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BRIEF REPORT

Networking Data and Intelligent Management in the Post-COVID19 Era: A Report on APNOMS 2021

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Abstract

This article presents a report on APNOMS 2021, which was held on September 8–10, 2021 in Tainan, Taiwan. The theme of APNOMS 2021 was "Networking Data and Intelligent Management in the Post-COVID19 Era."

Keywords IoT and Wireless Sensor Networks · Mobile and Wireless Networks · Edge/Fog Computing · 5G · Configuration and Fault Management · Intelligent Network Operations and Management · Software Defined Networks · Heterogeneous Networks · Network Function Virtualization · Intelligent Networking Services

1 Introduction

APNOMS (Asia-Pacific Network Operations and Management Symposium) has been a premier conference on network operations and management in the Asia-Pacific region. The symposium has been organizing the researchers' congregation since 1997 to exchange knowledge and ideas. The 22nd APNOMS 2021 (www.apnoms.org/2021/) was held on September 8–10, 2021 in Tainan, Taiwan. Due to the COVID-19 pandemic, APNOMS 2021 has been converted into a virtual conference with all authors and participants attending online. Almost all events and sessions have been held via the Zoom Webinar event platform, while the poster session, demo session and exhibitions have been held by using gather.town for interactive poster presentation. APNOMS 2021 was organized by the Institute of Electronics, Information and Communication Engineers (IEICE) Technical Committee on Information Communication Management (ICM), the Korea Information and Communications Society (KICS) Technical Committee on Korean Network Operations and Management (KNOM), National Yang Ming Chiao Tung University (NYCU) and Ministry

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of Science and Technology (MOST), Taiwan with support from IEEE ComSoc (IEEE Communications Society), Chunghwa Telecom and National Yang Ming Chiao Tung University/Okinawa Open Laboratory Joint Research Center.

APNOMS 2021 continues to play a key role in exchanging and discussing all aspects of operations and management of telecommunications networks, enterprise networks, the Internet and their services among the academic community, vendors and the telecommunication industry at large in the Asia-Pacific region. As in the previous APNOMS symposia [1–18], APNOMS 2021 was a great success as it attracted nearly 110 scholars, researchers, policymakers, practitioners, service providers and vendors from 10 countries.

The most significant impact on social life and economics worldwide since 2020 is definitely the COIVD-19 pandemic. The pandemic also affects various aspects of development, management, and application of telecom network and communications. To this end, the main theme of APNOMS 2021 is set to "Networking Data and Intelligent Management in the Post-COVID19 Era." We have invited several experts and researchers gathered together to discuss technologies for the post-COVID19 era in the data and network management aspect, sharing their experiences and challenges in various academia, industries and governments. The diverse topics cover virtual desktop infrastructure for telework, optimizing pandemic containment by social network analysis, roles of supercomputer in overcoming COVID-19, learning human behavior in the COVID-19 pandemic time, and many others. Another important trend of topics is about 5G. We have invited three keynotes covering the opportunities and challenges in the 5G era, the open-source movement in the 5G MEC, and the challenge for automated operation toward future 5G and cloud-native environment. Of course, APNOMS 2021 have offered sessions with topics on the Intelligent Network Operations and Management, Artificial Intelligence, Networking Intelligence, Intelligent Networking Services, Internet-of-Things (IoT) and Wireless Sensor Networks, Mobile and Wireless Networks, Edge/Fog Computing, Software Defined Networks (SDN), Heterogeneous Networks and Network Function Virtualization (NFV).

APNOMS 2021 prepared an excellent 3-full day program with keynotes, tutorials, technical sessions, poster sessions, innovation sessions, a demo session, a special session, exhibitions, and an interactive Distinguished Experts Panel (DEP). Synopses of each event are given in the following sections. The summarized events show the entire scenario of APNOMS 2021 and current trends of research on Networking Data and Intelligent Management in the Post-COVID19 Era.

2 Keynotes

There were three keynote speakers in the symposium. Keynote speakers shared their visions and perspectives on 5G technologies in this symposium. On the first day, Ms. Hey-Chyi Young (VP, Telecommunication Lab, Chunghwa Telecom Co. Ltd.) delivered a speech on "The Opportunities and Challenges in the 5G Era." She presented the new opportunities brought by 5G and pointed out the challenges we must face and overcome to achieve the 5G vision. In addition, she shared Chunghwa Telecom's relevant activities and achievements in response to the 5G new era. On the second

day, Prof. Sungwon Lee (Kyung Hee University, Korea) delivered a speech on "The Opensource Movement in the 5G MEC." He introduced the trend of open source over operating systems, networking protocols, virtualization, cloud computing and container technologies. In this keynote, he also explained the role and position of open source software in the 5G MEC movement. On the last day, Mr. Masanori Miyazawa (KDDI) delivered a speech on "The Challenge for Automated Operation Toward Future 5G and Cloud-Native Environment." He illustrated that telecom operators are expecting a dramatic transformation in network management and operation using an automation by starting into the 5G era. However, several problems still remain for efficient automated operation, especially in hybrid network. He introduced several problems in network operation and future technologies for advanced automation toward beyond 5G and cloud-native environment.

3 Tutorials

Four tutorial sessions in two parallel tracks covering the latest hot topics were held on the first day of the symposium. The themes of the first two tutorial sessions were "Internet of Vehicles" and "Edge Learning." Prof. Celimuge Wu (the University of Electro-Communications, Japan) presented his tutorial on "Federated Learning for Internet of Vehicles." Prof. Peng Li (the University of Aizu, Japan) gave his tutorial on "Edge Learning: Enabling Distributed Machine Learning in Cloud-Edge Environment." In the second two tutorial sessions, the themes were "Wireless Drone Networks" and "Learning from Data Science." Prof. Yu-Jia Chen (National Central University, Taiwan) gave his tutorial on "Trajectory Design in Wireless Drone Networks: Moving from Offline Optimization to Online Learning." Prof. Jinyoung Han (Sungkyunkwan University, Korea) presented his tutorial on "Human Behavior in the Time of COVID-19 Pandemic: Learning from Data Science."

The four tutorials attracted many audiences and generated discussions on these topics. A questionnaire requesting feedback about the tutorials showed all the tutorial sessions were useful. More than 92% of the audience answered that they learned something new from the tutorials.

4 Technical, Poster, Innovation and Demo Sessions

The symposium's main body consisted of ten technical sessions, three poster sessions, two innovation sessions and one demo session. This year, we have received 105 submissions for technical sessions and poster sessions from 10 different countries. We selected 40 technical papers for oral sessions. The acceptance rate was 38.09%. For each article, we provided at least three independent reviews, most of which were offered by TPC members and some were offered by a few external reviewers.

The accepted papers covered a wide range of important and latest results of research and development in intelligent network and service operations and management. The ten technical sessions covered research areas including Intelligent Network Management, Internet of Things (IoT) and Wireless Sensor Networks (WSN), Mobile and

Wireless Networks, Edge/Fog Computing, 5G Networks, Configuration and Fault Management, Software Defined Networks (SDN), Heterogeneous Networks, Network Monitoring and Measurements, and Network Function Virtualization (NFV). Each technical session was evaluated by questionnaire. The responses showed that more than 87% of attendees evaluated these sessions "Very Useful" or "Useful." Technical session 9 "Network Monitoring and Measurements" was the highest-rated according to the questionnaire and Technical Session 6 "Intelligent Network Management" attracted most of participants.

This year, we expanded the poster sessions and held three sessions in total. 45 poster presentations were held in the symposium, and each poster session presented essential and interesting topics. As we held the three poster sessions online, the average number of attendees in each poster session was equal to 57.3. The interested attendees to the poster presentations asked many questions to gather more information and make the sessions enjoyable.

The innovation sessions were also organized to present and discuss ongoing research, innovative ideas, work-in-progress ideas, practical solutions, experimental studies and various topics of interest to the community. Ten papers were selected and presented in the innovation sessions focusing on "Intelligent Network Operations and Management in a New Era" and "Intelligent & Secure Networking Services" topics. The average number of webinar attendees in each innovation session was equal to 18.

This year, we organized a demo session, in which three demos were introduced and shown in the session. In the demo session, the presentation was made in a live demonstration-style from three innovation papers. According to the questionnaire results, the demo session had a good reputation from audiences.

The steadfast effort of the TPC co-chairs Jen-Jee Chen (National Yang Ming Chiao Tung University, Taiwan), Ryo Yamamoto (UEC, Japan), and Kyungbaek Kim (Chonnam National University, Korea) along with other 98 PC members enabled us to meet the deadline to notify authors.

5 Special Session

One special session was held on the second day of the symposium. This session invited four distinguished speakers from the Asia–Pacific region and discussed the latest research topics on "Cloud Native in Telecom Network Infrastructure" and "Artificial Intelligence/Machine Learning for Network Management." Mr. Bruce Lan (Palo Alto Networks, Taiwan) introduced that an increasingly hyper-connected world would also open up new security vulnerabilities and threat vectors. He presented that a comprehensive, context-driven and automated security was needed across the 5G infrastructure to tap into the 5G business opportunities with minimal risk. Mr. Tomohiro Otani (KDDI, Japan) reviewed the rapid transition of telecom network infrastructure from PNF to CNF through NFV these days. He also introduced the corresponding change of network operation by network automation as well as AI/ML. Dr. Hiroaki Harai (NICT, Japan) overviewed automatic network control and management supported by AI. He also introduced AI application for resource monitoring and reconfiguration to meet QoS requirement on the service network platform

built on cloud-native networking environment. Dr. Dongkyun Kim (KISTI, Korea) introduced the KREONET softwarization (KREONET-S) project, which has developed and deployed a de-facto R&E wide-area SDN infrastructure in Korea for the advanced services above, as well as the status and direction of network intelligence for KREONET-S in particular.

6 Exhibitions

The exhibitions program provided vendors and service providers an opportunity to exhibit their latest technologies over three days. There was one exhibitor, Chunghwa Telecom (Taiwan), this year and two exhibitions are provided. Each exhibition attracted many attendees, lively discussions by all attendees were conducted. Chunghwa Telecom presented two exhibitions. In the first exhibition, a service assurance system, EyeSee, for Enterprise Private 5G Network was presented. Chunghwa Telecom (CHT) announces private 5G network solutions to provide safe, fast, and reliable mobile networks for enterprises by setting up dedicated base stations and MEC (Multi-Access Edge Computing) infra in enterprises' filed. EyeSee, a self-developed system of CHT, is a self-management platform used to monitor enterprises' various ICT services and infrastructure proactively. To ensure service quality of private 5G networks, Chunghwa Telecom extends EyeSee monitoring scope from ICT infrastructure to mobile network elements, including UE, RAN, MEC. EyeSee collects and analyzes performance metrics into meaningful information through visualized graphs and historical reports. Besides, EyeSee sends notification to users based on flexible rule combination created by administrators. With features described above, enterprise customers can log on to the unified web-based service portal and master their private 5G networks. In the second exhibition, a zero trust network access solution, EyeLAN, was introduced. EyeLAN is independently developed by Chunghwa Telecom Research Institute and has been used in Chunghwa Telecom's corporate network. Introducing EyeLAN, an easy-to-use, and affordable network provision & monitoring solution. It adopts Zero Trust Network Access (ZTNA) technologies, also known as the software-defined perimeter (SDP), that operates on an adaptive trust model. It monitors network devices such as PC, Printers, Notebook, IP camera, storage devices, and everything that has IP and is connected to the network. EyeLAN continuously monitors the network and provides an in-depth visibility and access control. In case of a fault, you can easily drill down to the root cause and eliminate it before operations are affected.

7 Distinguished Experts Panel

The DEP session was held as the last session of APNOMS 2021. The session was led by the session chair Prof. Yi-Cheng Chen (National Central University, Taiwan), where the five panelists from four different countries first made presentations, followed by a Q&A session. The theme of the DEP session was "Technologies for Post-

Covid19 era in the data and network management aspect: Sharing experiences and challenges in various academia, industries and governments."

The DEP Hong-Kong panelist Dr. Magnus Ewerbring (Ericsson) gave a talk on "Enterprise potential with 5G connectivity." He introduced that for enterprises, the possibilities of 5G are plenty as they digitalize. Be increasingly becoming data driven, higher values can be derived increasing performance and energy efficiency and safety in manufacturing plants. In his talk, recent advancement of 5G-based connectivity in enterprise environments was presented.

The DEP Japan panelist Mr. Shinji Yamashita (Fujitsu Ltd.) provided a speech on "VDI Service Quality Analysis System - Experiences and Challenges towards Post COVID-19 Era." He struck up his talk by introducing VDI quality analysis system that analyzes network capture data among users, cloud and VDI systems. By this system, VDI operators can detect anomalies from login time of users and analyze the load of cloud service. He also shared some lessons learnt from experiences to deal with sudden increase of telework traffic and introduce activities & challenges in Fujitsu towards post COVID-19 era.

The DEP Taiwan panelist Dr. De-Nian Yang (Sinica, Taiwan) gave a talk on "Optimizing Pandemic Containment for COVID-19 by Social Network Analysis." He initiated his speech by introducing the problem of Economy-aware Containment Operation through Non-Pharmaceutical Interventions (NPIs) that maximizes economic productivity while containing the epidemic by analyzing social contact networks built by Bluetooth, whereas Google and Apple have leveraged Bluetooth to construct social contact networks with user privacy and security in the core design. To solve the problem, he designed an approximation algorithm, namely NPI Selection and Scheduling (NPISS), to determine the particular time to implement an appropriate NPI in a region. He also shown that experiments on real social contact networks demonstrate that NPISS outperforms the existing approaches in public health and the state-of-the-art algorithms for containment.

The DEP Taiwan panelist Prof. Ping-Yu Hsu (National Central University, Taiwan) delivered a presentation on "Distinguishing Customer Satisfactions with Tones of Voices." In this talk, he introduced how they extract features from customers' voices to distinguish their satisfaction without resorting to Automatic Speech Recognition (ASR). With the lab data, they confirmed that the voice collected indeed is related to the analysis of satisfaction questionnaires. A primary study was also conducted to investigate if the predicted satisfaction can lead to customer repurchase. He also explained that the discussed studies show only a tip of the ice burg of the challenge faced with digital transformation. Companies in deed have collected tons of data with their operations. Data driven analysis methods indeed can come up with some analysis results. The main issue is how to integrate the outcome with traditional marketing and customer service theories so that companies can incorporate the analysis into their business operations and enhance their decisions. His study only serves as a very tiny step toward the goal. Much more effort is needed to substantiate the tide of digital transformation.

The DEP Korea panelist Dr. Sangjae Seo (Korea Institute of Science and Technology Information, Korea) gave a talk on "Roles of Supercomputer in Overcoming COVID-19." In this talk, he introduced examples of use of supercomputers to

overcome COVID-19 and discussed the importance of supercomputers to prepare for future pandemics.

After that, they held a panel discussion. Many questions were asked. The panelists and attendees made an abundant discussion. The number of webinar attendees in the DEP session was 69. The session was evaluated by questionnaire. The responses showed that 100% of attendees evaluated this session "Very Useful" or "Useful."

8 APNOMS 2021 Awards

The APNOMS 2021 organizing committee selected the top four papers presented in the technical session for the "Best Paper Award." The Best Paper Award Committee was organized within the organizing committee with TPC co-chairs as core members. Before the symposium, 12 papers were nominated for the best paper consideration from six countries. The award committee evaluated the nominees' presentations and finally selected four papers with the highest overall (paper and presentation) scores. The selected papers were "Cognitive Collision Resolution for Enhanced Performance in C-V2X Sidelink Mode 4," by Moin Ali, Young-Tak Kim (Yeungnam University, Korea)19, "Incentive-Stable Matching Protocol for Service Chain Placement in Multi-Operator Edge System," by Jen-Yu Wang, Li-Hsing Yen, Juliana Liman (National Yang Ming Chiao Tung University, Taiwan)20, "Robotic Assistance Operation for Effective On-Site Network Maintenance Works," by Takayuki Warabino, Yusuke Suzuki, Tomohiro Otani (KDDI Research, Inc., Japan)21, and "Energy-Efficient VNF Deployment for Graph-Structured SFC Based on Graph Neural Network and Constrained Deep Reinforcement Learning," by Siyu Qi*, Shuopeng Li*, Shaofu Lin*, Mohand Yazid Saidi**, Ken Chen** (*Beijing University of Technology, China, **University of Paris 13, France)22.

Also, The Best Paper Award committee selected four "Student Best Paper Award" from the student's speaker in the technical session. This award was given to students who have made excellent presentations and papers from the technical session speakers. The awarded persons were Khizar Abbas (Jeju National University, Korea) for the paper entitled "Network Data Analytics Function for IBN-Based Network Slice Lifecycle Management23," Buck Chung (National Yang Ming Chiao Tung University, Taiwan) for the paper entitled "P4MT: Designing and Evaluating Multi-Tenant Services for P4 Switches24," Haruo Oishi (Waseda University, Japan) for the paper entitled "Evaluation of Resource Sharing Framework for Heterogeneous Network Services25," and Siyu Qi (Beijing University of Technology, China) for the paper entitled "Energy-Efficient VNF Deployment for Graph-Structured SFC Based on Graph Neural Network and Constrained Deep Reinforcement Learning22."

9 Concluding Remarks

APNOMS 2021 paid attention to several interesting and important topics, such as SDN and NFV management, Edge and Fog management, IoT and WSN management, 5G network management, and intelligent network operations and management.

APNOMS 2021 was a very successful symposium. It was well attended, and the feedback on all aspects of the symposium program was very positive. It contributed to the growth of APNOMS into a very important international symposium. The attendees feedback reinforced the positive aspects of the symposium: well-mixed participation from both industry and academia in technical contributions, the tradition of special sessions focusing on experiences and lessons learned by different countries in the Asia-Pacific region, excellent venue and social events, and the overall collaborative, interactive and friendly atmosphere of the symposium.

In APNOMS 2021, the technical and poster session papers were published in IEEE Xplore like previous APNOMS. Also, the proceedings and innovation session papers have been distributed to the participants from the symposium website. Most of the presentation files (keynotes, tutorials, special sessions, and DEP) are all available on the symposium website: http://www.apnoms.org/2021/. The APNOMS 2022 will be held on September 28–30, 2022, in Takamatsu, Japan. We expect that APNOMS 2022 will be even more successful. For more information, please visit http://www.apnoms.org/2022/.

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Declarations

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