Poster presentation (GJWS5-JP-UEC)

Research on Wireless Information & Power Transfer in Indoor Factory Environment by Local B5G/6G

Koichi Adachi (The University of Electro-Communications), Takeo Fujii (The University of Electro-Communications), Yoshiaki Narusue (The University of Tokyo), Suguru Kameda (Hiroshima University), Yoshiaki Nonaka (Yamamoto Metal Technos, co., Ltd.)

Research and development of wireless information transmission (WIT) and wireless power transfer (WPT) is essential for effective frequency utilization. The dynamic allocation of multidimensional wireless resources such as time, frequency, space, and power in an integrated manner can further boost the realization of a smart society utilizing the Internet-of-Things (IoT) infrastructure. Smart factory is one of potential field of such a technology. The authors have been conducting research and development targeting indoor local B5G/6G system that integrates WIT and WPT by integrating physical control of devices and terminals and multidimensional radio resource allocation. We aim at effective use of frequencies between WIT and WPT in indoor factory environments with harsh communication conditions. In this presentation, we will report on the research results obtained so far.

Poster presentation (GJWS5-JP-UHIR)

Investigation of Interference Suppression and Pilot Assignment Strategies in User-Cluster-Centric Cell-Free Massive MIMO Systems

[Presenter]Sijie Xia (Hiroshima Univ.), Suguru Kameda (Hiroshima Univ.), Qiang Chen (Tohoku Univ.), Fumiyuki Adachi (Tohoku Univ.)

Cell-free massive multi-input multi-output (CF-mMIMO) is a promising system that deploys many distributed antennas to provide high-quality services. To address scalability and reduce fronthaul capacity and computational complexity in serving many users, a user-cluster-centric (UCC) CF-mMIMO approach was proposed. However, inter-cluster interference limits user capacity. To mitigate this, a dynamic partial interference suppression zero-forcing (DPIS-ZF) method was proposed to identify dominant interfering users outside the cluster. Additionally, a graph coloring (GC)-based pilot assignment method was introduced to improve channel estimation with a limited number of pilots. Simulation results show that the GC-based method outperforms random assignment and approaches the ideal channel estimation. Moreover, the UCC CF-mMIMO with DPIS-ZF approaches the user capacity achieved by partial interference suppression minimum mean square error (PIS-MMSE).

Poster presentation (GJWS5-JP-UIST)

Hierarchical Distributed Architecture for the Least Allan Variance Atomic Timekeeping

Jiayu Chen1, Takayuki Ishizaki1, Yuichiro Yano 2, Yuko Hanado2 (1Institute of Science Tokyo, 2NICT)

Current atomic time supply is typically organized in a centralized way, such as the Japan Standard Time generated and disseminated by NICT. Such architecture is vulnerable to malicious attacks and natural disasters. To enhance the robustness and broaden the application scenarios, it is natural to shift from a central to a distributed architecture. We propose a hierarchical distributed control architecture for an ensemble of atomic clocks. The goal is to achieve synchronized and stable timekeeping with least Allan Variance, especially under weak dependence upon GNSS anchors. The architecture is composed of three layers, i.e. synchronization layer (S-layer), floating layer (F-layer), and anchoring layer (A-layer), respectively. Accordingly, the overall control problem is also decoupled as three specific stabilizing sub-problems; In the S-layer, the difference between atomic clocks are stabilized; In the F-layer, the deviation of the synchronized ensemble from a desired destination is stabilized; In the A-layer, the deviation of the synchronized and floating ensemble from the ideal time-scale is stabilized. As a result, their combination provides a clear and coherent solution for distributed atomic timekeeping.

Poster presentation (GJWS5-JP-UTOH)

Development of high-performance Sub-THz/THz semiconductor devices for B5G wireless communications

Akira Satou, Research Institute of Electrical Communication, Tohoku University, Japan

For implementation of Beyond 5G (B5G) wireless communication network systems that utilize sub-THz/THz frequency bands, semiconductor devices operating in those bands with high efficiency, low latency, and low power-consumption are required. In this poster presentation, we review our recent works on the development of (1) optical-to-wireless carrier-frequency down-converters based on InGaAs-channel high-electron-mobility transistors and graphene-channel FETs, (2) THz detectors based on 2D plasmons in transistor channels for receivers, and (3) uni-traveling-carrier photodiodes embedded with guided-mode-resonance structures for transmitters. We show that those devices are promising candidates of high-performance sub-THz/THz devices for practical use in the B5G wireless communication network systems.

Poster presentation (GJWS5-JP-UTOK)

Toward 6G Mobility Network: Design of a Wireless Digital Twin for Connected Autonomous Vehicle

J. Nakazato, T. Iye, Y. Susukida, E. Sato, Y. Sasaki, K. Maruta, M. Tsukada（The University of Tokyo）

The importance of digital twins in 6G is rapidly increasing. However, while digital twins have been discussed in various contexts, defining their specific role within 6G remains crucial. This paper proposes a wireless digital twin (WDT) platform designed to ensure communication stability for connected autonomous vehicles (CAVs) integrated into networks. The proposed WDT reproduces 3D urban environments, calculates radio wave propagation using traffic simulators and ray tracing, and tracks CAV movement. Additionally, we discuss methods for evaluating multiple communication systems using proposed WDT, aiming to promote research and development toward 6G.

Poster presentation (GJWS5-JP-UTOT)

4.8 GHz Band Radio Propagation Channel Measurement by Unmanned Aerial Vehicle-based Virtual Array System

Kentaro Saito (Tottori University)

In this paper, we propose the UAV-based virtual array channel sounding system for the investigation of the air-to-ground (A2G) propagation channel characteristics. In our system, the channel data are continuously measured by the UAV receiver that flies along the measurement course. They are processed virtually as data of large array antenna to investigate the angular characteristics of the propagation channel. The experiment was conducted in an indoor workshop space in the 4.85 GHz band. The HPBW of the angular power spectrum was 3.2 deg.. and the azimuth angular and distance estimation

errors of the incident radio wave were approximately 0.1 deg. and 0.01 m. Future works will include conducting experiments in various radio propagation environments and analyzing more detailed channel characteristics.

Poster presentation (GJWS5-JP-KEYS）

Linearization of a 300-GHz-Band Power Amplifier Using Digital Predistortion and VNA-Based Wideband Measurements

Sam Kusano1, Teruo Jyo2, Hiroshi Hamada2, Munehiko Nagatani2, Miwa Mutoh2, Yuta Shiratori2, Hiroyuki Takahashi2, Hiroaki Katsurai3 1 Communications Solutions Group, Keysight Technologies Inc., Santa Rosa, California, USA 2 NTT Device Technology Labs, NTT Corporation, Kanagawa, Japan 3 Photonic Components Business Group, NTT Innovative Devices Corporation, Kanagawa, Japan

This poster presents an advanced measurement methodology and digital predistortion (DPD) technique applied to a 300-GHz-band power amplifier (PA) module, using a 35 GBaud signal centered at 260 GHz. The measurement setup integrates a vector network analyzer (VNA) with frequency extension modules and an arbitrary waveform generator (AWG), enabling precise calibration and characterization of the PA's gain, output power, and nonlinear behavior. By applying frequency-domain DPD, we effectively improve the error vector magnitude (EVM) performance for a 64QAM signal, demonstrating the potential of precise calibration and linearization. This work underscores its critical role in achieving ultra-high-speed sub-THz wireless links, paving the way for future high-capacity 6th generation (6G) systems.

Poster presentation (GJWS5-JP-NICT1)

Microring-resonator-based frequency comb sources as a building block for future telecommunication systems

Kentaro Furusawa, NICT

Frequency comb sources based on CMOS-compatible microresonator chips can generate high-quality high frequency signals spanning up to 1000 GHz in small footprints. Therefore, realization of high-performance signal sources at low-cost, useful for telecommunication in the sub-terahertz frequency range, is highly anticipated. Such devices could also lead to intimate link between photonic and wireless networks via tight synchronization enabled by the frequency combs themselves. We discuss the implementation of a compact signal generation module by injection locking to the pump laser diode from a high-Q microresonator is discussed along with the sophistication of the device fabrication technology.

Poster presentation (GJWS5-JP-NICT2)

Spce-Time synchronization Technologies for 6G communications

Motoaki Hara, Yuichiro Yano, Masahiro Fukuoka, Nobuyasu Shiga, Satoshi Yasuda, Ryuichi Ichikawa, Tetsuya Ido (NICT)

Here, we will introduce space-time synchronization technology that will contribute to next-generation communications beyond 5G/6G. NICT is currently taking the lead in the fabrication of microdevices for space-time synchronization, and the demonstration experiments of distributed time systems using our developed microdevices. Our development is broad, ranging from materials to device technology, communication networks to control theory, and the poster will focus on the latest information and present it along with our vision for the future.

Poster presentation (GJWS5-JP-NICT3)

Energy-Efficient Power Management Architecture for Open RAN towards Beyond 5G/6G era

Takaya Miyazawa, NICT

Open radio access network (O-RAN) has been expected to enhance both the openness of network components and the intelligence of control functions as a promising RAN architecture for Beyond 5G (B5G)/6G networks. Meanwhile, the power consumption of base stations (BSs) in RAN is a serious problem that needs to be addressed owing to the recent increase in service types such as 4G-LTE, 5G, and local 5G, and it will be more remarkable in the future B5G era. This poster presentation introduces our proposed energy-efficient power management architecture for O-RAN BSs, which extends the traditional standard O-RAN architecture. The proposed architecture effectively utilizes the pedestrian flow analytics results and non-terrestrial network (NTN) capacities to obtain a higher energy-saving effect for O-RAN BSs while maintaining the continuity of communications, bitrate, and other metrics.

Poster presentation (GJWS5-JP-NICT4)

Data Space Handling Functions for Multi-Stakeholder Digital Twin Interaction and Smart City Applications

Do-Van Nguyen, NICT Big Data Integration Research Center, Flavio Cirillo, NEC Laboratories Europe, Sadanori Ito, NICT Big Data Integration Research Center, Koji Zettsu, NICT Big Data Integration Research Center

Digital Twins replicate real-world assets in the digital domain, enabling efficient management and decision-making through advanced data handling, computation, analytics, and visualization. These digital representations serve multiple stakeholders, necessitating effective information sharing. Data Spaces provide the foundation for connecting diverse data sources, supporting a data economy, and facilitating Digital Twin implementations, particularly in complex, multi-domain use cases. However, integrating diverse Digital Twin systems across stakeholders poses significant challenges, often resulting in fragmented and time-consuming asset management.

This research focuses on designing data handling functions to enable seamless interaction between multiple Digital Twins and stakeholders. An orchestration framework is developed to support data exchange and cross-domain coordination. The framework is applied to real-world use cases such as hotspot prediction, eco-driving assistance, and congestion reduction route guidance. By leveraging these advancements, this work demonstrates the potential of Digital Twins and orchestration technologies to address complex challenges in smart city applications.

Poster presentation (GJWS5-JP-NICT5)

Terahertz Propagation and Communication Research Towards 6G

Hirokazu Sawada, Azril Haniz, Masafumi Moriyama and Takeshi Matsumura (NICT)

The use of sub-terahertz and terahertz waves is considered as a frequency band for next-generation wireless communication systems that will enable high-speed communication of tens of Gbps or more, and it is essential to clarify radio wave propagation characteristics and develop the physical layer design. Power loss coefficients are extracted based on the measurement results in office, corridor and data center environments for wide band frequency range from 232 to 500GHz, and delay profiles are also measured for indoor and outdoor environments. Furthermore, physical layer design has been studied using an FSK modulation scheme due to the power limitations of terahertz band devices.

Poster presentation (GJWS5-JP-NICT6)

Current Research Progress on Cluster Clock Systems: Hardware Development for High-Precision Time Synchronization in Beyond 5G

Yuichiro Yano(NICT),Takayuki Ishizaki(Science Tokyo), Takahiro Kawaguchi(Gunma Univ.), Masakazu Koike (TUMSAT), Tetsuya Iwamoto (Seiko Solutions Inc.), Yosuke Kurata (Seiko Solutions Inc.) Yuhei Nagao (Radrix Inc.),Motoaki Hara(NICT), Tetsuya Ido(NICT)

High-precision time synchronization technology is an important technology in B5G, supporting high-speed, large-capacity with distributed MIMO and local positioning by wireless communication. We are working on research and development of distributed time synchronization utilizing small atomic clocks and high-precision time-frequency technology, both of which have made significant progress in recent years. We call this synchronization system a cluster clock system because devices with small atomic clocks in a network cooperate with each other to keep precise and accurate time. In this presentation, we report on the status and current progress of the development of wired and wireless hardware for distributed time synchronization for Beyond 5G.

Demonstration display (GJWS5-JD-UHIR)

Simultaneous Multi-Location and Multi-Frequency-Band Measurements Using Real-time Spectrum Monitors with Wi-Wi

Tatsuya Hatagi/ Hiroshima University

In smart factories, understanding the wireless environment in real time is essential for the control of radio wave interference. This understanding allows for the effective utilization of frequency resources by flexibly allocating wireless resources for both wireless information transmission and wireless power transfer. To analyze the wireless environment in real time, we investigate combining multiple real-time spectrum monitors capable of measuring three frequency bands 920-MHz, 2.4-GHz, and 4.8-GHz with time synchronization technology. Here, we introduce a measurement system capable of simultaneous multi-location and multi-frequency band measurements. This system utilizes multiple monitors using time synchronization devices, Wireless Two-way Interferometry (Wi-Wi), to synchronize the clocks of the real-time spectrum monitors.

Both poster and demonstration (GJWS5-JB-UIST)

Impedance Matching Between a Waveguide and a Transmission Line Using a Flexible Conductive Membrane Micro-actuator for Beyond 5G/6G Communication (Poster)/Radio-Wave Absorbers, Radomes, and Performance Compensation via Mechanical Tuning in the Terahertz Band (Demonstration)

Keita Nagai, Chao Qi, Sangyeop Lee, Tadahiko Shinshi (Institute of Science Tokyo, Poster)/Sangyeop Lee, Motohiro Takayasu, Keita Nagai, Tadahiko Shinshi (Institute of Science Tokyo, Demonstration)

Poster abstract

Beyond 5G/6G technologies will employ terahertz waves for high-speed, low-latency communications. However, the short wavelength makes impedance matching highly sensitive to mechanical errors in transmission-line-to-waveguide transitions. To solve this, we propose a tunable impedance waveguide transition integrating a membrane micro-actuator as a back short. The actuator comprises a flexible conductive membrane (FCM) and a piezoelectric impact drive actuator (PIDA). The FCM, a bi-layer composite of Ag-based conductive and polymer layers, adjusts its deformation via the PIDA, enabling impedance tuning. The PIDA's self-locking mechanism ensures zero power consumption for maintaining deformation. The actuator achieves a reversible 100 μm stroke with 2 μm resolution. Reflection measurements from 220–330 GHz demonstrate effective waveguide impedance tuning through FCM deformation.

Demonstration abstract

Beyond 5G/6G technologies will utilize terahertz waves for higher-speed, lower-latency wireless communications. While substantial progress has been achieved in terahertz circuits and antennas, the development of radio-wave devices like absorbers and radomes remains limited, despite their necessity for realizing practical modules or systems. Moreover, the short wavelength in this frequency range heightens the sensitivity of impedance matching to mechanical errors in antennas and transmission-line-to-waveguide transitions. To tackle these challenges, we propose wideband, transparent absorbers and radomes operating at 150 GHz and 300 GHz, along with a 300-GHz tunable impedance waveguide transition featuring a membrane micro-actuator as a tunable back short.

Both poster and demonstration (GJWS5-JB-NICT1)

D-band antenna-coupled optical modulators using EO polymers

Takahiro Kaji (NICT), Toshiki Yamada (NICT), Akira Otomo (NICT)

Radio-over-fiber (RoF) technology, which transmits terahertz (0.1-10 THz) signals as optical signals using optical fiber, is attracting attention for the realization of ultra-high-speed wireless communication in Beyond 5G. In this study, we prototyped and evaluated D-band (110–170 GHz) antenna-coupled optical modulators using electro-optic (EO) polymer waveguides and non-coplanar patch antennas with the aim of realizing devices that directly convert a radio signal to an optical signal in RoF systems.

Both poster and demonstration (GJWS5-JB-NICT2)

Demonstration of Support Node Function for Reliability-ensuring Platform of Cybernetic Avatar

Homare MURAKAMI, Kazuo IBUKA, Atsushi Wakayama, Shinichi HAMA, Jun AMAGAI, Takeshi MATSUMURA (NICT)

We have developed a support node that serves as a reliability assurance infrastructure for the stable operation of cybernetic avatars (CAs) and functions as the foundation for end-to-end (E2E) communication.

In this demonstration, we show a game involving robot control via teleoperation. Participants can experience the challenges of operation under jitter conditions and observe the improvements in control when the support node suppresses the jitter.

Both poster and demonstration (GJWS5-JB-NICT3)

Prediction and Visualization of Ultra-High-Speed mmWave/THz Ultra-Spots based on Reinforcement Learning Powered by Extended Reality and Space-Time Synchronization

Phuc Duc Nguyen (NICT), Keitarou Kondou (NICT), Daniel Zakamulin (RWTH Aachen), Meliksah Canoglu (RWTH Aachen), Haris Gačanin (RWTH Aachen), Yozo Shoji (NICT)

The challenge of predicting the location of ultra-high-speed communication coverage using mmWave/THz waves (also known as ultra-spot) is increasingly prominent in beyond-5G, especially in communication between unmanned aerial vehicles (UAVs) and other UAVs, ground stations, or unmanned ground vehicles (UGVs), where mobilities are constantly moving at different speeds and environments are changing. In this study, we will introduce a proposed ultra-spot prediction method, adaptive flight path modification based on reinforcement learning, as well as the application of extended reality for ultra-spot visualization. Additionally, this research will analyze the effectiveness of high-precision space-time synchronization techniques to enhance the accuracy of ultra-spot location prediction, as well as the potential of this technique in beam steering and path planning applications.

Both poster and demonstration (GJWS5-JB-NICT4)

Space-Time Synchronization

Nobuyasu Shiga, NICT, Satoshi Yasuda, NICT

The vision of 5G is to achieve connectivity for all devices. To enhance the orchestration of these devices, precision in time synchronization and spatial coordination must be improved by orders of magnitude.

We have developed wireless two-way interferometry (Wi-Wi) to achieve precise space-time synchronization. Wi-Wi achieves picosecond-level synchronization and millimeter-level distance variation measurement by utilizing the carrier phase of wireless communication.

Wi-Wi will provide a wide range of space-time synchronization solutions, including indoor positioning and data center server synchronization in the context of B5G. In this workshop, we will introduce a demo and poster that demonstrate the concept of space-time synchronization.

Both poster and demonstration (GJWS5-JB-NICT5)

Leveraging Machine Learning and Full Duplex Relay for Resilient Robot Communication

Nann Win Moe THET, Khanh Nam NGUYEN, and Kenichi TAKIZAWA (NICT)

Remotely controlled swarm robots are increasingly utilized, particularly for operations in areas inaccessible to humans, often characterized by severe radio environments with significant propagation losses and interference. Ensuring stable wireless communication is critical for effective remote robot control. By leveraging machine learning, we predict radio signal strength by incorporating data from cameras and LiDAR equipped on robots, even in complex environments. This enables dynamic adjustments to the robot's movement path and communication parameters, reducing the risk of control line disruptions. To extend coverage between robots and the base station, we utilize a relay station based on in-band full-duplex (IBFD) technology. Promising for IMT-2030, IBFD enables simultaneous transmission and reception in the same frequency band, offering higher spectral efficiency. While strong self-interference (SI) poses a challenge, our proposed IBFD system incorporates a self-interference cancellation (SIC) design that minimizes processing delays, ensuring reliable communication for ultra-reliable low-latency and massive machine-type communication applications, such as factory automation.

Both poster and demonstration (GJWS5-JB-NICT6)

Real-time Demonstration of International Optical Network Testbed Data Sharing with Data Sovereign Features

Yusuke Hirota1, Sugang Xu1, Angela Mitrovska2, Yuki Yoshida1, Pooyan Safari2, Behnam Shariati2, Johannes K. Fischer2, Ronald Freund2, Hideaki Furukawa1, Kouichi Akahane1, and Yoshinari Awaji1 (1:NICT, 2:HHI)

In the 6G/B5G era, optical network testbeds are taking on a new role in delivering big data, such as telemetry data, which is crucial for training and validating Artificial Intelligence (AI) and Machine Learning (ML)-assisted network functions. Nevertheless, assembling a comprehensive dataset for the emerging disaggregated, multi-vendor environments, is too demanding for a single testbed. This situation highlights the need for collaboration among various network testbeds in the data domain. To this end, establishing a data governance framework for exchanging and sharing invaluable testbed data across organizations, particularly those from different counters, is indispensable. Here we demonstrate a real-time, international testbed data sharing between NICT and HHI testbeds with data sovereignty based on International Data Spaces Reference Architecture Model (IDS-RAM).