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In this issue

Technology Developed in GICE

Design of filters and antennas at 300 GHz

from Electromagnetics Group

Introduction

As the 5th generation wireless systems become commercially available, researchers start to study higher frequency communications to further increase the data rate and the reliability in the future. The next frequency band higher than the current popular millimeter wave frequency band is the terahertz frequency band (THz), frequencies between 300 GHz and 3 THz. The top challenge for communications in the THz band is the low energy efficiency: the efficiency of the generation and amplification of THz waves is low and the absorption in air or circuit boards is strong. In addition, coverage becomes another issue due to light-like propagation of THz waves. To solve these problems, researchers are trying new designs and new materials for better energy efficiency and applying beamforming techniques under the massive multiple-input and multiple-output geometry to improve coverage. Currently, our group is developing terahertz passive components. We have designed transmission lines and antennas in printed circuit boards and filters for WR3 waveguides at a target frequency of 300 GHz. The THz components are much smaller than the microwave components so the fabrication processes require higher accuracy. We choose simple designs that can be fabricated and measured.

Transmission lines

We have designed four different transmission lines at 300 GHz, including substrate integrated waveguides (SIW), microstrip lines, coplanar waveguides (CPW) and coplanar waveguides with ground (CPWG). The substrate is 40-μm-thick BT-epoxy whose dielectric constant is 3.0 and loss tangent is 0.004 at 100 GHz. We can measure both the dielectric constant and loss tangent at 300 GHz by THz time-domain spectroscopy.

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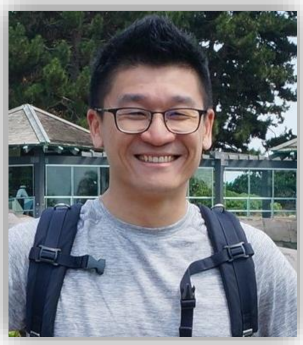
GICE Honors

Prof. Tzong-Lin Wu

IEEE EMC Society Board of Directors (2021-2023)



Prof. Shih-Yuan Chen

IEEE Antennas and Wireless Propagation Letter Outstanding Associate Editor

Message from the Director

Hsuan-Jung Su

Professor & GICE Director

While the other parts of the world are severely affected by COVID-19, we are grateful that we can still live and work normally in Taiwan. We have wonderful news to share in this issue. Prof. Tzong-Lin Wu has been re-elected to IEEE Electromagnetic Compatibility (EMC) Society Board of Directors for the 2021-2023 term. In this issue, we have asked Prof. Wu to share his vision as the first Editor-in-Chief of IEEE Transactions on EMC. Prof. Shih-Yuan Chen was named an Outstanding Associate Editor of IEEE Antennas and Wireless Propagation Letter. Way to go, Prof. Chen!

In this issue, we invite professors to share their research results on technologies for 5G and beyond. We first have Prof. Yu-Hsiang Cheng, one of our newest professors, introducing his research on filters and antennas at 300 GHz. Then, Prof. Wanjiun Liao shares her work on Intelligent Offloading for Multi-Access Edge Computing. To further touch on 5G technologies, we have an activity report on the "5G Trends and New Vision - Cyber Security x Field Demonstration x Chip Innovative Application Seminar" co-hosted by GICE Prof. Tsungnan Lin and Institute for Information Industry (III). Please sit back and enjoy this issue.

Technology *(Continued from page 1)*

One thing to notice is that the wavelength of 300 GHz waves is much shorter than the common radio wavelengths. The minimal spacing between vias, limited by the fabrication process, is not enough to confine the 300 GHz waves so we need more than one rows of vias. The simulation results are shown in Table 1. In SIW, the waves mainly propagate in the substrate so its insertion loss is higher than other transmission lines where portions of the waves propagate in the air. We can measure S-parameters of the CPWG at 300 GHz by a vector network analyzer with frequency extenders and a probe station. To measure other transmission lines, we designed TRL calibration kits with CPWG feeds and transition structures.

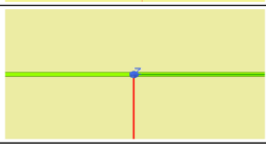
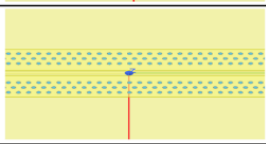
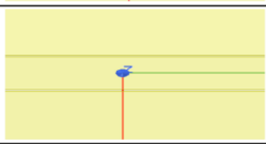
	Layout	S_{21} at 300 GHz
SIW (10mm)		-0.3928 dB/mm
Microstrip (10mm)		-0.2867 dB/mm
CPWG(10mm)		-0.2929 dB/mm
CPW (10mm)		-0.2175 dB/mm

Table 1. Comparison between different transmission lines

Antennas

We have designed patch antenna arrays at 300 GHz on 40-μm-thick BT-epoxy substrates. The structure and the simulation result are shown in Fig. 1. The patch antenna array is composed of a CPWG feed, a transition structure from CPWG to microstrip line, a power divider, and antenna elements. The CPWG structure is for measurements with a probe station. We choose the planar patch antenna as the antenna element because it is a simple design that can be fabricated on a printed circuit board or an integrated circuit chip. In the simulation, we compare the performances of one antenna, two antennas, and four antennas. The antenna elements are separated by one wavelength to increase gain. Our simulation result shows the -10dB bandwidth is wider than 10 GHz and the gain increases by 3 dB when the array size is doubled.

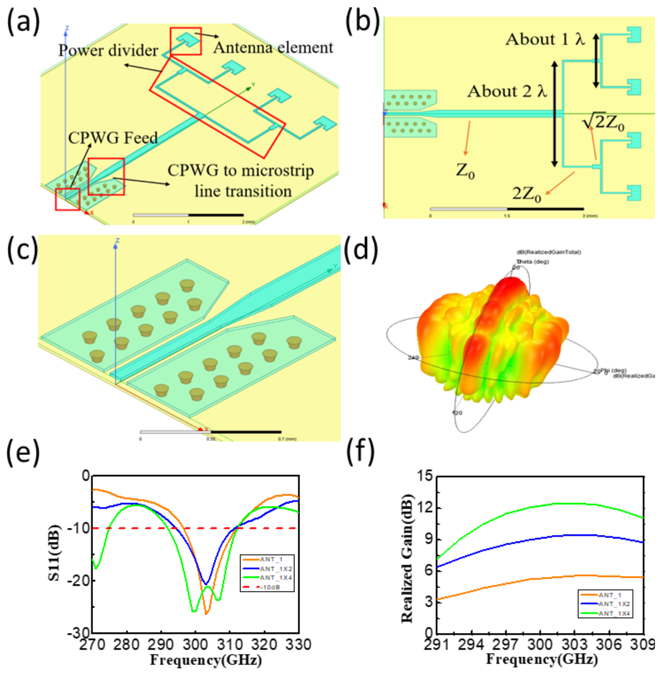


*Fig. 1. (a) Side view and
(b) Top view of 1× 4 antenna array structure.
(c) CPWG to microstrip line transition.
(d) Radiation pattern.
(e) Return loss. (f) Realized Gain*

Waveguide filters

We have designed a 4th-order Chebyshev filter at 300 GHz in a WR-3 rectangular waveguide with UG-387/U-M flanges. We set five irises to create four resonant cavities operating in TE101 mode. As shown in Fig. 2, our simulation results show that the fractional bandwidth is 20 %. In the passband, the insertion less is around -0.5 dB and the return loss is smaller than -15 dB. The waveguide filters can be fabricated by computer numerically controlled micromachining.

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Technology *(Continued from page 2)*

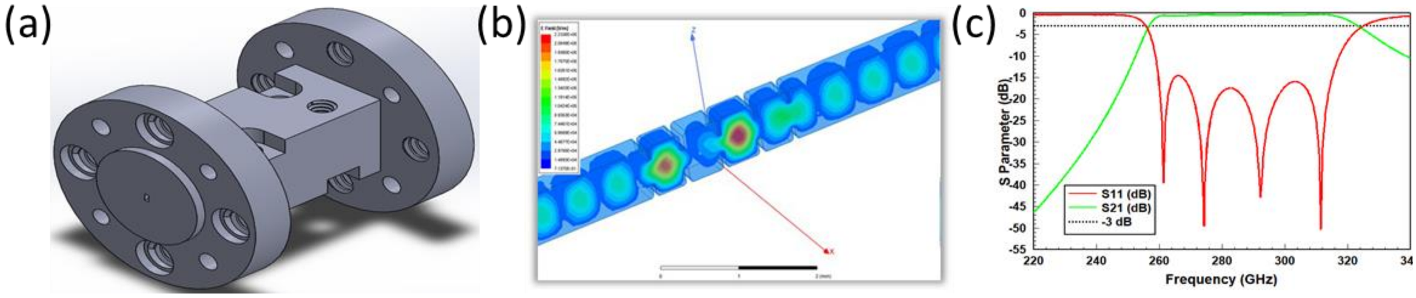

Fig. 2. (a) The waveguide filter design.
(b) The electric field pattern in the filter. (c) The S-parameters.

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Intelligent Offloading for Multi-Access Edge Computing in 5G and Beyond

from Data Science and Smart Networking Group

Introduction

The 5G network will accommodate computation intensive and delay-sensitive applications, such as virtual reality (VR), autonomous driving, and Tactile Internet. However, the computing capability and battery lifetime in UEs or various IoT devices may somehow be limited. Multi-access Edge Computing (MEC) in 5G was introduced to help the delivery of such applications with good quality of experience (QoE) for users. By deploying computing and storage resources at the mobile network edge (e.g., base station) in close proximity to UEs, delay-sensitive tasks from resource-constrained and battery-limited UEs could be offloaded to MEC servers via wireless channels to obtain more computing resources.

Compared with mobile cloud computing (MCC), MEC can significantly shorten the access delay between UEs and the computing server. Therefore, the low delay requirements of such applications could be more likely satisfied. On the other hand, the resource (including computing and storage) in MEC is much smaller than that in remote cloud. In multi-user MEC scenarios, the radio resource (e.g., bandwidth) and the MEC computing resource will be competed by a large number of UEs. Therefore, it requires a more efficient and effective allocation strategy to offload user tasks for resource sharing under various requirements of uploading tasks.

To tackle system uncertainties, many online algorithms based on deep reinforcement learning (DRL) have been proposed and targeted the long-term performance. We observe that existing DRL-based solutions are focused only on decision making for discrete actions. To handle continuous actions, such as resource allocation, the typically approach is 1) either to solve it in another problem, rather than through joint consideration in a DRL model, 2) or to discretize continuous actions to discrete actions with several granularities. As a result, the following problems may occur: either the curse of dimensionality due to fine-grained mode or the quantization noise due to coarse-grained mode. This motivates our work to jointly solve both discrete and continuous actions in one DRL model.

Discrete And Continuous (DAC) Actor-Critic DRL Model

We design a new DRL model called Discrete And Continuous (DAC) model to jointly determine the discrete action (offloading decision) and continuous actions (radio resource and computing resource allocation) for task offloading. Specifically, we combine the DDPG-based continuous control with a discrete Actor-Critic model in a multi-user MEC system. We consider the long-term performance of delay and energy consumption given that the user delay constraint is satisfied. The actor of the new model generates an output probability for the discrete action on offloading decision ($\hat{p}$) and a deterministic value for each of the two continuous actions on resource allocation ($\hat{w}$ and $\hat{f}$). Both kinds of actions are fed into a common critic. We further design a weighted loss function for both discrete and continuous

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Technology *(Continued from page 3)*

actions. For the discrete offloading decision action, we formulate the Actor-Critic cross-entropy loss as its actor's loss function. For the continuous radio resource allocation and computing resource allocation, we compute the gradients of Q-value from the critic to update the actor's parameters. Based on the new weighted loss function, the parameters of the actor network are trained iteratively with different learning rates. Figure 1 shows the three-phase training algorithm for the DAC model.

Simulation Results

We evaluate the performance of the proposed DRL model with different settings and compare the DAC model with four other schemes, including local computing, greedy, random, DDPG, and DQN. Figure 2 shows the convergence property of DAC as compared with DDPG. Figure 3 further shows the delay and energy consumption performance of DAC, respectively, as compared with DDPG, DQN, and greedy. The results demonstrate that DAC has better performance in terms of convergence speed, delay, and energy efficiency.

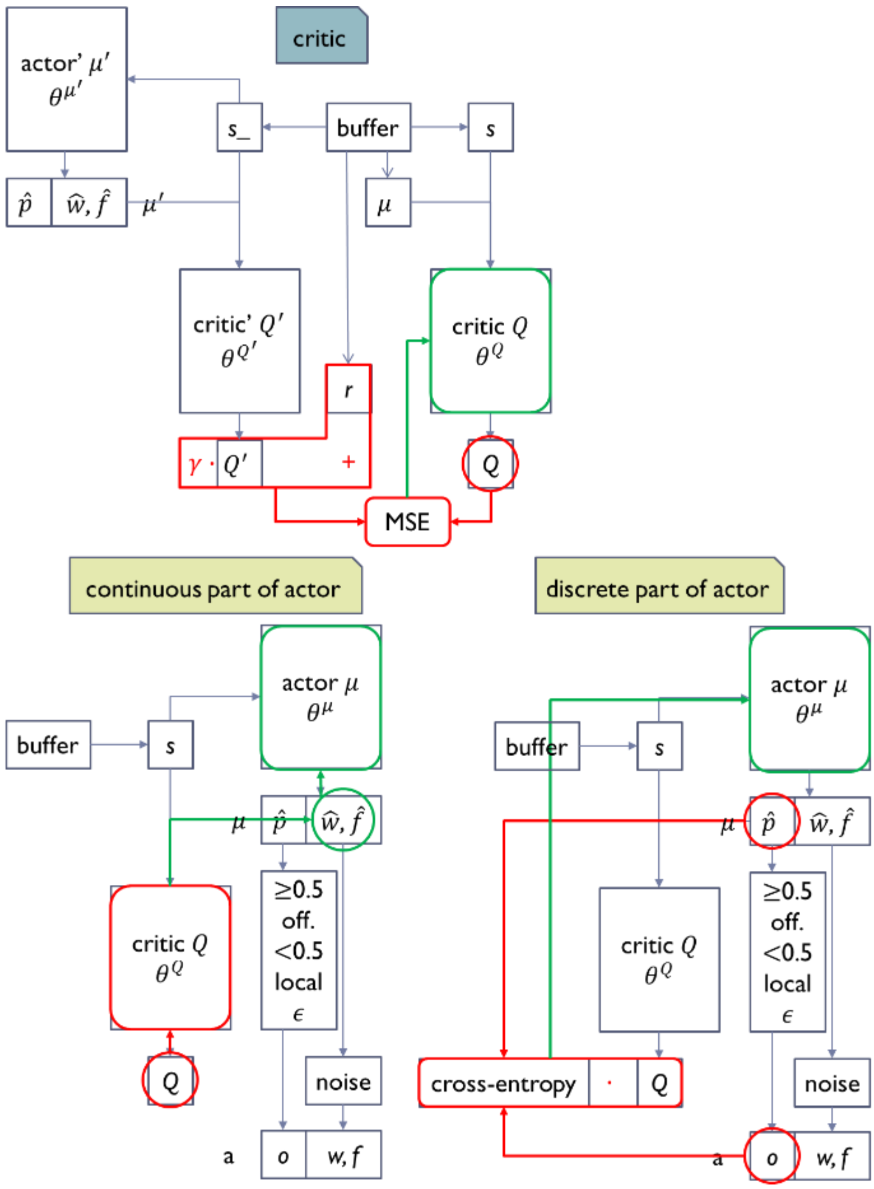

Figure 1: The three training phases, including 1) critic, 2) continuous-part actor, and 3) discrete-part actor. where off., MSE, and s_ is the abbreviation of offloading, mean-squared-error, and next state. Here, the loss function and the backpropagation are colored with red and green, respectively.

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Technology

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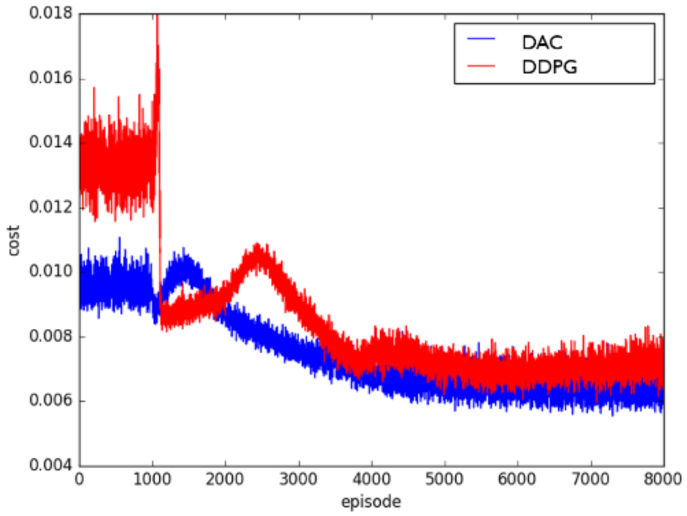
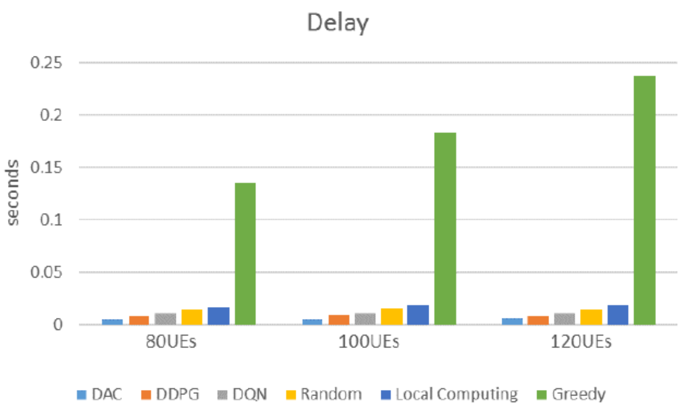
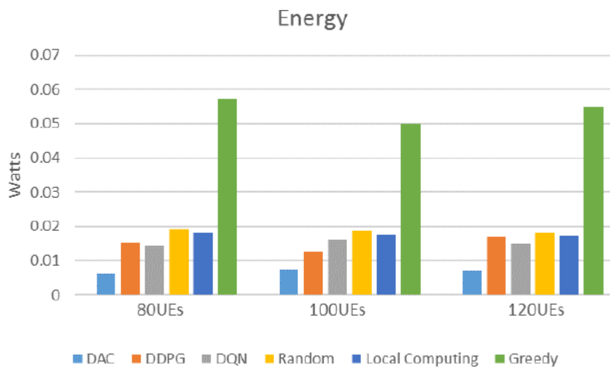


Figure 2: Convergence speeds of DAC and DDPG



(a) Delay



(b) Energy consumption

Figure 3: Delay and Energy Consumption Performance

Conclusion

In this work, we design a new Actor-Critic Deep Reinforcement Learning solution to train the network structure of the actors for computational offloading. The beauty of this model is that we combine the discrete action for offloading decision making and the continuous actions for both radio and MEC computing resource allocation in one model, instead of doing them in two separate models (i.e., discrete and continuous actions) as in existing DRL-based solutions. The simulation results show that the DAC algorithm indeed outperforms existing works based on DDPG, DQN, and others in terms of convergence speed, delay and energy consumption, even when the number of UEs is large.

The paper was published at IEEE ICC 2020 as follows: Kai-Hsiang Liu and Wanjiun Liao, "Intelligent Offloading for Multi-Access Edge Computing: A New Actor-Critic Approach," IEEE ICC 2020, Dublin, Irland, June 20202.

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Activity

First Asian Editor-in-Chief of IEEE Transactions on Electromagnetic Compatibility (T-EMC)：Prof. Tzong-Lin Wu

Prof. Tzong-Lin Wu was appointed as the Editor-in-Chief of IEEE Transactions on Electromagnetic Compatibility (T-EMC) since 2018 by the approval of the Board of Directors and Editorial Advisory Board of EMC Society. T-EMC is the flagship publication of EMC society with long term history since 1958. Prof. Wu is the first Asia scholar be nominated as the T-EMC Editor-in-Chief in the past years. T-EMC has become the most prestigious and professional journal to publish the state-of-the-art research in the field of EMC. It could not be achieved without the dedicated and excellent effort from past EiCs, Prof. M. d'Amore, Prof. F. Canavero, Dr. P. Wilson, Prof. H. Garbe, Prof. F. Rachidi, Prof. A. Orlandi. The paper submission number, paper quality, reviewing

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Activity

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efficiency are all steadily increased. Besides the leadership of past EiCs, the hardwork and collaboration of all Associate Editors, reviewers, and authors keep the T-EMC in high standard and reputation.

IEEE T-EMC publishes original and significant contributions related to all disciplines of EMC and relevant methods to predict, assess and prevent electromagnetic interference (EMI) and increase device/product immunity. The scope of the publication includes, but is not limited to Electromagnetic Environments; Interference Control; EMC and EMI Modeling; High Power Electromagnetics; EMC Standards, Methods of EMC Measurements; Computational Electromagnetics and Signal and Power Integrity, as applied or directly related to Electromagnetic Compatibility problems; Transmission Lines; Electrostatic Discharge and Lightning Effects; EMC in Wireless and Optical Technologies; EMC in Printed Circuit Board and System Design.

In Prof. Wu's term, he would like to continue pursuing **QATS** for T-EMC, which means **Q**uality, State of the **A**rt, **T**imeliness, and **S**cope. High quality of the paper - both in content and reviewing process - is the key to keep leading and influential for the journal in the community. The paper submission number has significantly increased in past few years. Prof. Wu will try his best to work closely with AE team to maintain the quality of T-EMC as high as past years. The baseline for each accepted papers would satisfy following two conditions: the research outcome is state-of-the-art and the discussed topic is within the scope of EMC. Both criteria are indispensable factors for the published papers in T-EMC. By making comparison with sufficient number of relevant papers that are among the latest published papers, authors are encouraged to give a complete discussion in introduction session: how EMC related and what novelties the work are. It is fair and essential to give credits to prior literature. Finally, as highlighted by past few EiCs, timely review and publication of the paper is a critical factor to attract good paper submission and to improve the journal metrics like impact factor. It has been and will be continuously maintained.

Tzong-Lin Wu received the B.S.E.E. and Ph.D. degrees from National Taiwan University (NTU), in 1991 and 1995, respectively. From 1995 to 1996, Tzong-Lin was a Senior Engineer at Micro-electronics Technology Inc., in Hsinchu, Taiwan. In 1996, after receiving his Ph.D. degree, he joined the Central Research Institute of the Tatung Company, Taipei, Taiwan, where he was involved in the analysis and measurement of electromagnetic compatibility/electromagnetic interference (EMC/EMI) problems of high-speed digital systems. In 1998, he decided in favor of an academic career and accepted a position at the Electrical Engineering Department, National Sun Yat-Sen University. Since 2006, he has been a Professor in the Department of Electrical Engineering and Graduate Institute of Communication Engineering (GICE), NTU. In summer 2008, he was a Visiting Professor with the Electrical Engineering Department, University of California at Los Angeles (UCLA). His research interests include EMC/EMI and signal/power integrity design for high-speed digital/optical systems. Tzong-Lin was the Director of the GICE in NTU from 2012 to 2018.

Tzong-Lin received the Excellent Research Award and the Excellent Advisor Award from National Sun Yat-Sen University in 2000 and 2003, respectively, the Outstanding Young Engineers Award from the Chinese Institute of Electrical Engineers in 2002, and the Wu Ta-You Memorial Award from the National Science Council (NSC) in 2005, Outstanding Research Award from NSC in 2011, 2014, and 2017, the IEEE Transactions on Advanced Packaging Best Paper Award in 2011, Outstanding Research Innovation Award from NTU in 2013, Outstanding Technology Transfer Contribution Award from NSC in 2013, 2014 Outstanding Teaching Award in NTU (top 1%), and 2015 IEEE EMC Society Motohisa Kanda Award for a IEEE T-EMC paper with highest citation for those published papers in past 5 years. He has served as the Chair of the Institute of Electronics, Information and Communication Engineers (IEICE) Taipei Section in 2007-2011, the Treasurer of the IEEE Taipei Section in 2007-2008. He is the member of Board of Directors (BoD) of IEEE EMC Society in 2016-2020. He served the IEEE EMC Society as a Distinguished Lecturer for the period 2008–2009. He was Co-Chair of the 2007 IEEE Electrical Design of Advanced Packaging and Systems (EDAPS) workshop, General Chair of the 2015 Asia Pacific EMC Symposium (APEMC), and Technical Program Chair of the 2010 and 2012 IEEE EDAPS Symposiums. He was the Associate Editor of IEEE Transactions on EMC (2015-2018) and IEEE Transactions on CPMT (2016-2018). He is now the Editor-in-Chief of IEEE Transactions on EMC and International Journal of Electrical Engineering (IJEE). Dr. Wu is IEEE Fellow.

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Activity

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As the EiC of T-EMC and member of BoD of IEEE EMC Society, Prof. Tzong-Lin Wu attend the EMCS BoD meeting at Piscataway, New Jersey, USA

5G Trends and New Vision – Advanced deployment of information security & Organizing a national 5G information security team

With the rise of 5G, the implementations of AI and the Internet of Things (IoT) applications have also accelerated. In the meantime, the "Cyber Security" issues are growing rapidly and affecting people's lives. The key to increasing the protection ability of information systems, 5G, industrial control systems, key infrastructures, endpoint devices, network connections, and cloud applications is to find a correct and appropriate cybersecurity protection plan and deployment method. President Tsai ing-wen said that cybersecurity is a significant strategic industry which is related to national security and industrial economic development, that is, "Cyber Security is National Security."

To conduct in-depth research on cybersecurity issues, NTUGICE and III co-hosted the "5G Trends and New Vision - Cyber Security x Field Demonstration x Chip Innovative Application Seminar". In this conference, we invited experts from three domains, including the information industry, academia, and education to discuss in depth the core technologies and new trends of 5G in cybersecurity development and applications. Through this event, we successfully understand the innovative application scenarios, the experience of cross-field integration, and find the correct and appropriate cybersecurity protection plan and deployment approach for organizing the 5G cybersecurity national team.

The list of speakers is as follows:

1. Yeali S. Sun, commissioner of the National Communications Commission (NCC)
2. Rong-Shy Lin, executive deputy general manager of Chunghwa Telecom (中華電信)
3. Qingxiang Xu, chairman of Liwang Electronics (力旺電子)
4. Dongyou Wu, director of Aegis (神盾)
5. Tsungnan Lin, professor of the department of electrical engineering, National Taiwan University (台大電機)
6. Wenlong Liang, Chairman of Jorjin Technologies (佐臻)

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Activity

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7. Wude Lin, Taiwan business area manager of Advantech (研華)
8. Peixuan Wu, project assistant of Liwang Electronics (力旺電子)
9. Jiandong Wu, chairman of Jrsys (捷而思)
10. Binxian Liang, chairman of Flowring Technology (華苓科技)

The eye-catching themes are Dr. Yeali S. Sun's "5G development trend under the information security challenges and management policy" (Fig. 1) and Dr. Rongci Lin's "5G vertical application scenarios and information security protection strategies" (Fig. 2). Dr. Yeali S. Sun said what NCC can do is ensure that 5G network operators are safe and reliable during construction. In addition to what they can do in terms of policies, they also hope to share our practice and experience with the world and learn from each other. 5G is safe, and the government will definitely ensure that 5G networks are safe, reliable, and resilient. Dr. Rongci Lin said that in the future for information security management, in addition to the maintenance of equipment and basic functions, the upper-layer applications must also be sufficiently secure. In the case of MEC, the purpose is to achieve enterprise private networks. Chunghwa Telecom will also provide management software to assist when providing MEC. The management of the user's network authority meets the demands of customers. In addition, MEC may be placed on the client's side. The physical security to the security of the upper-layer application must be done well when providing services. In addition to white-hat hacker security testing, it must also comply with NIST verification.

Finally, industry experts from III shared the cross-domain 5G information security protection system in the 5G private network, combined with the demonstration of Netcom products on the local private network protection trial, and the international security specifications of the 5G vertical application private network. We especially display real machines on-site, from smart manufacturing, industrial control to the Internet of Things. Gradually show the achievements of Taiwan's information security protection application, and allow seeing more aspects of information security.

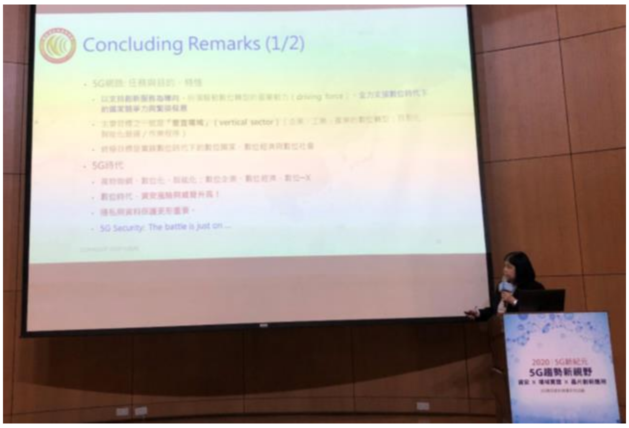

Fig. 1: Dr. Yeali S. Sun's gives a conclusion for the 5G network and security issues.

Fig. 2: Dr. Rong-Shy Lin introduces the ecosystem, innovation side and technical side of 5G network.

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