Advanced ICT Research Institute

National Institute of Information and Communications Technology

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2023.03

National Institute of Information and Communications Technology

MESSAGE

Director General,
Advanced ICT Research Institute

Wada Naoya, Ph.D.

"Creating and developing innovation beyond conventional concepts"

NICT has been engaged in R&D in five strategic areas characterized by five keywords: observe, connect, create, protect and pioneer. Five research institutes lead these R&D efforts. The Advanced ICT Research Institute is carrying out advanced basic research with a pioneering spirit, aiming to open up new horizons in ICT research.

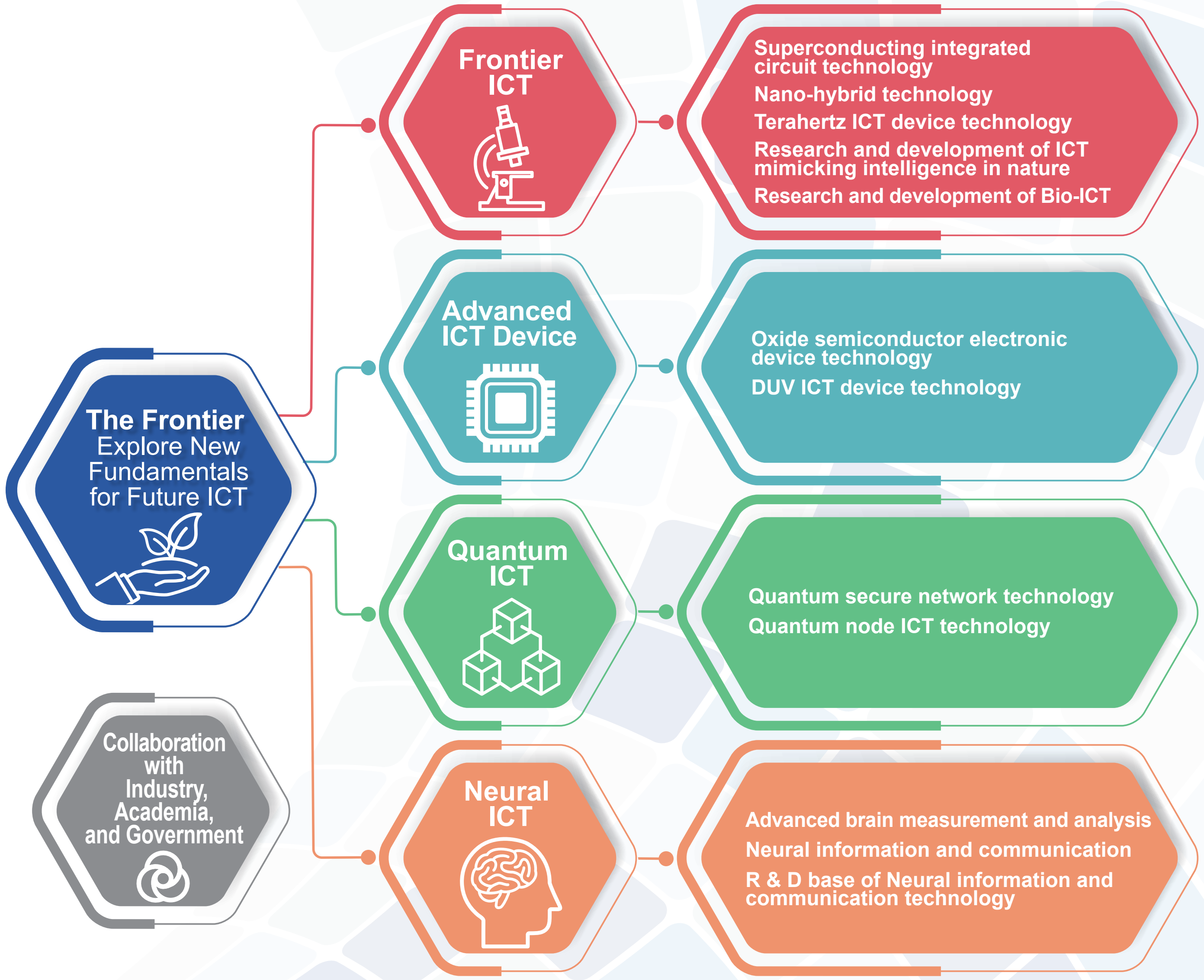
The Fifth Medium to Long-term Plan has been adopted in April 2021. Our area of R&D focus changed from frontier research to frontier science research. The term “science” is added to heighten expectations for us to make significant breakthroughs by performing cutting-edge R&D. We view ourselves as pioneers exploring the frontiers of science.

CiNet in Suita, Osaka is transferred to our institute in Kobe, Hyogo and Koganei, Tokyo. This arrangement has made the Advanced ICT Research Institute the largest research organization within NICT and has expanded our R&D capabilities.

The Advanced ICT Research Institute is working to create and develop innovation beyond conventional concepts.

Research outline of Advanced ICT Research Institute

We explore new concepts and new technologies that will produce the novel paradigms of future ICT. We also promote research collaboration between industry, academia and government.



Organization Chart of the Advanced ICT Research Institute

- Advanced ICT Research Institute (Director General)
  - General Planning Office (Kobe)
  - Kobe Frontier Research Center
    - Superconductive ICT Device Laboratory
    - Nano-scale Functional Assembly ICT Laboratory
    - Bio-ICT Laboratory
    - Neuro-ICT Laboratory
    - DUV ICT Device Laboratory
  - Koganei Frontier Research Center
    - Planning Office
    - Quantum ICT Laboratory
    - Terahertz ICT Device Laboratory
    - Green ICT Device Laboratory
  - Center for Information and Neural Networks (CiNet)
    - Planning Office
    - Brain Networks and Communication Laboratory
    - Brain Function Analysis and Imaging Laboratory
    - Neural Information Engineering Laboratory

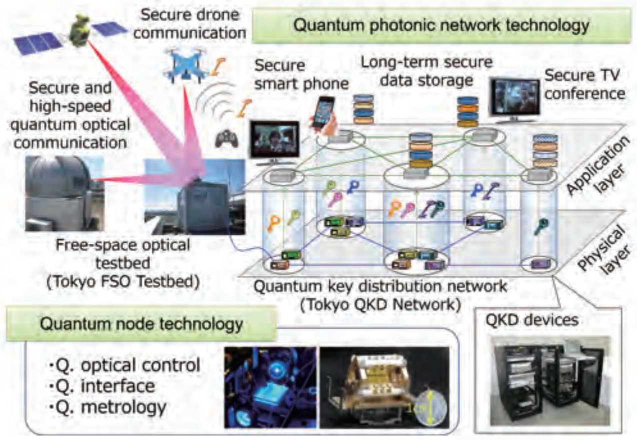
Koganei Frontier Research Center


Advanced ICT Research Institute (Koganei)

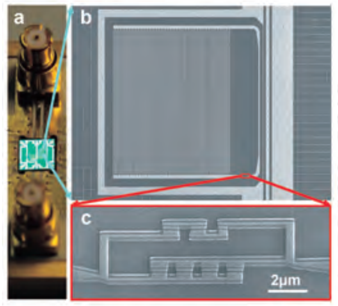
NICT started the fifth mid-term plan from 2021 to 2025. Koganei Frontier Research Center was newly installed under Advanced ICT Research Institute at the headquarters in Koganei, Tokyo. Three laboratories in the research center work on the cutting-edge science and technology as “frontiers” in the ICT field. Quantum ICT Laboratory develops a secure network with quantum key distribution by using quantum behavior of photons, and conducts fundamental research on control and measurement technologies of photons and materials based on quantum mechanics. Terahertz ICT Device Laboratory studies new semiconductor devices available at the ultra-high frequency bands, and develops wireless communication systems with the devices for broad-band communications superior to the fifth generation. Green ICT Device Laboratory pursues new-function electronic devices with high-efficiency semiconductor materials derived from gallium oxide for decreasing environmental load. Koganei Frontier Research Center will proceed the research and development on important element technologies for breakthroughs in the future communications, and will suggest new ICTs for our society first in the world.

Quantum ICT Laboratory

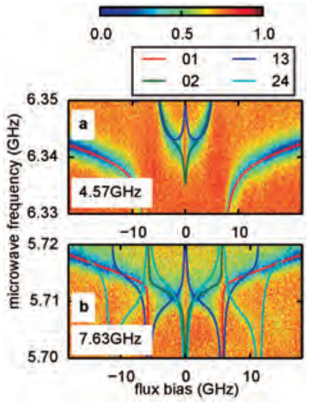
Our laboratory has two main R&D projects. One is the development of quantum photonic network technology, which includes quantum key distribution networks for realization of secure encryption in the future and free-space quantum optical communication enabling to choose the optimal balance between transmission efficiency and security for various applications. The other project involves quantum node technology and includes more fundamental research, such as investigation of quantum optical control techniques, quantum interfaces between photons and artificial atoms, and quantum metrology. These elements will eventually be integrated to develop novel functionalities in future communication network nodes. Our projects have a wide diversity, extending from new theoretical developments and proof-of-principle experiments to field trials using network testbeds. Thus, we aim to contribute to society through both fundamental science and industrial technology.



Quantum ICT Laboratory Macroscopic Quantum Physics Project



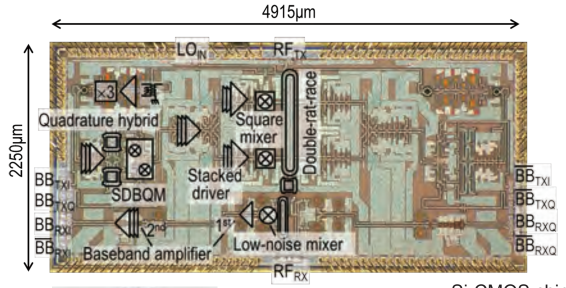
Experimental setup
a.The chip mounted on a sample holder
b.Laser microscope image of the circuit comprising a superconducting qubit and oscillator
c.A superconducting flux-qubit



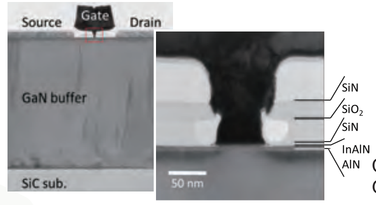
Transmission spectrum
Calculated transition frequencies are superimposed on theexperimental results. Coupling strength values are given in the panels.

We have discovered qualitatively new states of a superconducting artificial atom dressed with virtual photons. We used a micro-fabricated superconducting harmonic oscillator and an artificial atom (quantum bit: qubit), which has electronic states that follow quantum mechanics like a natural atom. We carefully designed a superconducting persistent-current qubit interacting with an LC harmonic oscillator that has a large zero-point fluctuation current via a large shared Josephson inductance (Left). Then we used spectroscopy (Right) to identify a new ground state like the stable molecular state of photons and artificial atom.

Terahertz ICT Device Laboratory Terahertz Wave Electronics Project



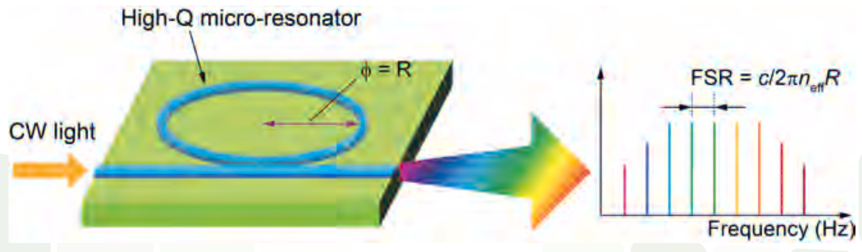
Si-CMOS chip



Cross-section of GaN-based HEMT

With the aim of developing 100-Gbps wireless communication systems using terahertz waves, the project is involved in research on electronic devices suitable for terahertz frequencies and measurement technology to evaluate such terahertz devices. We are focusing on the development of high electron mobility transistors (HEMTs) composed of several semiconductor materials. These materials include indium phosphide (InP) that shows the highest operating frequency among recent technologies, gallium nitride (GaN) that has high resistivity to voltage, heating, and radiation, and silicon germanium (SiGe) that is easy to combine with commercial silicon technologies. We are also exploring some new materials for future terahertz electron devices, such as indium antimonide (InSb) and graphene among others. With regard to research on terahertz transceivers, an early prototype of a 300-GHz 100-Gbps transmitter has been created based on a silicon integrated circuit, and we are involved in ongoing research to achieve higher performance.

Terahertz ICT Device Laboratory Terahertz Wave Photonics Project

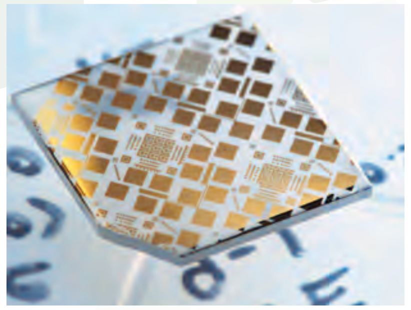


Multi-GHz optical frequency comb

The terahertz wave photonics project has the aim of developing key device technologies, such as signal sources and detectors, which are expected to be employed in 100 Gbps-class wireless communication systems and high-precision measurement systems working in the terahertz frequency and (sub-)millimeter wavelength regions. In particular, we are focusing our R&D on narrow linewidth and highly stable light sources (and on terahertz wave generation with these devices), which can be used for both high-capacity wireless communications and wideband spectrum measurement. Through our R&D activities, we hope to contribute to the realization of terahertz technologies involved in processes such as:

- Handling terahertz wave correctly (e.g. real-time processing of ultra-high-speed signals)
- Controlling terahertz waves accurately (e.g. advanced modulation for high-speed/high-capacity communication)
- Measuring terahertz waves precisely (e.g. high-precision broadband spectrum measurement up to the spurious band)

Green ICT Device Laboratory


Chip with fabricated Ga_2O_3 transistors and diodes

With the mission of realizing an energy-efficient society and promoting widespread utilization of environmentally friendly information and communication technologies (ICT), the Green ICT Device Laboratory is pioneering research and development (R&D) that targets electronic devices with new functionalities and unprecedented performance by exploiting material properties of novel oxide semiconductors.We currently focus on R&D of transistors and diodes based on a new semiconductor material-gallium oxide (Ga_2O_3). With its superior material properties, Ga_2O_3 is expected to be used to develop innovative power switching devices that can achieve large-scale energy savings by considerably reducing energy loss during power conversion. Ga_2O_3 can also be applied to harsh-environment signal processing and/or wireless communication devices that can operate at extremely high temperatures and/or in high radiation settings. An industry/academia/government consortium has been established to accelerate R&D of these promising technologies, which is expected to culminate in the commercialization of Ga_2O_3 devices and the birth of a new semiconductor industry in the near future.

Kobe Frontier Research Center

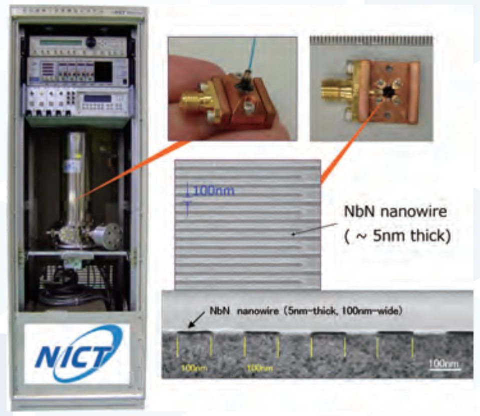
Established in 1989 as the Kansai Branch (now Advanced ICT Research Institute) of the Communications Research Laboratory (now NICT), the Kobe Frontier Research Center has been newly established under the Advanced ICT Research Institute as a unit in the field of Kobe-based research laboratories.

Our five laboratories are engaged in research on frontier ICT technologies and new ICT device technologies that create novel materials, structures and functions that lead to outstanding ICT functions, and bio-ICT technologies that elucidate and utilize biological mechanisms with a history of billions of years.

The Kobe Frontier Research Center is creating Innovative ICT research that is not an extension of existing technologies.

Superconductive ICT Device Laboratory

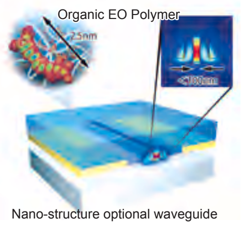
We have developed an ultrasensitive single-photon detector, a THz detector, and an integrated circuit operating at ultra-low power by using superconducting phenomena. Our unique research approach employs a niobium-nitride (NbN) superconductor, which has a higher superconducting transition temperature than the conventional niobium (Nb) superconductor, allowing higher operating temperatures and frequencies. Due to the requirement of cooling for operation of superconducting devices, we rarely see superconductors used in commercial products. However, ultrasensitive, low noise detectors based on our NbN thin films have already been employed in the ALMA radio telescope constructed in Chile with the cooperation of Japan, the EU, and the USA, and are also used in a quantum key distribution system that is expected to become a completely secure communication system in the future. We will spread information about the excellent performance of our superconducting devices and contribute to innovation by developing new applications of our superconducting technologies and promoting collaborative research with scientists in various fields.



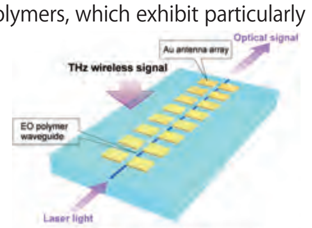
Superconducting single-photon detector(SSPD)system

Nano-scale Functional Assembly ICT Laboratory

In information and communication networks, which are the infrastructure of industry and society, high speed and large capacity are required at all scales from long-distance communication to short-distance optical interconnection. In order to increase the speed, it is necessary to use terahertz waves and light waves in wireless communication and to develop high-speed optical transmission / reception technology of over 100 Gbaud. In our laboratory, we aim to enhance the functionality and integration of light control devices by combining an organic material with excellent light control properties and nano-photonic structures using inorganic high index materials with high optical confinement functions. Also, we will research and develop basic technologies for controlling organic-inorganic interfaces and structures at the atomic and molecular levels in order to enhance the functionality of devices and develop new functions at the material level. Organic molecules exhibit large optical nonlinearity due to the resonance interaction between π electrons bound within a nanoscale single molecule and the electric field of light. Organic electro-optic (EO) polymers, which exhibit particularly large EO effects, are expected as new materials that realizes high speed and low power consumption of light control devices such as optical modulators and radio-light conversion devices that are indispensable for optical communication systems. On the other hand, silicon optical integrated circuits using mature semiconductor microfabrication technology are being put into practical use. Based on hybrid technology of organic EO polymer and silicon nanostructure, we are working on development of ultra-small optical modulators with ultra-high speed and low power consumption, light control devices such as optical phased arrays that integrate them, terahertz generators / detectors, etc.



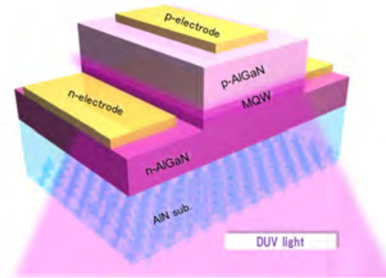
Nano-structure optional waveguide



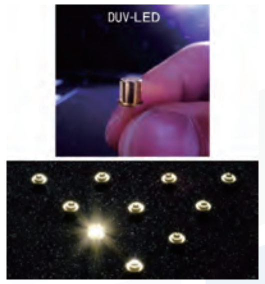
Antenna-coupled optical modulator

DUV ICT Device Laboratory

DUV ICT Device Laboratory is conducting R&D on deep-ultraviolet ICT devices with the aim of dramatically expanding the optical wavelength bands available for information and communications, as well as creating innovative optical ICT applications such as solar-blind optical communications that goes beyond the framework of existing visible and infrared optical communication technologies. Besides, we are also developing advanced technologies, including nanophotonic structure, semiconductor device, and practical technologies, to realize high-compact, environmental-friendly, and high-power deep-ultraviolet light-emitting diodes (DUV-LEDs), which can be used to create a safe, secure and sustainable society. It will also play a crucial role in the social development in the age of the New Normal with COVID-19. We have successfully demonstrated DUV-LEDs with light output power of over 520 mW (λ=265 nm), which has significantly updated the world record, and are working to further improve its performance. By taking up the challenge of breaking through the limitations of conventional DUV-LEDs, we anticipate that these advances will bring technological innovations in a wide range of fields, from information and communications to the environment, health and safety, and healthcare.



The device structure of DUV-LEDs



DUV solid-state light sources

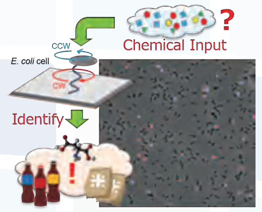
Bio-ICT Laboratory Protein Biophysics Project

The Protein Biophysics Project is conducting research and development activities that will lead to new concepts for information and communication technologies by learning from biological systems. Our research targets range from biomolecules up to the cellular network level. By measuring, analyzing, and controlling a wide range of biological materials, we are trying to understand and reproduce various biological functions. Our research activities include the following projects.

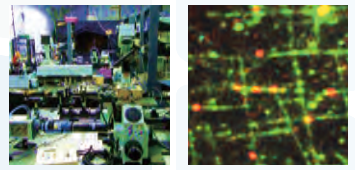
1.Reproduction of cellular and biomolecular sensing mechanisms: We are trying to reproduce the system for detecting information transmitted by chemical substances by combining the functions of living cells and machine learning techniques.

2.Research on biomolecular machines: We are analyzing the structure and functions of biomolecular machines by employing state-of-the-art technologies in order to understand how they work. We are also trying to understand the design concepts for biomolecular machines based on techniques for engineering biomolecules.

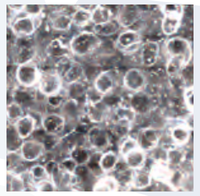
3.Research project on biomolecular systems: We are exploring the mechanisms underlying the formation of self-organized structures and their functions based on interactions among biomolecules.



Development of ChemicalBioSensor



Analysis and reconstitution of biomolecular machines



Self-organized biomolecular system

Bio-ICT Laboratory Cell Biology Project

We are exploring a new ICT paradigm based on the information and communications of living cells by carrying out investigations in the following three areas.

Development of bio-imaging technology

We are developing fluorescent microscope technology that can visualize the behavior of target molecules in living cells at ultra-high resolution to monitor information flow inside cells. Fluorescent microscopy is one of the most essential technologies for utilization of cellular ICT.

Construction of intracellular structures and control of cellular function

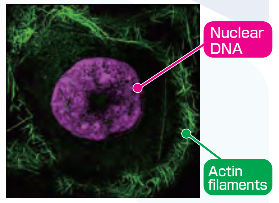
We are developing the technology to construct artificial structures in living cells that will allow us to control cellular function. Construction of functioning artificial organelles in cells will enable us to create various artificial cells that can act as sensors for specific substances, perform drugs screening, and generate various useful materials.

Analysis and application of cellular information systems

The genetic information system in cells is an excellent product of biological evolution for 3.5 billion years. We are clarifying the regulatory principles and molecular mechanisms of the genetic information system in order to create new ICT based on the cellular systems.

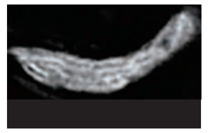
Tetrahymena
(a unicellular organism with two kinds of nuclei)

Cultured human cell



Chromosomes during sexual reproduction of *Schizosaccharomyces pombe*

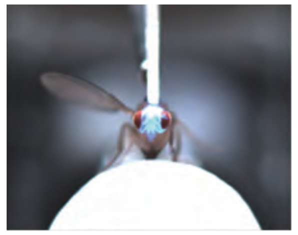
Conventional microscopy

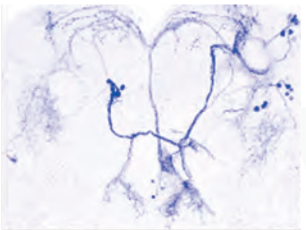


Super-resolution microscopy

Neuro-ICT Laboratory Neuro-network Evolution Project

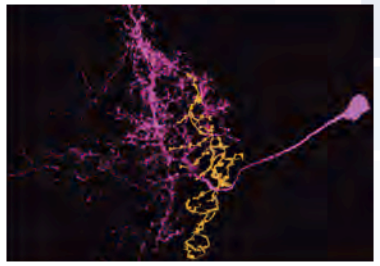
This new project launched in April 2018, aiming to unveil hitherto unexplored neural mechanisms underlying instinctive behavior of the fruit fly Drosophila, an outstanding model organism in genetic studies: the discovery of novel principles for controlling behavior will potentially pave the way to the creation of a solid substrate for innovating future ICT technologies.
Organisms are robust enough to sustain life when exposed to threat of environmental stress, yet they show highly plastic and sophisticated behavioral acts for enjoying their life under peaceful conditions. How does the simple nervous system of an insect manage these apparently contradictory requirements and find a solution for adaptive behavior? To this end, we attempt to untangle the entire neural circuit that orchestrates courtship, a behavior which is likely to be most rewarding for a fly, and to unravel the neuro-endocrine network that operates as the switch for survival vs. reproduction, representing the most challenging decision-making for a fly.

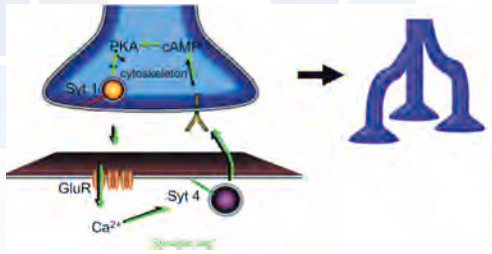

Courtship behavior was induced in a male fly upon illuminating neurons that had been engineered to be light-sensitive.


Sexually dimorphic neurons in the female brain acquired a male-like process when a male-specific protein was artificially expressed.

Neuro-ICT Laboratory Memory Neurobiology Project

The Memory Neurobiology Project is making Collaborators to establish basic mechanisms of memory using a fruit fly (Drosophila melanogaster) as a model animal, which allows us to perform genetic analysis at the single cell level. Although "memories" in computers are daily used devices, memory in our brain is not well understood because nobody has witnessed plastic processes when memories are formed. Our project involves real-time observation of memory formation on the "Feeding neuron", which commands feeding behavior of fruit flies, during Pavlovian conditioning. Through direct observation, we will study molecular and cellular mechanisms involved in memory formation. Understanding mechanisms of memory will allow us to design devices that mimic plasticity underlying memory formation. By connecting such devices, we are preparing to build circuits that may function for artificial intelligence in a similar way to that used in our brain.


"Feeding neuron",which commands feeding behavior of a fruit fly*(Drosophila melanogaster)*

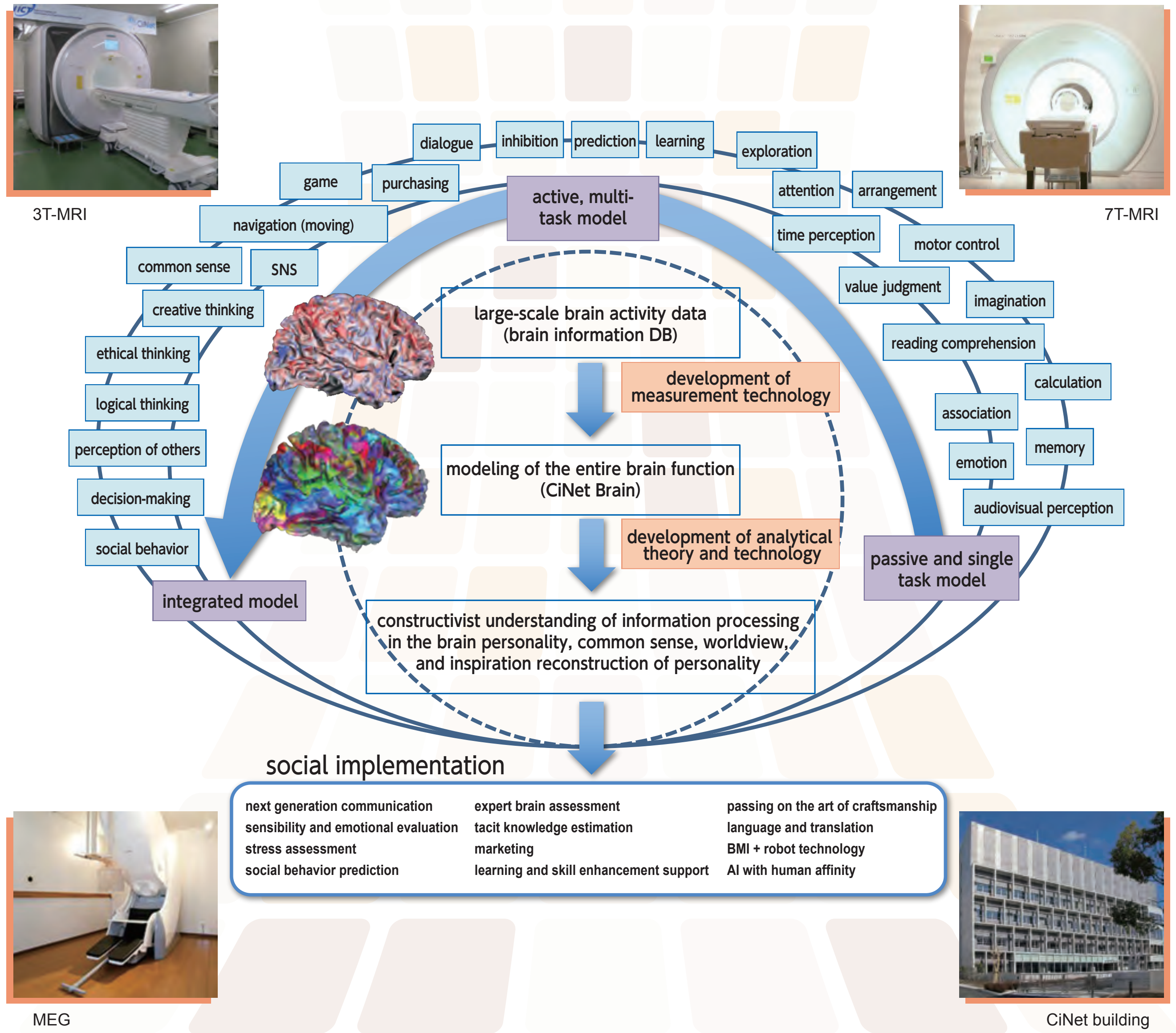


"Local feedback"hypothesis: a candidate principle of memory mechanism

Advanced ICT Research Institute
Official character

Brain Networks and Communication Laboratory
Brain Function Analysis and Imaging Laboratory
Neural Information Engineering Laboratory

The Center for Information and Neural Networks (CiNet) is a neuroscience technology research institute based in Suita City, Osaka, Japan, and aims at creating new ICT that will enable ultimate communication and the fulfillment of human potential through the collaboration of three laboratories, the Brain Networks and Communication Laboratory, the Brain Function Analysis and Imaging Laboratory, and the Neural Information Engineering Laboratory.
For this aim, we measure brain activity during various tasks using the latest functional brain imaging technology, accumulate large-scale data on brain activity, and analyze it using machine learning technology.
We believe that we will ultimately be able to reproduce how the brain understands, feels, judges, and acts upon a wide variety of input information by modeling the entire brain function. By utilizing this model, we aim to realize advanced ICT technologies such as next-generation communication, sensibility and emotion evaluation, social behavior prediction, and brain-machine interface.
The CiNet building was built in March 2013 on the Suita Campus of Osaka University, and is equipped with the latest brain function measurement machines such as 7T-MRI. In collaboration with Osaka University and many other universities, research institutes, and companies in Japan and abroad, the CiNet offers an interdisciplinary research opportunity for neuroscience, information science, bioengineering, and robotics and so on.



Fellow

Distinguished Researcher

Kazuhiro Oiwa, Ph.D.

Dr. Kazuhiro Oiwa joined the National Institute of Information and Communications Technology (NICT, former CRL) at Kobe, Japan in 1993, and he has achieved various landmark results in research on the biophysics of protein motors (biomolecular machines) using in vitro reconstitution systems and single-molecule measurements. Outstanding among his research achievements is a model of the force generation mechanism of the protein motor, dynein, which was proposed on the basis of biophysical and structural studies. His model has led to various important research projects and the results have greatly contributed to the progress of this research field. His research papers have been cited more than 400 times in leading scientific publications. As a research group leader, he has applied his knowledge and techniques to understanding the mechanical properties of protein motors and has published more than 50 papers in leading scientific journals, such as Nature and Cell. He has also applied his knowledge of protein motors to the development of nanometer-scale devices and nanometer-scale communications (also known as molecular communications) and to understanding of ensemble behavior of self-propelled particles and resultant pattern formation (tentatively named natural intelligence).After serving as the Director General of the Advanced ICT Research Institute at NICT from 2008 to 2013, he is currently a Distinguished Researcher and Fellow of NICT. He was awarded the 23rd Osaka Science Prize in 2005 and Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology in 2020.

Biography

2001-2008
Group Leader, Protein Biophysics Group, CRL, Ministry of Posts and Telecommunications
2008-2012
Director General, Advanced ICT Research Center, NICT
2013-present
Distinguished Researcher, NICT Fellow
2021-present
Associate Director General, Center for Information and Neural Networks (CiNet)

Research & Development Advisor of CiNet

Toshio Yanagida, Ph.D

Prof. Toshio Yanagida has established a technique for observing, manipulating, and measuring the dynamic properties of protein motors at the level of single molecules with extremely high spatial resolution at the nanometer level, temporal resolution at the millisecond level, and force detection at the piconewton level. Based on this research, he established the "Yuragi principle," which states that biomolecules effectively utilize thermal fluctuations for energy-saving and highly efficient energy conversion. Through molecular, cellular, and brain function measurements, he showed that this "Yuragi principle" is unique to living organisms that have acquired energy-saving, flexible, and autonomous working mechanisms at the expense of precision, and that it can be applied to all levels of biological activities driven by protein molecules. In 1998, Prof. Yanagida became a leader of the "Information and Communication Breakthrough Basic Research 21" project and led the Brain Function Group of the Advanced ICT Research Institute. Since then, Prof. Yanagida has pioneered a new research field at NICT that combines cognitive science and information science, and in 2011, he established the Center for Information and Neural Network (CiNet) and became its first director. Prof. Yanagida led this research for 11 years, bringing together talented individuals from around the world to establish a foundation for promoting integrated research on cognitive science and information and communication technology. Furthermore, under the slogan of "Omoroi research," Prof. Yanagida drew out the abilities of his researchers and produced many pioneering achievements in such fields as brain information decoding, computational social neuroscience, cognitive sensorimotor control and learning, and perceptual information processing. As indicated by his receipt of the Imperial Prize and the Japan Academy Prize and his election as a Person of Cultural Merit and a member of the Japan Academy, these original research achievements and leadership have been highly acclaimed in Japan and abroad. Prof. Yanagida became a NICT Fellow in 2022 and energetically continues his research on information processing in the brain using "Yuragi".

Biography

1988-2010
Professor, Osaka University
1998-2003
Leader, "Information and Communication Breakthrough Basic Research 21" project
2011-2022
Director General, Center for Information and Neural Networks (CiNet), NICT
2022-present
NICT Fellow

Effort

Collaboration with Industry and Academia

The Advanced ICT Research Institute promotes research & development and social application of the findings as a base of collaboration with Industry, Academia, and Government in advanced and multidisciplinary research fields.

Collaboration with Industry and Academia
Our institute and university promote research and development, as well as the exchange and develop human resources under a coordinated agreement on basic research.

Visiting the Facilities
We welcome visitors to our facilities.Various organizations may visit our institute, such as corporations, universities, high schools, and social groups.
Accepting visits to the facilities is part of our outreach activities.
In some cases, we exchange an MOU with the visiting high school.

Contribution to the Regional Community

AC・Net
Human Network for Researchers toward Advanced Telecommunications

AC・Net was established in 1990 as a place for exchange between researchers and engineers from the Kansai district working in the information and communications fields.
Since then, over 200 lectures have been given on the latest research and technology trends. AC・Net also provides the opportunity for close exchanges with Industry, Academia, and the regional community.

※AC・Net ended its activities at the end of March 2024.

NICT Open House in Kobe

Our institute holds an open house at the end of July every year. There are various hands-on exhibits which was provided by our researchers so that it can be enjoyed from children to adults.
At the same time, we hold the lecture for the public. The researcher explains their latest research results easily with familiar example.
There are a lot of visitors every year and it is an important event for get to know our activities.

Exhibitions

We have actively participated in exhibitions as a good opportunity to introduce the advanced studies of this institute.
At the same time, we publicize the results that can be introduced to society, such as intellectual property and technology transfer.
The exhibitions provide an opportunity to learn about the needs of society and a good chance for basic researchers to examine the direction of their research.

・International Nanotechnology Exhibition and Conference
・The Kobe International Industrial Fair
・Keihanna information and communications fair
・Hyogo Science Fair

Introduction of Related Departments

Advanced ICT Device LABO Network Research Institute

Background & Policy

Further development and increased sophistication of information and communication technology (ICT) is required to allow all people and things to be connected to networks, to freely utilize a large amount of content, and to lead a safe life based on access to a diverse range of information, as well as to achieve a world of abundance based on progress of sophisticated informatization. In particular, advanced and sophisticated systems are required to achieve such a world, and it is crucial to conduct research and development on areas that form the oundation･of these systems, such as state-of-the-art optical device technologies, high-frequency millimeter wave and terahertz wave technologies, convergence photonic and high-frequency technologies, and creation of new materials. Selection and concentration of topics have progressed with research and development supported by society, particularly by industry, while funding for cutting-edge research and development of challenging devices has decreased. This is primarily because funding of such research is usually based on a medium to long-term perspective and involves high risk, leading to uncertainty regarding future technological development capabilities. Against such a background, the National Institute of Information and Communications Technology (NICT) is a research organization for information and communication technology that displays a high degree of neutrality and support for the public interest. NICT considers it important to improve the framework for promoting research and development by widely promoting the newly established Advanced ICT Device Laboratory while maintaining strong collaboration with industry and academia.

We would like the Laboratory to evolve into an open research base where members of industry, academia, and the government can collaborate on research that advances the information and communications fields. In order to ensure that both domestic and international researchers can fully utilize this base, we will devise ways to continually improve maintenance and operation of the facilities and equipment on a daily basis. In order to improve access to this research and development environment, the facilities will be available to individuals outside NICT who can conduct research at NICT primarily under a joint research framework.

Outline of the Laboratory

Teams of experienced engineers and relevant internal research groups at NICT coordinate with each other to appropriately manage the facility so that users can enjoy a stable and safe work environment that meets standard requirements. Research and development at NICT encompasses the entire spectrum of ICT technologies, featuring the promotion of research on fundamental device technologies with an emphasis on the development of sophisticated information and communication systems at the Advanced ICT Device Laboratory.

Processing equipments in the clean room

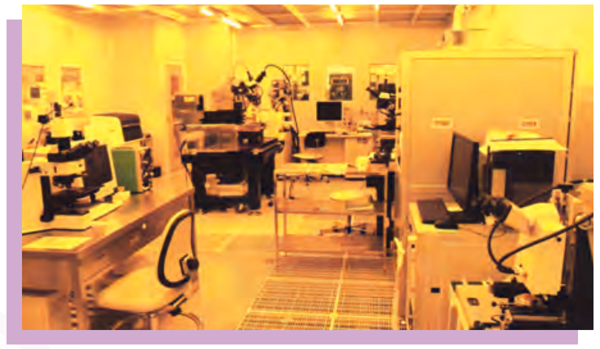


Photo-lithography equipments in the clean room with yellow lights

Advanced ICT Device Laboratory, Kobe Branch

Construction of the Clean Room at Kobe City, a new facility for promoting research and development that is operated as a unit of the integrated Clean Room facility at NICT headquarters, was completed in July 2015 and full-scale operation commenced in April 2016. The facility has class 1000 film-forming chambers, nanofabrication chambers, and class 1000 exposure chambers. It will be used to develop next-generation information and communication technologies, including a variety of devices required to create superconducting materials and organic nanomaterials as well as to evaluate the characteristics of thin films and devices. More specifically, the laboratory has a load-lock type vacuum film-forming device that is capable of fabricating devices with multiple layer structures, an atomic layer deposition device that can control film thickness at the atomic scale, an electron beam lithography system that can draw using a minimum line width of tens of nanometers, a reactive ion etcher that performs etching on the nanometer scale, and an inductively coupled plasma (ICP) etcher. The facility also has other devices that have been uniquely customized by researchers to perform specific functions. We aim to operate a world class facility that can be fully utilized to develop breakthroughs in information and communication technology.

Kobe Clean Room

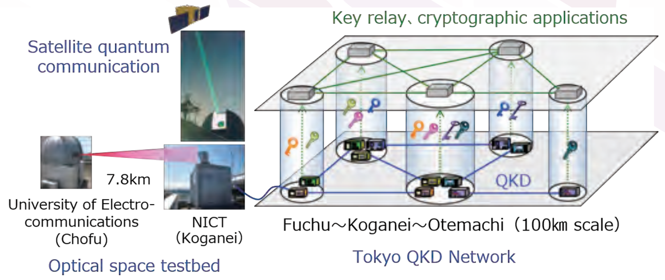
Facilities to fabricate nano-devices in the Kobe clean room

Quantum ICT Collaboration Center

The Quantum ICT Collaboration Center was established in April 2021 with the aim of advancing R & D in the areas of quantum security convergence and satellite quantum communications, as well as leading the construction of a quantum technology platform that integrates quantum computing, quantum communications and cryptography, and quantum measurement and sensing.　In cooperation with related research groups within the NICT, we will actively collaborate with other quantum innovation centers, universities, companies, and public organizations in Japan and overseas, and work on everything from basic research to technology verification, open innovation, and human resource development.

In January 2020, Integrated Innovation Strategy Promotion Council of Japan formulated Quantum Technology Innovation Strategy. This strategy aims to create a quantum innovation hub in Japan that will bring together excellent researchers and engineers from Japan and abroad, attract active investment from companies, and build an organic collaboration and cooperation system between universities and companies.

NICT has also been selected as the Quantum Security Innovation Hub, one of the eight quantum innovation hubs in Japan. The Quantum ICT Collaboration Center will serve as the core organization of the hub in NICT.



Promoting quantum technology platform by Industry-academia-government collaboration

PANDA, Remote Sensing Laboratory, Radio Propagation Research Center Radio Research Institute

The Remote Sensing Laboratory of the Radio Research Institute develops remote sensing technologies, and promotes R&D to improve the accuracy of predicting sudden atmospheric phenomena. In 2014, the Phased Array weather radar and Doppler lidar Network DAta system (PANDA) was installed on a 20-m tower in the site of the Advanced ICT Research Institute. PANDA has been developed to predict sudden torrential rain by using data fusion technology with multiple remote sensing sensors.

PANDA tower and container installed at the Advanced ICT Research Institute

Kobe substation for Japan Standard Time system, Space-Time Standards Laboratory, Electromagnetic Standards Research Center Radio Research Institute

NICT generates national frequency standards and Japan Standard Time (JST), and also disseminates them throughout Japan. While the ensemble of atomic clocks as a basis of the reference time scale for JST is operated exclusively at NICT headquarters in Tokyo, we now operate the atomic clocks also in Kobe to enhance the capability, reliability and disaster resilience of JST system. We also operate them for the study of clock ensemble system using the clocks in Tokyo, Kobe and two radio-clock stations.

Time measurement system

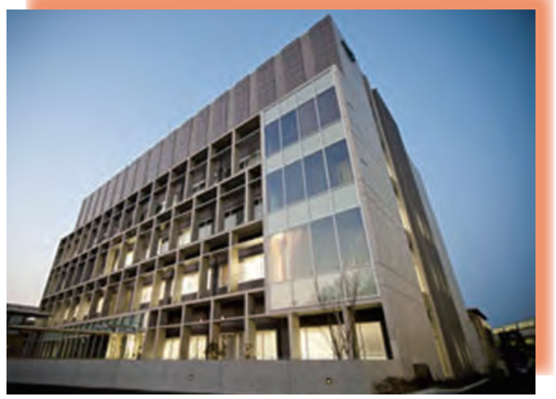
Free-Space Optical Communication System, Space Communication Systems Laboratory, Wireless Networks Research Center Network Research Institute

A small ground station was designed to perform free-space optical communications with an aircraft using near-infrared laser beams. The main part of the ground station is shown on the left of the picture, comprising the gimbal for tracking the target and the optical equipment for transmitting and receiving the laser beams. This system can track a mobile terminal installed onboard an airplane or a helicopter and can perform high-speed optical communications with data rates up to 40 Gbps.

Small Optical Ground Station

KOBE

OSAKA



TOKYO

Advanced ICT Research Institute (Kobe) Kobe Frontier Research Center

General Planning Office,Kobe Frontier Research Center
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Nano-scale Functional Assembly ICT Laboratory
Bio-ICT Laboratory
Neuro-ICT Laboratory
DUV ICT Device Laboratory
Quantum ICT Laboratory (Kobe)
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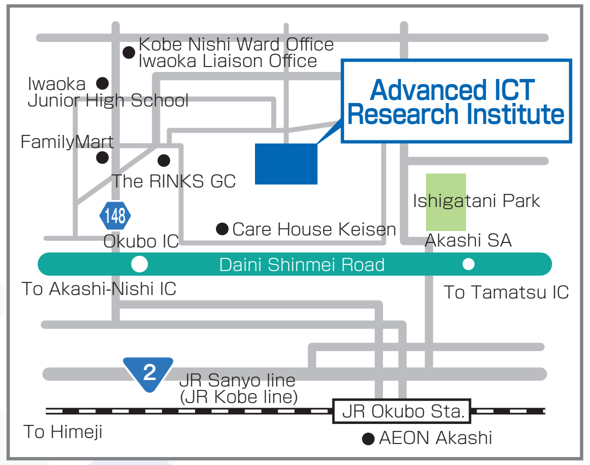

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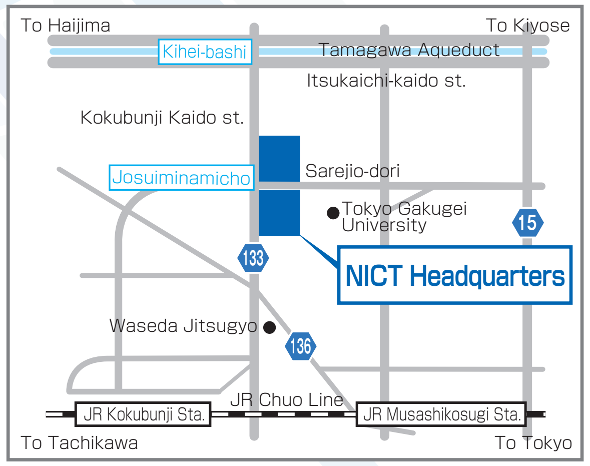

Advanced ICT Research Institute (Osaka) Center for Information and Neural Networks (CiNet)

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