BOOK OF ABSTRACTS

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IEEE HPSR'23 Conference Program

Day 1: Monday, June 6

Morning 8:30-12:40

Opening Speech: 8:30 - 8:45

Nirwan Ansari (New Jersey Institute of Technology, USA)

Keynote: 08:45 – 9:45

Speaker: Song Guo, The Hong Kong Polytechnic University, China
Topic: TinyML Systems for Edge Intelligence

This talk will focus on the field of Edge Learning. Specifically, learning paradigms, fundamental theories, and enabling technologies for Edge Learning consist the main components of this tutorial. We will first explain the background and motivation for ML running at the network edge. Then, we will review the challenge issues existing in Edge Learning. Furthermore, we will provide an overview of the overarching architectures, frameworks, and emerging key technologies for learning performance, security, privacy, and incentive issues toward training/inference at the network edge. Finally, we will discuss future research opportunities on Edge Learning.

Bio: Song Guo is a Full Professor at the Department of Computing, The Hong Kong Polytechnic University. He also holds a Changjiang Chair Professorship awarded by the Ministry of Education of China. Prof. Guo is a Fellow of the Canadian Academy of Engineering, Fellow of the IEEE, and ACM Distinguished Member. Prof. Guo's research interests are mainly in edge AI, big data and machine learning, mobile computing, and distributed systems. He published many papers in top venues with wide impact in these areas and was recognized as a Highly Cited Researcher (Clarivate Web of Science). Prof. Guo has served as an IEEE ComSoc Distinguished Lecturer, Director of ComSoc Membership Services, member of IEEE ComSoc Board of Governors, and the current Chair of IEEE Communications Society Space and Satellite Communications Technical Committee. He also serves for IEEE Computer Society on Fellow Evaluation Committee, the inaugural Editor-in-Chief of IEEE Open Journal of the Computer Society, and on editorial board of a number of prestigious IEEE Transactions and Journals. He has served as chair of organizing and technical committees of numerous international conferences.

Best Paper Award ceremony: 9:45-10:00

Recess: 10:00-10:20

Invited female session: 10:20-11:40

Topic: Data Mining for Security of the Industrial Internet of Things
Moderator: Yuanfang Chen, Shanghai Jiao Tong University, China

Title: Learning Based Privacy Protection in Internet of Things
Speaker: Liang Xiao, Xia Men University, China

The rapid development of the Internet of Things (IoT) has given birth to the emergence of service models such as intelligent transportation, telemedicine, and location-based services. However, they face different privacy issues, such as eavesdropping attack and advance persistent threat, which has caused huge economic losses and even harm national security. Additionally, these new service models face challenges such as the complexity of the IoT environment, the unknown privacy leakage model, the limited resources of the IoT devices, and the time-sensitive requirements. In this talk, we introduce the privacy protection schemes in three typical scenarios of cloud storage systems, mobile edge computing, and location-based services for privacy leakage in the IoT. We apply game theory, reinforcement learning, and differential privacy to investigate intelligent privacy protection scheme. This work provides a theoretical basis and useful suggestions for the future design of the IoT privacy protection framework.

Bio: Liang Xiao is currently a Professor in the Department of Informatics and Communication Engineering, Xiamen University, Fujian, China. As an IEEE Senior member, she has served in several editorial roles, including an associate editor of IEEE Transactions on Information Forensics & Security, IEEE Transactions on Communication and IEEE Transactions on Dependable and Secure Computing, and Guest Editor of IEEE Journal on Selected Topics in Signal Processing. Her research interests include wireless security, privacy protection, and wireless communications. She published two books and three book chapters. She won the best paper award for 2017 IEEE ICC, 2018 IEEE ICCS and 2016 IEEE INFOCOM Big security WS. She received the B.S. degree in Communication engineering from Nanjing University of Posts and Telecommunications, China, in 2000, the M.S. degree in Electrical engineering from Tsinghua University, China, in 2003, and the Ph.D. degree in Electrical engineering from Rutgers University, NJ, in 2009. She was a visiting professor with Princeton University, Virginia Tech, and University of Maryland, College Park.

Title: Cybersecurity in Microgrid
Speaker: Yanwei Wu, University of Wisconsin, USA

A microgrid is a small-scale distribution grid, made up of electricity users with local renewable and other energy sources. The smart microgrid can make intelligent decisions to produce significant savings by lowering energy costs and by managing onsite energy usage to avoid peak energy prices while supporting grid stability and improving return on investment. However, when utility companies extend their proprietary substation industrial network to the Internet to cover the grids, they face more critical cyber threats than other industries. Our project is to build a smart microgrid system on campus, develop cybersecurity technologies, and offer cybersecurity validation services to local companies.

Bio: Yanwei Wu is currently an Associate Professor in Computer Science and Software Engineering Department at University of Wisconsin, Platteville, Wisconsin, USA. She received her Ph.D. degree in Computer Science from Illinois Institute of Technology. She published in IEEE transactions and served as an editor, conference chair, member or reviewer in selected journals and conferences. Her research interests are cybersecurity. Her currently funded projects are “Risk Assessment in Pioneer Farm” and “Cybersecurity Testbed in Microgrid”.

Title: A Research on Device-free Human Activity Recognition using Physical Layer Information
Speaker: Linlin Guo, Shandong Normal University, China

Passive human activity recognition is a hot research topic with important theoretical value and broad application prospect in the field of wireless intelligent sensing. At present, there are many achievements in passive human activity recognition domain using wireless signals, such as activity detection, activity recognition, attribute estimation and trajectory tracking of people. Our research mainly explored the influence mechanism of human activity on WiFi signal changes by combining signal sensing theoretical model and deep learning algorithm. Through the exploration of signal propagation model, data representation, individual behavior habits and other aspects to gradually build the environment model, human model and activity model. The presentation will introduce our research on human behavior sensing in terms of human activity detection, human activity segmentation and human activity recognition. Our goals are to promote the human activity recognition in large-scale scene or the application of complex application environments, and provide theoretical model for further research and experience of enlightenment.

Bio: Linlin Guo is currently a lecturer in School of Information Science and Engineering at Shandong Normal University. She received the B.S. degree in Computer and Technology Department from Taishan University in 2011,

the M.S. degree from Qufu Normal University in 2014, the Ph.D. degree from Dalian University of Technology in 2020. Her current research interests include Wireless sensing (device-free indoor localization and human activity recognition), wireless network, and machine learning. She has been actively publishing more than 10 papers in the high quality international journals and conferences.

Topic: Variational Inference Assisted Ground Truth Analysis for Data Management of IIoT

Speaker: Jia Liu, Hangzhou Dianzi University, China

The continuous expanded scale of the industrial Internet of Things (IIoT) leads to IIoT equipments generating massive amounts of uncertain user data every moment. How to make use of these uncertain data in an efficient and safe way in the field of IIoT is still an open issue, such that it has attracted extensive attention from academia and industry. As a new machine learning paradigm, variational inference (VI) has great advantages in obtaining the ground truth from uncertain data. This article studies the VI technology applications to manage IIoT equipment data in wireless network environments. Therefore, we propose a VI algorithm assisted ground truth analysis for data management of IIoT (VIIIoT), which can take into account the privacy and efficiency of data training of IIoT equipment. VIIIoT provides more general insights into the forming of user features, can be easily extended to higher dimensions and has the merits of low complexity, easy scaling and generality. Experiments show that VIIIoT outperforms the other existing type of machine learning algorithms, and it has higher accuracy in terms of mean absolute error (MAE) and root mean square error (RMSE).

Bio: Jia Liu is currently a lecturer in the School of Cyber Security, Hangzhou Dianzi University, Hangzhou, China. She received the Ph.D. degree in software engineering from the Dalian University of Technology, Dalian, China, in 2021. From 2018 to 2019, she was a visiting PhD student in school of biomedical engineering from the University of California, Irvine, sponsored by China Scholarship Council. Her research interests include artificial intelligence, machine learning, variational inference, crowdsourcing, and computer vision. She published 11 papers in MONET, WCMC, Sensors, IECON etc.

Panel: 11:40-12:40

Topic: Intelligent Network Technologies, What's Next?
Moderators: **Stefano Giordano** (Universita di Pisa, Italy) and **Prasad Calyam** (University of Missouri-Columbia, USA)
Panel Speakers:
David Dai (Futurewei)
Gianni Antichi (Queen Mary London)
Travis Neely (Microsoft)

We envision the panel theme to be around next-generation network technologies to perform intelligent/agile integration of communication, computation and storage with innovative approaches such as e.g., offloading to GPUs/FPGAs or edge-cloud offloading. Also, the panel discussions will be about potential application areas since the data-driven approaches for offloading will need to consider application domain considerations.

Keywords: 5G/6G, data center networking, edge-cloud continuum, data-driven design, service chaining, real-time applications/middleware, energy-aware networking, clean-slate approaches, in-network data processing/aggregation, distributed intelligence, intent-based networking/automation.

Bios:

David Dai is a senior technical director of system architecture at Huawei, working on various aspects of trustworthy computing. He has over 25 years of experience in the computer networking industry and previously held various technical leadership and managerial roles at Cisco, Andiamo, Sanera, and Nortel. His interests are focused on future mobile architecture and platforms, cloud and edge computing, SDN, NFV, cloud-based networking and heterogeneous computing.

Gianni Antichi is a senior lecturer (associate professor) at the School of Electronic Engineering and Computer Science of Queen Mary University of London. His research interests cover a broad spectrum of topics in both networks and systems: network monitoring, data plane offloading, end host networking and Software Defined Networking. He has been awarded with the best paper at ACM SIGCOMM 2017, the EPSRC new investigator in 2020 and the Facebook Faculty in 2020.

Travis Neely is a software engineer at Microsoft working on their Azure for Operators platform. His work involves enabling network operators to provide core infrastructure, combining cloud and edge resources for low latency, broad reach, and service intelligence. His research interests include Software Defined Networking, network monitoring,

and Security as a Service. He has previously worked on intelligent network technology projects for AT&T in USA and has publications in venues such as ACM ICDCN and Elsevier FGCS.

Recess: 12:40-13:00

Afternoon 13:00-18:00

Invited session on New IP I: 13:00-14:40

Title: An Introduction to New IP
Speakers: Richard Li, Futurewei, USA and **Lijun Dong,** Futurewei, USA

Many new applications enabled by 5G/B5G/6G require new features and new capabilities for the network protocols. In this talk we start with future trends and market drivers, identify their requirements, and analyze the technical gaps. In particular, we will discuss the following use cases: integration of spatial (non-terrestrial) networks and terrestrial networks, OT Networks (Operational Technology Networks) such as Industrial Networks for manufacturing and control, Cloud Driving (Remote Driving, Tele-driving), and Holographic Type Communications. From many use cases we conclude that the future networking protocols need to evolve along three dimensions: (1) omni-convergence; (2) KPI guarantee; (3) social sustainability. In order to meet requirements from these three dimensions, we discuss a new network protocol design, called New IP. In particular I we discuss (1) A free-choice addressing mechanism to connect and converge various vertical communication networks; (2) A contract mechanism for application KPI and sender's intent in business critical and life critical applications; (3) Qualitative Communication mechanism for volumetric holographic type communications; (4) Green Internet support and energy consumption reduction in routers/switches. New IP is being developed by extending IPv4/IPv6 to enlarge and improve the Internet so that emerging and future applications will be supported and implemented.

Bio: Richard Li is Chief Scientist and Vice President of Network Technologies at Futurewei, USA. Richard served as the Chairman of the ITU-T FG Network 2030 from 2018 to 2020, and as the Vice Chairman of the Europe ETSI ISG NGP (Next-Generation Protocols) from 2016 to 2019. He has also served as Co-Chairs of steering committees and technical program committees of some academic and industrial conferences. Richard is extremely passionate about advancing ICT infrastructure technologies and solving problems in their entirety, thus creating a bigger and long-term impact on the networking industry. During his career, Richard spearheaded network technology innovation and development in Routing and MPLS, Mobile Backhaul, Metro and Core Networks, Data Center, Cloud and

Virtualization. Currently he leads a team of scientists and engineers to develop technologies for next-generation network architectures, protocols, algorithms, and systems in the support of emerging and forward-looking applications and industry verticals in the context of New IP, Network 2030, and 5G/B5G/6G.

Lijun Dong is a Principal Research Engineer at Futurewei Technologies, USA. She has broad and in-depth research in the areas of Internet of Things, Machine-to-Machine communications, Information-Centric Networking and Future Internet Architecture for more than a decade. She is one of the voting members of ComSoc Industry Communities Board (2022-2023). She was one of the board members of the WOCC conference 2017-2018. She won Futurewei President Awards in 2020, InterDigital Innovation's Awards in 2013, travel grant of Globecom 2009. She received best paper awards in WOCC 2018, AFIN 2018, Internet 2021. She has been an active and influential contributor, and responsible for internal strategy development and execution for standards, including oneM2M, IETF, 3GPP and ITU. She is the major inventor to 100+ granted patents. She has 60+ publications and several book chapters.

Recess: 14:40-14:45

Invited session on New IP II: 14:45-16:25

Moderator: Lijun Dong, Futurewei, USA

Topic: Programmable Data Plane for New IP using eXpress Data Path (XDP) in Linux
Speaker: Mohit P. Tahiliani (NITK Surathkal, India)

This talk will present a new dimension in packet programming and processing by leveraging New IP technology since applications are sensitive to different types of network constraints. For instance, emerging industry operations, manufacturing, and autonomics are limited by the stochastic quality of services and inflexible address structures. Instead, they require efficiency and deterministic networks. In this talk, we demonstrate a programmable data plane for New IP packet processing and show how network headers could evolve in the future. We discuss the implementation of New IP stack to encompass three goals: (1) address customization: applications and routers can forward packets between hosts with different address formats. (2) design an end-to-end model to meet service delivery guarantees: routers implement various in-network New IP contracts as described by the applications. (3) Rapid experimentation of the New IP components. With New IP, developers can describe packet processing functionalities without depending on the specifics of the underlying hardware. Our implementation of the New IP stack uses the existing toolsets and capabilities of the Linux platform, such as eXpress Data Path (XDP) and Traffic Control (TC) subsystem. It consists of an end-to-end solution with a new network stack on the host side and a

corresponding packet processing and forwarding engine on the network. It is validated using Network Stack Tester (NeST), a lightweight tool built on Linux network namespaces.

Bio: Mohit P. Tahiliani is a faculty of Computer Science and Engineering at NITK Surathkal, Mangalore, India. He is a Member of the Steering Committee of ns-3 network simulator and is a co-maintainer of TCP and traffic-control modules in ns-3. He works on TCP optimizations, Linux queue disciplines and Wi-Fi rate adaptation. Mohit and his students have developed Network Stack Tester (NeST), an open-source Python package that simplifies the process of performing networking experiments by using Linux network namespaces which is the foundation to the New IP sandbox that will be discussed in his talk. This work is an academic effort. Mohit served as architect and mentor to the students who developed the code.

Topic: Crrier-Grade Minimalism Multicast with Stateless Explicit Path
Speaker: Junjie Wan, Huawei Technologies, China

Group communication is a communication pattern where data is distributed from one sender to many receivers. It is widely applied in content distribution scenarios, such as IPTV, live streaming, video conference, data delivery, and others. Multicast is an efficient one-to-many data distribution method. However, application-layer multicast still has problems of inefficient network utilization as it is not allowed to control network elements. Existing network assisted multicast is unable to meet the newly emerging demand, such as multicast traffic engineering and load balancing. Some implementations of network assisted multicast are also limited to scalability issues caused by limitations of per-flow state maintained in network elements. In this paper, we introduce a novel multicast technology called Carrier-Grade Minimalism Multicast (CGM2) which leverages a string of bits, the bitmap, to instruct node to locally duplicate packets and forward them over several links without per-flow state and encapsulates bitmaps as binary in-packet tree for explicit forwarding path.

Bio: Junjie Wan received the MS degree in information science from the University of North Carolina at Chapel Hill, USA, in 2017. He is currently a senior engineer of Network Technology Laboratory at Huawei, China. His research interests include network architecture, routing protocol and network service.

Topic: The Effects of Packet Wash on SVC Video in Limited Bandwidth Environments
Speaker: Stuart Clayman, University College London, England

This paper describes the effects of the Packet Wash process on the transmission of layered SVC video streams. We

show how the packet size is adapted when using a number of different packing strategies, that map the video data into the BPP packets, and discuss the relationship between the packing strategies on the sender side and the chunk removal in the washing process. We demonstrate how the packing strategy causes different impacts on the number of and the sizes of the washed chunks. As the bandwidth reduces, more of the chunks in a packet get washed away. Although the receiver gets packets that are much smaller than those transmitted by the sender, it is still able to play video with a high QoE as zero packets are dropped. This traffic engineering enables a direct implementation of an in-network video adaption scheme. The experimental evaluation highlights that the effects of Packet Wash become more obvious in environments where there is limited bandwidth.

Bio: Stuart Clayman received his PhD in Computer Science from University College London in 1994. He is currently a Principal Research Fellow at UCL EEE department, and he has worked as a Research Lecturer at Kingston University and at UCL. He co-authored over 60 conference and journal papers. His research interests and expertise lie in the areas of software engineering and programming paradigms; distributed systems; virtualised compute and network systems, network and systems management; digital media; sensor systems and smart city platforms, and artificial intelligence systems. He is looking at new techniques for large-scale sensor systems in Industry 4.0, and at end-to-end systems for Computational Genomics. He also has extensive experience in the commercial arena undertaking architecture and development for software engineering, distributed systems and networking systems.

Topic: Enabling Advanced In-Network Processing in Programmable Network Dataplanes with P4: Experiences, Challenges and Lessons learned
Speaker: Jérôme FRANCOIS, Inria Nancy Grand Est, France

Recently, network softwarization empowers the paradigm of programmable networks where network functions or even tasks of these functions can be programmed with high flexibility to fit user or operator needs independently of hardware used. Programming network data-plane allows to program the processing of each packet and is supported by novel technologies like P4. A main advantage of programmable data-planes is to deploy custom functions such as monitoring, in-band network telemetry, attack detection and counter-measures within network switches.

In a nutshell, we can count on programmable dataplanes to setup custom in-network processing to enable new or more efficient applications by allowing programming specific packet processing at each network hop. However, P4 and P4-compatible hardware come also with limitations. Implementing any function is unfeasible. In this talk, we will review some applications to implement some functions (detection of multi-steps attacks, monitoring of DNS

requests, in-band telemetry, etc) and highlight the main difficulties we face and also the remaining challenges. This notably includes computation of real-valued functions, handling TLV fields or stateful processing, etc.

Bio: Jérôme Francois obtained his Ph.D. in Computer Science from the University of Lorraine, France in December 2009. He was then appointed as research associate at the University of Luxembourg. He is now research scientist at Inria and deputy leader of the RESIST team. His main research areas are focused on the use of data analytics techniques for security and also its coupling with network softwarization. In 2019, he received the IEEE Young Professional award in Network and Service Management. He is also co-funder of Cybi, a startup developing AI-based cybersecurity solutions. He is in charge of different international collaborations of the research team with the University of Waterloo in Canada, the DFKI in Germany and Osaka Metropolitan University. He has participated in several collaborative European projects and was the project coordinator of ThreatPredict, a NATO-funded project on cyberthreat monitoring. In addition to major publications in networking and network management conferences, he started as associate Editor-in-Chief of Wiley IJNM and as co-chair of NMRG at IRTF (Internet Research Task Force) in 2019.

Recess: 16:25-16:30

TS1: 16:30-18:00 High performance, programmable networks for the Internet of Things

Session chair: Yurui Cao, Xidian University

Paper 1 - LRP: Long-Lifetime and Reliable Percolation Routing for Underwater Sensor Networks

Authors: Yuan Liu (Northwestern Polytechnical University, China); Lin Cai and Junhao Hu (University of Victoria, Canada); Xiaohong Shen and Haiyan Wang (Northwestern Polytechnical University, China)

Abstract: Underwater acoustic sensor networks (UANs) have been shown as a promising technology to monitor and explore the oceans. Nevertheless, the routing design for data gathering of UANs considering the acoustic channel communication characteristics and limited energy is a pressing, open issue. To address this challenge, we propose the long-lifetime and reliable percolation routing protocol (LRP) for UANs to ensure the reliability of the network and prolong the network lifetime. The proposed protocol adaptively selects the forwarders to deliver each message. By estimating the reliability of the next-hop and considering the remaining energy of candidates, the proposed protocol takes a recursive approach to avoid trapping in a locally optimal solution. Simulations results validate the

feasibility of the proposed protocol and demonstrate its superiority over the existing routing algorithms by prolonging the lifetime of LRP by up to 35%.

Paper 2 - V2X Communication Aided Emergency Message Dissemination in Intelligent Transportation Systems

Authors: Xini Xiang (University of Macau, Macao); Bo Fan (Beijing University of Technology, China); Minghui Dai and Yuan Wu (University of Macau, Macao); Cheng-Zhong Xu (University of Macau, China)

Abstract: With the development of vehicular networks, the vehicle-to-everything (V2X) communication aided emergency warning is envisioned to improve the safety of driving service in intelligent transportation systems (ITS). By considering the delay sensitivity of different vehicles receiving warning information, this paper investigates the V2X communication aided emergency message dissemination. Specifically, according to the distance between the vehicle and the emergency point, we divide the vehicles in the coverage of the roadside unit (RSU) into two groups, namely, the primary priority group and the secondary priority group. Then, we formulate a joint optimization problem for content partition, user grouping and channel allocation to improve the resource utilization and the efficiency of emergency message delivery. The objective is to ensure that all vehicles in the primary priority group can reliably receive the warning messages within a fixed deadline, and meanwhile, the RSU can send as many warning messages as possible to the vehicles in the secondary priority group. Despite the nature of mixed integer and non-linear programming problem, we propose a layered approach to solve the problem. Finally, we conduct simulations to validate the efficiency and effectiveness of the proposed algorithm, compared to some benchmark algorithms.

Paper 3 - Performance Analysis of Vehicle Platoon Communication in C-V2X Autonomous Mode

Authors: Ruirui Ning, Xiaokang Zhang and Weiyang Feng (Beijing Jiaotong University, China); Ning Zhang (University of Windsor, Canada); Siyu Lin (Beijing Jiaotong University, China)

Abstract: As one of the essential application scenarios of autonomous driving, vehicle platoon has remarkable advantages in enhancing traffic capacity and reducing fuel consumption. When considering cellular vehicle-to-everything (C-V2X) supported platoon communication in autonomous mode, the existing theoretical analysis works for C-V2X can not be applied to the vehicle platoon scenario due to the unique movement features of the platoon led by the platoon leader. In this paper, an analytical model is proposed to analyze the packet delivery probability of

the platoon in C-V2X autonomous mode, using stochastic geometry. Theoretical analysis and simulation verification of the proposed model is carried out and it is demonstrated that the analysis results are in accordance with the simulations results. The proposed analytical model is of significance to evaluate the performance and provide design insights for the platoon communication supported by C-V2X.

Paper 4 - RPQ- Resilient-Priority Queue Scheduling for Delay-Sensitive Applications

Authors: Xinqiao Li and Mingyuan Liu (Beijing Jiaotong University, China); Nan Cheng (Xidian University, China); Liu Kang and Wei Quan (Beijing Jiaotong University, China); Liang Guo (China Academy of Information and Communications Technology, China); Yajuan Qin (Beijing Jiaotong University, China)

Abstract: With the continuous development of autonomous vehicles, telemedicine, digital media and other time-sensitive applications, a soaring number of network services have high demand for the quality of service (QoS) with extra low delay and jitter. Traditional network architecture only offers best-effort services which cannot meet the stringent delay and jitter requirements. In this paper, we propose a resilient-priority queue scheduling algorithm (RPQ) for delay-sensitive services. RPQ can guarantee stable delay in a fine-grained manner. Particularly, on the premise of meeting the delay requirements of high priority streams, RPQ can give consideration to the delay requirements of lower priority streams depending on its resilient scheduling mechanism. We implement RPQ on programmable switch. The experimental results show that RPQ not only guarantees QoS with low delay and low jitter for delay-sensitive streams but also improves network throughput by comparing with the existing solutions, i.e., SP-PIFO and WRR.

Paper 5- Wireless Charging Energy-Relay Scheme for Wireless Sensor Networks

Authors: Jianfan Zhu and Xilong Liu (Yunnan University, China)

Abstract: Driven by the development of the Fifth Generation (5G) Communication and Internet of Things (IoT), Wireless Sensor Network (WSN) has received unprecedented attention from industry and academia. Wireless Power Transfer (WPT) technology is a promising technique to alleviate the energy sustainment issue of WSN. WPT enables WSN playing significant roles in smart farmland, intelligent factory, as well as smart city. In these application scenarios, in order to save the on-grid power and protect the environment, green charging base station (GBS) is proposed to first harvest green energy and then wirelessly power the wireless sensors with WPT. However, when a GBS omnidirectionally powers its surrounding wireless sensors, the sensors closer to the GBS may be overcharged, while the sensors far from the GBS may not receive enough energy supply. In this paper, we propose a scheme to

leverage the sensors with abundant energy replenishment to relay energy for the sensors with less energy. A heuristic algorithm is further proposed to solve the relay assignment problem between relays and sensors. By this algorithm, the sensors far from the GBS can also receive considerable energy transmitted by the relays. Extensive simulations have validated that, compared to the conventional scheme of wireless charging without energy-relay, our proposed scheme can dramatically improve wireless charging performance in reducing the Dead Sensors Percentage (DSP) of the local WSN by around 50%.

Day 2: Tuesday, June 7

Morning 9:00-11:40

Opening Speech: 9:00 - 9:15

Jiajia Liu (Northwestern Polytechnical University, China)

Keynote: 9:15 – 10:15

Topic: New Uses for Higher-speed Passive Optical Networks
Keynote Presentation: Frank Effenberger, Futurewei, USA

The remarkable success of passive optical networks (PON) is without equal. From the start of serious deployment in 2001, the industry has reached a billion users served by PON in 2021. This rapid deployment of a new access infrastructure was necessitated by the explosion of bandwidth demand from primarily residential users. This has been made even more acute with the Covid19 pandemic causing many people to work from home, and climate change is expected to continue this trend. The volume of PON equipment and devices has resulted in a virtuous cycle of lower costs which induce more deployment that reduce costs even lower. The current generation, XG-PON, delivers 10 Gb/s bandwidth at a low price point.

Now that a very significant portion of the world's homes have the availability of fiber, we can start to think about new applications for the underlying technology. This talk will review several of these new use cases and explore how they might impact network design. One example is fiber to the room (FTTR), which uses PON technology to move data through the home. This fills a need as current in-home networks are of lower quality and often fail to meet service requirements. Another is Industrial control, where PON is used to interconnect all the machines, robots, and sensors in a factory. This leverages the highly deterministic nature of the PON to provide low latency and jitter transport. A third application is FTTWireless, where a selection of PONs can provide ultra-high capacity backhaul

and fronthaul to cellular antenna sites. This is important as the number of wireless sites will increase dramatically over the next decade. Taken together, these new use cases could produce another leap in the scale of fiber access technology.

Bio: Frank Effenberger has worked in the optical access field at Bellcore, Quantum Bridge Communications (Motorola), and Futurewei Technologies, where he is now the Fellow for fixed access network technology. His team works on forward-looking fiber access technologies, with several "world's first" prototypes and trials. Frank is the rapporteur for ITU-T Q2/15, vice chair of ETSI F5G ISG, is a Fellow of the OSA and the IEEE, and holds 130 US patents.

Recess 10:15 - 10:20

Invited session: 10:20 - 11:40

Topic: Approaches and Methods for Monitoring and Management of Edge Computing Systems and Networks
Moderators: Behnam Dezfouli, Santa Clara University, USA, and **Iraklis Anagnostopoulos**, Southern Illinois University, USA

Title: Digital Twin Edge Networks
Speaker: Yan Zhang, University of Oslo, Norway

In this talk, we mainly introduce our proposed new research direction: Digital Twin Edge Networks (DITEN). We first present the concept and model related to Digital Twin and DITEN. Then, we focus on new research challenges and results related to DITEN. Edge association and Digital Twin mobility, as unique research questions, will be defined and analyzed. We are also expecting that the talk will help the audience understand the future development of edge computing, e.g., digital twin edge networks in the context of Metaverse.

Bio: Yan Zhang is currently a Full Professor with the Department of Informatics, University of Oslo, Norway. His research interests include next-generation wireless networks leading to 6G, green and secure cyber-physical systems. Dr. Zhang is an Editor (or Area Editor, Senior Editor, Associate Editor) for several IEEE transactions/magazine, including IEEE Network Magazine, IEEE Transactions on Green Communications and Networking, IEEE Transactions on Network Science and Engineering, IEEE Transactions on Vehicular Technology, IEEE Transactions on Industrial Informatics, IEEE Internet of Things Journal, IEEE Systems Journal, IEEE Vehicular Technology Magazine, and IEEE Blockchain Technical Briefs. He is a program/symposium chair in a number of conferences,

including IEEE IWQoS 2022, IEEE ICC 2021, IEEE SmartGridComm 2021. He is the Chair of IEEE Communications Society Technical Committee on Green Communications and Computing (TCGCC). He is an IEEE Communications Society Distinguished Lecturer and IEEE Vehicular Technology Society Distinguished Speaker. He was an IEEE Vehicular Technology Society Distinguished Lecturer during 2016-2020. Since 2018, Prof. Zhang was a recipient of the global "Highly Cited Researcher" Award (Web of Science top 1% most cited worldwide) for four years. He is Fellow of IEEE, Fellow of IET, elected member of Academia Europaea (MAE), elected member of the Royal Norwegian Society of Sciences and Letters (DKNVS), and elected member of Norwegian Academy of Technological Sciences (NTVA).

Title: System-Level Optimization for Applied Machine Learning
Speaker: Lei Yang, University of New Mexico, USA

Machine learning (ML) techniques for applications have been widely studied from the algorithmic level; however, these applications can take effects only when they can be deployed to computing devices. This raises new challenges and we need to identify the unique requirements from various applications, and provide automation solutions to build the system on especially the resource constrained computing devices. In this talk, I will introduce the road from the Hardware/Software co-design to the systematical optimizations for real-world applications, then the next.

Bio: Lei Yang is an Assistant Professor with the Department of Electrical Computer Engineering, University of New Mexico, Albuquerque, NM, USA. She received the B.E. and Ph.D. degrees from Chongqing University, Chongqing, China, in 2013 and 2019, respectively. Her research interests are in automated machine learning, embedded systems, and high-performance computing architectures.

Title: Harnessing Programmable Networks for Scalability and Performance
Speaker: Sean Choi, Santa Clara University, USA

Programmable networks, consisting of a set of network devices that can be programmed using a domain-specific language, which allow programmers to easily customize all aspects of the network, ranging from routing, congestion control and more, brought huge opportunities to improve existing networking features and also allow many new possible use cases. This talk introduces new types of programmable network hardware, unique characteristics of each type of hardware and software that allow programmers to easily interact with the hardware and easily deploy new types of applications on the hardware at a large scale with significant performance gains.

Bio: **Sean Choi** is an assistant professor in the computer science and engineering department at Santa Clara University. Sean completed a Ph.D. in electrical engineering and M.S. degree in computer science at Stanford University and B.S. degree in computer science and business economics and management at California Institute of Technology. He has industry experience working at LinkedIn as a machine learning engineer, VMware as a senior member of technical staff, Facebook as a network research engineer and consulting for many startups. His current research work is about adding programmability to network switches and network interface cards (NIC) and finding new applications to take advantage of the newly available programmable hardware to greatly improve their performance and reduce overheads.

Title: Leveraging Machine Learning for Spectrum Sharing in Wireless Networks
Speaker: Suzan Bayhan, University of Twente, Netherlands

With increasing dependence on wireless technologies, e.g., not only during the current pandemic but also with the envisioned smart cities or smart agriculture, ensuring efficient use of the wireless spectrum and having a profound understanding of its spatio-temporal usage dynamics have become more crucial. As machine learning has unlocked many possibilities in various domains, a natural question is whether ML-based approaches can introduce improvements also for spectrum sharing over the traditional schemes. In this talk, we will overview some state-of-the-art approaches that illustrate the potential of ML toward the goal of improving spectrum utilization efficiency and more accurate spectrum analysis.

Bio: Suzan Bayhan is an assistant professor at the University of Twente and an adjunct professor (docent) at the University of Helsinki. She earned her Ph.D. in computer engineering in 2012 from Bogazici University. She received the best paper awards at ACM ICN ’15 and IEEE WoWMoM ’20, and best demo award at IEEE INFOCOM ’20. Her current research interests include spectrum sharing, coexistence of wireless networks, WiFi and LTE resource management, and edge computing.

Recess: 11:40-13:00

Afternoon: 13:00-18:15

Workshop: 13:00-14:00 Intelligent Data Networks

Moderator: Zhi Liu, University of Electro-Communications, Japan

A Priority-Based Online Container Placement Strategy for 5G MEC Cloud Enabled Smart Grid

Peizhe Xin (State Grid Economic and Technological Research Institute Co., Ltd., China); Jing Jiang (State Grid Corporation of China, State Power Economic Research Institute, China); Yi Zhang (State Grid Zhejiang Electric Power Company Information Telecommunication Branch, China); Yudong Wang (State Grid Economic and Technological Research Institute CO., LTD, China)

Fuzzing Seed Filtering Based on Generative Adversarial Networks Model

Zhijuan Liu, Li Zhang and Xuangou Wu (Anhui University of Technology, China); Wei Zhao (Anhui University of Technology (Xiushan), China & Anhui Engineering Laboratory for Intelligent Applications and Security of Industrial Internet, China)

Graph Convolution Union Computing Based Critical Nodes Identification in Temporal Networks

Chuan-hua Zhou, Li-chun Cao, Wei Zhao, Zi-han Zhou, Tai-jiao Ren and Lan Luo (Anhui University of Technology, China)

An QUIC Traffic Anomaly Detection Model Based on Empirical Mode Decomposition

Gang Lei, Junyi Wu, Lejun Ji, Keyang Gu and Yuanlong Cao (Jiangxi Normal University, China); Xun Shao (Kitami Institute of Technology, Japan)

Recess: 14:00-14:05

TS2: 14:05-15:20 Space-Air-Ground Integrated Networks

Session chair: Xilong Liu, Yuannan University

Paper 1: Optimal Task Offloading for Deep Neural Network Driven Application in Space-Air-Ground Integrated Network

Authors: Rongfei Fan and Xiang Li (Beijing Institute of Technology, China); Zhi Liu (The University of Electro-Communications, Japan); Cheng Zhan (Southwest University, China); Han Hu (Beijing Institute of Technology, China)

Abstract: Running intelligent applications on a satellite is in urgent need, which can help to extract useful information from massive surveillance or remote sensing data and return it to ground in time. However, the limited computing ability on a satellite prohibits it from completing the whole application by itself quickly.

Within the circumstance of space-air-ground integrated network (SAGIN), we propose to let the satellite to offload

part of its computation task to the ground station rich in computing ability, through the way of the airship who can assist the satellite not only by relaying but also in computing. To save the energy consumption of the satellite and airship, task offloading policy, together with the allocation of communication and computation resources, are investigated for a special task model supporting deep neural network (DNN), which is popular in intelligent application. An optimization problem is formulated, which involves integer variables and is non-convex. We achieve the global optimal solution in an easy way through the following operations: 1) Transform the formulated problem into two levels, with every level dealing with discrete or continuous variables exclusively; 2) Explore implicit monotonicity and convexity of concerned functions so as to solve the non-convex lower level problem optimally only with several rounds of bisection or Golden search; 3) Solve the upper level problem optimally by enumeration but with polynomial complexity. Numerical results verify the effectiveness of our proposed method.

Paper 2 - Modeling and Analysis of Multi-UAV Networks Using Mat´ern Hard-Core Point Process

Authors: Yajie Zhu and Shangwei Zhang (Northwestern Polytechnical University, China)

Abstract: Multiple unmanned aerial vehicles (UAVs) can function as aerial base stations to provide flexible and reliable communication services for massive ground devices (GDs). It is quite a challenging task to analyze such multi-UAV networks when considering practical mutually exclusive relationships among UAVs. Based on the tools of stochastic geometry, we develop in this paper a theoretical framework for modeling and analyzing the coverage probability and average rate in a 3D air-ground network with UAVs following Mat´ern HardCore Point Process (MHCPP) distribution. As the tractable probability generating functional (PGFL) for such repulsive point processes is unavailable, we employ the approximate signal to interference ratio (SIR) analysis based on the Poisson point process (ASPPP) to obtain the Laplace transform approximation expressions of an arbitrary GD's cumulative interference in the network by considering both line-of-sight (LoS) and none-line-of-sight (NLoS) communications. Finally, extensive simulation results are presented to validate the effective and accuracy of our proposed framework.

Paper 3 - A Traffic Scheduling Scheme for Load Balancing in SDN-Based Space-Air-Ground Integrated Networks

Authors: Jing Tao and Shidong Liu (State Grid Smart Grid Research Institute Co., Ltd, China); Chuan Liu (State Grid Smart Grid Research Institute Co., Ltd., China)

Abstract: The deployment of Low-Earth-Orbit (LEO) constellations and Unmanned Aerial Vehicles (UAV) is an

emerging trend for future network construction to improve global connectivity. To achieve fast global communication, inter-satellite links (ISL) need to be deployed between LEO satellites. However, unlike terrestrial networks, the deployment of space links requires a series of processes such as alignment, ranging, and tracking. Therefore, it becomes a challenge to design suitable routing schemes in the Space-Air-Ground integrated networks (SAGIN) for global data transmission in order to achieve full utilization of the transmission capacity. In this paper, we consider enhancing the transmission capability of SAGIN with Software Defined Networking (SDN) architecture. A load balancing based traffic scheduling scheme for SAGIN is designed. For each pair of source and destination nodes in SAGIN, the transmission capacity of the possible links is predicted. The traffic scheduling problem is turned into a modified maximum flow problem. Considering the dynamic and complicated SAGIN, the deep reinforcement learning model is utilized to make global optimal traffic scheduling decisions. The simulation results show that the proposed scheme can significantly improve the transmission capacity of the SAGIN while guaranteeing network load balancing.

Paper 4 - Joint Optimization in UAV-Ground Communications Empowered by Multiple Aerial RISs

Authors: Jingyi Li (Xidian University, China); Jiadai Wang (Northwestern Polytechnical University, China)

Abstract: Being capable of controlling the radio environment well, the contemporary advanced technique, namely reconfigurable intelligent surface (RIS), has been expected to facilitate unmanned aerial vehicle (UAV) communications. The existing studies mainly focus on terrestrial RIS to realize communication performance improvement, which can achieve only half-space reflection and may experience serious signal attenuation brought by several reflections. Motivated by this reason, this paper proposes to install multiple aerial RISs on the balloons to cooperatively boost the received signal power at ground users. Based on this architecture, we jointly optimize UAV trajectory, active beamforming, and passive beamforming, so as to maximize the average system sum rate. Considering that the composite channel gain becomes a complex function of UAV trajectory in the presence of multiple RISs, the block coordinate descent method is developed to address the formulated optimization problem. The mathematical treatment involves three stages, which can be executed by an iterative algorithm. Finally, numerical results verify the competitive superiorities of multiple aerial RISs and the excellence of joint optimization design compared with other benchmark ones.

Paper 5 - Robust Placement and Power Control Algorithm for NOMA-UAV Networks

Authors: Zhengqiang Wang, Hao Zhang, Yang Liu, Xiaoyu Wan and Zifu Fan (Chongqing University of Posts and Telecommunications, China)

Abstract: Unmanned aerial vehicle (UAV) combined with non-orthogonal multiple access (NOMA) can overcome the high-capacity demand in hotspots. This paper studies the resource allocation for UAV downlink NOMA network with the user's location uncertainty, where UAV is deployed in the air as an aerial base station and sends information to ground users. Under the condition of user's location uncertainty, we investigate sum-rate maximization problem, which is a mixed binary non-convex optimization issue. Therefore, to resolve the issue, we transform paired variables into successive variables by processing inequality constraints and then introduce a robust iterative placement and power control optimization algorithm based on first-order Taylor technology, penalty function approach, and variable substitution. Our proposed algorithm can effectively improve the sum rate compared with the traditional orthogonal multiple access (OMA) algorithm.

Recess: 15:20-15:25

TS3: 15:25-16:55 High-speed optical networks

Session chair: Zhenjiang Shi, Xidian University, China

Paper 1: Highspeed 50 Gb/s Passive Optical Network (50G-PON) Applications in Industrial Networks (invited paper)

Authors: Dezhi Zhang (China Telecom, China); Yuanqiu Luo (Futurewei Technologies, USA); Jialiang Jin (China Telecom, China)

Abstract: 50 Gb/s passive optical network (50G-PON) is the latest highspeed access network standard approved by the International Telecommunication Union-Telecommunication Standardization Sector (ITU-T). 50G-PON is developed to meet the ever-growing bandwidth requirements from broadband access users, especially for new applications in the areas other than traditional residential and business access. This paper focuses on new applications of using 50G-PON in industrial networks. These applications employ the highspeed capability of 50G-PON to facilitate industrial manufacturing, product quality assessment, as well as smart factory management. After introducing the main features of 50G-PON and the recent progress in industrial networks, an architecture is proposed to employ 50G-PON for industrial networks. Key requirements of industrial networks are analyzed, including bandwidth, delay, and jitter. Use cases are discussed to illustrate typical applications and scenarios. A testbed with a 50G-PON prototype system is setup to evaluate the industrial network application. Test results show salient performance of using 50G-PON for industrial network management and automation.

Paper 2- Regenerator-Aware Inter-Core and Inter-Mode Crosstalk-Avoided Resource Allocation for Spectrally-Spatially Elastic Optical Networks

Authors: Joy Halder (South Asian University, India); Eiji Oki (Kyoto University, Japan); Bijoy Chand Chatterjee (South Asian University, India)

Abstract: Optical regenerators are beneficial in resource utilization as they provide additional functionalities, like modulation format (MF) and spectrum conversion, besides signal regeneration. In SS-EONs, regenerators can perform core and mode switching, which further improves the spectrum utilization. For the first time, this paper proposes a regenerator-aware routing, spectrum, core, and mode allocation (RSCMA) model while avoiding inter-mode and inter-core XT during resource allocation to enhance the spectrum utilization in SS-EONs. The proposed model performs core/mode switching operations at the regeneration sites along with spectrum and MF conversions. Apart from the regeneration sites, the proposed model maintains the spectrum continuity, spectrum contiguity, core continuity, and mode continuity constraints in the remaining intermediate nodes. We model the regenerator-aware resource allocation as an integer linear programming (ILP) to minimize the highest utilized spectrum slot index under the condition that a limited number of regenerators with their placement are given in the network. We introduce a heuristic when the optimization problem is not tractable. Numerical results indicate that the proposed model improves resource utilization compared to a benchmark model that does not consider core and mode switching.

Paper 3 - Inter-Core and Inter-Mode Crosstalk-Avoided Virtual Network Embedding in Spectrally-Spatially Elastic Optical Networks

Authors: Vinay Kumar and Joy Halder (South Asian University, India); Abhijit Mitra (IIIT-Delhi, India); Eiji Oki (Kyoto University, Japan); Bijoy Chand Chatterjee (South Asian University, India)

Abstract: Optical regenerators are beneficial in resource utilization as they provide additional functionalities, like modulation format (MF) and spectrum conversion, besides signal regeneration. In SS-EONs, regenerators can perform core and mode switching, which further improves the spectrum utilization. For the first time, this paper proposes a regenerator-aware routing, spectrum, core, and mode allocation (RSCMA) model while avoiding inter-mode and inter-core XT during resource allocation to enhance the spectrum utilization in SS-EONs. The proposed model performs core/mode switching operations at the regeneration sites along with spectrum and MF conversions. Apart from the regeneration sites, the proposed model maintains the spectrum continuity, spectrum contiguity, core continuity, and mode continuity constraints in the remaining intermediate nodes. We model the regenerator-aware resource allocation as an integer linear programming (ILP) to minimize the highest utilized spectrum slot index

under the condition that a limited number of regenerators with their placement are given in the network. We introduce a heuristic when the optimization problem is not tractable. Numerical results indicate that the proposed model improves resource utilization compared to a benchmark model that does not consider core and mode switching.

Paper 4 - A Non-Blocking Network Design for Terabit Capacity Optical Interconnects

Authors: Xiaoxue Yang and Bing Hu (Zhejiang University, China)

Abstract: With the rapid development of internet applications such as cloud computing and streaming media, people put higher demands on data center (DC) switching capabilities. Technology limitations of the backplane cause bottlenecks in its performance, which limits the growth rate of the communication ability of DC. The technology of waveguides based on polymer materials and waveguide connectors on backplane has become an essential issue in the last few years. Architectures of optical interconnection remain to be explored. We propose a strictly non-blocking Clos-based optical architecture, which uses densely integrated optical waveguides to connect optical chips and achieve on-board networking. In addition, we propose a Ring-Clos architecture to reduce the packet loss rate. The simulation results indicate that our design has good performance in throughput, packet loss rate, and latency.

Paper 5 - A Comparison Study on Different Data Sets for Span-Level QoT Regression in EONs

Authors: Farhad Arpanaei, José Alberto Hernández, Gonzalo Martínez and David Larrabeiti (Universidad Carlos III de Madrid, Spain)

Abstract: In this paper, we have generated and examined three different datasets based on the symbol rate and traffic load of the link states to estimate the quality of transmission (QoT) in terms of Generalized Signal to the Noise Ratio (GSNR) for an optical span. The results reveal that in datasets generated for different symbol rates and traffic loads, the outlier data degrades the accuracy in estimating the GSNR. The results show that nearly 99% of the mismatchings had less than 0.3 dB of error for a synthesized dataset in which the symbol rate and traffic load were considered fixed.

Paper 6 - Riley: An Inside-Out Network

Authors: Sean Choi (Santa Clara University, USA)

Abstract: In data center networks today, switches sitting inside the network perform packet forwarding and the hosts sitting at the edge of the network perform congestion control. In this work, we argue that this convention is

completely backwards and that data center networks can be significantly simplified and improved by performing congestion control inside the switch, where the congestion actually occurs, and making forwarding decisions at the edge, where there is more context of the traffic.

To support our thesis, we present a new network architecture named Riley that consists of simplified switches with no control plane and end hosts that are knowledgeable of the network topology, which a design that essentially flips data center networks inside-out. Riley provides the following two benefits from the traditional network architecture: First, Riley forwarding protocol enables fast routing without any switch forwarding state and switch local control plane, which both are implemented as highly complex and resource intensive software running on costly hardware. Second, switches in Riley collect detailed link-level statistics entirely in the data plane, such as latency and congestion, allowing the switches to make local congestion control decisions and end-hosts to use the statistics to make more informed traffic engineering decisions. By doing so, we show that Riley greatly reduces switch resource consumption and improves congestion control performance, while incurring nearly no traffic reductions or increase in end-host resource usage.

Recess: 16:55-17:00

TS4: 17:00-18:15 Network security and privacy protection

Session chair: Junman Qin, Xidian University, China

Paper 1 - Anonymous Jamming Detection in 5G with Bayesian Network Model Based Inference Analysis

Authors: Ying Wang (Stevens Institute of Technology, USA); Shashank Jere (Virginia Tech, USA); Soumya Banerjee (Old Dominion University, USA); Lingjia Liu (Virginia Tech, USA); Sachin Shetty (Old Dominion University, USA); Shehadi Dayekh (2200 Ross Ave Ste 1600 & Deloitte, USA)

Abstract: Jamming and intrusion detection are some of the most important research domains in 5G that aim to maintain use-case reliability, prevent degradation of user experience, and avoid severe infrastructure failure or denial of service in mission-critical applications. This paper introduces an anonymous jamming detection model for 5G and beyond based on critical signal parameters collected from the radio access and core network's protocol stacks on a 5G testbed. The introduced system leverages both supervised and unsupervised learning to detect jamming with high-accuracy in real time, and allows for robust detection of unknown jamming types. Based on the given types of

jamming, supervised instantaneous detection models reach an Area Under the Curve (AUC) within a range of 0.964 to 1 as compared to temporal-based long short-term memory (LSTM) models that reach AUC within a range of 0.923 to 1. The need for data annotation effort and the required knowledge of a vocabulary of known jamming limits the usage of the introduced supervised learning-based approach. To mitigate this issue, an unsupervised auto-encoder based anomaly detection is also presented. The introduced unsupervised approach has an AUC of 1 with training samples collected without any jamming or interference and shows resistance to adversarial training samples within certain percentage.To remain transparency and allow domain knowledge injection, a Bayesian network model based causation analysis is further introduced.

Paper 2 - Enhancing the Security of a Private Network by Using A Multi-Level Hierarchical NAT Scheme

Authors: Shie-Yuan Wang and Yu-Hsun Yuan (National Yang Ming Chiao Tung University, Taiwan)

Abstract: Nowadays, attacks coming from the Internet are posing serious threats to the hosts in an institution, campus, company, etc. The Network Address Translator (NAT) is a device that allows a host in a private network to interact with the hosts on the public Internet. Due to the property of NAT, unless a host that is behind a NAT actively contacts a host on the Internet, hosts on the Internet cannot actively reach the host behind the NAT. In this work, we exploit NATs and propose a multi-level hierarchical NAT scheme to protect and enhance the security of a private network. We have designed and implemented our scheme over P4 programmable hardware switches. Experimental results show that our scheme functions correctly and provides high throughput, low latency, and high stability. In addition, according to our tests, our scheme works correctly with most existing network applications.

Paper 3 - Resource Allocation for Secure Transmission in Wireless Powered Communication Networks

Authors: Xun Tong, Shuaiying Kong, Guanqun Shen, Shubin Zhang and Kaikai Chi (Zhejiang University of Technology, China)

Abstract: Nowadays, the Internet of Things (IoT) acts as a key enabler for smart cities, intelligent transportation systems, precision medicine, smart grids, etc. However, the computing power of IoT nodes is weak, and encryption algorithms cannot be used to ensure the secure transmission of data because of the high complexity. In recent years, the emerging technologies of wireless powered communication network (WPCN) and physical layer security (PLS) are regarded as potential solutions to allow IoT nodes to harvest energy from radio frequency (RF) and ensure the

secure data delivery. The secrecy rate, which is defined as the difference of main channel capacity and eavesdropping channel capacity, represents for the secure data delivery ability. How to maximize the secrecy rate with the rather limited energy for IoT network is a challenging problem. In this paper, we formulate the secrecy rate maximization problem as an optimization problem. We solve this problem by two steps: using one-dimension research to find the optimal energy harvesting duration and find the closed-form solution for transmission power and transmission duration for every node. Compared with the heuristic algorithm, the proposed algorithm can obtain a better performance from secrecy rate perspective.

Paper 4 - LLDM: Low-Latency DoS Attack Detection and Mitigation in SDN

Authors: Zixu Huang, Xuanbo Huang, Jian Li, Kaiping Xue, Qibin Sun and Jun Lu (University of Science and Technology of China, China)

Abstract: Software-Defined Networking (SDN) is a new and highly flexible network architecture, but the bottleneck between the control plane and the data plane makes it vulnerable to the control plane saturation DoS attacks. When the attack happens, traditional schemes in DoS scrubbing agent use a binary classification and a First In First Out (FIFO) queue to filter attack flows. However, this scheme is inimical to the end-to-end latency of benign traffic. To tackle this issue, we propose LLDM, leveraging a dynamic priority scheme and a priority queue to detect, mitigate the attacks while ensuring low latency for benign traffic. After detecting the attack, LLDM leverages a two-phase scheme for mitigation. First, LLDM marks packets from the ports under attack as suspicious and migrates them to the mitigation agent. Then, the dynamic priority manager assign each packet a priority corresponding to its legality, which is used in the priority queue for DoS scrubbing. We evaluate LLDM in a simulation SDN environment. The experimental results show that LLDM can reduce 90.4% of the queuing delay compared with the traditional scheme under a 5000 Packets Per Second (PPS) attack, and it is also resistant to more sophisticated attacks. Under the high rate attack of 50000 PPS, LLDM installs a flow rule for legitimate traffic in 0.2 seconds. Moreover, for benign HTTP requests, LLDM can keep the request time at 1.39 seconds.

Paper 5 - Communication-Aware Fairness in Blockchain Transaction Ordering

Authors: Mohammad Nassar and Ori Rottenstreich (Technion - Israel Institute of Technology, Israel); Ariel Orda (Technion, Israel)

Abstract: Blockchain leader-based protocols elect leaders for proposing the next block of transactions. Proposed blocks need to pass a validation routine in order to be added to the blockchain. Proposers may prioritize certain

transactions based on their fees or accounts. A fair block selection follows a random selection of transactions among pending transactions that a proposer is aware of. The validators may only have partial knowledge of the network transactions making it challenging to validate the random selection. We propose a protocol to encourage fair block selection in a leader-based blockchain network. Our protocol offers two main contributions. First, suggesting an algorithm that evaluates the proposed blocks based on both their transactions' issuance times and zone structure. Second, providing incentives for acting honestly and diminishing malicious and dishonest nodes. To accomplish this, we use a reputation system, whereby each node is given a reputation score based on its actions (i.e. latest proposals and evaluations). We demonstrate the improved accuracy of our protocol by implementing experiments based on Ethereum topology, comparing it with Helix [1], an existing consensus algorithm for a fair block selection.

Day 3, Wednesday June 8

Morning 9:00-12:10

Tutorial 1: 9:00-10:30

Moderator: Eirini Eleni Tsiropoulou, University of New Mexico, USA

Title: Wireless Federated Learning for Mobile Edge Computing
Presenters: Xiang Sun, University of New Mexico, USA

Federated learning (FL) is an emerging approach that enables different clients (i.e., devices) to collaboratively and distributively train machine learning models at the mobile edge. As compared to the centralized machine learning model training process, FL can preserve clients' privacy and potentially reduce network traffic load as users are not required to share their raw data to third-party computing facilities. FL has been proposed to be applied in various applications, such as eHealth, next word prediction, and additive manufacturing. However, FL is still in its infancy, there are still many challenges, such as efficient client selection and model aggregation to reduce the learning time, and malicious client detection for robust FL. This tutorial will provide the introduction of FL and its applications, overview state of the art FL technologies, and highlights the challenges of FL and the potential solutions.

Bio: Xiang Sun is an assistant professor with the Department of Electrical and Computer Engineering at the University of New Mexico. He received his Ph.D. degree in Electrical Engineering from New Jersey Institute of Technology (NJIT) in 2018, and his M.E. and B.E. degrees both from Hebei University of Engineering in 2011 and 2008, respectively. His research interests include free space optics, wireless networks, cooperative machine learning,

Internet of Things, edge computing, and green communications and computing. He has received several honors and awards, including NJIT Ross Fellowship 2014-2015, 2016 IEEE International Conference on Communications (ICC) Best Paper Award, 2017 IEEE Communications Letters Exemplary Reviewers Award, 2018 NJIT Hashimoto Price, and 2019 IEICE Communications Society Best Tutorial Paper Award. He is an associate editor of the IEEE Open Journal of the Computer Society and Digital Communications and Networks.

Recess: 10:30-10:40

Tutorial 2: 10:40-12:10

Moderator: Zubair Fadlullah, Lakehead University, Canada

Title: Data-Driven Resource Management in 5G+ Wireless Networks
Presenters: Muhammad Ismail, Tennessee Tech University, USA

Recent trends in 5G and beyond (5G+) wireless networks have encouraged the migration from the already congested radio frequency (RF) spectrum to higher frequency bands. However, the signals at such bands suffer from severe deterioration in quality due to link instability induced by users' mobility. In this context, this tutorial discusses one possible solution, namely, seamless integration of heterogeneous networks through intelligent vertical handover policies. Due to the ubiquitous presence of lighting systems, this tutorial focuses on the integration of LiFi networks (operating in the visible light band in the downlink and infrared band in the uplink), as an example of 5G+ network, and RF networks. First, to develop a better understanding of the channel characteristics of LiFi networks in presence of users' mobility, this tutorial presents a method to generate realistic channel dataset. The mobile channel generation method creates realistic human mobility traces that capture human behaviour on macro- and micro-timescales. The mobility traces are then used to realize the spatio-temporal characteristics of the LiFi wireless channels under long-term environment-confined mobility. Statistical analysis of the generated channel data proves that there does not exist a general mathematical model to accurately describe the LiFi channel under environment-confined user mobility. In turn, this motivates the adoption of a data-driven approach to design effective and intelligent vertical handover policies among LiFi and RF networks. A wise handover policy would not trigger lots of handovers for short absence of LoS links in the LiFi channels as this would increase the overall network latency. Hence, a data-driven algorithm will be presented to: (a) predict abrupt outages in Line-of-Sight (LoS) LiFi links and evaluate the channel quality through deep learning and (b) implement optimal vertical handover decisions with the quality- of-service (QoS) guarantee if the LiFi channel is deemed to be in extended outage, via a reinforcement-learning-based approach. This tutorial will highlight the challenges that face the development of such a data-driven framework.

Specifically, due to the sparse nature of the LiFi LoS link induced by user mobility and the associated frequent outages, conventional sequence- to-sequence regression techniques would fail to carry out useful predictions of the link quality. As such, this tutorial presents novel methods for wireless channel abstraction and densification to enable the reuse of the conventional Long Short-Term Memory (LSTM)-based Recurrent Neural Networks (RNNs) for efficient prediction of optical LoS links. Given the channel dataset and the status prediction of the LiFi link, a reinforcement learning strategy is adopted to learn the environment dynamics and decide whether a vertical handover is needed to minimize the network latency. The numerical results will be presented to demonstrate considerable improvement in overall latency and handover rate under user mobility for bidirectional links, which reflects seamless integration of LiFi and RF networks.

Bio: Muhammad Ismail (Senior Member, IEEE) received the B.Sc. (Hons.) and M.Sc. degrees in Electrical Engineering (Electronics and Communications) from Ain Shams University, Cairo, Egypt, in 2007 and 2009, respectively, and the Ph.D. degree in Electrical and Computer Engineering from the University of Waterloo, Waterloo, ON, Canada, in 2013. He is an Assistant Professor with the Computer Science Department, Tennessee Tech University, USA. His research interests include wireless networks, smart grids, and cyber- physical security. He was a co-recipient of the Best Paper Awards in the IEEE ICC 2014, the IEEE Globecom 2014, the SGRE 2015, the Green 2016, the IEEE Technical Committee on Green Communications and Networking (TCGCN) Best Paper Award at the IEEE ICC 2019, and IEEE IS 2020. He was the Workshop Co-Chair of the IEEE Greencom 2018, the TPC Co-Chair of the IEEE VTC 2017 and 2016, the Publicity and Publication Co-Chair of CROWNCOM 2015, and the Web-Chair of the IEEE INFOCOM 2014. He is an IEEE Senior Member and an Associate Editor for the IEEE Internet-of-Things (IoT) Journal and IEEE Transactions on Vehicular Technology (TVT). He was an Associate Editor for the IEEE Transactions on Green Communications and Networking, the IET Communications, and Elsevier PHYCOM. He was an Editorial Assistant of the IEEE Transactions on Vehicular Technology from 2011 to 2013.

Recess: 12:10-13:00

Afternoon: 13:00-17:00

TS5: 13:00-14:30 Architecture and management of 5G and beyond

Session chair: Yawen Tan, Xidian University

Paper 1 - How Does 5G NR V2X Mode 2 Handle Aperiodic Packets and Variable Packet Sizes?

Authors: Alejandro Molina-Galan (Universidad Miguel Hernández de Elche, Spain); Baldomero Coll-Perales (Universidad Miguel Hernandez de Elche (UMH), Spain); Luca Lusvarghi (University of Modena and Reggio Emilia, Italy); Javier Gozalvez (Universidad Miguel Hernandez de Elche, Spain); Maria Luisa Merani (University of Modena and Reggio Emilia, Italy)

Abstract: 5G NR V2X complements LTE V2X to support advanced V2X services for connected and automated driving. 5G NR V2X introduces novel features at the MAC layer that are designed to cope with potential packet collisions, and that could help address the LTE V2X MAC inefficiencies observed under aperiodic traffic of variable size. This is the case of the re-evaluation mechanism that is a mandatory MAC feature of 5G NR V2X, and that seeks to avoid possible packet collisions detected before a vehicle transmits in selected resources. Evaluations conducted to date of 5G NR V2X do not consider the re-evaluation mechanism, and have focused on traffic patterns that do not fully account for the traffic variability of advanced V2X services. This paper extends the current state of the art with the first evaluation of a fully standard compliant 5G NR V2X implementation under the traffic patterns recommended by 3GPP for advanced V2X services. Our study shows that 5G NR V2X Mode 2 still faces MAC challenges when using semi-persistent scheduling (SPS) to efficiently support aperiodic traffic of variable size.

Paper 2 - Joint Routing and Scheduling for Deterministic Networking - A Segment Routing Approach

Authors: Tianchi Li and Yueping Cai (Chongqing University, China)

Abstract: Deterministic networking (DetNet) provides guaranteed transmission services for the time-sensitive traffic. However, how to route and schedule the traffic to enable bounded latency and jitter remains a great research challenge. This paper proposes a joint routing and scheduling method for DetNet based on Segment Routing (SR). This method includes three parts. The first part is prediction of the end-to-end (E2E) delay based on the delay budget. The second part is probabilistic packet dropping according to its deadline information. The third part is the three-queue cyclic queuing and forwarding. SR technology is utilized to implement the above functions. Simulation results show that the proposed method improves the performance of the worst-case E2E latency bound compared with the traditional method such as the Cycle Specified Queuing and Forwarding (CSQF). The packet receiving rate within the delay budget is increased by 1.9% and the worst-case E2E latency is decreased by 14.3% when the offered load is 0.8.

Paper 3 - A Deep Reinforcement Learning Approach for Deploying SDN Switches in ISP Networks from the Perspective of Traffic Engineering

Authors: Yingya Guo, Jianshan Chen and Kai Huang (Fuzhou University, China); Jianping Wu (Tsinghua University, China)

Abstract: Nowadays, hybrid Software-Defined Network (hybrid SDN), which combines the robustness of distributed network and the flexibility of centralized network, is a prevailing network architecture. The performance of Traffic Engineering (TE) in a hybrid SDN is largely influenced by the location of SDN switches. To derive the optimal location of SDN switches, previous SDN switches deployment strategies mainly focus on manually designing heuristics to search for the SDN deployment sequence and only take a static Traffic Matrix (TM) into consideration. However, the manually-designed heuristics cannot capture the complex intrinsic relations among the location of SDN switches, network topology and dynamic traffic demands. In addition, the SDN deployment strategy optimized under a single TM exhibits poor performance in dynamic environment. Therefore, in this paper, we propose a Deep Reinforcement Learning (DRL)-based algorithm SEED to intelligently learn the SDN deployment strategy under multiple TMs. Specifically, to capture the dynamic traffic information, we first cluster the historical traffic demand matrices for obtaining the representative Traffic Matrices (TM) that can depict the dynamic traffic. Then, to intelligently learn the intrinsic relations between the topology, TMs and the location of SDN switches, we design a DRL agent under multiple TMs through interacting with the environment in a trial and error manner. The extensive experiments on three real network topologies and traffic demands demonstrate that our proposed SDN switches deployment strategy can better adapt to the dynamic traffic and better improve the TE performance than the other deployment strategies.

Paper 4 - Age of Information Minimization in Wireless Powered NOMA Communication Networks

Authors: Weiwei Jin, Liang Huang and Kaikai Chi (Zhejiang University of Technology, China)

Abstract: For real-time monitoring applications, the age of information (AoI) is used as a key metric to quantify the freshness of updated information. In this paper, we consider the wireless powered networks where multiple source nodes observe processes and send update packets to the base station. Time is divided into slots which are equal duration. At each slot, either wireless energy transfer or packet update via non-orthogonal multiple access (NOMA) communication is scheduled. We aim to minimize the long-term average weighted sum of AoI of processes at the

base station. Particularly, we formulate the AoI minimization problem as a multi-stage stochastic non-linear integer programming subject to the battery energy constraints. By adopting the Lyapunov optimization, we decouple the multi-stage stochastic problem into per-frame deterministic subproblems and solve it with a low computational complexity algorithm. Simulation results show that our proposed scheme can achieve much smaller average weighted AoI than the benchmark algorithm.

Paper 5 - A Novel Personnel Counting Method Based on WiFi Perception

Authors: Shen Wang and Yijie Xun (Northwestern Polytechnical University, China); Jie Zhao and Yuanyuan Sun (Xidian University, China)

Abstract: In the Internet of Things (IoT) era, WiFi is now commonly implemented worldwide as a convenient wireless data transmission technology and brings much convenience to people's life. Personnel counting, which plays an indispensable role in many areas, such as indoor crowd control, public safety, and marketing analytics, is also important in some special events. In emergencies, such as bank robberies, where police need to capture the number of robbers and hostages in a robbed bank, counting the number of people within the region using WiFi perception technology is more reliable and safer than traditional counting methods based on video streaming. In the early work of others, researchers used received signal strength indicator (RSSI) from the MAC layer for personnel counting studies. In recent years, it has been found that the channel state information (CSI) from the physical layer is more stable and the personnel counting method based on CSI has a higher accuracy rate. In their excellent works, however, researchers do not take into consideration the unpredictability of crowd behavior in real life. Meanwhile, the experimental accuracy needs to be greatly improved. This paper, therefore, focuses on proposing a novel CSI-based WiFi perception personnel counting method using the Long Short Term Memory (LSTM) algorithm that is useful for hidden counting the number of people in different situations. We conducted people counting experiments under three real experimental scenarios. In addition, we have compared three other algorithms for machine learning and optimized some parameters to achieve an overall accuracy of over 97% for our method.

Paper 6 - A Dynamic Flow Table Management Method Based on Real-Time Traffic Monitoring

Authors: Jinyuan Zhang, Xuanbo Huang, Jian Li, Kaiping Xue, Qibin Sun and Jun Lu (University of Science and Technology of China, China)

Abstract: In Software-Defined Networking (SDN), the controllers implement flexible and scalability networking

policies by installing different flow rules. Each rule matches a specific class of flows, instructs the switches to execute actions, then expires when they finish their tasks. OpenFlow introduces the timeout mechanism to manage these flow rules. However, finding a reasonable timeout value becomes a difficult problem for the network managers. When a relatively small timeout value is given to an elephant flow, the rule expires early, introducing extra cost for the controller and long latency for the matching flow, respectively. On the contrary, a large timeout value for a mice flow makes a rule occupy the switch memory too long, wasting the caching memory and causing the flow table prone to overflow. Therefore, it is necessary to allocate appropriate timeouts for different flows dynamically. In this paper, we achieve this goal with real-time traffic monitoring and heuristic algorithms. By considering different network loads and designing corresponding dynamic timeout algorithms for different scenarios, we make full use of the advantages of SDN to improve the utilization rate of the switch memory and save the controller resources. Further, we implement our scheme in a simulation SDN platform and evaluate the algorithms with the public dataset. Experiments show that our scheme has low control overhead and is memory efficient compared with current mechanisms.

Recess: 14:30-14:35

TS6: 14:35-16:05 Intelligent traffic scheduling and computation offloading

Session chair: Xiaoyi Zhou, Xidian University, China

Paper 1 - Photonic-Aware Neural Networks for Packet Classification in URLLC Scenarios

Authors: Emilio Paolini (Scuola Superiore Sant'Anna, Italy); Federico Civerchia (SmaRTy Italia SRL, Italy); Lorenzo De Marinis and Luca Valcarenghi (Scuola Superiore Sant'Anna, Italy); Luca Maggiani (SmaRTy Italia SRL, Italy); Nicola Andriolli (National Research Council of Italy, Italy)

Abstract: Ultra Reliable Low Latency Communications (URLLC) scenarios require very low latency and high reliability, imposing an optimization of every aspect of 5G data processing, transmission, and networking. Artificial Intelligence (AI)-based tools can be helpful resources in this context, enhancing multiple functionalities, from network resource allocation to network security.

In this paper we propose a solution placed at the next generation eNB (gNB)-Central Unit (CU) level, relying on

Neural Networks (NNs), capable of classifying incoming packets. The developed system increases the security of 5G and B5G architectures, protecting the 5G Core (5GC) from potential attacks. To comply with URLLC requirements on latency, the proposed architecture leverages photonic hardware able to speed-up NN computations. The solution, namely Photonic-Aware Neural Network (PANN), complies with physical layer constraints raised by photonic analog computing and can achieve high throughput and time-of-flight latency.

The classification performance of the devised PANN model has been assessed through simulation on the distilled Kitsune dataset, suited for 5G scenarios, showing the in blocking malicious packets directed to the 5GC. Our experiments proved that PANN performance increases with the bit resolution supported by the analog photonic physical layer. With a 6-bit resolution, PANN can also accurately classify the majority of malicious packet categories, thus guaranteeing an improved security of the 5G and B5G networks.

Paper 2 - A Data Analytics Based Approach to Cloud Resource Auto-Scaling

Authors: Murali Kodialam (Nokia Bell Labs, USA); Fang Hao (Bell Labs, Nokia, USA); Sarit Mukherjee (Nokia Bell Labs, USA); T. V Lakshman (Bell Labs, Nokia, USA)

Abstract: Multiplexing resources is the core savings principle upon which the economic model of the Cloud is built. Cloud customers can flexibly purchase additional resources when needed, and trim these down when the need has past, while Cloud providers can direct resources when and where customers might require. One aspect which poses a challenge to this capability is the allocation process itself, which can be costly in terms of time and energy. Indeed, both provider and customer would prefer if resource allocation would be continuous, fast and with low energy overhead. Since this is not the case, there is an inherent tension between limiting the number of allocation events and efficient resource utilization.

This paper considers this tension using several different models, and proposes a history-based dynamic allocation scheme that minimizes the number of resource allocation transition points for both average and adversarial use cases. We prove performance bounds and use extensive simulation to study the performance of our scheme.

Paper 3 - Trajectory Planning for UAV Assisted Mobile Edge Computing via Reinforcement Learning

Authors: Simeng He and Shangwei Zhang (Northwestern Polytechnical University, China)

Abstract: The development of the fifth-generation (5G) communication technology and various emerging Internet

of Things (IoT) applications have brought in great challenge of seamless connectivity for massive IoT devices. Recently, unmanned aerial vehicle (UAV) has been regarded as a promising solution to improve network coverage and energy efficiency for IoT devices in disaster or remote areas. Under this circumstance, how to minimize the data transmission delay with respect to the limited UAV energy is crucial. Thus we in this paper try to solve the problem by optimizing the UAV trajectory. Specifically, we first formulate the device grouping issue as a maximum clique problem, which is solved by an ant colony algorithm. Then, a Q-learning algorithm is proposed to solve the UAV trajectory planning problem. Simulation results show that the proposed algorithms can yield a globally optimal solution, and outperform the existing K-means and NTE based algorithms.

Paper 4 - Storage-Enabled Adaptive Multi-Path Scheduling Method for Data Transfers in Task Offloading

Authors: Xiao Lin and Shuo Ji (Fuzhou University, China); Shengnan Yue (Shanghai Jiao Tong University, China); Jun Li (Soochow University, China); Feng Chen (FuZhou University, China)

Abstract: The delay-sensitive and resource-limited natures of multi-access edge computing (MEC) applications make it necessary to offload local tasks to nearby MEC servers. Large amounts of offloading data are transferred among MEC servers within the stringent deadline constraints. The offloading system hence needs to deliver the data over end-to-end (E2E) connections as soon as they arrive. However, traffic fluctuations make the offloading system difficult to provision the required bandwidth over the E2E connections and guarantee the deadline. In this paper, we present a storage-enabled adaptive multi-path scheduling method (SAM) for offloading transfers across the optical metro network. Instead of delivering the whole data across a single path, SAM can adaptively split the data into small segments and route them through multiple paths. This not only improves the throughput, but also enables large time windows to schedule segments on their own paths within the given deadline. With the large time window, SAM can leverage MEC storage to temporarily store the segment at the intermediate servers when provisioning the entire E2E path fails. Studies show that compared with the state-of-the-art scheduling methods, SAM can accommodate more transfer requests, shorten delivery time and accelerate offloading transfers efficiently. SAM is beneficial to task offloading.

Paper 5 - C-LSTM - CNN and LSTM Based Offloading Prediction Model in Mobile Edge Computing (MEC)

Authors: Ming Zhao, Yixiang Li, Sohaib Asif, Yusen Zhu, and Fengxiao Tang (Central South University, China)

Abstract: In the face of intensive computing tasks with massive data, cloud computing is difficult to provide high-

quality services.Edge computing extends cloud services to the edge of the network by introducing edge devices between terminal devices and the cloud. For limited edge server resources, it is especially important to optimize offload strategies by accurately predicting the load on the terminal device. This paper proposes a C-LSTM prediction model based on deep neural network to predict the CPU utilization of terminal equipment in the future, and then proposes a distributed greedy algorithm for offloading decision. The simulation results show that the accuracy of C-LSTM prediction model is higher than other baseline models, reduces energy consumption and delay, and provides high-quality computing services.

Paper 6 - Dynamic Task Division and Allocation in Mobile Edge Computing Systems - A Latency Oriented Approach via Deep Q-Learning Network

Authors: Pengcheng Tan and Yang Li (University of Macau, China); Minghui Dai and Yuan Wu (University of Macau, Macao)

Abstract: With the rapid development of Internet of Things (IoTs), various sensors are deployed to sense different physical information. Smart surveillance is one of applications by analyzing the real-time video generated by camera sensors. However, due to the limited computing capability of camera sensors, running the video analysis models (i.e., different neural networks, like AlexNet, YOLO3) on camera sensors directly generally consumes a lot of computing time. In addition, transferring video to the remote cloud suffers a long-distance transmission latency. Fortunately, edge computing has been considered as a promising solution for enabling computation-intensive yet latency-sensitive applications at resource-constrained devices. Thanks to edge computing, camera sensors can upload video to different edge servers employed at the edge of networks for processing. Moreover, the lightweight Kubernetes for edge computing, i.e., K3S, enables a fine-grained task division and parallel computing. In this paper, we consider a heterogeneous edge cooperative video analysis, i.e., face recognition, with the objective of minimizing the processing latency. Specifically, we use a Deep Q-learning network (DQN) to dynamically adjust the size of pieces video allocated to different edge servers connected via wireless networks. In addition, to improve the resource utility of edge servers and reduce the processing latency, each edge server further divides the received video into multiple segments that are processed by different containers in parallel. To validate the effectiveness of our scheme, we implement a small-scale prototype system and conduct numerous experiments. Experimental results show that our proposed algorithm outperforms the other four schedule schemes while testing on the tasks of face recognition and pose recognition.

Recess: 16:05-16:10

16:10-17:00 Workshop: Leveraging Machine Learning and Artificial Intelligence in Mobile Edge Computing

Moderator: Kaikai Chi, Zhejiang University of Technology, China

A Non-Intrusive Security Estimation Method Based on Common Attribute of IIoT Systems
Kai Fang, Yuanyuan Pan, Penglai Guo, Xiaoling Peng, Tingting Wang, Xun Yuan and Jianqing Li (Macau University of Science and Technology, China)

Incremental Learning Assisted Dynamic Driver identification: A New Perspective
Wei Guo and Junman Qin (Xidian University, China); Yijie Xun (Northwestern Polytechnical University, China)

Deep Reinforcement Learning for VRC Deployment in Mobile Edge Computing
Yuanzhuo Wu, Guanqun Shen and Shubin Zhang (Zhejiang University of Technology, China); Gang Chen (Zhejiang Institute of Mechanical and Electrical Engineering, China)

Close session: 17:00-17:20