R&D Activities that Drive NEC’s Growth

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Katsumi Emura
Senior Vice President, NEC


 Orchestraing a brighter world

未然に向け、人が住む、思い生きるために欠かせないもの。それは「安全」「安心」「公平」「民主」という理想を実現する社会です。

NECでは、ネットワーク技術とコンピュータサイエンスを基盤に、世界のあらゆるインテグレーターとしてリーダーシップを発揮し、実現した技術とさまざまな知見やアイデアを融合することで、世界の国々や地域の人々と寄与しつつ、明るく安全な未来を築き上げる社会を創り出し、手伝っていきます。
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NEC's Social Value Creation

Use the power of ICT to help solve society’s future challenges

The Earth in 2050
- Population: 3.5 billion → 6.3 billion (1.8 times)
- Energy demand: 1.8 times
- Demand for water: 1.6 times
- Demand for food: 1.7 times

Japan 2050
- Population: 120 million → 80 million (0.7 times)
- Decline in labor force
- Infrastructure maintenance
- Safety for people

Diagnosis of infrastructure deterioration
Solutions for enhancing operational efficiency
Agricultural ICT
Smart water management
Smart energy

Increase in urban population
Public safety

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Key domains in Social Value Creation

Solutions for society through seven themes for social value creation

Seven Themes for Social Value Creation

- Sustainable Earth
- Safer Cities & Public Services
- Lifeline Infrastructure
- Communication
- Quality of Life
- Work Style
- Industry Eco-System
IoT as a Driver of Social Transformation

The key to resolving social challenges will be the fourth industrial revolution brought about by IoT

Technological evolution

Steam engines
Energy (oil, electric power)
Computers/Internet

Social/business transformation (paradigm shift)

First industrial revolution:
Mass production in light industries

Second industrial revolution:
Mass production in heavy industries

Third industrial revolution:
Information revolution/manufacturing automation

Internet of Things (IoT)

Broader connections deepen understanding

Higher level of intelligence

Wisdom
Knowledge
Information
Data

Physical things

Provider

Customer

Resolve challenges as connections evolve and change society

Social transformation, service revolution
Continuous service, work style, customization, etc.

AI

Context

Wisdom
Knowledge
Information
Data

Physical things

Physical things

Physical things

Orchestrating a brighter world

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IoT, which is to be the driver for transformation

The key to resolving social challenges will be the fourth industrial revolution brought about by IoT
Enhanced ability to resolve challenges by higher level of intelligence

The ability to take on greater challenges, based on a deep understanding of the real world, by spawning advanced knowledge from real-world data.

Enhanced quality of challenges that can be resolved

Wisdom
- The power to provide suggestions toward a person’s decision-making

Knowledge
- Tendencies/knowledge used for decision-making

Information
- Organize/define based on certain standards

Data
- Raw data/numerical values/symbols

(DIKW model from information science)
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(DIKW model from information science)
Social value creation through NEC’s ICT technology that enables a deep understanding of physical things in the real world

Value creation

NEC’s ICT technology

AI (data science)

ICT platform

Understanding of 'physical things'

Insights

Organization

Abnormality

Work process

Understanding of 'contexts'

Vibrations

Temperature

Linkage of data in real-time

Linkage of contexts

Deeper understanding of 'contexts'

(Experience)

Point of view

 Causes

Advanced decision-making

Wisdom

Knowledge

Information

Data

2015

2018

2020

Safety

Security

Efficiency

Equality

2015

2018

2020

Safety

Security

Efficiency

Equality

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The social value creation process brought about by ICT in the world of IoT

Provide safety, security, efficiency and equality to life and industries by having a deep understanding of the real world through IoT and working on it.
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NEC R&D policies for contributing to NEC’s growth

NEC’s “Value Co-creation Laboratories” for driving growth
(1) Concentrate to deliver high value solutions
(2) Deliver core competency with No.1/Only 1 technologies
(3) Co-create strong solutions with our partners and customers

Focus Solutions
Customer challenges
Competitor analysis, NEC’s strategy

7 Themes
Social Value Innovation:

Create solutions for society

Core competency
No.1/Only 1 technology
Solution prototype
Validate value with partners and leading customers

Partners (Technical cooperation)

Customers (Knowledge/Validate)

Safety
Security
Efficiency
Equality
R&D policies toward further growth

Drive NEC’s growth by focusing on the domains in which NEC can offer high value and refine solutions to the point where customers’ essential challenges are resolved.

- Focus on the domains in which NEC can offer high value.
- Refine solutions to the point where customers’ essential challenges are resolved.

Create seeds for solutions with great potential that would drive NEC’s growth.

Offer value:
- Offer essential value.
- Offer value at an early stage.

Focus on:
- Solution candidates.

Deepening of solutions:
- Offer essential value.

One to Many:
- First customer.
- Second customer and beyond.

Broaden solutions:
- Plan for optimizing water supply.
- Water leak detection.
- Demand prediction.
- Smart water management.
- Water leak detection.
- Large-scale plants.
- Safer Cities.

Value Enhancement:
- Water leak detection.
[Case Study] Value enhancement at a large-scale plant

Enhance value ranging from facility maintenance to revolutionizing the main business operation by combining core technologies, such as visualization, analyses and security.

Operational innovation

- **Transform work flow**
  - Individual optimization → Overall optimization
  - Overwhelming efficiency of the main business

- **Transform operational maintenance**
  - Deal individually → Deal in a collaborative manner
  - Deal early with abnormalities, including inside jobs

- **Transform repairs/maintenance**
  - After the fact → During stages when signs emerge
  - Implement measures without having to stop the facility

Understanding of 'physical things'

Understanding of 'contexts'

Deeper understanding of 'contexts'

Optimize operations

- System log analysis
- Work log analysis

Stable operation

- Cyber security
- Face recognition/Behavior analysis

Detect signs of abnormality

- Invariant analysis

Delivered to the Shimane Nuclear Power Plant in March 2015 (The Chugoku Electric Power Co., Inc.)
Contribute to strengthening NEC’s business competitiveness by focusing on activities that reinforce solutions towards businesses with high potentials.

**Solutions with great business potential**

- **Smart water management**
  - Water leak detection
  - Heterogeneous mixture learning
  - Predictive Robust Optimization Framework
  - Automatic optimization of a water supply plan

- **Public transportation management**
  - Driver management
  - Profiling Across Spatio-Temporal Data
  - Optimized operations/reduced delays

- **Safer Cities**
  - Face recognition/Black list comparison
  - Automated Security Intelligence
  - Integrated access control
  - Upfront crime prevention

- **Integrated cyber/physical security**
  - Defend against attacks from the outside
  - Integrated cyber/physical security
  - Protect against unknown external/internal attacks

**Realize value enhancement by utilizing strong core technologies**

- Heterogeneous mixture learning
- Predictive Robust Optimization Framework
- Profiling Across Spatio-Temporal Data
- Automated Security Intelligence
- Integrated access control
Introduce the project-style solution creation process that has been successful at NEC Laboratories Singapore to all NEC research laboratories to accelerate activities for creating solutions.

(1) Solution design

Thorough understanding of customers’ issues
- Go to customer sites to thoroughly understand their operations
- Uncover root-cause issues to innovate underlying operations

Solution design
- Design strong "One" solutions and create scenarios for value enhancement
- Properly identify technologies as Make or Buy

(2) Solution creation

Core technology development
- NEC focuses on No.1/Only 1 technologies
- Gather core technologies from NEC's global laboratories

Open innovation
- Procure technologies other than those of our focus from partners

Case study
NEC Laboratories Singapore
Public transportation management project

Customer
Singaporean bus company

Go into
Understand Issues

(1) NEC Laboratories Singapore

Project leader

(2) Development of core technologies
- NEC Central Research Laboratories
- NEC Laboratories Europe
- NEC Laboratories America Inc.

(2) Open innovation
- Singapore Management University
Major business achievements (2015)

Seven themes for social value creation

- Sustainable Earth
- Safer Cities & Public Services
- Lifeline Infrastructure
- Communication
- Industry Eco-System
- Work Style
- Quality of Life

Business track record

- Technology validation of landslide risk estimation at local authorities both in Japan and overseas
- Established face recognition technology development center and introduced face recognition solutions at airports in Brazil, etc.
- Built Comprehensive Disaster Control System in Toshima Ward
- Validating optimal water supply facilities management in cities and towns in the UK
- Delivered over 250 SDN systems globally
- Started offering NEC Industrial IoT, a next-generation manufacturing solution
- Started offering a solution for predicting demand for repair parts
- Released customers’ voice analysis solution
- 4K terrestrial broadcast test conducted with the largest commercial television broadcaster in Chile

No.1/Only 1 technology

- **Data analysis technology**
- **Face recognition**
- **Crowd behavior analysis**
- **Hybrid sensor**
- **Predictive Robust Optimization Framework**
- **Object fingerprint**
- **Invariant analysis**
- **Heterogeneous mixture learning**
- **Textual Entailment Recognition**
- **Ultra high-resolution compression technology**

Partners/customers

- Town of Tsuwano, Shimane Prefecture
- The Department of Federal Revenue of Brazil
- Toshima-ku, Tokyo
- Sutton and East Surrey Water, United Kingdom
- East Japan Railway Company, etc.
- Companies participating in NEC’s manufacturing co-creation program
- NEC Fielding, Ltd
- Sumitomo Mitsui Banking Corporation
- Chilevisión in Chile

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Value creation process by ICT

Enable enhancement of social value by refining NEC’s No.1/Only 1 core technologies that support social value creation

Value for society brought by ICT and source of value enhancement

Real world
- People
- Physical things
- Environ

Cyber world
- Visualization
- Analysis
- Control/Guidance
- AI (data science)

ICT Platform
- Computing
- Networking
- Security

Source of value enhancement
- Real time
- Dynamic
- Remote
- Secure

Social value
- Broadening of connections
- Security
- Efficiency
- Equality
- Society

Broadening of connections

People
Physical things
Environ
NEC’s No.1/Only 1 core technologies that realize value enhancement

### AI (data science)

**Visualization**
- Face recognition
  - No.1
- GLVQ (quantifying general learning vector)
- Self-learning super resolution
- Only 1
- Crowd behavior analysis
- Only 1
- Object Fingerprint
- Only 1
- Optical Vibration Sensing
- Only 1
- Speech recognition
- Emotion recognition
- Only 1

**Analysis**
- Invariant analysis
- Only 1
- Heterogeneous mixture learning
- Only 1
- Scent analysis
- Only 1
- Textual Entailment Recognition
- No.1
- RAPID machine learning
  - (deep learning)
- High speed
- Profiling Across Spatio-Temporal Data
- Only 1

**Control/Guidance**
- Autonomous and Adaptive Control
- Only 1
- Predictive Robust Optimization Framework
- Only 1

### ICT Platform

**Computing**
- Vector computing
- No.1
- I/O virtualization (ExpEther)
- Only 1
- NanoBridge®
- First in the world
- Phase change cooling
- Only 1
- CWB*5

**Networking**
- Applicable rate control
- Only 1
- SDN/NFV
- Leading commercialization

**Security**
- Authenticated encryption
- First in the world
- Secure computing
- Automated Security Intelligence
- Only 1
- Integrated access control

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*1: Ranked 1st three consecutive times in task assessment as sponsored by National Institute of Standards and Technology (NIST) of the US  
*2: As of November 2015 based on research by NEC  
*3: Ranked 1st in task assessment as sponsored by National Institute of Standards and Technology (NIST) of the US (2012)  
*4: As of November 2013 based on research by NEC  
*5: CyberWorkBench

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Create major businesses by leveraging accumulated technology and business track record over half a century and AI technologies that rank at the top around the world.

**NEC’s strong AI technology and the Solutions for Society**

- **Optimize water supply plan**
  - Automated water supply plan
- **Smart water management**
  - Water pipe repair plan
    - Predict water demand
  - Detect leakages
    - Specify leakage areas
- **Safe/secure cities**
  - Urban surveillance
  - Crowd behavior analysis
- **Safe/secure facilities**
  - Management of critical facilities
  - Citizen’s ID/Immigration control
- **Safe/secure service**
  - Cyber security
- **Public safety**
  - Landslide disaster detection/prediction
  - Prediction for electric power demand
  - Prediction for failure monitoring of power plants
- **Safe/secure facilities**
  - Management of critical facilities
  - Citizen’s ID/Immigration control
- **Cyber security**

**NEC’s strong AI technologies**

- Face recognition
- Object fingerprint
- Crowd behavior analysis
- Automatic feature value design
- RAPID machine learning
- Heterogeneous mixture learning
- Predictive robust optimization framework
- GLVQ
- Speech recognition
- Optical vibration sensing
- Super resolution
- Emotion recognition
- Profiling across Spatio-Temporal data
- Textual entailment recognition
- Invariant analysis
- Autonomous and adaptive control

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Case study (1) In pursuit of value enhancement
- Mechanics of water management

Control water flow to meet demand without waste by appropriately adjusting pumps and bulbs

Problems that arise when not controlled appropriately

Leakage due to deteriorating pipes
Lack of water supply (water outage)
Reduced electric power efficiency due to oversupply of water

- Rate of water leakages: London: 15%, Japan: 7% (60 years ago: 20%)
  (amount of loss at 15.0 billion yen/year in cases where total water supply volume in one city is 500 million m³/year, water leakage rate at 20% and production cost at 150 yen/m³)
- Electric power usage volume at water supply facility:
  Total of 7.5 billion kWh/year for all of Japan
  (around 1% of nationwide electric power usage volume)
Case study (1) In pursuit of value enhancement
- Smart water management

- Innovate operation by value enhancement through automated optimization of a water supply plan
- Evolve AI technology from analysis of complex systems to a control plan

Operational innovation

Visualization | Analysis | Control / Guidance

Manual water supply plan

Automated water supply plan

Optimize water supply plan
- Satisfy total demand × minimize electric power × minimize water leakage × extend the life of facilities
- Intuition/experience → Automated optimization
- Reduction of 20% in electric power costs

Transform repairs/maintenance
- In the order starting with old items
- An all-out extension of the life of the water supply system

2013
- Specify leakage areas
  - Optical vibration Sensing

2014
- Predict water demand
  - Heterogeneous mixture learning

2015
- Optimizing technology for predictive decision-making

(announced on November 2)
Applications of predictive robust optimization framework technology

Points regarding predictive robust optimization framework technology

Realize large-scale, advanced decision-making with high speed and high accuracy

Dynamic water supply plan in cities
Dynamic pricing
Transport plan for public facilities
Maintenance plan for facilities

- Electric power costs cut by 20% by prolonging the life of the water supply system
- 11% improvement in retail store sales (speedily create price strategy in less than one second)
- Improvement in the number of commuters traveling comfortably without having to wait
- Safe/secure social infrastructure
Case study (2) In pursuit of value enhancement - Safer Cities

Detect suspicious behavior even among those not registered on a list by utilizing strength in recognition technology in a spatial-temporal context → Enables upfront crime prevention

Detect suspects registered on a black list

- Face recognition technology (still images)
- Blacklist

Adopted by international airports, such as in Brazil, around the world

Detect "unregistered suspicious persons" who are behaving in a questionable manner

- Profiling across Spatio-Temporal data (video)

Suspicious people loitering around checking things out, looking for something

Lost tourists who are going back and forth

Early resolution of criminal investigation → Value Enhancement → Upfront crime prevention
Points regarding Profiling Across Spatio-Temporal Data technology

Categorize specific movement patterns from visual footage data of a great number of people in real time with high accuracy.

Crime prevention
- Classify people
- Detect suspicious people wondering about for a long period of time to check things out ahead of time to break into an empty home or for car theft.

Hospitality
- Classify people
- Find lost tourists who are walking back and forth and provide guidance.

Marketing
- Classify movements
- Analyze why a consumer has not purchased an item even when there is interest and then recommend a promotion plan.

Future outlook
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Strengthen platform technologies that support value enhancement

Strengthen "real-time, dynamic, remote, and secure," which are sources of value creation, and thoroughly utilize broad and large-scale information from IoT for value enhancement

**Computing**
- **Pursue real time performance and power efficiency**
  - Instant understanding of the current state (cloud processing)
  - Accurately predict situations that could occur next and immediately execute optimal control (Wide area decentralized processing)

**Networking**
- **Optimal control of the overall network in a flexible manner**
  - Reduction of CAPEX/OPEX*
  - Offer a new experience

**Security**
- **Integrated real world/cyber security**
  - Cyber system protection
  - Provide stable social system including operation

Respond to large-scale/complex challenges in the real world

※: CAPEX/OPEX: Capital Expenditure/Operating Expense
Strengthen computing that supports value enhancement

Processing dispersed among devices that are partial to the real world as a way to respond in real time to changes in the real world; small-scale intellectual processing realized with low electric power consumption level

- **2015**: Create crime map, Pursue criminals, Detect criminals
- **2018**: Respond to increased complexity/larger scale
  - Create crime map, Pursue criminals/suspects
  - Detect criminals, Detect suspects
- **2020**: Create crime map, Pursue criminals/suspects

Optimal structure based on use

- Technology utilizing vector processors
- Technology utilizing FPGA*
  - CWB: CyberWorkBench

*(Field-Programmable Gate Array)

(1) Large-scale processing in real time
(2) with low electric power consumption level
Strengthen networking that supports value enhancement

Offer ICT infrastructure that responds to various application requirements in a flexible and secure manner through progress in layer integration

<table>
<thead>
<tr>
<th>Layer 1</th>
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2015 SDN  
Application

Layer 6
Layer 5
Layer 4
Layer 3
Layer 2
Layer 1

2018 Integrated control of wireless and internet

- **Requirements**
  - Internet
  - Monitor
  - Control

- **Internet**
  - **SDN** (OpenFlow, etc.)
  - **Wireless**

- **Monitor**
- **Control**

2020 Integrated control of ICT infrastructures based on application requirements

- **Public transport**
- **Public safety**
- **Medical treatments**

- **Fewer delays**
- **Highly reliable**
- **Availability**
- **Large volume**
- **Sensitivity**
- **Privacy**

- **Integrated control of wireless and the Internet according to application requirements**

- **Capture flexible control and active things (requirements) by understanding these things belonging to various applications**

- **Return at the edge**
- **Secure large capacity**
- **Isolate information**

CAPEX/OPEX reduction

New experience

New service creation
Strengthen security that supports value enhancement

Integrated real-world/cyber-world integrated security that guarantees stable operations, not only for protection in cyber space, but also various social systems in the real world.

Data protection ~2017
- Malicious terminal
  - Terminal authentication
- Intruder
  - User authentication
  - Behavioral analysis
  - Internal crime prevention
- Cyber attack
  - Secure computing
  - Prevent information leaks
  - Detect and respond to cyber attack

Guarantee stable system operation ~2020
- OT* system
  - Monitoring of spoofing terminal
  - Internal crime
  - Detect and respond to equipment failures
  - Detect and respond to cyber attack
  - Automated Security Intelligence
  - Also detects unknown attacks, malfunctions
- IoT system
  - Authenticated encryption
  - High speed
  - Announced on July 21
  - OT* system
    *Operational Technology
New service creation through the evolution of platforms

Realizing an ICT platform that operates in real time and is dynamic, remote and secure based on service requirements

Transportation: Low Latency
Social infrastructure: Availability
Public safety: Sensitivity
Medical treatment: Privacy
Agriculture: Environmental durability
Education: Operational availability

ICT platform

- Low Latency
- Highly reliable
- Availability
- Sensitivity
- Large volume
- Privacy
- Environmental durability
- Operational availability
- Ease of use
- Edge wraparound
- Interactive
- Real time
- Dynamic
- Remote
- Secure

- Edge
- Device

AI

- Wide area
- & secure
- Large volume
- & secure
- Isolate information
- Operation on low power consumption
- Interactive

Large & secure

- AI

- Isolate information
- Operation on low power consumption
- Interactive

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Advanced technology research into the future

Work on advanced technology that brings about a future breakthrough by rendering the world view of technology and its evolution as well as utilizing open innovation

<table>
<thead>
<tr>
<th>To present</th>
<th>2017</th>
<th>2020</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Things are connected</td>
<td>Contexts are connected</td>
<td>Assumption/Decisions</td>
<td></td>
</tr>
<tr>
<td>Analysis/recognition</td>
<td>Understanding of contexts</td>
<td>Autonomous cooperation</td>
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<tr>
<td>Utilization of software</td>
<td>Utilization of services</td>
<td></td>
<td>Right brain work</td>
</tr>
<tr>
<td>Partially operated</td>
<td></td>
<td>Deconcentration of function</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Total security</td>
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</tbody>
</table>

Secure dominance in the advanced technology area by strengthening open innovation

- **Pervasive Connectivity**
- **Augmented Wisdom**
- **Service-Oriented Hardware**
- **Adaptive Robotics**
- **Brain-Inspired Computing**
- **Cloud to the Edge**
- **Holistic Security**

- **Things are connected**
- **Analysis/recognition**
- **Utilization of software**
- **Partially operated**
- **Left brain work**
- **Concentrated on data center**
- **Cyber security**
- **Data center/Edge linkage**
- **IoT security**
- **Deconcentration of function**
- **Right brain work**

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NEC’s social value creation and the direction of AI technology

NEC is advancing AI technology by looking at the resolution of social challenges from two sides

- Visualization
  - Emotion recognition
  - Textual Entailment Recognition
  - RAPID machine learning
  - Invariant analysis
  - Optical vibration sensing
  - Speech recognition
  - Face recognition
  - GLVQ

- Analysis
  - Crowd behavior analysis
  - Self-learning super resolution
  - Heterogeneous mixture learning
  - Predictive Robust Optimization Framework
  - Profiling Across Spatio-Temporal Data

- Control/Guidance
  - Autonomous adaptive control
  - GLVQ Predictive Robust Optimization Framework
  - Emotion recognition
  - Profiling Across Spatio-Temporal Data

Problems with clear single goal
- Overwhelming efficiency (Pursuit of value enhancement)
- Problems without clear single goal
- Advancements in suggestions to humans (Cooperation between human and AI)

- • Management decision
- • Caring for people
- • New product development

- • A secure town
- • Quality management

- Wisdom
- Knowledge
- Information
- Data

Wisdom: Understanding and insight
Knowledge: Structured information
Information: Data and facts
Data: Raw information
Resolving social challenges by coordinating human and AI

Resolve issues efficiently by using AI that can support human thinking/reasoning to deal with shortage of talent who can deal with social problems that have become increasingly serious/complex.

Shortage of talent who can deal with increasingly serious social challenges

Need to utilize diverse labor

AI to support human thinking/reasoning by suggesting various perspectives

Expand AI support to the wisdom level

Labor force (Japan)

Outsourcing

Full-time

Robots

Employees with nursing constraints

Foreign employees

Employees with childcare constraints

Outsourcing

Full-time

2013

66 million people

57 million people

-40%

38 million people

2030

2060

*Projections by the Cabinet Office

Need to utilize diverse labor

Wisdom

Knowledge

Information

Data
New challenge – Resolving challenges through support at the wisdom level

Reduce the time required for human and AI to coordinate and resolve a difficult problem for ones without clear single goal, and reduce risk of errors

Approaching the resolution of problems

Understanding through knowledge

Learn from past cases

Verify hypotheses through the cooperation between human and AI

(1) Extract causes/create hypotheses
   Extract causes that will lead to results and create logical solutions

(2) Verify hypotheses/come to agreement
   Look for something that gives a sense of understanding among people and determine a plan for implementation

Cooperation between human and AI

A problem for which one goal cannot be established
Strongly reflect a person’s intention in uncertain situations

Support the expansion of thoughts among people
(Machine learning+α: add a new perspective that is aware of people)

Realize the provision of suggestions from various perspectives for decisions made by people
Points regarding support at the wisdom level

For social challenges that are based on decision-making involving a person’s sense of acceptance and agreement, cooperation of AI and humans guides people quickly to solutions, which are more precise and satisfying.

- **Management support**: Reduce the risk of errors by providing suggestions to matters, such as management decision, for cases without a single clear goal.

- **Support new product development**: AI coordinates and makes suggestions from different perspectives for cases such as new product development.

- **Caring for people**: Assist caring for people by respecting the other person’s intention.
Challenges toward new computing for advanced wisdom level processing

Brain-Inspired Computing

- **Real time**
- **Super low electric power consumption**

**Brain**

- **Electric power consumed**: 20Wh
- **Significantly improved power efficiency**

**Soft computing**

- Computing that can flexibly respond to questions that have more than one answer, even if accuracy deteriorates, it can respond flexibly to challenges

**Hard computing**

- Outputs accurate answers

**Promote using open innovation**

- **Processing capacity (MIPS/$1000)**

- **Wisdom**
- **Knowledge**
- **Information**
- **Data**

- **20MWh** (cutting-edge super computer)

**Processors**

- **CPU**
- **Vector processor**
- **FPGA**

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Focus on key domains and utilize open innovation

An even more efficient investment in research and development by reinforcing internal resources by focusing on key domains and increasing the use of open innovation.

- Utilize open innovation
- Accelerate implementation of advanced technology
- Complement core technologies
- Accelerate creation of Solutions for Society
- Increase the number of researchers for key domains
- Reinforce hiring of top researchers
- Enhance diversity in specialized fields

Focus on key domains

Investment on research:
- Open innovation
- Other domains
- Key domains

Years:
- 2013
- 2015
- 2018 (target)
Research on advanced technologies through open innovation

Regarding research on advanced technologies, reinforce the use of large-scale open innovation to accelerate research

Track record of major areas of cooperation (fiscal 2015)

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Policy on cooperation</th>
<th>Content of cooperation</th>
<th>Contact information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerate implementation of advanced technologies</td>
<td>Cooperate with top universities in the world in target domains</td>
<td>• Brain inspired computing</td>
<td>• Osaka University</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Human behavior</td>
<td>• Stanford University</td>
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<tr>
<td></td>
<td></td>
<td>• Programmable materials</td>
<td>• MIT Media Lab</td>
</tr>
<tr>
<td>Complement core technologies</td>
<td>Complement NEC’s strong technology and cooperate with a research organization that has the potential to lead to greater value</td>
<td>• High-performance/low electric power consumption computing</td>
<td>• Osaka University</td>
</tr>
<tr>
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<td>• Confidential computing</td>
<td>• Bar-Ilan University</td>
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<tr>
<td></td>
<td></td>
<td>• SDN security</td>
<td>• The Swiss Federal Institute of Technology</td>
</tr>
<tr>
<td>Accelerate creation of Solutions for Society</td>
<td>Cooperate with advanced customers, research organizations that are working on major social challenges</td>
<td>• Smart water management</td>
<td>• Sutton and East Surrey Water, UK</td>
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<td></td>
<td></td>
<td>• Public transportation management</td>
<td>• Imperial College London</td>
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<td></td>
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<td>• A bus company in Singapore</td>
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</tbody>
</table>
Strengthen hiring and cultivating talent to continue creating strong technology in focus areas

Increase the number of researchers working on focus areas

Hire researchers with broad view and deep insights

Double the number of AI technology researchers

Planning to increase to around 300 in Fiscal 2018

Strengthen Security and Computing areas and concentrate 70% of researchers in focus areas

- Continue the policy to recruit Ph.Ds for more than half of new hires
- Enhance recruits from top universities worldwide

Enhance diversity in specialized fields

- Strengthen hiring from fields of math and sciences who has high potential for data analysis
- Strengthen recruiting from humanities fields to achieve problem-solving solutions based on human-AI cooperation
Policy on strengthening talent: Create Solutions for society

Secure and cultivate diversified talent as a way to expand perspectives toward creating new value

Strengthen cultivating global talent

Strengthen talent who would work on advanced challenges around the world, such as on smart water management

70% of researchers to have experience in global operations (goal for fiscal 2018)

Strengthen hiring of domain specialists

Strengthen mid-career hires who have experience in social infrastructure operations

To drive the creation of projects on Solutions for Society

Strengthen cultivation of global talent

Cultivate talent who will drive the business

Strengthen capability to drive the business through personnel exchanges between business divisions and Labs

Early realization of establishing a business on Solutions for Society
Cultivate talent who will drive business

Strengthen the ability to promote business through personnel exchange between business and research, such as in No.1/Only 1 AI technology, cultivating talent by gifted researchers in security technology.

- Central Research Laboratories
- Cultivate talent as project leaders, technological architects through exchanges among talented people

Business units (business)

- Public
  - Face recognition technology development center
- Enterprise
- Telecom Carrier
- Smart Energy

System Platform

Business Innovation Unit

- Big Data Strategy Division
- Cyber Security Strategy Division
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Summary

Strengthen core technologies and create solutions with great business potential

- Accelerate concentration of R&D investments on focus areas, double the number of AI researchers
- Strengthen/cultivate talent who would drive business in key domains, such as AI, security

Expand use of open innovation in research on advanced technologies and aim for efficient R&D with a sense of speed

Enhance the value of Solutions for Society to bring growth for NEC
Orchestrating a brighter world

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