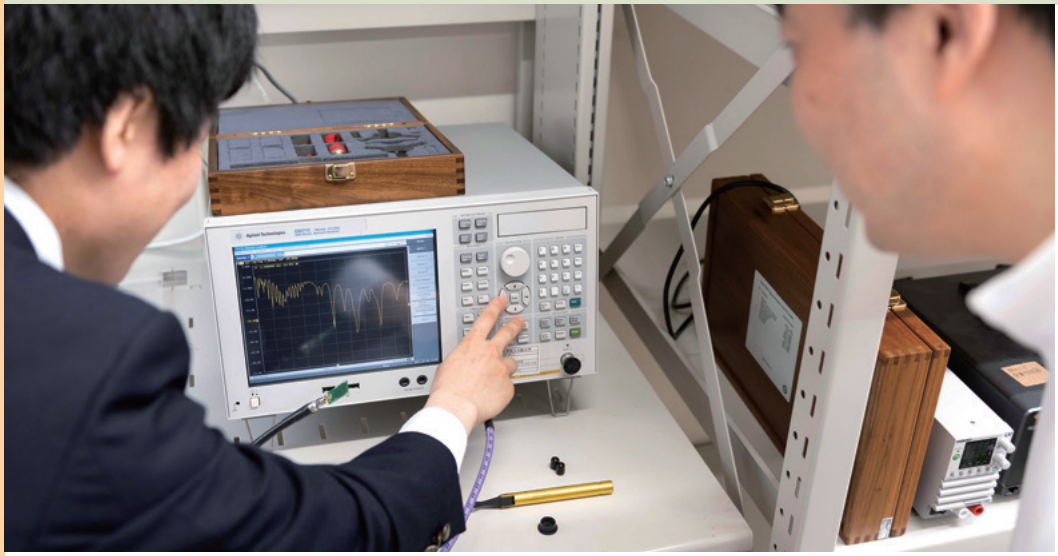
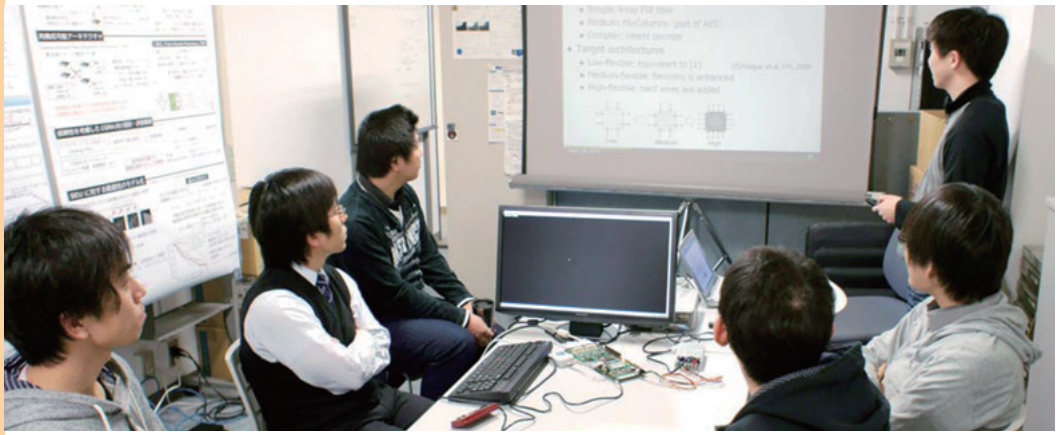
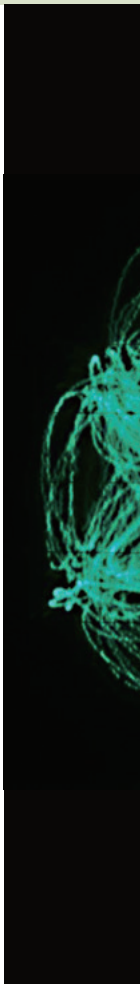
Department of Communications and Computer Engineering

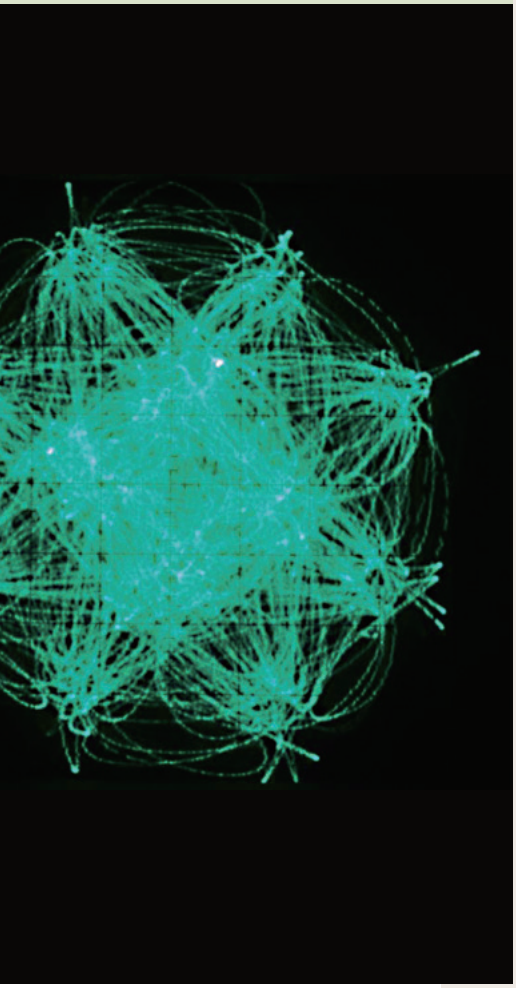
Towards the Establishment of Fundamental Technologies in the Information Age

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 Department of Communications and Computer Engineering supports the development of future technologies in the fields of information processing devices and digital communications.









"Invisiblizing" software

Some people say "Software weighs nothing." What do you think? Here is an anecdote from 1960s, at the dawn of the computer age: "How much does the software on this airplane weigh?" "Nothing." "That's ridiculous. It costs a million dollars and doesn't weigh anything? What about that deck of punched cards? It does weigh something." "See those holes on the cards? Those holes are the only part of the software that actually goes into the plane."

Some people say "Software is invisible." What do you think? Well, even if it is holes, it's very questionable that software is really invisible. Indeed, software bugs frequently annoy us, making software "visible". Software---especially one that works as part of social infrastructure---should be so invisible that we don't even notice its existence.

Our research group conducts a wide range of research to contribute to improving safety and dependability of software, thereby "invisiblizing" software. We develop new programming languages and automated program verification techniques based on theory of computer programs, which we also study.

The Department of Communications and Computer Engineering focuses on education and research in areas such as future computer systems, communications, and integrated systems, which are also "invisible" infrastructure technology. Broad topics ranging from academic research to cutting-edge industrial problems are waiting to challenge you. Why don't you aim for being a "world-visible" researcher at our Department?

Atsushi Igarashi
Department of Communications and Computer Engineering

He received his B.S., M.S., and Ph.D degrees from Department of Information Science, University of Tokyo in 1995, 1997, and 2000, respectively. He joined the faculty of Graduate School of Informatics, Kyoto University in 2002 as a Lecturer after two years as a Research Associate at Graduate School of Arts and Sciences, University of Tokyo. He became an Associate Professor in 2006 and a Professor in 2012. His main research interest is in principles of programming languages. He received the 20th Japan IBM Science Prize in Computer Science in 2006, the Young Scientists' Prize, the Commendation for Science and Technology by the Japan Minister of Education, Culture, Sports, Science and Technology in 2009, the 1st Microsoft Research Japan New Faculty Award in 2009, and the Dahl-Nygaard Junior Prize in 2011.

Outline

Divisions and Groups

Division	Group	Research and Education Topics	Professor
Computer Engineering	Computer Algorithms	Algorithms, Discrete Structures, Complexity, and Logic Circuits	Shin-ichi Minato
	Computer Architecture	Reconfigurable computing, parallel computing, superconductive digital circuits	Naofumi Takagi
	Computer Software	Theory of Programs, Program Verification, Programming Languages	Atsushi Igarashi
Communications Systems Engineering	Digital Communications	Highly Reliable and Secure Broadband Digital Communication Systems	Hiroshi Harada
	Integrated-Media Communications	Integrated Transmission System and Applications	
	Intelligent Communication Networks	Design and Performance Analysis of Information and Communication Networks	Eiji Oki
Integrated Systems Engineering	Processor Architecture and Systems Synthesis	Large-scale, High-performance Information Circuit Architecture, and Design Technology	Takashi Sato
	Ultrafast Signal Processing	Design and application of integrated systems	Masanori Hashimoto
Radio Atmospheric Sciences (Affiliated)	Remote Sensing Engineering	Atmospheric Measurement and Geophysical Environmental Information by Radio Waves, Light, and Acoustic Waves Using Electronic Engineering	Mamoru Yamamoto
	Atmospheric Observations		Hiroyuki Hashiguchi

Graduate Curriculum

Courses for the Master's Program

Courses for the Master's Program
Theory of Discrete Algorithms
Digital Communications Engineering
Information Networks
Integrated Circuits Engineering (Advanced)
Theory of Computational Complexity
Parallel Computer Architecture
Parallel and Distributed Systems
Digital Signal Processing (Advanced)
Formal Semantics of Computer Programs
Advanced Study in Communications and Computer Engineering I
Advanced Study in Communications and Computer Engineering II
Introduction to Algorithms and Informatics
Hardware Algorithm
Transmission Media Engineering (Advanced)
Integrated System Architecture and Synthesis
System-Level Design Methodology for SoCs
Atmospheric Measurement Techniques
Remote Sensing Engineering

Courses for the Doctoral Program

Seminar on Computer Engineering, (Advanced)
Seminar on Communication Systems Engineering, (Advanced)
Seminar on Integrated Systems Engineering, (Advanced)
Seminar on Radio Atmospheric Science, (Advanced)
Seminar on Communications and Computer Engineering, (Advanced)

Teaching Staff

(S): Research Institute for Sustainable Humanosphere

Professors

Shin-ichi Minato; Naofumi Takagi; Atsushi Igarashi; Hiroshi Harada; Eiji Oki; Takashi Sato; Masatoshi Hashimoto; Mamoru Yamamoto (S); Hiroyuki Hashiguchi (S)

Associate Professors

Jun Kawahara; Jesper Jansson; Kohei Suenaga; Koji Yamamoto; Takehiro Sato; Hiromitsu Awano; Tatsuhiro Yokoyama (S); Koji Nishimura (S)

Assistant Professors

Yuni Iwamasa; Ryota Yasudo; Masaki Waga; Ryo Shirai

Computer Engineering

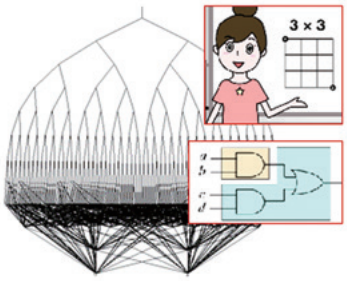
Enhancing the performance of computers is a clear challenge for the age of advanced information. Our goal is to respond to this challenge by conducting research and education on advanced technology for computer systems, including computer architectures for massively parallel information processing, the theory and art of algorithms, and fundamental software such as operating systems, and programming language systems.

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.

[Professor: Shin-ichi Minato;
Associate Professors: Jun Kawahara, Jesper Jansson;
Assistant Professor: Yuni Iwamasa]

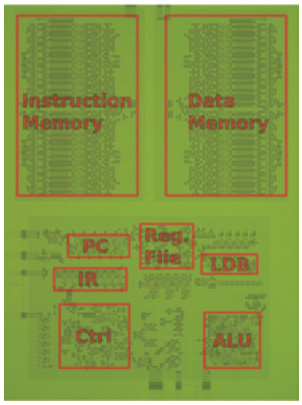


Computer Architecture

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.

[Professor: Naofumi Takagi; Assistant Professor: Ryota Yasudo]



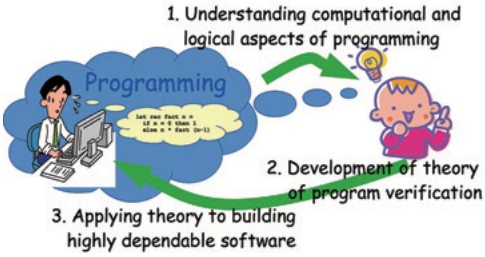
CORE e4: the world's first superconducting RSFQ stored-program microprocessor

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.

[Professor: Atsushi Igarashi; Associate Professor: Kohei Suenaga;
Assistant Professor: Masaki Waga]



Outline

Communications Systems Engineering

This division aims to conduct education and research on state-of-the-art technology with the goal of developing highly advanced information communication networks for handling multimedia information without network awareness. Topics include fundamental technologies for information communication networks such as the building of integrated wired and wireless digital information communication networks as well as adaptive digital signal processing and transmission technologies, information transmission media, network design and control technologies, and communication protocols that support them.

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.

[Professor: Hiroshi Harada]

Integrated-Media Communications

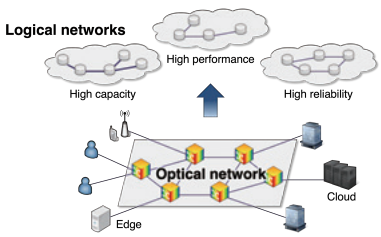
Towards an integrated wireless platform leveraging emerging technologies in different fields

The millimeter wave communications will be a key part of the next-generation radio access system and it will enable high-speed and large capacity wireless networks. However, there are many open issues such as a human blockage problem, where the received signal strength seriously decreases when pedestrians block line-of-sight paths. To solve the problems, we research on an integrated wireless platform leveraging emerging technologies in different fields such as computer vision and machine learning.

[Associate Professor: Koji Yamamoto]

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.

[Professor: Eiji Oki; Associate Professor: Takehiro Sato]

Integrated Systems Engineering

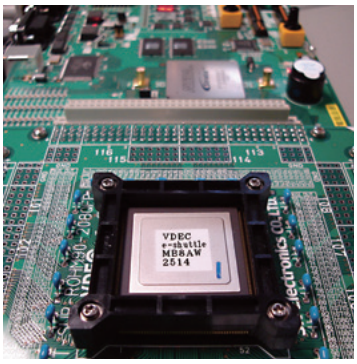
We conduct lectures and researches on high-performance, multifunctional, and highly-reliable large-scale integrated circuits and systems, which are fundamental infrastructures of future multimedia devices, computers, and communication systems. The research area includes processor architecture, algorithms for fast signal processing, massively parallel computing, and design methodologies for their circuit realization on advanced device technologies.

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.

[Professor: Takashi Sato; Associate Professor: Hiromitsu Awano]



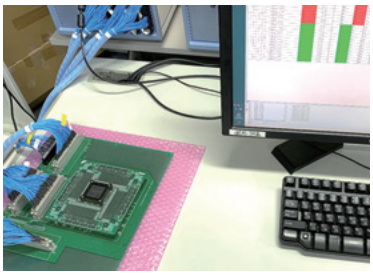
A reconfigurable LSI fabricated using 65nm process technology and its evaluation board

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.

[Professor: Masanori Hashimoto; Assistant Professor: Ryo Shirai]



Measuring a newly designed and fabricated FPGA chip with novel nano devices

Outline

Radio Atmospheric Sciences (Affiliated)

The Division of Radio Atmospheric Sciences conducts research and education regarding radio science, radio engineering, and information communication engineering related to the expansive atmospheric environment from the surface to the ionosphere. Our research focuses on the fields of applied radio engineering and information processing such as the development of different kinds of radar systems using sophisticated electronic circuit and computer technology, radar signal processing, radar observations of atmospheric waves, and remote-sensing systems.

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 100km 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 more prevalent there than anywhere else.

[Professor: Mamoru Yamamoto;
Associate Professor: 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.

[Professor: Hiroyuki Hashiguchi;
Associate Professor: Koji Nishimura]

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