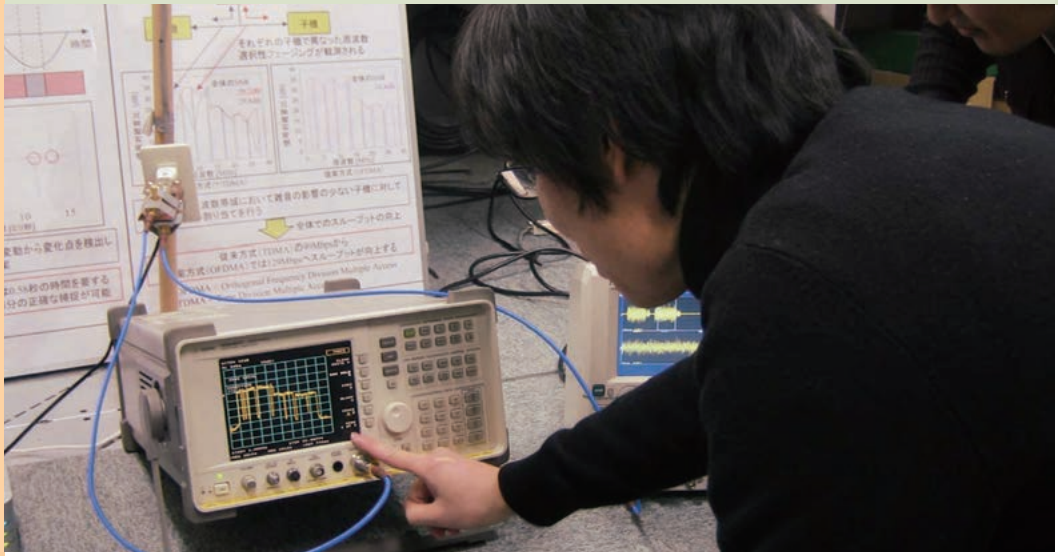
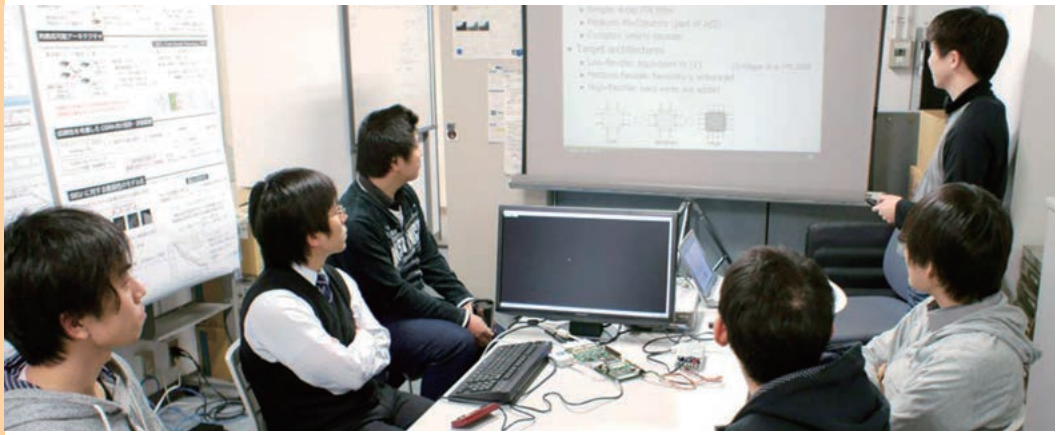
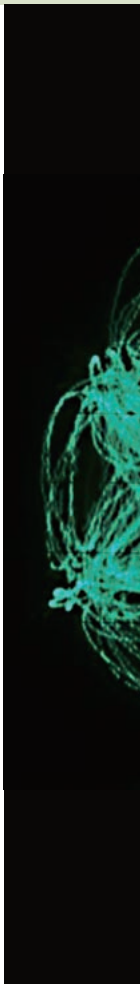
Department of Communications and Computer Engineering

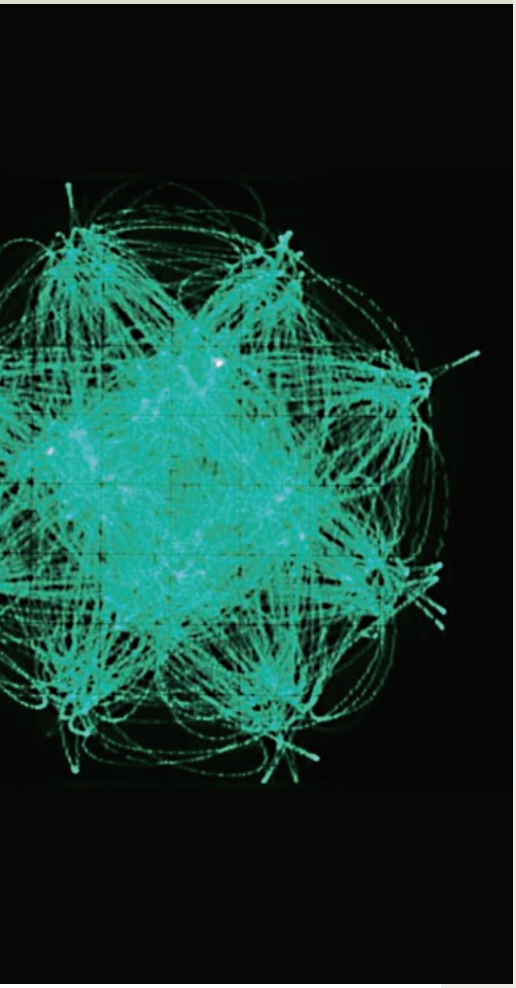
Towards the Establishment of Fundamental Technologies in the Information Age

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?

IGARASHI Atsushi
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	Logic Circuits, Algorithms and Complexity Theory	Logic Circuits, Algorithms and Complexity Theory	MINATO Shin-ichi
	Computer Architecture	Arithmetic Circuits, Embedded System Design, and Superconducting Processors	TAKAGI Naofumi
	Computer Software	Theory of Programs, Program Verification, Programming Languages	IGARASHI Atsushi
Communications Systems Engineering	Digital Communications	Highly Reliable and Secure Broadband Digital Communication Systems	HARADA Hiroshi
	Integrated-Media Communications	Integrated Transmission System and Applications	MORIKURA Masahiro
	Intelligent Communication Networks	Design and Performance Analysis of Information and Communication Networks	OKI Eiji
Integrated Systems Engineering	Processor Architecture and Systems Synthesis	Large-scale, High-performance Information Circuit Architecture, and Design Technology	SATO Takashi
	Integrated Circuits Design Engineering	Design Technology of High Performance Large-scale Integrated Circuits	ONODERA Hidetoshi
	Advanced Signal Processing	High-speed and High-precision Digital Signal Processing Methods	SATO Toru
Radio Atmospheric Sciences (Affiliated)	Remote Sensing Engineering	Atmospheric Measurement and Geophysical Environmental Information by Radio Waves, Light, and Acoustic Waves Using Electronic Engineering	YAMAMOTO Mamoru
	Atmospheric Observations		HASHIGUCHI Hiroyuki

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

MINATO Shin-ichi; TAKAGI Naofumi; IGARASHI Atsushi; HARADA Hiroshi; MORIKURA Masahiro; OKI Eiji; SATO Takashi; ONODERA Hidetoshi; SATO Toru; YAMAMOTO Mamoru (S); HASHIGUCHI Hiroyuki (S)

Associate Professors

LE GALL François; TAKAGI Kazuyoshi; SUENAGA Kohei; MURATA Hidekazu; MATSUMURA Takeshi; YAMAMOTO Koji; SHINKUMA Ryoichi; ISHIHARA Tohru

Senior Lecturer

HIROMOTO Masahuki

Assistant Professors

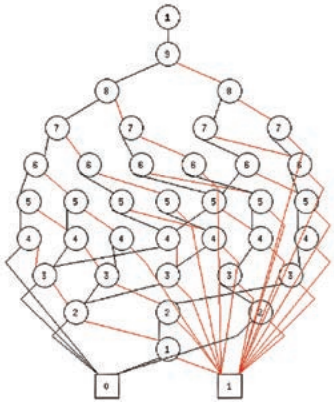
TAMAKI Suguru; TAKASE Hideki; UMATANI Seiji; MIZUTANI Keiichi; NISHIO Takayuki; SATO Takehiro; SHIOMI Jun; HASHIMOTO Taishi; FURUMOTO Jun-ichi (S); YABUKI Masanori (S)

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 and fundamental software such as logic circuits, operating systems, and programming language systems.

Logic Circuits, Algorithms and Complexity Theory

The challenge of difficult computational problems

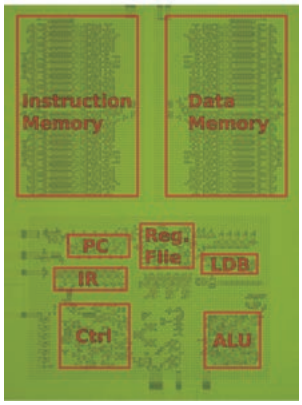


Our main education and research theme is the design of algorithms for efficiently solving problems by computer. An algorithm is a procedure for solving problems automatically on computers. Arithmetic operations can be performed using logic circuits, or if it is a high-level operation, using a program. Computing the value of pi (π) is a typical example in which computers perform well. On the other hand, scheduling problems, such as time schedules for schools or trains, are known to be computationally difficult problems for computers. We are meeting the challenge of such difficult computational problems from an algorithm engineering standpoint so as to enable computers to make increasingly significant contributions to society.

［Professor: MINATO Shin-ichi, Associate Professor: LE GALL François,
Assistant Professor: TAMAKI Suguru］

Computer Architecture

Advanced computing mechanisms and design technologies



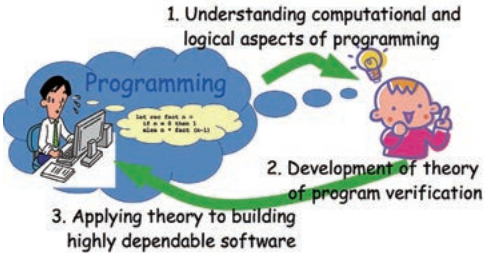
CORE e4: the world's first superconducting RSFQ stored-program microprocessor

We conduct education and research on high-speed and low-power computing mechanisms of the next generation and design technologies for them. Our research topics include arithmetic algorithms suitable for FPGA (reconfigurable hardware device) implementation, software-oriented design environment for embedded systems based on programmable SoCs, system software technologies for low-power embedded real-time systems, and, logical design and design methodologies of superconducting microprocessors/accelerators.

［Professor: TAKAGI Naofumi, Associate Professor: TAKAGI Kazuyoshi,
Assistant Professor: TAKASE Hideki］

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: IGARASHI Atsushi, Associate Professor: SUENAGA Kohei,
Assistant Professor: UMATANI Seiji］

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: HARADA Hiroshi, Associate Professor: MURATA Hidekazu, Associate Professor: MATSUMURA Takeshi,Assistant Professor: MIZUTANI Keiichi]

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.

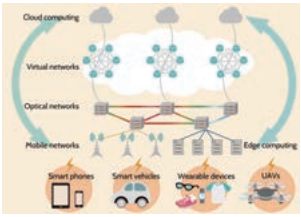
[Professor: MORIKURA Masahiro, Associate Professor: YAMAMOTO Koji, Assistant Professor: NISHIO Takayuki]

Intelligent Communication Networks

Toward ultimate form of information and commucation networks as social infrastructure

In the era of Internet of Things (IoT), big data, and artificial intelligent, evolution of information and communication networking technologies are required.
Information and communication networks connect people and things, including smart phones that collect various data, IoT devices, data centers, clouds bringing values to people, and applications. They are expected to maximize the benefits to people. This laboratory is working on the research and development of high-speed, reliable, and flexible networking technologies, with both theoretical and practical approaches, considering various aspects of social, information, devices, and energy.

[Professor: OKI Eiji, Associate Professor: SHINKUMA Ryoichi, Assistant Professor: SATO Takehiro]



Integrated Systems Engineering

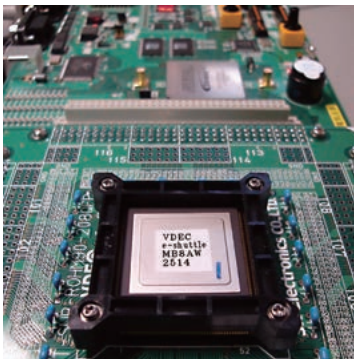
We conduct lectures and researches on high-performance, multifunctional, and highly-reliable large-scale integrated circuits and systems, which are fundamental infrastructures of future multimedia devices, computers, and communication systems. The research area includes processor architecture, algorithms 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: SATO Takashi, Senior Lecturer: HIROMOTO Masayuki]



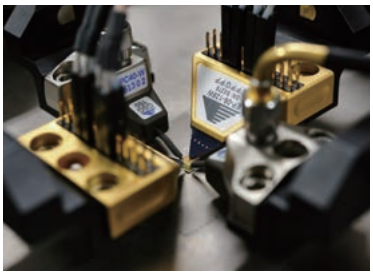
A reconfigurable LSI fabricated using 65nm process technology and its evaluation board

Integrated Circuits Design Engineering

Research on design methodology for advanced LSIs

Integrated circuits are important devices that enhance functionality, improve performance, and reduce the cost of electronic systems. Since the integration of several devices in 1959, an integrated circuit today can accommodate more than one billion devices. With this rapid growth in circuit scale, how to configure and design circuits has become a key item of concern. Furthermore, as we enter the era of nanoscale integrated circuits, we are facing many challenging issues such as performance variability and reduced manufacturability. This Group is conducting research and education regarding circuit configuration and design technologies for large scale integration and high miniaturization of LSIs; techniques for facilitating the production of highly manufacturable and reliable LSIs; and design methodology for high performance and energyefficient embedded systems.

[Professor: ONODERA Hidetoshi, Associate Professor: ISHIHARA Tohru, Assistant Professor: SHIOMI Jun]



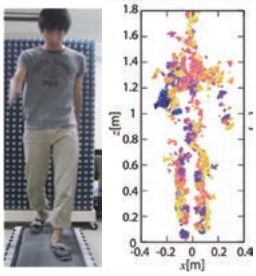
A test chip originally designed and its probing test

Advanced Signal Processing

Extracting the essence of the information in signals

The definition of desired information to be extracted from signals is subjective and dependent on its application. It is thus necessary to thoroughly understand the essence of physical phenomena and mathematical formulations. We develop innovative signal processing algorithms through unique approaches by redefining the desired information to achieve significant performance improvements. Our research covers wide range of topics including ultra wide-band radar imaging, medical ultrasound systems and atmospheric radars.

[Professor: SATO Toru, Assistant Professor: HASHIMOTO Taishi]



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

The Indonesian equatorial region is the driving source of global atmospheric circulation, as well as phenomena such as the El Niño Southern Oscillation (ENSO) in the equatorial region, both of which influence weather in Japan. We have developed a VHF-band Equatorial Atmosphere Radar (EAR), and studied atmospheric phenomena in the equatorial region based on expertise acquired from our Middle and Upper atmosphere (MU) radar observations. We have also developed a variety of radars for observing specific phenomena. Among such developed radars, the Japan Meteorological Agency adopted for its radar network (WINDAS) our small atmosphere radar specialized to observe the lower atmosphere (below 10 km). This network consists of 33 atmospheric radars and is used for weather forecasting. The scope of our research is not confined solely to the lower atmosphere, but also covers a wide area of the Earth' s middle atmosphere (10-100 km) and the ionosphere (above 100 km).

[Professor: YAMAMOTO Mamoru]

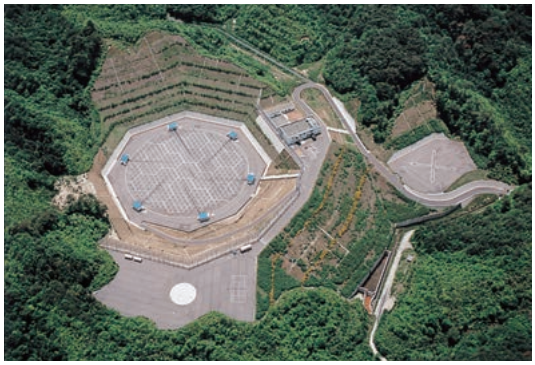
Equatorial Atmosphere Radar in West Sumatra, Indonesia. Its size is about the same as that of an MU radar.

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: HASHIGUCHI Hiroyuki,
Assistant Professor: FURUMOTO Jun-ichi,
Assistant Professor: YABUKI Masanori]



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