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Transoceanic-class Ultra-long-haul Transmission Technologies with High-speed Optical Signals

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KDDI Research Inc.

1. Introduction

It is a great honor for me to have been named an IEICE fellow for my contributions to the research on ultra-long-haul high-speed optical transmission technologies for transoceanic submarine cable systems. In around 20 years of my research on ultra-long-haul transmission, the capacity transmitted in an optical fiber has increased by more than three thousand as shown in Fig. 1. These achievements could not be made without many people’s support. I express my deepest thanks for all of them.

In this article, I summarize my main research activities on ultra-long-haul high-speed optical transmission technologies.

2.40 Gbit/s optical soliton transmission

Optical soliton utilizing the nonlinearity and the chromatic dispersion of optical fibers was considered as a possible high-speed optical transmission technology because of its ability to maintain the signal pulse shape over long distances [1]. In high-speed optical soliton transmission, Gordon-Haus timing jitter [2] is the most serious constraint and various solutions had been proposed. In 1995, as a simple and practical solution we proposed the dispersion-managed soliton transmission scheme [3], where the chromatic dispersion accumulated in the transmission line is periodically compensated as shown in Fig. 3, and demonstrated 40 Gbit/s transmission over 10000 km without any active transmission control. At that time, the bit rate in the commercial submarine cable systems was 5 Gbit/s and the bit rate in transoceanic distance transmission was successfully increased eight times. The effectiveness of the proposed scheme was well recognized through this demonstration, which has stimulated the many theoretical and experimental studies worldwide.

3. 40 Gbit/s-based wavelength-division-multiplexing transmission

After the study on single-channel transmission, we tried to expand the capacity of wavelength division multiplexing (WDM) systems based on the dispersion-managed concept. To increase the spectral efficiency in WDM systems, the pre-filtering scheme was introduced. By optimizing the pre-filtering and dispersion management for 40 Gbit/s ultra-long-haul transmission as shown in Fig. 4 and Fig. 5, the spectral efficiency was successfully increased to 0.8 bit/s/Hz and 2.56 Tbit/s WDM transmission over 8200 km with 64 channels of 40 Gbit/s Return-to-Zero Differential Phase Shift Keying (RZ-DPSK) signals was demonstrated in 2003 [5]. The achieved spectral efficiency was more than three times higher than the previous spectral efficiency record in transoceanic distance transmission with the conventional optical amplifiers. This is the first demonstration showing the feasibility of multi-terabit transmission with the conventional optical amplifiers, which opened a new era of WDM transmission with high-speed signals.

Fig. 1 Evolution of fiber capacity

Fig. 2 Conventional Soliton

Fig. 3 Dispersion-managed Soliton

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Fig. 4 Optical spectra of 40 Gbit/s RZ-DPSK signals

Fig. 5 Dispersion managed span

4. 100 Gbit/s transmission using advanced modulation formats

To increase the signal bit rate to higher than 100 Gbit/s, we focused on the advanced modulation formats which can relax the required bandwidth of the electrical and optical components. After the first demonstration of 100 Gbit/s transmission using Differential Quadrature Phase Shift Keying (DQPSK) in 2006 [6], our group proposed optical Orthogonal Frequency Division Multiplexing (OFDM) and demonstrated several high-speed long-haul transmission, including 20 Gbit/s transmission over 4160 km [7] and 40 Gbit/s-based WDM transmission over 4160 km in 2007 [8] and 100 Gbit/s-based WDM transmission over 1000 km in 2008 [9].

Fig. 6 Constellation of DPSK and DQPSK signals

5. High-capacity optical fiber transmission using space division multiplexing

In order to break the capacity limit of the conventional single-mode fiber of around 100 Tbit/s, a new multiplexing scheme using “space” dimension, namely space division multiplexing (SDM), was proposed by Extreme Advanced Transmission Technologies (EXAT) Initiative [10], which was organized by NICT (the National Institute of Information and Communications Technology) in 2008 and shifted to IEICE technical committee in 2010. I have been a member of the committee since its establishment and currently serve as the chair of IEICE EXAT technical committee.

We demonstrated the first transoceanic distance transmission using 7-core fiber in 28.8 Tbit/s transmission over 6160 km in 2012 [11], where the transmission distance was more than doubled from the previous record of Multi-core fiber (MCF) transmission. After this demonstration, the fiber capacity was further expanded to 140.7 Tbit/s in 2013 by introducing more spectrally efficient scheme with duobinary pulse shaping and maximum likelihood sequence estimation [12]. The obtained capacity-distance product in 140.7 Tbit/s transmission over 7326 km was 1.03 Exabit/s·km and it is the first demonstration with the capacity-distance product of larger than 1 Exabit/s·km.

These demonstrations indicate that the MCF transmission will be one of promising technologies for future high capacity ultra-long-haul transmission systems.

Fig. 8 Optical OFDM

Fig. 7 Optical spectra of DPSK and DQPSK signals with same bit rate

Fig. 9 Cross sections of optical fibers
6. Conclusion

My main research activities on ultra-long-haul high-speed optical transmission technologies are reviewed. The fiber capacity has increased by more than three thousand in last two decades. Since the data traffic in communication systems has been continuously increasing and the demands will be enlarged furthermore in the “new normal” era, a further capacity expansion in ultra-long-haul transmission systems is expected by introducing some innovative technologies. I hope to continue to contribute to the progress of such technologies by interacting with many people through IEICE activities.

7. References


Network Technologies for IoT Services and their International Standardization
Tetsuya Yokotani
Kanazawa Institute of Technology

1. Introduction
To deploy various Internet of Things (IoT) services, “connection” is ultimately an indispensable function. The author has propelled networking technologies focusing on communication control and performance evaluation and has promoted their standardization. For instance, the author has contributed to R&D to various areas in the industrial field, including standardization on industrial local area networks (LANs), asynchronous transfer mode (ATM), optical access system, and home network system.

In line with these backgrounds, the author tries to promote network technologies on IoT services. In this study, service trends on IoT focusing communication network and their technologies are surveyed. Then, some highlighted topics are described. Finally, the IoT communication platform, referred to as IoT data exchange platform (IoT-DEP), which has been standardized in ISO/IEC JTC1/SC41, is introduced.

2. Overview of IoT services on networks
Various IoT services have been considered for real-life deployments. Most IoT services expect wide area network (WAN) services [1], as shown in Fig. 1. Some of these services require low latency communication. The network requirements on typical industrial domains are overviewed in Table 1 [2].

Communication sequences of IoT services can be categorized into three types, as shown in Fig. 2. In these sequences, Type 1 is the majority because a huge number of sensors are commercialized for end devices in various fields. The Internet Engineering Task Force has specified classes of end devices [3]. End devices with the simplest functionality, i.e., class 0, seem to be popularized in the mature stage of IoT services.

3. Landscape of network technologies
Network technologies have the most important position in the deployment of IoT services. In this section, the technologies are examined, as shown in Fig. 3.

The detailed description has been provided in [4].

As shown in Fig. 3, dedicated lower-layer protocols for IoT services can be applied to the LAN case, which includes standalone services and distributed services connected to the WAN via gateways. However, in WAN, IoT services should be coexistent with other legacy services. The generic lower-layer protocols are applied to this case.
This paper highlights three protocols, i.e., low-power wide-area (LPWA), IEEE 802.1 time-sensitive networking (TSN), and information centric network (ICN)-related protocols. The author has promoted proposals on the enhancement and creation of new aspects in these protocols, as described below.

(1) LPWA

Wireless networks for IoT services are presented in Fig. 4. LPWA is deployed to collect data from sensors. It can be combined with WAN and/or can be a standalone network.

![Summary of wireless network between power consumption and distance](image)

Fig. 4 Summary of wireless network between power consumption and distance

One of the advantages of LPWA is the low power consumption. In LPWA, several protocols have been proposed, such as low-power wide-area networking (LoRaWAN). As shown in Fig. 5, LoRaWAN consists of three transfer modes, i.e., Classes A, B, and C. Class A is the majority, and its power consumptions should be reduced. One of the approaches has been proposed by the author’s group in [5].

![Architecture of LoRaWAN](image)

Fig. 5 Architecture of LoRaWAN

In the proposed approach, although the current MAC in Class A of LoRaWAN specifies the random-access mechanism, a centralized access mechanism is proposed instead of the current specification. This proposal has achieved a power consumption saving of 17%. The benchmark test using the same platform is shown in Table 2.

### Table 2 Benchmark test for enhancement of LoRaWAN in power consumption

<table>
<thead>
<tr>
<th></th>
<th>Existing mechanism</th>
<th>Proposed mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption</td>
<td>0.6013mAh</td>
<td>0.5107mAh</td>
</tr>
<tr>
<td>Estimated life time</td>
<td>1039 days</td>
<td>1223 days</td>
</tr>
</tbody>
</table>

(2) IEEE 802.1 TSN

In IoT communication, some applications described in Table 1 requires low latency. However, when legacy communication is mixed on a network, large-size data frames increase latency on tiny data frames of IoT communication. To solve this problem, specifications of IEEE 802.1 TSN Task Group (TSN TG) can be applied.

IEEE 802.1 TSN TG has been applied as an extension of IEEE 802.1 Audio/Video Bridging for real-time communication at home. It provides switching mechanisms, and, recently, it has been expected to provide services that co-exist among various others already operating on WANs. Most existing studies assumed a non-preemptive priority control that cannot interrupt a packet transfer even if high-priority packets are received. However, when time-sensitive services in IoT are deployed on WANs, as shown in Fig. 6, the packets they transmit should interrupt the packets of lower-priority services. Therefore, a preemptive priority control is required. One of such approaches is IEEE 802.1 TSN [6]. However, it requires modification of data formats to indicate interrupted packets and does not invoke cut-through transfer to reduce transfer delay. The author’s group have proposed an enhancement of the specifications, referred to as the “copy approach” published in [7].

![Traffic characteristics and TSN approach](image)

Fig. 6 Traffic characteristics and TSN approach

(3) ICN and MQTT

Generally, most application protocols are operated on TCP/IP or UDP/IP. However, if a huge number of data blocks on IoT services are required to be transferred across IP-based networks, then simplified application-layer protocols are required. The Constrained Application Protocol and MQTT are promising candidates. Comparison studies considering various application protocols, including legacy protocols and HTTP, have been published by several articles. For example, the author’s group has published their comparison in [8]. In this comparison, three components are necessary to provide simplified processing: small...
overhead, independence from TCP handshake sequences, and streamlined data discovery. One of the possible solutions is the introduction of an ICN. In addition, although MQTT expects TCP connections as transmission pipes, it also provides an information base transfer. Thus, it can be included in an ICN in a broad sense.

An ICN has several options surveyed in [9]. This section focuses on the content-centric network (CCN), which is one of the typical options of an ICN. The operation of a CCN is illustrated in Fig. 7.

![Fig. 7 Operations of CCN](image)

Some issues are still encountered when an ICN is deployed widely for IoT services. These issues and the challenge faced by the author’s group are described in the next section.

4. ICN for IoT services

The advantages of ICNs are simplified communication sequences and traffic volume reduction by the networked cache. When an ICN is applied to various IoT services, including the low-latency services indicated in Table 1, the following items should be discussed to make the most use of these advantages.

(1) Routing among IWPs

Generally, on the Internet, several routing protocols have been standardized, e.g., Routing Information Protocol and Open Shortest Path First. However, because ICNs are operated independently of the IP, these protocols are not applied. Several approaches have been considered to solve this issue. The author’s group has clarified these approaches in [10]. These approaches are summarized in Table 3.

![Table 3 Approaches of routing mechanisms](image)

(2) Support of Type 1 communication

In IoT communication, Type 1 is the majority, as described in Section 2. However, how to support Type 1 communication sequences in ICNs, especially CCNs, is a challenge. To solve this problem, three schemes, e.g., dual commitment, piggyback, and cyclic transfer, are considered.

![Fig. 8 Operations in the Indirect mode](image)

A comparison among approaches identified in Table 3 should be considered continuously. However, the author’s group has proposed the detailed operations with prototyping on Approaches 5 and 6, e.g., see [11]. In [11], IWPs were connected on a virtual ring because redundant features are feasible.

![Fig. 9 Overview of Cyclic transfer scheme by CCN](image)

The author’s group has surveyed and compared these schemes in [12]. They concluded that the cyclic transfer scheme is reasonable for low-latency IoT services based on the cyclic communication indicated in Table 1. This group has described the detail operations based on the CCN and performance evaluation in [13]. The overview of this scheme is shown in Fig. 9.
5. Standardization on the IoT platform

Standardization takes an important role for the acceleration of IoT communication for various services. The author has promoted standardization on the IoT platform, including ICN, i.e., IoT-DEP standardized in ISO/IEC JTC1/SC41. Japanese activities, including IoT DEP, has been reported in [14].

IoT-DEP, i.e., ISO/IEC 30161, consists of two parts. Part 1 has been published as an international standard and specifies requirements on the IoT platform, architecture (Fig. 10), and functional blocks on IPWs. Part 2 is still an ongoing project and will specify co-operations among IPWs.

Fig. 10 Architecture of IoT-DEP

6. Conclusions

This paper describes communication technologies for IoT services from the author’s view and presents the challenges encountered in these technologies. Particularly, this paper highlights the role of ICNs in IoT services. Finally, it reports standardization on IoT platforms, including ICNs. For widespread IoT services, technology, standardization, and moral of users should be achieved. The author expects that the moral of users should be discussed in the near future.

Acknowledgments

A part of this work has been supported by the “Strategic International Standardization Promotion Project” of the Ministry of Economy, Trade and Industry in Japan. The authors would like to heartily thank the members concerned.

References


2020 Activity Report of Technical Committee on Communication Systems

Yuki Yoshida†, NICT; Kazutaka Hara†, NTT; Takahiro Yamaura‡, Toshiba; Yuta Ida‡, Yamaguchi Univ.; Daisuke Umehara**, Kyoto Inst. of Tech.; Jun Terada*, NTT; *Chair, **Vice-Chair, †Secretary, ‡Assistant, CS Technical Committee,
Web page: https://www.ieice.org/cs/cs/

1. Introduction
Technical Committee on Communication Systems (CS) is one of origins of technical committee in IEICE Communications Society and has 60-years of history. We organized seven technical conferences and one special workshop every year at various cities in Japan. Our technical interests include wide topics in wireless/wired communication systems and technologies from physical layer to application layer. In particular, our topics of interest include (but are not limited to):
- Network control
- Transport
- Modulation, coding and signal processing
- Network architecture and implementation
- Network application

In this report, we summarize our activities in the fiscal year of 2020 (from April 2020 to March 2021), including seven technical conferences and two annual conferences (IEICE Society Conference and IEICE General Conference). In addition, the winners of 2020 CS Technical Committee Awards are introduced.

For the latest information, such as the technical conference schedule in FY2021, please kindly visit our web site (https://www.ieice.org/cs/cs/). We always welcome your contributions and discussions in our conference.

2. Summary of Activities in FY2020
Table 1 summarizes the annual activities of CS Technical Committee from FY2017 to FY2020.

In FY2020, we successfully held seven CS Technical Conferences as in previous years. Due to the COVID-19 pandemic, most of the conferences were held online. Nevertheless, nearly 150 papers, including 13 special invited papers, were presented in total. The CS committee deeply appreciates the presenters and attendees for their continued support under the current situation with COVID-19.

The topics of the special invited talks were quite diverse, e.g., nanophotonic neural networks, open source software for private 5G, and Hayabusa2, the asteroid explorer. Particularly, we had two invaluable talks from outside of Japan; this was made possible by going online. Prof. Andrea Detti, Univ. of Rome,

Table 1  Summary of CS Technical Committee annual activities.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of presented papers</th>
<th>Special session in IEICE Society Conference</th>
<th>Special session in IEICE General Conference</th>
<th>Number of participants of CSWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY2017</td>
<td>114</td>
<td>29/55</td>
<td>Promotion of research and development toward future ICT (60)</td>
<td>- History and Challenge in optical access network (54) - IoT over All (56)</td>
</tr>
<tr>
<td>FY2018</td>
<td>113</td>
<td>32/44</td>
<td>ICT x SPORTS: Applications and Technologies (27)</td>
<td>- Innovative evolution of network technologies for efficient radio resource utilization in 5G and IoT (32) - Applications of communication technologies in various areas (47)</td>
</tr>
<tr>
<td>FY2019</td>
<td>117</td>
<td>35/45</td>
<td>- Innovative evolution of network technologies for efficient radio resource utilization in 5G and IoT (54) - Communication technologies for manufacturing in Society 5.0 (50)</td>
<td>- Extreme-Environments Communications --- Communication Technologies in Various Areas</td>
</tr>
<tr>
<td>FY2020</td>
<td>148</td>
<td>17/33</td>
<td>Optical communications technology towards Beyond 5G/6G (129)</td>
<td>New frontiers in quantum information processing (46)</td>
</tr>
</tbody>
</table>
introduced the EU-Japan IoT platform project, Fed4IoT, which aims at federating IoT devices and edge/cloud computing infrastructures in a scalable and interoperable manner via virtualization [1]. Prof. David Crawford, Ravensbourne Univ. London and PlayLa.bZ CIC, gave a talk on the GenieMo project [2], which investigates a range of video and virtual reality imaging tools to provide easy-to-use volumetric imaging service for patients and front-line health staffs under COVID-19.

In the technical conference in July, we organized a student presentation award session. In FY2020, 11 students joined the competition. Based on the votes from the audience and the committee members, the Student-Session Presentation Award went to Kotomi Takahashi [3], ChibaTech, and Ryota Tsuji [4], Osaka Univ. The award ceremony was held in the technical conference in November (Fig. 1). Congratulations!

IEICE Society and General Conferences also went virtual in FY2020. We had 50 presentations in the ordinary sessions and more than 150 participants in the special sessions in these conferences in total. The topics of the special sessions were Optical communications technology towards 5G/6G in the society conference (co-organized with OCS and PN committees) and New frontiers in quantum information processing in the general conference. Unfortunately, Communication Systems Workshop (CSWS) was cancelled because of COVID-19 in FY2020.

3. Activity Plan in FY2021
3.1 Technical Conferences
In FY2021, we plan to have seven technical conferences, two annual conferences and one technical workshop as usual. See Table. 2 for the technical conference schedule and the topics. As of July 2021, the technical conferences were decided to go virtual until November 2021. For the conferences after January 2022, please find the latest update from the conference web site (https://www.ieice.org/cs/cs/).

3.2 Special Sessions on IEICE Society and General Conferences
The IEICE society conference will be held online on September 14th – 17th. In the conference, the CS committee organizes six technical sessions and a special symposium titled Sensing and Communication Technologies towards Cyber Physical Society. For more detail, please visit the society conference website (https://www.ieice-taikai.jp/2021society/en/index.html). We are also planning an attractive symposium in the IEICE General Conference in March 2022. The detail will be announced soon.

3.3 CS Workshop (CSWS)
CS Workshop will be held online together with the CS technical conference on October 14th to 15th, 2021. The main theme of this workshop is Digital Transformation Accelerating Decarbonization and Achievement of SDGs. Please visit the web site for the details (https://www.ieice.org/cs/jpn/csws/).

3.4 CS Technical Committee Awards
Finally, we announce the 2020 CS Technical Committee Awards winners. The awards are for authors or speakers who submitted excellent papers or gave excellent presentations. The aims and regulations of the committee’s awards are summarized in Table 3.

Table 2  Technical conference schedule, May 2021 – March 2022.

<table>
<thead>
<tr>
<th>Date</th>
<th>Venue</th>
<th>Jointly held with</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 13th -14th</td>
<td>Nagoya -&gt;</td>
<td>CQ</td>
<td>Optical/Wireless Access and Their Integration, Communication Behavior, QoE and Psychology, Assessment / Measurement / Control / Optimization of Communication Quality, Network Services, Wireless Networks, MIMO/Diversity/Multiplexing Techniques, etc.</td>
</tr>
<tr>
<td></td>
<td>Online</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Online</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sep. 9th – 10th</td>
<td>Sendai -&gt;</td>
<td>NS, IN, NV</td>
<td>Session management (SIP/IMS), Interoperability/Standardization, NGN/NwGN/Future networks, Cloud/Data center networks, SDN (OpenFlow, etc.)/NFV, IPv6, Machine learning, etc.</td>
</tr>
<tr>
<td></td>
<td>Online</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov. 25th – 26th</td>
<td>Online</td>
<td>IPSJ-AVM, IE, ITE-BCT</td>
<td>Image Coding, Communications and Streaming technologies, etc.</td>
</tr>
<tr>
<td>Mar. (TBA)</td>
<td>TBA</td>
<td>CAS</td>
<td>Network Processor, Signal Processing Circuits for Communication, Wireless LAN / PAN, etc.</td>
</tr>
</tbody>
</table>
The CS committee carried out a rigorous review process and the chairman’s award in FY2020 goes to

- **“Real-time ADX-RoF based fronthaul for (B)5G radio access network [5]”** by Paikun Zhu (GPI), Yuki Yoshida (NICT), and Ken-ichi Kitayama (GPI), and

- **“Device identification based on RF circuit imperfections [6]”** by Taisei Nakada, Ryota Shinoda, Yuichi Miyaji, and Hideyuki Uehara (TUT).

The encouraging award winners are

- **Rintaro Harada (NTT)**, the author and presenter of “A study on optical access systems for 6G radio access networks [7],”

- **Yamato Yoshikawa (KIT)**, the author and presenter of “Performance analysis of success-prioritized DCF in non-saturated condition [8],” and

- **Anan Sawabe (NEC)**, the author and presenter of “A self-learning traffic analysis method for self-driving private mobile networks [9].”

Congrats to the winners! The award ceremony will be held in the CS technical conference on Sep. 9th – 10th, 2021. In the ceremony, the winners are invited to present their latest updates.

1. GPI: The Graduate School for the Creation of New Photonics Industries
2. TUT: Toyohashi University of Technology

### 4. Conclusion

In this report, we summarized FY2020 activities of Technical Committee on Communication Systems. Any comments and feedbacks are appreciated to improve our activities. We hope for your contributions to IEICE Communication Society and CS Technical Committee ([https://www.ieice.org/cs/cs/](https://www.ieice.org/cs/cs/)).

### 5. References

Report on ICM English Session at 2021 IEICE Society Conference – BS-6, Network and Service Design, Control and Management –

Cheng Zhang
Session Organizer, Ibaraki University

1. Introduction

The 2021 IEICE Society Conference was held on September 14-17, 2021, where three Societies of Engineering Sciences Society (ESS), Communications Society (CS), and Electronics Society (ES) joined. Since the COVID-19 pandemic in Japan is still severe, the Conference is held online.

In the Conference, the IEICE Technical Committee on Information Communication Management (ICM) [1] hosted a full English Session entitled “Network and Service Design, Control and Management” as one of seven Symposium Sessions which focused on special topics of advanced technologies.

2. Background of ICM English Session

ICM has been hosting English session every year since 2004. The purpose of this English session is to contribute to the globalization of IEICE by offering the chance of the presentation and discussion in English to the foreign researchers/students living in Japan and the overseas researchers/students.

Figure 1 shows the change in the number of contribution papers since 2004. When the session began in 2004, only 15 papers were submitted. Since then, the number of papers has gradually increased and it reached 55 papers in 2013. Although it decreased after 2013, it keeps over 30 between 2008 and 2019. Since there is the COVID-19 pandemic in Japan, the number of submitted papers has been only less than the half of time before COVID-19. It decreased to only 11 papers in this year, which is the lowest number in the history of ICM English session.

3. Presentations in ICM English Session

The contribution papers were classified into four sub-sessions according to the topics. Various topics are discussed in each sub-session every year.

Figure 2 shows the percentage of papers corresponding to their topics. About 37 percentage of papers are on machine learning (ML), which reflects the artificial intelligence (AI) research boom in recent years. Wireless network and ICN (information-centric networking) are ranked in the second, and both of them are about 18 percentage of papers. Other topics, such as edge computing and routing were also presented.

4. Authors

Figure 3 shows the number of papers corresponding to the categorization of the presenter’s affiliations. 100% of the speakers belonged to the university. The situation in which the contribution from the university occupied the majority did not change.

Although most of speakers were international students studying in Japan, three presenters were Japanese students or researchers. In this symposium, ICM expects the open contribution from not only the university but also enterprise, and expects the various presenters from not only the international students and
the foreign researchers but also Japanese students and researchers, too.

Every speaker and audience enthusiastically discussed the ideas and opinions in the time assigned for question and answer. Since the assigned time passed quickly, some speakers and questioners continued their discussion using the chat box in Zoom even in the break time.

5. Award of ICM English Session

ICM will select the best papers and award a prize of the session in the near future to encourage their continuous activities. The best papers will be awarded in the upcoming ICM workshop in March 2022.

Table 1 shows the awarded papers in this March, which are presented in the 2020 IEICE Society Conference [2,3]. The certificate of ICM English session award is shown in Fig. 4.

6. Conclusions

ICM English session in 2021 successfully finished with a lot of excellent presentations and a very active discussion. The organizer believes that this session became fruitful for all people and was able to contribute to the globalization of IEICE. He wishes that more papers will be contributed to the session in the next year.

7. Acknowledgement

The organizer would like to thank Prof. Yoshiaki Tanaka at Waseda University, who made a great contribution in soliciting papers, utilizing his nationwide academic authority and human relations. He would also like to thank all the members of the ICM committee, the attendees and everyone who contributed to the discussions and supported the session.

8. References

1. Overview
The 7th International Conference on Network Softwarization (NetSoft) 2021 was held from June 28th to July 2nd as a virtual conference [1]. It is organized by the IEEE Communications Society and is technically co-sponsored by Technical Committee on Information and Communication Management, the Institute of Electronics, Information and Communication Engineers (IEICE ICM) and the IEICE Communications Society. NetSoft 2021, with its theme being “Accelerating Network Softwarization in the Cognitive Age,” consists of 5 keynote speeches, a distinguished expert panel, 6 plenary sessions, 5 technical sessions, 1 demo session, and 5 tutorial sessions. It also includes 5 workshops. 275 people from 41 countries participated in the conference.

2. Highlights
Five executives delivered keynote speeches. Three of them are about Beyond 5G, including “Developing B5G/6G Communication Systems: Opportunities and Challenges” by Dr. Hideyuki Tokuda from NICT, “Innovative Network Beyond 5G: IOWN” by Mr. Yoshikatsu Okazaki from NTT, and “Edge Intelligence for B5G/6G and IoT” by Prof. Ai-Chun Pang from NTU. Besides, Dr. Ying Zhang from Facebook gave a speech on “Robotron: Top-down network management at scale” and Mr. Luis Miguel Contreras Murillo from Telefonica introduced “Transformation of Transport Networks through Softwarization.”

In the distinguished expert panel session, six panelists discussed various emerging topics about edge computing towards Beyond 5G/6G era with moderator and audiences.

A total of 89 papers were submitted to NetSoft 2021, among which 18 papers were accepted to be presented in plenary sessions. Besides, 25 papers were accepted to be presented in technical sessions. Frequent keywords in submitted papers are shown in Fig. 1. The technical program committee and organizing committee gave the best paper award to “Physical Wireless Resource Virtualization for Software-Defined Whole-Stack Slicing,” presented by Matthias Sander-Frigau from Iowa State University and the best student paper award to “SoftTap: A Software-Defined TAP via Switch-Based Traffic Mirroring,” presented by Sogand Sadrhaghighi from University of Calgary.

In the demo session, six videos were introduced. Five one-day or half-day workshops were co-located, such as the 1st International Workshop on Theory and Practice of Programmable Forwarding (TaPoPF 2021), the 4th International Workshop on Advances in Slicing for Softwarized Infrastructures (S4SI 2021), the 1st International Workshop on Intent-based Networking (WIN 2021), the 3rd International Workshop on Cyber-Security Threats, Trust and Privacy Management in Software-Defined and Virtualized Infrastructures (SecSoft 2021), and the 2nd International Workshop on Network Softwarization Techniques for IoT Applications (SoftIoT 2021).

3. Summary
Unfortunately, NetSoft 2021 was not held in Tokyo, Japan as planned due to COVID-19 pandemic. In a virtual style, however, it was closed with great success. On behalf of all organizing committee members, we would like to express our appreciation to all parties involved in this conference.

NetSoft 2022 will be held in Milano, Italy.

4. Reference
Report on the 9th International Conference on Smart Grid (icSmartGrid2021)

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1. Introduction

The 9th International Conference on Smart Grid (icSmartGrid2021) was held from June 29 to July 1, 2021. Although the conference was planned to be held in Setubal, Portugal, it was held as a digital conference due to the COVID-19 pandemic all over the world. icSmartGrid is the annual world-class technical forum presenting the latest research topics in the smart grid, renewable energy technologies and their applications.

The icSmartGrid2021 is organized by the International Journal of Renewable Energy (IJRER), IEEE Industry Applications Society (IAS) and IEEE Industrial Electronics Society (IES) have joined as one of the technical co-sponsors. The IEE-Japan Industry Applications Society Conference (IEEJAS), one of the divisions of the Institute of Electrical Engineers of Japan (IEEJ), and the Institute of Electronics, Information and Communication Engineers (IEICE) support the conference in cooperation.

2. Opening Ceremony and Keynote Speeches

The conference program consisted of 5 keynote addresses, 1 tutorial, and 12 virtual technical sessions.

On June 29, the first day of the conference, the opening ceremony was held by General Chair, Prof. Vitor Pires, General co-chairs, Prof. Ilhami Colak and Prof. Fujio Kurokawa. After the opening ceremony, two high-profile keynote speeches were presented. The first keynote speaker, Mr. Masayuki Tobita, who is vice president of Toshiba Mitsubishi-Electric Industrial Systems Corporation (TMEIC), talked about “Contributions to Carbon Neutral through PEiE, Power Electronics in Everything”. The second keynote speaker, Prof. Thomas Strasser, Austrian Institute of Technology, Austria, presented on “Recent Research Trends in Designing and Validating Smart Grids” to realize a sustainable energy supply by the integration of renewable energy resources.

On the morning of June 30, the second day of the conference, the keynote speaker Prof. Kazuto Yukita, Aichi Institute of Technology, talked about “Study on AC/DC microgrids at Aichi Institute of Technology Eco-Electricity Research Center.” Also, Prof. Khaled Ahmed, University of Strathclyde, Glasgow, UK, gave the keynote speech about “Unlocking Opportunities for DC Grids by Fault Tolerant DC-DC Converters” to discuss the fault tolerant high power DC-DC converters with clarifying different topologies advantages and disadvantages.

On the morning of July 1, the last day of the conference, Prof. Peter Palensky, TU Delft, Netherlands, talked about “IEC61850 and Cyber-Physical Security of Power Systems” as the fifth keynote speech.

3. Technical Program

In this conference, 84 papers are submitted from 26 countries. The technical program committee selected papers for presentation by careful peer review process. Finally, 52 papers were presented. All presentations were organized in 12 technical sessions by using Microsoft Teams. The technical program was scheduled from Tuesday afternoon through Thursday afternoon. Each session was kept to the schedule, and attendees discussed about the interesting subjects, advances and developments in smart grid technologies and their applications. The best papers were selected from the conference proceeding. Selected papers will be published in the following journals cited in Web of Science with high impact factors: IEEE Transactions on Industrial Applications, International Journal of Renewable Energy Research, International Journal of Smart Grid, International Journal of Engineering Science and Applications, and Energies (in a Special Issue organized by the organizing committee of icSmartGrid).

4. Conclusions

The purpose of icSmartGrid is to bring together researchers, engineers, manufacturers, practitioners and customers from all over the world to share and discuss advances and developments in smart grid research and applications. icSmartGrid will continue promoting and disseminating the knowledge concerning several topics and technologies related to smart energy systems and sources.
1. Introduction
The symposium on Quality of Service (IWQoS) 2021 was held virtually in Tokyo from 25th through 28th June 2021. Because of the travel restrictions imposed by the COVID-19 pandemic, the IWQoS 2021 was held as an online conference. IWQoS was sponsored by the IEEE and the ACM, cosponsored by Cisco Systems and the National Institute of Information and Communications Technology (NICT), and technically cosponsored by the IEICE Technical Committee on Communication Quality (CQ). Since 1993, IWQoS has established itself as a highly reputable forum to present novel ideas on all QoS-related subjects. IWQoS 2021 set the goal to continuing to be a premier symposium and an international forum for presentation and discussion of cutting-edge research in the field.

The scope of IWQoS 2021 covered both the newest theoretical and experimental research papers. 256 papers were submitted from 29 countries, and 104 papers were accepted. 109 talks were presented in 28 sessions, and the number of participants was 179. The symposium consisted of 4 keynote sessions, 16 technical sessions, 6 short paper sessions, 1 poster session, and 1 industrial talk session.

2. Keynote Sessions
The first keynote presentation was provided by Dr. Hideyuki Tokuda, the president of the NICT, and the presentation title was “Challenges in Developing B5G/6G Communication Systems”. He introduced the outline of the NICT Beyond 5G/6G (B5G/6G) White Paper and explained use cases of B5G/6G such as Cybernetic Avatar Society, Working at a Moon base, and Beyond space and time. He also discussed NICT’s research and development of fundamental technologies supporting B5G/6G infrastructure.

The second keynote presentation was provided by Prof. Jie Wu from Temple University, USA, and the presentation title was “Enhancing Scalability and Liquidation in QoS Lightning Networks”. He overviewed a micropayment and liquidation technique of the lightning network which was a special network in Bitcoin.

The third keynote presentation was provided by Prof. Masayuki Murata from Osaka University, and the presentation title was “Brain-inspired Networking and QoE Control”. He introduced brain-inspired approaches for networking problems by formulating the “Yuragi”, meaning fluctuation in Japanese, theory and extending it to the machine learning approach.

The fourth keynote presentation was provided by Prof. Albert Y. Zomaya from University of Sydney, Australia, and the presentation title was “Edge Computing Meets Mission-critical Industrial Applications”. He provided a few answers for the industrial requirements by combining real-time computing strengths into modern data- and intelligence-rich computing ecosystems.

3. Technical Sessions

4. Best Paper Awards
Two presentations were selected for the best paper award, and one presentation was selected for the best paper award runner-up.

Best Paper Award:
- **LightNF: Simplifying Network Function Offloading in Programmable Networks**, Xiang Chen (Peking University, Pengcheng Lab, and Fuzhou University, China); Qun Huang (Peking University, China); Peiqiao Wang (Fuzhou University, China); Zili Meng (Tsinghua University, China); Hongyan Liu (Zhejiang University, China); Yuxin Chen (University of Science and Technology of China, China); Dong Zhang (Fuzhou University, China); Haiyong Zhou (Zhejiang University, China); Boyang Zhou (Zhejiang Lab, China); Chunming Wu (College of Computer Science, Zhejiang University, China)

- **Efficient Fine-Grained Website Fingerprinting via Encrypted Traffic Analysis with Deep Learning**, Meng Shen, Zhenbo Gao and Liehuang Zhu (Beijing Institute of Technology, China); Ke Xu (Tsinghua University, China)

Best Paper Award Runner-up:
- **Understanding and Improving User Engagement in Adaptive Video Streaming**, Chunjun Qiao and Jiliang Wang (Tsinghua University, China); Yanan Wang (I/QIYI Science & Technology Co., Ltd., China); Yunhao Liu (Tsinghua University & The Hong Kong University of Science and Technology, China); Hu Tuo (I/QIYI Science & Technology Co., Ltd., China)
1. Introduction

OECC 2021, the 26th Optoelectronics and Communications Conference was held virtually on July 3rd - 7th, 2021 [1] and on July 3rd, 2021, a workshop on the latest SDM (Space-division multiplexing) optical technologies entitled “SDM is beginning to reach its capacity limit? What is a viable path to 100 Pbit/s per fiber and beyond?” was held virtually at 14:00-18:00 (four hours), technically co-sponsored by Technical Committee on Extremely Advanced Optical Transmission Technologies (EXAT), IEICE [2].

Optical fiber communication has been one of the key technologies enabling the growth of the various communication services. However, we are now approaching the capacity limit of present optical communication systems based on single-core, single-mode optical fibers. SDM technologies based on multi-core fibers (MCFs) and/or multi-mode fibers (MMFs) have been proposed by EXAT and have attracted a lot of attention as a promising approach to overcome such limit. 10 Pbit/s per fiber transmission has already been demonstrated based on SDM technologies by the EXAT members [3].

In this workshop, novel enabling technologies were discussed from the standpoint of how we can further increase the transmission capacity towards 100 Pbit/s per fiber and beyond, such as MCF/MMF transmission technologies with spatial counts higher than 100, advanced modulation/coding technologies, and ultra-wide-band amplification technologies.

2. Workshop Program

Eight eminent invited speakers from around the world presented their views on the state of the art as well as their future perspectives on the topics ranging from devices (SDM optical fibers, SDM amplifiers, SDM MUX/DEMUX), SDM transmission and node systems, to its applications to data center networks as listed in Table 1. Each talk was 25 min. including 5 min. Q&As.

Table 1 List of invited speakers.

<table>
<thead>
<tr>
<th>Speakers</th>
<th>Affiliation</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chongjin Xie</td>
<td>Alibaba, USA</td>
<td>“Capacity demand of data center networks”</td>
</tr>
<tr>
<td>Kazunori</td>
<td>Furukawa Electric, Japan</td>
<td>“Technologies to increase the number of cores in a fiber - beyond 100”</td>
</tr>
<tr>
<td>Yushke Sasaki</td>
<td>Fujikura, Japan</td>
<td>“High density spatial channel fibers, few-mode”</td>
</tr>
</tbody>
</table>

3. Discussion

After eight presentations, a panel discussion was held among invited speakers and three organizers on the following topics, which were answered by relevant speakers.

1. Traffic demands will continue to increase?
2. SDM is beginning to reach its capacity limit per fiber?
   a. What is the important factor? Number of cores/modes or density?
   b. Maximum number of cores and modes for transmission (short reach/long-haul)
   c. Networking perspective, goals
3. What is a viable path to 100 Pbit/s per fiber and beyond?
   a. 100 Pbit/s (>1,000 spatial channels)
   b. Beyond towards 1 Ebit/s (>10,000 spatial channels)
   c. Alternatives to SDM? Combinations with SDM?
   d. Multi-band transmission (O, E, S, C, L, U…) and issues
   e. Higher order modulation formats?
4. Conclusion

Although definite solutions towards 100 Pbit/s transmission were not derived from the workshop, it did raise awareness that we need to cooperate and advance relevant SDM technologies to the forthcoming goal of achieving 100 Pbit/s per fiber transmission very soon.

5. References

From Editor’s Desk

●IEICE General Conference 2022
IEICE General Conference 2022 will be held online, from 15th to 18th of March 2022. Complete English sessions are also scheduled in the conference. Please check out the latest conference information on the IEICE web site: https://www.ieice-taikai.jp/2022general/en/index.html

We welcome your contribution of article submissions to GNL. For article submission, please refer to the Submission Guideline of IEICE-CS GLOBAL NEWSLETTER:
[ENG] https://www.ieice.org/cs_r/eng/gnl/submission_guideline.html
[JPN] https://www.ieice.org/cs_r/jpn/gnl/submission_guideline.html

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IEICE General Conference 2022

15-18 March 2022
Online Conference

Every spring, the four Societies, together with the Human communications Group, jointly hold a General Conference to provide a forum where members can present their study results and exchange views. Besides the presentation of papers, there are special events, conferment ceremonies of Young Investigators Awards, and a social party. The Communications Society holds English-language sessions as well.

Please check out the latest information on the IEICE web site at: