NEC CSR Report 2017	CSR Man	agement Governance	Society	Environment
	26-27	Corporate Governance	28-32	Compliance and Risk Management
	33	Basic Approach on Tax Matters	34-37	Fair Trade
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	65-74	Innovation Management		

# **Innovation Management**

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

The pillars of this strategy rest on a concentrated investment in those technology areas that are NEC's strengths as well as aggressive use of open innovation. In fiscal 2017, NEC made a concentrated investment in data science, an NEC strong point, and launched "NEC the WISE," NEC's first technology brand.

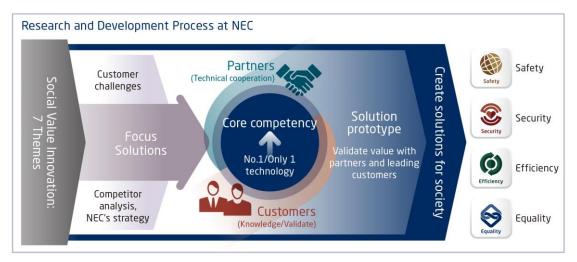
NEC is also creating innovation valuable to customers and society by moving forward with co-creation with customers by employing social value design. (Social value design is an approach that creates value from the social point of view).

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

#### Policy

The CTO is responsible for overall technology development, optimizing development investment company-wide, drawing up an open innovation strategy and proceeding with the process design.

For research and development, which is the source of this technology development, we address those solutions for social issues and incorporate the "No.1/Only 1" core technologies needed to realize those solutions within the basic policy by rigorously refining them in keeping with trends in technology. The following figure shows the process of our research and development.



NEC's research and development process

To ensure that our investment in R&D (about 4-5% of sales) is used effectively and efficiently, we are investing intensively into focused areas and also investing in open innovation that will promote cooperation and collaboration with other research organizations on the technology needed for value amplification. In fiscal 2017, our R&D expenditure was 109.3 billion, which was 4.1% of sales revenues.

NEC CSR	Report	2017
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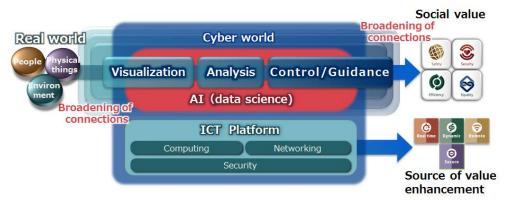
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26-27	Corporate Governance	28-32	Compliance and Risk Management
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52-58	Personal Information Protection	59-64	Supply-Chain Management
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R&D investment

# Concentrated investment in strong technology areas

We are concentrating investment in two areas of technology: (1) data science to create new value from big data using artificial intelligence (AI) for visualization, analysis and the like, and (2) ICT platforms that are needed to address large-scale and complex real-world issues. NEC 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.

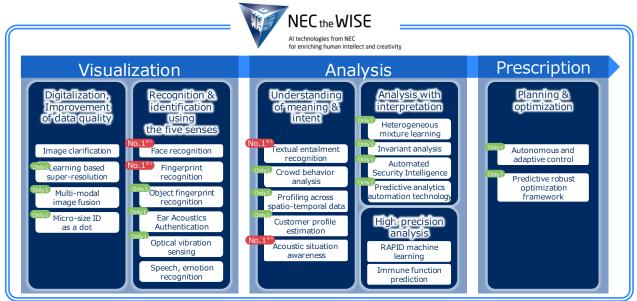


Contributing to the creation of solutions for society in the areas of data science and platforms that are driven by AI technology

In data science, we are working on AI technologies that will create new value by visualizing, analyzing, prescribing the real world. In the area of ICT platforms, we are also working on computing network technologies that adapt dynamically and in real-time to changes in the real world, and security measures that allow social systems to operate securely and stably.

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A part of the concentrated investment in these areas is the strength of our "NEC the WISE" launched in July 2016 as a leading-edge AI technologies brand. "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.



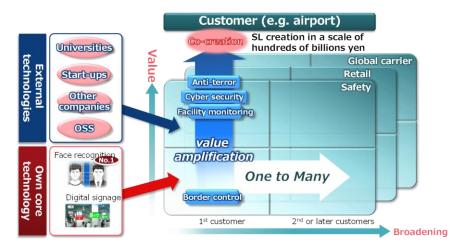
\*1: Ranked 1st four consecutive times in task assessment sponsored by NIST, \*2: Ranked 1st fore times in task assessment sponsored by NIST, \*3: Ranked 1st in task assessment sponsored by NIST (2012), \*4: Ranked 1st in task assessment sponsored by IEEEAASP Challenge DCASE2016

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

# Promoting open innovation

Increasing the value provided to society requires a concentrated investment of limited resources in the areas of technology where our strength lie. It is also necessary to continuously perform open innovations to promote the development of technologies needed for value amplification in cooperation with other research organizations and the like.

Since fiscal 2017, we have been promoting solution creation initiatives to the tune of several hundred billion yen by incorporating cutting-edge technology from outside the company and refining our core technologies in the three areas of safety, retail and global carriers that will be coming into focus in the 2018 mid-term management plan.



Promoting open innovations

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# Strengthening our IP portfolio and protecting our brand

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

As we focus on social solutions, it is critical to implement an intellectual property network throughout our businesses including customers and partners. We are now not only implementing an entry barrier by intellectual property rights and securing a competitive edge but are also creating, implementing and leveraging an intellectual property network to strengthen and protect cooperation with customers and partners.

And as we strengthen and protect our global brand, we are launching a technology brand and actively protecting intellectual property rights globally, for example, by securing the global trademarks when we launched "NEC the WISE," the leading-edge AI technology brand.

As of March 2017, NEC holds about 53,000 patents in total (approximately 23,000 in Japan).

# Improving system services by social value design

To create new social value, we need to illustrate what society should be, 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. The NEC Group 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 to create new value in society or for its customers by depicting the future from two points of view represented by user experience and social experience. User experience can be improved by employing human centered design or design that considers the "people's point of view." Social experience can be improved by employing human-centered design or design that looks at it from "society's point of view."

For example, for solutions that solve a variety of problems at airports, using social value design we strive to create social value for airports by employing social value design from a higher level 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 the user to easily reach the destinations.

#### Promotion Framework

NEC has created a new CTO (Chief Technology Officer) position to establish a company-wide perspective in our effort to optimize our overall development investments, and link our corporate strategy with the planning of collaboration strategies with other companies. The CTO will also organize our technology roadmaps and portfolios towards focused investment in our technological strengths, and promote the timely introduction of technology through strategic collaboration with other organizations.

# Technology strategy committee / CTO council

In the business of creating new value and the innovation of technology, the president, chief officers and business unit managers provide a corporate culture to stimulate open discussion throughout NEC in regular information-sharing channels and at events such as training camps. At the technology strategy committee chaired by the CTO, decisions are made regarding the planning and execution of technology strategies that contribute to NEC's management strategy and business strategy.

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As a subordinate organization, a CTO council chaired by the CTO convenes once a month to discuss technology strategy and implementation policies of NEC's focus areas. At the CTO council, each business unit's executive officer and the general managers of NEC's Central Research Laboratories and Intellectual Property Headquarters raise issues relating to the company-wide technology strategy, discuss how these issues can be addressed, and instigate plans for resolving these issues.

# Value creation at our Central Research Laboratories

Value creation is the foremost objective of NEC's Central Research Laboratories. By driving innovation based on strategies developed by the Technology Strategy Committee, we are combining our strong technical ability with the creative potential of our customers to produce solution prototypes that contribute to social value creation, leading to growth of society.

We are not only focusing on R&D in NEC's strong areas, but we are also studying future focus areas by back casting from the technology requirements of the future, and we are promoting cooperative efforts with the world-leading research organizations and universities. We believe cooperation with them will only be possible if NEC has really strong technologies. So, we have been intensifying our focus on the R&D of NEC's core competence technologies where we are considered to be the "No.1" or "Only 1" expert.

For example, we are addressing the open innovation initiatives at the NEC Brain Inspired Computing Cooperative Research Center launched in 2016 with Osaka University and the AIST-NEC Artificial Intelligence Collaborative Research Laboratory to incorporate No.1 technologies from outside. We are also moving forward with future AI research to find solutions on social issues under 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 April 2016 at the Suita campus of Osaka University for use in interdisciplinary courses, and aims to promote platform research activities. In these courses, we are promoting 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 and the RIKEN Quantitative Biology Center (QBiC) to provide a center 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 <u>Technology</u> (Press release)
  - "NEC Brain-Inspired Computing Research Alliance Laboratories" established -

#### AIST- NEC Artificial Intelligence Collaborative Research Laboratory

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

Since this laboratory is having to plot a course through uncharted territory due to the lack of prior data on issues dealing with rare events such as disasters or abnormal situations, or the design of new products and new services, we are using simulations to compensate for the lack of information, and are developing technology to maximize the potential of AI by combining it with simulation. By combining the laboratory's simulation technologies with the world's top-class AI-related technology such as machine learning, prediction/notification and optimal planning/control that have been cultivated by NEC since the 1980s, we are targeting 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.

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#### 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 September 2016. It focuses on sharing a vision and issues relating to executing advanced basic research and applying research results to society under the interorganizational agreement, validation of social receptivity after the research has been applied, and promotion of comprehensive co-creation initiatives including the development of human resources who will be forging the future.

Specifically the agreement advocates the following:

- 1) Promotes 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) Expecting that solutions using AI will filter deep into society, promotes research on laws, guidelines, social consensus, ethics, etc., to coordinate social rules and human feelings in which solutions using AI can achieve that goal.
- 3) Promotes the new "NEC/University of Tokyo Future AI Scholarship" that is designed to foster students in doctoral programs who are researching AI at the University of Tokyo.

In 2016, starting with holding the "Brain Morphic AI" symposium, NEC worked on a variety of projects, focusing on a basic review of an information processing system simulating the brain and nervous systems.

<u>NEC and the University of Tokyo embark on industry-academia alliance for strengthening innovation</u> (Press release)
 Joint research on artificial intelligence (AI), the investigation of ethics and legal systems and the promotion of human resource development -

# Overseas research laboratories for global social value creation

For social value creation on a global scale, NEC is promoting R&D that exploits the local strengths of each area by placing R&D centers at five locations worldwide (in North America, Europe, China, Japan and Singapore). Each research center belongs to a partnering strategy with advanced customers and leading universities and research organizations. By promoting collaboration with the world's top universities and research organizations and competition with local customers, we have expanded our technology from the viewpoint of solutions, and established technology that is superior to that of 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, we are creating many core technologies while strengthening our ties with local universities and research organizations. In particular, we are working on the R&D of autonomous system control and management, data management, energy control and management, integrated systems, machine learning, media analysis, mobile communication networks, optical networks and sensing technology.

#### NEC Laboratories Europe

NEC is actively participating in European national projects; in Heidelberg, Germany, we are working on the R&D of technologies including networks, security and smart transportation/energy. We are also involved in standardization efforts and R&D marketing centered on networks.

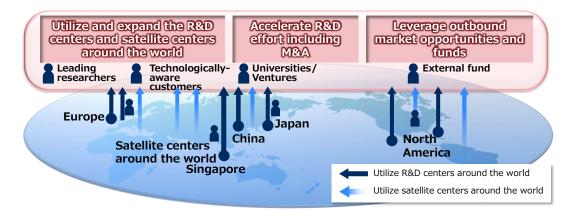
#### NEC Laboratories China

NEC's R&D is focused on creating new social solutions through the development and verification of technologies in the huge Asian market. In particular, we are working on R&D aimed at creating new social solutions businesses primarily aimed at the Chinese market. Working in close cooperation with other research laboratories, we will create solutions that address various social issues that have come about during the rapid development of the Chinese market.

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#### NEC Laboratories Singapore

By building flexible joint research systems with local research organizations and customers and actively participating in verification trials, we are creating new solutions using NEC's own advanced technology. While constructing flexible joint research systems with governments, research organizations, universities and customers, we are actively participating in projects aimed at resolving urban issues, and are creating new solutions using NEC's advanced technology. We are particularly active in the fields of safety, big data, security and smart energy. Solutions created here are being developed on a global scale in ASEAN countries, South America, Africa and other emerging countries where there is a particularly strong need for an enhanced social infrastructure.



A global system of research laboratories

# Driving business innovation: Business innovation integration unit

The business innovation integration unit proposes strategies relating to company-wide focus areas and promotes new reforms of business models that go beyond the framework of existing business.

For globally launching the social solutions business, we have placed a strategic headquarters under the business innovation integration unit. The aim is to formulate a business strategy using digital transformation by leveraging AI or IoT technologies and promoting new social value creation beyond existing organizations and business models

The business innovation integration unit maintains reform frameworks for existing businesses and the creation of new businesses by combining the functions of corporate marketing, technical innovation strategy and business innovation strategy.

# Intellectual property headquarters responsible for strengthening our IP portfolio

In anticipation of our future global business expansion, we are focusing on the construction of a global intellectual property network at our intellectual property headquarters, actively providing intellectual property centers in North America, Europe and China and launching other global intellectual property activities. In particular, in terms of solutions for society, we are developing strategic patent projects across the entire NEC Group to acquire strong patents and patents that can be put to use. In strengthening and protecting our global brand, we have revamped and publicized our corporate brand statement.

NEC's Brand Statement: "Orchestrating a brighter world"

# A standardization promotion department that uses standardization to contribute to the creation and expansion of markets

At NEC, we are promoting strategic standardization activities to create business eco-systems and expand our business opportunities. To consolidate our business, we are actively promoting the strengthening and utilization of patents related to

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standardization in order. We also expect our participation in standardization activities to contribute to the creation and expansion of markets and facilitate a stable supply of products and services, and we are actively participating in and promoting standardization efforts, including chairing standardization organizations.

# Human resource development to support innovation

NEC is focusing on cultivating human resources to strengthen our core technologies for the creation of innovation in solutions for society, and cultivating and strengthening human resources in order to create social solutions. We are also promoting the fostering of business minds and the diversification of human resources.

#### Stronger diversity for human resource development

At NEC, we are working towards greater diversity and the employment of top researchers in targeted areas in order to strengthen our core technologies that work well in delivering social solutions. By increasing the number of researchers in targeted areas, we plan to double their number in data science, reaching 300 by fiscal 2019. In fiscal 2017, we increased the number to 220.

When hiring new employees, increasing the diversity of our human resources is also essential. At our research laboratories, in order to continue strengthening our "No. 1/Only 1" core technologies, we are actively employing the top local talent at each of our laboratories worldwide, increasing the employment of those with doctoral degrees from Japan, and stepping up our recruitment from top universities worldwide. Also in fiscal 2017, we are continuing with our policy of taking at least half of our new employees from applicants with doctoral degrees and are recruiting growing numbers from the Indian Institute of Technology. By establishing suboffices around the world, we can recruit top local talent from those areas. The result is that about 40% of our new recruits are so called "global human resources."

We are also changing our organization in order to 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 operating inside and outside NEC, such as foreign study and work placement programs in emerging countries in cooperation with NPOs. To achieve greater diversity in specialist fields, we are strengthening our employment not only in information science but also in the physical sciences where it is necessary to handle data expertly. To resolve issues through cooperation between people and AI, we are also strengthening our employment in the humanities.

#### Cultivating and strengthening human resources for the creation of solutions for society

To provide solutions for society, we need to cultivate and strengthen researchers who not only have the required specialist core skills, but also have a business mind and far-reaching knowledge of diverse domains. To broaden our scope on the creation of new value, we are working on strengthening the cultivation of global human resources, enhancing the hiring of domain specialists, and developing people with a business mind who can drive business forwards.

For example, with the aim of strengthening our human resources to tackle advanced issues globally, we are planning that 70% of our researchers should have global business experience in fiscal 2019. In the creation of solutions for society, it is also necessary to have not only specialist knowledge of specific technologies, but also wide-ranging knowledge in the domain of social issues to provide value to society by bringing these technologies together. We will therefore recruit domain experts with this sort of knowledge. This means we are also strengthening mid-career recruitment.

In our in-house human resources, we also aim to quickly realize solutions for society by strengthening our promotion of commercialization through the exchange of personnel between the business sector and research sector. In particular, we will strengthen our promotion of business in our "No. 1/Only 1" AI technology and security technology by strengthening the development of human resources by top engineers, and cultivating project leaders and technology architects by exchanging personnel between the business divisions and research laboratories.

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### Main Activities and Results for Fiscal 2017

# Main business achievements for No. 1/Only 1 technologies

In fiscal 2017, we are continuing to adapt our "No. 1/Only 1" technology to business that contributes to the realization of seven themes in social value creation. Our main business achievements are shown below:

Social value creatio – 7 themes	n Accomplishment	No.1/Only 1 technology
Sustainable	Marketed "Landslide Prediction System"	Technology to estimate the landslide risks
Earth	<ul> <li>Marketed AI software that analyzes a video image from a surveillance camera and searches for a particular person quickly and with high-precision</li> </ul>	Profiling Across Spatio-Temporal Data
Safer Cities & Public Services	<ul> <li>Provided the Australian government with a biometric system</li> <li>Delivered a face recognition system for immigration checks at a major airport in the US</li> </ul>	<b>Face recognition</b>
Lifeline Infrastructure	<ul> <li>Delivered an automatic determination system for babies and real faces</li> </ul>	Liveness authentication
Communication	<ul> <li>Started jointly an operation support service for thermal electric power generation</li> </ul>	Invariant analysis
Communication	ullet Started laying a Trans-South Atlantic undersea optical cable	first 100-GB optical transmission
Industry Eco-System	Collaborated with the security company to provide a new security system	No.1 Face recognition
	<ul> <li>Provided a cloud-type security camera service for the distribution company</li> </ul>	Light encryption
Work Style	Renewed the Contact Center operations Marketed "Auto Response Solution"	Textual Entailment Recognition
Quality of Life	$\cdot$ More than 1 billion people registered with the Unique ID System in India	<b>1</b> Fingerprint, Face recognition

Face recognition: Achieved first place four times in succession in evaluations by the United States National Institute of Standards and Technology (NIST)

Textual entailment recognition: Achieved first place in an evaluation (in 2012) by the United States National Institute of Standards and Technology (NIST)

Fingerprint: Achieved first place in the benchmark test of finger print authentication technology (2012)

# Results and effects of the open innovation approach

The open innovation approach includes collaborations, acquisitions, spin-offs, the use of open-source solutions, and licensing. NEC's cooperation with others is widely varied, and includes links through national projects and links with local governments. Also, in the use of open-source solutions, we are already using standardized tools, and are also actively involved with standardization efforts centered on academic institutions. We are also performing licensing with the aim of achieving widespread use.

#### Entering the drug discovery business using leading-edge AI technology

NEC launched a drug discovery business as a part of its efforts to strengthen its healthcare business to find important drug candidate compounds by leveraging its proprietary advanced AI technologies and supporting commercialization of discovered drugs. To launch this business, NEC established a new company that will develop and commercialize a peptide vaccine for cancer treatment. The new company will develop investigational agents for a vaccine that contains a peptide as the active compound, perform non-clinical or clinical tests, review commercial viability with a pharmaceutical company and proceed to commercialize the vaccine as a new cancer drug.

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NEC has its proprietary immune function prediction technology, which efficiently finds candidate peptides for vaccines by combining machine learning and tests in a short period of time and at low-cost. We will expand our base in social solutions by enhancing our health care business including drug discovery by leveraging our leading-edge ICT such as this immune function prediction technology and NEC's AI technology.

- NEC aims to discover new drugs harnessing advanced AI technology (Press release)
  - New company established to promote development and application of therapeutic cancer vaccines -

#### NEC joined FIWARE Foundation as a platinum member

NEC joined the FIWARE Foundation as a platinum member. The FIWARE Foundation is a private-sector-led non-profit organization that promotes FIWARE, the infrastructure software developed and implemented by the Future Internet Public-Private Partnership Programme (FI-PPP) in the EU. NEC is the first and only Japanese company that joined this organization. FIWARE is infrastructure software that has open API, developed and standardized as open source to promote data usage and service linking across organizations and companies providing public services. It is applied to many systems to realize a smart city in many cities and corporations mainly in Europe. Aiming to accelerate the businesses using the IoT such as "Smart City", NEC, joining the FIWARE Foundation as a platinum member, will lead efforts to expand and strengthen the FIWARE functions on a technical level.

NEC joins FIWARE Foundation as a platinum member (Press release)
 Accelerating smart city and IoT-related business -

#### Developed a customer profile estimation AI technology

NEC developed a customer profile estimation technology, which can automatically estimate a detailed profile on each customer such as hobbies or favorite foods without marketing experts getting involved. This technology, using NEC's proprietary relationship mining technology, precisely and automatically estimates a detailed profile for each customer from the basic profile and buying history. This enables users to address continuously changing lifestyles, quickly identify invisible personal needs and create an effective marketing plan. NEC will further proceed with its R&D, aiming to apply this technology to the retail and distribution industries such as department stores, supermarkets, convenience stores, EC sites, point card system operators, etc.

NEC Develops AI-based Customer Profile Estimation Technology (Press release)

#### Developed a remote visual line estimation technology

NEC developed a remote visual line estimation technology, which allows the user to detect a person's visual line in real time from a remote location by using existing surveillance cameras installed on streets and in stores. This technology can detect the direction of a visual line precisely, with an error margin of less than 5 degrees top/bottom and right/left by using a regular camera. The technology uses facial features detection technology, a core technology of the facial recognition technology that is NEC's world No.1 technology, and precisely identifies a facial feature such as the corner of the eye, pupil, etc. to detect the visual line. NEC will apply this technology in the areas of safety and security where, by monitoring people's visual lines, you can set up evacuation/guidance signs at optimal locations or on streets or monitor suspicious individuals. It will also apply this technology to marketing where you can estimate popular products or contents by detecting the visual lines of, for example, customers who are shopping in a supermarket or looking at digital signage.

<u>NEC technology knows where you are looking</u> (Press release)
 Real-time detection of a person's line-of-sight -