, NICT will utilize its technical knowledge to conduct cybersecurity trainings that contribute to improving the ability of national organizations and local governments/organizations to respond to cyber-attacks, and to survey IoT devices with inadequate password settings, etc.

4. Universal Communication

With the goal of realizing universal communication so that everyone can understand each other, NICT will conduct R&D on multilingual communication technologies that realize practical-level automatic and simultaneous interpretation via deep learning technologies that utilize enormous amounts of data, such as voice and text data; on social knowledge communication technologies aiming for advanced dialogue by acquiring and melding, via advanced deep learning technologies, etc., information that has been accumulated from the internet, etc.; and on smart data utilization infrastructure technologies that mutually link a variety of sensing data. Additionally, NICT will work to promote the social implementation of systems that support a variety of user interfaces, and will conduct R&D of technologies that contribute to solving various social issues and create new value for the Beyond 5G era.



5. Frontier Science

Aiming to create revolutionary ICT that will contribute to the dramatic development of future ICTs and sensing technologies, NICT will conduct cutting-edge and fundamental R&D on a variety of research topics, such as fundamental technologies for frontier ICT that create novel materials, structures, and capabilities; quantum ICTs aimed at the future realization of a secure and global quantum network integrating both terrestrial and satellite quantum cryptography networks; fundamental technologies for advanced ICT devices that create devices aimed at practical application to a wide range of information and communication fields via the utilization of new principles and of new material properties; and brain-inspired ICTs that aim for the ultimate in communication by clarifying brain functions.

Activities to boost open innovation

NICT, in order to maximize R&D results and lead to the creation of innovation, will promote cooperative results among the various fields within NICT, encourage collaboration and strategic standardization activities across NICT and domestic and overseas industries, universities, users, and local communities, etc., and will carry out activities aimed at realizing and securing superiority in the advanced ICT that will become the core of the Beyond 5G era.

Promotion of Beyond 5G research and development

In order to gain a lead on the rest of the world and to realize ICT that will support the Beyond 5G era after 2030, it is necessary to strongly promote the pioneering and R&D of the cutting-edge constituent technologies that will become the ICT core in the Beyond 5G era. Aiming to create results that contribute to the early establishment of the constituent technologies that are the key to realizing Beyond 5G, and with this medium- to long-term plan period as a period of focused efforts, NICT will conduct R&D via open-call sponsored R&D programs through funding utilization, etc., based on the R&D policies formulated by MIC in order to promote R&D in industry and universities, etc., and to create synergistic effects.

Strengthening Industry-Academia-Government collaboration to create open innovation

While collaborating with various players and so as to promptly return our R&D results to society, NICT, in addition the creation and utilization of social demonstration opportunities for R&D results, and the technology transfer of R&D results, will contribute to the promotion of open innovation by strategically and actively promoting a variety of initiatives, such as support for the creation and growth of ventures that utilize the technological seeds from NICT. NICT will also focus on building and promoting a concrete promotion system, strengthening its social implementation system, strengthening industry-academia-government collaborations to solve social and regional issues, the promotion of open innovation via the formation of a R&D hub, the promotion of strategic standardization activities, and strategic ICT human resources development, etc.

Additionally, as research support and project promotion duties, NICT will invite overseas researchers and will support the commercialization of information and communications venture companies.

NICT, as its statutory duties based on the Act on the National Institute of Information and Communications Technology, conducts work related to standard radio wave emissions, standardized time notifications, space weather forecasting, and the testing and calibration of radio devices and equipment, as well as contributing to the maintenance of infrastructure for socio-economic activities and to realizing safe and secure ICT utilization.

Aiming for the Beyond 5G era, NICT will strategically take on numerous challenges with an open mind to enrich Japan and society.

* Information and Communications Council, "Fourth Interim Report of Information and Communications Council in Response to Inquiry about Ideal State of New Information and Communications Technology Strategy" (August 2020) The four strategic research areas: realization of Beyond 5G, AI (data utilization and analytics, brain-inspired information and communications), quantum ICT, and cybersecurity.

NICT's Efforts Towards Beyond 5G / 6G

Leading Japan's Research and Development of Beyond 5G / 6G by Publishing White Papers and Utilizing Open-Call Sponsored Research and Development

NICT has released its Beyond 5G / 6G (hereinafter referred to as "B5G/6G") white paper (1st edition), which has been under review since last year. NICT's 5th Medium- to Long-Term Plan has just begun with a new research and development system for B5G/6G, and, going forward, NICT will lead Japan's B5G/6G research and development through research that NICT conducts on its own as well as with sponsored research, etc.

■NICT's B5G/6G White Paper

Starting with the "Salon" (a forum within NICT to exchange opinions) focused on 6G in September 2020, discussions began on scenarios to be included in the white paper, and three scenarios were completed which imagine a future society in the years 2030-2035: "Cybernetic Avatar Society," "Moon City," and "Across TIME and SPACE." By the time these scenarios were completed, there had been numerous online conferences held across NICT as a whole, as well as lively individual discussions by the volunteers for each scenario.

In creating the white paper, we were conscious of the flow of uncovering and identifying the necessary constituent technologies by using the backcasting technique to work backwards from the future society described in these scenarios. The white paper summarizes the scenarios and the use cases appearing therein, the constituent technologies and necessary conditions to realize them, and a research and development roadmap and deployment strategy, etc.

In this white paper, NICT, as a group of experts, examines the realization of a B5G/6G world, but the lives and society that it depicts cannot be realized solely by NICT's research and development. It is necessary to conduct discussions with a variety of stakeholders and to have collaborative creation activities, and, as part of those activities, NICT plans to periodically revise this white paper.

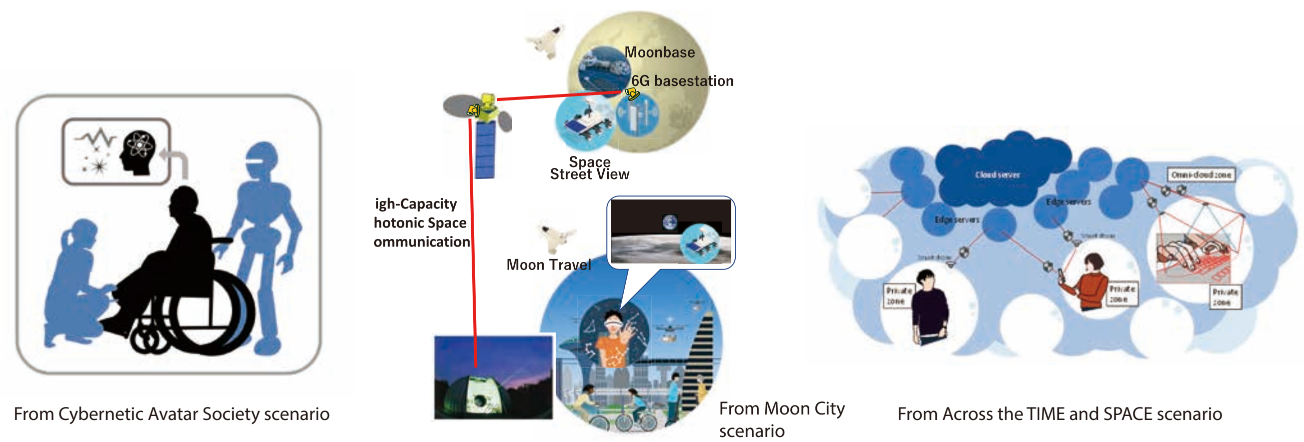
■The Open Summit

In publishing this white paper, the NICT Open Summit 2020 was held for two days on January 20th and 21st, 2021, so that NICT staff could widely discuss its contents. At the event, each of the authors shared their thoughts on the use cases in the white paper and on the constituent technologies. Additionally, individuals familiar with mobile communication system concepts and individuals well versed in B5G/6G application services were invited as experts, and we received valuable advice and strong support regarding the research and development directions that NICT should pursue for B5G/6G research and development. Each session had a panel discussion time where there was enthusiastic discussion about flexible use cases, the importance of architecture, and the need to create value from the user's perspective. Additionally, the international portion, held in English, was able to have discussions with central figures in Europe's B5G/6G discussions.

From the perspective of preventing COVID-19 infections, the entire event was held through web conferencing this time, and, thanks to that, it was attended by nearly 200 people, including not just researchers from different fields, who usually have few opportunities for discussion, but also by NICT leaders and staff from support departments. We were also able to share the need for more collaborative research and development by NICT staff in order to provide results that are useful to society.

■Open-Call Sponsored Research and Development

As for the constituent technologies necessary to realize B5G/6G, NICT is implementing the "Beyond 5G R&D Promotion Project" that aims to strengthen Japan's international competitiveness, etc., by conducting open-call sponsored research and development for private companies and universities, establishing the constituent technologies, and then reflecting them in international standards. The first open call for sponsored research was held in January, and, for technologies whose research and development should be advanced and prioritized, we plan to conduct research and development through successive sponsored research going forward.



From Cybernetic Avatar Society scenario

From Moon City scenario

From Across the TIME and SPACE scenario

Figure Three Future Scenarios in B5G/6G Whitepaper

Improving the Resiliency of Optical Networks through Disaggregation and Openness

Sugang Xu

Ph.D. (Engineering), Senior Researcher, Infrastructure Laboratory, Resilient ICT Research Center

Biography

1994 Graduated from Beijing University of Technology, School of Computer Science and Technology

1997 Completed master course at the Beijing University of Technology, Graduate School

2002 Completed doctoral course at the University of Tokyo, Graduate School

2002 Research Associate, Waseda University, Global Information and Telecommunication Institute

2005 Joined NICT

2021 Current job

Awards, etc.

2000 IEEE APCC-APB Best Paper Award

2020 IEEE TAOS GC 2019 ONS Symposium Best Paper Award

*Title and Department are as of March 2021

Q&As

Q What do you like the most about being a researcher?

A Being able to explore and pioneer unknown domains for a bright future, and being able to conduct research to enrich people's lives and to do things that are useful for society's progress.

Q What advice would you like to pass on to people aspiring to be researchers?

A Besides being an independent researcher, it is also important to always respect and look to teachers, older students, bosses, colleagues, and researchers from external institutions as mentors and instructors, to learn ways of thinking, ways of working, and attitudes towards difficulties, and to grow yourself through teamwork.

Q How do you normally spend your holidays?

A I go driving with my family on holidays and enjoy the beautiful ocean and mountains.

Conventional legacy optical networks are usually built with vendor-specific technologies and are highly dependent on that vendor. However, this means that emergency recovery might be hard due to the shortage of the vendor's products, and this problem is exacerbated during large-scale disasters. In recent years, there have been several new technology trends in industry, such as (1) consideration of the optimal disaggregation of functions of the originally integrated optical equipment from a single vendor, and the construction of optimal communication systems with the disaggregated products from different vendors, and (2) opening up system construction, control and management accompanying disaggregation (Figure 1). With these new technologies, the problem of insufficient recovery resources during a disaster can be qualitatively improved by using products from different vendors. Therefore, I strongly feel that the disaggregation and openness of optical networks are essential, and it is necessary to study the approach to the disaggregated and open optical networks.

Research and development of optical networks via disaggregation and opening up is underway, but research on strengthening their resilience, which I strongly believe optical networks should be prepared for in the future, is still a blank page. In particular, there are diverse configurations and functions for disaggregated devices, and the complexity of disaggregated optical networks is greater than that of conventional optical networks, so enhancing optical network resilience becomes more difficult. In the future, mixed optical networks, in which new-style optical networks and legacy optical networks coexist, will become even more complex, and improving their resiliency is an unexplored challenge.

Currently, I am promoting research to make it possible to quickly restore functions that are lost by optical networks in a disaster, etc., by using lightweight and portable emergency recovery optical devices that are based on the disaggregation method, as shown in Figure 2. Additionally, being able to handle device diversity is essential under a disaggregated environment. Therefore, in collaboration with the National Institute of Advanced Industrial Science and Technology (AIST) and KDDI Research, Inc., I am expanding prior research on universal modeling that enables integrated management and control of generalized optical networks consisting of arbitrary device configurations. Furthermore, proposal of open specifications with collaborators is envisioned as one of the future works.

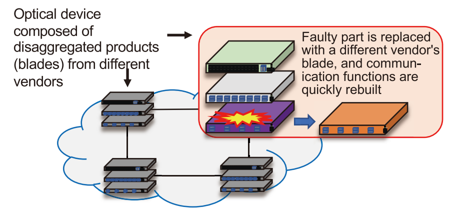


Figure1 Disaggregating/Opening Up Optical Networks and Failure Recovery

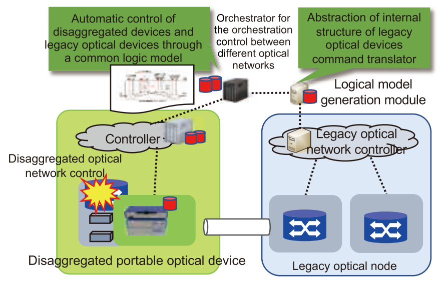


Figure 2 Trial of Legacy Optical Network Recovery by Disaggregated Optical Devices

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