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Table of Contents

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182 Dr. Jin Xu (Beijing University of Posts and Telecommunications, China)
183 Dr. Juan Bai (Air Force Engineering University, China)
184 Dr. Jukka Lempiainen (Tampere University of Technology, Finland)
185 Dr. Kapila W S Palitharathna (University of Cyprus, Cyprus)
186 Dr. Kenji Leibnitz (NICT, Japan)

187 Dr. Khoirul Anwar (Telkom University, Indonesia)
188 Dr. Koji Yamamoto (Kyoto Institute of Technology, Japan)
189 Dr. Kunnthphong Srisathit (Rajamangala University of Technology Rattanakosin, Thailand)
190 Dr. Leanna Vidya Yovita (Telkom University, Indonesia)
191 Dr. Linda Meylani (Telkom University, Indonesia)
192 Dr. Long Chen (Guangdong University of Technology (GDUT), China)
193 Dr. Luca Reggiani (Politecnico di Milano, Italy)
194 Dr. M. Fahim Ferdous Khan (The University of Tokyo, Japan)
195 Dr. Mahmud Dwi Sulistiyo (Telkom University, Indonesia)
196 Dr. Masami Yoshida (Ritsumeikan University, Japan)
197 Dr. Mauro De Sanctis (University of Rome "Tor Vergata", Italy)
198 Dr. Michael McGuire (University of Victoria, Canada)
199 Dr. Miguel López-Benítez (University of Liverpool, United Kingdom (Great Britain))
200 Dr. Min Xu (Lenovo, China)
201 Dr. Ming Xia (Google, USA)
202 Dr. Mohammad Abdulrahman Al-Mashhadani (Al-Maarif University College, Iraq)
203 Dr. Mohammad Khaja Shaik (St. Ann's College of Engineering and Technology Chirala AP India, India)
204 Dr. Mohammad Khalili (University of Oulu, Finland)
205 Dr. Mohd Riduan Ahmad (Universiti Teknikal Malaysia Melaka, Malaysia)
206 Dr. Muhammad Reza Kahar Aziz (Institut Teknologi Sumatera, Indonesia)
207 Dr. N Nasimuddin (Institute for Infocomm Research, Singapore)
208 Dr. Naveen Aggarwal (Panjab University, India)
209 Dr. Nico Saputro (Florida International University, USA)
210 Dr. Oluwakayode Onireti (University of Glasgow, United Kingdom (Great Britain))
211 Dr. Omar Ibrahim Al saif (Northern Technical University, Iraq)
212 Dr. Osamu Mizuno (Kogakuin University, Japan)
213 Dr. Osamu Muta (Kyushu University, Japan)
214 Dr. Paschalis C. Sofotasios (Khalifa University, United Arab Emirates)
215 Dr. Pavel Loskot (ZJU-UIUC Institute, China)
216 Dr. Peng Pan (Hangzhou Dianzi University, China)
217 Dr. Peng-Yong Kong (Khalifa University, United Arab Emirates)
218 Dr. Ping Zhou (Apple, USA)
219 Dr. Pitz Gerald G. Lagrazon (Southern Luzon State University, Philippines)

220 Dr. Pradini Puspitaningayu (Universitas Negeri Surabaya, Indonesia)
221 Dr. Priyatosh Mandal (Centre for Development of Telematics, New Delhi, India)
222 Dr. Qutaiba Ibrahim Ali (University of Mosul, Iraq)
223 Dr. Ridwan Pandiya (Institut Teknologi Telkom Purwokerto, Indonesia)
224 Dr. Rodrigo Campos Bortoletto (Instituto Federal de São Paulo, Brazil)
225 Dr. Roopa Manjunatha (Energy Institute Bengaluru, India)
226 Dr. Rostyslav Sklyar (Independent Professional, Ukraine)
227 Dr. Saifullah Khalid (Civil Aviation Research Organisation, India)
228 Dr. Sandeep Singh Sengar (Cardiff Metropolitan University, United Kingdom, United Kingdom (Great Britain))
229 Dr. Sandhya Sandeep Save (TCET University of Mumbai, India)
230 Dr. Sanjay Singh (Manipal Institute of Technology, India)
231 Dr. Seung-Que Lee (ETRI, Korea (South))
232 Dr. Shashikant S. Patil (Atlas SkillTech University Kurla West, India)
233 Dr. Sirikan Chucherd (Mae Fah Luang University, Thailand)
234 Dr. Suppakarn Chansareewittaya (Mae Fah Luang University, Thailand)
235 Dr. Surapong Uttama (Mae Fah Luang University, Thailand)
236 Dr. Susumu Ishihara (Shizuoka University, Japan)
237 Dr. Tariq Umer (COMSATS University Islamabad Lahore Campus, Pakistan)
238 Dr. Tenia Wahyuningrum (Institut Teknologi Telkom Purwokerto, Indonesia)
239 Dr. Titiek Suryani (Institut Teknologi Sepuluh Nopember, Indonesia)
240 Dr. Tran Hoa (Kumoh National Institute of Technology, Korea (South))
241 Dr. Vanita Pawar (DIAT, Pune, India)
242 Dr. Vasilis Friderikos (King's College London, United Kingdom (Great Britain))
243 Dr. Ved P. Kafle (National Institute of Information and Communications Technology, Japan)
244 Dr. Wael A. Salah (Palestine Technical University - Kadoorie, Palestine)
245 Dr. Wahyu Pamungkas (Telkom University, Indonesia)
246 Dr. Watcharapan Suwansantisuk (King Mongkut's University of Technology Thonburi, Thailand)
247 Dr. Wei Feng (Tsinghua University, China)
248 Dr. Wei Feng (Tsinghua University, China)
249 Dr. Weihan Goh (Singapore Institute of Technology, Singapore)
250 Dr. Wenjun Xu (Beijing University of Posts and Telecommunications, China)
251 Dr. Willy Anugrah Cahyadi (Telkom University, Indonesia)
252 Dr. Wirawan (Institut Teknologi Sepuluh Nopember, Indonesia)

253 Dr. Wiseto Agung (ARS University, Indonesia)
254 Dr. Withawat Withayachumnankul (The University of Adelaide, Australia)
255 Dr. Xiang Gui (Massey University, New Zealand)
256 Dr. Xinchen Lyu (Beijing University of Posts and Telecommunications, China)
257 Dr. Xuefei Zhang (Beijing University of Posts and Telecommunications, China)
258 Dr. Yanzhao Hou (Beijing University of Posts and Telecommunications, China)
259 Dr. Yosuke Tanigawa (Osaka Metropolitan University, Japan)
260 Dr. Youjia Chen (Fuzhou University, China)
261 Dr. Yudha Purwanto (Telkom University, Indonesia)
262 Dr. Yue Yin (Keio University, Japan)
263 Dr. Zeeshan Kaleem (COMSATS University Islamabad, Wah Campus, Pakistan)
264 Dr. Zhi Liu (The University of Electro-Communications, Japan)
265 Dr. Zhongyang Yu (Henan University of Engineering, China)

Welcome Message from the General Chair

Dear Ladies and Gentlemen,

It is our great pleasure and honor to welcome you to the 29th Asia-Pacific Conference on Communications (APCC 2024) and welcome you to the beautiful island of Bali, one of over seventeen thousand islands in the Republic of Indonesia. At this event, we will have the opportunity to exchange knowledge and information on the latest research and foster connections and relationships among us while enjoying the relaxing yet entertaining environment of Bali.

Since 1993, APCC has been acknowledged as a technical forum for researchers and engineers to interact and disseminate information on the latest developments in advanced communication and information technologies, particularly in the Asia-Pacific region. In this 29th APCC, the event is organized by IEEE Communication Society Indonesia Chapter. APCC 2024 is made possible through the technical co-sponsorship of the KICS, IEICE-CS and CIC. In addition, my appreciation goes to the steering committee, the technical program committee, reviewers, authors, and especially for the wonderful organizing team, who have contributed their time and energy with smart work and strong support to make this event successful.

Many advanced technologies in the communication field are now embedding intelligence across various segments and subsystems of communication systems. Novel methodologies and approaches are introduced to achieve a higher level of communication quality. Nevertheless, human life is still a very important aspect to consider in each technological development, including communication technology. Today, we have witnessed the rise of broad, intelligent digital technologies on devices, sensors, networks, controls, and, not to mention, millions of applications. These Emerging intelligent technologies span computing, broadcasting and media, content, advertising, social media, platforms, applications, and Services. Aligned with the theme "Sustainable Connectivity: Advancing Green Technologies for a Smarter Future," APCC 2024 will provide an opportunity for us to discuss this issue. Nonetheless, many challenges still need to be addressed, including issues related to technology, infrastructure, traffic, spectrum, privacy/security, energy efficiency, eco-friendly development, lifestyle changes, and others.

Advanced technologies in the communication field are increasingly incorporating intelligence across various segments and subsystems, enhancing efficiency and connectivity. New methodologies and approaches are being introduced to improve communication quality while considering the impact on human life and the environment in every technological advancement. Today, we see a rapid rise in smart digital technologies across devices, sensors, networks, controls, and countless applications. These emerging technologies span areas such as computing, media, content, advertising, social media, platforms, applications, and services, all aiming for a sustainable, connected future. In line with the theme "Sustainable Connectivity with Green Technologies for a Smarter Tomorrow", the APCC 2024 offers a platform for us to explore these issues. However, many challenges remain, including addressing technology infrastructure, traffic, spectrum, privacy/security, energy efficiency, eco-friendly development, lifestyle changes, and many more.

I wish you all delegates and attendees have a productive and fruitful event during your participation at APCC'24.

Welcome to Bali and enjoy the food, beaches, arts, and tropical beauties; I hope the conference and its surroundings will be memorable.

Best regards,
General Chair

Assoc. Prof. Dr. Muhammad Ary Murti (Telkom University, Indonesia)
Arief Hamdani (PT. Telkom Indonesia)

Welcome Message from the TPC Chair

Dear Ladies and Gentlemen,

It is a great honor for all of us to host the APCC 2024 at Bali, where the high qualified papers in Communications Technology will be presented. The conference received 203 papers from 715 authors and through high qualification of reviewing process and tight registration process APCC 2024 will publish 105 high qualified papers from 245 countries, with acceptance ratio 58.6%.

This represents a great achievement in the mid of global economic turbulence, yet this event remains a self-proof to be strong magnetism to which the best contributors coming from excellent laboratories and schools throughout the world, precipitate to come and contribute their finest works. Not only the high qualified papers, the conference is supported by 5 distinguished experts in keynote sessions and 2 experts in panel discussion session.

This conference shall become the landmark for Communications Society to express their thoughts and skills in finding best solution for the future of communications. We also express special appreciation to 161 technical program committee members and 265 active reviewers that enable us to present high qualified conference in communications technology.

We hope all participants will have valuable and also enjoyable experience during this event.

Best regards,
TPC Chair

Prof. Gamantyo Hendrantoro (IEEE Indonesia Section)
Prof. Sungrae Cho (KICS, Chung-Ang University, Korea (South))
Dr. Toru Takahashi (IEICE-CS)
Prof. Xiaofeng Tao (CIC)

Welcome Message from the ASC Chair

Welcome to APCC 2024!

The Asia-Pacific Conference on Communications (APCC) has served as a vital platform for collaboration and innovation in communications and information technology for nearly three decades. We are delighted to host this prestigious international forum in Indonesia for the fourth time, continuing our tradition of fostering groundbreaking research and connecting minds across the globe.

With our 2024 theme, "Sustainable Connectivity with Green Technologies for a Smarter Tomorrow" APCC reflects our collective commitment to advancing telecommunications in a way that prioritizes environmental responsibility. As the world increasingly embraces green technologies and sustainable practices, we in the communications field play a pivotal role in developing smarter, more energy-efficient solutions that ensure connectivity while protecting our planet for future generations.

As we celebrate the 29th APCC, we are thrilled to convene on the vibrant island of Bali, Indonesia. Known for its breathtaking natural landscapes, rich cultural heritage, and welcoming spirit, Bali provides a fitting backdrop for this year's conference, symbolizing the harmony between technology, sustainability, and community. From serene beaches to the lush rice terraces and vibrant arts scene, this island invites us to envision a future where connectivity coexists with sustainability.

I express my deepest gratitude to the dedicated individuals who have made APCC 2024 possible. My sincere appreciation goes to the organizing team, the steering committee, the general chairs, technical program chairs, authors, reviewers, and everyone who has contributed their time and energy to this event.

I eagerly anticipate welcoming each of you all to the conference venue in Bali from November 5 to 7, 2024. Let’s come together, share our knowledge, explore innovative solutions, and contribute to a smarter, more sustainable tomorrow. May APCC 2024 inspire new ideas, lasting collaborations, and unforgettable memories on this beautiful island. I look forward to seeing you all and continuing to build on the legacy of this remarkable conference.

Warm regards,

Prof. Chung G. Kang
(Korea University, Seoul, Korea)

Program at a Glance

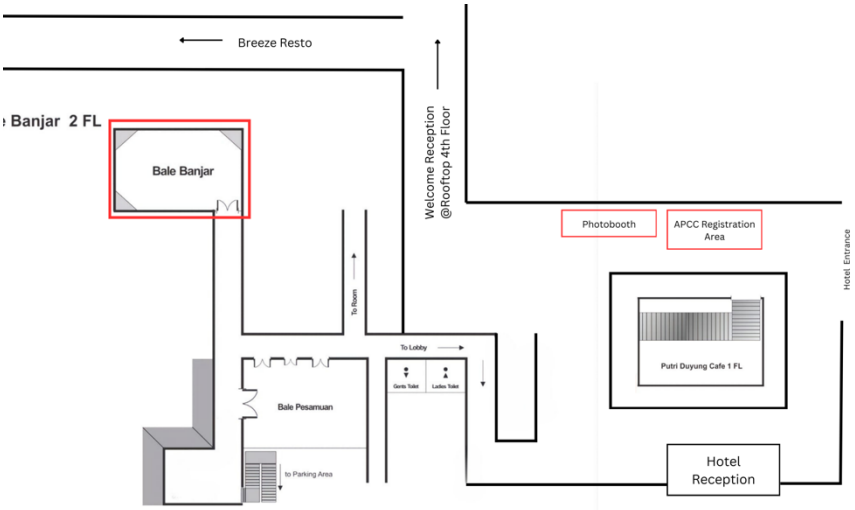
Time (UTC+8)	R1: Bale Banjar	R2: Bale Paseban 2	R3: Bale Paseban 3	R4: Bale Paseban 4
Pre-Conference Day: Monday, November 4th 2024				
15.00 - 17.00 (120 Minutes)	**Registration**			
17.00 - 18.30 (90 Minutes)	**Welcome Reception**			
Day 1: Tuesday, November 5th 2024				
07:30 - 08:00 (30 Minutes)	**Registration**			
08:00 - 08:30 (30 Minutes)	**Opening Ceremony (R1: Bale Banjar)** - Opening Remarks from APCC 2024 General Chairs - Opening Remarks from KICS - Opening Remarks from IEICE Communications Society - Opening Remarks from CIC			
08:30 - 09:30 (60 Minutes)	**Keynote speaker #1 (R1: Bale Banjar)** **Prof. Dr. Shoji Kasahara** Topic: Performance Modeling of Blockchain Technologies: How Does the Consensus Mechanism Affect Transaction Confirmation and Security in Blockchain Networks Keynote Session Chair: **Dr. Dong-Hyun Jung**			
09:30 - 09:50 (20 Minutes)	**Coffee break**			
09:50 - 10:50 (60 Minutes)	**Keynote speaker #2 (R1: Bale Banjar)** **Satoshi Nagata** (Senior Manager, 6G Network Innovation Department, NTT DOCOMO, INC.) Topic: Evolution of Mobile Communication Technology for 5G Evolution and Toward 6G Keynote Session Chair: **Dr. Dong-Hyun Jung**			
10:50 - 11:50 (60 Minutes)	**Keynote speaker #3 (R1: Bale Banjar)** **Prof. Dr. Yang Yang** (Professor, HKUST (Guangzhou), China) Topic: Collaborative Edge Computing for Large AI Models on Wireless Networks Keynote Session Chair: **Dr. Dong-Hyun Jung**			
11:50 - 13:00 (70 Minutes)	**Lunch break**			
13:00 - 15:00 (120 Minutes)	**R1: Parallel Session 1** Session Chair: Prof. Duk Kyung Kim	**R2: Parallel Session 1** Session Chair: Prof. Dr. Raqibul Mostafa	**R3: Parallel Session 1** Session Chair: Dr. Manolo D. Hina	**R4: Parallel Session 1** Session Chair: Dr. Estananto
15:00 - 15:30 (30 Minutes)	**Coffee break**			
15.30 - 17.10 (100 Minutes)	**R1: Parallel Session 2** Session Chair: Dr. Debasis Das	**R2: Parallel Session 2** Session Chair: Prof. Dr. Yafei Hou	**R3: Parallel Session 2** Session Chair: Prof. Dr. Noor Zaman Jhanjhi	**R4: Parallel Session 2** Session Chair: Dr. Zhongyang Yu
19:00 - 21:00 (120 Minutes)	**Local committee & VIP networking meeting**			

Day 2: Wednesday, November 6th 2024				
08:00 - 08:30 (30 Minutes)	**Registration**			
08:30 - 09:30 (60 Minutes)	**Keynote speaker #4 (R1: Bale Banjar)** **Prof. Dr. Nasimuddin** (Institute for Infocomm Research, A-STAR, Singapore) Topic: Innovations in Reconfigurable Antennas: A Comprehensive Overview and Applications Keynote Session Chair: **Dr. Pradini Puspitaningayu**			
09:30 - 10:30 (60 Minutes)	**Keynote speaker #5 (R1: Bale Banjar)** **Prof. Dr. Claes Beckman** (Senior Researcher, KTH Royal Institute of Technology, Stockholm and Icomera AB, Göteborg Sweden) Topic: The successes and failures of 5G to meet its original objectives and what we can hope for with 6G Keynote Session Chair: **Dr. Pradini Puspitaningayu**			
10:30 - 11.00 (30 Minutes)	**Coffee break**			
11:00 - 12:40 (100 Minutes)	**R1: Parallel Session 3** Session Chair: Dr. Madhusudhan Mishra	**R2: Parallel Session 3** Session Chair: Dr. Pei Liu	**R3: Parallel Session 3** Session Chair: Dr. Roopa Manjunatha	**R4: Parallel Session 3** Session Chair: Dr. Hirofumi Suganuma
12:40 - 13:30 (60 Minutes)	**Lunch break**			
13:30 - 15:10 (100 Minutes)	**R1: Parallel Session 4** Session Chair: Dr. Sudhakara Rao Yepuri	**R2: Parallel Session 4** Session Chair: Prof. Bambang Soelistijanto	**R3: Parallel Session 4** Session Chair: Prof. Sayan Kumar Ray	**ASC Meeting**
15:10 - 15:30 (20 Minutes)	**Coffee break**			
15:30 - 17:10 (100 Minutes)		**R2: Parallel Session 5** Session Chair: Dr. Suchi Kumari	**R3: Parallel Session 5** Session Chair: Dr. Yasunori Suzuki	**ASC Meeting**
18:30 - 21:00 (120 Minutes)	**Gala Dinner (R1: Bale Banjar)**			
Day 3: Thursday, November 7th 2024				
08:30 - 09:50 (100 Minutes)	**R1: Parallel Session 6** Session Chair: Prof. Safiqul Islam	**R2: Parallel Session 6** Session Chair: Dr. Pradini Puspitaningayu	**R3: Parallel Session 6 (Special Session)** Session Chair: Dr. Eng. Faisal Budiman	**R4: Parallel Session 6 (Special Session)** Session Chair: Dr. Estananto
09:50 - 10:10 (20 Minutes)	**Coffee break**			
10:10 - 11:10 (60 Minutes)	**Panel Discussion (R1: Bale Banjar):** Moderator: **Dr. Pradini Puspitaningayu** Prof. Dong Seog Han (Korean Institute of Communication Sciences, Korea) Prof. Dr. Takaya Yamazato (Institute of Liberal Arts and Sciences, Nagoya University, Japan) Mr. Bernardus Satriyo Dharmanto (Chief Technical Officer TVRI, Indonesia)			
11:10 - 11:30 (20 Minutes)	**Closing Ceremony**			
11:30 - 12:30 (60 Minutes)	**Lunch**			

Session Room Location

2nd Floor

- Registration Area (Near Lobby)
- R1: Bale Banjar
- Coffee Break Area 1
- Lunch: Breeze Resto



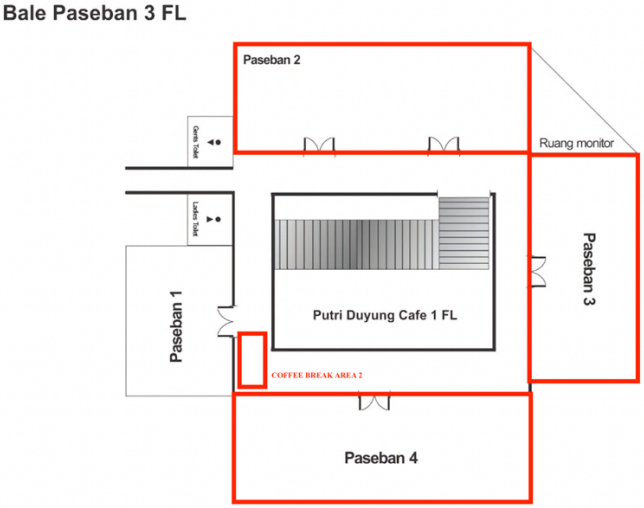
a. Truntum Hotel 2nd Floor Map

b. Registration Area (Near Lobby)

c. Lunch Location: Breeze Resto

3rd Floor

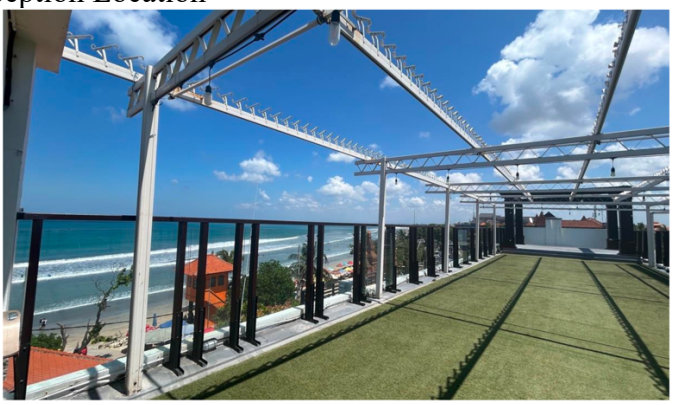
- R2: Bale Paseban 2
- R3: Bale Paseban 3
- R4: Bale Paseban 4
- Coffee Break Area 2



d. Truntum Hotel 3rd Floor Map

4th Floor (Rooftop)

- Welcome Reception Location



Keynote Session

Prof. Dr. Shoji Kasahara
Professor of Division of Information Science,
Nara Institute of Science and Technology

Short Bio:

Shoji Kasahara received the B. Eng., M. Eng., and Dr. Eng. degrees from Kyoto University, Kyoto, Japan, in 1989, 1991, and 1996, respectively. Currently, he is a Professor of Division of Information Science, Nara Institute of Science and Technology. His research interests include stochastic modeling and analytics of large-scale complex systems based on computer/communication networks. He was the Editor-in-Chief of IEICE Transactions on Communications during 2016-2018, the Director of Journal and Transactions, IEICE, during 2020–2022, and the President of Communications Society, IEICE, during 2023-2024. He is a fellow of IEICE and ORSJ, and a senior member of IEEE.

Topic:

Performance Modeling of Blockchain Technologies: How Does the Consensus Mechanism Affect Transaction Confirmation and Security in Blockchain Networks

In the blockchain technologies, consensus algorithms such as Proof-of-Work (PoW) and Proof-of-Stake play a crucial role for ensuring agreement among decentralized network participants on the validity of transactions, maintaining the integrity and security of the blockchain. In this talk, we first focus on the PoS, introducing a performance modelling approach to the transaction-confirmation time analysis using queueing theory. Then, we discuss the interaction between miner decision and user action for Bitcoin blockchain. We also show the security issue of PoS-based voting mechanism for Decentralized Autonomous Organizations (DAOs).

Satoshi Nagata
Senior Manager, 6G Network Innovation Department, NTT DOCOMO, INC.

Short Bio:
Satoshi Nagata received his B.E. and M.E. degrees from Tokyo Institute of Technology, Tokyo, Japan. He joined NTT DOCOMO, INC., and worked on the research and development for wireless access technologies for LTE, LTE-Advanced, 5G, and 6G. He had contributed to 3GPP over 20 years, and contributed 3GPP TSG-RAN WG1 as a vice chairman during November 2011 to August 2013, and contributed as a chairman during August 2013 to August 2017. He had also contributed 3GPP TSG-RAN as a vice chairman during March 2017 to March 2021, and currently a vice chairman of 3GPP TSG-SA since March 2021.

Topic:

Evolution of Mobile Communication Technology for 5G Evolution and Toward 6G

5G is characterized by high data rate / high capacity, low latency and massive connectivity. With these features, 5G is expected to further upgrade multimedia communication services from the level achieved by the previous generations including 4G, and to provide new value as a fundamental technology that supports future industry and society along with AI and IoT. Now, 6G related research activity is very active in the world. In this presentation, we will show the direction of evolution of mobile communication technology for 5G Evolution and toward 6G, which represents a vision of the world in the 2030's. We will also show the concepts for the requirements, use cases and technological development and research activity.

Prof. Dr. Yang Yang
Professor, HKUST (Guangzhou), China

Short Bio:
Dr. Yang Yang is a Professor with the IoT Thrust, the Director of Research Center for the Digital World with Intelligent Things (DOIT), and the Associate Vice-President for Teaching and Learning at the Hong Kong University of Science and Technology (Guangzhou), China. His research interests include multi-tier computing networks, 5G/6G systems, AIoT technologies, intelligent services and applications, and advanced wireless testbeds. He has published more than 300 papers and filed more than 120 technical patents in these research areas. Yang is a Fellow of the IEEE.

Topic:

Collaborative Edge Computing for Large AI Models on Wireless Networks

Large AI models have emerged as a crucial element in various intelligent applications at the network edge, such as voice assistants in smart homes and autonomous robotics in smart factories. Computing big AI models, e.g., for personalized fine-tuning and continual serving, poses significant challenges to edge devices due to the inherent conflict between limited computing resources and intensive workload associated with training. Despite the constraints of on-device training, traditional approaches usually resort to aggregating data and sending it to a remote cloud for centralized computation. Nevertheless, this approach is neither sustainable, which strains long-range backhaul transmission and energy-consuming datacenters, nor safely private, which shares users' raw data with remote infrastructures. To address these challenges, we alternatively observe that prevalent edge environments usually contain a diverse collection of trusted edge devices with untapped idle resources, which can be leveraged for edge training acceleration. Motivated by this, we propose to leverage edge collaboration, a novel mechanism that orchestrates a group of trusted edge devices as a resource pool, for expedited, sustainable large AI model computing at the edge. As an initial step, we present a comprehensive framework for building collaborative edge computing systems and analyze in-depth its merits and sustainable scheduling choices following its workflow. To further investigate the impact of its parallelism design, we empirically study a case of four typical parallelisms from the perspective of energy demand with realistic testbeds. Finally, we discuss open challenges for sustainable edge collaboration to point to future directions of edge-centric large AI model computing.

Prof. Dr. Nasimuddin
Institute for Infocomm Research, A-STAR, Singapore

Short Bio:
He received a B.E. and M.E. from Tokyo Institute of Technology in 2001 and 2003. In 2003, he joined NTT DOCOMO, where he engaged in the research and development for wireless access technologies for Long-Term Evolution (LTE), LTE-Advanced, and 5G. He has been contributing to 3GPP for over 15 years and served as a vice chairman of 3GPP TSG-RAN WG1 from November 2011 to August 2013 and as a chairman from August 2013 to August 2017. He also served as a vice chairman of 3GPP TSG-RAN from March 2017 to March 2021 and has been a vice chairman of 3GPP TSG-SA since March 2021.Dr. Nasimuddin (M'2003-SM'2009) earned his M.Tech. and Ph.D. from the University of Delhi in 1998 and 2004. He served as a Senior Research Fellow at the University of Delhi (1999-2003) and as an Australian Postdoctoral Research Fellow at Macquarie University (2004-2006). Currently, he is a Principal Scientist at the Institute for Infocomm Research (I2R), A*STAR, Singapore. Dr. Nasimuddin has authored over 240 papers, holds three patents, and has edited books, including a notable work on microstrip antennas. Recognized among the top 2% of world scientists in 2023, he is a distinguished speaker, reviewer, and conference organizer. A Senior Member of IEEE and IEEE APS, he has received awards such as the URSI Young Scientist Award (2005) and IEEE APS Exceptional Performance Reviewer accolades. He also serves as an Associate Editor for IJAP/IEEE OJAP and is actively involved with Antennas and Propagation-related journal editorial boards.

Topic:
Innovations in Reconfigurable Antennas: A Comprehensive Overview and Applications

D

Prof. Dr. Claes Beckman
Senior Researcher, KTH Royal Institute of Technology,
Stockholm and Icomera AB, Göteborg Sweden.

Short Bio:
Prof. Claes Beckman is a Swedish engineer, physicist, and professor with a distinguished career spanning over 40 years in microwave engineering and antenna systems. He has been instrumental in developing technologies that have shaped modern communication systems, with significant contributions to 4G and 5G standards. Currently, he holds a dual role as a senior researcher at the KTH Royal Institute of Technology in Stockholm and as a Senior Expert at Icomera AB, where he has played a key role in transforming the company from a start-up to a global leader in passenger internet solutions for trains.

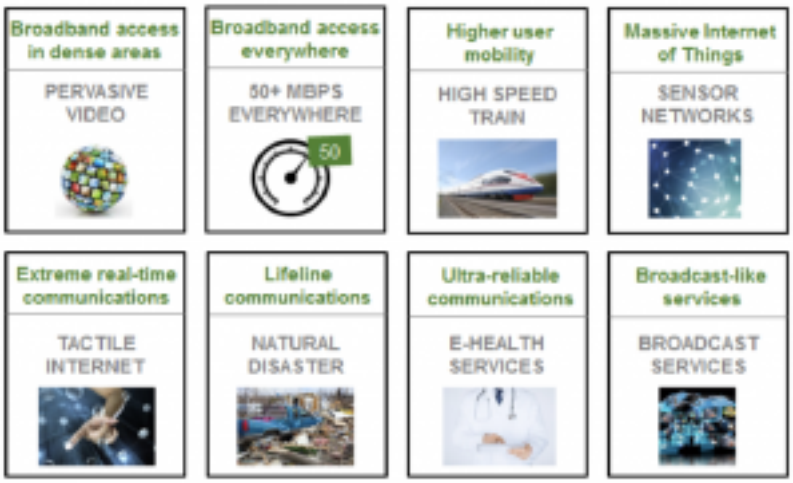
Throughout his career, Dr. Beckman has been at the forefront of innovation, leading projects that have resulted in numerous products, patents, and scientific publications. He has designed antennas for 1G, 2G, and 3G systems, and his work in the EU-funded METIS project contributed to the first 5G standard. An advisor to over 100 M.Sc. and 7 Ph.D. students, he has also been involved in the founding of multiple start-ups. Today, his research focuses on Converged Satellite and Cellular Connectivity, a promising technology for the upcoming 6G networks.

Topic:
The successes and failures of 5G to meet its original objectives and what we can hope for with 6G

SK Telecom launched their fifth generation (5G) mobile phone system on the 3rd of April 2019 and shortly thereafter Verizon launched in the US. 5G was introduced with a hype that matches nothing else in the history of Telecom. Suddenly the World was gifted with a communications system that was going to become the solution for not only the everyday Netflix consumer but also for the digitization of society as a whole, transportation, Industry 4.0, Blue-lights, you name it!

The hype was caused by both the telecom vendors as well as the Mobile Network Operators (MNOs), whose revenues have been falling dramatically since around 2007. In an attempt to improve the operator's profitability and revenues, the ambition behind 5G's was to produce data at a much lower cost than 4G, while also enabling a number of new use cases and, hence, possible new revenue streams.

In 2015 the Next Generation Mobile Networks Alliance (NGMN) published a white paper with the ambition to announce the expectations that the MNOs had on 5G. In short, the paper presented eight use-cases/services within various new verticals, which 5G would enable for the MNOs to enter.



Eight new use-cases proposed for 5G by the Next Generation Mobile Network Aliance in 2015

Almost a decade later, we are still to see any successful use-case besides broadband internet access. Broadband in rural areas are still scarce due to cost of deployment. High speed trains are when it is possible, still mainly connected to 4G at sub 1 GHz bands. IoT still lacks a cost efficient 5G narrowband modems. Ultra Reliable and Low Latency Communications (URLC) envisioned as an enabler for Industry 4.0, is still only a vision and industry communications is dominated by Wi-Fi; Unicast broadcast services are today of little or no interest and communications systems for Public Protection and Disaster Relief (PPDR) is still most often based on systems such as TETRA or LTE.

Still, both society and Industry and have a lot to gain by implementing cellular technology for the use cases described above and it is a major failure by the industry that 5G has not met its expectations. This talk will analyse both the successes and failures of 5G to meet its original objectives, some of the reasons behind those failures and, what we can hope for with the development of 6G?

Panel Discussion

Dr. Dong Seog Han
(Korean Institute of Communication Sciences, Korea)

Short Bio:
Dong Seog Han (Senior Member, IEEE) received his B.S. degree in Electronic Engineering from Kyungpook National University (KNU), Daegu, South Korea, in 1987, and the M.S. and Ph.D. degrees in Electrical Engineering from Korea Advanced Institute of Science and Technology (KAIST), Daejeon, South Korea, in 1989 and 1993, respectively. From 1987 to 1996, he worked at Samsung Electronics Company Ltd., where he developed the transmission systems for HDTV receivers. Since 1996, he has been a professor at the School of Electronics Engineering, KNU. In 2004, he was a Courtesy Associate Professor in the Department of Electrical and Computer Engineering at the University of Florida. He was the Director of the Center of Digital TV and Broadcasting at the Institute for Information Technology Advancement from 2006 to 2008. He has been the Director of the Center for ICT and Automotive Convergence (CITAC) at KNU since 2011. His research interests include intelligent signal processing, autonomous vehicles, and wireless communications.

Topic:

Deep Learning Approaches for Parameter Estimation in OFDM Communication Systems

Prof. Dr. Takaya Yamazato
(Institute of Liberal Arts and Sciences, Nagoya University, Japan)

Short bio:
Dr. Takaya Yamazato is a professor and Deputy Director at the Institute of Liberal Arts and Sciences at Nagoya University in Japan. He earned his Ph.D. from the Department of Electrical Engineering at Keio University in Yokohama, Japan, in 1993. From 1993 to 1998, he served as an Assistant Professor at the Department of Information Electronics at Nagoya University. During 1997 to 1998, he was a visiting researcher at the Research Group for RF Communications at the University of Kaiserslautern. In 2006, he received the IEEE Communication Society's Best Tutorial Paper Award. Dr. Yamazato initiated the Nagoya University OCW in 2005 and has been involved in its management and operation since then. He has been a board member of JOCW since 2005 and is currently a board member of OEJ. From 2016 to 2017, he was a member of the Board of Governors (BoG) of the IEEE Communication Society and served as the Director of the Asia/Pacific Board. Additionally, from 2009 to 2011, he was the editor-in-chief of the Japanese Section of IEICE Transactions on Communications. He also chaired the IEICE Communication Society editorial board from 2020 to 2021. Dr. Yamazato's research interests encompass visible light communication (VLC), intelligent transport systems (ITS), stochastic resonance (SR), and open educational resources (OER).

Topic:

The Secret of the Eyes of Mona Lisa "The Review Policy and Current Status of the IEICE Transactions"

Mr. Satriyo Dharmanto
(TVRI, Indonesia)

Short bio:
Mr. Bernardus Satriyo Dharmanto is a seasoned professional with a distinguished career in ICT and Digital Economy. With extensive experience in technical management, business development, and rural development, Satriyo Dharmanto has fostered strong relationships across Telcos, IT, and Broadcasting industries in Asia-Pacific, UK, and Norway.

He has made significant contributions to national broadband initiatives, public-private partnerships, and rural-SME-community development. Satriyo Dharmanto is also a prolific author, having published five books and numerous journal articles on ICT, broadcasting, and business strategy.

Satriyo Dharmanto is a member of Indonesia-ITU Concern Forum (IICF), an Advisory Board of IEEE Indonesia Section, a Senior Member of IEEE, and actively contributes to IEEE Communication Society, IEEE Broadcasting Society, and IEEE Computer Society. He was the IEEE R10 Asia Pacific Industry Relation Committee, IEEE Communication Society Indonesia Chapter Chair, and IEEE Indonesia Section Chair. Currently, Satriyo Dharmanto is Chief Technical Officer (CTO) of TVRI – Indonesia.

Topic:

Demystifying Technology For Public Service Media
How Information and Communication Technology is Revolutionizing Public Communication

Technical Paper

Session-Parallel Session Day 1: November 5th, 2024

Parallel Session 1 - R1: Bale Banjar

Session Chair: Prof. Duk Kyung Kim

Paper	Authors
Coverage Extension through MA-DQN-based Relaying for V2V Communications	Insung Lee, Duk Kyung Kim (Inha University, Republic of Korea)
Enhancement of Reliability of Message Delivery in Many-Subscriber MQTT Networks	Sumika Kojima, Takumi Wada, Yui Yamashita, Yoshito Tobe (Aoyama Gakuin University, Japan), Yuusuke Kawakita (Kanagawa Institute of Technology, Japan)
Enhancing the Reliability of NR-V2X Sidelink Broadcast through Relay	Shiro Aoki, Suhua Tang (The University of Electro-Communications, Japan)
TCP CUBIC with HyStart: Congestion Control for Satellite Communication in OMNeT++ INET	Luigi Martino, Jörg Deutschmann, Kai-Steffen Hielscher, Reinhard German (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany)
A Method for Reducing End-to-End Delay with Priority Assignment in CAN-CAN Gateway	Shimpo Tsuchimoto, Ryo Kurachi, Hiroaki Takada (Nagoya University, Japan)

13:20 PM **Coverage Extension through MA-DQN-based Relaying for V2V Communications**

Authors: Insung Lee, Duk Kyung Kim (Inha University, Republic of Korea)

Abstract: In the realm of vehicular communication, ensuring robust and extensive coverage in high-speed highway environments is paramount. This paper introduces an innovative approach that employs Multi-Agent Reinforcement Learning (MARL) to optimize the selection of relay entities, aiming to enhance V2V communication coverage. Also, we propose a novel resource reservation scheme based on 5G New Radio (NR) Mode 2, tailored for relaying entities to ensure adherence to the latest 3rd Generation Partnership Project (3GPP) protocols. Simulation results reveal that the implementation of our resource reservation strategy markedly boosts the Packet Reception Ratio (PRR), confirming the effectiveness of the proposed method. By juxtaposing scenarios with and without our resource allocation technique, we demonstrate an enhancement in PRR performance, thereby validating the benefits of our approach.

13:40 PM **Enhancement of Reliability of Message Delivery in Many-Subscriber MQTT Networks**

Authors: Sumika Kojima, Takumi Wada, Yui Yamashita, Yoshito Tobe (Aoyama Gakuin University, Japan), Yuusuke Kawakita (Kanagawa Institute of Technology, Japan)

Abstract: A message protocol called message queuing telemetry transport (MQTT) is being used in large-scale energy-efficient communications. However, even when using MQTT, if the network quality and capacity are insufficient, especially when there

are many subscribers, nodes may fail to receive messages. Therefore, we propose a new communication control mechanism, eXchanging attributes of transmission uniformity (Xatu). The goal of Xatu is to establish a reliable new method that can compensate for message loss even in long-time and large-scale environments. Xatu sets up a state called bridge, and a conventional MQTT subscriber switches to a bridge. Xatu allows messages to be sent to all subscribers without missing messages.

14:00 PM **Enhancing the Reliability of NR-V2X Sidelink Broadcast through Relay**

Authors: Shiro Aoki, Suhua Tang (The University of Electro-Communications, Japan)

Abstract: NR-V2X sidelink (SL) broadcast is used for the real-time exchange of position and other information between adjacent vehicles. However, its reliability degrades much in non-line-of-sight environments, where Blind ReTransmission (BReTX) does not work well. Relay can effectively address this issue, and a relay-based SL broadcast method was proposed in previous work. However, in this method, each vehicle must detect communication Link Quality (LQ) and exchange LQ Indicators (LQIs) with its neighbors to select a proper relay, which causes much overhead. This paper aims to improve the relay-based SL broadcast from two aspects. (i) To reduce the overhead, we suggest aggregating LQIs per direction, making the overhead of sharing LQIs irrelevant to the number of vehicles. (ii) To further improve reliability, we use an explicit ACK to deal with the potential failure of the transmission from the source vehicle to the relay. Using explicit ACKs allows the source vehicle to retransmit the packet until the relay vehicle correctly receives it, after which the relay vehicle handles the remaining retransmissions. Simulation results confirm that the proposed method, RReTX-ACK, improves the packet dissemination rate by approximately 8.30% within a 200m distance from the source vehicle in an intersection scenario, compared to BReTX without using relay vehicles.

14:20 PM **TCP CUBIC with HyStart: Congestion Control for Satellite Communication in OMNeT++ INET**

Authors: Luigi Martino, Jörg Deutschmann, Kai-Steffen Hielscher, Reinhard German (Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany)

Abstract: In the context of satellite communication, unique challenges arise, such as long delay links that can impact the network performance also at the Transport Layer. With regard to the Transmission Control Protocol (TCP), congestion control plays a crucial role in managing network traffic and ensuring efficient data transmission over the Internet. This paper wants to give an overview of how TCP congestion control mechanisms adapt to mitigate the effects of long link delays, highlighting the importance of optimizing protocols for these specific environments. Within this context, where signals travel extended distances, traditional TCP algorithms designed for terrestrial networks with relatively low latency, may struggle to maintain optimal performance. As a result, specialized congestion control algorithms, like TCP CUBIC, can be employed to address these challenges. Through the integration of TCP CUBIC with HyStart within a simulation framework based on OMNeT++ and INET, this study sheds light on the

importance of tailoring congestion control strategies to suit specific network environments including satellite communication.

14:40 PM **A Method for Reducing End-to-End Delay with Priority Assignment in CAN-CAN Gateway**

Authors: Shimpo Tsuchimoto, Ryo Kurachi, Hiroaki Takada (Nagoya University, Japan)

Abstract: Multiple controller area network (CAN) buses are often integrated in in-vehicle networks to support various functions and control systems. Although the CAN-CAN gateway has a critical role in relaying messages between these buses, it increases the end-to-end (E2E) delay of messages. This study proposes a method for reducing the E2E delay of messages transmitted through a CAN-CAN gateway by changing their CAN IDs. The E2E delay of gateway messages is minimized using a simulated annealing algorithm. An evaluation of the proposed method demonstrates that it can significantly reduce the E2E delay of gateway messages compared to that obtained with methods in which CAN IDs remain unchanged or are randomly altered and a method that uses the Targeted Priority Assignment algorithm.

Parallel Session 1 - R2: Bale Paseban 2

Session Chair: Prof. Dr. Raqibul Mostafa

Paper	Authors
OHDRL-Based Energy Consumption Optimization for Joint Content Fetching and Trajectory Design of UAVs	Elhadj Moustapha Diallo, Rong Chai, Chengchao Liang, Qianbin Chen (Chongqing University of Posts and Telecommunications, China), Abuzar. B. M. Adam (University of Luxembourg, Luxembourg)
Average System Cost Minimization-Based Joint UAV Deployment and Resource Allocation	Qinyuan Wang, Rong Chai, Chengchao Liang, Qianbin Chen (Chongqing University of Posts and Telecommunications, China)
System Design for ML based Detection of Unauthorized UAV and Integration within the UTM Framework	Mashuk Ahmed, Md. Ridoy Ad Sumon, Uma Sutradhar, Raqibul Mostafa (United International University, Bangladesh)
Optimization of Vehicular Network Resource Allocation Based on MAAC Algorithm	Jun-Han Wang, He He, Kosuke Tamura, Jaesang Cha, Chang-Jun Ahn (Chiba University, Japan), Shun Kojima (The University of Tokyo, Japan)
On the bit error probability for constant Log-MAP decoding of convolutional codes with rate k/n	Hideki Yoshikawa (Tohoku Gakuin University, Japan)

13:20 PM **OHDRL-Based Energy Consumption Optimization for Joint Content Fetching and Trajectory Design of UAVs**

Authors: Elhadj Moustapha Diallo, Rong Chai, Chengchao Liang, Qianbin Chen (Chongqing University of Posts and Telecommunications, China), Abuzar. B. M. Adam (University of Luxembourg, Luxembourg)

Abstract: In this study, we investigate minimization of energy consumption in multi-UAV assisted networks. We formulate an energy minimization optimization problem with UAV trajectory design, content fetching, power allocation and content placement constraints. The problem is a mixed integer nonlinear programming (MINLP); therefore, we convert the formulated problem into semi-Markov decision process (SMDP). To tackle this SMDP optimization challenge, we introduce an option-based hierarchical deep reinforcement learning (OHDRL) approach. We designate UAV trajectory planning and power allocation as the low level action space, and content placement and content fetching as the high level option space. Through simulations, we demonstrate the effectiveness of the proposed OHDRL method.

13:40 PM **Average System Cost Minimization-Based Joint UAV Deployment and Resource Allocation**

Authors: Qinyuan Wang, Rong Chai, Chengchao Liang, Qianbin Chen (Chongqing University of Posts and Telecommunications, China)

Abstract: Unmanned aerial vehicles (UAVs) are expected to act as aerial relays which forwards data packets for ground users (GUs) leveraging their advantages of low cost, high flexibility and maneuverability. One challenging problem in UAV-assisted cellular systems is how to design the efficient UAV deployment, GU association and resource allocation strategy which achieves system performance optimization. In this paper, we address the data transmission problem in a UAV-assisted cellular system with the knowledge of statistical GU positions. Stressing the energy consumption of base station (BS) and UAVs, and the cost of UAVs, we formulate the joint UAV deployment, GU association and power allocation problem as a constrained system cost minimization problem. To solve the formulated problem, we decouple it into three subproblems, i.e., UAV deployment, GU association and power allocation subproblem. Then, the UAV deployment subproblem is modeled as a Markov decision process (MDP), and an embedded multi-agent double deep Q network (DDQN) algorithm is proposed. Specifically, given the state and action of the MDP, we formulate and solve the power allocation subproblem and determine the transmit power of the UAVs by applying the Lagrange dual method-based algorithm. The GU association subproblem is then tackled by utilizing a proposed Kuhn-Munkres (K-M) algorithm-based scheme. Based on the obtained power allocation and GU association strategy, the reward of the MDP can be computed and the UAV deployment strategy is determined which maximizes the long-term average reward. Simulation results demonstrate the effectiveness of the proposed algorithms.

14:00 PM **System Design for ML based Detection of Unauthorized UAV and Integration within the UTM Framework**

Authors: Mashuk Ahmed, Md. Ridoy Ad Sumon, Uma Sutradhar, Raqibul Mostafa (United International University, Bangladesh)

Abstract: Unauthorized UAVs present a major concern for public safety, and their detection poses challenges in terms of technical solution and integration with existing aviation regulatory systems. This paper presents an effective detection system setup in this regard and its integration with the UTM system for monitoring the airspace for UAVs. The detection mechanism relies on measuring received RF power at the detector units emanating from the UAV and using machine learning techniques on these measured powers to estimate the location of the unauthorized UAV. The proposed system has been tested for both location estimation and tracking of the flight trajectory of the UAV. With a three-detector system, the R-squared values for detection achieve 0.99 in both LOS and NLOS propagation environments while the accuracy performance in distance yields percentage error of (4.13%, 4.62%) and (1.14% and 1.59%) in (line-of-sight (LOS) and non-LOS (NLOS)) environments for three and four detector system, respectively. The detector system includes an auxiliary visual detection system based on 120◦ sectored camera system for supporting law enforcement steps after the successful detection stage. Lab measurements for estimating the distance of a test object for visual detection has been performed and reported in this paper. Additionally, the neutralization of such UAVs by the proposed detector units has been presented. The integration of the proposed detection system with an existing UTM system has been discussed in detail in this paper.

14:20 PM **Optimization of Vehicular Network Resource Allocation Based on MAAC Algorithm**

Authors: Jun-Han Wang, He He, Kosuke Tamura, Jaesang Cha, Chang-Jun Ahn (Chiba University, Japan), Shun Kojima (The University of Tokyo, Japan)

Abstract: Internet of Vehicles (IoV) is an emerging technology that has been rapidly developing in recent years, which combines the internet, wireless communication technology, and vehicle electronics to realize the intelligence of interaction between vehicles and greatly improve the efficiency and safety of the transportation system. However, high-frequency and cyclical communications between vehicles and the limited system capacity in the region have led to serious conflicts in the allocation of wireless resources for vehicle networking. To solve this problem, this paper models resource allocation as a multi-agent deep reinforcement learning problem and proposes a Multi-Agent Actor-Critic (MAAC) algorithm based on distributed execution. The multi-agent algorithm can achieve distributed computing by modeling the training mechanism and reward function, thus improving resource utilization. Experimental results show that the proposed algorithm improves the total Vehicle-toInfrastructure (V2I) link capacity and Vehicle-to-Vehicle (V2V) link transmission success rate.

14:40 PM **On the bit error probability for constant Log-MAP decoding of convolutional codes with rate k/n**

Authors: Hideki Yoshikawa (Tohoku Gakuin University, Japan)

Abstract: Maximum a posteriori probability (MAP) decoding minimizes the symbol or bit error probability. However, few studies have focused on exact error performance evaluations, although optimality does not require explanation. The MAP algorithm is considerably more complex than maximum likelihood decoding methods. Therefore, suboptimal MAP algorithms are considered for practical systems. The Max-Log-MAP decoding algorithm is one of several near-optimum algorithms that can reduce decoding complexity; however, turbo decoding using MaxLog-MAP decoding degrades error performance compared with MAP decoding. Log-MAP decoding can be realized using MaxLog-MAP decoding with a correction term that corrects errors induced by the maximum approximation. Constant Log-MAP decoding uses a constant correction term rather than of a logdomain correction term. In this paper, the analytical results of the bit error probabilities of convolutional codes using constant Log-MAP decoding are presented, and the analytical results are compared with the MaxLog-MAP decoding results. Additionally, theoretical improvement using the correction term, which corrects errors induced by the maximum approximation, is shown. Results demonstrate that the error performance of constant Log-MAP decoding is marginally better than that of Max-Log-MAP decoding.

Parallel Session 1 – R3: Bale Paseban 3

Session Chair: Dr. Manolo D. Hina

Paper	Authors
Implementation of Channel Deinterleaver for 5G NR PUCCH Channel	Samudrala Soujanya, Arjun Menon K, Prem Singh (IIIT Bangalore, India), Ekant Sharma (IIT Roorkee, India)
An OFDM Compatible Sensing Waveform Design for 6G ISAC System	Juan Liu, Wenjia Liu, Xiaolin Hou, Lan Chen (DOCOMO Beijing Communications Laboratories Co., Ltd, China)
Evaluation of Link Quality and Constellation Distance for RIS-Based Spatial Modulation System	Issei Maesaki, Tsuyoshi Inoue, Yafei Hou, Satoshi Denno (Okayama University, Japan)
Extreme Learning Approach for Timing Synchronization of ACO-OFDM under Nonlinear Distortions	Abhaynarasimha K S, Renikunta Mallaiah, V Venkata Mani (NIT Warangal, India), Miriyala Ganesh (MLR Institute of Technology, India)
Evaluation of Atomic Clock-based Joint Transmission for Full-Duplex in IEEE 802.11	Muhammad Harry Bintang Pratama, Yuhei Nagao, Masayuki Kurosaki, Hiroshi Ochi (Kyushu Institute of Technology, Japan)

13:20 PM **Implementation of Channel Deinterleaver for 5G NR PUCCH Channel**

Authors: Samudrala Soujanya, Arjun Menon K, Prem Singh (IIIT Bangalore, India), Ekant Sharma (IIT Roorkee, India)

Abstract: This study focuses on designing a 3GPP-compliant channel deinterleaver for the 5G new radio (NR) physical uplink control channel (PUCCH) for field programmable gate array (FPGA). The PUCCH transmit chain employs a complex triangular structure for channel interleaving which typically requires nested 'for' loops, while the channel deinterleaver in the receive chain has to perform the reverse operation using LLRs, which requires handling multiple bits, thereby increasing complexity. We present a novel algorithm for FPGA implementation of the channel deinterleaver with reduced complexity by replacing the nested 'for' loop with a single 'for' loop and conditional variable increment. Our design is benchmarked using a 2-tier testing strategy with the Matlab 5G NR toolbox, with test vectors covering all configurations. Our FPGA implementation demonstrates that the designed channel deinterleaver completes its operation within a slot duration of 5G NR with minimal resource utilization.

13:40 PM **An OFDM Compatible Sensing Waveform Design for 6G ISAC System**

Authors: Juan Liu, Wenjia Liu, Xiaolin Hou, Lan Chen (DOCOMO Beijing Communications Laboratories Co., Ltd, China)

Abstract: Integrated sensing and communication (ISAC) is an important new research topic for sixth-generation (6G), where the waveform design should be studied. The chirp-based waveform is widely used in radar systems due to its low peak-to-average power ratio (PAPR) and good autocorrelation properties and is a candidate waveform for ISAC systems. To realize the chirp-based waveform in ISAC systems without additional hardware cost, an orthogonal frequency division multiplexing (OFDM) compatible sensing waveform is proposed in this paper. Firstly, a frequency domain processing (FDP) module is proposed to realize chirp signal under the OFDM transmitter structure. Then, to satisfy different communication requirements, the sensing symbol pattern is designed on top of the FDP module to realize multiple orthogonal chirps with flexible patterns. Evaluation results demonstrate that the proposed chirp-based waveform based on the unified waveform structure can achieve 4 dB and 13 dB signal-to-noise ratio (SNR) gain over traditional OFDM waveform with Zadoff-Chu (ZC) sequence or random payloads under the same range and velocity estimation accuracy.

14:00 PM **Evaluation of Link Quality and Constellation Distance for RIS-Based Spatial Modulation System**

Authors: Issei Maesaki, Tsuyoshi Inoue, Yafei Hou, Satoshi Denno (Okayama University, Japan)

Abstract: In recent years, reconfigurable intelligent surface (RIS) technology is stimulating the usage on the field of wireless communication due to its low-cost hardware and powerful functionality. RIS is composed of many unit cells (reflective cells), and each one can be designed to control the phase of input electromagnetic waves. This enables the adjustment of reflected wireless signals towards the desired direction. By leveraging this feature, RIS can significantly enhance link power and capacity

by concentrating reflected waves on the receiver. In addition, by controlling the phases of all unit cells, it can increases the total number of different channel patterns or channels, which can be used as the constellations of spatial modulation (SM) and improve the capacity of wireless system. The main purpose of RIS based SM is to find the appropriate set of cell phases to maximize the minimum distance of the constellation points which is an NP-complete problem. In this paper, we will propose a genetic algorithm (GA) based method to find the appropriate set of cell phases. In addition, we divide all cells into two groups for increasing link quality and generating the constellation points of SM respectively. This paper also evaluates the trade-off between link quality and GA-based constellation distance when the ratio of two groups are changed. The evaluated results show that it exists some ‘good' ratios to make the system has appropriate constellation distance with good link quality.

14:20 PM **Extreme Learning Approach for Timing Synchronization of ACO-OFDM under Nonlinear Distortions**

Authors: Abhaynarasimha K S, Renikunta Mallaiah, V Venkata Mani (NIT Warangal, India), Miriyala Ganesh (MLR Institute of Technology, India)

Abstract: Asymmetrically-clipped optical orthogonal frequency division multiplexing (ACO-OFDM) is the optimal power-efficient modulation technique for the intensity-modulated (IM) and the direct-detection (DD) based visible light communication (VLC) systems. In ACO-OFDM, the non-linear distortions of light-emitting diodes (LEDs) and diffused channels will affect the estimation of delay offset from the received data frame. These distortions corrupt the timing metric (TM) by generating several peaks around the position of the actual delay, thus affecting the delay offset estimation. In this paper, we propose a timing synchronization method for ACO-OFDM using an extreme learning machine (ELM) based delay offset estimator by considering the identification of delay offset position as a feature extraction problem. Then, the simulations are carried out considering the real-time effects of high-power LED distortions and diffused channel characteristics. The simulation results show a reduction in the probability of error (PoE) of delay offset estimation and bit error rate (BER) for the received signal of different frame lengths, diffused channels, and randomly varied LED non-linear conditions compared to the conventional methods.

14:40 PM **Evaluation of Atomic Clock-based Joint Transmission for Full-Duplex in IEEE 802.11**

Authors: Muhammad Harry Bintang Pratama, Yuhei Nagao, Masayuki Kurosaki, Hiroshi Ochi (Kyushu Institute of Technology, Japan)

Abstract: Self-interference cancellation is an important technology to achieve full-duplex communication. The self-interference (SI) signal in IEEE 802.11 networks can be suppressed using Joint Transmission (JT) with null beamforming. This method requires a weight matrix that is obtained from the Channel State Information (CSI). However, JT requires very tight synchronization between multiple access points (APs). Since multiple APs run on different clock sources, offsets between APs might occur, making it difficult to cancel the SI signal. In this paper, we evaluate

the SI cancellation of JT with null beamforming when an atomic clock is used in our simulation model. Our results show that SI cancellation with an atomic clock can have results similar to the ideal condition (i.e., the same external clock source is applied to all APs).

Parallel Session 1 - R2: Bale Paseban 4

Session Chair: Dr. Estananto

Paper	Authors
Bandwidth Enhancement in Circular Patch Antenna using Inset Feed and Slot for Ku-band Applications	Alif Fathoni Zidni, Catur Apriono (Universitas Indonesia, Indonesia), Aditya Inzani Wahdiyat (National Research and Innovation Agency, Indonesia)
Hybrid Beamforming Structure Using Grouping with Reduced Number of Phase Shifters in Multi-User MISO	Hiroya Hayakawa, Yudai Handa, Riku Tanaka, Kosuke Tamura, Jaesang Cha, Chang-Jun Ahn (Chiba University, Japan)
A QoS-aware Handover Mechanism for LEO Satellite Networks based on Multi-agent DRL	Chengchao Liang, Yihang Guo, Zhanglei Wu, Rong Chai (Chongqing Univ. Posts & Telecom, China)
BER for QAM Schemes and LDPC Coding Rates in the Presence of Strong Phase Noise in Sub-THz Bands	Manato Murakami, Takashi Ohiwa, Yuki Mabuchi, Mamoru Sawahashi (Tokyo City University, Japan), Satoshi Suyama (NTT DOCOMO INC., Japan)
PCID Detection Probabilities in the Presence of CFO and Strong Phase Noise in Sub-THz Bands	Takashi Ohiwa, Yuki Mabuchi, Mamoru Sawahashi (Tokyo City University, Japan), Satoshi Nagata, Satoshi Suyama (NTT DOCOMO INC., Japan)

13:20 PM **Bandwidth Enhancement in Circular Patch Antenna using Inset Feed and Slot for Ku-band Applications**

Authors: Alif Fathoni Zidni, Catur Apriono (Universitas Indonesia, Indonesia), Aditya Inzani Wahdiyat (National Research and Innovation Agency, Indonesia)

Abstract: Circular patch antennas with inset feed and slot configurations have been developed to enhance bandwidth for Ku-band applications. By integrating an inset feed, the impedance matching of the circular patch antenna is significantly improved, while the slot introduces additional resonances, effectively broadening the antenna's bandwidth. A comprehensive parametric analysis of the design parameters was conducted to confirm the bandwidth enhancement. Furthermore, the combination of the inset input and the slot optimizes the input impedance, resulting in enhanced performance. The final antenna design achieves an impressive bandwidth in a range of 11 to 13.5 GHz (20.4%).

13:40 PM **Hybrid Beamforming Structure Using Grouping with Reduced Number of Phase Shifters in Multi-User MISO**

Authors: Hiroya Hayakawa, Yudai Handa, Riku Tanaka, Kosuke Tamura, Jaesang Cha, Chang-Jun Ahn (Chiba University, Japan)

Abstract: This paper proposes a novel hybrid beamforming (HBF) structure for gain-aware grouping transmit antennas and users in multiuser multiple-input single-output (MU-MISO) systems. In the conventional HBF structure, all transmit antennas form a beam to each user. In this case, the gain of each antenna varies depending on the location of the base station and each user, and the transmit power after digital beamformer is allocated to the antenna with the smallest gain. Signals transmitted from antennas with small gains are susceptible to noise and interference. Therefore, this paper proposes an HBF structure in which only the antenna with the highest gain forms the beam for each user. Simulation results show that the proposed scheme can reduce the number of phase shifters used on the transmit side compared to the conventional HBF scheme while maintaining sum-rate performance.

14:00 PM **A QoS-aware Handover Mechanism for LEO Satellite Networks based on Multi-agent DRL**

Authors: Chengchao Liang, Yihang Guo, Zhanglei Wu, Rong Chai (Chongqing Univ. Posts & Telecom, China)

Abstract: In future space-ground integrated networks, a satellite-based core network can reduce frequent signaling interactions between satellites and ground stations, thereby enhancing network architecture and supporting global communications. Users can achieve end-to-end communication through the satellite-based User Plane Function (UPF). However, the high dynamics of Low Earth Orbit (LEO) satellites result in frequent inter-satellite handovers, significantly affecting user service continuity. Existing satellite handover strategies are overly simplistic and fail to ensure the Quality of Service (QoS). Additionally, ground users compete for satellite links based on limited observations, leading to network congestion. This paper proposes a load-balanced, distributed, multi-agent deep reinforcement learning method for satellite handover. We formulate a combinatorial optimization problem to maximize the total utility of user-satellite associations across various service types. Each user acts based on local information and engages in distributed matching with satellites. Simulation results indicate that our method ensures QoS for various service types, optimizes load balancing, and outperforms basic handover strategies in terms of handover success rate and frequency.

14:20 PM **BER for QAM Schemes and LDPC Coding Rates in the Presence of Strong Phase Noise in Sub-THz Bands**

Authors: Manato Murakami, Takashi Ohiwa, Yuki Mabuchi, Mamoru Sawahashi (Tokyo City University, Japan), Satoshi Suyama (NTT DOCOMO INC., Japan)

Abstract: This paper presents the bit error rate (BER) performance for various quadrature amplitude modulation (QAM) schemes with low-density parity-check (LDPC) coding using pilot-symbol assisted (PSA) - extended Kalman filter (EKF) phase-noise compensation (PNC) in the presence of strong phase-noise (PN) for orthogonal frequency division multiplexing (OFDM) in sub-terahertz (sub-THz) bands. In the sub-THz bands, PN is a significant hardware impairment and comprises random Wiener PN and uncorrelated Gaussian PN. Hence, in this paper, we propose to compensate for the correlated Wiener PN using PSA-EKF PNC and

to make use of the large coding gain from the LDPC code to mitigate the effect of the uncorrelated Gaussian PN in sub-THz bands. Computer simulation results show that the loss in the required received signal-to-noise ratio (SNR) at the BER of 10 −6 compared to the case without PN is suppressed to less than 1.0 dB for QPSK and 16QAM with the LDPC coding rate of R = 8/9 for the power spectral density level of an uncorrelated Gaussian PN of -105 dBc/Hz or lower. We also show that the 64QAM scheme achieves the BER of 10 −6 by utilizing the LDPC coding gain at the cost of an increase in the required received SNR in the presence of strong PN in the sub-THz bands.

14:40 PM **PCID Detection Probabilities in the Presence of CFO and Strong Phase Noise in Sub-THz Bands**

Authors: Takashi Ohiwa, Yuki Mabuchi, Mamoru Sawahashi (Tokyo City University, Japan), Satoshi Nagata, Satoshi Suyama (NTT DOCOMO INC., Japan)

Abstract: This paper presents detection probabilities for the physical layer cell ID (PCID) in the presence of a large carrier frequency offset (CFO) and strong phase noise (PN) for the New Radio downlink in sub-terahertz (sub-THz) bands. In the sub-THz bands, CFO due to the frequency error of the local oscillator of a set of user equipment (UE) is large. The PN power becomes large because of the increase in uncorrelated Gaussian PN with high frequency components due to a significantly wide transmission bandwidth. We compare the PCID detection probabilities of PCID detection methods that employ two promising CFO estimation methods. Computer simulation results show that the PCID detection method using fractional frequency offset (FFO) estimation based on the autocorrelation using the cyclic prefix waveform and joint integer frequency offset (IFO) estimation with the primary synchronization signal (PSS) achieves a higher PCID detection probability than that using FFO estimation based on the cross-correlation of the PSS and joint IFO estimation with the secondary synchronization signal (SSS) sequence in the presence of a large CFO and strong PN in the sub-THz bands.

Parallel Session 2 - R1: Bale Banjar

Session Chair: Dr. Debasis Das

Paper	Authors
Increasing LoRa-like Physical Layer Capacity by Introducing Orthogonal Code	Harland Fitriadi Amin, Youki Kadobayashi, Yuzo Taenaka (Nara Institute of Science & Technology, Japan)
Design of a Rocket-Shaped 2D Photonic Crystal Coupler for Ultra-Compact 4x2 Encoder	Wafa Mehrez, Monia Najjar (University of Tunis El Manar, Tunisia)
A Study on Point Cloud Clustering for Geo-referenced Positioning using mmWave Radar Sensor	Daeseung Park. Jaemin Choi, Hojong Chang, Chae-Seok Lee (Korea Advanced Institute of Science and Technology, Korea (South))
Dynamic User Clustering for mmWave-Based NOMA Networks	Sudhakar Rai (IIT Kanpur, India), Ekant Sharma (Indian Institute of Technology Roorkee, India), Neeraj Varshney (National

	Institute of Standards and Technology, USA), Aditya K. Jagannatham (Indian Institute of Technology Kanpur, India)
PISTON: PUF-Integrated Secure, Throughput-Optimized Network Protocol for IoV	Koustav Kumar Mondal, Debasis Das (IIT Jodhpur, India), Ashi Gupta (NIT Patna, India), Debasis Das (IIT Jodhpur, India), Chun-I Fan (National Sun Yat-sen University, Taiwan)

15:30 PM **Increasing LoRa-like Physical Layer Capacity by Introducing Orthogonal Code**

Authors: Harland Fitriadi Amin, Youki Kadobayashi, Yuzo Taenaka (Nara Institute of Science & Technology, Japan)

Abstract: Currently, LoRa suffers from scalability issues, making it still far from a feasible option for LPWAN in large deployment scenarios. During Signal Transmission, no other signal employing the same Spreading Factor should be transmitted simultaneously, as this condition would render both signals unrecoverable. We proposed introducing orthogonal codes to the LoRa Physical layer. We demonstrated that the introduction of orthogonal codes significantly enhanced the signal recovery rate, achieving a Detection Error Rate (DER) of 99.5% for single-device scenarios and maintaining robust performance with an 85.33% DER for two devices per SF.

15:50 PM **Design of a Rocket-Shaped 2D Photonic Crystal Coupler for Ultra-Compact 4x2 Encoder**

Authors: Wafa Mehrez, Monia Najjar (University of Tunis El Manar, Tunisia)

Abstract: There is a growing need for computers and mo-bile devices to analyze and transmit data more quickly, driv-ing a growing interest in utilizing photonic crystals to develop advanced all-optical processors and communication systems. This study introduces an all-optical 4x2 encoder based on a triangular lattice photonic crystal structure. The device features four input waveguides and two output waveguides. The frequency modes and encoder design were analyzed using the plane wave expansion (PWE) method. Numerical analysis, simulations, and optimizations were conducted using the finite difference time domain (FDTD) technique. Operating at 1550 nm, the proposed encoder supports operations where only one input port is active at a time. It boasts a compact footprint of 129.6 μm^2, a rapid response time of 209 fs, and a high contrast ratio of 30.6 dB.

16:10 PM **A Study on Point Cloud Clustering for Geo-referenced Positioning using mmWave Radar Sensor**

Authors: Daeseung Park. Jaemin Choi, Hojong Chang, Chae-Seok Lee (Korea Advanced Institute of Science and Technology, Korea (South))

Abstract: In the field of urban safety, extensive research is being conducted on the application of mmWave radar sensors for both indoor and outdoor environments. These advanced sensing technologies are gaining attention due to their potential to enhance monitoring and response capabilities in complex urban settings.

Traditional CCTV-based geo-referenced positioning technology predicts Geographic coordinates data to enable real-time site response in the event of an incident. However, pixel-based relative geo-referenced methods of CCTV suffer from low recognition rates and precision due to terrain characteristics. mmWave radar sensors, in contrast, are minimally affected by weather conditions, use high frequencies in the 60-63 GHz range, and offer high precision. Additionally, these sensors can penetrate structures up to 15 cm thick. Despite these advantages, the number, shape, and position of recognized objects in three-dimensional space vary depending on the sensor installation angle and position, complicating the application of geo-referenced technology for accurate positioning. Consequently, mmWave radar sensors have not been widely utilized for positioning. This study proposed and implemented a geo-referenced positioning model using mmWave radar sensors to address these technical challenges. The proposed model employed a dimension transformation clustering technique based on orthogonal projection methods. Implementation and experimental results demonstrated that the average geo-referenced error using mmWave radar sensors was reduced to 3.5 cm, representing a 95.33% improvement in precision compared to traditional CCTV-based geo-referenced methods.

16:30 PM **Dynamic User Clustering for mmWave-Based NOMA Networks**

Authors: Sudhakar Rai (IIT Kanpur, India), Ekant Sharma (Indian Institute of Technology Roorkee, India), Neeraj Varshney (National Institute of Standards and Technology, USA), Aditya K. Jagannatham (Indian Institute of Technology Kanpur, India)

Abstract: This study focuses on the user clustering performance of millimeter-wave (mmWave) massive multiple- input multiple-output (MIMO) non-orthogonal multiple access (NOMA) networks. Two novel spectral and energy-efficient user clustering algorithms are proposed that exploit the similarity between user channels and condition number (CN) as the correlation index, toward dynamic selection of the number of clusters and number of users in each cluster, thus ensuring that the users in different clusters are spatially uncorrelated. Our simulation results demonstrate that the proposed user clustering techniques attain a 100% performance gain over a naive random clustering technique.

16:50 PM **PISTON: PUF-Integrated Secure, Throughput-Optimized Network Protocol for IoV**

Authors: Koustav Kumar Mondal, Debasis Das (IIT Jodhpur, India), Ashi Gupta (NIT Patna, India), Debasis Das (IIT Jodhpur, India), Chun-I Fan (National Sun Yat-sen University, Taiwan)

Abstract: This research introduces PISTON, a novel protocol designed to enhance the security, efficiency, and performance of Internet of Vehicles (IoV) networks. PISTON integrates advanced authentication mechanisms utilizing Physically Unclonable Functions (PUFs) and multifactor authentication with dynamic challenges and zero-knowledge proof-based authentication to ensure robust security and mitigate various cyber threats, including Denial-of-Service (DoS) attacks. The protocol further incorporates sleep-wake scheduling, priority-based scheduling, and adaptive modulation and coding to optimize network performance.

The communication overhead in PISTON is derived through a formula that incorporates latency, energy consumption, and throughput, demonstrating the protocol's efficiency in dynamic vehicular environments. Comparative analysis against existing protocols highlights PISTON's superiority in seamless handover, provable security, and DoS attack resilience. Experimental results show that PISTON reduces energy consumption by 30% and achieves 20% higher data throughput while maintaining low latency, essential for real-time IoV applications. The empirical findings underscore PISTON's advancements in establishing a new benchmark for future IoV deployments, ensuring secure, energy-efficient, low-latency, and high-throughput communication.

Parallel Session 2 - R2: Bale Paseban 2

Session Chair: Prof. Dr. Yafei Hou

Paper	Authors
Dual-Band Triple-Slot Microstrip Antenna for X-Band and Ku-Band Communication	Muhammad Danny Naufal Syach, Catur Apriono (Universitas Indonesia, Indonesia), Aditya Inzani Wahdiyat (National Research and Innovation Agency, Indonesia)
Spectral Efficiency Analysis for Grant-Free Random Access Cell-Free Massive MIMO with Ricean Fading	Shuai Xiao, Pei Liu (Wuhan University of Technology, China), Qi Zhang (Nanjing University of Posts and Telecommunications, China), Jie Ding (Deakin University, Australia), Jinho Choi (The University of Adelaide, Australia)
Overloaded Multi-User MIMO With Receive Spatial Filters	Kosuke Ota, Satoshi Denno, Yafei Hou (Okayama University, Japan)
Secrecy Analysis of RIS-Aided mmWave Systems over Independent Fluctuating Two-Ray Fading Channels	Phuc V. Trinh, Shinya Sugiura (The University of Tokyo, Japan)
Investigation of Reconfigurable Intelligent Surface for Millimeter-Wave Coverage Enhancement	Xiang Li, Xin Wang, Xiaolin Hou, Lan Chen (DOCOMO Beijing Communications Laboratories Co, China)

15:30 PM **Dual-Band Triple-Slot Microstrip Antenna for X-Band and Ku-Band Communication**

Authors: Muhammad Danny Naufal Syach, Catur Apriono (Universitas Indonesia, Indonesia), Aditya Inzani Wahdiyat (National Research and Innovation Agency, Indonesia)

Abstract: This paper presents the design and optimization of a dual-band triple-slot rectangular microstrip antenna for X-band (8.60 GHz) and Ku-band (13.89 GHz) applications. The primary objective is to enhance satellite communication and radar system performance by achieving efficient dual-band operation with significant improvements in key performance metrics. The antenna is fabricated using a Rogers Duroid 5880 substrate, which offers a dielectric constant of 2.2 and a thickness of 1.6 mm, reducing dielectric losses and improving overall efficiency.

The inclusion of a Defected Ground Structure (DGS) further enhances bandwidth and radiation efficiency. Simulation results show substantial improvements, with return loss values of -16.24 dB at 8.33 GHz and -38.45 dB at 13.89 GHz, and a gain of 4.959 at X-band and 5.149 dBi at Kuband. These results demonstrate efficient impedance matching, minimal signal loss, and improved radiation patterns, making the design well-suited for advanced communication applications in satellite and radar systems.

15:50 PM **Spectral Efficiency Analysis for Grant-Free Random Access Cell-Free Massive MIMO with Ricean Fading**

Authors: Shuai Xiao, Pei Liu (Wuhan University of Technology, China), Qi Zhang (Nanjing University of Posts and Telecommunications, China), Jie Ding (Deakin University, Australia), Jinho Choi (The University of Adelaide, Australia)

Abstract: The spectral efficiency in cell-free massive MIMO with grant-free random access under Ricean fading, utilizing a linear maximal-ratio combining detector, is the focus of this paper. Firstly, explicit expressions for the effective signal-to-interference-plus-noise ratio (SINR) are introduced, using the least squares (LS) and minimum mean squared error (MMSE) estimation methods, valid for varying Ricean K-factor and for varying numbers of access point antennas M. Furthermore, we drive the asymptotic SINR expressions under extreme conditions of infinite Ricean K-factor, infinite M, and the appropriate scaling of the users' power. The corresponding analysis shows that as M approaches infinity, the sum uplink rate converges to log 2 M, regardless of the Ricean K-factor. Particularly, in the case of LS estimation, reducing each user's transmit power by $1/\sqrt{M}$ maintains the rate, converging to a definitive value irrespective of the Ricean K-factor. In the case of MMSE estimation, power is able to be scaled down by $1/\sqrt{M}$ to achieve it when Ricean K-factor is zero, whereas the power of nonzero Ricean K-factor necessitates a reduction by 1/M. Finally, simulations confirm all theoretical outcomes.

16:10 PM **Overloaded Multi-User MIMO With Receive Spatial Filters**

Authors: Kosuke Ota, Satoshi Denno, Yafei Hou (Okayama University, Japan)

Abstract: This paper proposes overloaded multi-user multiple-input-multiple-output (MU-MIMO) that is able to increase network throughput by increasing the number of the signal streams to more than that of receive antennas. The spatial filter is employed at each user for such spatial multiplexing. In addition, the proposed overloaded MU-MIMO applies the non-linear precoding with the lattice reduction for improving the transmission performance with low computational complexity. The use of the non-linear precoding can simplify the receiver configuration where amplifiers and the spatial filters are only needed. Computer simulation shows that the proposed overloaded MU-MIMO can double not only the user throughput but also the network throughput compared with the conventional MU-MIMO based on the block diagonalization (BD). In spite of the superior throughput enhancement, the proposed overloaded MU-MIMO achieves 13 dB better transmission performance than the conventional MU-MIMO at the BER of 10^{-4}.

16:30 PM **Secrecy Analysis of RIS-Aided mmWave Systems over Independent Fluctuating Two-Ray Fading Channels**

Authors: Phuc V. Trinh, Shinya Sugiura (The University of Tokyo, Japan)

Abstract: In this paper, we examine a millimeter-wave (mmWave) wiretap scenario where a multiple-antenna base station (Alice) communicates with a legitimate user (Bob) via a reconfigurable intelligent surface, while multiple colluding eavesdroppers (Eves) attempt to passively intercept the communications using the maximal-ratio combining scheme. We develop a framework for achieving the maximum effective secrecy throughput (EST) that meets both reliability and secrecy constraints. Firstly, we derive a generalized and tractable form of the independent fluctuating two-ray (IFTR) distribution for accurately modeling mmWave fading channels. Secondly, we propose a novel approximation method to statistically characterize the end-to-end channels, considering the phase-shift estimation errors at both Bob and the colluding Eves over the IFTR channels. Finally, we derive a new closed-form EST metric and its asymptotic expression.

16:50 PM **Investigation of Reconfigurable Intelligent Surface for Millimeter-Wave Coverage Enhancement**

Authors: Xiang Li, Xin Wang, Xiaolin Hou, Lan Chen (DOCOMO Beijing Communications Laboratories Co, China)

Abstract: Reconfigurable intelligent surfaces (RISs) for coverage enhancement in millimeter-wave bands are investigated through system-level simulations. A large-scale RIS model is developed to approximate the forwarding beam pattern in both far-field and near-field conditions, and a pragmatic low-complexity RIS assignment procedure is considered. The impacts of RIS in regular cellular scenarios and those with blind-spot areas are compared. This study identifies that a substantial portion of users benefit from RIS deployment; RIS-induced interference is generally negligible, except in rare cases; and strategically deploying small- to medium-sized RISs effectively addresses blind-spot coverage.

Parallel Session 2 – R3: Bale Paseban 3

Session Chair: Prof. Noor Zaman Jhanjhi

Paper	Authors
Study on the Role of Adaptive Power Control in Jamming Mitigation for Remote Keyless Entry Systems	Hamza Alkofahi (Jordan University of Science and Technology, Jordan), Amani Altarawneh (Tennessee Tech University, US)
Multi-dimensional Quality of Experience for Customized User Requirements	Yingzhi Liu, Mulei Ma, and Chenyu Gong (HKUST(GZ), China), Yang Yang (HKUST(GZ), Peng Cheng Laboratory, and Terminus Group, China)
DL-based Satellite Image Segmentation for Improved Situational Awareness in Defense Operations	Dhruv Sarju Thakkar, Kavya Alpit Patel, Rajesh Gupta, Sudeep Tanwar (Institute of Technology, Nirma University, India), N.Z

	Jhanjhi, Sayan Kumar Ray (Taylor's University, Malaysia)
Multi-objective Hierarchical Task Offloading in IoV: an Attentive Multi-agent DRL Approach	Chenhao Wu, Jiang Liu, Kazutoshi Yoshii, Shigeru Shimamoto (Waseda University, Japan)
A Software-Defined Reconfigurable Battery System Prototype	Siyu Jin (Tsinghua University and ShanghaiTech University, China), Baochang Liu (Tsinghua University, China), Yanglin Zhou, Song Ci (Tsinghua University, China), Junrui Liang (ShanghaiTech University, China)

15:30 PM **Study on the Role of Adaptive Power Control in Jamming Mitigation for Remote Keyless Entry Systems**

Authors: Hamza Alkofahi (Jordan University of Science and Technology, Jordan), Amani Altarawneh (Tennessee Tech University, US)

Abstract: Remote keyless entry (RKE) systems have become a standard feature in modern vehicles, offering the convenience of wireless control. However, this convenience is accompanied by significant security vulnerabilities, particularly susceptibility to jamming attacks. These attacks disrupt communication between the key fob and the vehicle, potentially leading to unauthorized access and vehicle theft. This study investigates the effectiveness of adaptive power control as a countermeasure to jamming attacks on RKE systems and examines the influence of jammer placement on data transmission success rates. We conducted experiments using a custom-built jammer, transmitter, and receiver to simulate real-world scenarios. Our findings demonstrate that jammer proximity significantly affects transmission success, and while increasing key fob power can initially mitigate jamming, its effectiveness diminishes beyond a certain threshold.

15:50 PM **Multi-dimensional Quality of Experience for Customized User Requirements**

Authors: Yingzhi Liu, Mulei Ma, and Chenyu Gong (HKUST(GZ), China), Yang Yang (HKUST(GZ), Peng Cheng Laboratory, and Terminus Group, China)

Abstract: Designing an everyone-centric customized service system is a crucial stage in the intelligent transformation of the digital world. As such, Quality of Experience (QoE) for user requirements design has become an essential research topic. Among the existing works, part of them assumes user requirements through ideal distributions. Another portion uses real-world data, but they analyze it from the system side. Both do not give a pervasive description of user requirements to support future research efforts. To tackle the above challenges, based on the Service Requirements Zone (SRZ), we propose an extended integrated multi-dimensional QoE, Acceptable Performance Zone (APZ), which includes both preferred and acceptable user requirements. We also detail the eight Key Performance Indicators (KPIs) in the SRZ. To provide more math support to the user requirements, we adopt real-world cluster trace datasets from Alibaba for analysis, aiming to explore the characteristics of real-world user requirements. The results show that the characteristics of user tasks generally obey some specific

distributions. Specifically, the task size and memory requirement both follow bimodal log-Gaussian distributions, whereas the delay and computing requirements follow unimodal log-Gaussian distributions. At the same time, the energy consumption follows the log-beta distribution.

16:10 PM **DL-based Satellite Image Segmentation for Improved Situational Awareness in Defense Operations**

Authors: Dhruv Sarju Thakkar, Kavya Alpit Patel, Rajesh Gupta, Sudeep Tanwar (Institute of Technology, Nirma University, India), N.Z Jhanjhi , Sayan Kumar Ray (Taylor's University, Malaysia)

Abstract: In dynamic defense operations, satellite imagery has a major role in offering crucial insights into geographical landscapes and possible dangers. Satellite imagery provides an aerial view of the battlefield environment, which helps strategically improve decision-making. The proposed framework makes use of deep learning techniques to segment satellite images into particular regions. The image is segmented into different classes, such as land, buildings, roads, vegetation, and water. The combination of the segmentation model with a comprehensive situational awareness framework allows military personnel in analyzing terrain, identification of infrastructure, and detection of anomalies. This helps improve operational effectiveness and rapid response in dynamic battlefield environments.

16:30 PM **Multi-objective Hierarchical Task Offloading in IoV: an Attentive Multi-agent DRL Approach**

Authors: Chenhao Wu, Jiang Liu, Kazutoshi Yoshii, Shigeru Shimamoto (Waseda University, Japan)

Abstract: In most Internet of Vehicles (IoV) scenarios, intelligent vehicle terminals are required to cope with a multitude of heterogeneous tasks, each of which is subject to increasingly strict constraints on delay and energy consumption. Task offloading is an efficient way to tackle this issue. However, due to performance constraints, a single or two-tier offloading strategy can not enable fine-grained task allocation and flexible service deployment. To address the above problems, we propose a collaborative cloud-edge-end task offloading scheme for IoV scenarios. Since traditional single-agent Deep Reinforcement Learning (DRL) makes it difficult to coordinate multiple objectives of dynamic services simultaneously, we propose a task offloading strategy based on multi-agent Deep Deterministic Policy Gradient (DDPG), to jointly consider service delay and energy consumption. We further introduce attentive experience replay (AER) to mitigate the issue of insufficient experience sampling in the DDPG algorithm caused by the catastrophic forgetting problem. Through simulation of IoV scenarios, our proposed model significantly enhances task offloading effectiveness and concurrently reduces delay by 10.6% and energy consumption by 8.1% compared to other state-of-the-art baseline algorithms.

16:50 PM **A Software-Defined Reconfigurable Battery System Prototype**

Authors: Siyu Jin (Tsinghua University and ShanghaiTech University, China), Baochang Liu (Tsinghua University, China), Yanglin Zhou, Song Ci (Tsinghua University, China), Junrui Liang (ShanghaiTech University, China)

Abstract: In the energy internet era, distributed energy storage systems will be widely used in various industrial, commercial, and residential scenarios. However, the modeling of energy flow and the digital flow of information operate on different temporal and spatial scales in traditional energy storage systems, lacking deep integration between energy flow and information flow. This prevents it from completely addressing the complex battery cell balancing and low safety issues in current distributed energy storage systems. The proposal of software-defined energy storage provides a new approach to solve the inherent problems in the battery industry by introducing the idea of internet shielding terminal differences into energy storage system. We proposed a software-defined reconfiguration battery system (SRBS) in this paper, which can manage different types of energy storage media to adapt to varying loads and operating conditions. Energy-type batteries, power-type batteries, and supercapacitors are integrated together to form an efficient and safe energy storage and power supply system. The hardware architecture and software control method of SRBS are described in detail. Finally, a real-world prototype is charged and discharged to show the successful coexistence and operation of different energy storage media within a single system.

Parallel Session 4 – R4: Bale Paseban 4

Session Chair: Dr. Zhongyang Yu

Paper	Authors
Optimal Coding Scheme Selection for LoRa-Based Satellite IoT Transmission	Zhongyang Yu and Yuqian Yan (Henan University of Engineering, China), Lingxi Guo (North China University of Water Resources and Electric Power, China), Wei Wang, Mengmeng Xu, Hengzhou Xu, Hai Zhu (Henan University of Engineering, China)
Enhanced Resource Allocation for Beam-Hopping Satellite Networks with Rate-Splitting Multiple Access	Chengchao Liang (Carleton Univ., Canada and Chongqing Univ. Posts & Telecom, China), Yuran Huang, Yidian Liu, Rong Chai, Qianbin Chen (Chongqing Univ. Posts & Telecom, China)
Performance Enhancement of ATSC3.0 Using Polarization Property and Frequency Symbol Spreading	Yudai Handa, Kosuke Tamura, Hiroya Hayakawa, Riku Tanaka, Jaesang Cha, Chang-Jun Ahn (Chiba University, Japan)
Optimizing Time Slot Allocation in LEO Satellite Beam Hopping for Uneven Traffic Demands	Satya Chan (ETRI, Korea)
Interference evaluation between HAPS and neighboring HAPS considering overlapped ground service cove	Hyunduk Kang, Ho-kyung Son (Electronics and Telecommunications Research Institute, South Korea)

15:30 PM **Optimal Coding Scheme Selection for LoRa-Based Satellite IoT Transmission**

Authors: Zhongyang Yu and Yuqian Yan (Henan University of Engineering, China), Lingxi Guo (North China University of Water Resources and Electric Power, China), Wei Wang, Mengmeng Xu, Hengzhou Xu, Hai Zhu (Henan University of Engineering, China)

Abstract: Considering the extremely low signal-to-noise ratio (SNR) environment in future satellite internet of Things (IoT) transmission in which the traditional Hamming coded LoRa (Long Range) system in the ground IoT communication is of difficulty to guarantee high reliability, optimal coding scheme selection for the LoRa-based satellite IoT is studied for the first time. In specific, the corresponding system model is described in detail, followed by derivations of two noncoherent detection methods of coded LoRa signals. Subsequently, the channel capacity of the coded LoRa system is provided and used to develop the corresponding relationship between the signal-to-noise ratio (SNR) and the code rate. Based on the obtained relationship and the Monte-Carlo method, it is found that the coded LoRa system with different spreading factors (SFs) can achieve the lowest SNR when the code rate is close to 1/2. Finally, the performance of several coded LoRa systems (including Hamming code, BCH code, RS code, Turbo code, LDPC code and LDGM code with code rates of about 1/2) is compared by means of the Monte-Carlo method. Simulation results show that Turbo or LDPC coded LoRa systems exhibit more than 4.5dB performance advantages over the Hamming coded LoRa system.

15:50 PM **Enhanced Resource Allocation for Beam-Hopping Satellite Networks with Rate-Splitting Multiple Access**

Authors: Chengchao Liang (Carleton Univ., Canada and Chongqing Univ. Posts & Telecom, China), Yuran Huang, Yidian Liu, Rong Chai, Qianbin Chen (Chongqing Univ. Posts & Telecom, China)

Abstract: Low Earth Orbit (LEO) satellite systems provide geographically unrestricted services to ground users. However, the conflict between existing resource allocation schemes and the variability of inter-beam traffic is becoming increasingly prominent. To address this issue, this paper proposes a resource allocation strategy for beam-hopping satellite networks based on Rate-Splitting Multiple Access (RSMA) technology, aiming to reduce co-channel interference while improving system resource utilization. First, by analyzing the resource allocation challenges faced by beam-hopping satellite networks, including low spectrum utilization and co-channel interference, the background and motivation for the proposed strategy are provided. Next, RSMA technology is introduced, dividing user messages into common and private parts, and a corresponding resource allocation algorithm is designed to enhance spectrum utilization and reduce co-channel interference. Through the construction of a system model and simulation experiments, the effectiveness and performance advantages of the proposed strategy are verified. This study provides new ideas and methods for resource allocation in beam-hopping satellite networks, which is significant for improving system performance and service quality.

16:10 PM **Performance Enhancement of ATSC3.0 Using Polarization Property and Frequency Symbol Spreading**

Authors: Yudai Handa, Kosuke Tamura, Hiroya Hayakawa, Riku Tanaka, Jaesang Cha, Chang-Jun Ahn (Chiba University, Japan)

Abstract: In recent years, advanced television systems committee (ATSC) 3.0 has been developed, and 4K ultra-high-definition and simultaneous multiple high-definition broadcasting services have soft-landed. A unique transmitter identification (TxID) sequence is assigned with long spread coding to mitigate the inference of the broadcasting signal. In this case, the achievable data transmission rate is limited. Currently, to increase the transmission rate of data signal as a TxID, various researches are conducted. In this paper, we propose a novel method to suppress interference in data communications by using cross-polarization discrimination (XPD) property. The proposed system can reduce the inference from both of the broadcasting signal and TxID signal using polarization property. Therefore, the proposed system can enhance the data transmission rates without causing the interference to the broadcasting signal.

16:30 PM **Optimizing Time Slot Allocation in LEO Satellite Beam Hopping for Uneven Traffic Demands**

Authors: Satya Chan (ETRI, Korea)

Abstract: This paper investigates beam hopping (BH) in a multibeam low Earth orbit (LEO) satellite system, addressing the challenges posed by uneven traffic demand (TD) distributions across different cells. Traditional approaches, such as the largest queue policy (LQP)-based greedy algorithm, often fail to adequately serve cells with lower traffic demands, leading to inefficiencies and potential service failure. In response, we propose a modified BH algorithm that prioritizes cells without assigned time slots before applying the LQP-based greedy approach, ensuring more equitable time slot allocation. The proposed method enhances the adaptability of the system to varying TD distributions while maintaining computational efficiency. Through simulation, we demonstrate that our approach achieves a 100% time slot allocation success rate across all cells, significantly improving system performance compared to the conventional LQP-based algorithm. This research provides a foundation for future work aimed at developing low-complexity methods for optimizing resource allocation in LEO satellite systems.

16:50 PM **Interference evaluation between HAPS and neighboring HAPS considering overlapped ground service cove**

Authors: Hyunduk Kang, Ho-kyung Son (Electronics and Telecommunications Research Institute, South Korea)

Abstract: A High Altitude Platform Station (HAPS) is known as one of the promising solutions that can enlarge service coverage of current mobile communication systems. We evaluate interference in the overlapped ground service coverage deployed by HAPS and neighboring HAPS operating on the typical spherical cap. The probability of interference is derived based on various parameters such as the

distance between the typical ground user and neighboring HAPS, the distance (i.e., arc length) between HAPS and neighboring HAPS on the spherical cap, and the elevation angle and the Earth-centered zenith angle of neighboring HAPS. Numerical results demonstrate the impact of these parameters on interference probability, highlighting the need for careful consideration in deploying both HAPS in the air and their ground service coverage.

Technical Paper

Session-Parallel Session Day 2: November 6th, 2024

Parallel Session 3 - R1: Bale Banjar

Session Chair: Dr. Madhusudhan Mishra

Paper	Authors
MFeRNet: A Deep CNN Approach for Detecting Median Filter Tampering in Re-Compressed Images	Vijayakumar Kadha (Amaravati Campus, India), Kamireddy Rasool Reddy (NRI Institute of Technology (Autonomous), India), Santos Kumar Das (National Institute of Technology Rourkela, Rourkela, India), Madhusudhan Mishra (North Eastern Regional Institute of Science and Technology, India)
Multi-Feature Based Client Selection and Feature Weight Update for Volatile Federated Learning	Yanyu Liu, Qiang Wang (Beijing University of Posts and Telecommunications, China), Wenqi Zhang, Chen Sun (Sony (China) Research Laboratory, China)
Integrating AI with Robotic Process Automation (RPA): Advancing Intelligent Automation Systems	Chua JingXuan, Muhammad Tayyab, Syeda Mariam Muzammal, N. Z. Jhanjhi, Sayan Kumar Ray, Farzeen Ashfaq (Taylor's University, Malaysia)
AI-based Approach for Radio Frequency Jamming Attack Detection in Unmanned Aerial Vehicles	Jetani Harshil, Harikrushna Goti, Nikunjkumar Mahida, Rajesh Gupta, Sudeep Tanwar (Nirma University, India), Geetika Bhardwaj (Guru Nanak Dev Engineering College, India), N.Z Jhanjhi, Sayan Kumar Ray (Taylor's University, Malaysia)
One-shot Data Adaptive Semantic Communication for Image Transmission	Shiqi Cheng, Xuefei Zhang, Qimei Cui, Kechen Chen (Beijing University of Posts and Telecommunications, China)

10:50 AM **MFeRNet: A Deep CNN Approach for Detecting Median Filter Tampering in Re-Compressed Images**

Authors: Vijayakumar Kadha (Amaravati Campus, India), Kamireddy Rasool Reddy (NRI Institute of Technology (Autonomous), India), Santos Kumar Das (National Institute of Technology Rourkela, Rourkela, India), Madhusudhan Mishra (North Eastern Regional Institute of Science and Technology, India)

Abstract: The utilisation of median filtering (MF), a nonlinear signal processing technique, offers distinct advantages within picture anti-forensics. Consequently, there has been an increased focus on the forensic investigation of MF. However, due to lossy compression, identifying MF in the compressed domain is challenging. Towards

this, research presents a novel approach for forensic analysis of MF in compressed images based on utilising deep noise residuals. In this framework, median filtering residuals (MFR) are employed to preprocess the images by passing through two streams. After that, the MFR output is extended to encompass two parallel blocks with different dilation rates to form a fusion feature vector. Further, the MFeRNet framework incorporates convolution, specifically developed to enhance information integration from several streams compared to conventional techniques. The proposed method, MFeRNet, aims to effectively integrate the three-level information of an image and comprehensively extract forensic clues in a compressed scenario. In addition, the experimental results demonstrate that the proposed methodology exhibits superior performance and reduced training time compared to the early reported techniques with equivalent convolution depth.

11:10 AM **Multi-Feature Based Client Selection and Feature Weight Update for Volatile Federated Learning**

Authors: Yanyu Liu, Qiang Wang (Beijing University of Posts and Telecommunications, China), Wenqi Zhang, Chen Sun (Sony (China) Research Laboratory, China)

Abstract: This paper investigates a novel client selection for the volatile Federated Learning (FL) systems, where volatility means that the state of the client set, client datasets, and client training status will change over time. We study how to select clients dynamically to mitigate the volatility. Particularly, the volatile client selection problem is formulated as a classification problem, and we propose two new metric features. The Multi-Feature Volatile Client Selection (MFVCS) algorithm, which considers client training capacity, client-weighted data quality, and client historical selection entropy, is proposed to solve the volatile client selection problem. Moreover, we have developed an adaptive dynamic weighting algorithm that allows for dynamic updating of the weight for each feature. We propose a volatility ratio to measure client volatility. The experimental results indicate that the proposed algorithm demonstrates strong robustness and better performance under different volatility ratios of the client set. In particular, the proposed MFVCS algorithm improves the model accuracy at most by 9.2%, 9.6% and 12.5% under 0.01 volatility ratio, 0.05 volatility ratio and 0.1 volatility ratio, respectively.

11:30 AM **Integrating AI with Robotic Process Automation (RPA): Advancing Intelligent Automation Systems**

Authors: Chua JingXuan, Muhammad Tayyab, Syeda Mariam Muzammal, N. Z. Jhanjhi, Sayan Kumar Ray, Farzeen Ashfaq (Taylor's University, Malaysia)

Abstract: The quick progress of technology has greatly influenced multiple industries, with Artificial Intelligence (AI) and Robotic Process Automation (RPA) leading the way in this transformation. When combined, these technologies can improve business procedures, increase productivity, and lower operational expenses in various sectors. The primary goal of this task is to examine how AI technologies can be incorporated into current RPA frameworks to promote the development of intelligent automation systems. These improved systems are created to not just complete specific tasks but also to autonomously make decisions and flexibly optimize operations. This research aims to link AI theoretical models with their

practical uses in RPA, highlighting recent advancements and predicting future trends in AI-driven RPA solutions.

11:50 AM **AI-based Approach for Radio Frequency Jamming Attack Detection in Unmanned Aerial Vehicles**

Authors: Jetani Harshil, Harikrushna Goti, Nikunjkumar Mahida, Rajesh Gupta, Sudeep Tanwar (Nirma University, India), Geetika Bhardwaj (Guru Nanak Dev Engineering College, India), N.Z Jhanjhi, Sayan Kumar Ray (Taylor's University, Malaysia)

Abstract: Unmanned Aerial Vehicles (UAV) are highly versatile systems with applications expanding in various fields, for instance, Surveillance, Reconnaissance, Disaster Response, Agriculture, and many more. Although UAVs have many important advantages over conventional manned aircraft, such as cheaper operating costs and a lower risk for human pilots, their vulnerability to Radio Frequency (RF)-jamming poses a substantial risk to navigation and communication systems by disrupting signals. UAVs depend on remote control and autonomous operations. These attacks are concerning in many application areas. Communication and navigation play crucial roles in these autonomous systems. This paper aims to explore different deep-learning algorithms for the detection of RF-jamming attacks in UAVs. A comparison analysis is conducted to evaluate five distinct architectures using conventional evaluation metrics criteria comprising accuracy, precision, recall, confusion matrices, and the area under the ROC curve. These comparative analyses helped in selecting an accurate architecture for the definition, RNN architecture gave an impressive accuracy of 93% and demonstrated a superior performance than other architectures. This paper aims to strengthen RF-jamming detection systems in UAVs to enhance their safety and operational reliability in several scenarios.

12:10 PM **One-shot Data Adaptive Semantic Communication for Image Transmission**

Authors: Shiqi Cheng, Xuefei Zhang, Qimei Cui, Kechen Chen (Beijing University of Posts and Telecommunications, China)

Abstract: Semantic communications rely on deep neural networks (DNNs) to reduce the amount of transmitted data by only transmitting the semantics of data rather than the whole data, showing the potential on image transmission even in low signal-to-noise-ratio (SNR) conditions. However, the performance deficiency happens once the real-time data do not follow the independent identical distribution (i.i.d) with the training dataset, which results from the poor generalization of DNNs. To tackle this problem, a promising solution is to align the real-time data to follow the similar distribution with the training dataset at the feature level. Thus, we propose a one-shot data adaptive semantic communication (ODASC), where domain adaptation is incorporated as a pre-processing module to cope with domain shift by aligning the distribution between the real-time data and the training dataset. Image transmission is considered as a case study to demonstrate the big plus of ODASC on data recovery and task accuracy.

Parallel Session 3 – R2: Bale Banjar

Session Chair: Dr. Pei Liu

Paper	Authors
LoRa Microstrip Antenna with DGS and Truncated Corner Structure for CubeSat	Marisa Putri Supriadi, Edwar Edwar, Khilda Afifah, Dio Widiantono, Puput Nurfaidah Taufik, Syachrul Gibran Muzhaffar, Tania Aprilya Fatimatudzahra, Nita Hanifah (Telkom University, Indonesia)
MSE-Aware Performance Analysis in Multi-Cell Massive MIMO Systems Over Rician Fading	Yihang Sun, Shuai Xiao, Kehao Wang (Wuhan University of Technology, China), Pei Liu (Wuhan University of Technology Advanced Engineering Technology Research Institute of Zhongshan City, China), Xinghua Sun (Sun Yat-sen University, China)
Performance Evaluation of mmWave Terminal Cooperative Communications Using Directional Antennas	Hiraku Okada, Yiche Li, Chedlia Ben Naila (Nagoya University, Japan)
Sidelobe Suppression in Antenna Array via Amplitude Tapers for Ku-band Internet of Things Satellites	Muhammad Athallah Adriansyah, Catur Apriono (Universitas Indonesia, Indonesia), Aditya Inzani Wahdiyat (National Research and Innovation Agency, Indonesia)
Experimental Performance of Null-Space Expanded MIMO Reception Technique	Shohei Kobayashi, Yuki Ohi, Hidekazu Murata (Yamaguchi University, Japan), Makoto Taromaru (Fukuoka University, Japan), Tatsuhiko Iwakuni, Daisei Uchida, Takafumi Fujita (NTT Corporation, Japan)

10:50 AM **LoRa Microstrip Antenna with DGS and Truncated Corner Structure for CubeSat**

Authors: Marisa Putri Supriadi, Edwar Edwar, Khilda Afifah, Dio Widiantono, Puput Nurfaidah Taufik, Syachrul Gibran Muzhaffar, Tania Aprilya Fatimatudzahra, Nita Hanifah (Telkom University, Indonesia)

Abstract: The development of CubeSat is currently experiencing a rapid increase. One of the growing missions is the space-based Internet of Things (IoT) network using LoRa protocol. The antenna installed on the spacecraft is essential for receiving data from sensors. Compact and adaptable microstrip antennas are commonly used in this design. This study has investigated a microstrip antenna design that incorporated the truncated corner and defected ground structure (DGS) method to improve the antenna performance. Its shape was designed to fit the CubeSat form factor. The antenna is working at 922 MHz of frequency. The experiment result showed that the antenna has return loss of 12.746 dB, 12 MHz of bandwidth, and 1.8 of VSWR. It produces bi-directional beam pattern that has 1.14 dBi of gain

with elliptical polarization. The antenna has been integrated with a LoRa module and a range test has been conducted to validate the antenna performance. The result was the antenna was able to communicate with the other LoRa module.

11:10 AM **MSE-Aware Performance Analysis in Multi-Cell Massive MIMO Systems Over Rician Fading**

Authors: Yihang Sun, Shuai Xiao, Kehao Wang (Wuhan University of Technology, China), Pei Liu (Wuhan University of Technology Advanced Engineering Technology Research Institute of Zhongshan City, China), Xinghua Sun (Sun Yat-sen University, China)

Abstract: The performance of mean square error (MSE) in channel estimation for multi-cell massive multiple-input multiple-output (MIMO) systems with Rician fading is studied. In this report, we initially derive the closed-form expressions of the probability distribution function and cumulative distribution function of MSE, which are applicable for any number of base-station antennas M and any Rician K-factor. Furthermore, we perform an asymptotic analysis for both strong line-of-sight (LOS) and Rayleigh fading scenarios. Subsequently, we present closed-form expressions for the expectation of MSE (Expmse) and the variance of MSE. Next, utilizing maximal-ratio combining detector, we investigate the relationship between achievable downlink spectral efficiency and Expmse. It is observed that as Expmse increases, the achievable downlink spectral efficiency constantly reduces, eventually reaches a given constant. Finally, Monte-Carlo simulations are performed to corroborate the results discussed earlier.

11:30 AM **Performance Evaluation of mmWave Terminal Cooperative Communications Using Directional Antennas**

Authors: Hiraku Okada, Yiche Li, Chedlia Ben Naila (Nagoya University, Japan)

Abstract: This study focuses on an uplink terminal cooperative wireless communication system that provides high-speed and stable communications in Beyond 5G/6G technologies. This system involves sharing mobile station (MS) information among multiple cooperating terminals (Helpers) using millimeter wave (mmWave) wireless communication with directional antennas. We evaluated the influence of directional antennas on the number of Helpers. Simulation results show that directional antennas can increase the number of Helpers as the number of MSs increases. In addition, for a larger number of MSs, directional antennas enable increased inter-terminal distances.

11:50 AM **Sidelobe Suppression in Antenna Array via Amplitude Tapers for Ku-band Internet of Things Satellites**

Authors: Muhammad Athallah Adriansyah, Catur Apriono (Universitas Indonesia, Indonesia), Aditya Inzani Wahdiyat (National Research and Innovation Agency, Indonesia)

Abstract: This study provides an in-depth analysis of the impact of different amplitude distributions on sidelobe level (SLL) suppression in Ku-band Internet of Things (IoT) satellite antenna arrays. Key findings reveal that distributions such as Chebyshev and Taylor achieve significant reductions in sidelobe levels, lowering

SLL by up to 30 dB compared to the baseline uniform distribution, while maintaining respectable gain levels of 27.8 dBi and 27.2 dBi, respectively. A comprehensive comparison is conducted across uniform, cosine, cosine squared, binomial, Chebyshev, and Taylor amplitude distributions, evaluating their influence on critical performance metrics, including SLL, gain, and half-power beamwidth (HPBW). Notably, the cosine squared distribution achieved the highest sidelobe suppression at -30.6 dB, although with trade-offs in gain and beamwidth. These results underscore the importance of selecting appropriate amplitude distributions to enhance communication reliability and minimize interference in IoT satellite systems operating in the Ku-band. The insights gained from this study contribute to the ongoing optimization of antenna array designs for high-performance satellite communication in emerging IoT applications.

12:10 PM **Experimental Performance of Null-Space Expanded MIMO Reception Technique**

Authors: Shohei Kobayashi, Yuki Ohi, Hidekazu Murata (Yamaguchi University, Japan), Makoto Taromaru (Fukuoka University, Japan), Tatsuhiko Iwakuni, Daisei Uchida, Takafumi Fujita (NTT Corporation, Japan)

Abstract: This research focuses on multiple-input multiple-output signal separation in environments with changing channels, such as mobile communications. When separating linear signals by fixing combining weights to packets, the orthogonality between interfering signals and combining weights is broken due to the movement of the receiver, resulting in interference leakage. To suppress such degradation, we use the null-space expansion technique in the frequency-domain, assuming that there are extra antennas at the receiver side. This technique improves channel time-varying immunity by using extra receiving antennas to form a null space that suppresses interference between streams. Experiments evaluated the performance of the fluctuation tolerance when combining weights were applied to the entire packet.

Parallel Session 3 - R3: Bale Paseban 3

Session Chair: Dr. Roopa Manjunatha

Paper	Authors
A Review on Near-Field Communications for 6G and Beyond	The Vi Nguyen, Thi My Tuyen Nguyen, Thanh Phung Truong, Sungrae Cho (Chung-Ang University, Korea (South))
Investigation on Information Set Optimization of Polar Codes Using Concatenated NNDs	Tsukasa Bando, Nobuhiko Miki (Kagawa University, Japan), Satoshi Suyama, Satoshi Nagata (NTT DOCOMO, INC., Japan)
Human-Blockage Comparison Between SHF and UHF Bands: A Reciprocating Motion Pedestrian Case	Shotaro Shigenaga, Xin Du, and Hidekazu Murata (Yamaguchi University, Japan), Satoshi Suyama, Huiling Jiang (NTT DOCOMO, INC, Japan)

Dynamic Resource Allocation in Cell-Free MEC: Leveraging Attention Mechanism with MADDPG	Fitsum Debebe Tilahun, Chung G. Kang ((Korea University, Korea (South))
Generalization Performance of Deep Learning-based Multi-User Detection for GF-SCMA Systems	Metasebia D. Gemeda, Chung G. Kang (Korea University, Seoul, Republic of Korea), Minsig Han, Ameha T. Abebe (Samsung Research, Seoul, Republic of Korea)

10:50 AM **A Review on Near-Field Communications for 6G and Beyond**

Authors: The Vi Nguyen, Thi My Tuyen Nguyen, Thanh Phung Truong, Sungrae Cho (Chung-Ang University, Korea (South))

Abstract: Recently, there has been a growing interest in exploring new multi-antenna technologies for 6G wireless networks, including the use of extremely large-scale antenna arrays, tremendously high frequencies, and novel antenna technologies. These emerging trends introduce unique characteristics that cannot be adequately addressed by classical far-field communication techniques with planar wavefronts. As a result, there is a need to investigate near-field communication design with spherical wavefronts. In this paper, we present a comprehensive overview of near-field communications, focusing on basic concepts, applications, and future directions.

11:10 AM **Investigation on Information Set Optimization of Polar Codes Using Concatenated NNDs**

Authors: Tsukasa Bando, Nobuhiko Miki (Kagawa University, Japan), Satoshi Suyama, Satoshi Nagata (NTT DOCOMO, INC., Japan)

Abstract: One of the possible methods for obtaining reduced latency is the use of neural network decoder (NND) on polar codes. However, the number of information bits K for one NND is limited, since the training complexity increases exponentially according to K. Therefore, concatenated NNDs are promising for practical information length. In the paper, we propose an iterative approach to optimize the information set for concatenated NNDs. Specifically, we first optimize the information set within same NND. We then optimize the information set between different NNDs. This process is iteratively performed until the block error rate (BLER) performance improvement is saturated. The simulation results show that the BLER performance is enhanced by using the proposed iterative approach.

11:30 AM **Human-Blockage Comparison Between SHF and UHF Bands: A Reciprocating Motion Pedestrian Case**

Authors: Shotaro Shigenaga, Xin Du, Hidekazu Murata (Yamaguchi University, Japan), Satoshi Suyama, Huiling Jiang (NTT DOCOMO, INC, Japan)

Abstract: The use of high-frequency bands is becoming increasingly popular for achieving higher speed, lower latency, and higher capacity in wireless communication systems. One way to use high-frequency bands is to improve the transmission performance by linking neighboring terminals. However, it is recognized that high-frequency band wireless communications are susceptible to obstructions. In

particular, the shadowing effect caused by the human body between neighboring terminals is a major problem, especially when high-frequency bands are used for terminal collaboration. This paper reports the comparison results of the shadowing effects measured in the super high-frequency and ultra high-frequency bands for a reciprocating motion pedestrian case. In this research, experiments are conducted in the electromagnetic anechoic chamber room to measure the effects of human shadowing in the 25.9 GHz and 438 MHz bands. As a result, it was confirmed that the 25.9 GHz band has a shorter shadowed time and smaller shadowing gain than the 438 MHz band.

11:50 AM **Dynamic Resource Allocation in Cell-Free MEC: Leveraging Attention Mechanism with MADDPG**

Authors: Fitsum Debebe Tilahun, Chung G. Kang ((Korea University, Korea (South))

Abstract: This paper presents a novel approach for dynamic resource allocation in cell-free massive MIMO enabled mobile edge computing (MEC) systems, employing an attention mechanism within a Multi-Agent Deep Deterministic Policy Gradient (MADDPG) framework to adaptively weigh the contributions of other agents. This approach allows for a more nuanced understanding of the interactions between agents, leading to a more efficient resource distribution. We demonstrate the effectiveness of the proposed algorithm in meeting delay requirements while reducing energy consumption of the users. Notably, our scheme exhibits robust generalization capabilities, effectively accommodating varying number of users beyond the training scenario.

12:10 PM **Generalization Performance of Deep Learning-based Multi-User Detection for GF-SCMA Systems**

Authors: Metasebia D. Gemeda, Chung G. Kang (Korea University, Seoul, Republic of Korea), Minsig Han, Ameha T. Abebe (Samsung Research, Seoul, Republic of Korea)

Abstract: Deep learning (DL) has emerged as a transformative tool in wireless communications, offering powerful methods for optimizing complex systems. One critical challenge in deploying DL-based solutions is ensuring that models can generalize effectively across various channel conditions. This paper investigates the generalization capabilities of a DL-based Collision-Aware Multi-User Detection (CA-MUD) system within Grant-Free Sparse Code Multiple Access (GF-SCMA) frameworks, which are vital for efficient massive machine-type communication (mMTC). By exploring different training environments, such as independent and identically distributed (IID) Rayleigh and tapped delay line (TDL) channels, the study aims to identify optimal strategies to maintain robust communication performance under diverse conditions.

Parallel Session 3 - R4: Bale Paseban 4

Session Chair: Dr. Hirofumi Suganuma

Paper	Authors
Experimental Demonstration of Passive Channel Sounding in 28-GHz-band 5G Systems	Hirofumi Suganuma, Kota Kuramitsu (Anritsu Corporation, Japan), Tsutomu Mitsui, Takahiro Matsuda (Tokyo Metropolitan University, Japan)
Throughput Efficient Dynamic Spectrum Sharing Between 4G-LTE and 5G-NR Using LTE CRS	Goutham L (Samsung R&D Institute Bengaluru, India), Prem singh (IIIT Bangalore, India)
Resource Scheduling for User-Centric Cell-Free Network with Computing-Constrained Access Points	Xiyue Li, Na Li, Xiao Li, Xiaofeng Tao (Beijing University of Posts and Telecommunications, China)
Evaluation of 6G Candidate Waveforms Under RF Impairments	Wei Qi, Wenjia Liu, Juan Liu, Xiaolin Hou, Chen Li, Lan Chen (DOCOMO Beijing Communications Laboratories Co., Ltd., China)
Digital Self-Interference Cancellers for In-Band Full-Duplex Systems with High-Power Amplifiers	Motoshi Tawada and Yuki Takagi (SoftBank Corp., Japan)

10:50 AM **Experimental Demonstration of Passive Channel Sounding in 28-GHz-band 5G Systems**

Authors: Hirofumi Suganuma, Kota Kuramitsu (Anritsu Corporation, Japan), Tsutomu Mitsui, Takahiro Matsuda (Tokyo Metropolitan University, Japan)

Abstract: This paper experimentally investigates passive channel sounding in millimeter-wave (mmWave)-band fifth-generation (5G) mobile communication systems. A mmWave-band base station (BS) generally steers narrow beams, leading to a significant impact on radio propagation channels. Taking advantage of the fact that the BS transmits channel state information reference signals (CSI-RSs) over the entire band with changing beam patterns, a passive channel sounder estimates multipath component (MPC) parameters for each beam. In addition, the frequency-domain space-alternating generalized expectation-maximization (FD-SAGE) algorithm is employed to analyze the MPC parameters. Passive channel sounding for a commercial 28 GHz-band 5G BS is experimentally demonstrated in indoor environments. The experimental results reveal the effect of the different BS beams on the radio propagation channel in both line-of-sight (LOS) and non-line-of-sight (NLOS) environments.

11:10 AM **Throughput Efficient Dynamic Spectrum Sharing Between 4G-LTE and 5G-NR Using LTE CRS**

Authors: Goutham L (Samsung R&D Institute Bengaluru, India), Prem singh (IIIT Bangalore, India)

Abstract: Dynamic Spectrum Sharing (DSS) enables fourth-generation long-term evolution (4G-LTE) and fifth-generation new radio (5G-NR) technologies to coexist within

the same frequency bands, facilitating efficient spectrum utilization. This paper presents a novel approach leveraging cell-specific reference signals (CRS) 4G-LTE for 5G-NR channel measurements, which allows 5G-NR channel state information reference signals (CSIRS) for data transmission. By repurposing LTE CRS for NR measurements and utilizing NR CSI-RS resource elements (REs) for data transmission, the proposed method enhances the throughput of the NR network without compromising LTE operations. i.e., it does not demand any extra REs from LTE for NR data transmission. The simulation results demonstrate improvements in data throughput, validating the feasibility and benefits of the proposed approach over the traditional methods in which LTE and NR use separate reference signals for their measurements.

11:30 AM **Resource Scheduling for User-Centric Cell-Free Network with Computing-Constrained Access Points**

Authors: Xiyue Li, Na Li, Xiao Li, Xiaofeng Tao (Beijing University of Posts and Telecommunications, China)

Abstract: To meet future ultra-low latency and extensive computing requirements, resource-constrained users should utilize ubiquitously available computing resources at the network edge. User-centric cell-free networks can effectively utilize the resources of multiple access points (APs) to serve users. However, the computing resources of a single AP are often limited due to deployment environment or cost, which makes the resource allocation problem more challenging. In this paper, we propose a parallel offloading scheme with limited AP computing resources under user-centric cell-free networks. Maximize the total users' uplink rate and minimum delay margin by optimizing the users' uplink transmission power and task allocation ratio. And we solve the non-convex optimization problem based on fractional programming (FP). Simulation results show that jointly scheduling the computing and communication resources of multiple APs can effectively alleviate problems such as task offloading failure caused by limited computing resources of a single AP.

11:50 AM **Evaluation of 6G Candidate Waveforms Under RF Impairments**

Authors: Wei Qi, Wenjia Liu, Juan Liu, Xiaolin Hou, Chen Li, Lan Chen (DOCOMO Beijing Communications Laboratories Co., Ltd., China)

Abstract: Sub-Terahertz (sub-THz) communication is a potential technology to enable 6G wireless communication with extreme experience due to its rich spectrum resources. Working on sub-THz frequency, radio frequency (RF) impairments including phase noise (PN) and non-linear power amplifier (PA) become more severe and will heavily degrade communication performance. Considering the new characteristics in such high frequency, various waveform schemes have been proposed to achieve better performance under RF impairments, among which the enhanced waveforms based on discrete Fourier transform spreading orthogonal frequency diversion (DFT-s-OFDM) are highly regarded for the low peak to average power ratio (PAPR) characteristic. This paper focuses on 6G candidate waveforms of orthogonal frequency division multiplexing with cyclic prefix (CP-OFDM), DFT-s-OFDM and enhanced DFT-s-OFDM including unified non-

orthogonal waveform (uNOW), DFT-s-OFDM with frequency-domain spectral shaping (DFT-s-OFDM with FDSS), and DFT-s-OFDM with FDSS and spectral extension (DFT-s-OFDM with FDSS and SE). In this paper, 6G candidate waveforms are evaluated for different sub-carrier spacing (SCS) considering PN and non-linear PA in sub-THz. Specially, waveforms are compared and analyzed from various aspects including PN robustness without compensation, PN compensation performance based on phase tracking reference signal (PT-RS), and output power back-off (OBO). In addition, under non-linear PA, this work has in-depth discussions on the changing trend of each RF requirement as OBO increases for different 6G candidate waveforms. The results indicate that uNOW outperforms other waveforms for BLER performance considering both PN compensation and OBO, making it the promising 6G candidate waveform.

12:10 PM **Digital Self-Interference Cancellers for In-Band Full-Duplex Systems with High-Power Amplifiers**

Authors: Motoshi Tawada and Yuki Takagi (SoftBank Corp., Japan)

Abstract: In-band full-duplex (IBFD) communication enables simultaneous transmission and reception in the same frequency band. It offers improved spectral efficiency and is considered a promising mode of operation for future wireless networks. However, in IBFD, the transmission signal feedback creates strong self-interference, requiring interference cancellation. Previous studies have proposed digital cancellation using polynomial models or neural networks; however, experimental verifications have been assumed for their implementation on user equipment with low-output amplifiers to ensure linearity. Therefore, in this study, we evaluated the performance of various digital cancellations using a high-power amplifier with a 6 W-class Gallium Nitride high-electron-mobility transistor (GaN HEMT) for implementing IBFD systems at the base or relay stations. The performance of digital self-interference cancellation (DSIC) in a channel using the embedded GaN HEMT PA indicates that the IBFD system can be effectively utilized in base stations and relay stations. These findings offer insights for implementing a versatile IBFD system, a key technology poised to shape the future of wireless networks.

Parallel Session 4 – R1: Bale Banjar

Session Chair: Dr. Sudhakara Rao Yepuri

Paper	Authors
Impact of Transceiver Alignment on a Software-defined Underwater Visible Light Communication System	Sana Rehman, Yue Rong, Peng Chen (Curtin University, Australia)
Blind Interleaver Classification Using Deep Learning Techniques over Rayleigh Fading	Nayim Ahamed, Swaminathan Ramabadran (Indian Institute of Technology Indore, India), Sudhakara Rao Yepuri (Singapore Institute of Technology, Singapore)

Synchronization for VLC Using Orthogonally Aligned Rolling Shutter Cameras and LED Array	Ayumu Otsuka, Takaya Yamazato, Hiraku Okada, Toshiaki Fujii, Shan Lu (Nagoya University, Japan), Koji Kamakura, Masayuki Kinoshita (Chiba Institute of Technology, Japan), Shintaro Arai (Okayama University of Science, Japan), Tomohiro YENDO (Nagaoka University of Technology, Japan)
Performance Analysis of ASTARS-Assisted Uplink Communication Networks	Fangxin Liu, Yingjie Pei, Xuefei Zhang, Xiaofeng Tao (Beijing University of Posts and Telecommunications, China)
Optimizing Voice Biometric Verification in Banking with Machine Learning for Speaker Identification	Oyebode Oluwatobi Oyewale, Md Delwar Hossain, Yuzo Taenaka, Youki Kadobayashi (Nara Institute of Science and Technology, Japan)
Collaborative Decentralized Learning for Detecting Bearing Faults in Industrial Internet of Things	Made Adi Paramartha Putra, Nengah Widya Utami (Primakara University, Indonesia), Ahmad Zainudin, Dong-Seong Kim, Jae-Min Lee (Kumoh National Institute of Technology, South Korea), Gabriel Avelino Sampedro (University of the Philippines Open University, Philippines)

13:30 PM **Impact of Transceiver Alignment on a Software-defined Underwater Visible Light Communication System**

Authors: Sana Rehman, Yue Rong, Peng Chen (Curtin University, Australia)

Abstract: Underwater visible light communication (UVLC) is believed to revolutionize the future of optical communication, where visible light of wavelength 400-500 nm range is used to transmit data underwater. In this paper we aim to find how the position of the receiver affects the accuracy of the received optical signal. The message signal is modulated using pulse position modulation (PPM) because of its high noise resistance through water. The position of the receiver is changed accordingly and the bits in error are recorded to discuss the relationship between angle of the receiver, bit-error-rate and received signal power.

13:50 PM **Blind Interleaver Classification Using Deep Learning Techniques over Rayleigh Fading**

Authors: Nayim Ahamed, Swaminathan Ramabadran (Indian Institute of Technology Indore, India), Sudhakara Rao Yepuri (Singapore Institute of Technology, Singapore)

Abstract: Channel encoders and interleavers are crucial for correcting random and burst errors introduced by noisy channels in digital communication systems. Typically, information about the types of channel encoders and interleavers, along with their parameters used at the transmitting end, is available at the receiver. However, in military communication systems, the encoder/interleaver type and parameters are often partially known or unknown. In reconfigurable receivers and adaptive

modulation and coding (AMC)-based systems, blind identification of channel encoders and interleavers enhances spectral efficiency. This paper explores the use of a deep learning approach to identify three different types of interleavers namely block, convolutional, and helical, under Rayleigh fading conditions. We propose a hybrid convolutional neural network (CNN)- support vector machine (SVM) model for classification, with input data consisting of block-encoded and convolutional-encoded data. Our hybrid CNN-SVM model achieves over 95% classification accuracy across varying signal-to-noise ratio (SNR) values. The findings also show that accuracy improves with longer input sample lengths, albeit at the cost of increased training and testing time. Finally, our proposed model demonstrates superior classification accuracy compared to the CNN model.

14:10 PM **Synchronization for VLC Using Orthogonally Aligned Rolling Shutter Cameras and LED Array**

Authors: Ayumu Otsuka, Takaya Yamazato, Hiraku Okada, Toshiaki Fujii, Shan Lu (Nagoya University, Japan), Koji Kamakura, Masayuki Kinoshita (Chiba Institute of Technology, Japan), Shintaro Arai (Okayama University of Science, Japan), Tomohiro YENDO (Nagaoka University of Technology, Japan)

Abstract: This research addresses challenges in visible light communication (VLC) systems that use two orthogonally aligned rolling shutters (RS) image sensors as receivers and an LED array as a transmitter. The study focuses on overcoming burst signal loss caused by unsensed periods between frames in RS image sensors. To improve VLC performance, we propose and compare three different schemes. The first is a conventional approach that superimposes a Barker code synchronization signal on the transmission signal using pulse width modulation (PWM). The second introduces a new method of spatial synchronization by dedicating specific LEDs in an array for synchronization signals. The third scheme extends this spatial approach by incorporating a 4-level PWM for information transmission to increase data rates. The study aims to evaluate and compare the error rate characteristics of these three schemes, assessing their effectiveness in mitigating burst errors and enhancing overall VLC system performance. This research has potential applications, including vehicle communication, Internet of Things devices, and smartphones.

14:30 PM **Performance Analysis of ASTARS-Assisted Uplink Communication Networks**

Authors: Fangxin Liu, Yingjie Pei, Xuefei Zhang, Xiaofeng Tao (Beijing University of Posts and Telecommunications, China)

Abstract: Active simultaneously transmitting and reflecting reconfigurable intelligent surface (ASTARS) warrants in-depth research to enhance the reliability and efficiency of sixth-generation wireless communication. This paper investigates the performance of ASTARS-assisted uplink communication networks. We derive new closed-form expressions for the outage probability, considering both perfect and imperfect successive interference cancellation scenarios, and subsequently calculate the throughput and energy efficiency. Numerical results indicate that

ASTARS-assisted networks significantly outperform passive counterpart networks.

14:50 PM **Optimizing Voice Biometric Verification in Banking with Machine Learning for Speaker Identification**

Authors: Oyebode Oluwatobi Oyewale, Md Delwar Hossain, Yuzo Taenaka, Youki Kadobayashi (Nara Institute of Science and Technology, Japan)

Abstract: Biometric verification is essential for secure identity verification and authentication during banking transactions using fingerprints, facial features, irises, and voices. Among these methods, voice biometrics is a promising alternative owing to its potential for robust and convenient user authentication. However, their effectiveness is significantly challenged by variations in the voice caused by different device configurations and environmental conditions. These variations can reduce the effectiveness of speaker identification and undermine the reliability of voice-based systems for securing online transactions. For an effective comparative solution, this study addresses these challenges by focusing on the difficulties posed by voice variations due to differences in device hardware, microphone quality, and environmental noise. Our approach employs machine-learning techniques using advanced speech enhancement methods to improve the consistency and accuracy of voice biometric verification across diverse devices. Specifically, we employ an adaptive filter model that enhances signal extraction, noise suppression, and predictive precision. Furthermore, our empirical demonstration showed that the adaptive filter significantly improved the accuracy of voice biometric systems by mitigating the impact of device-induced voice variations. In addition, we evaluate the performance of this model using a range of metrics.

15:10 PM **Collaborative Decentralized Learning for Detecting Bearing Faults in Industrial Internet of Things**

Authors: Made Adi Paramartha Putra, Nengah Widya Utami (Primakara University, Indonesia), Ahmad Zainudin, Dong-Seong Kim, Jae-Min Lee (Kumoh National Institute of Technology, South Korea), Gabriel Avelino Sampedro (University of the Philippines Open University, Philippines)

Abstract: An essential aspect of Industrial Internet of Things (IIoT) systems lies in their reliability and resilience against failures. Fault detection serves as a crucial method for mitigating errors, leading to reduced downtime. Previous studies have predominantly focused on fault detection using centralized Artificial Intelligence (AI) approaches, wherein participant in-formation is centralized and forwarded to a central server. However, Federated Learning (FL) offers a solution to these issues, enhancing the system's reliability. In this study, we propose a Decentralized FL (DFL) approach for collaborative learning in bearing fault detection. DFL is preferred over centralized FL due to its elimination of a single point of failure.
By leveraging the decentralized FL concept, the vulnerability of the collaborative framework to attacks can be minimized. Our proposed DFL integrates continual learning techniques to reduce communication overhead. The results demonstrate

that decentralized collaborative learning achieves satisfactory performance, with an accuracy rate of 96.08% and a learning time reduction of up to 37.52%.

Parallel Session 4 – R2: Bale Paseban 2

Session Chair: Prof. Bambang Soelistijanto

Paper	Authors
A Publish/Subscribe Forwarding Scheme Based on Mobility Information for Opportunistic Networks	Bambang Soelistijanto (Sanata Dharma University, Indonesia)
Efficient Coordination in Internet-of-Things through Fast Many-to-Many Conveyance of Bulk-data	Anwesha Patel, Jagnyashini Debadarshini, Sudipta Saha (Indian Institute of Technology Bhubaneswar, India)
Maximum Doppler Shift Identification using Decision Feedback Channel Estimation	Yudai Handa, Kosuke Tamura, Hiroya Hayakawa, Riku Tanaka, Jaesang Cha, Chang-Jun Ahn (Chiba University, Japan)
Queue Assisted Random Early Detection for Congestion in Software Defined Networks	Ata Ullah, Sobia Bibi, Moeenuddin Tariq (National University of Modern Languages, Pakistan), NZ Jhanjhi, Sayan Kumar Ray (Taylor's University, Malaysia)
Empowering Seamless Handover Authentication for High-speed UEs via Dual-blockchain over STINs	Shiyun Xie, Guoshun Nan, Xiaofeng Tao (Beijing University of Posts and Telecommunications, China)

13:30 PM **A Publish/Subscribe Forwarding Scheme Based on Mobility Information for Opportunistic Networks**

Authors: Bambang Soelistijanto (Sanata Dharma University, Indonesia)

Abstract: This paper presents PuFLo, a publish/subscribe forwarding strategy, to deliver content to interested nodes in opportunistic networks. Most of the existing schemes typically use temporal or social knowledge when building routing tables. Instead, PuFLo considers node mobility information when making forwarding decisions. Initially, a node stores the ID of each location it visits in a sequence list. When a node contact occurs, PuFLo selects suitable relays based on two forwarding metrics: mobility similarity and centrality. The former evaluates the mobility diversity of two nodes based on dynamic time warping. The latter assesses node activeness based on Shannon entropy, which reflects the variation of previously visited places. Finally, the two metrics are integrated using the entropy weight method to define the PuFLo forwarding utility. Extensive simulations using the ONE simulator show that PuFLo consistently outperforms Epidemic and SimBet routing in terms of dissemination efficiency, latency, and cost.

13:50 PM **Efficient Coordination in Internet-of-Things through Fast Many-to-Many Conveyance of Bulk-data**

Authors: Anwesha Patel, Jagnyashini Debadarshini, Sudipta Saha (Indian Institute of Technology Bhubaneswar, India)

Abstract: In advanced applications of Internet of Things (IoT), sharing of multimedia data is one of the common requirements which is not explicitly addressed in the existing works. The constraints of the low-power IoT-devices in their processing capability, memory, and energy, make efficient coordination based on the shared data quite challenging. In this paper, we study one such situation in the context of an IoT-assisted lightweight Intelligent-Transportation System (ITS). A many-to-many data-sharing strategy called ChainBus is proposed for fast sharing of bulk-data among the Road-Side Units (RSU) in ITS. Next, an efficient inter-RSU coordination mechanism is designed to dynamically infer the road-connectivity structure among the RSUs without the help of cloud. We show that our strategy can achieve its goal upto 54.3% faster compared to the solutions obtained by the existing best-known strategies.

14:10 PM **Maximum Doppler Shift Identification using Decision Feedback Channel Estimation**

Authors: Yudai Handa, Kosuke Tamura, Hiroya Hayakawa, Riku Tanaka, Jaesang Cha, Chang-Jun Ahn (Chiba University, Japan)

Abstract: High mobility environment often generate Doppler shift caused by the relative motion of the trans-mitter and receiver, leading to inter-carrier interference (ICI) that degrades communication quality, emphasizing the need for adaptive communication systems for beyond 5G and 6G. The most extreme of estimation method, which inserts pilot signals at the initial and last part of the packet, enables highly accurate estimation. However, this method has serious latency problem because of inserting pilot signals at the last part of the packet. This paper proposes a novel estimation method for the maximum Doppler shift using decision feedback channel estimation (DFCE). Our proposed method can identify the channel and compensate the faded signal. In this case, we can use the defeated signal as a reference signal. Therefore, our proposed method can estimate the Doppler shift without any additional pilot signal at the last part of the packet.

14:30 PM **Queue Assisted Random Early Detection for Congestion in Software Defined Networks**

Authors: Ata Ullah, Sobia Bibi, Moeenuddin Tariq (National University of Modern Languages, Pakistan), NZ Jhanjhi, Sayan Kumar Ray (Taylor's University, Malaysia)

Abstract: Software Defined Networks (SDN) utilize the network devices as virtual devices to analyze the traffic and transmit the relevant packets. It is quite beneficial for the internet of Things (IoT) where the huge number of devices share the packets which cannot be handled by the conventional networks. SDN is also essential to manage congestion scenarios during massive communication especially in video streaming. The main problem arises when the residual queues on the network path are left underutilized whereas the bandwidth is reduced as per the minimum bandwidth link between any two nodes in the path. It occurs based on the feedback based congestion avoidance mechanism. This work presents a proposed mechanism to utilize the residual queue in the communication path to enhance the

minimum bandwidth. It maintains the average queue length to analyze the percentage of queue utilized and then decide about the packet dropping probability. In proposed scheme, the congestion can be managed earlier whereas the base scheme applies a constraint of double the size of previous threshold which may result in identifying the congestion at a later stage where the retreat is hardly possible. According to the findings in results after simulations, the proposed IAGRED dominates the counterparts in terms of queue delay, queue length, link utilization and throughput.

14:50 PM **Empowering Seamless Handover Authentication for High-speed UEs via Dual-blockchain over STINs**

Authors: Shiyun Xie, Guoshun Nan, Xiaofeng Tao (Beijing University of Posts and Telecommunications, China)

Abstract: Satellite-terrestrial integrated networks (STINs) offer wide coverage and ubiquitous connectivity for massive mobile equipments (UEs). However, the security issues in STINs should not be ignored. Authentication and key agreement is the fundamental way to protect STINs from unauthorized access. Nevertheless, high-speed UEs, such as those in vehicles and trains, may encounter frequent handovers among heterogeneous access points in STINs, resulting in reduced authentication efficiency and an increased rate of access failures. To tackle these challenging issues, this paper proposes DBC-Auth, a seamless and universal handover authentication scheme that relies on a dual-blockchain architecture supporting all handover scenarios over STINs. Specifically, the proposed dual-blockchain architecture involves two chains that reside on the ground base stations and satellites, respectively, to efficiently manage the handover authentication in different segments of STINs. Leveraging the blockchain's global availability and tamper-resistance, the authentication receipts can be recorded on the blockchain in advance, which can significantly improve the handover authentication efficiency and alleviate the handover failures. Security analysis demonstrates that our scheme achieves various security requirements, and performance evaluation shows superior efficiency compared to existing works.

Parallel Session 4 – R3: Bale Paseban 3

Session Chair: Prof. Sayan Kumar Ray

Paper	Authors
xPayments: Cross-Domain End-to-End Payment Protocol using Payment Channel Network	Anupa De Silva, Subhasis Thakur, John Breslin (University of Galway, Ireland)
Suggestion of JP Zone Authoritative DNS Server Locations by Country Analysis of Query IP Address	Katsuya Sugizaki, Rei Nakagawa, Nariyoshi Yamai (Tokyo University of Agriculture and Technology, Japan), Shinta Sato, Takeshi Mitamura (Japan Registry Services Co., Ltd., Japan)
Design of a Communication Protocol for a Hoverboard Mobile APP: Mobility For Smart City	Suraksha R, Roopa Manjunatha (Energy Institute Bengaluru, India)

Ontology Development for Sustainable Intelligent Transportation Systems	Bikram Pratim Bhuyan, Jean Tshibangu-Muabila, Yunus Emre Coban, Amar RamdaneCherif (University of Paris Saclay, France), Manolo Dulva Hina (ECE Engineering School, France)
Inter Smart Contract Communication for Smart Bag to Enhance Child Safety in Blockchain Environment	Priyal Bhinde, Dhruvi Tanna, Keyaba Gohil, Rajesh Gupta, Sudeep Tanwar (Nirma University, India), N.Z Jhanjhi, Sayan Kumar Ray (Taylor's University, Malaysia)

13:30 PM **xPayments: Cross-Domain End-to-End Payment Protocol using Payment Channel Network**

Authors: Anupa De Silva, Subhasis Thakur, John Breslin (University of Galway, Ireland)

Abstract: The rapid integration of digital technologies has precipitated a substantial transition from traditional in-person commerce to digital trade, even encompassing physical goods. This transformation not only simplifies the purchasing process but also broadens the market reach for vendors, enabling global connectivity with consumers. Presently, there is a shift towards Metaverse-based applications, with blockchains serving as the foundational infrastructure for data management, thereby enhancing the overall user experience. Given this context, integrating payment methods becomes pivotal, particularly in light of the widespread adoption of blockchain technology. Our proposal introduces xPayment, a decentralised payment protocol designed to facilitate end-to-end and cross-domain transactions for digital goods via payment channel networks (PCNs). Initially, we introduce the concept of cyclic exchange and formally demonstrate its atomicity, on which we develop xPayment protocol to facilitate an independent and interoperable payment mechanism integrated into blockchain-based ownership transfers. We provide both theoretical and empirical evidence of its atomicity, minimal merchant opportunity cost, and customisable privacy features.

13:50 PM **Suggestion of JP Zone Authoritative DNS Server Locations by Country Analysis of Query IP Address**

Authors: Katsuya Sugizaki, Rei Nakagawa, Nariyoshi Yamai (Tokyo University of Agriculture and Technology, Japan), Shinta Sato, Takeshi Mitamura (Japan Registry Services Co., Ltd., Japan)

Abstract: IP anycast is a technology that assigns a common IP address to multiple devices on the Internet. With the recent development of the Internet, the use of anycast technology in the operation of authoritative DNS servers is crucial to ensure stability, reliability, and accessibility. The main objective of IP anycast is to reduce response time for DNS queries. However, in the multisite deployment of anycast, there are many cases where the traffic distribution anticipated for fast query response is not achieved even after the installation of new sites. This paper focuses on the number of hops of DNS queries and makes suggestions to encourage domestic processing of DNS queries sent from within the country for a fast response time. As a result, the domestic consumption rate in the Netherlands is

below 70% and the network has room for improvement. And adding a node for JP zone authoritative DNS server in Ireland, where there are many queries to the German and UK nodes, would improve the effectiveness of anycasting.

14:10 PM **Design of a Communication Protocol for a Hoverboard Mobile APP: Mobility For Smart City**

Authors: Suraksha R, Roopa Manjunatha (Energy Institute Bengaluru, India)

Abstract: As the demand for alternative mobility solutions increases in urban areas, hoverboards have captured the attention of smart city applications. The generic hoverboard can be transformed into a smart and intelligent board by incorporating a communication protocol between the board and a mobile user. This paper proposes developing a communication protocol to connect the hoverboard with the user's mobile app. The Controller Area Network (CAN) protocol sends and receives data from the slave controller and Battery Management System (BMS). The Inter-Integrated Circuit (I2C) protocol receives input from the gyroscope, while the Universal Asynchronous Receiver/Transmitter (UART) sends information to the speaker. The microcontroller uses Bluetooth to interface with the mobile app. With this communication interface, the user can track the State of Charge (SOC), State of Health (SOH) of the battery, voltage level, current consumption, trip details, temperature details, etc. The hoverboard's speed and remaining range can be estimated and monitored. Different drive modes-ECO, Drive, and Sport-can be selected. By establishing communication between the board and the mobile app, the board can be monitored for any faults, and virtual assistance can be provided to the customer to take appropriate action. This intelligent, lightweight hoverboard offers safe and eco-friendly last-mile mobility.

14:30 PM **Ontology Development for Sustainable Intelligent Transportation Systems**

Authors: Bikram Pratim Bhuyan, Jean Tshibangu-Muabila, Yunus Emre Coban, Amar RamdaneCherif (University of Paris Saclay, France), Manolo Dulva Hina (ECE Engineering School, France)

Abstract: Urban areas globally face escalating challenges in traffic congestion, air pollution, and inefficient transportation systems. Traditional traffic management strategies are increasingly inadequate for handling the growing complexity of urban mobility. To address these issues, this paper presents the development of an ontology for Intelligent Transportation Systems (ITS) aimed at enhancing traffic management and safety through sustainable practices. The research problem focuses on the lack of comprehensive and standardized ontologies that integrate diverse data sources, support real-time decision-making, and incorporate sustainability considerations. Utilizing SUMO Eclipse for simulations and tools like Protégé and OwlReady2 for ontology development, the project integrates environmental considerations and vehicular communication protocols. The ontology's structure encompasses five main concepts: Environment, Communication, System, WeatherState, and ValuePartition.

14:50 PM **Inter Smart Contract Communication for Smart Bag to Enhance Child Safety in Blockchain Environment**

Authors: Priyal Bhinde, Dhruvi Tanna, Keyaba Gohil, Rajesh Gupta, Sudeep Tanwar (Nirma University, India), N.Z Jhanjhi, Sayan Kumar Ray (Taylor's University, Malaysia)

Abstract: In today's world, the safety of children is of utmost importance due to numerous compelling factors, for example, accidents and injuries. In this fast-paced lifestyle of the new age parents, they might not always be able to accompany their children everywhere therefore the need for the tracking of the child including safety considerations and also the parent's desire to stay connected with their child and in the absence of the parents the guardian of the child can look up for the safety of the child. This paper presents an implementation of the smart bag for toddlers which is built using blockchain technology and language solidity that ensures the tracking facility of the child. blockchain is the decentralized ledger technology that provides transparency and security between the networks. Therefore we have created a digital contract known as the smart contract on blockchain technology named a smart bag for toddlers. A smart contract is a digital agreement that is signed and stored on the blockchain and executes automatically when its terms and conditions are met.

Parallel Session 5 - R2: Bale Paseban 2

Session Chair: Dr. Suchi Kumari

Paper	Authors
MMSE Equalization-Based MIMO Demodulation with Random Walk along Gradient Descent Direction	Ryo Kikuchiahra, Yukitoshi Sanada (Keio University, Japan)
Statistical Analysis of the Properties of Geometric Network with Node Mobility	Md. Arquam (IIIT Sonepat, India), Utkarsh Tiwar, Suchi Kumari (Shiv Nadar Institute of Eminence, India)
Hardware Evaluation of Multi-Scalable Video Transmission	Keigo Fukuda, Masayuki Kurosaki, Yuhei Nagao, Hiroshi Ochi (Kyushu Institute of Technology, Japan)
UV-Plane Beam Mapping for Non-Terrestrial Networks in 3GPP System-Level Simulations	Dong-Hyun Jung (University of Science and Technology and University of Science and Technology, Korea), Sucheol Kim, Joon-Gyu Ryu (University of Science and Technology, Korea), Miyeon Lee, Junil Choi (Korea Advanced Institute of Science and Technology, Korea)
Erasure Demodulation Characteristics with Erasure Overflow threshold	Akira Sato, Yukitoshi Sanadaa (Keio University, Japan)

15:30 PM **MMSE Equalization-Based MIMO Demodulation with Random Walk along Gradient Descent Direction**

Authors: Ryo Kikuchiahra, Yukitoshi Sanada (Keio University, Japan)

Abstract: This paper proposes a minimum mean square error (MMSE) equalization-based multi-input multi-output (MIMO) demodulation scheme with Metropolis-Hastings random walk along a gradient descent direction. The conventional scheme using intermediate search points works effectively for higher-order modulation symbols. However, its performance is deteriorated for lower-order modulation symbols. The proposed scheme suppresses the coefficients in the off-diagonal components of a channel matrix by applying MMSE equalization and improves performance in low signal-to-noise power ratio conditions even for lower-order modulation symbols. Numerical results obtained thorough computer simulation show that the proposed scheme improves by about 2.0 dB at a bit error rate of 10 −-2 when the number of iteraitons is 10 for QPSK symbols with 64 transmit and receive antennas.

15:50 PM **Statistical Analysis of the Properties of Geometric Network with Node Mobility**

Authors: Md. Arquam (IIIT Sonepat, India), Utkarsh Tiwar, Suchi Kumari (Shiv Nadar Institute of Eminence, India)

Abstract: The movement changes the underlying spatial representation of the participated mobile objects or nodes. In real-world scenarios, such mobile nodes can be part of any biological network, transportation network, social network, human interaction, etc. The change in the geometry leads to the change in various desirable properties of real-world
networks, especially in human interaction networks. In real life, human movement is concerned with a better lifestyle where they form their new connections due to the geographical changes. Therefore, in this paper, we design a model for geometric networks with mobile nodes (GNMN) and conduct a comprehensive statistical analysis of their properties. We analyze the effect of node mobility by evaluating key network
metrics such as connectivity, node degree distribution, secondhop neighbors, and centrality measures. Through extensive simulations, we observe significant variations in the behavior of geometric networks with mobile nodes.

16:10 PM **Hardware Evaluation of Multi-Scalable Video Transmission**

Authors: Keigo Fukuda, Masayuki Kurosaki, Yuhei Nagao, Hiroshi Ochi (Kyushu Institute of Technology, Japan)

Abstract: In recent years, high-definition video content such as YouTube and Netflix has become an integral part of our lives, increasing the demand for wireless transmission of 4K and 8K images with high quality. Consequently, many technical papers have proposed systems for high-quality video transmission. However, most of these systems extend international standards, making implementation difficult. Therefore, in this paper, we construct a system compliant with IEEE 802.11ac/ax/be standards using a multi-scalable image transmission system. The multi-scalable image transmission system enables high-quality image transmission by structuring packets so that layers ordered by their contribution to

image quality in JPEG 2000 can be sent to Sub STAs with larger channel capacities. By configuring the receiver using multiple Sub STAs, data with different contributions to image quality can be transmitted using the multi-user functionality of IEEE 802.11ac/ax/be standards. As a result, the MIMO system using multi-scalable image transmission can achieve high-quality communication without extending the IEEE 802.11ac/ax/be standards.

16:30 PM **UV-Plane Beam Mapping for Non-Terrestrial Networks in 3GPP System-Level Simulations**

Authors: Dong-Hyun Jung (University of Science and Technology and University of Science and Technology, Korea), Sucheol Kim, Joon-Gyu Ryu (University of Science and Technology, Korea), Miyeon Lee, Junil Choi (Korea Advanced Institute of Science and Technology, Korea)

Abstract: Due to the high altitudes and large beam sizes of satellites, the curvature of the Earth's surface can impact system-level performance. To consider this, 3GPP introduces the UV-plane beam mapping for system-level simulations of non-terrestrial networks (NTNs). This paper aims to provide a comprehensive understanding of how beams and user equipments (UEs) are placed on the UV-plane and subsequently mapped to the Earth's surface. We present a general process of projecting UEs on the UV-plane onto the Earth's surface. This process could offer a useful guideline for beam and UE deployment when evaluating the system-level performance of NTNs.

16:50 PM **Erasure Demodulation Characteristics with Erasure Overflow threshold**

Authors: Akira Sato, Yukitoshi Sanadaa (Keio University, Japan)

Abstract: The erasure demodulation is possible to reduce a block error rate (BLER) and extend the communication range of a wireless system. In the erasure demodulation a demodulator regards a decoded bit as an erasure bit if its corresponding likelihood at the output of the decoder is smaller than a threshold. The demodulator outputs both 0 and 1 for the erasure bit and CRC error detection following the erasure demodulation checks which output is correct. As one of those outputs must be a correct bit, BLER performance improves. On the other hand, as the number of erasure bits increases, the number of CRC decoding operations grows exponentially. Thus, in this paper, a trade-off between computational complexity and performance improvement is investigated Packets are treated as an erasure overflow state if the number of erasure bits in each packet exceeds a threshold. They are counted as the packets with date recovery errors (DREs). Numerical results obtained through computer simulation show that the proposed scheme improves the DRE probability.

Parallel Session 5 - R3: Bale Paseban 3

Session Chair: Dr. Yasunori Suzuki

Paper	Authors
Experimental Performance of Frequency-Domain MIMO Receiver Using 25.9 GHz Terminal Collaboration	Ryosuke Kanda, Hidekazu Murata, Xin Du (Yamaguchi University, Japan), Satoshi Suyama, Huiling Jiang (NTT DOCOMO, INC, Japan)
Effect of Fractal Geometry in Bowtie Antennas for Terahertz Applications	Andrano Mario Hitipeuw, Catur Apriono (Universitas Indonesia, Indonesia), Aditya Inzani Wahdiyat (National Research and Innovation Agency, Indonesia)
Improvement in EVM by Cryogenically Cooled Technique for Millimeter Wave Band Receiving Amplifiers	Yasunori Suzuki (NTT DOCOMO, INC., Japan), Tomoyuki Furuichi, Noriharu Suematsu (Tohoku University, Japan)
Field Experiment of a Dynamic Area Optimization Algorithm Using a Cylindrical Antenna for HAPS	Yohei Shibata, Wataru Takabatake, Kenji Hoshino (SoftBank Corp. Technology Research Laboratory, Japan)
Energy Efficiency Improvement in One-Layer Rate-Splitting Multiple Access	Desti Madya Saputri (Institut Teknologi Bandung and Telkom University, Indonesia), Iskandar, Mohammad Sigit Arifianto (Institut Teknologi Bandung, Indonesia), Aloysius Adya Pramudita (Telkom University, Indonesia)

15:30 PM **Experimental Performance of Frequency-Domain MIMO Receiver Using 25.9 GHz Terminal Collaboration**

Authors: Ryosuke Kanda, Hidekazu Murata, Xin Du (Yamaguchi University, Japan), Satoshi Suyama, Huiling Jiang (NTT DOCOMO, INC, Japan)

Abstract: The terminal-collaborated multiple-input multiple-output (MIMO) reception technology can equivalently increase the number of receiving antennas by collaborating the receiving terminals. Using this technology, the spectrum efficiency of communication between the base station and the collaborating terminals can be increased. It is desirable to use high frequency bands with high-speed and low-latency for collaborative communication. In this paper, we report the initial implementation results of a transmission experiment system for MIMO reception with terminal collaboration that uses the 25.9 GHz band for terminal-to-terminal communication, with the goal of future outdoor experiments. As a result, we show that the error rate performance is improved as the number of collaborating terminals is increased.

15:50 PM **Effect of Fractal Geometry in Bowtie Antennas for Terahertz Applications**

Authors: Andrano Mario Hitipeuw, Catur Apriono (Universitas Indonesia, Indonesia), Aditya Inzani Wahdiyat (National Research and Innovation Agency, Indonesia)

Abstract: This paper investigates the potential impact of applying fractal geometries to bowtie antennas for Terahertz (THz) applications, with a particular focus on

evaluating whether fractalizing can enhance the gain of traditional bowtie designs. Traditional bowtie antennas are known for their simplicity and broad bandwidth, making them a popular choice in various applications. However, the possible benefits of incorporating fractal geometries into these antennas, especially in the THz frequency range, have not been thoroughly explored. In this study, we apply several fractal iterations to the conventional bowtie antenna and analyze the S11 parameter, the resulting gain, radiation patterns, and the electric field distribution. Using simulation measurement techniques in the CST, we assess the electromagnetic properties introduced by the fractal modifications, such as increased surface area and multiresonant behaviors. Our findings provide a comprehensive analysis of the fractal bowtie antenna's performance in the THz range, highlighting any changes in gain compared to the traditional design. The technique demonstrates the potential to transform a single-band antenna into a multi-band antenna, and increasing the number of fractals in the antenna design results in lower resonant frequencies. Although the study does not conclusively claim that fractalizing improves gain, it offers valuable insights and data that contribute to the ongoing exploration of fractal geometries in antenna design.

16:10 PM **Improvement in EVM by Cryogenically Cooled Technique for Millimeter Wave Band Receiving Amplifiers**

Authors: Yasunori Suzuki (NTT DOCOMO, INC., Japan), Tomoyuki Furuichi, Noriharu Suematsu (Tohoku University, Japan)

Abstract: This paper presents to improve transmission quality and capacity employing cryogenically cooled technique for millimeter-waveband receiving amplifiers. It is known that noise figure and small signal gain of millimeter wave band receiving amplifier can be improved under cryogenic temperature environment. Because these features mean to enhance signal to noise power ratio, error vector magnitude (EVM) can improve under cryogenic temperature environment. Furthermore, radio communication system can improve capacity upgrading higher-order modulation such as 1024 QAM. The simulation results confirm to improve EVM values and capacity when employing the experimental results of 60 GHz band amplifiers under cryogenic temperature environment. From these results, the cryogenically cooled technique for millimeter wave band receiving amplifiers is effective for improving radio communication system performance.

16:30 PM **Field Experiment of a Dynamic Area Optimization Algorithm Using a Cylindrical Antenna for HAPS**

Authors: Yohei Shibata, Wataru Takabatake, Kenji Hoshino (SoftBank Corp. Technology Research Laboratory, Japan)

Abstract: High-Altitude Platform Stations (HAPSs) are attracting much attention as novel mobile communication platforms for ultra-wide coverage areas and disaster-resilient networks. In a service area, the distribution of users differs from location to location; therefore, cell configuration optimization is required for non-uniform user distributions to deliver a better communication service. The problem is an increased number of parameters because each cell requires different antenna parameters for a non-uniform user distribution compared to a uniform user

distribution. To address this problem, we proposed a dynamic cell optimization algorithm using the genetic algorithm (GA). In this paper, we implement the dynamic cell optimization algorithm in a cylindrical antenna that has been developed so far and conduct a field experiment to show its functionality. Furthermore, we also conducted another experiment to show the effect of the footprint fixation technique on moving cell issues caused by the movement of aircraft by mounting the cylindrical antenna on a tethered balloon.

16:50 PM **Energy Efficiency Improvement in One-Layer Rate-Splitting Multiple Access**

Authors: Desti Madya Saputri (Institut Teknologi Bandung and Telkom University, Indonesia), Iskandar, Mohammad Sigit Arifianto (Institut Teknologi Bandung, Indonesia), Aloysius Adya Pramudita (Telkom University, Indonesia)

Abstract: Power distribution adjustment in Rate-Splitting (RS) is able to improve the sum-rate performance of multi-antenna systems. By adding a compensator at the transmitter, the channel might be compensated in, which it is possible to increase the sum rate in downlink communication networks. The addition of this compensator, however, requires more power to operate. This research discusses about the impact of adding a compensator on Energy Efficiency (EE) using 1-layer RS scheme in a Multiple-Input Single-Output (MISO) system. The performance of the system with the compensator as compared to the system without the compensator to evaluate its impact on EE. Although the presence of the compensator required additional power at the transmitter, the EE achieved was found still better compared to the existing method.

Technical Paper

Session-Parallel Session Day 3: November 7th, 2024

Parallel Session 6 - R1: Bale Banjar

Session Chair: Prof. Safiqul Islam

Paper	Authors
Spoofing Attack Detection Method by Estimating Transmitting Device on 10BASE-T1S	Kazuki Iehira, Hiroyuki Inoue (Kyoto Sangyo University, Japan)
Block Group Distribution Methods that Ensure Persistence in Blockchain	Fumiya Wakinaka, Takeshi Ogawa (Tokyo Denki University, Japan)
Firmware Distribution with Erasure Code for IoT applications on IEEE 802.15.4g Mesh Network	Takenori Sumi (Mitsubishi Electric Corporation and Shizuoka University, Japan), Yukimasa Nagai (Mitsubishi Electric Corporation, Japan), Jianlin Guo (Mitsubishi Electric Research Laboratories, USA), Hiroshi Mineno (Shizuoka University, Japan)
TeachNet: A Lightweight and User-Friendly Network Visualization and Experimentation Tool	Safiqul Islam, Visar Morina, Boning Feng (Oslo Metropolitan University, Norway), Michael Welzl (University of Oslo, Norway)
Smart Device Counting and Tracking for People Flow Observation	So-Yeon Kim, Dae-Ho Kim, Goo-Rak Kwon, Jae-Young Pyun (Chosun university, Korea)

08:30 AM **Spoofing Attack Detection Method by Estimating Transmitting Device on 10BASE-T1S**

Authors: Kazuki Iehira, Hiroyuki Inoue (Kyoto Sangyo University, Japan)

Abstract: In recent years, the introduction of advanced driver assistance systems in automobiles has significantly increased the communication volume of in-vehicle networks. Automotive Ethernet has been introduced to solve this problem, which enabling the application of security protocols and providing substantial high communication capacity. In particular, the 10BASE-T1S protocol, which is compatible with Ethernet at the MAC layer, has been specified for bus networks designed for use at the end point of in-vehicle networks. However, like Ethernet, 10BASE-T1S, lacks a mechanism to authenticate the transmitting device as a standard feature, making it vulnerable to spoofing attacks. Currently, threat analysis and countermeasures against 10BASE-T1S have not been reported. Therefore, studying threats and countermeasures for 10BASE-T1S is a critical task. In this study, we propose a method for detecting spoofing attacks on bus-based networks using 10BASE-T1S. The proposed method detects spoofing attacks by monitoring the transmission timing, focusing on the characteristics of physical-layer collision avoidance (PLCA), which is a collision avoidance

mechanism of 10BASE-T1S. Evaluations were conducted using reception records obtained in a minimally configured actual environment using 10BASE-T1S. The results show that the proposed method can estimate the transmitting device and detect spoofing attacks.

08:50 AM **Block Group Distribution Methods that Ensure Persistence in Blockchain**

Authors: Fumiya Wakinaka, Takeshi Ogawa (Tokyo Denki University, Japan)

Abstract: The amount of data stored by a node participating in a blockchain increases in proportion to the total number of transactions processed in the blockchain. In a public blockchain, each full node participating in consensus building must maintain all transaction data from the past to the present. Considering the future increase in the number of transactions, we expect more than 315 TB, even if limiting the number of transactions to 20 years. Therefore, a personal PC may not be able to participate as a full node. A method to reduce the amount of data per full node by distributing data among full nodes has been proposed. However, there is a risk of data loss due to the departure of multiple nodes with copies of a particular block group or a DoS attack by collusion. In this paper, we report a method for maintaining a stable network over a long period of time while reducing the amount of data per full node by having each full node maintain data in a distributed manner.

09:10 AM **Firmware Distribution with Erasure Code for IoT applications on IEEE 802.15.4g Mesh Network**

Authors: Takenori Sumi (Mitsubishi Electric Corporation and Shizuoka University, Japan), Yukimasa Nagai (Mitsubishi Electric Corporation, Japan), Jianlin Guo (Mitsubishi Electric Research Laboratories, USA), Hiroshi Mineno (Shizuoka University, Japan)

Abstract: Sub-1 GHz (920 MHz) frequency bands for LPWAN (Low Power Wide Area Network) wireless communications systems are attracting attention from various IoT applications. Environmental and infrastructure monitoring systems, such as smart meter, ground inclinometer, and bridge sensor, are widely deployed. With LPWAN wireless communication systems on 920 MHz bands having the features of long distance, low rate and low power consumption, a huge number of IoT devices distributed in wide area can be connected to communication networks. Although these networks can be configured in a star configuration for a relatively small area, the mesh configuration has been emerging recently. IEEE 802.15.4g-FSK PHY/OFDM PHY is a typical PHY technology in mesh networks for the purpose of transferring IoT application data over a wider area. When distributing the same data such as firmware to IoT devices during network operation, improving the efficiency of distribution method becomes critical. On the one hand, using broadcast transmission, the delivery confirmation cannot be performed. On the other hand, unicast transmission is very time consuming if the number of IoT devices is large. Therefore, we proposed a new firmware distribution method with erasure code for large number of IoT devices. Our computer simulation result shows that the proposed method improves the efficiency of distribution by 1.48 times compared with conventional method and achieves higher spectrum efficiency for IEEE 802.15.4g-OFDM PHY.

09:30 AM **TeachNet: A Lightweight and User-Friendly Network Visualization and Experimentation Tool**

Authors: Safiqul Islam, Visar Morina, Boning Feng (Oslo Metropolitan University, Norway), Michael Welzl (University of Oslo, Norway)

Abstract: Network researchers, academics, and students often need to deal with complex scripting in order to design a network topology, configure network nodes, automate experimentation, and visualize network performance metrics. Current simulation or emulation tools lack the ability to provide a comprehensive understanding of the network. This paper introduces TeachNet, a lightweight and user-friendly network tool that provides a graphical user interface for designing, configuring, and automating network experiments. We explain TeachNet's design and present results to demonstrate its effectiveness and efficiency using our TCP experimentation-focused prototype, and Mininet in the backend. TeachNet creates a repository of log files and offers a framework for future research that is easily extensible to accommodate other tools such as OMNeT++ and ns3.

09:50 AM **Smart Device Counting and Tracking for People Flow Observation**

Authors: So-Yeon Kim, Dae-Ho Kim, Goo-Rak Kwon, Jae-Young Pyun (Chosun university, Korea)

Abstract: This paper introduces a smart device counting and tracking approach for people flow observation, which can be applied to various people flow applications, including cases where vision-based methods cannot be used. The proposed system detects nearby smart devices and counts them by selecting valid devices within the suitable range, that observed by the path loss model for the target service area. This method is more effective than existing counting methods used at people flow applications because it moniotrs devices carried by individuals or crowds passing through the limited specific locations. The performance evaluation showed that the effectiveness of our method was demonstrated with an average improvement of 19.9% in the correlation coefficient.

Parallel Session 6 – R2: Bale Paseban 2

Session Chair: Dr. Pradini Puspitaningayu

Paper	Authors
Joint AP Selection and Power Control Optimization for Uplink User-centric Cell-free Massive MIMO	Xiao Li, Na Li, Xiyue Li, Xiaofeng Tao (Beijing University of Posts and Telecommunications, China)
Plane Wave Expansion-based Codebook Design for 6G Near-field MIMO	Fan Wang, Xiaolin Hou, Xiang Li, Lan Chen (DOCOMO Beijing Communications Laboratories Co., Ltd, China)
Hotspotter: An Incentivized Crowdsensing System for WiFi and Cellular Network Coverage Visualization	Sebastian Luis S. Ortiz, Justin Gabriel R. Enriquez, Wilson M. Tan, Cedric Angelo M. Festin (University of the Philippines, Philippines)

Affiliation Macrocell Switching of Picocells in Uplink for Distributed Antenna System	Ayumu Takada, Yukitoshi Sanada (Keio University, Japan)
Joint Task Offloading and Beam Hopping for Satellite-Terrestrial-MEC Networks with MADRL	Zhihao Yan, Ailing Xiao, Sheng Wu (Beijing University of Posts and Telecommunications, Beijing, China)

08:30 AM **Joint AP Selection and Power Control Optimization for Uplink User-centric Cell-free Massive MIMO**

Authors: Xiao Li, Na Li, Xiyue Li, Xiaofeng Tao (Beijing University of Posts and Telecommunications, China)

Abstract: Selecting access points (APs) and power control are crucial issues in resource allocation within cell-free massive multiple-input multiple-output (MIMO) networks. The aim of these challenges is to manage inter-user interference, lessen the fronthaul load, and ensure system performance is maintained as the number of users increases. Unlike previous works that address these issues separately, this paper introduces an integrated optimization approach for both AP selection and power control in a user-centric cell-free network, constrained by users' minimum quality of service (QoS) to ensure system fairness. The problem at hand is a mixed-integer non-convex challenge, and we address it by utilizing fractional programming techniques for its transformation and solution. Simulations were carried out for environments, both indoors and outdoors, following 3GPP standards. The results indicate that the joint optimization approach greatly enhances the overall network sum spectral efficiency (SE) compared to solving these issues independently, emphasizing the proposed method's effectiveness.

08:50 AM **Plane Wave Expansion-based Codebook Design for 6G Near-field MIMO**

Authors: Fan Wang, Xiaolin Hou, Xiang Li, Lan Chen (DOCOMO Beijing Communications Laboratories Co., Ltd, China)

Abstract: To meet the stringent spectrum efficiency requirements of International Mobile Telecommunications (IMT)-2030 (6G), it is essential to explore the application potential of higher frequency bands and extremely large antenna arrays (ELAA). This shift introduces near-field effects, where electromagnetic waves deviate from the far-field plane wavefront assumption and must be modeled as spherical waves under certain distance conditions. Consequently, introducing beam focusing codebooks for the near-field is crucial. The typical fifth-generation New Radio (5G NR) high-precision Type II codebook, constructed from a two-dimensional discrete Fourier transform (DFT)-based grid of beams, enables the channel state information (CSI) feedback of a set of orthogonal beam selections along with corresponding amplitude and phase information. However, it is not optimized for near-field characteristics. To satisfy the 3rd Generation Partnership Project (3GPP) Releases' requirement for backward compatibility, we introduce the plane wave expansion (PWE) method of focused beams. This method allows for the generation of focused beams through the weighted superposition of multiple DFT beams. Based on this approach, we define a set of additional feedback contents and formats within the NR Type II codebook framework, enabling a more accurate

representation of the nearfield line-of-sight (LoS) CSI for feedback. Numerical simulation results substantiate the performance of the proposed NR Type II codebook enhancement scheme, achieving a performance within 2dB of the optimal beam focusing scheme with appropriate configuration.

09:10 AM **Hotspotter: An Incentivized Crowdsensing System for WiFi and Cellular Network Coverage Visualization**

Authors: Sebastian Luis S. Ortiz, Justin Gabriel R. Enriquez, Wilson M. Tan, Cedric Angelo M. Festin (University of the Philippines, Philippines)

Abstract: Reliable internet access is a key enabler for economic growth. Although the Philippine government launched initiatives to improve connectivity, connection speeds remained below the global average, especially for mobile networks. This paper presents Hotspotter, a system that aims to aid implementers and stakeholders in quantifying and addressing network coverage issues. Hotspotter is an incentivized crowdsensing system that collects, maps, and visualizes WiFi and cellular data to pinpoint hotspots and dead zones for the effective deployment and relocation of WiFi access points. A mobile application for Android was developed to facilitate data collection on geolocation, nearby WiFi access points, and connected cellular networks. The user interface visualizes the aggregated data in a hexagon-grid map. Fieldwork was conducted in two sitios of Barangay San Lorenzo, Norzagaray, Bulacan to stress-test the Hotspotter system in a Geographically Isolated and Disadvantaged Area (GIDA). It was found that 2G and 4G had the widest coverage and strongest signals overall, with modal signal strengths of 4.0 and 3.0, respectively. Being at the cutting edge, 5G was not yet supported. In the end, the mobile application's passive sensing, collecting, and caching of data successfully operated even in the most isolated areas without an internet connection.

09:30 AM **Affiliation Macrocell Switching of Picocells in Uplink for Distributed Antenna System**

Authors: Ayumu Takada, Yukitoshi Sanada (Keio University, Japan)

Abstract: This paper proposes the affiliation macrocell switching of picocells in a distributed antenna system (DAS). In a conventional DAS, a macrocell is composed of a fixed number of picocells. On the other hand, in the proposed scheme, picocells can switch their affiliation to adjacent macrocells so that the throughputs of cell-edge users improve. The proposed scheme aims to improve a system throughput with the moderate increase of backhaul complexity. Numerical results obtained through computer simulation show that the proposed scheme improves the system throughput by approximately 0.3 bps/Hz/cell and maintains user fairness. Moreover, the system throughput improves regardless of the distance between distributed antennas.

09:50 AM **Joint Task Offloading and Beam Hopping for Satellite-Terrestrial-MEC Networks with MADRL**

Authors: Zhihao Yan, Ailing Xiao, Sheng Wu (Beijing University of Posts and Telecommunications, Beijing, China)

Abstract: Mobile edge computing (MEC) supported by Low Earth Orbit (LEO) satellite communication systems is a promising approach to improve the Quality of Service (QoS) of terrestrial users. Most existing offloading methods neglect the downlink connectivity of satellites during task offloading, which may bring in extra delay and affect the offloading efficiency. This paper considers satellite-terrestrial-MEC networks in which the tasks are generated by source devices, and the computing services are provided by destination devices or the LEO satellites. Furthermore, we propose a joint task offloading and beam hopping optimization method, which aims to minimize the average time delay of all computation tasks. We formulate the joint optimization problem as a zero-one integer programming problem, which is NP-hard, and provide a multi-agent deep reinforcement learning (MADRL) framework for the intelligent task offloading scheme. In this framework, each agent is responsible for either task offloading or beam hopping, with shared rewards to enhance cooperation between agents. Additionally, to reduce the training time of traditional reinforcement learning algorithms, an attention mechanism is incorporated into MADRL. Simulation results demonstrate that our method effectively reduces the average offloading delay compared with other baseline schemes.

Parallel Session 6 – R3: Bale Paseban 3

"Spesial Session"

Session Chair: Dr. Eng. Faisal Budiman

Paper	Authors
Custom Dataset for Bus Passenger and Comparing Human Pose Estimation Model	Dong Gyu Lee, Dong Seog Han (Kyungpook National Univ, Korea), Jae Woo Lee (Auto-IT, Korea)
Partial Traffic Estimation with Compressed Sensing for VM Placement Problem	Ami Yamamoto, Takahiro Matsuda (Tokyo Metropolitan University, Japan); Reiko Kondo, Junichi Higuchi, Takeshi Kodama, Hitoshi Ueno (Fsas Technologies Inc., Japan), Takashi Shiraishi (Fujitsu Ltd., Japan)
On exposing Kubernetes service: Container networking through the OSPF protocol	Quyen Ha Long, Lam Le Ngoc, Anh Trieu Tuan (Viettel High Technology Industries Coporation, Vietnam)
A review in multi-modal semantic communication systems	Tung Son Do, Thanh Phung Truong, Quang Tuan Do, Dongwook Won, Sungrae Cho (Chung-Ang Universit, South Korea), Nhu-Ngoc Dao (Sejong University, South Korea)
Proposed Method for Incorporated Robot Control Platform in IoT DEP	Masaki Mitsuuchi, Koichi Ishibashi, Tetsuya Yokotani (Kanazawa Institute of Technology, Japan)

08:30 AM **Custom Dataset for Bus Passenger and Comparing Human Pose Estimation Model**

Authors: Dong Gyu Lee, Dong Seog Han (Kyungpook National Univ, Korea), Jae Woo Lee (Auto-IT, Korea)

Abstract: Bus passengers can experience an emergency situation as they fall due to a sudden start, sudden stop of the bus driver, passenger's carelessness, or physical abnormalities. Most buses are equipped with closed-circuit cameras on the bus so that the driver can know about the passenger's abnormality, but it is still difficult to know the passenger's abnormality right away. This paper aims to recognize the passenger's behavior through cameras to recognize the passenger's emergency situation on the bus. However, buses have a complex environments, such as chairs, handles, and other passengers, so it is difficult to recognize the passenger's behaviors. In addition, there is a problem in learning a deep learning-based model because there is not a public database with information on passenger behaviors in the bus about a complex environment. To this end, we built a database by directly constructing a complex bus environments and acquiring image data according to the scenario. The acquired data were compared in performance using various models to find an appropriate deep learning method to recognize passenger behavior on the bus. The accuracy of each behavior of passengers on the bus was compared using skeleton-based key points models.

08:50 AM **Partial Traffic Estimation with Compressed Sensing for VM Placement Problem**

Authors: Ami Yamamoto, Takahiro Matsuda (Tokyo Metropolitan University, Japan); Reiko Kondo, Junichi Higuchi, Takeshi Kodama, Hitoshi Ueno (Fsas Technologies Inc., Japan), Takashi Shiraishi (Fujitsu Ltd., Japan)

Abstract: For cloud computing environments with virtual machines (VMs), we previously proposed a VM placement (VMP) method using a traffic estimation scheme based on compressed sensing (CS). This scheme estimates the traffic volumes between all pairs of VMs (flow traffic volumes) from the transmitted and received traffic volumes of VMs (node traffic volumes), and it assigns VMs to physical hosts (PHs) according to the estimated traffic volumes to balance traffic loads within PHs and traffic loads passing through physical network interface cards (NICs) on each PH. In this study, by extending the VM placement method, we propose a sequential VM placement method to efficiently estimate the traffic volumes when their statistics change. The proposed method divides the time axis into measurement periods and determines the placement of VMs in each period. From the node traffic volumes measured in the period, to reduce the computational cost, a subset of VMs is extracted, and the partial traffic volumes are estimated using the CS-based estimator for the subset. We evaluated the performance of the proposed method through simulation experiments.

09:10 AM **On exposing Kubernetes service: Container networking through the OSPF protocol**

Authors: Quyen Ha Long, Lam Le Ngoc, Anh Trieu Tuan (Viettel High Technology Industries Coporation, Vietnam)

Abstract: Server virtualization is a widely used IT innovation, providing a platform for running OS services in the cloud. It enables the creation of multiple virtual machines on a single physical machine through hypervisors or containers. The emerging technology for hosting microservices involves smaller individually deployed services, increasing the demand for low-overhead virtualization. Docker, an opensource platform, is one of many lightweight virtualization technologies allowing developers to build and run applications. However, its management can be challenging for administrators. Kubernetes (K8s) is a popular tool for container orchestration in the cloud, offering methods like NodePort, Ingress, and LoadBalancer for external client communication. Yet, it lacks control over Transport layer traffic between containers. Various container network interface (CNI) solutions exist, but most are fee-based plugins. This paper proposes a new solution to handle Transport layer traffic for containers, replacing traditional CNI plugins by exposing IP services through the OSPF protocol.

09:30 AM **A review in multi-modal semantic communication systems**

Authors: Tung Son Do, Thanh Phung Truong, Quang Tuan Do, Dongwook Won, Sungrae Cho (Chung-Ang Universit, South Korea), Nhu-Ngoc Dao (Sejong University, South Korea)

Abstract: Multi-modal data which encompasses diverse formats like text, audio, images, and video, offers a rich representation of information in today's interconnected world. However, transmitting such data efficiently within the constraints of limited bandwidth and energy resources poses a significant challenge for traditional communication systems. Semantic communications has emerged as a promising solution. This survey paper explores the evolving landscape of multi-modal semantic communication systems, analyzing various approaches and frameworks that leverage deep learning techniques to extract, transmit, and fuse semantic information across different modalities. By providing a comprehensive overview of current research trends and future directions, this paper aims to guide researchers and practitioners in developing efficient, robust, and intelligent communication systems for the next generation of applications.

09:50 AM **Proposed Method for Incorporated Robot Control Platform in IoT DEP**

Authors: Masaki Mitsuuchi, Koichi Ishibashi, Tetsuya Yokotani (Kanazawa Institute of Technology, Japan)

Abstract: Internet of Things (IoT) services are being introduced in various sectors. This has led to a significant increase in connected IoT devices. To accommodate these efficiently, it is considered necessary to have a lightweight platform for processing. One such platform is the IoT Data Exchange Platform (IoT DEP) standardized by ISO/IEC JTC1/SC41 IoT DEP is a platform architecture that actively utilizes Pub/Subtype communication. Previous studies have used a method where multiple brokers are connected in a ring-like to share information between Nodal Points of an IoT DEP. However, in this method, there has been concern about the increase in delay time due to the rise in the number of hops according to the number of brokers. Future work includes developing an architecture to extend the connection capabilities to intelligent devices such as robots, and to build a model that can be

directly accommodated by Nodal Point. Therefore, this paper reports on the linkage between the End System and Nodal Point, as well as a proposed device abstraction method in the End System in conjunction with ROS 2, for which a prototype has been created.

Parallel Session 6 – R4: Bale Paseban 4
"Spesial Session"
Session Chair: Dr. Estananto

Paper	Authors
A Review and Vision of Quantum Communications and Networking	Thanh Phung Truong, Tung Son Do, Donghyeon Hur, Sungrae Cho (Chung-Ang University, Korea (South))
Solving Maximum Bottleneck Link Problem with Particle Swarm Optimization	Yuki Norimatsu, Takuya Asaka (Tokyo Metropolitan University, Japan)
A Review on Recent Advances in Metasurface Architectures for Future Wireless Networks	Thi My Tuyen Nguyen, The Vi Nguyen, Donghyun Lee, Sungrae Cho (Chung-Ang University, Seoul, Korea (South))
Average System Cost Minimization-Based Joint UAV Deployment and Resource Allocation	Qinyuan Wang, Rong Chai, Qianbin Chen (Chongqing University of Posts and Telecommunications, China), Chengchao Liang (Chongqing University of Posts and Telecommunications, China & Carleton University, Canada)

08:30 AM **A Review and Vision of Quantum Communications and Networking**
Authors: Thanh Phung Truong, Tung Son Do, Donghyeon Hur, Sungrae Cho (Chung-Ang University, Korea (South))
Abstract: Quantum communications and networking represent a paradigm shift in information technology, promising unprecedented capabilities in secure communication, distributed computing, and sensing. This paper provides a comprehensive review and forward-looking vision of quantum communications and networking, a field poised to revolutionize information technology. We begin by exploring the fundamentals of quantum communications and then examine the current state of quantum communication, surveying recent advancements in this field. Looking ahead, we explore future directions and the technologies that will enable them. The paper culminates in a vision for the future of quantum communications, presenting a roadmap towards a global quantum internet and its potential impacts on usage services. By synthesizing current knowledge and projecting future trends, this work provides a comprehensive understanding of the transformative potential and vision for quantum communications and networking.

08:50 AM **Solving Maximum Bottleneck Link Problem with Particle Swarm Optimization**
Authors: Yuki Norimatsu, Takuya Asaka (Tokyo Metropolitan University, Japan)

Abstract: As network technologies improve, the capacity for data transmission over networks is increasing. Efficiently transmitting large amounts of data requires careful consideration of routing in terms of link capacity. However, the conventional routing algorithms based on shortest paths are not suitable for large-volume data transfer.Therefore, we define the maximum bottleneck link problem to find better paths that avoid low-capacity links. To solve this problem, we adapt particle swarm optimization as a method for solving combinatorial optimization problems. In this paper, we conduct simulations under various conditions and verify the feasibility of our approach.

09:10 AM **A Review on Recent Advances in Metasurface Architectures for Future Wireless Networks**

Authors: Thi My Tuyen Nguyen, The Vi Nguyen, Donghyun Lee, Sungrae Cho (Chung-Ang University, Seoul, Korea (South))

Abstract: The next generation of wireless networks is expected to support various applications such as digital twins, metaverse, and holographic communications. To meet the stringent demands of these applications, new transceiver technologies are necessary. Among these technologies, intelligent reconfigurable surfaces (IRS) are attracting significant attention in both academia and industry because of their ability to manipulate the propagation environment, leading to improved coverage. This paper provides an overview of recent advances in RIS architectures, including their related capabilities, challenges, and approaches to addressing the related issues. Next, future directions are discussed regarding the implementation of RIS in rapidly time-varying propogation environments.

09:50 AM **Average System Cost Minimization-Based Joint UAV Deployment and Resource Allocation**

Authors: Qinyuan Wang, Rong Chai, Qianbin Chen (Chongqing University of Posts and Telecommunications, China), Chengchao Liang (Chongqing University of Posts and Telecommunications, China & Carleton University, Canada)

Abstract: Unmanned aerial vehicles (UAVs) are expected to act as aerial relays which forwards data packets for ground users (GUs) leveraging their advantages of low cost, high flexibility and maneuverability. How to design the efficient UAV deployment, GU association and resource allocation strategy in UAV-assisted cellular systems is a key problem that optimizes system performance. In this paper, we consider a UAV-assisted cellular system with the knowledge of statistical GU positions. Considering the system energy consumption and the deployment cost of UAVs, we formulate the joint UAV deployment, GU association and power allocation problem, which minimizes the system cost. To tackle the formulated problem, we decouple it into three subproblems, i.e., UAV deployment, GU association and power allocation subproblem. Then, the UAV deployment subproblem is modeled as a Markov decision process (MDP), and an embedded multi-agent double deep Q network (DDQN) algorithm is proposed. Specifically, given the state and action of the MDP, the power allocation strategy is determined by applying the Lagrange dual method. Then we propose a Kuhn-Munkres (K-M) algorithm-based to obtain the GU association strategy. Based on the obtained

power allocation and GU association strategies, the reward of the MDP can be computed and the UAV deployment strategy is determined which maximizes the long-term average reward. Numerical results show that our proposed algorithms outperform the benchmark scheme.

Venue

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Transportation to and from Hotel

The official venue for the Asia Pacific Conference on Communications 2024 is Truntum Kuta Hotel, conveniently located in Kuta, Bali. To ensure smooth transportation for all participants, the following options are available:

From Ngurah Rai International Airport (DPS) to Truntum Kuta Hotel:

- By Taxi: Taxis are available 24/7 at the airport. The ride to Truntum Kuta Hotel takes approximately 10-15 minutes, depending on traffic. The fare is around IDR 100,000 - IDR 150,000.
- By Ride-Hailing Services: Ride-hailing apps such as Grab and Gojek operate in Bali. Simply order a ride via the app from your mobile device.
- Hotel Shuttle: Truntum Kuta Hotel provides a paid airport shuttle service. Please contact the hotel in advance to arrange pickup.

From Truntum Kuta Hotel to Conference Venue:

- Walking: The conference will be held at the Truntum Kuta Hotel itself, ensuring easy access for all participants. No additional transportation is required.
- Transportation Around Bali:
- Car Rental: If you wish to explore Bali, various car rental services are available. Driving yourself provides flexibility, but traffic in Kuta and surrounding areas can be dense.
- Scooter Rental: For those looking for a more agile way to move around the city, scooters are a popular option. Rentals are available near the hotel.
- Public Transportation: Public buses (Trans Sarbagita) and bemos (minivans) operate in Bali but are less reliable and recommended for short-distance travel only.

Travel Information

You will need a visa to enter Indonesia.

It is most likely that you can apply for it on arrival, but check this official website if your country iseligible: bali.com/bali/bali-visa-indonesia-entry-regulations/ or kemlu.go.id/bern/en/news/17810/entering-indonesia-updated-on-2-august-2022

Also available e-Visa on Arrival (eVoA) at evisa.imigrasi.go.id

Also, have a look at this interesting map: en.wikipedia.org/wiki/Visa_policy_of_Indonesia

A Publish/Subscribe Forwarding Scheme Based on Mobility Information for Opportunistic Networks

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***Abstract*—This paper presents PuFLo, a publish/subscribe forwarding strategy, to deliver content to interested nodes in opportunistic networks. Most of the existing schemes typically use temporal or social knowledge when building routing tables. Instead, PuFLo considers node mobility information when making forwarding decisions. Initially, a node stores the ID of each location it visits in a sequence list. When a node contact occurs, PuFLo selects suitable relays based on two forwarding metrics: mobility similarity and centrality. The former evaluates the mobility diversity of two nodes based on dynamic time warping. The latter assesses node activeness based on Shannon entropy, which reflects the variation of previously visited places. Finally, the two metrics are integrated using the entropy weight method to define the PuFLo forwarding utility. Extensive simulations using the ONE simulator show that PuFLo consistently outperforms Epidemic and SimBet routing in terms of dissemination efficiency, latency, and cost.**

Keywords—content dissemination, publish-subscribe system, mobility similarity and centrality, opportunistic networks

I. INTRODUCTION

Content dissemination is a prominent application in today's pervasive and mobile networking scenarios. For decades, it has shaped conventional networks since the introduction of the Internet [1]. A process called a server is regarded as a crucial element in the system as it frequently produces content to be distributed across the network. An application that is interested in the particular content (called a client) establishes end-to-end communication with the server to acquire the information. Content retrieval can broadly be divided into two modes [2]: real-time streaming and push-based distribution. The former requires persistent end-to-end paths between sources and destinations since its QoS is closely linked to the capability to receive isochronous streams of data packets, e.g., video data units of real-time video streaming. The latter, however, does not need permanent end-to-end paths, as it relies on asynchronous delivery of bundles or bigger application data units towards a single receiver or a group of receivers.

The authors of [3] showed how push-based content distribution can be implemented in delay-tolerant networking (DTN) scenarios, such as opportunistic networks (ONs) [4], where instantaneous end-to-end communications are hard to achieve due to nodes' high mobility and intermittent connectivity. The works in [5-7] proposed a content-based architecture for ONs that shifts the search paradigm from "where the server is" to "where the content is". Thanks to the tremendous rise in computational power and storage capacity of mobile devices nowadays, DTN-based content delivery can be readily implemented on ONs. Additionally, it is able to complement content distribution based on infrastructures by allowing mobile users to receive bundles from the infrastructure, and subsequently share them with other users in areas with limited or no communication access. The objectives of content dissemination are typically to increase bundle delivery ratio, achieve minimum delivery delays, and maximize resource efficiency. Given that ON bundle relays are known for their ability to store and forward bundles to several contacts, a DTN-based forwarding mechanism is therefore well suited to data sharing and multicast services. Forwarding approaches in ONs attempt to adjust replication and forwarding in a way that makes it possible to achieve the abovementioned goals.

This paper presents an approach for content distribution in ONs based on publish/subscribe communications [8]. The targeted use case is asynchronous/non-real-time distributions of bigger, self-contained information bundles, e.g., web pages or audio/video podcast files. In publish/subscribe, sources and destinations are detached in terms of time and space, reflecting the disconnected nature of end-to-end communications in ONs. There are three distinct actors in the publish/subscribe system: publisher, subscriber, and broker. A publisher actively generates content and injects it into the network without necessarily knowing who would be interested in the information. A subscriber, who is the interested sink, broadcasts its interest to the entire network as it has no idea of which provider to contact. A broker acts as an intermediate node to facilitate the forwarding process.

In this study, nodes not only receive bundles that are of interest to them but also collect other bundles in order to proactively disseminate them in the network, reducing the overall delivery time to the intended receivers. Selecting the best brokers is thus crucial in the publish/subscribe system. Yet, this becomes a challenging task in ONs because nodes rarely have access to the network's state knowledge. Alternatively, nodes' local information is used to make forwarding decisions. This knowledge is often derived from the contexts and attributes of the nodes, such as contact history, social properties, and location information. Encounter-based routing algorithms exploit contact statistics to optimize message forwarding, resulting in higher delivery rates and lower overhead costs [9,10]. Other approaches consider social features of mobile users, such as social behaviors and relations, in order to identify suitable relays [11,12]. Meanwhile, with the availability of richer location information, approaches based on spatial information have been used to develop routing algorithms in ONs [13,14].

Accordingly, we introduce **Pu**blish/Subscribe **F**orwarding based on **Lo**cation Information (PuFLo), aimed at identifying the best relays based on node movement information. We first define a mobility profile, which reflects the long-term

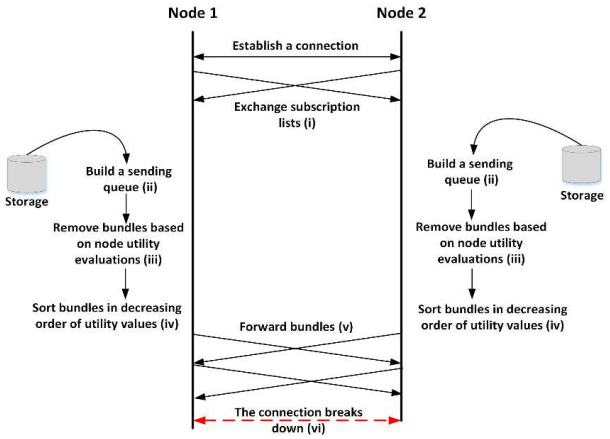

Fig. 1. The PuFLo process sequences

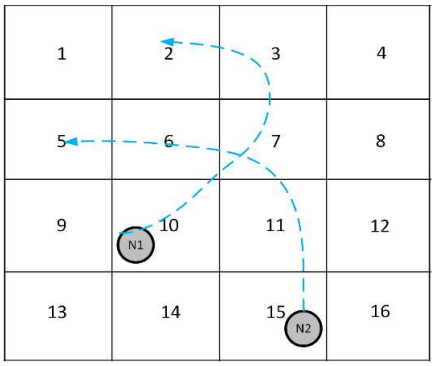

Fig. 2. The movement trajectories of two illustrative nodes in the given region

mobility pattern of a node. In contrast to prior studies [15,16], we propose a more concise and simplified form of mobility profiles. We characterize a mobility profile as a sequence of locations visited by a node. First, a node records the ID of each location it visits in a sequence list and considers this as a reference for its mobility behavior. Second, when a contact occurs, the node's forwarding utility is calculated, considering both its mobility similarity and centrality. Mobility similarity is calculated by comparing the movement sequences of two nodes based on dynamic time warping (DTW) [17], while mobility centrality is determined based on Shannon entropy [18], which measures the location variability in the node's mobility sequence list. Finally, the node's forwarding utility is calculated by integrating these mobility measures. When a content bundle has to be distributed, it is always forwarded to the brokers that have the highest utility score with the intended subscriber.

II. PuFLo Algorithm

A. Publish/Subscribe Systems in ONs

We now discuss a publish/subscribe (Pub/Sub) protocol to deliver bundles to the intended receivers in ONs. In these networks, nodes do not keep a view of the network topology in order to choose the best paths. Instead, they replicate bundles to the peers during contacts, allowing the bundles to be delivered over multiple hops of store-carry-forward. In our Pub/Sub model, content is recognized by means of a topic-based subscription system: interested users (subscribers) send out their interest packets (subscriptions) with an attention to get content on a particular topic in the network, and the relay nodes (brokers) that possess the requested content try to forward it to the subscribers. Publishers, on the other hand, generate content on a certain topic and disseminate it to the network without knowing who is interested in the data. Thus, both publishers and subscribers are entirely separated in both time and network structure.

The core of the PuFLo's work is the transfer of subscriptions and bundles between two nodes in contact. We illustrate the process sequence in Fig. 1. When a contact occurs between two nodes, they begin exchanging their subscription lists (i). Following this, each node creates a sending queue of bundles from its current buffer (ii). When a node has several contacts concurrently, a sending queue should be built for each connection. Subsequently, the bundles in the queue are handed to a utility-based forwarding function, which eliminates bundles whose delivery probability does not increase when replicated to the current peer (iii). Next, the algorithm sorts the bundles in the decreasing order of utility values (iv). Finally, the node begins transmitting the bundles (v), until the queue is empty or the contact terminates (vi). The peer receives not only the bundles for content to which it subscribes, but also other bundles in order to proactively disseminate them in the network, leading to a high network delivery performance. Obviously, the heart of the PuFLo algorithm is the calculation of node forwarding utility. As previously stated, node utility is computed by taking mobility similarity and centrality into account. We discuss these two mobility measures in detail in the next sections.

B. Node Mobility Similarity

We assume that when a node has a similar movement pattern with the bundle destination, it will be an optimal relay for the given target. Here, the similarity of two nodes is evaluated based on their mobility profiles, which are derived from their movement trajectories. To make the discussion tractable, we first define the region where nodes move in the network. We simply adopt a square area divided into m equal-size grid cells as the movement region, as showed in Fig. 2 (m =16). Besides, we illustrate the movement trajectories of two illustrative nodes $N1$ and $N2$ in the region. $N1$ has a movement sequence of [10, 7, 3, 2], while $N2$ has a sequence of [15, 11, 7, 6, 5]. To define the mobility similarity between the nodes, these series are compared. Nodes with higher similarity scores are more probable to meet in the near future.

Euclidean distance (ED) [19] is frequently used to determine the similarity of two data series. The ED of two series p and q of length n is calculated as $d(p,q) = \sqrt{\sum_{i=1}^{n}(p_i - q_i)^2}$. The similarity between two series increases as the distance between them decreases, and vice versa. ED examines two data series in a one-to-one correspondence with identically positioned elements. For such a comparison to be valid, both sequences must be of the same length. Nonetheless, in this study, PuFLo is most likely examining the comparability of two nodes with varied mobility sequence lengths. PuFLo tracks node positions as they move; therefore, nodes with more mobility will have bigger record sizes than those with lower mobility. As a result, ED cannot be applied to identify the similarity distance between two nodes with different mobility rates. To address this ED's shortcoming, we introduce the dynamic time warping (DTW) technique [17]. As opposed to the ED's one-to-one matching, the DTW's one-to-many matching allows us to compare two series of variable lengths.

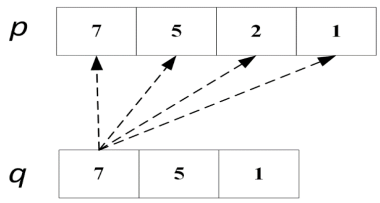

Fig. 3. The DTW's one-to-many comparison over two data series with unequal sizes

We now briefly discuss how DTW calculates the similarity distance between two series with unequal sizes. Suppose we have two series $p = [7, 5, 2, 1]$ and $q = [7, 5, 1]$ (we illustrate the DTW's one-to-many matching over the two series in Fig. 3). The DTW similarity calculation starts by building an empty local cost matrix from the pairwise series with x and y axes representing the values of the two series. Subsequently, the matrix is iteratively filled using (1) starting from the bottom left corner. For example, $d(1,1) = (7\text{-}7)^2 = 0$. Lastly, the resulted local cost matrix is depicted in Fig. 4 (a).

$$d(p(x), q(y)) = (p(x) - q(y))^2 \quad (1)$$

The solution of optimal warping path is computed based on (2) that yields a similarity matrix in Fig. 4 (b).

$$s(x, y) = d\big(p(x), q(y)\big) + \min \alpha \quad (2)$$

with α is a minimum similarity value of the direct neighbouring cells. The final similarity calculation between p and q results in 1, which is in the upper right corner of Fig. 4 (b). The lower the similarity value, the more similar the two series are. Thus, the obtained similarity value indicates that the series p and q are closely related.

C. Node Mobility Centrality

In addition to mobility similarity, we also introduce mobility centrality for PuFLo's forwarding metrics. We define the mobility centrality of a node as its activity degree within the network, as demonstrated by how frequently it moves between different locations. We believe that the more central the node is, the better the content broker it becomes, because the node with greater mobility centrality can meet more nodes in the network. Since PuFLo records the current location-ID only when the node moves to another region, the frequency with which a node travels from one area to another, which in turn reveals its mobility centrality, appears to be simply evaluated by counting its location transitions. However, this is not always the case. For instance, suppose we have the movement sequences of two distinct nodes $N4$ and $N5$, as described in Fig. 5. Clearly, both nodes equally perform seven location changes. In fact, $N4$ just moves back and forth between areas 1 and 7, and, therefore, $N4$ is likely to have a lower sequence variation than $N5$.

1	36	16	0
2	25	9	1
5	4	0	16
7	0	4	36
	7	5	1

(a)

1	65	25	1
2	29	9	1
5	4	0	16
7	0	4	40
	7	5	1

(b)

Fig. 4. (a) Local cost matrix, and (b) DTW similarity matrix

Here, we propose the Shannon entropy measure [18] to evaluate the variability of a mobility sequence. This metric evaluates the degree of randomness in a set of data. The Shannon entropy is widely used in many fields. In physics, the term refers to a system's thermal energy, which is linked to the degree of random mobility of molecules. In computer science, it is often used to calculate the likelihood of a specific character appearing next in a string of text. In genetics, it is utilized to calculate the variability of protein sequences. The Shannon entropy is computed as:

$$H(x_1, \ldots, x_n) = -\sum_{i=1}^{n}[P(x_i) \,.\, \log_b P(x_i)] \quad (3)$$

where $P(x_i)$ is the probability of a single event x_i occurring, and when dealing with computers, b is commonly set to 2 and the unit of entropy is known as a bit. Recalling the preceding problem in Fig. 5, we can calculate the mobility centrality of $N4$ and $N5$ using the Shannon entropy as follows:

$$N4 : H(1,7) = -\left(\tfrac{4}{8}.\log_2\tfrac{4}{8} + \tfrac{4}{8}.\log_2\tfrac{4}{8}\right) = 1 \text{ bit.}$$

$$N5 : H(1,2,5,7) = -\left(\tfrac{3}{8}.\log_2\tfrac{3}{8} + \tfrac{1}{8}.\log_2\tfrac{1}{8} + \tfrac{2}{8}.\log_2\tfrac{2}{8} + \tfrac{2}{8}.\log_2\tfrac{2}{8}\right) = 1.906 \text{ bit.}$$

D. Node Forwarding Utility

PuFLo chooses the best brokers for each subscriber based on node forwarding utility, calculated by taking into account node mobility similarity and centrality metrics. During the warm-up time, a node keeps a pathInfo list with entries representing the IDs of locations it has visited before. When a contact occurs, the node always exchanges its pathInfo list with its peer. In the end of the warm-up phase, each node will obtain pathInfo lists of all the network's nodes.

After the warm-up phase, the network enters a content dissemination period. In this phase, subscribers start broadcasting their interest packets with an attention to receive content related to their interests. Publishers begin creating content and distribute it to the interested nodes during contacts. Brokers, on the other hand, assist publishers by proactively disseminating content throughout the network in order to minimize the delivery time. When two nodes, $N1$ and $N2$, come into contact, they share subscription lists including information about their own interests as well as the interests of their neighbours. Based on this knowledge, the nodes update their subscription lists. Next, they inspect each bundle in the buffers. When a bundle contains information that corresponds to an interest in the subscription list, $N1$ calculates its forwarding utility to deliver the bundle to its subscriber node *ND*, as follows:

$$Util_{N1}(ND) = \alpha \;.\; Sim_{N1}(ND) \;+\; \beta \;.\; Cent(N1) \quad (4)$$

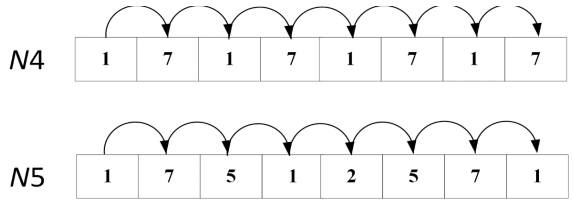

Fig. 5. Movement sequences of two illustrative nodes

where $\alpha+\beta=1$, and α and β are tuneable parameters to vary the relative significance of the two measures. Typically, both parameters can be assigned the same weight value, e.g., 0.5. However, we use the entropy weight method (EWM) to allow a single node to independently define the weight values of the PuFLo's forwarding metrics using locally available information. The following section explores the EWM theory used in PuFLo.

The EWM addressed here relies on the assessment approach given by Qui *et al.* [20], with minor adjustments to suit the needs of PuFLo. Assuming there exist m indicators assessing n objects, thus an indicator value matrix $X = (x_{ij})_{m\times n}$ is constructed as

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (5)$$

Here, x_{ij} denotes the j-th routing metric of node i. The matrix is then normalized to obtain a new one $R = (r_{ij})_{m\times n}$, where r_{ij} is the contribution degree of the routing metric j of node i and is computed as

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (6)$$

Afterwards, the entropy of routing metric j is given as

$$H_j = -k \sum_{i=1}^{m} r_{ij} \ln r_{ij} \quad (7)$$

for $k = 1/\ln m$, and $0 \le H_j \le 1$. Next, the entropy of the j-th routing metric can be utilized to define the weight of the given routing metric as follows. We set d_j as the contribution degree of each node i at the j-th routing metric, which can be expressed as $d_j = 1 - H_j$. Finally, the weight of the routing metric j is computed as

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \quad (8)$$

Lastly, we talk about incorporating EWM into the PuFLo's forwarding approach. When node $N1$ meets $N2$, for every bundle m with the final destination ND in $N1$'s buffer, $N1$ constructs an indicator matrix X comprising the similarity and centrality values of all previously encountered nodes in relation to ND. For instance, in (9) we depict the matrix X_{N1} of $N1$ for the bundle m with the final target ND when $N1$ has prior contacts with several nodes, namely $N2$, $N3$, $N4$, and $N5$, and as a result, it has similarity and centrality scores of each the encountered node in relation to ND. However, if, for example, $N3$ has not seen ND yet, then $Sim_{N3}(ND) = 0$.

$$X_{N1}(ND) = \begin{bmatrix} Sim_{N2}(ND) & Cent(N2) \\ Sim_{N3}(ND) & Cent(N3) \\ Sim_{N4}(ND) & Cent(N4) \\ Sim_{N5}(ND) & Cent(N5) \end{bmatrix} \quad (9)$$

Afterwards, $N1$ calculates the values of α and β using (6)-(8), and eventually determines $Util_{N1}(ND)$ using (4), which is the PuFLo's utility value of $N1$ for the destination ND. $N1$ then exchanges its forwarding utility score with its peer $N2$. Whenever $Util_{N2}(ND) > Util_{N1}(ND)$, then $N1$ transmits the bundle m to $N2$. Thus, this EWM computes the weights of similarity and centrality per bundle m in the storage of the sending node $N1$. Since in PuFLo, matrix X contains only two columns, but the row size depends on the number of nodes contacted, we then believe that the calculation of α and β for each bundle in the node buffer is still reasonable for mobile nodes with constrained resources and computing power. We summarize how PuFLo works in Alg. 1 below.

Algorithm 1. PuFLo distributed forwarding

The warm-up phase:
Begin
All nodes record the ids of all visited places and save them into the pathInfo lists;
Each node exchanges its pathInfo list with the peers during contacts;
End

The content dissemination phase:
Begin
When a contact occurs between nodes *N1* and *N2*
Node *N1* exchanges its subscription list with *N2*;
For each bundle $m \in N1$'s buffer
For all subscriptions that match with the content of m
calculate Similarity (*N1*, subscriber(m));
calculate Centrality (*N1*);
exchange Similarity (*N1*, subscriber(m)) and Centrality (*N1*) with *N2*;
calculate *N1*'s forwarding utility;
calculate *N2*'s forwarding utility;
If *N2*'s forwarding utility > *N1*'s forwarding utility
then forward bundle m to *N2*;
End if
End for
End for
End

III. Result and Discussion

A. Simulation Setup

To assess PuFLo's performance in ONs, we use the ONE simulator [21]. In this study, we use two different scenarios to evaluate PuFLo. For all scenarios, we use the simulation area of 1200 × 1200 m, which is divided into 16 equal-size grid cells as shown in Fig. 2. The number of nodes for simulations is 150. For the first case, as a reference, we use a scenario that is almost identical to the one used by the authors of Epidemic routing [22]. We randomly place all of the nodes in the given region. Furthermore, the nodes move following the random way-point model at speeds ranging from 0 to 20 *m/s*.

For the second scenario, we consider a more realistic movement model. We adopt the community model presented in [23]. In this case, the 16 sub-areas of Fig. 2 are organized into 15 communities (location-IDs 1-15) and one gathering place (location-ID 16). Afterwards, all nodes are evenly distributed across all the communities. As a result, each node has one home community that it prefers to visit than others, and each community has 10 nodes that share that home community. Furthermore, a node selects a destination, travels there, stops for a bit, and then chooses a new destination. When a node is at home, it is more likely to visit the gathering place, and when the node is not at home, it is more probable to return home. This type of mobility can occur in real-world settings, for instance human mobility in which the communities could be residences, or animal movement where

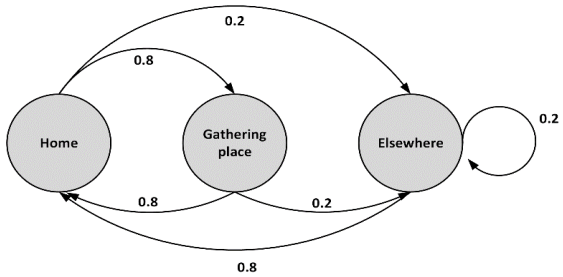

Fig. 6. The transition probabilities between locations in the community model

the gathering point is a feeding area and the communities are herd homes. We summarize the transition probabilities used in the community model in Fig. 6. In addition to the nodes with community-based mobility, we also employ 10 "super nodes" in the network, which have an equal chance of visiting any place in the simulation area. These nodes have a high mobility centrality and thus can serve as a global information broker in the network.

Both scenarios also share several simulation settings as follows. To generate content and interest classes, we consider the interval-valued scheme [24], and for the simulations we choose 5 categories for both content and interest. The content and interest are created at randomly selected nodes in every 1660−2660 seconds, with the time-to-live is 18,000 seconds. The content bundle size varies between 500K−1MB. The nodes' buffer size ranges from 10 MB to 100 MB. The simulation time is 259,200 seconds, with the warm-up time is 28,800 seconds to allow every node collecting pathInfo lists from all other network nodes.

To evaluate PuFLo, we use two distinct algorithm benchmarks: Epidemic routing [22] and SimBet routing [25]. The former is flooding-based forwarding, where a node simply forwards copies of a bundle to each encountered node that does not have it yet. The latter, however, takes into account social similarity and centrality when selecting the optimal relays. For performance metrics, we consider the following. First is *average utility*, which measures how many bundles are successfully delivered to intended receivers. Second is *delivery efficiency*, which reflects how many replicas are required to transmit a single piece of content to the subscribers. Third is *delivery latency*, which is the average delay time to send a bundle to the recipient nodes.

B. Simulation Results

We run each scenario several times, each time changing the buffer size at the nodes. For each setup, we perform simulation five times using dissimilar random seeds. The results shown in the graphs are averages of five simulation runs. Each of these graphs contains curves for PuFLo, Epidemic and SimBet for a single performance metric under a specific mobility scenario. On the *x*-axis in each graph, the buffer size can be observed. Eventually, in Figs. 7, 8, and 9, we present the simulation results that characterize the utility, efficiency, and latency performances of the algorithms, respectively, in the random and community scenarios.

First of all, we discuss the utility performances of all protocols in different scenarios presented in Fig. 7. A utility metric implies the likelihood of a bundle being successfully forwarded to the intended recipients. It is clear that the buffer size affects PuFLo's performance: as the queue size grows, the number of bundles sent to the destinations also increases for all the algorithms. This makes sense since a larger buffer size allows for more bundles to be stored and reduces the chance of removing a bundle due to a buffer overflow. In the random scenario, the Epidemic's flooding strategy works effectively for delivering bundles to the destinations. In contrast, the similarity/centrality-based routing algorithms, PuFLo and SimBet, are less effective at detecting suitable relays and perform worse in this scenario. In the community scenario, on the other hand, PuFLo and SimBet increase their performances approaching the Epidemic's upper-bound utility performance across all buffer sizes. This implies that the forwarding metrics of PuFLo and SimBet, which are based on node similarity and centrality, are effective in selecting optimal relays in the community model. Furthermore, PuFLo performs slightly better than SimBet in this performance metric.

We next discuss the delivery efficiency of all the routing algorithms, reflecting the cost (i.e., the number of replicas) required to successfully deliver a single bundle to the destination. Looking at the graphs in Fig. 8, it is evident that both PuFLo and SimBet make fewer replicas during the simulation and have a lower delivery overhead than Epidemic in both scenarios. As a result, these utility-based forwarding techniques greatly surpass Epidemic in terms of efficiency in both mobility scenarios. This is because both PuFLo and SimBet only forward bundles to a few "best relays" during node contacts, while Epidemic transmits all possible bundles to each encountered node. Moreover, this improved efficiency performance has no negative impact on the bundle delivery

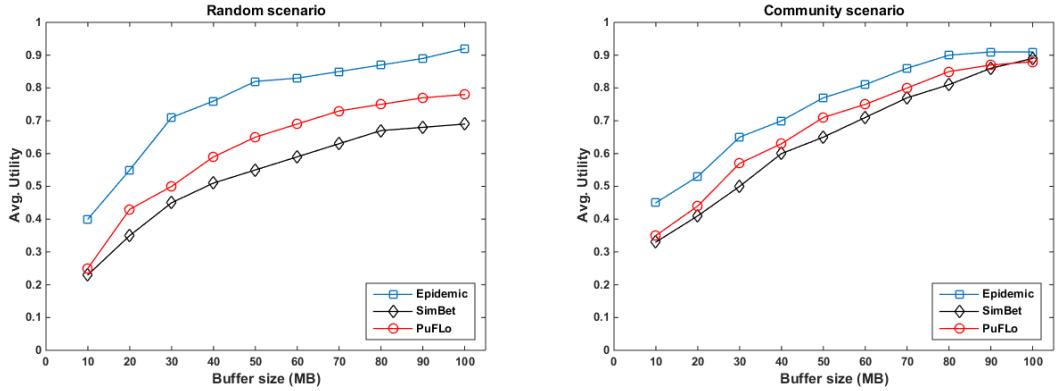

Fig. 7. The utility performances of PuFLo and its benchmarks in the random and community scenarios

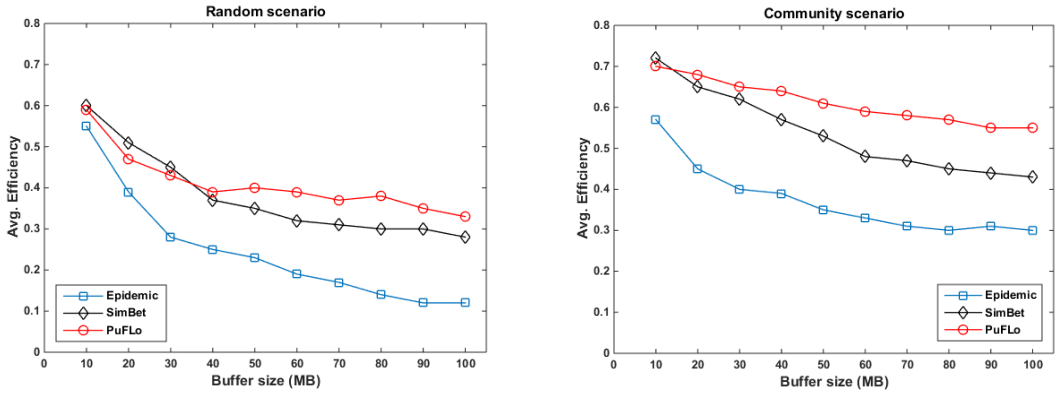

Fig. 8. The efficiency performances of PuFLo and its benchmarks in the random and community scenarios

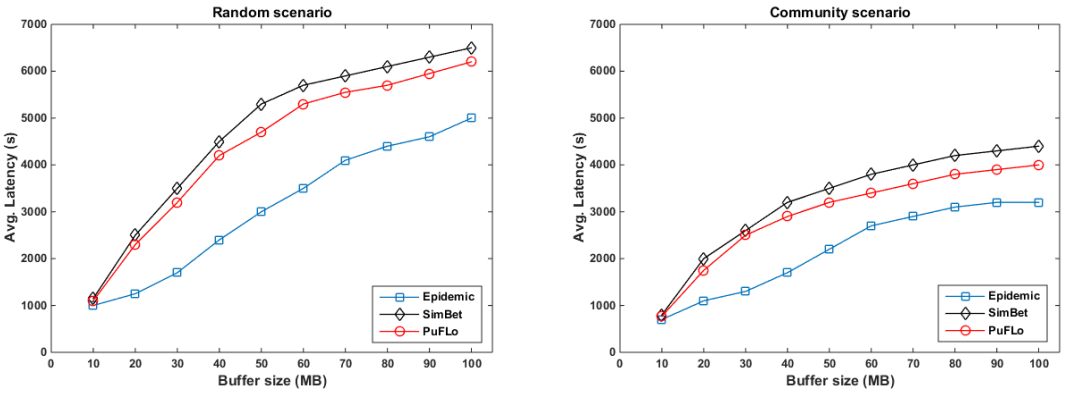

Fig. 9. The delay performances of PuFLo and its benchmarks in the random and community scenarios

probability, and both the algorithms are able to deliver bundles as many as Epidemic in the community scenario (as shown in the utility performance graph in Fig. 7 (right)). In addition, PuFLo outperforms SimBet in this performance metric, indicating that PuFLo's forwarding metrics based on mobility information works more effectively than SimBet's forwarding metrics based on social information in selecting suitable relays, resulting in a substantial reduction of total replicas below SimBet's.

Finally, we discuss the delay performance of PuFLo compared to the given benchmarks. Even though the content distribution under study is considered to be delay-tolerant, it is worthwhile to evaluate the average time required to send content to the interested sinks. Looking at the latency graphs in Figs. 9, it is easy to notice that increasing buffer size also increases the delivery latency for bundles. The fundamental reason for this observed tendency is that more bundles can now be delivered with a bigger buffer capacity. These extra delivered bundles could be bundles that were discarded due to smaller buffer sizes, but are now able to reside in the buffer long enough to be sent to the destinations. This incurs a longer delivery time for these bundles. In the random scenario, Epidemic shows its best performance, while PuFLo and SimBet increase their delivery delays beyond that of Epidemic. Yet, in the community scenario, their delays slowly approach the Epidemic's latency when the queue size grows larger. In the DTN studies, Epidemic's delay is commonly used as a lower-bound delivery time, since the flooding strategy of Epidemic can theoretically achieve the shortest delivery latency, but at the expense of a high overhead cost. PuFLo and SimBet, on the other hand, can attain delivery delay as low as Epidemic in the community scenario, but at a significantly lower delivery cost (as demonstrated by the PuFLo's and SimBet's higher efficiency in the graph in Fig. 8 (right)). Furthermore, as in the utility and efficiency evaluations, PuFLo also outperforms SimBet in this delay evaluation, slightly decreasing the latency below SimBet's in both scenarios. This again indicates that PuFLo's forwarding metrics based on mobility information are more effective than SimBet's forwarding metrics based on social information in selecting suitable relays.

IV. Conclusions

This paper proposed PuFLo, a publish/subscribe forwarding technique to distribute content in opportunistic networks. It makes use of mobility similarity and centrality to efficiently identify the most appropriate relays for a certain (content) subscriber. Mobility similarity between a pair of nodes is calculated using the dynamic time warping (DTW) technique, and mobility centrality is evaluated based on the Shannon entropy measure. Both measures are subsequently used to define a node's forwarding utility. A pair of nodes with a higher utility score is more likely to meet shortly. When a bundle has to be distributed, it is always sent to the brokers that have the highest utility value with the intended receivers. Simulations under the community mobility model showed that PuFLo is superior to Epidemic particularly in the efficiency performance metric, where PuFLo made a significant lower number of replicas during the simulations while maintaining delivery success rate and latency comparable to Epidemic. Moreover, when compared to SimBet, the simulation results revealed that the forwarding metrics based on mobility information of PuFLo works more effectively than the forwarding metric based on social information of SimBet in

choosing optimal relays, with PuFLo outperforming SimBet in all evaluation metrics in both random and community scenarios.

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