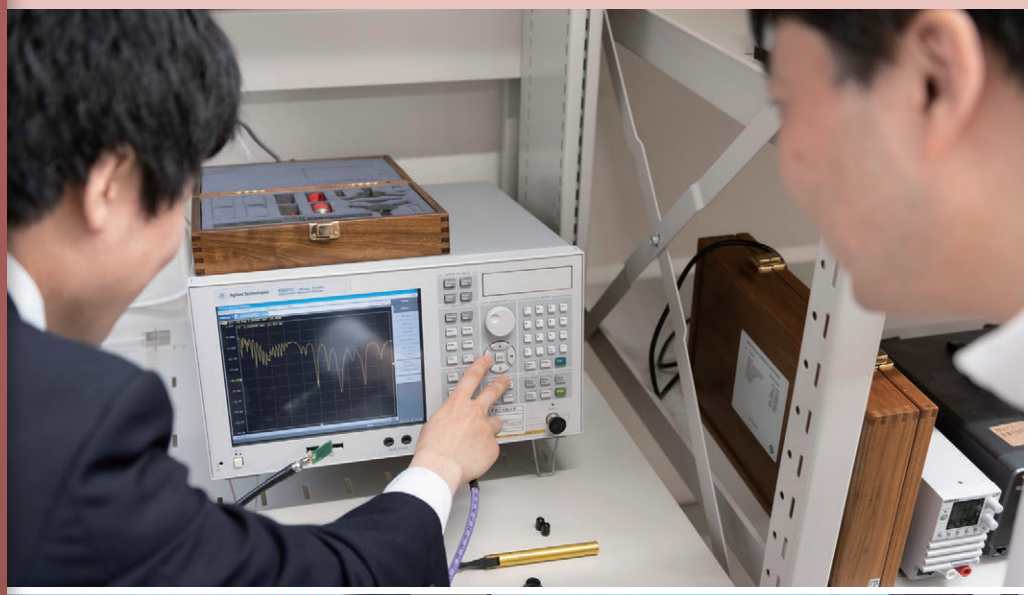
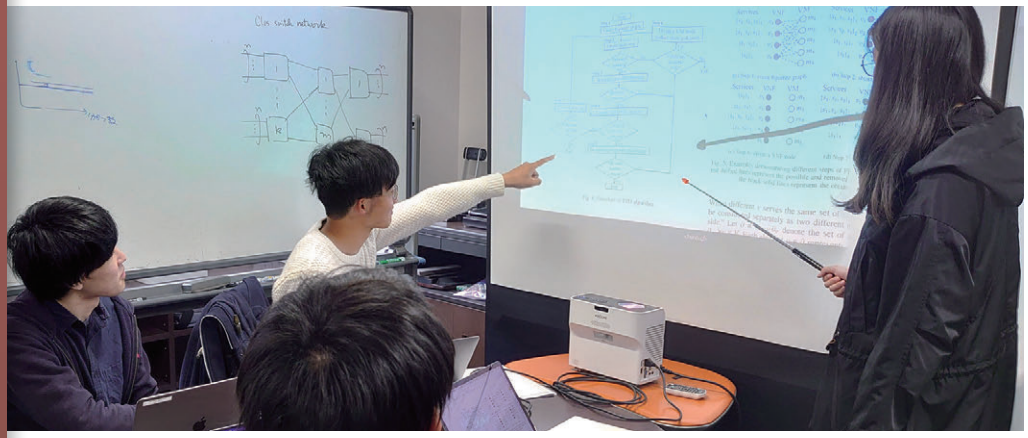
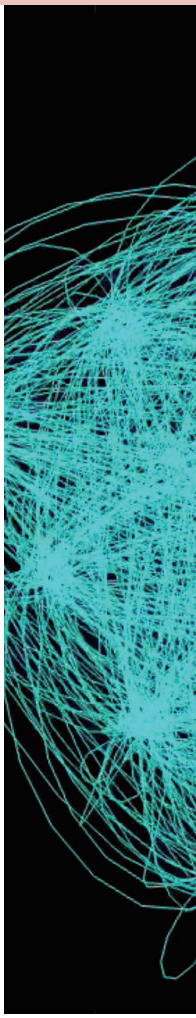
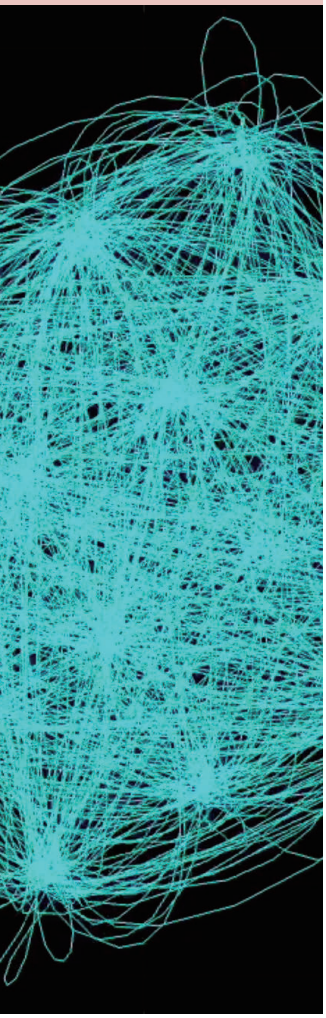
Towards the Establishment of Fundamental Technologies in the Information Age

Advanced information processing and communications are indispensable for our society to prosper in the 21st century.
Information processing devices typified by computers are called upon to achieve high performance and be highly functional and compact.
In communications, we should be able to enjoy high-speed, reliable transmission of a vast amount of multimedia data anytime, anywhere.
The Course of Communications and Computer Engineering supports the development of future technologies in the fields of information processing devices and digital communications.









Constructing Information and Communication Infrastructure for an Innovative Society

Dramatic changes in socioeconomic conditions and globalization have given rise to a mountain of new and increasingly complex social challenges involving multiple different domains and fields. To address these challenges, information and communication "platforms" that take advantage of real-time data from the real (physical) world, as well as massive quantities of accumulated data from the virtual (cyber) space of servers and clouds are being used.

This information and communication infrastructure will generate new value and resolve social issues by using various sensing technologies to collect different kinds of information that are ubiquitous in the physical world, storing this information in cyberspace over a wide area using communication technologies, and then processing it using information technologies for data organization, analysis, feature extraction, and prediction, and finally, feeding the results of processing back into the physical world using communication technologies to share the results for a variety of purposes.

This kind of infrastructure requires various kinds of devices built from integrated circuits, taking into consideration size and power consumption to enable high-speed data collection and processing, computers (hardware and software) for high-speed, high-efficiency processing of data stored in virtual spaces, and a communication system that can reliably connect an extremely large number of devices across cyberspace at high speed. The R&D on these devices, computers, and communication systems needs to be integrated, rather than conducted separately.

The Communication and Computer Engineering Course provides education and research on computers, communications, and integrated systems, the fundamental technologies for building this platform, all within a single course. Research findings in this field are at the forefront of shaping the world, as they are implemented in Japan and internationally through joint research with industry, international standardization, and other means, to support a wide range of social and economic systems. Come to study with us in the Communications and Computer Engineering Course and help to generate new value for the benefit of society, through innovations in essential information and communication technologies and systems.

Hiroshi Harada

Professor, Communications and Computer Engineering Course

He received his Ph.D. degree from the Graduate School of Engineering, Osaka University in 1995. He joined the Communications Research Laboratory, Ministry of Posts and Communications, (currently National Institute of Information and Communications Technology: NICT). After working as a researcher at Delft University of Technology, the Netherlands, a research manager and research director at NICT, and laboratory director at the Singapore Laboratory of NICT, he became a professor at Graduate School of Informatics, Kyoto University in 2014. Since 1995, he has been involved in the research, development, international standardization, and commercialization of mobile wireless communication systems and wireless communication systems for the Internet of Things.
He received the Commendation for Science and Technology from the Minister of Education, Culture, Sports, Science and Technology in 2014, the Achievement Awards from IEICE in 2006 and 2018, and the Working Group Chair Awards from IEEE Standard Association for the contributions of five international standards on wireless communication

Outline

Group and Teaching Staff

Group	Teaching Staff
Computer Algorithms	Shin-ichi Minato/Professor Jun Kawahara/Associate Professor Jesper Jansson/Associate Professor Yuni Iwamasa/Assistant Professor
Computer Architecture	Naofumi Takagi/Professor Ryota Yasudo/Assistant Professor
Computer Software	Atsushi Igarashi/Professor Kohei Suenaga/Associate Professor Masaki Waga/Assistant Professor Mirai Ikebuchi/Assistant Professor
Digital Communications	Hiroshi Harada/Professor Keiichi Mizutani/Associate Professor Yusuke Koda/Assistant Professor
Integrated-Media Communications	
Intelligent Communication Networks	Eiji Oki/Professor Takehiro Sato/Associate Professor Ryuta Shiraki/Assistant Professor
Processor Architecture and Systems Synthesis	Takashi Sato/Professor Hiromitsu Awano/Associate Professor
Integrated Circuits Design Engineering	Kiichi Niitsu/Professor
Advanced Signal Processing	Masatoshi Hashimoto/Professor Ryo Shirai/Assistant Professor
Remote Sensing Engineering	Mamoru Yamamoto/Professor Tatsuhiro Yokoyama/Associate Professor
Atmospheric Observations	Hiroyuki Hashiguchi/Professor Koji Nishimura/Associate Professor
Supercomputing	Keiichiro Fukazawa/Associate Professor
Multimedia and Secure Networking	Yasuo Okabe/Professor Daisuke Kotani/Assistant Professor

Curriculum of Communications and Computer Engineering Course

Doctoral Program (Informatics)

3rd: Doctoral Thesis

2nd / 1st: **Subjects provided by the Course (total 6 credits including 4 credits from seminars)**
Seminar on Communications and Computer Engineering, Adv. A, B *E* (1 credit each)
Seminar on Computer Engineering, Adv. A, B *E*, Seminar on Communication Systems Engineering, Adv. A, B *E*, Seminar on Integrated Systems Engineering, Adv. A, B *E*, Seminar on Radio Atmospheric Science, Adv. A, B *E*, Seminar on Communication and Computer System, Adv. A, B *E* (2 credits each)

Research Guidance

Master's Program (Informatics)

Master's Thesis

2nd / 1st: **Subjects provided by the Course (optional 12 credits or more, including recommended subjects provided by other Courses)**

Advanced Subjects
Design in ICT, Theory of Computational Complexity *E*, Parallel Computer Architecture, Hardware Algorithm, System Verification *E*, Formal Semantics of Computer Programs, Transmission Media Engineering, Adv., Integrated System Architecture and Synthesis, System-Level Design Methodology for SoCs *E*, Atmospheric Measurement Techniques *E*, Remote Sensing Engineering, Computer Network, Advanced, Supercomputing, Advanced (2 credits each)

Basic Subjects
Theory of Discrete Algorithms, Introduction to Algorithms and Informatics, Digital Communications Engineering, Information Networks, Integrated Circuits Engineering, Adv. (2 credits each)

Recommended subjects provided by other Course (4 credits, Mandatory)
Language Information Processing, Adv. *E* (IST), Biosphere Informatics *E* (SI)
Cryptography and Information Society (SI) (2 credits each)

General Subjects provided by the school

Interdisciplinary subjects of the Perspectives in Informatics (Mandatory 2 credits or more, up to 4 credits)
Perspectives in Informatics 1 Perspectives in Informatics 2
Perspectives in Informatics 3*E* Perspectives in Informatics 4*E*
Perspectives in Informatics 5*E* (2 credits each)

Perspectives in Platform Studies (2 credits), Computational Science, Introduction (2 credits), Computational Science, Exercise A (1 credit), Information and Intellectual Property (2 credits), Innovation and Information (2 credits), Information Analysis and Management (2 credit), Information Analysis and Management, Exercise (1 credit), Social Contributions through Informatics *E* (1 credit), Internship in the Field of Informatics *E* (1 credit)

Seminars and exercises for Master's thesis (Mandatory 10 credits)
Advanced Study in Communications and Computer Engineering 2*E* (Assigned to M2, 5 credits)
Advanced Study in Communications and Computer Engineering 1*E* (Assigned to M1, 5 credits

Specific Subjects provided by the school

Prior to admission: Communications and Radio Engineering | Logic and Integrated Circuits Engineering | Computer Engineering | Theoretical Computer Science — Required to earn more than 2 credits from the four subjects on the left

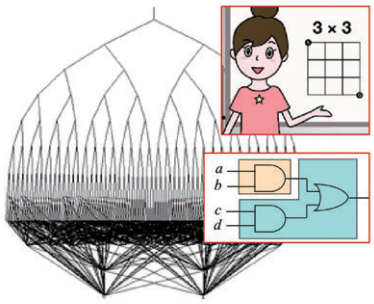
Note: Subjects marked with the letter "E" will be provided in English.

Computer Algorithms

The theory and art of algorithms, with real-life applications

A computer system consists of hardware and software. Both parts work according to a logical procedure: "algorithm." The art of algorithms and complexity theory are core areas in computer science, and needless to say have a multitude of applications. We investigate fundamental theory, state-of-the-art techniques, and real-life applications of "algorithms," a keyword of our laboratory. We aim to enable computers to make increasingly significant contributions to society.

[Shin-ichi Minato , Jun Kawahara , Jesper Jansson , Yuni Iwamasa]

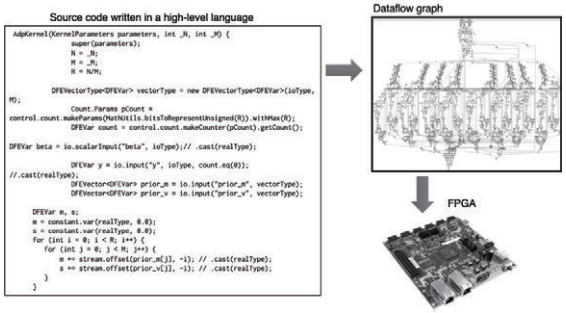


Computer Archtecture

Advanced computing mechanisms and design technologies

We conduct education and research on new computing mechanisms and their design technologies for the post-Moore era in which exponential improvement in computer performance is difficult to achieve. Our main research topics include computing methods utilizing FPGA which is a reconfigurable hardware and GPU which enables high-speed parallel computing, high-capacity memory systems based on packet transfer, systems for uniform handling of combinational optimization, and design of superconductive digital circuits and development of their design support technologies.

[Naofumi Takagi , Ryota Yasudo]



Computer Software

Theory and practice for efficient and dependable software

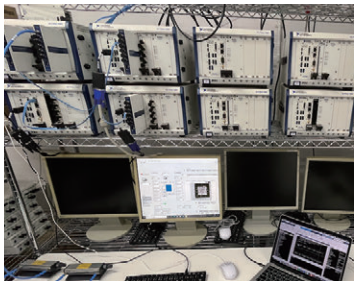
Centering around programming languages, we conduct research and education on theory and practice for building highly efficient and dependable software. Our main focuses are on theory of program verification techniques based on mathematical logic, such as type theory and model checking, and the design and implementation of high-level programming languages, backed by rigorous foundations.

[Atsushi Igarashi , Kohei Suenaga , Masaki Waga , Mirai Ikebuchi]

Outline

Digital Communications

Toward ubiquitous wireless information networks



Wireless communication networks, accelerated by cellular radio together with short-range wireless communications and RFID tag technologies, for instance, have been advancing significantly towards the goal of so-called ubiquitous networks. That is, we are on the verge of an era when people can enjoy various benefits unconsciously from totally connected network where various equipments, devices, and sensors are closely connected each other and linked to the Internet via wireless technologies. With wireless distributed self-organizing information networks which will be expected to play core roles in such a next generation information networks in mind, we are actively working to conduct education and research on highly efficient radio resource management techniques including spectrum sharing among multiple wireless systems, and highly spectrum- efficient signal processing techniques for broadband wireless transmission, etc.

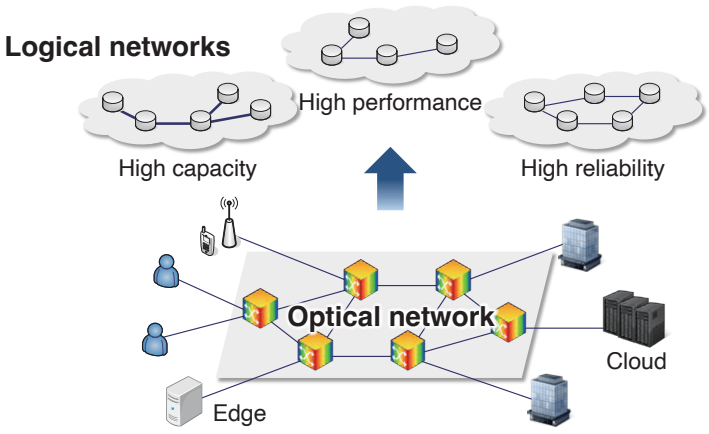
[Hiroshi Harada , Keiichi Mizutani , Yusuke Koda]

Intelligent Communication Networks

Exploring information and communication network paradigms

The advancement of the Internet of Things (IoT) and big data technologies has enabled the networking of all types of devices around us and the provision of a diverse variety of services through data processing on cloud and edge platforms. Establishing these types of systems as social infrastructure will require technologies for the sophisticated design and control of networks for the transmission and reception of large volumes of traffic and computer resources to collect and analyze data. Our laboratory conducts research on high-speed, reliable, and flexible information communication networks using a broad range of theoretical and practical approaches.

[Eiji Oki , Takehiro Sato , Ryuta Shiraki]



Processor Architecture and Systems synthesis

Architecture design methodology for system LSIs

Architecture design of integrated circuits is a key enabler for exploiting full potential of advance semiconductor technologies. Real-time signal processing on media data, extremely low power operation to prolong battery lifetime, and maximizing reliability of the system are of utmost importance. We conduct researches on the following areas: (1) methodologies for circuit analysis, circuit design techniques, and circuit-performance optimization, (2) architectural design for processors and reconfigurable devices for system LSI, and (3) hardware and embedded software algorithms for codecs, digital communications, image recognition, and their design methodologies.

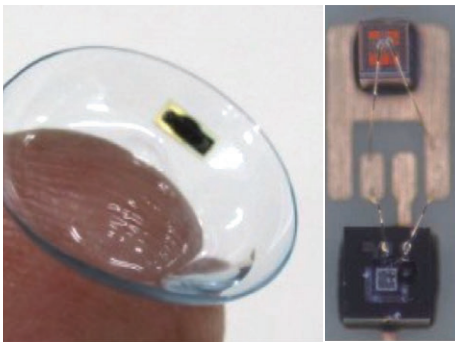
[Takashi Sato , Hiromitsu Awano]

Integrated Circuits Design Engineering

Circuit and Design Technologies for Large-Scale, High-Performance CMOS LSIs

Large-scale integrated (LSI) circuit systems are now essential elements of the public infrastructure that supports our modern information society. Our focus is doing fundamental R&D on design technology for energy-efficient semiconductor LSI circuits and developing new applications for them. Our approach is to envision a finished product, as well as the services in which it will be utilized, and even the social impact of those services, and then design and develop the high-energy efficiency LSI circuits to enable that product. Our R&D work ranges widely, from drawing up public acceptance scenarios to formulating necessary LSI circuit specifications, trial manufacturing of ICs, and creating prototypes in a consistent manner.

[Kiichi Niitu]



Power-independent continuous blood glucose monitor contact equipped with 65 nm CMOS IC and glucose power element

Ultrafast Signal Processing

Design and application of integrated systems

Our society is increasingly dependent on information system infrastructures, such as AI and Internet of Things (IoT). As they deal with human lives and property, information systems are required to offer high reliability. Ultra-low power, ultra-small volume semiconductor devices have been made possible by miniaturized transistors, and are realizing ambient computing that blends in with the environment. On the other hand, as the miniaturization of transistors seems to have reached its limit, efforts are underway to seek computing based on new principles. Under the banner of "creating computing infrastructure," this group is seeking ways to design reliable, high-performance computers, realize next-generation computing based on new principles, and define a computing system that changes our lifestyles.

[Masanori Hashimoto , Ryo Shirai]

Experiment to evaluate the reliability of an integrated system against cosmic rays

Outline

Remote Sensing Engineering

Exploration of the Earth's atmosphere through radars

We aim to elucidate various phenomena observed in the Earth's atmosphere, through the development of radio remote sensing and computer modeling. We are developing radar technology and/or simulation codes for studying various atmospheric phenomena (e.g., turbulence, rain, clouds, plasma) over a wide altitude range -- from phenomena that occur near the surface and hence are directly related to human activities, to phenomena that occur at the ionosphere above 100 km altitude, which is the boundary between the atmosphere and space. We study phenomena over Japan by the MU radar, and focus on the atmospheric and space weather phenomena. In addition to an atmospheric radar located in Indonesia (Equatorial Atmosphere Radar; EAR), we deploy an observation network in Southeast Asia under international collaboration in order to understand the atmospheric/ionospheric phenomena near the equator, where deep cumulus convection is moreprevalent there than anywhere else.

[Mamoru Yamamoto , Tatsuhiro Yokoyama]

Equatorial Atmosphere Radar in West Sumatra, Indonesia. Its size is about the same as that of the MU radar.

Atmospheric Observations

Towards developing new observation techniques to obtain atmospheric environmental information

We are developing new techniques to observe the atmosphere using radio waves, light, and acoustic waves, and conduct research and education to collect, process, and disseminate global observational atmospheric data. More specifically, our research topics include profiling of atmospheric temperature and humidity by using radio-acoustic sounding and laser radar techniques, development of radar digital receivers using software-defined radio for radar imaging observations of atmospheric turbulence, and development of adaptive clutter suppression techniques using the MU radar. We also carry out atmospheric observations around the world and combine a variety of techniques such as satellite data analysis and numerical modeling in order to elucidate various phenomena of the Earth's atmosphere, which is a protective coat of the humanosphere.

[Hiroyuki Hashiguchi , Koji Nishimura]

MU radar in Shigaraki, Koka City , Shiga Prefecture. The diameter of the antenna is 103 m.

Supercomputing

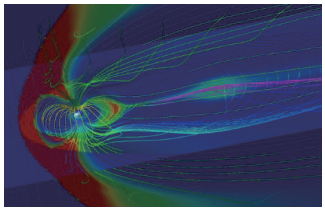
Aiming to be at the forefront of computing performance

We are involved in research into supercomputers, their software, and systems that are thousands or tens of thousands of times more powerful than ordinary personal computers.

Our focus is on research related to fundamental technologies to support future high-performance parallel computing, such as high-performance and highly parallel program development techniques suitable for state-of-the-art processors and computers, research on program scheduling to maximize the computing performance per unit of power consumption, and development of applications that can take advantage of supercomputers. Much of this research is in the form of joint research projects that extend beyond the field of computer science to involve researchers in the fields of medicine, physics, engineering, and other areas.

[Keiichiro Fukazawa]

Supercomputer at the Academic Center for Computing and Media Studies



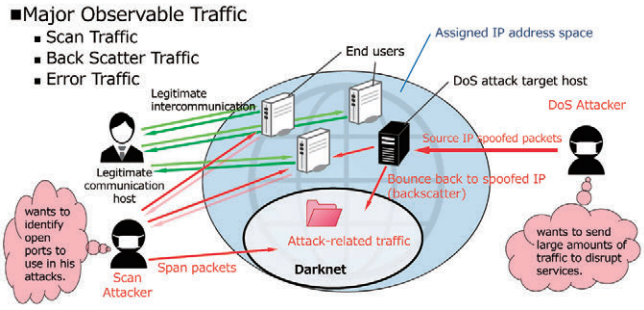
Global magnetosphere simulation using massively parallel computing

Multimedia and Secure Networking

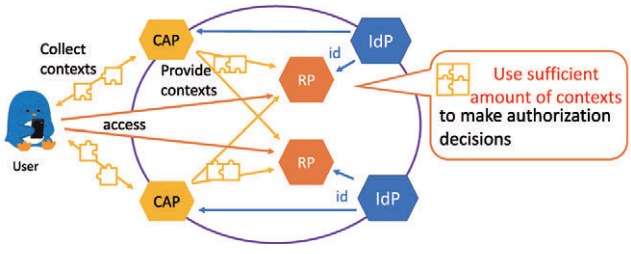
Towards a ubiquitous networking world

Society 5.0 is a vision of a future society in which computers and network functions are embedded into everything, characterized by a high degree of integration between cyberspace and physical space through "anytime, anywhere" network connections. As fundamental technologies to support this kind of society, we are pursuing research on next-generation Internet technologies such as programmable networks and protocols that use such networks, operational technologies such as automated configuration, platform technologies that support assorted services such as identity federation, and security. As the network research division of the Academic Center for Computing and Media Studies, we also perform numerous empirical studies using operational networks, both on and off campus.

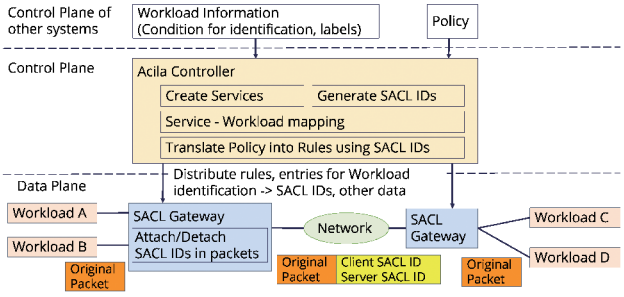
[Yasuo Okabe , Daisuke Kotani]



Investigating cyberattack trends by observing darknets (unused IP address spaces)



Linking contextual information suitable for identity federation in a Zero Trust system



Network access control using workload identities for cloud operations