Innovation Management

Policy

NEC believes that innovation is the key to continuing to provide social value. Under the direction of its Chief Technology Officer (CTO), we have formulated a technology strategy to ensure future growth.

The pillars of this strategy rest on an aggressive use of open innovation and a concentrated investment in the areas of data science that uses NEC's strengths in artificial intelligence (AI), and ICT platforms that are necessary in dealing with large-scale, complex real-world issues. In fiscal 2018, NEC conceptualized the "Bio-IDiom," a brand to integrate its biometric authentication products as part of concentrated investments in data science. The company also enhanced "NEC the WISE," NEC's first technology brand launched in fiscal 2017.
NEC is also creating innovation valuable to both customers and society by leveraging "social value design®," an approach for creating value from a societal perspective, in pursuing co-creation with customers.

What follows is an introduction to NEC's concepts and approaches that are designed to maximize its corporate value through managing innovation in technology development, research and development, and co-creation.

Strategy

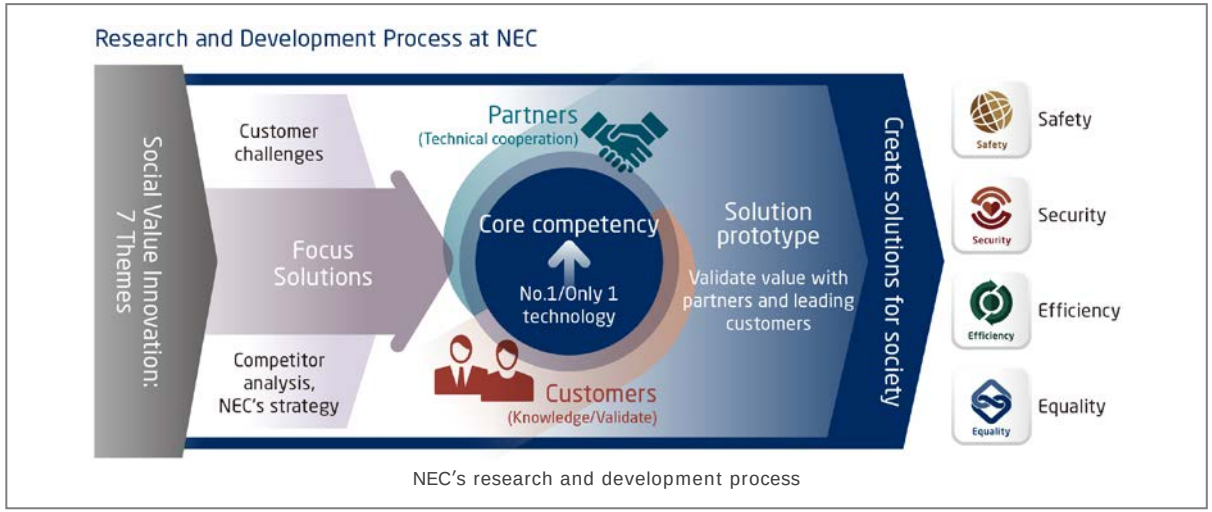
The following are the strategies for NEC's initiatives in technology development, intellectual properties, and design.

Technology Development Strategy

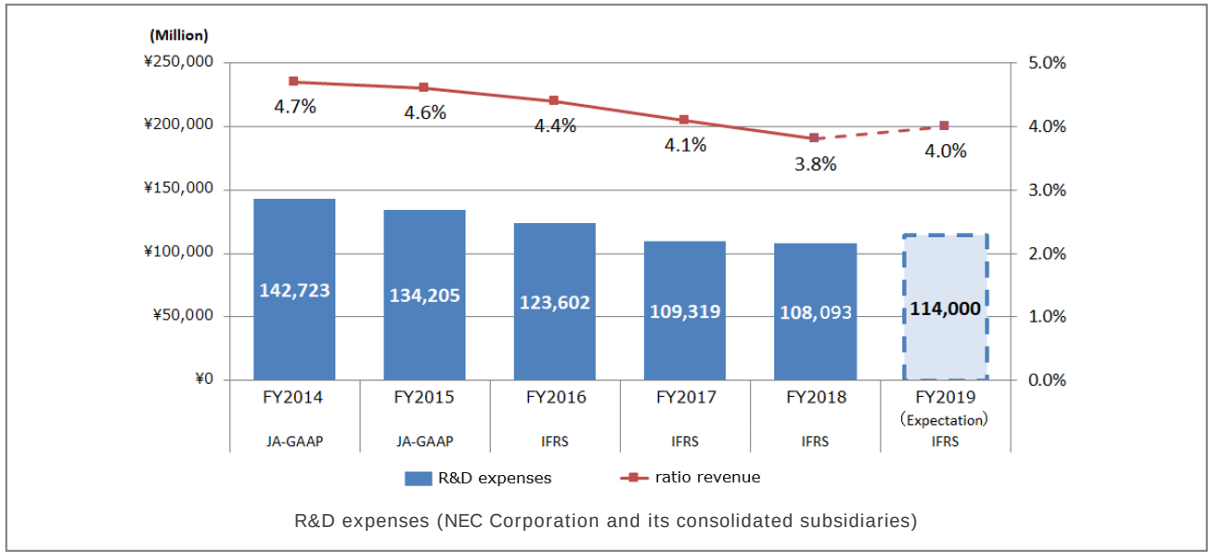
At NEC Corporation, the CTO is responsible for overall technology development, company-wide optimization of development investment, optimizing development investment company-wide, and drawing up an open innovation strategy and the formulation of open innovation strategies and process design.

R&D is a source of technological development. NEC's basic approach to R&D is to deliver value to society as quickly as possible by identifying the best solutions we should create for the social issues presented in NEC's "Seven Themes for Social Value Creation," SDGs and other guidelines, then efficiently and rapidly aligning the necessary technology assets to realize them. These technology assets include NEC's No.1/Only 1 core technologies that have been refined to a high level based on technology trends, as well as technologies produced through open innovation.

We have set our investment in R&D at around 4% of revenues. To ensure that these investments are used effectively and efficiently, we are investing also in collaborations with external research organizations, in addition to concentrated investments in the key business areas. In fiscal 2018, our R&D expenses was 108.1 billions of yen, which was 3.8% of revenues. Although the ratio against revenue has decreased due to increase in sales, we have set aside the same amount of R&D expenses as with last fiscal year.



NEC's research and development process



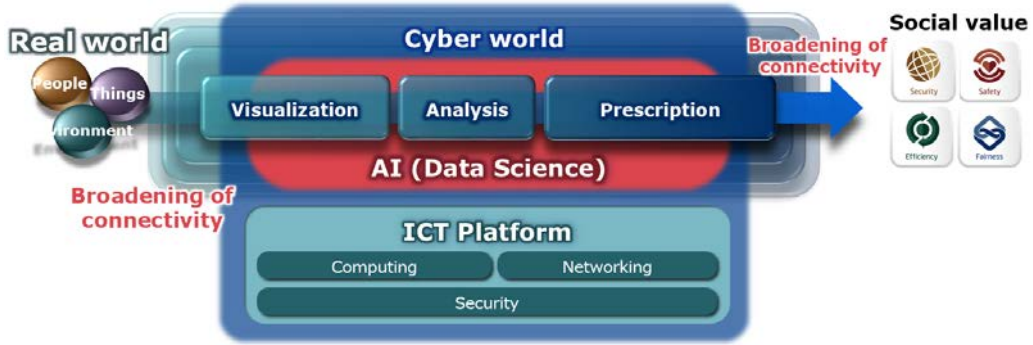
R&D expenses (NEC Corporation and its consolidated subsidiaries)

Concentrated Investment in Strong Technology Areas

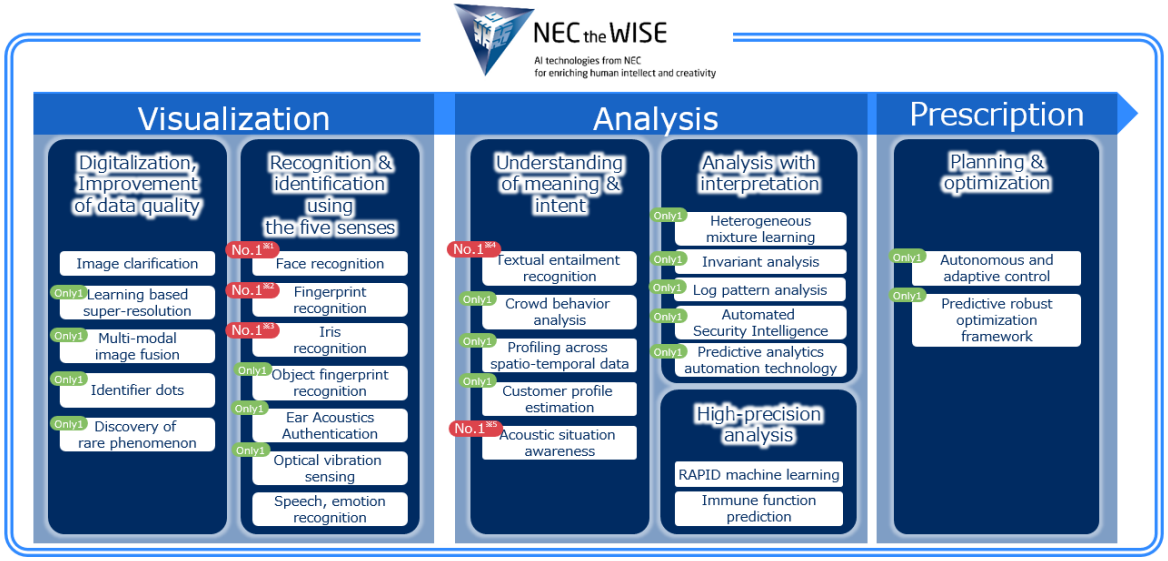
We are concentrating investment in two areas of technology: (1) data science that is artificial intelligence (AI) technologies to create new value from big data, and (2) ICT platforms that are needed to address large-scale and complex real-world issues. NEC Corporation has many unique and competitive technology assets in these two areas, and we believe that continuously building strength in these areas will improve our competitive edge in delivering solutions for society.

In the areas of data science, we are developing AI technologies that contribute to the creation of new values by carrying out “visualization” “analysis” and “control/guidance” for the real world. In the areas of ICT platforms, we are developing computing and network technologies that can adapt dynamically and in real-time to changes in the real world, and security technologies that allow social systems to operate securely and stably.

As part of the concentrated investment in strong technology areas, we launched “NEC the WISE” in fiscal 2017 as a leading edge AI technology brand. For fiscal 2018, we continued our selection of technologies to be included in the brand, and clearly systematized the issues targeted by the technologies. “The WISE” refers to “wise people.” Social issues have become quite complex and they are in so many areas. It is not practical to address all these issues through one universal AI technology. “NEC the WISE” expresses our determination to address the foremost and complex social issues by combining the many AI technologies of which NEC is proud.



Contributing to the creation of solutions for society in the areas of data science and platforms that are driven by AI technology

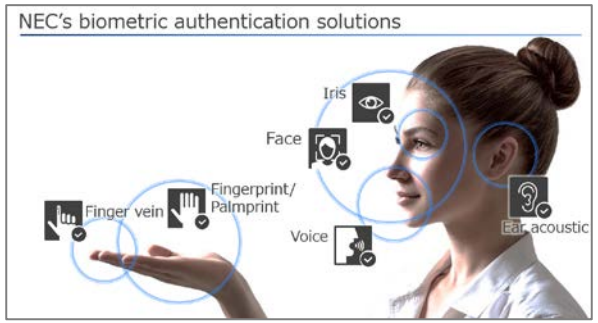


*1: Ranked 1st four consecutive times in task assessment sponsored by NIST
*2: Ranked 1st eight times in task assessment sponsored by NIST
*3: Ranked 1st in task assessment sponsored by NIST (2018) *4: Ranked 1st in task assessment sponsored by NIST (2012)
*5: Ranked 1st in task assessment sponsored by IEEE AASP Challenge DCASE2016

NEC’s No. 1/Only 1 core technologies for social value creation

In April 2018, we launched the “Bio-IDiom,” as a comprehensive brand for our biometric authentication products covering six biometric authentication technologies for face, iris, fingerprint and palmprint, finger vein, voice, and ear acoustic. One of NEC’s strengths is in multimodal authentication, which combines multiple biometric authentication technologies to achieve higher accuracy. Also, we take pride in our ability to provide completely new social values and user experiences by combining another strength of NEC, for example, our video analytic technologies such as “crowd behavior analysis” and “remote gaze detection,” with these biometric authentication technologies.

Our biometric authentication technologies, which are a product of more than 40 years of research and development, are world-class technologies that we will continue to leverage and concentrate our investments in to further contribute to society.



Promoting Open Innovation

We will also continue our open innovation initiatives in cooperation with other research organizations to develop technologies needed for value amplification. Approaches to open innovation include collaborations, acquisitions, spin-offs, the use of open source solutions, licensing, and investments to start-ups or venture capitals.

NEC Corporation and wide-ranging tie-ups with other entities include national cooperation projects and collaborations with municipal governments. In the use of open-source solutions, we make use of already standardized tools and are actively involved in standardization activities mainly through academic conferences. Also, we conduct licensing aimed at wider use of tools and software.

NEC Corporation promotes the creation of solutions through the proper combination of these open innovation approaches, in addition to refining our own core technologies.

Intellectual Property Strategy

At NEC Corporation, because intellectual property is regarded as an essential business resource supporting our group’s competitiveness and stability, as well as for contributing to co-creation with our customers, we strive to strengthen and protect not only our patents and know-how but also the designs and trademarks that support our global brand.

To create and develop social value, we are not only building IP-based barriers to entry and securing competitive advantage, but also building and using our IP portfolio to strengthen and protect collaborations with customers and partners.

We have applied trademarks globally for “Bio-IDiom,” the newly launched brand for our biometric authentication technologies.

NEC owns some 51,000 patents worldwide including approximately 22,000 Japanese patents as of March 2018.

“Social Value Design®” Strategy

To create new social value, we need to illustrate what society should be in the future, for example, by creating a city vision from the corporate, government, and community points of view. To address these needs, it is imperative to find ways to increase the value of systems and services from a societal perspective in addition to individual points of view. NEC has embedded this way of thinking based on “Social Value Design” into the planning and development of new products and services and is thereby creating innovation.

Social Value Design is NEC’s design policy aimed at providing “innovation” to customer’s business and to the future society by creating value from two points of view, namely, “user experience,” which is aimed at improving the value of human experience, and “social experience,” which is aimed at achieving the vision for what society should become.

For example, for solutions that solve a variety of problems at airports, we strive to create social value for airports by employing Social Value Design from a higher perspective than “what the airport should be originally.” We have so far designed a flight information system that allows airport users to obtain accurate and easy-to-understand information and display installations and guidance signs that take into consideration user movements and thus allow users to easily reach their destinations.

Promotion Framework

NEC has created a Chief Technology Officer (CTO) position to establish a company-wide perspective in our effort to optimize development investment company-wide, and link our corporate strategy with the planning of collaboration strategies with others. The CTO also organizes our technology roadmaps and portfolios towards focused investment in our technological strengths, and promotes the timely introduction of technology through open innovation.

Technology Strategy Committee / CTO Council

In the business of creating new value and the innovation of technology, the President, Chief Officers, and Executive Officers supervising the Business Units share the corporate culture that NEC needs to nurture via open discussions in regular information-sharing meeting and at events such as executive retreats. At the Technology Strategy Committee chaired by the CTO, decisions are made regarding the planning and execution of technology strategies that contribute to NEC Corporation's management strategy and business strategy.

As a subordinate organization, the CTO Council chaired by the CTO is convened once a month. At the CTO Council, Senior Vice Presidents in charge of the Business Units and the General Managers of the Central Research Laboratories and the Intellectual Property Management Division raise issues relating to technology strategies for NEC Corporation's key business areas and company-wide technology strategies, discuss how these issues can be addressed, and formulate plans for resolving these issues.

Corporate Technology Division: Promoting the Innovation of Technologies

In order to strongly drive the innovation of technologies forward and promote growth across the different Business Units, we have established the Corporate Technology Division as an independent organization apart from the Business Innovation Integration Unit, and clarified its commitments to management. It will continue to work with the CTO in collaboration with the Senior Vice Presidents in charge of the Business Units and the General Managers of the Central Research Laboratories and the Intellectual Property Management Division to formulate NEC Corporation's technology strategies and implementation plans, including strategies for open innovation, standardization, and regulation.

Standardization Promotion Department: Contributing to Market Creation and Expansion

The Standardization Promotion Department, which is under the Corporate Technology Division, is involved in strategic standardization activities, such as building business ecosystems, expanding business opportunities, and utilizing standardization-related patents needed for strengthening business. Also, realizing that participation in standardization activities contribute to the creation and growth of markets and to the stable provision of products and services, we also promote standardization by heading standardization bodies within and outside Japan.

Business Innovation Unit: Driving Business Innovation Forward

The Business Innovation Unit, which reorganized and took on a new name from the Business Innovation Integration Unit in April 2018, promotes the transformation into new business models that transcend existing business frameworks and the development of business from NEC's core technologies.

The Unit is involved in formulating business hypotheses based on NEC's core technologies, on social issues, and on market opportunities, and in carrying out business exploration functions for verifying values via open innovation and ecosystems, as well as business development functions that follow business hypothesis testing. In addition, it also carries out business implementation, which is a function aimed at the materialization of new business models and sustaining business growth. For business implementation, we not only establish business within NEC, but also promote business incubation through various schemes that include spin-outs and carve-outs.

Intellectual Property Management Division: Strengthening NEC's Intellectual Property Capability

In anticipation of future global business expansion, the Intellectual Property Management Division is focusing on the construction of an IP portfolio that is at par with global leaders. To this end, we have established intellectual property centers in North America, Europe, and China to carry out global intellectual property activities. Moreover, for our solutions for society business, we are implementing strategic patent projects across the entire NEC Group to acquire strong patents and patents that can be leveraged to our advantage, and promoting the establishment of a comprehensive IP portfolio centered on those patents to encompass all our businesses. In terms of strengthening and protecting our global brand, we are ensuring the proper communication of our corporate brand statement and the protection of rights.

NEC Brand Statement: "Orchestrating a brighter world"

Central Research Laboratories: Aiming to Create Value

As "Value Creation Research Laboratories," the Central Research Laboratories take the lead in driving technology innovation based on strategies developed by the Technology Strategy Committee. Armed with our strong technological capability and through co-creation with our customers, the Central Research Laboratories produces solution prototypes that contribute to social value creation and drives the growth of NEC forward.

We are also collaborating with world-leading research organizations and universities to study technologies that have potential to become key business areas in the next generation by back casting from the technologies envisioned for the future.

Examples of these initiatives include our open innovation activities through the "NEC Brain Inspired Computing Cooperative Research Center" launched in 2016 with Osaka University, the "NEC-AIST AI Cooperative Research Laboratory" established within the AIST Artificial Intelligence Research Center (AIRC), and the "RIKEN AIP-NEC Collaboration Center."

Another example is our research on AI carried out based on the NEC/University of Tokyo Strategic Partnership Agreement for Future AI Research and Education, concluded with the University of Tokyo in 2016 to execute a comprehensive co-creation initiative that includes ethics, legal systems, development of human resources for advanced basic research and implementation of those initiatives in society.

NEC Brain Inspired Computing Cooperative Research Center

The NEC Brain Inspired Computing Cooperative Research Center was established in 2016 at Osaka University for use in interdisciplinary courses, and is aimed at promoting platform research activities. Through these courses, we are conducting joint research into "brain-inspired computing"—a new information processing technique that involves studying the brain's characteristics, including its superior environmental adaptability, cognitive ability, reasoning ability, and highly efficient electrical power consumption.

We have also strengthened our ties with the Center for Information and Neural Networks (CiNet) and the RIKEN Quantitative Biology Center (QBiC) to provide a base for industrial innovation in the use of computational neuroscience to create a new telecommunications industry.

- NEC and Osaka University Jointly Establish a Research Institute for the Development of Brain-Inspired Computing Technology (Press Release)

NEC-AIST AI Cooperative Research Laboratory and RIKEN AIP-NEC Collaboration Center

In 2016, the NEC-AIST Artificial Intelligence Collaborative Research Laboratory was launched as an organization to research AI within the National Institute of Advanced Industrial Science and Technology (AIST).

Through this laboratory, we conduct research on decision-making under unknown conditions and insufficient past data, such as in dealing with disasters, abnormal situations, and other rare events, or in designing new products and new services.

We combine the laboratory's simulation technologies with the world's top-class AI-related technologies, such as machine learning, prediction/sign-detection, optimal planning, and control, which have been nurtured by NEC Corporation since the 1980s. In other words, we combine simulation and AI to carry out R&D and industrial applications of technology that facilitate decision-making even in situations where it is difficult to gather enough of the prior data needed for analysis.

Also, the RIKEN AIP-NEC Collaboration Center established in 2017 combines RIKEN AIP's knowhow on cutting technologies in the field of AI with NEC Corporation's experience in developing AI-related technologies to bring about innovations needed for dealing with critical social issues.

NEC/University of Tokyo Strategic Partnership Agreement for Future AI Research and Education

The NEC/University of Tokyo Strategic Partnership Agreement for Future AI Research and Education was concluded in 2016. It focuses on sharing a vision and issues relating to executing advanced basic research and applying research results to society under the inter-organizational agreement, validation of social receptivity after the results have been applied, and promotion of comprehensive collaboration initiatives including the training of future leaders.

Specifically the agreement advocates the following:

1) Research and development of "Brain Morphic AI Technology," which realizes an information processing system that simulates the brain and nervous systems, by assembling the world's top researchers under the leadership of Professor Kazuyuki Aihara of the Institute of Industrial Science, The University of Tokyo.

2) Research on laws, guidelines, social consensus, ethics, etc., to integrate social rules and human sensations, in view of the widespread uptake of solutions using AI throughout society.

3) Establishment of the new "NEC/University of Tokyo Future AI Scholarship" that is designed to nurture doctoral program students who are researching AI at the University of Tokyo.

As part of these initiatives, in fiscal 2018, we conducted basic research on information processing systems modeled after the brain and the nervous system.

- NEC and the University of Tokyo embark on industry-academia alliance for strengthening innovation (Press Release)

Overseas Research Laboratories: Aiming to Create Global Social Values

To carry out social value creation on a global scale, we are promoting R&D that takes advantage of the local strengths of each area by placing R&D centers at five locations worldwide, namely, in Japan, North America, Europe, China, and Singapore. Further, as part of our open innovation strategy, we collaborate with the world's top universities and research organizations and promote co-creation activities with local customers to reinforce our technologies from the solutions perspective and establish competitive advantage over other companies. The characteristics of each laboratory are described below:

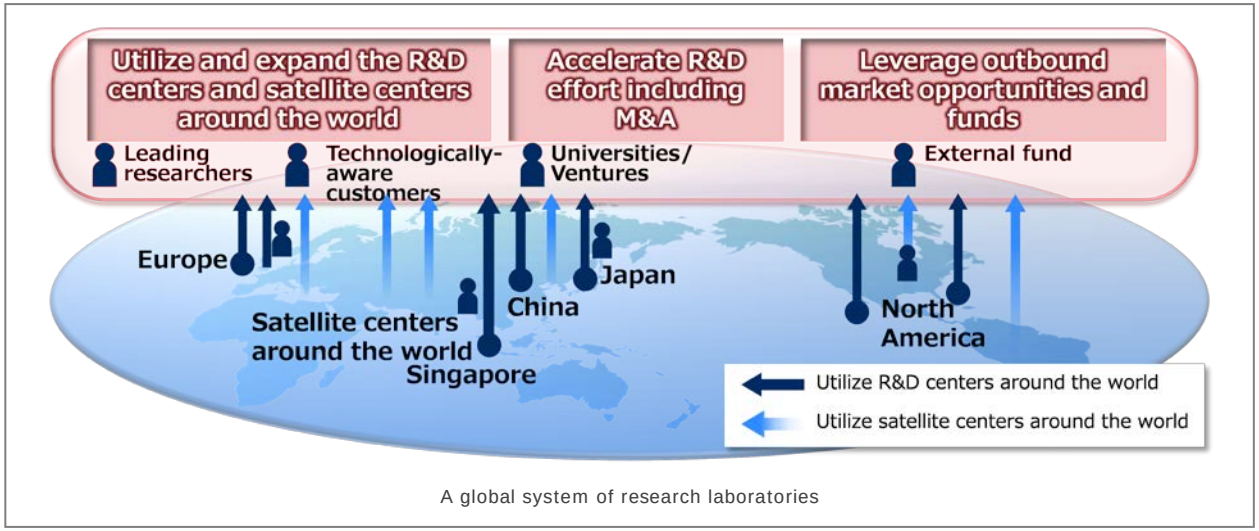
NEC Laboratories America

At Princeton on the East Coast and Cupertino in Silicon Valley on the West Coast, NEC Labs America is creating many core technologies while strengthening our ties with local universities and research organizations. In particular, we are working on the R&D of analysis and security technologies of complex systems, cutting-edge network and sensing technologies, system solution technologies for surveillance, and media analytics and machine learning technologies.

NEC Laboratories Europe

NEC Labs Europe is engaged in advanced research on solutions for society and ICT platforms that incorporate trends not only in Europe but also around the world. Located in the central part of Heidelberg, the birthplace of Germany's oldest university, NEC Labs Europe also promotes collaboration with nearby universities and research institutions, as well as with enterprises in the communications, ICT, and automobile industries. Through these initiatives, we drive the realization of next-generation AI and IoT platforms and communication networks that underpin smart, safe, and secure transportation and industries.

Moreover, we also actively participate in national projects in Europe and in standardization activities mainly in the field of networks, and promote R&D marketing as well.



A global system of research laboratories

NEC Laboratories China

NEC Labs China is engaged in cutting-edge research aimed at the creation of solutions for society by focusing on AI and 5G technologies and standardization.

Located in Beijing, the most innovative city in China, NEC Labs China conducts R&D of technologies while pursuing close collaborations with top local universities, standardization organizations, and industry partners in transportation and retail.

NEC Laboratories Singapore

NEC Labs Singapore is building flexible joint research frameworks with local governments, research organizations, universities, and customers, while actively participating in projects aimed at solving urban problems and promoting the creation of new solutions using NEC's unique cutting-edge technologies. NEC Labs Singapore is particularly active in the fields of safety, security, public transportation, and healthcare. Solutions created here are being deployed in ASEAN countries, South America, Africa, and other emerging countries where there is a particularly strong need for advanced social infrastructure.

We have also opened an Advanced Centre for Experimentation (ACE) as a "living lab" for proof-of-concepts of advanced and innovative solutions. The Centre will partner with government and enterprises to co-create solutions and conduct trials in an environment approximating the real society to verify their usefulness before deployment.

Human Resource Development to Support Innovation

NEC is focusing on cultivating human resources to create solutions for society businesses, as well as to strengthen our core technologies, for the creation of innovations. In addition to reinforcing our global human resources, we are also promoting the nurturing of business minds and the diversification of our human resources.

Human Resource Development Aimed at the Creation of Solutions for Society Businesses

To create solutions for society businesses, we need to cultivate and strengthen researchers who not only have specific core technology expertise, but also possess broad and diverse domain knowledge as well as a business mind. To broaden our scope on the creation of new value, we are working on strengthening the development of global human resources, bolstering efforts to hire domain specialists, and developing leaders who are equipped with the business acumen to drive business forward.

Aiming to strengthen our human resources tasked with tackling advanced global issues, we are implementing measures to raise the number of researchers with global business experience to 70% by fiscal 2019.

In the creation of solutions for society businesses, it is also necessary to have not only specialist knowledge of specific technologies, but also wide-ranging knowledge of the social issue domains into where these technologies will be provided as value to society. Thus, we are also strengthening our mid-career recruitment programs.

We are also endeavoring to accelerate the realization of solutions for society businesses by strengthening the ability of our in-house human resources to promote business development through the exchange of personnel between our business and research divisions. In particular, we are reinforcing the training of human resources by top engineers and nurturing project leaders and technology architects through personnel exchange in order to strengthen business development capability for our No. 1/Only 1 AI technologies and security technologies.

Human Resource Development Aimed at Strengthening Core Technologies and Enhancing Diversity

At NEC, we are working towards enhancing diversity and concentrating our human resources to our key business areas, in order to strengthen the core technologies that contribute to solutions for society, as well as to sustain these technologies and solutions into the future.

To reinforce our researchers in the key areas, we plan to increase the number of data science researchers at the Central Research Labs to 300 by fiscal 2019, which is double the number in fiscal 2016.

Our overseas research laboratories are actively recruiting top local talent while our research labs in Japan are stepping up recruitment of doctoral degree holders. We are continuing with our policy of hiring applicants with PhDs at around 50% of new hires, and will be recruiting more graduates from the Indian Institute of Technology and other notable institutions. As a result of these policies, 40% of our new recruits are now classified as “global human resources.”
We are also instituting organizational reforms that will facilitate major innovations by engaging in multi-faceted and mutually respectful discussions with specialists in a wide range of fields, regardless of their gender or nationality.
For example, for Japanese researchers, we are promoting a shift from domestic human resources to global human resources by using training programs inside and outside NEC, such as work-study programs and overseas trainings in emerging countries in cooperation with NPOs.

To promote diversity in specialist fields, we are strengthening recruitment not only in information science but also in the physical sciences, which provide excellent training in the proper handling of data. Likewise, we are also strengthening recruitment of diverse talents in the humanities, law, and other fields to realize solutions to issues based on the cooperation between humans and AI.

Major Activities and Results for Fiscal 2018

Major Research Achievements for No. 1/Only 1 Technologies

In fiscal 2018, we are continuing to apply our No. 1/ Only 1 technology to business that contributes to the realization of the "Seven Themes for Social Value Creation." Our major business achievements are shown below:

Development of the World's Fastest Blockchain Technology That Allows a Throughput of 100,000 Transactions Per Second

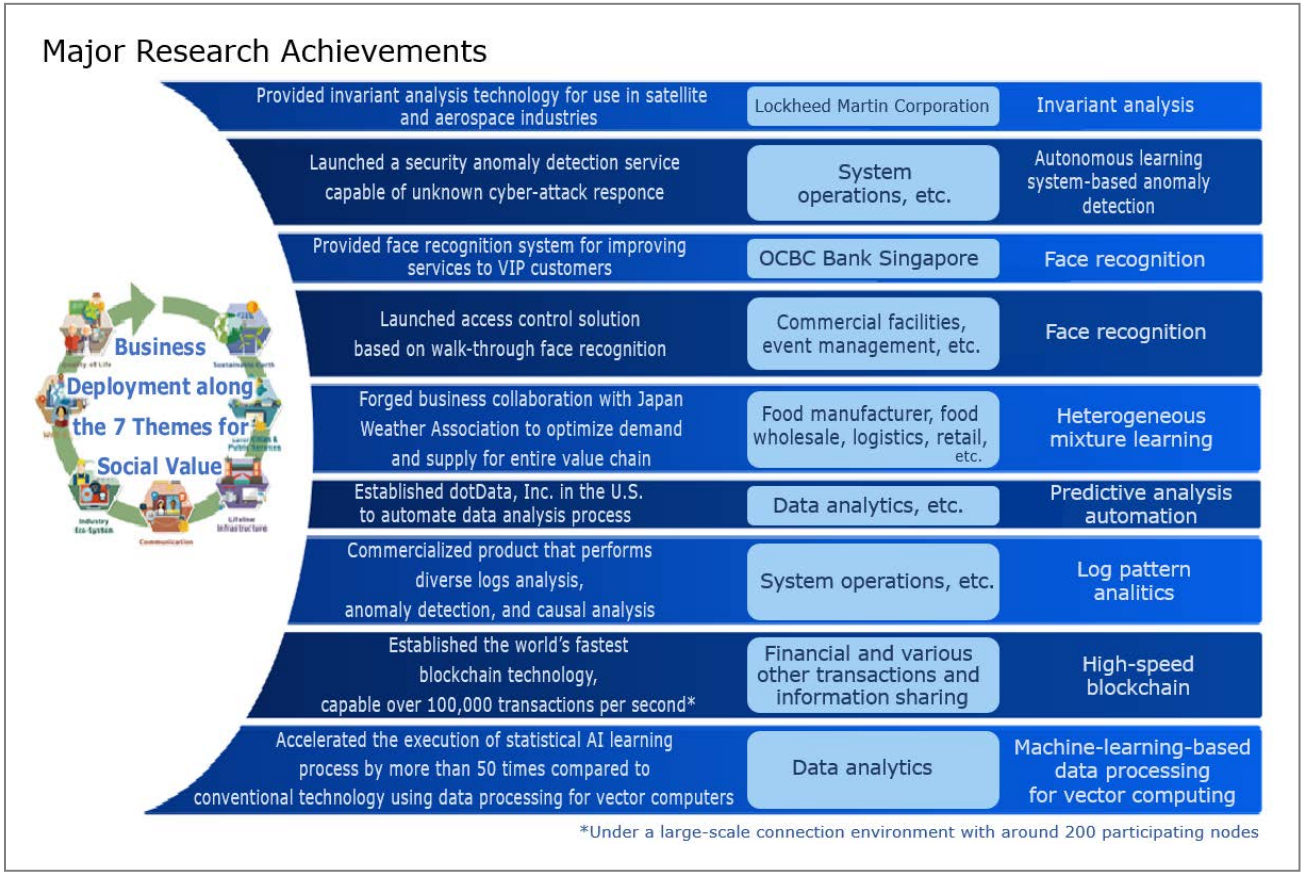
NEC Corporation and NEC Labs Europe have developed the world's fastest consensus building algorithm for blockchain, which has achieved a recording performance of more than 100,000 transactions per second, under a large-scale connection environment with around 200 participating transaction nodes. This feat exceeds the performance necessary for systems supporting worldwide credit card transactions, making it a technology that will accelerate the full-scale use of blockchain in business.

Development of Data Processing Technology for Machine Learning in Vector Computers

NEC Corporation has developed a data processing technology for high-speed execution of machine learning optimized for vector computers. The technology can execute machine learning at more than 50 times faster than conventional methods that connect multiple servers for analysis.

For example, the technology enables timely use of results of analysis since optimization of web ad placement, recommendations, and document analysis can be performed more quickly. Also, with fewer servers needed, analysis can be performed at lower costs, making it possible to offer value to a wider layer of users.

- NEC accelerates machine learning for vector computers (Press Release)



Development of "mIDot" Technology Utilizing 1-mm Ink Dots as Identification Tags

NEC Corporation has developed the mIDot (micro-sized Identifier Dot on Things) for individually recognizing camera images of "dots" written using off-the-shelf ink pens on various objects.
The technology recognizes images of tiny patterns in the ink of individual dots, which are difficult to identify with the naked eye, to distinguish each dot. Due to random particles in the ink, identical patterns are unlikely to be formed, making each 1-mm dot a unique identification tag that is difficult to duplicate. Dots can be easily applied to a wide range of objects by hand, enabling the technology to be conveniently used by anyone, anywhere, to identify products or property. It can also be used to distinguish dots uniformly made using machines.

This technology is expected to be used for a broad range of applications, including identification tags for ultra-small electronic components that are too small for the use of barcodes; tags for managing goods that are lent or taken out; keys and tickets used for entry/exit control; and identification tags for linking physical objects with electronic payment or voucher data.

- NEC technology enables ink dots to become identification tags (Press Release)

Results and Effects of Open Innovation

The following are some concrete results of open innovation.

Establishment of FIWARE Lab Node in India for Building of Smart Cities

Staring fiscal 2017, NEC has been a platinum member of "FIWARE Foundation e.V.," a non-profit, private-sector-led organization that promotes the uptake of FIWARE, the infrastructure software developed and implemented by the Future Internet Public-Private Partnership Programme (FI-PPP) in the EU.

In this connection, with NEC Technologies India, we established and started operations of FIWARE Lab node in India. Creating a cloud environment for experiencing FIWARE technology in Europe and other regions enables application developers, solution providers, government agencies, academic organizations, and various organizations, enterprises, and individuals to co-create with each other and experiment and test solutions for smart cities using open data publicized by cities and other organizations.

- NEC to establish FIWARE Lab node in India (Press Release)

Joint Development of Technology to Wirelessly Control Robots with Nidec

NEC Corporation and Nidec Corporation jointly developed a technology that enables highly precise, real-time remote control of Intelligent Motors®*, motors incorporating microcomputers, through a wireless network.

As the uptake of IoT accelerates, the growing robotics industry has seen a greater need for the evolution from individual robot operations to cooperative operation between multiple robots. To address this demand, we have successfully developed a new technology that combines NEC's wireless communication technology with Nidec's motor synchronization technology to enable highly precise, real-time remote control of robots equipped with Intelligent Motors®. The technology has been verified to improve transportation efficiency by 30% compared to conventional methods in simulation testing with automated guided vehicles (AGVs) in factory and warehouse environments where wireless communications are unstable due to the data transmission of peripheral equipment and the influence of electromagnetic noise.

- NEC and Nidec develop technology to control robots equipped with Intelligent Motors (Press Release)

* "Intelligent Motors®" is a registered trademark of Nidec Corporation.

NEC, AIST, and RIKEN Start AI Research Collaborations

NEC Corporation, the National Institute of Advanced Industrial Science and Technology, and RIKEN have come to an agreement to join hands in accelerating cutting-edge research on AI—from the development of platform technologies to their commercialization.

The collaboration aims to optimize the fitting of applied solutions and component technologies, streamline activities through a higher-level of consistency, and maximize research results through the sharing of information pertaining to R&D, the joint development of software, and the shared use of equipment and other research resources for activities of the "NEC-AIST AI Cooperative Research Laboratory" and "RIKEN AIP-NEC Collaboration Center."

AI research themes under this three-pronged collaboration include "decision-making under unknown conditions," where past data are insufficient for big data analysis, and "automated coordination among AIs," which has become necessary due to the development of smart individual systems. Aiming to further accelerate AI research and contribute to society and industries, the three organizations will jointly tackle the establishment of new fields of technology pertaining to the smooth operation of massive systems underpinning the real world, which is rendered uncertain and complex by constantly changing phenomena.