

R&D Activities that Drive NEC's Growth

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Orchestrating a brighter world

未来に向かい、人が生きる、SMEで生きるために欠かさないもの。
それは「安全」「安心」「効率」「公平」という価値が実現された社会です。

NFCは、ネットワーク技術とクラウドサービス技術をお互いに持つ

独自のハイブリッドリーダーとしてリーダーシップを築き、

革新的な技術とさまざまな知見やアイデアを融合することによって

世界の国々や地域の人々と連携しながら、

明るく希望に満ちた暮らしと社会を実現し、未来につなげていきます。

Contents

1. NEC's Social Value Creation
2. R&D Activities that Support NEC's Growth
3. Core Technologies that Enhance the Value of Solutions
 - 3.1. AI (Data Science)
 - 3.2. ICT Platform
4. Cutting-Edge R&D Activities into the Future
5. Research Management Toward Further Growth
6. Summary

Contents

1. NEC's Social Value Creation
2. R&D Activities that Support NEC's Growth
3. Core Technologies that enhance the Value of Solutions
 - 3.1. AI (Data Science)
 - 3.2. ICT Platform
4. Cutting-Edge R&D Activities into the Future
5. Research Management Toward Further Growth
6. Summary

NEC's Social Value Creation

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

The Earth in 2050



Japan 2050



Energy demand

1.8 times

Demand for water

1.6 times

Demand for food

1.7 times

Decline in labor force

Infrastructure maintenance

Safety for people

Smart energy



Smart water management



Agricultural ICT



Solutions for enhancing operational efficiency



Diagnosis of infrastructure deterioration



Public safety



Key domains in Social Value Creation

Solutions for society through seven themes for social value creation



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

Internet of Things (IoT)



Broader connections deepen understanding

Social/business transformation (paradigm shift)

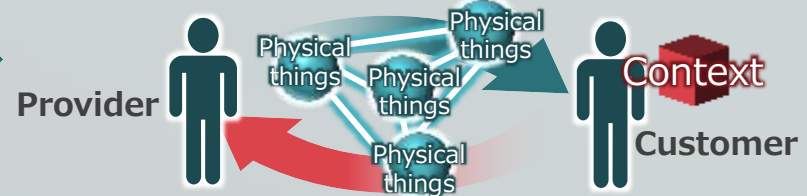
First industrial revolution:
Mass production in light industries

Second industrial revolution:
Mass production in heavy industries

Third industrial revolution: Information
revolution/manufacturing automation

Fourth industrial revolution

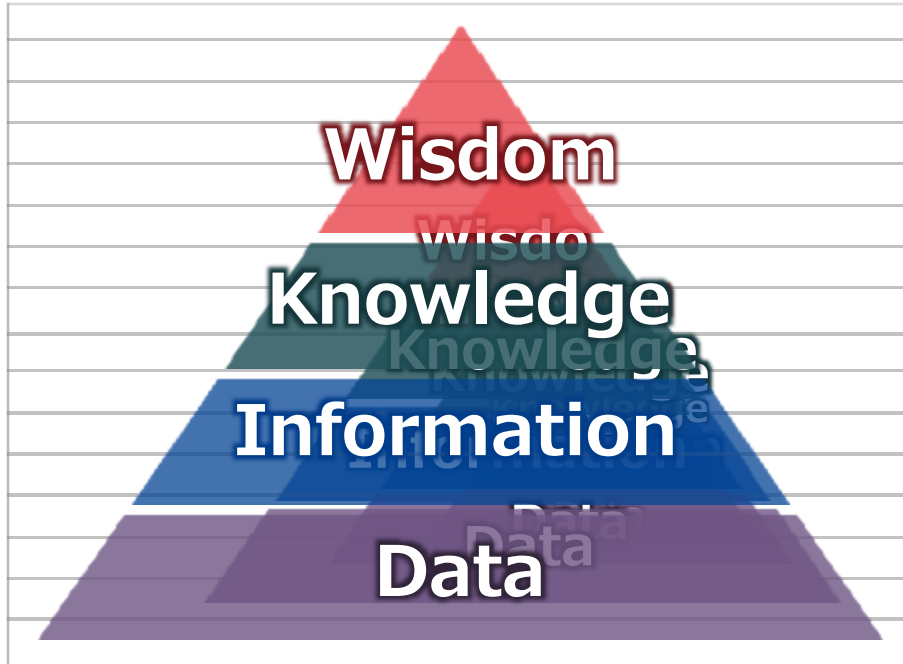
Social transformation, service revolution
Continuous service, work style, customization, etc.



Resolve challenges as connections evolve
and change society

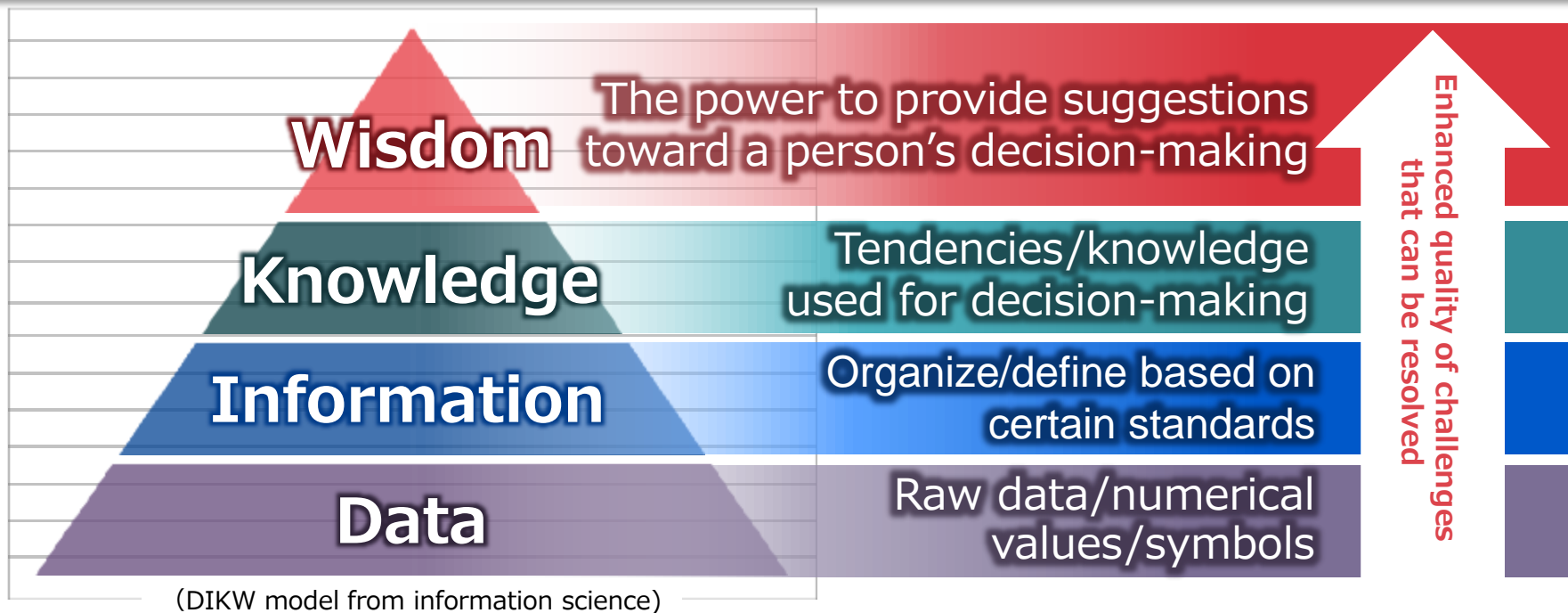
IoT, which is to be the driver for transformation

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



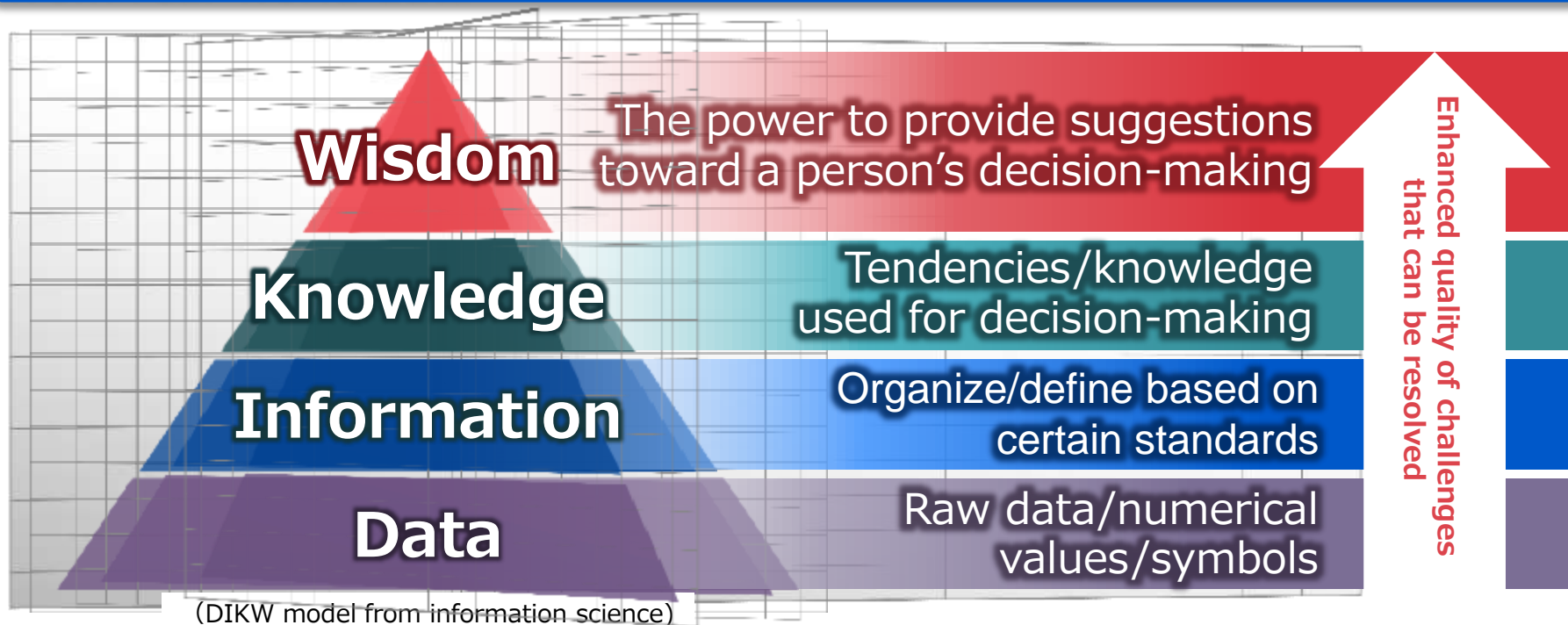
Enhanced ability to resolve challenges by higher level of intelligence

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



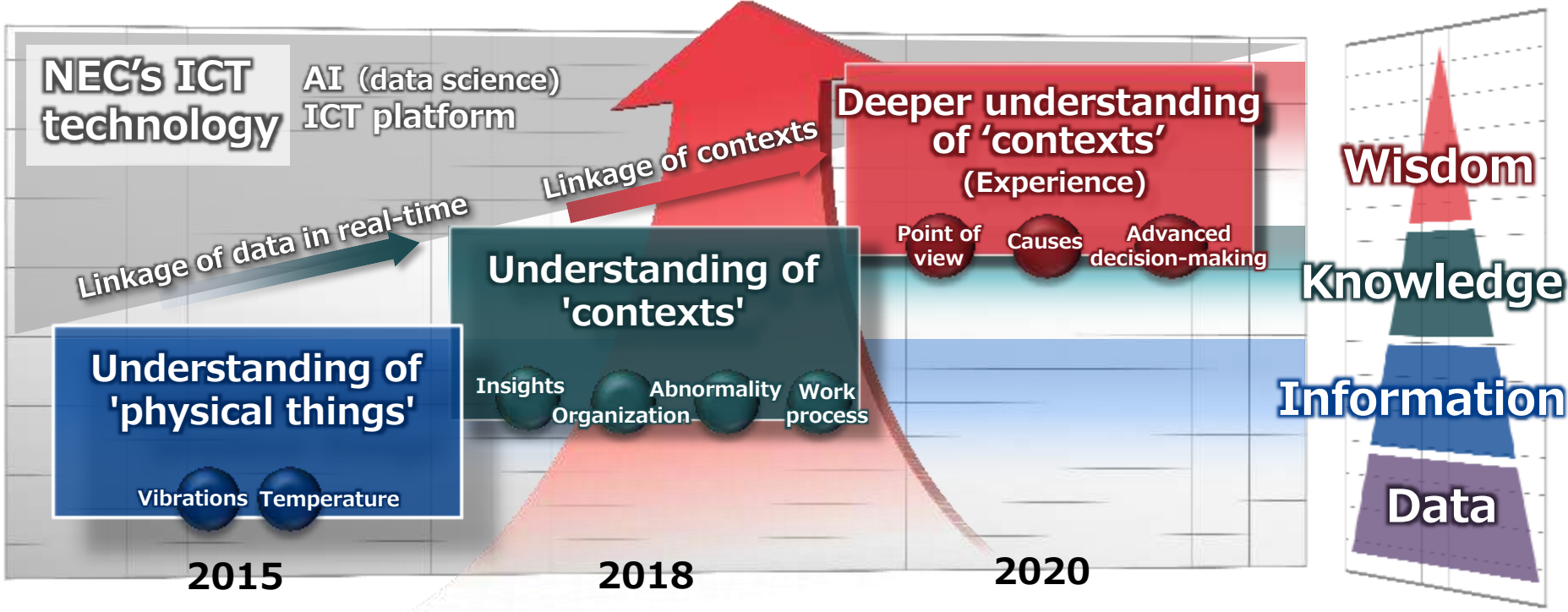
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Social value creation through NEC's ICT technology that enables a deep understanding of physical things in the real world

Value creation  **Safety**  **Security**  **Efficiency**  **Equality**



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

Social value spawned by ICT

Real world



Cyber world

AI (data science)

Visualization

Pervasive Connectivity

Analysis

Augmented Wisdom

Control/Guidance

Service-Oriented Hardware

Adaptive Robotics

ICT Platform

Brain-Inspired Computing

Cloud to the Edge

Holistic Security

Broadening of connections

Continuous service

Super customization

Social value



Safety



Security



Efficiency



Equality

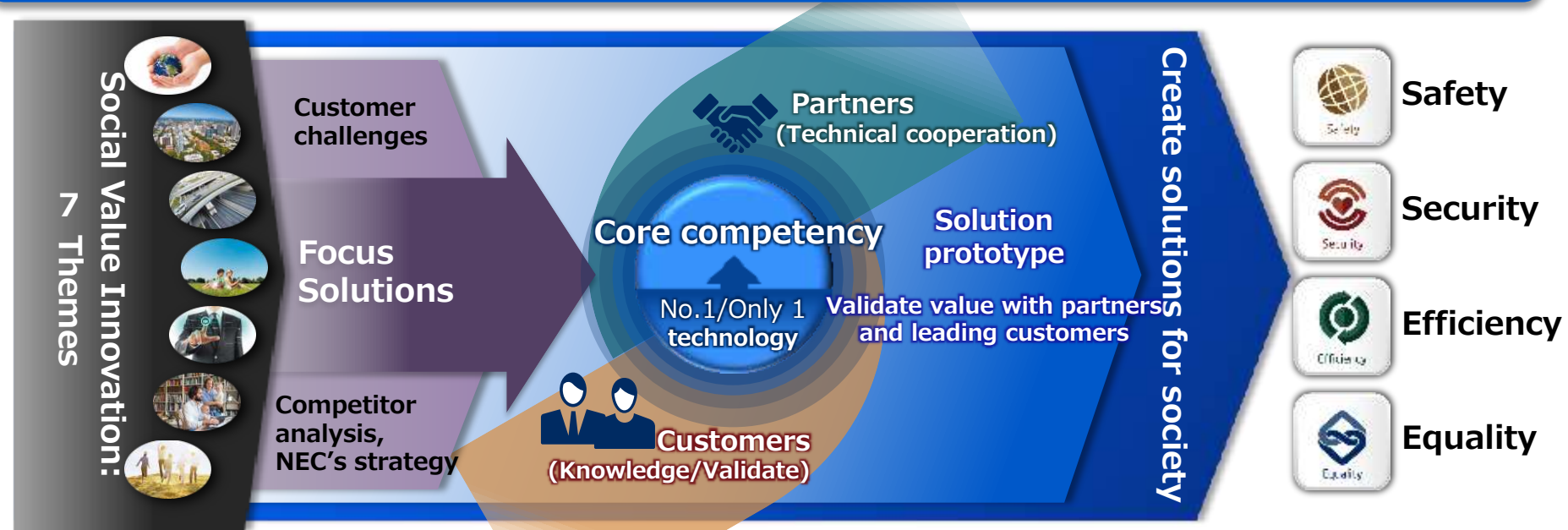
Contents

1. NEC's Social Value Creation
2. R&D Activities that Support NEC's Growth
3. Core Technologies that Enhance the Value of Solutions
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4. Cutting-Edge R&D Activities into the Future
5. Research Management Toward Further Growth
6. Summary

NEC R&D policies for contributing to NEC's growth

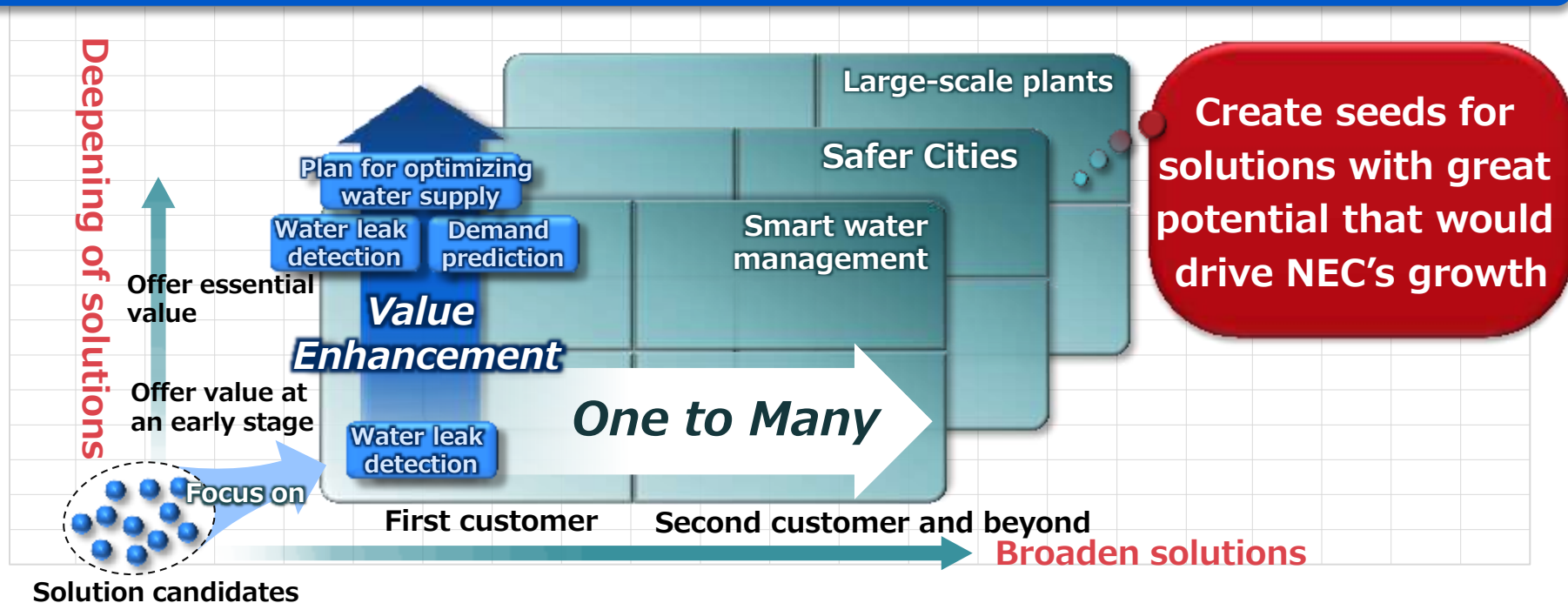
NEC's "Value Co-creation Laboratories" for driving growth

- (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



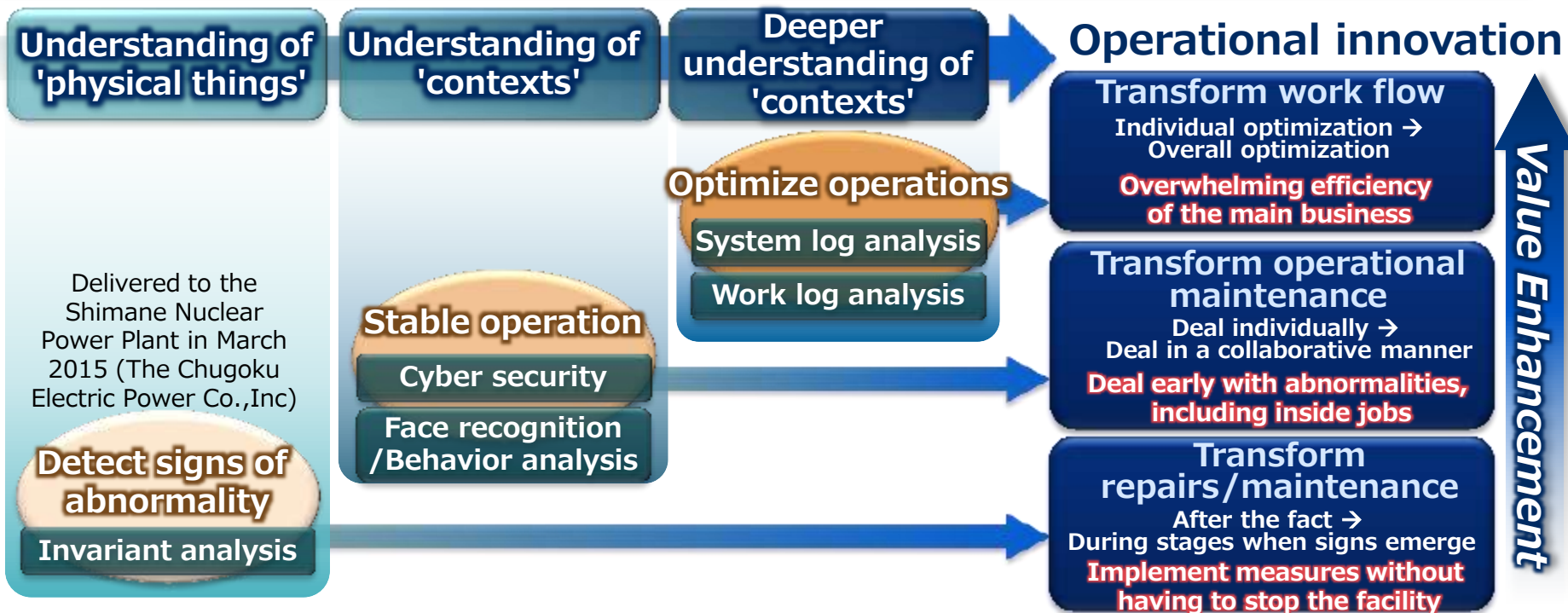
R&D policies toward further growth

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



[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

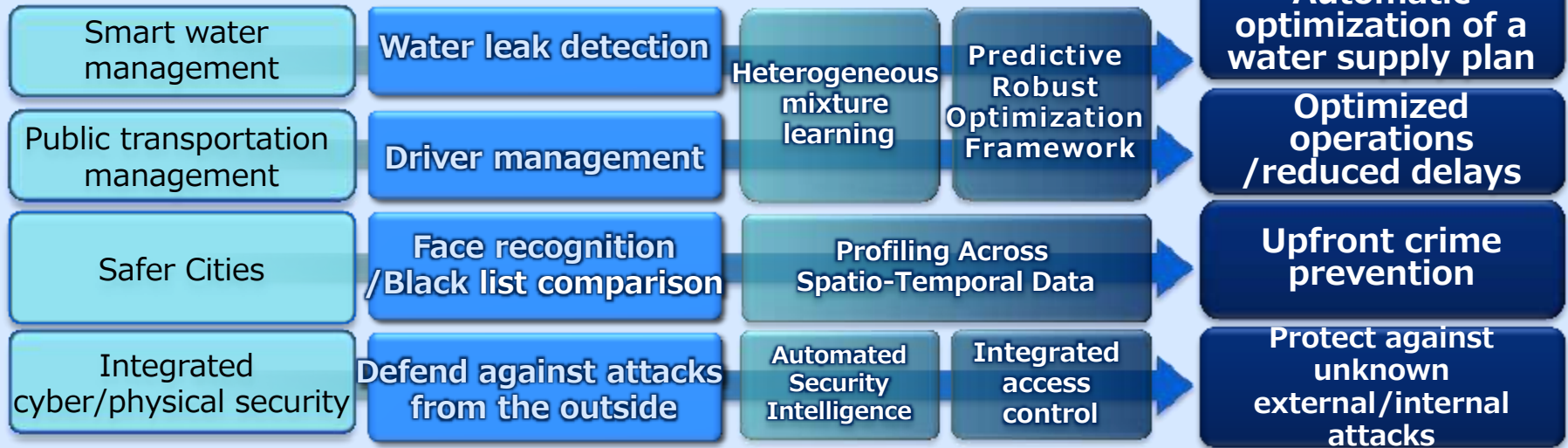


Strengthen solutions with great business potential

Contribute to strengthening NEC's business competitiveness by focusing on activities that reinforce solutions towards businesses with high potentials

Solutions with great business potential

Realize value enhancement by utilizing strong core technologies



Accelerated creation of social solutions through projects

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



Major business achievements (2015)

Seven themes for social value creation

Business track record

No.1/Only 1 technology

Partners/customers

Sustainable Earth

- Technology validation of landslide risk estimation at local authorities both in Japan and overseas

Only 1

Data analysis technology

Town of Tsuwano, Shimane Prefecture

- Established face recognition technology development center and introduced face recognition solutions at airports in Brazil, etc.

No.1

Face recognition

The Department of Federal Revenue of Brazil

- Built Comprehensive Disaster Control System in Toshima Ward

Only 1

Crowd behavior analysis

Toshima-ku, Tokyo

- Validating optimal water supply facilities management in cities and towns in the UK

Only 1

Hybrid sensor

Sutton and East Surrey Water, United Kingdom

- Delivered over 250 SDN systems globally

Only 1

Predictive Robust Optimization Framework

East Japan Railway Company, etc.

- Started offering NEC Industrial IoT, a next-generation manufacturing solution

Only 1

Object fingerprint

Companies participating in NEC's manufacturing co-creation program

- Started offering a solution for predicting demand for repair parts

Only 1

Invariant analysis

NEC Fielding, Ltd

- Released customers' voice analysis solution

No.1

Textual Entailment Recognition

Sumitomo Mitsui Banking Corporation

- 4K terrestrial broadcast test conducted with the largest commercial television broadcaster in Chile

High Speed

Ultra high-resolution compression technology

Chilevision in Chile

※ : Software-Defined Networking

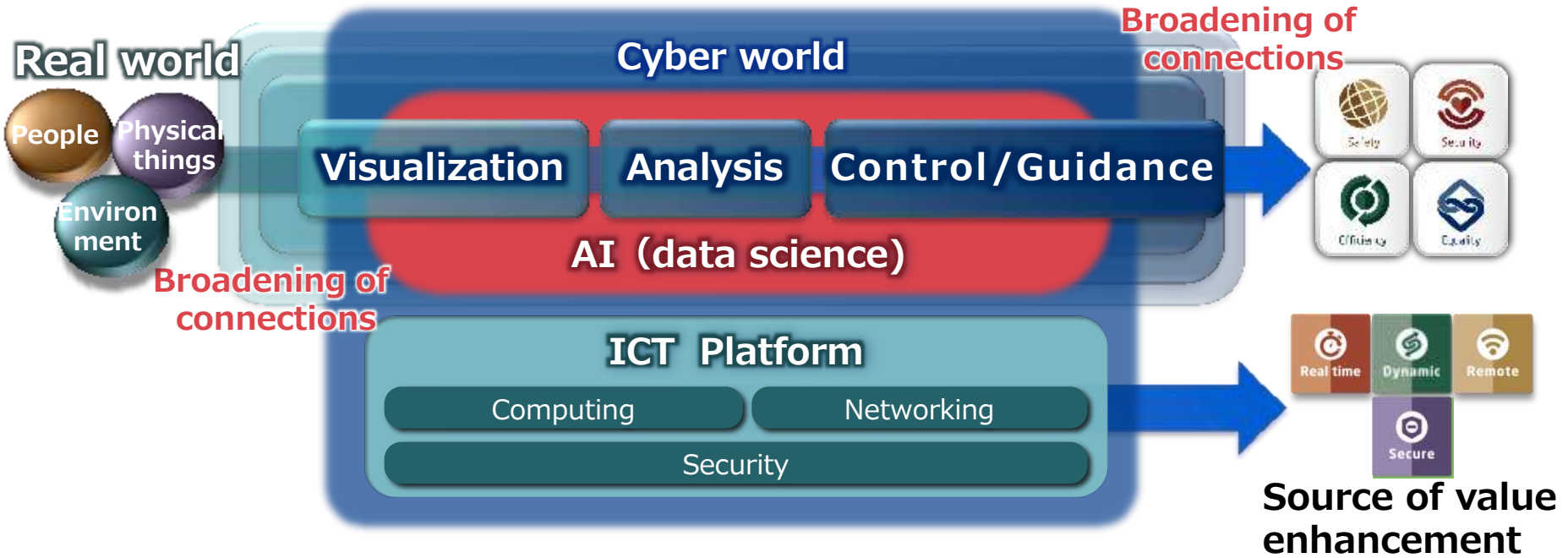
Contents

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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



AI (data science)

Visualization

- No.1^{*1}** Face recognition
 - GLVQ (Quantifying general learning vector)
- Only 1** Self-learning super resolution
- Only 1** Crowd behavior analysis
- Only 1** Object Fingerprint
- Only 1** Optical Vibration Sensing
- No.1 in patent ownership in Japan^{*2}** Speech recognition
- Emotion recognition

Analysis

- Only 1** Invariant analysis
- Only 1** Heterogeneous mixture learning
 - Scent analysis
- No.1^{*3}** Textual Entailment Recognition
- High speed** RAPID machine learning (deep learning)
- High speed** Profiling Across Spatio-Temporal Data

Control/Guidance

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

ICT Platform

Computing

- No.1^{*4}** Vector computing
- First in the world** I/O virtualization (ExpEther)
- Only 1** NanoBridge®
- First in the world** Phase change cooling
- Only 1** CWB^{*5}

Networking

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

Security

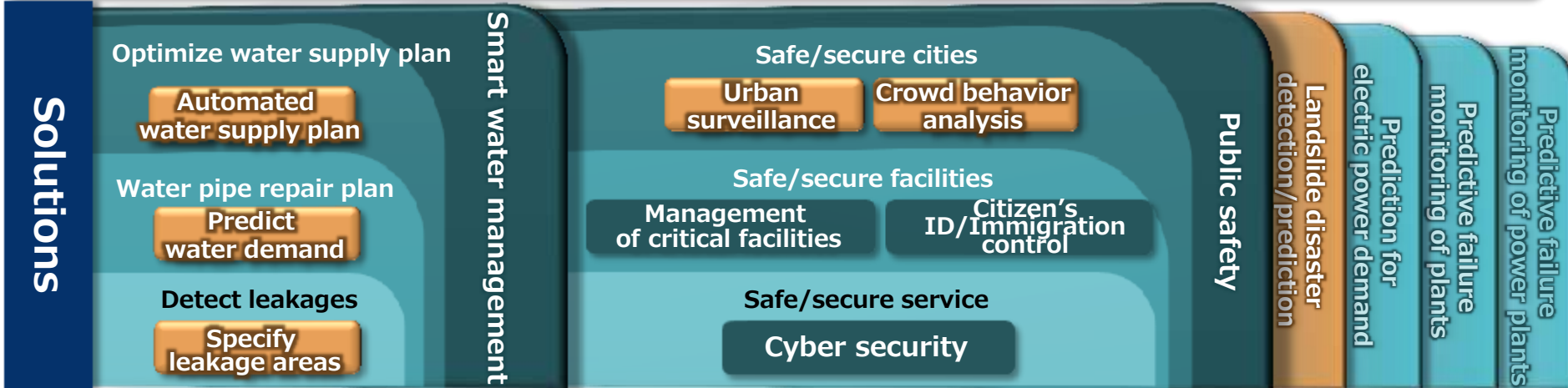
- High speed** authenticated encryption
- First in the world** Secure computing
- Only 1** Automated Security Intelligence
- Integrated access control

*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

Contents

1. NEC's Social Value Creation
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 - 3.1. AI (Data Science)
 - 3.2. ICT Platform
4. Cutting-Edge R&D Activities into the Future
5. Research Management Toward Further Growth
6. Summary

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

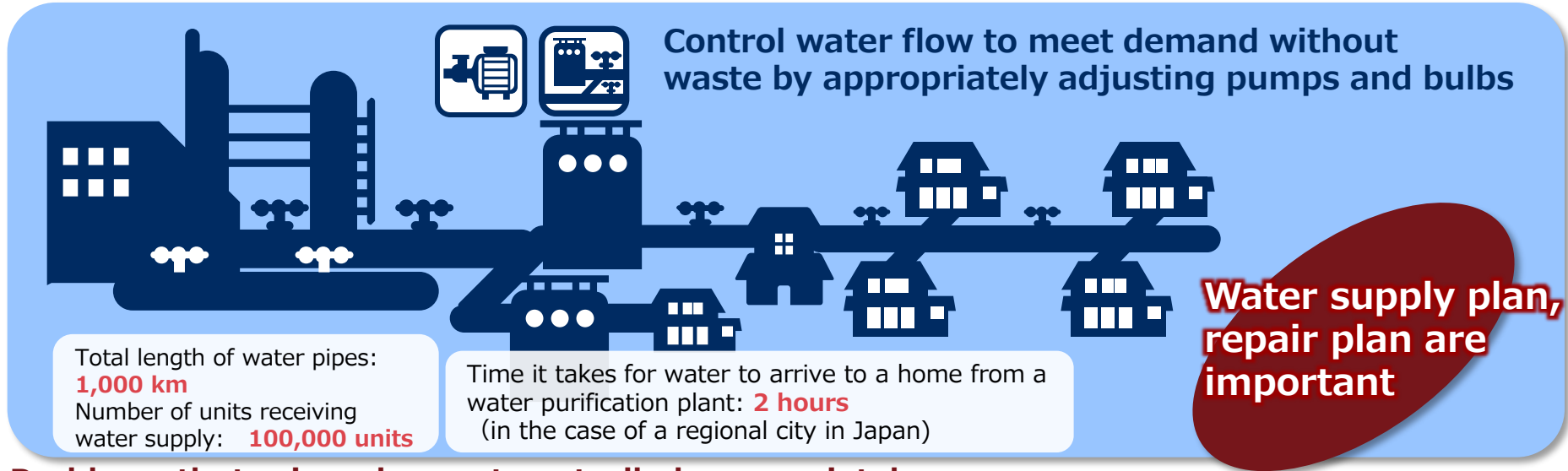


NEC's strong AI technologies

- 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

Case study (1) In pursuit of value enhancement

- Mechanics of water management



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

Visualization

Analysis

Control / Guidance

Operational innovation

Manual water supply plan

2015
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

Optimizing technology for predictive decision-making
(announced on November 2)

2013

Specify leakage areas
Optical vibration Sensing

2014

Predict water demand
Heterogeneous mixture learning

Transform repairs/maintenance

In the order starting with old items
→ in the order of starting with the most deteriorated

An all-out extension of the life of the water supply system

Value Enhancement

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



Electric power costs cut by 20% by prolonging the life of the water supply system

Dynamic pricing



11% improvement in retail store sales (speedily create price strategy in less than one second)

Transport plan for public facilities



Improvement in the number of commuters traveling comfortably without having to wait

Maintenance plan for facilities



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

Early resolution of criminal investigation

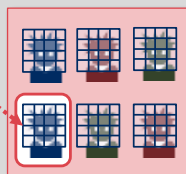
Value Enhancement

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**

Application of technology on Profiling Across Spatio-Temporal Data

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

Future outlook



Classify movements

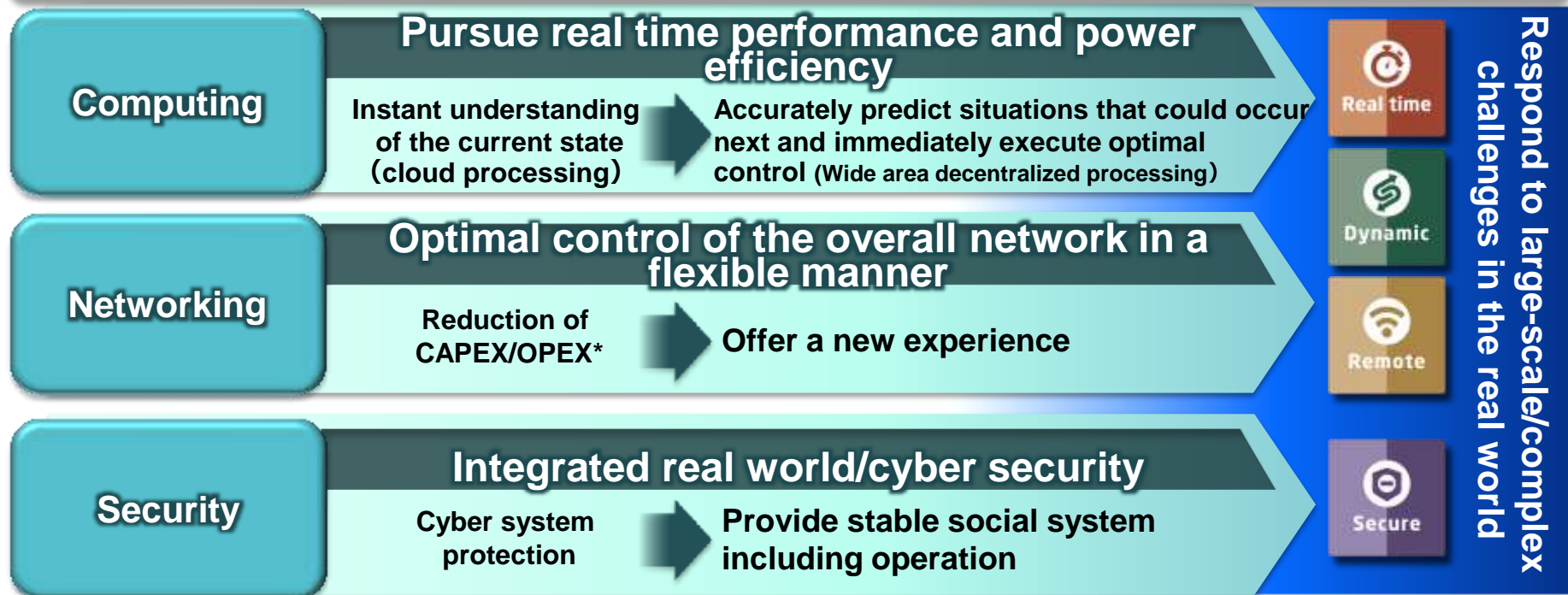
Analyze why a consumer has not purchased an item even when there is interest and then recommend a promotion plan

Contents

1. NEC's Social Value Creation
2. R&D Activities that Support NEC's Growth
3. Core Technologies that Enhance the Value of Solutions
 - 3.1. AI (Data Science)
 - 3.2. ICT Platform
4. Cutting-Edge R&D Activities into the Future
5. Research Management Toward Further Growth
6. Summary

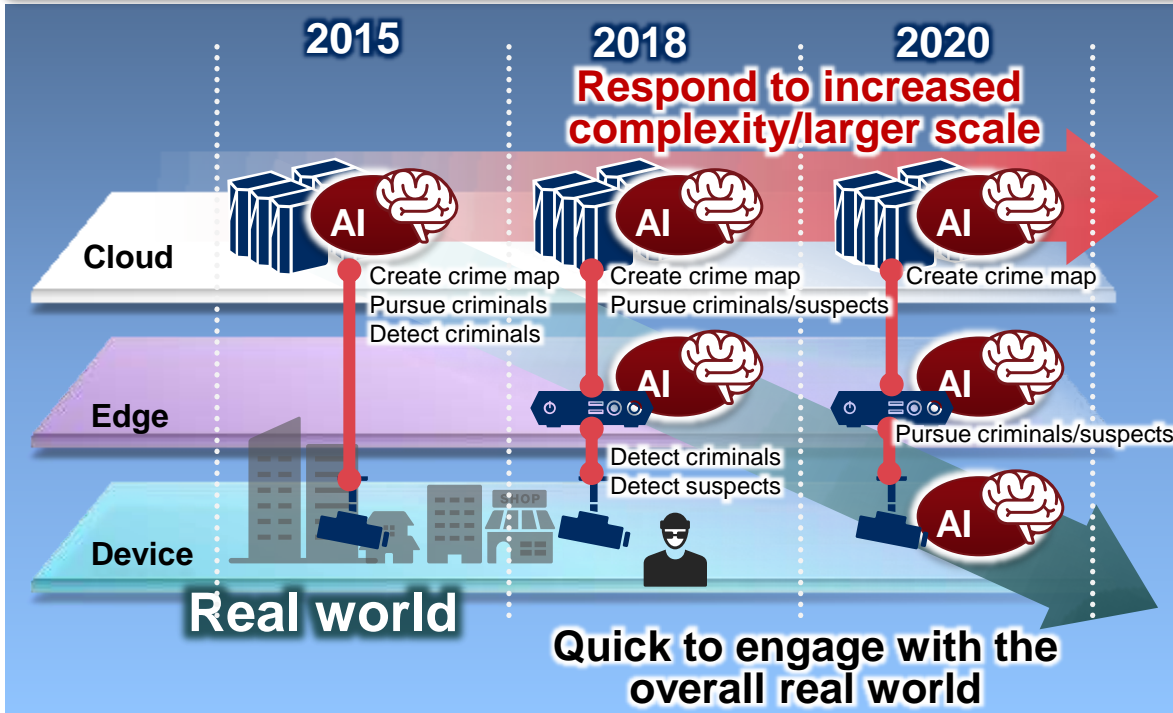
Strengthen platform technologies that support value enhancement

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



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



Optimal structure based on use

Technology utilizing vector processors

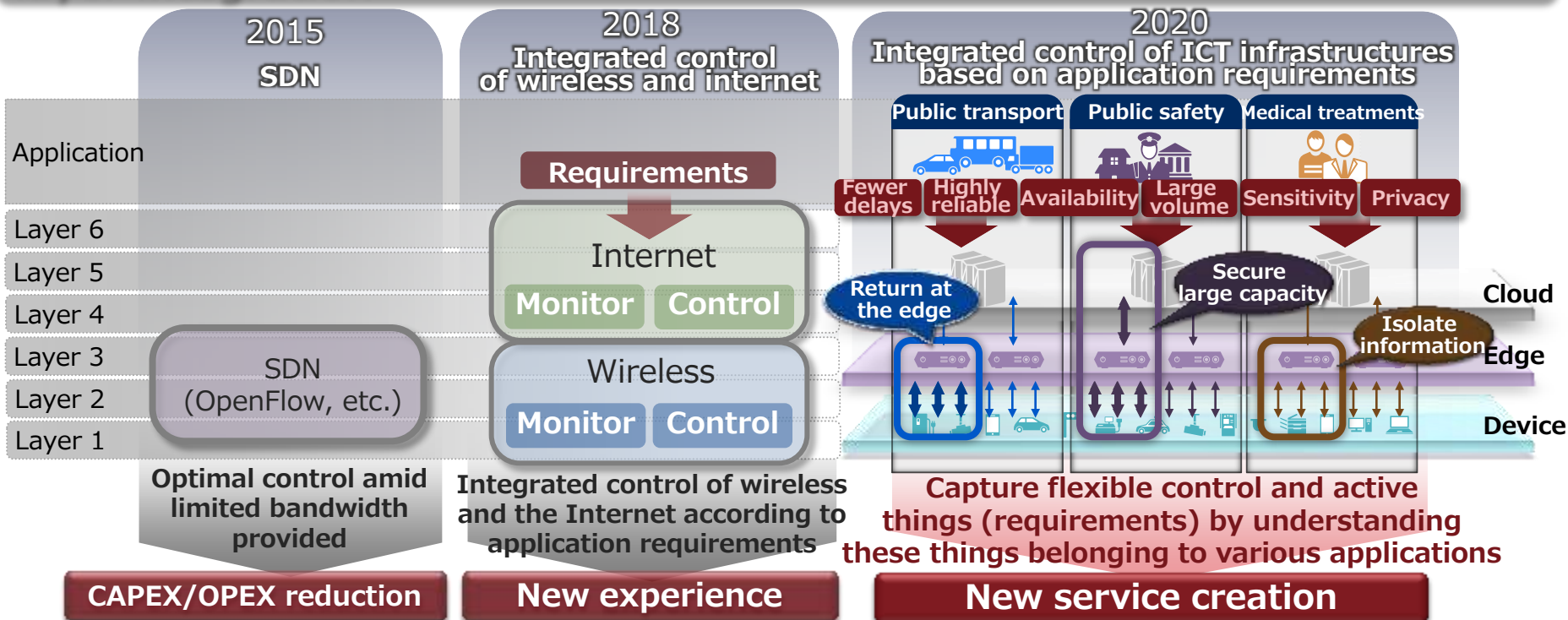
Technology utilizing FPGA*
(CWB: CyberWorkBench)

*Field-Programmable Gate Array

- (1) Large-scale processing in real time
- (2) with low electric power consumption level

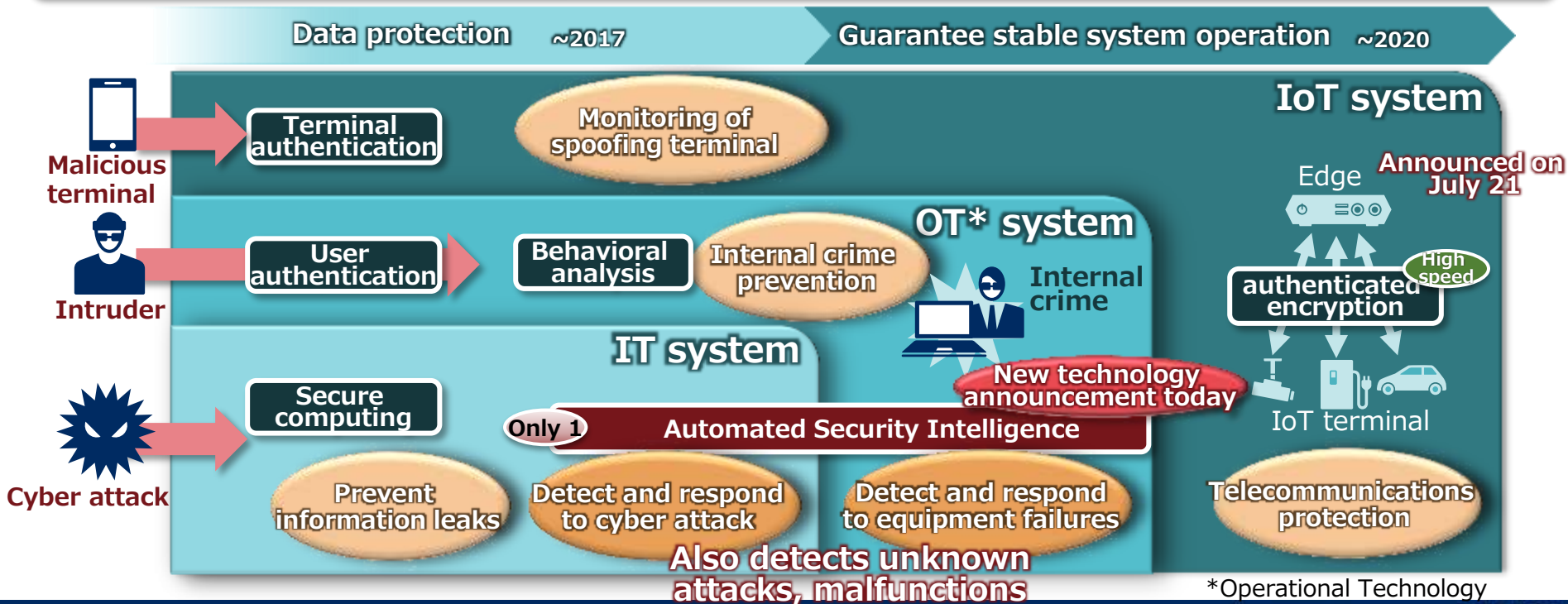
Strengthen networking that supports value enhancement

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



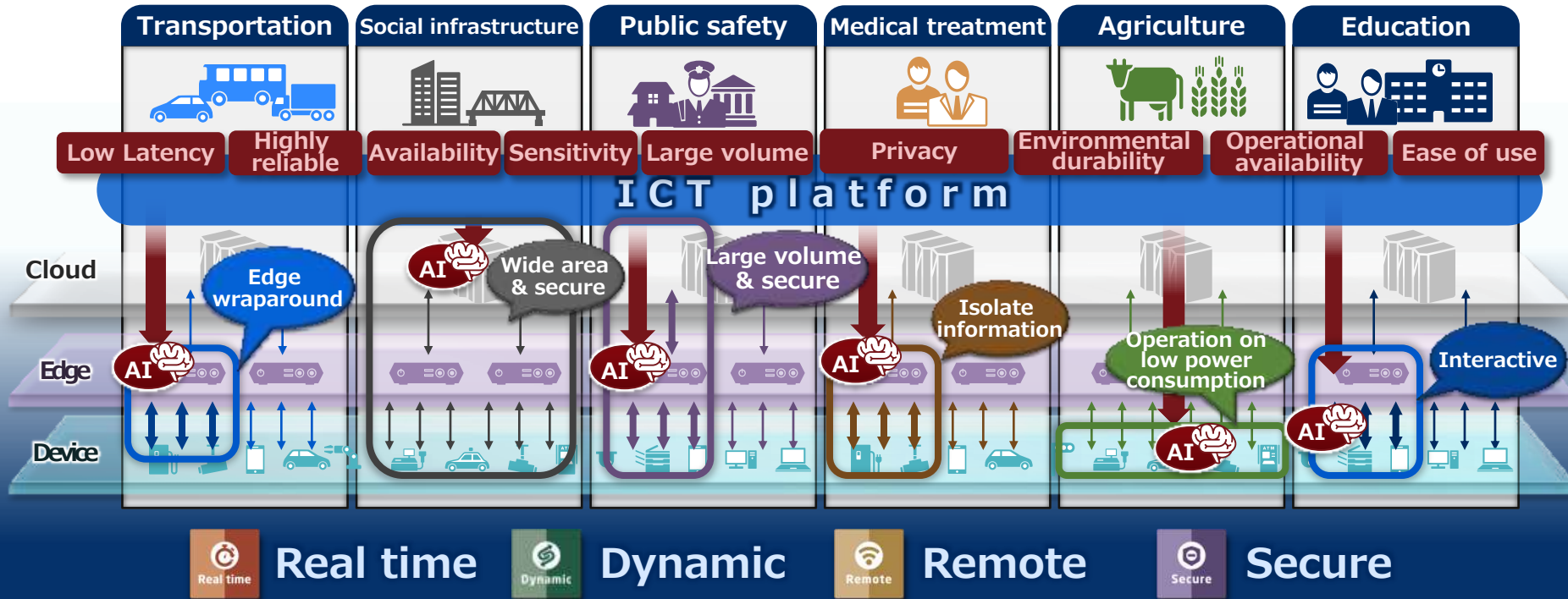
Strengthen security that supports value enhancement

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



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



Contents

1. NEC's Social Value Creation
2. R&D Activities that Support NEC's Growth
3. Core Technologies that Enhance the Value of Solutions
 - 3.1. AI (Data Science)
 - 3.2. ICT Platform
4. Cutting-Edge R&D Activities into the Future
5. Research Management Toward Further Growth
6. Summary

Advanced technology research into the future

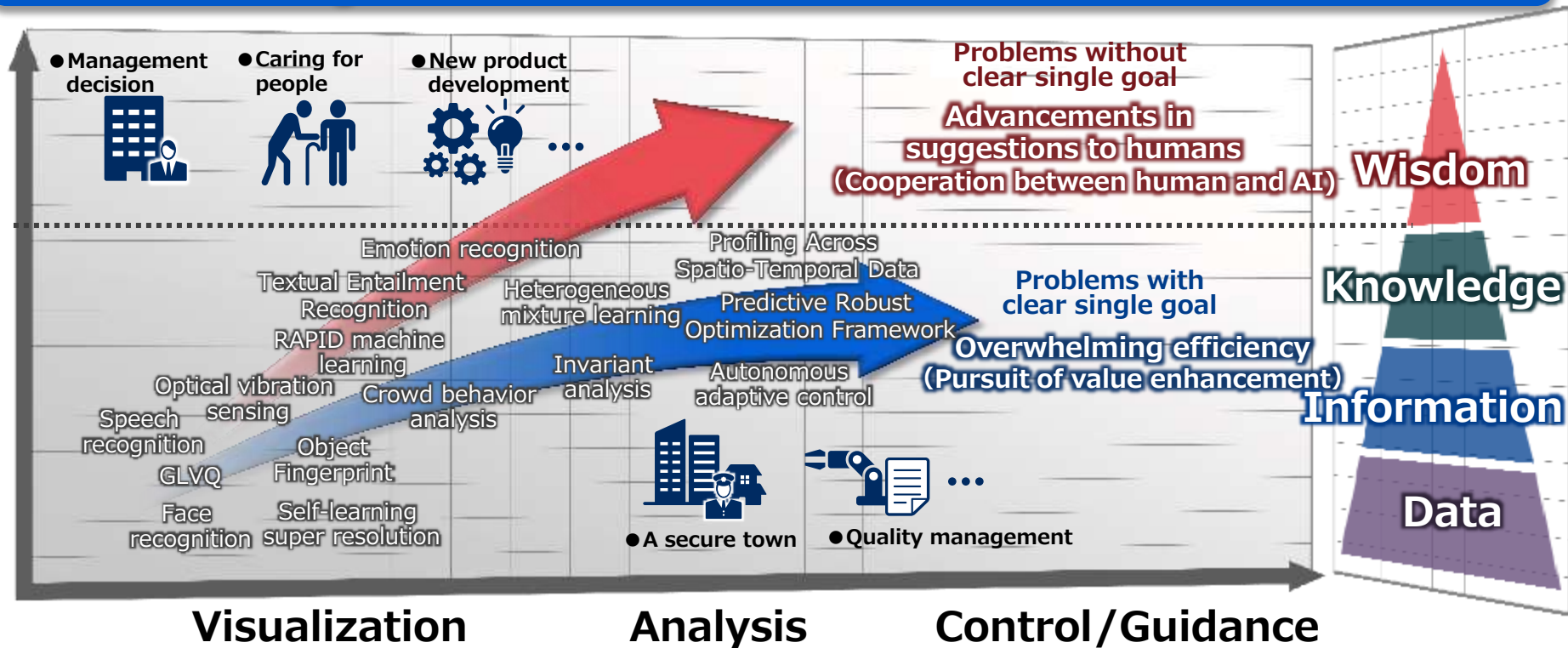
Work on advanced technology that brings about a future breakthrough by rendering the world view of technology and its evolution as well as utilizing open innovation

	To present	2017	2020	2025
Pervasive Connectivity	Things are connected	Contexts are connected		
Augmented Wisdom	Analysis/recognition	Understanding of contexts	Assumption/Decisions	
Service-Oriented Hardware	Utilization of software	Utilization of services		
Adaptive Robotics	Partially operated		Autonomous cooperation	
Brain-Inspired Computing	Left brain work			Right brain work
Cloud to the Edge	Concentrated on data center	Data center/Edge linkage	Deconcentration of function	
Holistic Security	Cyber security	IoT security	Total security	

Secure dominance in the advanced technology area by strengthening open innovation

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

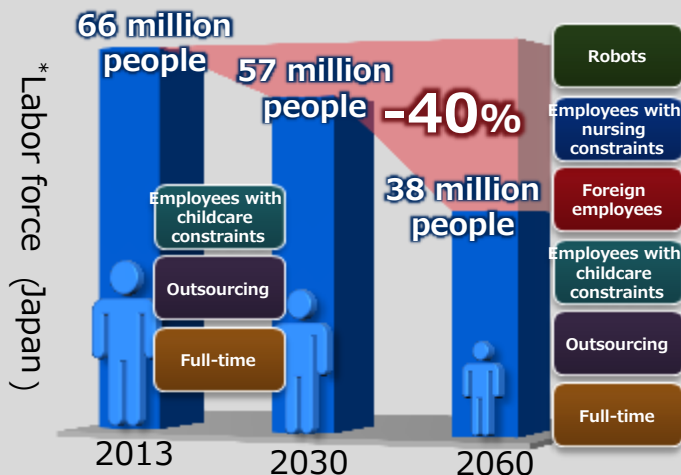
NEC is advancing AI technology by looking at the resolution of social challenges from two sides



Resolving social challenges by coordinating human and AI

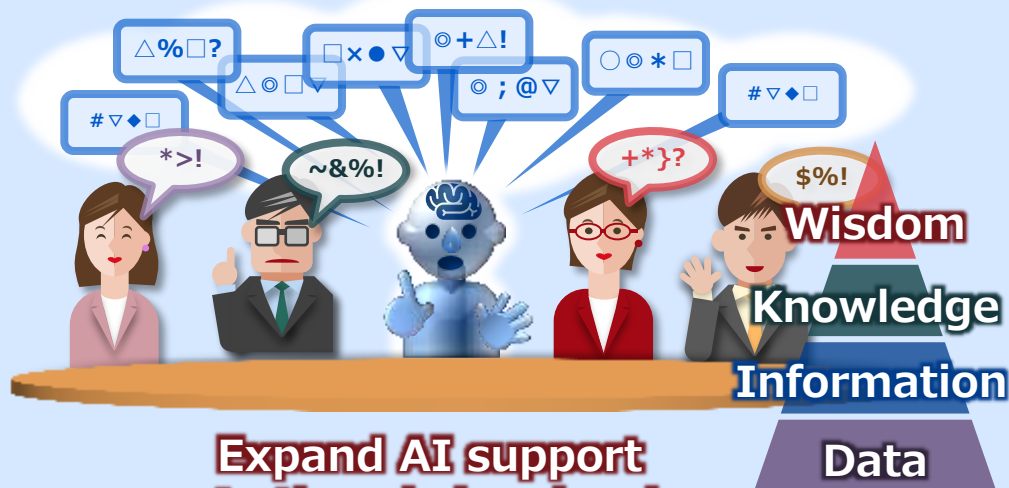
Resolve issues efficiently by using AI that can support human thinking/reasoning to deal with shortage of talent who can deal with social problems that have become increasingly serious/complex

Shortage of talent who can deal with increasingly serious social challenges



Need to utilize diverse labor

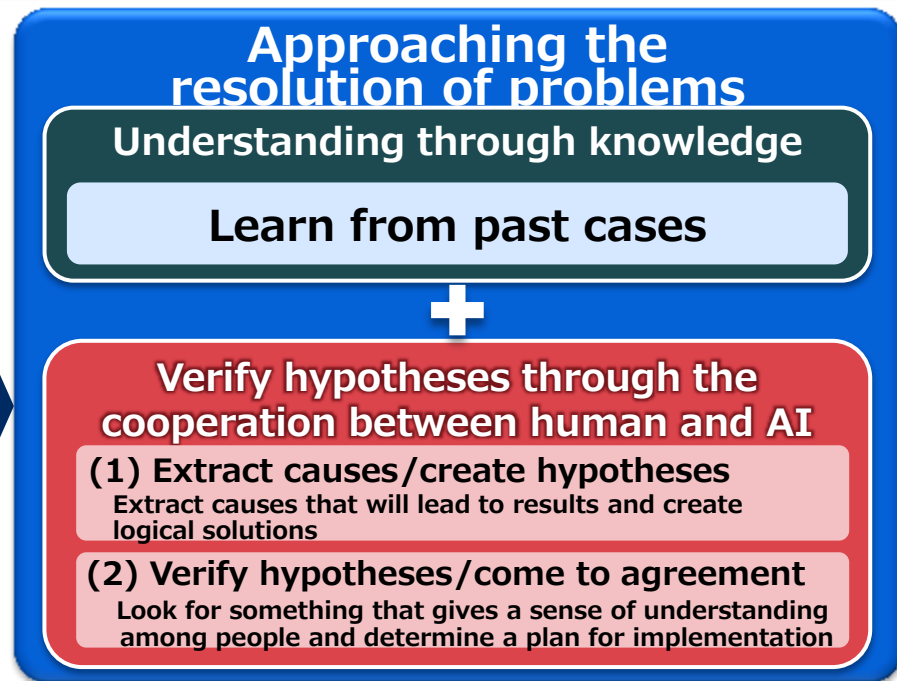
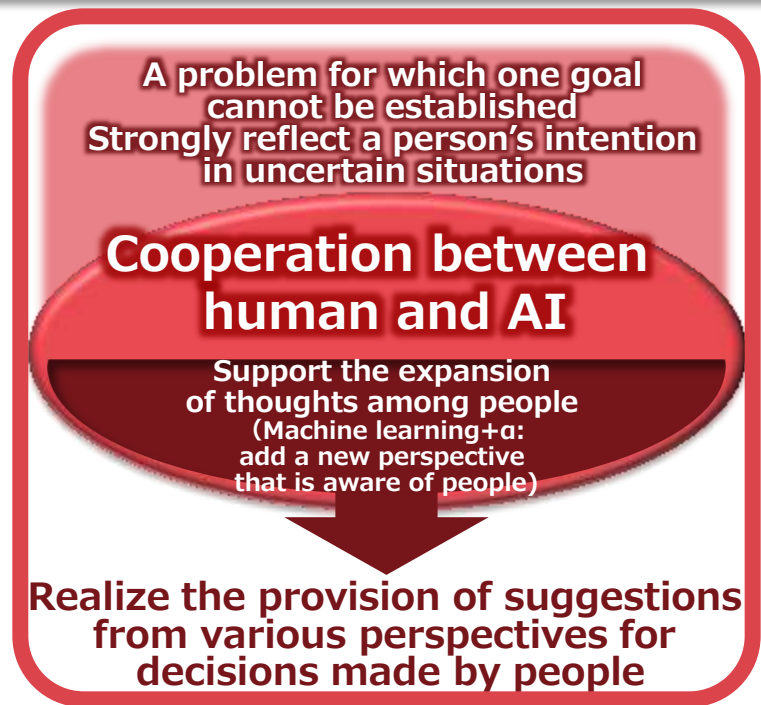
AI to support human thinking/reasoning by suggesting various perspectives



*Projections by the Cabinet Office

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



Applicable places for support at the wisdom level

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

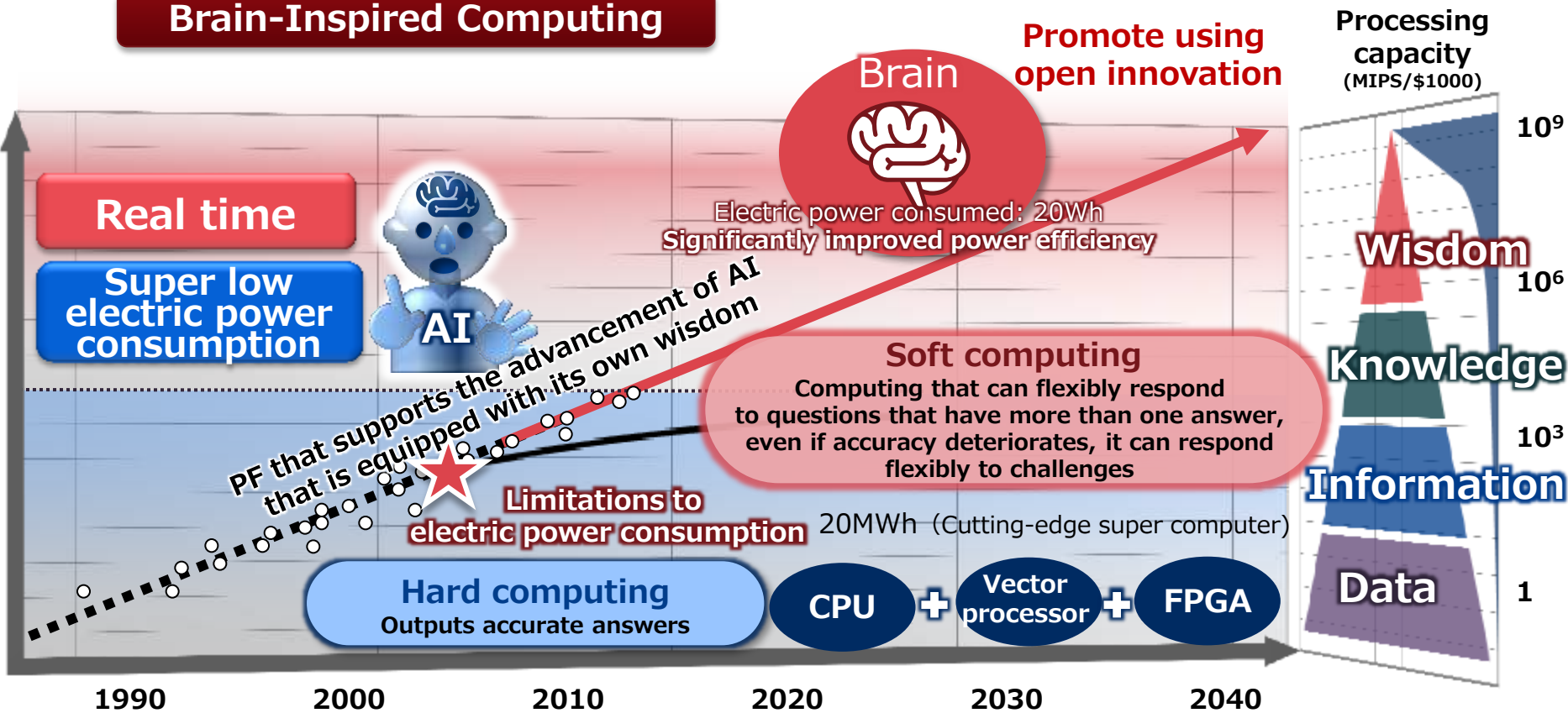
Caring for people



Assist caring for people by respecting the other person's intention

Challenges toward new computing for advanced wisdom level processing

Brain-Inspired Computing

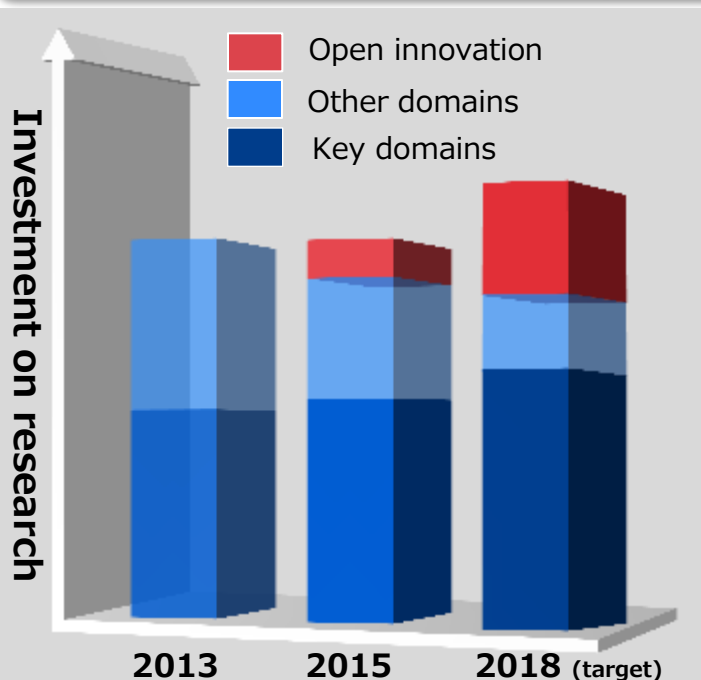


Contents

1. NEC's Social Value Creation
2. R&D Activities that Support NEC's Growth
3. Core Technologies that Enhance the Value of Solutions
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 - 3.2. ICT Platform
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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

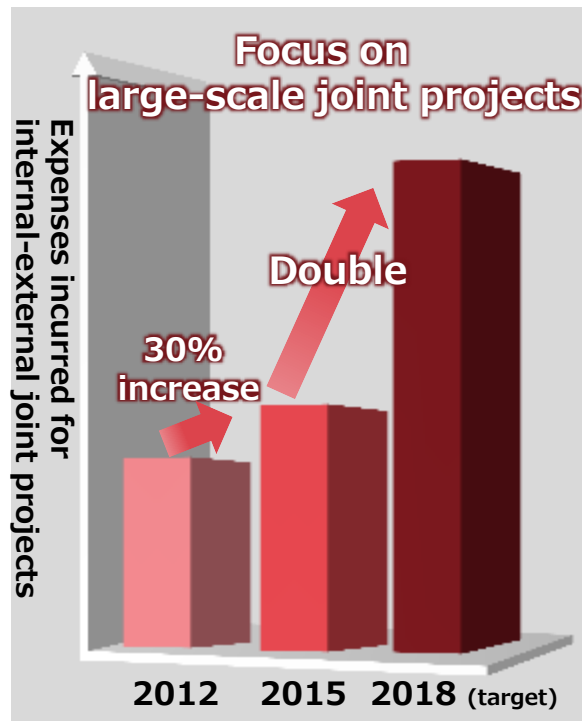
Reinforce hiring of top researchers

Enhance diversity in specialized fields

Focus on key domains

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)

Purpose	Policy on cooperation	Content of cooperation	Contact information
Accelerate implementation of advanced technologies	Cooperate with top universities in the world in target domains	<ul style="list-style-type: none"> Brain inspired computing Human behavior Programmable materials 	<ul style="list-style-type: none"> Osaka University Stanford University MIT Media Lab
Complement core technologies	Complement NEC's strong technology and cooperate with a research organization that has the potential to lead to greater value	<ul style="list-style-type: none"> High-performance/low electric power consumption computing Confidential computing SDN security 	<ul style="list-style-type: none"> Osaka University Bar-Ilan University The Swiss Federal Institute of Technology
Accelerate creation of Solutions for Society	Cooperate with advanced customers, research organizations that are working on major social challenges	<ul style="list-style-type: none"> Smart water management Public transportation management 	<ul style="list-style-type: none"> Sutton and East Surrey Water, UK Imperial College London A bus company in Singapore

Policy on strengthening talent: Strengthen core technologies

Strengthen hiring and cultivating talent to continue creating strong technology in focus areas

Increase the number of researchers working on focus areas Hire Cultivate

Double the number of AI technology researchers



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

Hire researchers with broad view and deep insights Hire

- 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 Hire

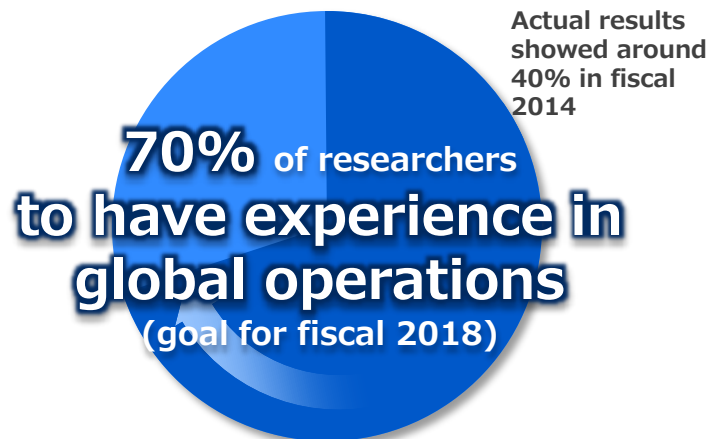
- **Strengthen hiring from fields of math and sciences** who has high potential for data analysis
- **Strengthen recruiting from humanities fields** to achieve problem-solving solutions based on human-AI cooperation

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 Hire Cultivate

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



Strengthen hiring of domain specialists Hire

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

To drive the creation of projects on Solutions for Society

Cultivate
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



Contents

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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

NEC

CAUTIONARY STATEMENTS:

This material contains forward-looking statements pertaining to strategies, financial targets, technology, products and services, and business performance of NEC Corporation and its consolidated subsidiaries (collectively "NEC"). Written forward-looking statements may appear in other documents that NEC files with stock exchanges or regulatory authorities, such as the Director of the Kanto Finance Bureau, and in reports to shareholders and other communications. NEC is relying on certain safe-harbors for forward-looking statements in making these disclosures. Some of the forward-looking statements can be identified by the use of forward-looking words such as "believes," "expects," "may," "will," "should," "seeks," "intends," "plans," "estimates," "targets," "aims," or "anticipates," or the negative of those words, or other comparable words or phrases. You can also identify forward-looking statements by discussions of strategy, beliefs, plans, targets, or intentions. Forward-looking statements necessarily depend on currently available assumptions, data, or methods that may be incorrect or imprecise and NEC may not be able to realize the results expected by them. You should not place undue reliance on forward-looking statements, which reflect NEC's analysis and expectations only. Forward-looking statements are not guarantees of future performance and involve inherent risks and uncertainties. A number of important factors could cause actual results to differ materially from those in the forward-looking statements. Among the factors that could cause actual results to differ materially from such statements include (i) global economic conditions and general economic conditions in NEC's markets, (ii) fluctuating demand for, and competitive pricing pressure on, NEC's products and services, (iii) NEC's ability to continue to win acceptance of NEC's products and services in highly competitive markets, (iv) NEC's ability to expand into foreign markets, such as China, (v) regulatory change and uncertainty and potential legal liability relating to NEC's business and operations, (vi) NEC's ability to restructure, or otherwise adjust, its operations to reflect changing market conditions, (vii) movement of currency exchange rates, particularly the rate between the yen and the U.S. dollar, (viii) the impact of unfavorable conditions or developments, including share price declines, in the equity markets which may result in losses from devaluation of listed securities held by NEC, and (iv) impact of any regulatory action or legal proceeding against NEC. Any forward-looking statements speak only as of the date on which they are made. New risks and uncertainties come up from time to time, and it is impossible for NEC to predict these events or how they may affect NEC. NEC does not undertake any obligation to update or revise any of the forward-looking statements, whether as a result of new information, future events, or otherwise.

The management targets included in this material are not projections, and do not represent management's current estimates of future performance. Rather, they represent targets that management will strive to achieve through the successful implementation of NEC's business strategies.

Finally, NEC cautions you that the statements made in this material are not an offer of securities for sale. Securities may not be offered or sold in any jurisdiction in which required registration is absent or an exemption from registration under the applicable securities laws is not granted.

Note: The consolidated financial statements in this presentation have been prepared in conformity with the Japanese GAAP. In this presentation, the accounting periods of the fiscal years for March 31, 2014 and 15 were referred as FY14/3 and FY15/3 respectively. Any other fiscal years would be referred similarly.