Application Guidelines: Attachment

Chapter 6 Areas and Grand Challenges Targeted for Application

This chapter describes the philosophy of Program Officers (PO) for each area and the details of the Grand Challenges (GC).

The Grand Challenges are designed to invite and promote challenging research and development beyond conventional wisdom. The technical and application examples detailed in this chapter are hypothetical. The research and development proposals (R&D proposals) we seek are not limited to these examples. Therefore, when applying, please broadly consider the relationship between the research and development project (R&D project) you wish to pursue and the Grand Challenge.

Furthermore, applicants can design their own Grand Challenge (GC00) separate from GC01–GC10 Grand Challenges to create an R&D proposal.

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6.1 Implementation of the program

Program Director

SHINOHARA Hiromichi

Corporate Advisor, NIPPON TELEGRAPH AND TELEPHONE CORPORATION

Advances in information and communication technology (ICT) have not only brought convenience and efficiency to social life and economic activities; it is undeniable that they have also created new value and business in various fields as an essential infrastructure in society. The continuous development of ICT is a crucial factor in Japan's sustainable growth. Nevertheless, the rapid development of ICT has raised concerns concerning the increase in the proportion of recent research and development on ICT in terms of specific themes or themes on technological development as an extension of conventional research.

In this program, we aim to set challenging goals that will have a significant impact on society and create innovative technologies. To pave the way for a new era, we are eagerly awaiting challenges that break the conventional wisdom and push the boundaries of technology.

6.2 Areas

6.2.1 AREA 1：Mainly in the area of information and communication

Program Officer

NAKAO Akihiro

Professor, Graduate School of Engineering, The University of Tokyo

I. Scope of the area

In recent years, a “next-generation cyberinfrastructure” that will support the “cyber world” based on information and communication devices such as computers, networks, etc., has become more important for socio-economic activities and life sustenance.

Japan has been plagued by numerous natural disasters, and the disruption to information distribution becomes increasingly serious each time such disasters occur. Furthermore, it has become clear that a large-scale communications failure might lead to the collapse of Japan's social and economic activities. With this in mind, the realization that information and communications are an important lifeline for social infrastructure is growing.

If the value that the citizens expect for cyberinfrastructure is expressed as "mission-critical," meaning it is essential for mission accomplishment, and it does not tolerate obstacles or malfunctions that can affect human life, business, and organizational continuity, then it is undeniable that our cyberinfrastructure has not yet fully met the expectations of the citizens.

With this in mind, we aim to create a highly resilient cyberinfrastructure by encouraging technological innovation based on new ideas that combine communications engineering and information science. Another important initiative is human resource development in the information and communications field in Japan. Industrial policy alone is not sufficient to keep a sustainable “pool of human resources” in the information and communications industry circulating. We will strongly promote research and development of next-generation cyberinfrastructure, which is a “lifeline of humanity” and which determines the fate of nations, through industry-academia-government cooperation. We will also promote human resource development in the information and communications fields.

II. PO policy for proposal selection and R&D management

１． Policy for proposal selection

[Grand challenge design that shatters common knowledge]

Around 2010, a worldwide research and development challenge to redesign the Internet from scratch emerged. At the time, Clean Slate - the idea of erasing blackboards and redesigning information and communications infrastructure - took the world by storm. Clean Slate highlights that “successful and widely adopted technologies (e.g., the Internet!) are subject to ossification, which makes it hard to introduce new capabilities.” This research and development have birthed new academic fields such as SDN (Software Defined Networking), network virtualization, programmable networks, and software-enabled networks.

As mentioned above, CRONOS aims to challenge the conventional wisdom that has been taught in academic conferences and university lectures and encourages bold rethinking from scratch. When applying, we welcome not only the grand challenges outlined in the recruitment guidelines but also the proposers' unique grand challenges. We hope that this will serve as an opportunity to develop research and development concepts based on bold ideas.

[Expectations for an R&D proposal]

Defining the problem statement and presenting the proposed methodology constitute half of the research process, and it is not an exaggeration to say that the remaining half involves evaluating and demonstrating the usefulness of the proposal. When submitting a proposal, we ask for a clear problem statement that breaks with conventional wisdom.

Evaluators with diverse specialized knowledge and life experiences seek social values common to all humankind. We expect research proposals that embody the passionate aspirations of proposers towards technological innovations to build the backbone of future society's cyberinfrastructure, proposals that resonate with the evaluators.

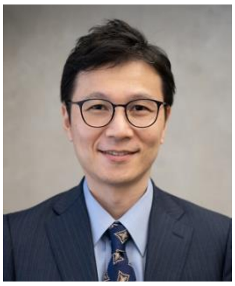
２． Policies for R&D management

The term 'Next-Generation cyberinfrastructure' encompasses two ideas. One is the fusion of communication engineering and information sciences such as machine learning and AI, leveraging large-scale computational capabilities. The other is the need for an interdisciplinary approach based on 'integrated knowledge' that takes into account the social acceptance of data and new technologies.

Improving human well-being through the realization of high-capacity, low-latency, and multi-connection communications is also important. To enrich people's lives, it is necessary to implement numerous use cases on the cyberinfrastructure and drive the economy. For example, the cyberinfrastructure can eliminate human mobility constraints and contribute to carbon neutrality through new mobility solutions that leverage the cyber world. It is important to not only focus on improving the precision of communication engineering but also consider how to contribute to society from a broader perspective.

Additionally, as all academic and business domains become increasingly globalized, the potential of any single country becomes limited. The fundamental basis of research lies in the connection between people, and having the ability for international collaboration is an essential quality for researchers who will support the future society. Therefore, in promoting research, we will incorporate the perspective of international collaboration."

6.2.2 AREA 2 : Mainly in the area of information processing



Program Officer

KAWAHARA Yoshihiro

Professor, Graduate School of Engineering, The University of Tokyo

I. Scope of the area

Information and communication technology (ICT) has become essential to modern society and daily life. Since the birth of the Internet, new paradigms have been proposed consecutively, and through intense debate in the research community and selection in the market, the technologies that comprise today's information and communications infrastructure have been selected. Many innovative ideas (i.e., TCP/IP, Wi-Fi, software-defined radio, cloud computing, P2P, Named Data Networking, sensor networks, public key cryptography, blockchain, and deep learning) have provided solutions to the grand challenges of each era. Technological innovation creates new services, and these services continue to drive the next generation of information and communication infrastructure, opening a new era as technology and applications interact with each other. We believe that it is extremely important for top researchers to make bold future predictions and propose grand challenges based on their knowledge, experience, and intuition to create this kind of cycle.

Therefore, what characteristics should a good Grand Challenge possess? Setting ambitious goals that are technically challenging to achieve is important. However, what matters more is that the challenge itself is exciting—a mountain worth climbing—that a diverse range of stakeholders can empathize with and want to work together to achieve the goal. Looking back over history, many innovative technologies initially have noticeable disadvantages; however, through long-term perspective and extensive improvement efforts, they eventually gain widespread acceptance. Rather than locking ideas away, hardware and software should be opened, shared, and used by the academic community and developers as research platforms. The construction and publication of benchmark data in the field of

AI is also an example of an effective grand challenge. In this way, the essence of a good Grand Challenge is to encourage the evolution of technology through challenges and to work together to create a better future.

II. PO policy for proposal selection and R&D management

１． Policy for proposal selection

This area focuses on information services, information processing infrastructure, information security, devices, computing methods, etc. The Application Guideline lists Grand Challenges GC01 to GC10 but is not necessarily limited to these.

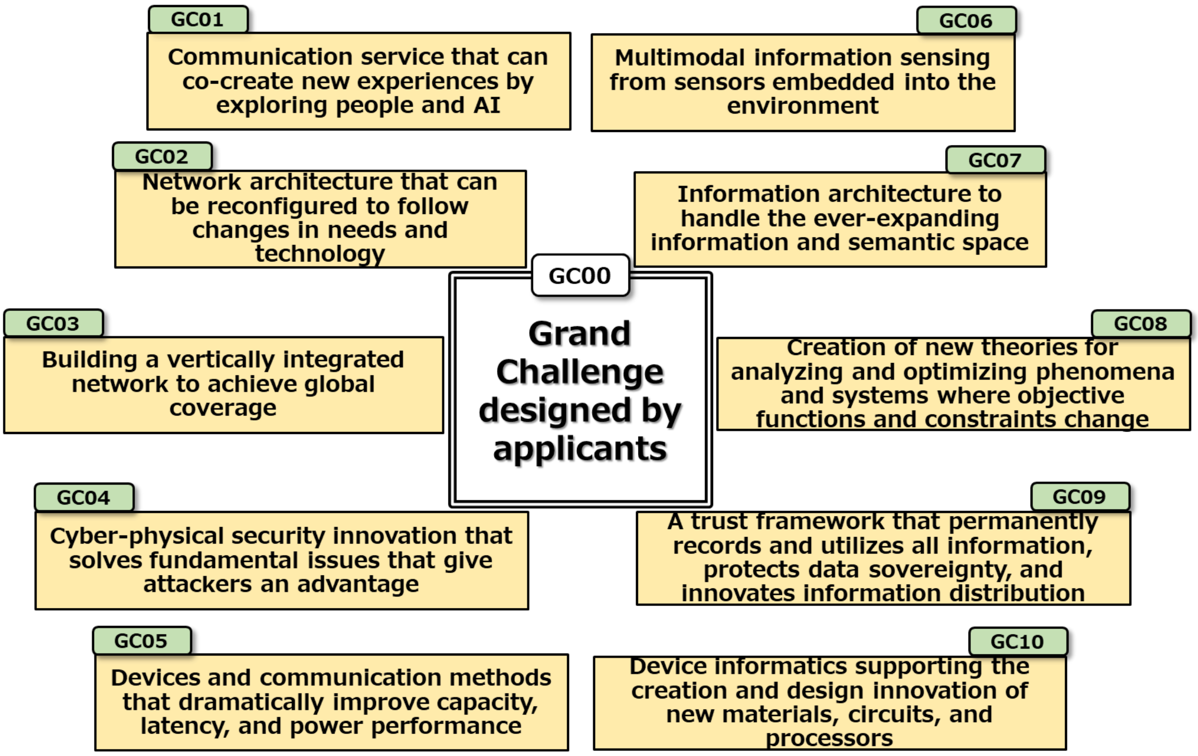
We expect proposals that clearly indicate specific applications and desired breakthroughs, maximizing the strengths of the proposing researchers. In other words, we welcome challenges that are based on new technologies, new theories, new discoveries, and are also of interest to the academic community. Please explain in an easy-to-understand manner why working on the selected challenge is important not only for the applicant personally but also for surrounding researchers and future society. Furthermore, after the research period ends, we welcome proposals that are expected to lead to smooth development that will lead to the creation of new businesses and the practical application of new technologies.

２． Policies for R&D management

In addition to Fundamental Research, you may receive additional funding to undertake Applied Research. Examples of migration research include proof of concept (POC), open sourcing, production, and distribution of software infrastructure and hardware, holding workshops, social implementation, sharing datasets, and establishing benchmarks. Please use this as an opportunity to go back and forth between research and social implementation, such as involving society, highlighting new issues, and reviewing Fundamental Research. We hope that Applied Research will be used effectively to standardize, build business models, involve, and collaborate with a wide range of stakeholders, and evaluate impact.

6.3 Grand Challenges in the 2024 application

The Grand Challenges for the FY2024 application are as follows: The Grand Challenge will be designed as something common to both areas. We also welcome proposals for Grand Challenges designed by applicants themselves.



GC00: Grand Challenge designed by applicants

In addition to GC01 to GC10 presented in this section, we also welcome R&D proposals based on Grand Challenges designed by the applicants themselves. In that case, select Grand Challenge “GC00” in the R&D Proposal Form 1. Please ensure you describe the title and outline of your Grand Challenge.

When considering this, you can also refer to the “(Appendix) Examples of "Conventional wisdom" and "Challenge" as a reference for designing your own Grand Challenge” at the end of this chapter. Please note that this list is intended as reference material based on examples for consideration; therefore, making proposals based on the contents of this list is not required.

GC01: Communication service that can co-create new experiences by exploring people and AI

[Background]

Online communication technology has made it possible to communicate free from time and space constraints. However, video and audio transmissions may not sufficiently convey the atmosphere, emotions, and intentions as in face-to-face communication. Furthermore, even in traditional face-to-face communication, differences in language, culture, and knowledge can become major barriers. In recent years, opportunities to use AI have increased; however, there are times when users are unable to understand the operating status of AI. Additionally, problems such as AI not understanding human intentions are becoming apparent. Furthermore, in the future, AI technology is expected to improve performance by allowing AI to communicate autonomously with each other. However, even in that case, problems may arise in cooperation owing to differences in knowledge structures between AIs.

Within this context, this GC will take on the challenge of creating services that augment human and AI capabilities to co-create new communication experiences.

[Technical examples] Not limited to the following, other proposals are also welcome.

- Technology that detects, conveys, and presents multimodal information regarding mood, emotions, intentions, etc.
- Technology that automatically presents information necessary for mutual understanding and automatically complements optimal communication information.
- Technology that can explain AI's intentions and status, technology that allows AI to understand human emotions and intentions
- Technology to detect and correct fake information, excessively biased information, and flaming situations
- Technology that reproduces an individual's personality and knowledge as an avatar
- Technology that supports autonomous communication between AIs and collective intelligence formation
- Technology to miniaturize devices (wireless power supply, thin client implementation, etc.), share them, and make them stealthy (direct retina projectors, directional speakers, etc.)
- Technology to obtain information directly from the brain, technology to input information directly into the brain

[Application examples] Not limited to the following, other proposals are also welcome.

- Online communication service that is more comfortable and smooth than face-to-face communication
- Services that realize communication that overcomes differences in language, culture, and knowledge
- Services that prevent communication troubles and social divisions on SNS, etc.
- Avatar AI/robot with communication skills equal to or better than humans
- Communication skills training using avatar AI and robots; conversation assistance service for elderly people living alone

GC02: Network architecture that can be reconfigured to follow changes in needs and technology

[Background]

The Internet has developed into a worldwide communication network. However, changing specifications requires a great deal of consensus-building. Flexibly revising specifications and continuously evolving technology (migration) to flexibly follow changes in needs and technology has become difficult. An example of a countermeasure to address this problem is an architectural innovation centered on virtualization technology that can multiplex a wide variety of logical networks. However, further technological innovations are expected in the future. Additionally, as network systems become larger and more complex, they are not only the cause of large-scale failures, but it is also difficult to instantly identify the causes of disconnections or deterioration of communication quality in our daily lives, and improving resilience has become an important issue. In the future, it is predicted that it will become difficult to manually grasp operating conditions in detail and recover from failures, and there will be a strong demand for automation.

Within this context, this GC will take on the challenge of creating a network architecture that can be reconfigured to follow changes in needs and technology.

[Technical examples] Not limited to the following, other proposals are also welcome.

- Technology and architecture that allow for the construction and operation of optimal networks in response to changes in needs and technology
- Virtualization technology that enables multiplexed execution of multiple logical networks
- Communication protocol conversion technology between logical networks, load arbitration technology, isolation guarantee technology
- Technology to seamlessly access resources on different logical networks
- System design theory that facilitates a detailed understanding of the situation and instant recovery
- Technology that automates the process of understanding system specifications and operating status, recovering from failures, and identifying measures to prevent failures.
- Software architecture that enables quality improvement through self-modification (automation of debugging and programming)
- Technology and architecture that can achieve both communication performance and scalability even when mixed with heterogeneous hardware.

[Application examples] Not limited to the following, other proposals are also welcome.

- Network services that best match the needs of each service and user
- Global network that balances update freedom, scalability, and security robustness
- Global real-time environmental monitoring and functionally distributed computing (disaggregated computing, split computing)
- Highly resilient networks and systems that can recover instantly, even in the event of a large-scale failure
- Network infrastructure that can be built by a small startup and scaled up by gradually adding equipment
- Services and systems that give users peace of mind by instantly and clearly presenting operational status

GC03: Building a vertically integrated network to achieve global coverage

[Background]

High-performance communications via the Internet, mobile communications, satellite communications, etc. have become possible in many areas on Earth. On the other hand, radio waves do not reach most isolated areas on land, at sea, underwater, or in space where power supply is difficult, making it difficult to communicate and understand the situation. It is expected that the use of technologies such as HAPS, underwater drones, energy harvesting, and wireless power supply will increase. In addition, it should be noted that while there are specific communication systems in place in such regions (such as low-earth orbit (LEO) satellite broadband, underwater optical/acoustic communication, IoT communication, etc.), each of these systems operates within its own closed network and has limited reach in terms of space and time. Achieving efficient and effective communication and real-time understanding of the current situation worldwide remains challenging. Furthermore, key concerns include the reduction of labor and costs associated with checking and installing submarine cables, as well as constructing and managing the vast amount of cable wiring for large-scale data centers.

Within this context, this GC will undertake the task of constructing a vertically integrated network to achieve global coverage.

[Technical examples] Not limited to the following, other proposals are also welcome.

- Technology that vertically integrates land/sea/air/space networks with different physical characteristics and frequency bands
- Wireless environment construction technology using HAPS, underwater drones, etc.
- Energy harvesting and wireless power supply technology that reduces maintenance costs for HAPS and underwater drones
- Technology for building high-performance virtual sensors by linking multiple sensors on land/sea/air/space and assimilating data
- Technology that automates optimal cable installation, modification, and removal

[Application examples] Not limited to the following, other proposals are also welcome.

- Internet covering the entire globe
- Real-time environmental monitoring across the globe
- Continuous monitoring service of social infrastructure status
- Providing on-demand communication network services to disaster areas

・ Internet redundancy (automatic switching to a space line when a landline is disconnected, etc.)

GC04: Cyber-physical security innovation that solves fundamental issues that give attackers an advantage

[Background]

Existing security technology relies on passive defensive strategies, applying multilayered defense at the system level, using probability statistics derived from historical operational data for anomaly detection and protection, and regularly updating system vulnerabilities. The fundamental problem is that it provides attackers with an overwhelming advantage. Moreover, when an attacker utilizes an anonymized pathway like Tor, it becomes very challenging to identify the source of the attack. Examples of countermeasures to address this issue include disabling connection route anonymization, constant monitoring of cyber-physical space, pre-detection of attacks, neutralizing the attacker before the attack, intelligent enhancement of security mechanisms, and active cyber defense such as more precise multi-layered defense at the application level.

Within this context, this GC will undertake the task of cyber-physical security innovation that solves fundamental issues that give attackers an advantage.

[Technical examples] Not limited to the following, other proposals are also welcome.

- Technology that constantly monitors worldwide cyber-physical space and detects the presence of attackers and the impending occurrence of attacks
- Technology to neutralize connection route anonymization systems and identify attackers
- Technology to collect information on attacker systems and neutralize them as necessary
- Technology that guides access from an attacker's system to a decoy system (honeypot) and automatically analyzes it
- An architecture in which all applications and services run on separate virtual machines managed by security mechanisms.
- Security AI technology (always grasping system operating specifications and operating status, attack detection, attack nullification, automation of security updates, etc.)

[Application examples] Not limited to the following, other proposals are also welcome.

- Active cybersecurity constellation
- Internet without anonymity
- Security mechanism optimized for each application and service
- Systems and applications that automatically generate security patches and perform autonomous security updates

GC05: Devices and communication methods that dramatically improve capacity, latency, and power performance

[Background]

To realize a society without limitations by integrating cyberspace and physical space, remotization, automation, and reducing labor costs, we require a network system that significantly enhances capacity, latency, and power efficiency. To achieve this, in addition to performance issues (high speed, large capacity, low latency, and low power consumption), reorganizing the architecture of devices and communication methods is also necessary, considering operational issues that are expected to become more serious in the future (fault tolerance and maintenance cost), using methods that include new ideas and clean-slate redesign.

Within this context, this GC will undertake the task of developing devices and communication methods that dramatically improve capacity, latency, and power performance.

[Technical examples] Not limited to the following, other proposals are also welcome.

- Low-speed but ultra-wideband optical and wireless communication devices
- Low cost and low power consumption self-position detection method, ultra-high precision time synchronization method (nsec order)
- Self-free network using beamforming devices that operate autonomously and distributedly
- Sensors, actuators, and processors that do not require power lines
- Internet architecture redesigned from a hierarchical structure to a clean slate
- New Internet architecture based on information transmission via AI
- BMI (Brain Machine Interface) technology

[Application examples] Not limited to the following, other proposals are also welcome.

- Reduction of delay time using optical circuit switched network
- Ultra-high-speed control of swarm intelligent microrobots, ultra-high-speed control of ultra-multi-axis robots
- Cloud robotics
- Disaggregated computing with ultra-precise time synchronization
- Reducing delay time and power consumption by flat redesigning the Internet layer
- Overhead-free network that minimizes retransmission control by supplementing communication errors with AI
- Direct brain-to-brain transmission of intentions and thoughts through personal BMI devices

GC06: Multimodal information sensing from sensors embedded into the environment

[Background]

The information that can be obtained from single-function sensors is limited, and there is a significant gap between this and the advanced information that users require. Building a society-wide sensor network that can constantly collect multimodal information emitted from sensors that blend into the environment is necessary to overcome this problem. Creating highly accurate and functional virtual sensors using mathematical models that integrate information from multiple sensors and deep learning is effective. Furthermore, current sensor systems have significant implementation and maintenance constraints, such as laying wiring for power supply and periodic replacement of batteries, making it difficult to construct a wide-ranging sensor network as described above. However, long-term monitoring is also expected to be realized through the application of energy harvesting and wireless power supply. Using AI to interpret multimodal information obtained from such sensor networks has the potential to contribute to the realization of healthier, more efficient lives and a sustainable society.

Within this context, this GC will undertake the task of multimodal information sensing from sensors embedded into the environment.

[Technical examples] Not limited to the following, other proposals are also welcome.

- Technology that brings maintenance constraints of various sensor systems closer to zero using energy harvesting and wireless power supply
- Data assimilation technology that integrates a large number of fragmented sensor information
- Technology for building highly accurate and highly functional virtual sensors by linking multiple small-scale sensors
- Technology that understands the information the user wants, makes optimal decisions based on multiple sensor information, and takes action.
- Technology that automates contract negotiations, etc. required for the use of various sensors
- Technology to supplement missing sensor information with AI
- Multimodal information representation and encoding technology that is highly compatible with deep learning

[Application examples] Not limited to the following, other proposals are also welcome.

- Health checkup service and life log recording service based on records of a person's entire life

- Real-time social activity monitoring and high-precision prediction using a huge number of sensors
- Digital social simulation based on local and global multi-scale information as well as services that support decision-making on national and local policies
- Cloud robotics with the ability to identify and perform complex tasks as well as skills for a wide range of non-routine tasks
- A globally distributed hyperscale deep learning model that prioritizes privacy while being executed on the Internet across the entire planet

GC07 : Information architecture to handle the ever-expanding information and semantic space

[Background]

A unified theory that defines the meaning of information has yet to be established. In the field of engineering, Shannon's definition of the amount of information is based on the scarcity of information. Nevertheless, scarcity alone is insufficient to address numerous crucial facets of information. Language, as an example, consists of information that possesses a complex semantic structure. To effectively process this, extensive language models that can evaluate vast quantities of text data must be employed. Causality is another type of information that is useful for handling hypothetical situations with different specific conditions and is being analyzed and utilized through methods such as counterfactual virtual machine learning. The amount of diverse information is always increasing at an exponential rate, as data is being generated, modified, and duplicated across many devices and applications. These approaches expand our understanding of the diverse aspects of information and its meaning and have the potential to be the beginning of a new discussion on how the essential meaning of information should be handled in infrastructure.

Within this context, this GC will undertake the task of developing an information architecture to handle the ever-expanding information and semantic space.

[Technical examples] Not limited to the following, other proposals are also welcome.

- Technology that associates all unstructured information, including social activities (who did what, when, what, and what)
- Technology for inferring causal structure based on associations between information
- Information theory that understands the meaning and value of information based on causal structure
- Zero-query search technology that automatically presents information with the desired meaning and value
- Technology that automatically generates information with new meaning and value

[Application examples] Not limited to the following, other proposals are also welcome.

- Realization of information infrastructure that understands people's intentions and conveys them efficiently
- Automatic ranking of real-world information based on meaning and value
- Zero-query search that allows you to obtain meaningful information without searching

・ Real-time marketing

・ Explainable AI

・ Generation of AI-based models related to communication, digital humans, and digital society

GC08: Creation of new theories for analyzing and optimizing phenomena and systems where objective functions and constraints change

[Background]

By employing mathematical optimization techniques, we can better grasp how to optimize situations with predetermined objective functions and constraints. Furthermore, researchers are now developing several optimization techniques, such as reinforcement learning and Bayesian optimization, to address issues in which the objective function is unknown. These methods fall under the umbrella of black-box optimization. Optimization in situations where the objective function and constraints change is being researched within the framework of online optimization. However, the foundation of its theory and technology has not yet been established. However, many real-world optimizations, epidemics, market price movements, scientific developments, human decision-making, etc. depend on historical and memory-based factors; as such, complex system phenomena involving dynamically changing objective functions and constraints must be handled. Developing theories and technologies that can optimize these is extremely important.

Within this context, this GC will undertake the task of creating a new theories for analyzing and optimizing phenomena and systems where objective functions and constraints change.

[Technical examples] Not limited to the following, other proposals are also welcome.

- Theories and methods for optimizing events and systems where objective functions and constraints dynamically change depending on history
- Theories and methods for optimizing events and systems that have contradictory objective functions and constraints
- Theories and methods for analyzing non-Markov processes where the future is not uniquely determined only by the current state
- Theories and methods for advancing and merging knowledge structures that cannot be described using existing natural language or mathematical formulas while remaining in a black box state.
- Basic theory for the structural analysis of the energy state space leading to optimization, and theories and methods for making the energy state space unimodal and converging optimization at once

[Application examples] Not limited to the following, other proposals are also welcome.

- Automatic recovery in the event of system failure and optimization of defense methods in the event of system attack

- Control technology that can optimize the balance between centralized processing and distributed processing in real time
- GPU-free AI learning model that dramatically reduces learning costs
- AI with emergent ability that exceeds the ability of humans; AI that can make decisions on your behalf
- Precise predictions of earthquakes, epidemic spread, market price movements, etc.
- Discovering a more efficient learning method for humans

GC09: A trust framework that permanently records and utilizes all information, protects data sovereignty, and innovates information distribution

[Background]

Digital rights management (DRM) is a method used to safeguard the data sovereignty of content. DRM (Digital Rights Management) involves encrypting distributed content using a specialized cloud service or application. This encryption prevents copying and imposes restrictions on the number of times the content can be used and the expiration date of its use. Nevertheless, no established mechanism exists that is capable of tracking and ensuring the secondary usage of duplicated content, whether copied in its entirety or in part. Furthermore, despite the widespread generation of digital data, no progress has been made in creating a platform that promotes the secondary usage of this data. Large amounts of data are required for AI learning, especially in recent years. However, tracing its provenance and usage status is challenging, and the only way to obtain appropriate licenses and redistribute royalties is based on contracts. The solutions include the development of technology that enables efficient management, collaboration, and use of unstructured information on all social activities (who did what, when, etc.) related to people, information, and calculations while protecting individual data sovereignty; technology that ensures compliance with appropriate secondary usage methods for all information, including copy information, and fair redistribution of copyright royalties; and technology that can accurately track the source and usage history of illegal and fake information. Furthermore, in the computing field, applications are expected to dramatically reduce calculation costs by efficiently reusing all calculation result data from the program execution process.

Within this context, this GC will undertake the task of creating a trust framework that permanently records and utilizes all information, protects data sovereignty, and revolutionizes information distribution.

[Technical examples] Not limited to the following, other proposals are also welcome.

- Device technology and information architecture that can record all information permanently, and at high speed and use it at all times
- Technology that permanently guarantees the location of data copyrights using DID (distributed identifier) technology, blockchain technology, etc.
- Technology that permanently records all information related to secondary use (including reference, reproduction, redistribution, etc.)
- Technology that guarantees compliance with secondary usage methods for all information,

including duplicated information.

- Complete version control and copy information tracking based on permanent storage of all secondary usage information
- Detection of information plagiarism, high-speed search for related information, identification of sources of fake information
- Technology that can permanently record and utilize all calculation data during the program execution process
- Technology that flexibly and reliably protects privacy rights regarding recorded information

[Application examples] Not limited to the following, other proposals are also welcome.

- Services that promote the secondary use of data
- Service that allows copyright holders to dynamically specify how data can be used for secondary purposes (including billing rules for copying, etc.)
- Service that guarantees the redistribution of copyright royalties, the tracking of copy data, and ensure compliance with secondary use methods.
- Service that identifies, tracks, and prevents fake news sources
- Information processing services that save energy by reusing past calculation data as much as possible

GC10: Device informatics supporting the creation and design innovation of new materials, circuits, and processors

[Background]

Years of expertise and technical proficiency have provided support for the design, development, and production of devices. When it comes to cutting-edge devices like optical devices, research and development procedures are often established using the extensive knowledge and expertise of experienced individuals. For example, as the characteristics of the manufacturing equipment are intricately intertwined, changing the manufacturing equipment can lead to numerous problems, such as resetting the conditions from the beginning. Therefore, the advancement of new materials, circuits, and processors necessitates the expertise of skilled individuals, extensive timeframes, and substantial financial investments. However, in recent years, automation of design, development, and manufacturing has progressed because of advances in large-scale simulation technology and machine learning-based technology for predicting unknown physical phenomena and optimizing logic circuits as computer performance improves. We are beginning to see the possibility of efficiently verifying new ideas in a brief period by simply inputting the required specifications, even without years of experience or knowledge.

Within this context, this GC will undertake the task of device informatics supporting the creation and design innovation of new materials, circuits, and processors.

[Technical examples] Not limited to the following, other proposals are also welcome.

- Technology that predicts the structure, manufacturing method, etc. of potential new materials simply by inputting the desired physical properties
- Technology that automatically predicts optimal circuit design, wiring, effective performance, etc. by simply inputting calculation principle specifications
- Technology that automatically creates firmware and verification software by simply inputting processor design specifications and circuit diagrams
- Technology that automates the setting of conditions due to changes in manufacturing equipment
- Technology to estimate the theoretical meaning of manufacturing know-how and recipes based on experience

[Application examples] Not limited to the following, other proposals are also welcome.

- Device prototyping service that delivers prototype chips and evaluation software in a short period of time and at low cost by simply inputting specifications

(Example)

- Low-speed but large-capacity optical communication devices
- Processors specializing in secure calculations
- Processors that perform advanced information processing using only size comparisons and addition/subtraction
- Processors, etc. that perform general-purpose digital processing that does not require any synchronization

(Appendix) Examples of "Conventional wisdom" and "Challenge" as a reference for designing your own Grand Challenge

***This is an example for reference and is not limited to this example.**

[Information and communication]

・Common knowledge: Routers are essential for Internet

→Challenge: Internet without a router

・Common knowledge: Standardization is essential for communication systems

→Challenge: Internet without standardization

・Common knowledge: Sharing complex information requires a lot of communication

→Challenge: Information sharing through automatic knowledge generation

・Common knowledge: Data are lost because of disaster or communication failure

→Challenge: Communication system that prevents data loss

・Common knowledge: The internet only sends and receives information

→Challenge: Internet with information processing functions

[Information science]

・Common knowledge: Advanced information processing is performed using numerical calculations

→Challenge: Advanced information processing based on pattern search

・Common knowledge: Multiplication and division are essential for highly efficient information processing.

→Challenge: Highly efficient information processing based on size comparison and addition/subtraction

・Common knowledge: Learning is based on error reduction calculations for target values

→Challenge: Learning based solely on relational memory

・Common knowledge: Knowledge is constructed by accumulating consistent basic information

→Challenge: Emergence of knowledge by reduction from infinite information including contradictions

・Common knowledge: Physical quantum entanglement is essential for quantum computation

→Challenge: Approaching quantum computing with deep learning

・Common knowledge: One type of intelligence evolves quantitatively

→Challenge: Generating new types of intelligence from the interaction of diverse intelligence structures

[System]

・Common knowledge: Decentralized systems are inefficient

→Challenge: General-purpose digital processing that does not require any synchronization

・Common knowledge: Systems have an administrator with privileges

→Challenge: A system that can only be used with user privileges

・Common knowledge: Systems only work according to the program

→Challenge: A system that understands its own specifications and operations

・Common knowledge: Security updates are performed manually

→Challenge: A system that self-modifies as appropriate

・Common knowledge: The principle of the Internet is the guarantee of anonymity

→Challenge: Internet where anonymous communication is not possible

・Common knowledge: Copied information cannot be tracked

→Challenge: Permanently track copied information

・Common knowledge: Fully automatic association of all information is dangerous

→Challenge: Correlate all information from around the world automatically

・Common knowledge: Even if you connect low-performance PCs, it will not become a supercomputer.

→Challenge: Build a supercomputer from a group of low-performance PCs

・Common knowledge: Robot control, automatic operation, etc. are performed at the edge.

→Challenge: Real-time control is realized in the cloud

・Common knowledge: Time synchronization in distributed systems has msec accuracy

→Challenge: Time synchronization with nsec accuracy in distributed systems

[Service and society]

・Common knowledge: Developing and operating huge services is expensive

→Challenge: Automatically generate and operate services on demand

・Common knowledge: It is impossible to have a society or SNS without bias

→Challenge: Visualize evidence of sources of bias

・Common knowledge: Decisions are made by people

→Challenge: AI that can make decisions