Empowered by Innovation NEC

NEC's Research & Development

Katsumi Emura

Associate Senior Vice President &

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NEC Corporation

December 5, 2012

- Environmental Recognition
- R&D Strategies
- R&D Activities Contributing to the C&C Cloud
  - ① Big Data Analytics
  - ② Software-Defined Networking (SDN）
  - ③ Real-World Data Processing
  - ④ Security
  - ⑤ Smart Energy
- Promoting R&D Activities to Contribute to NEC's Growth

- **Environmental Recognition**
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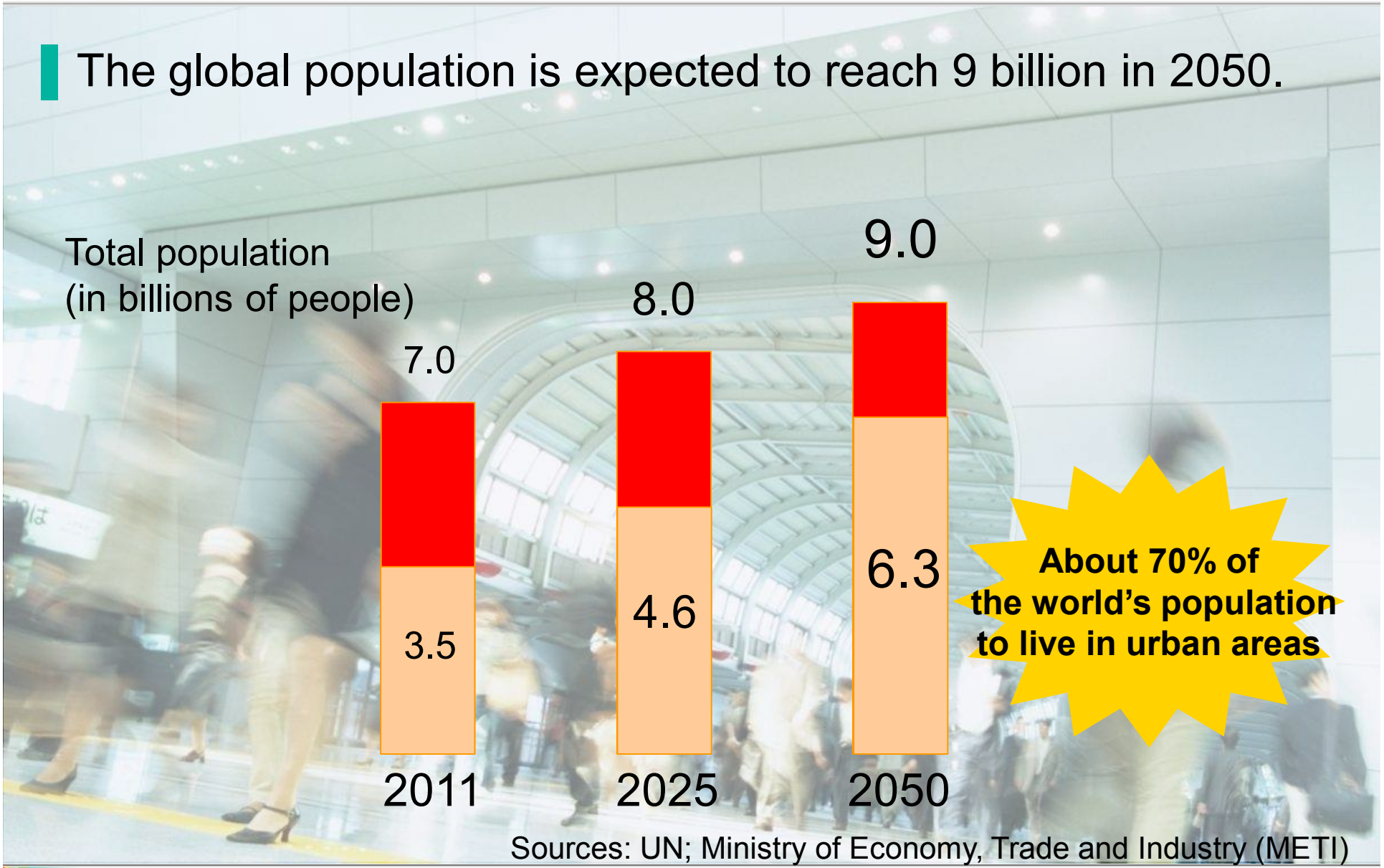
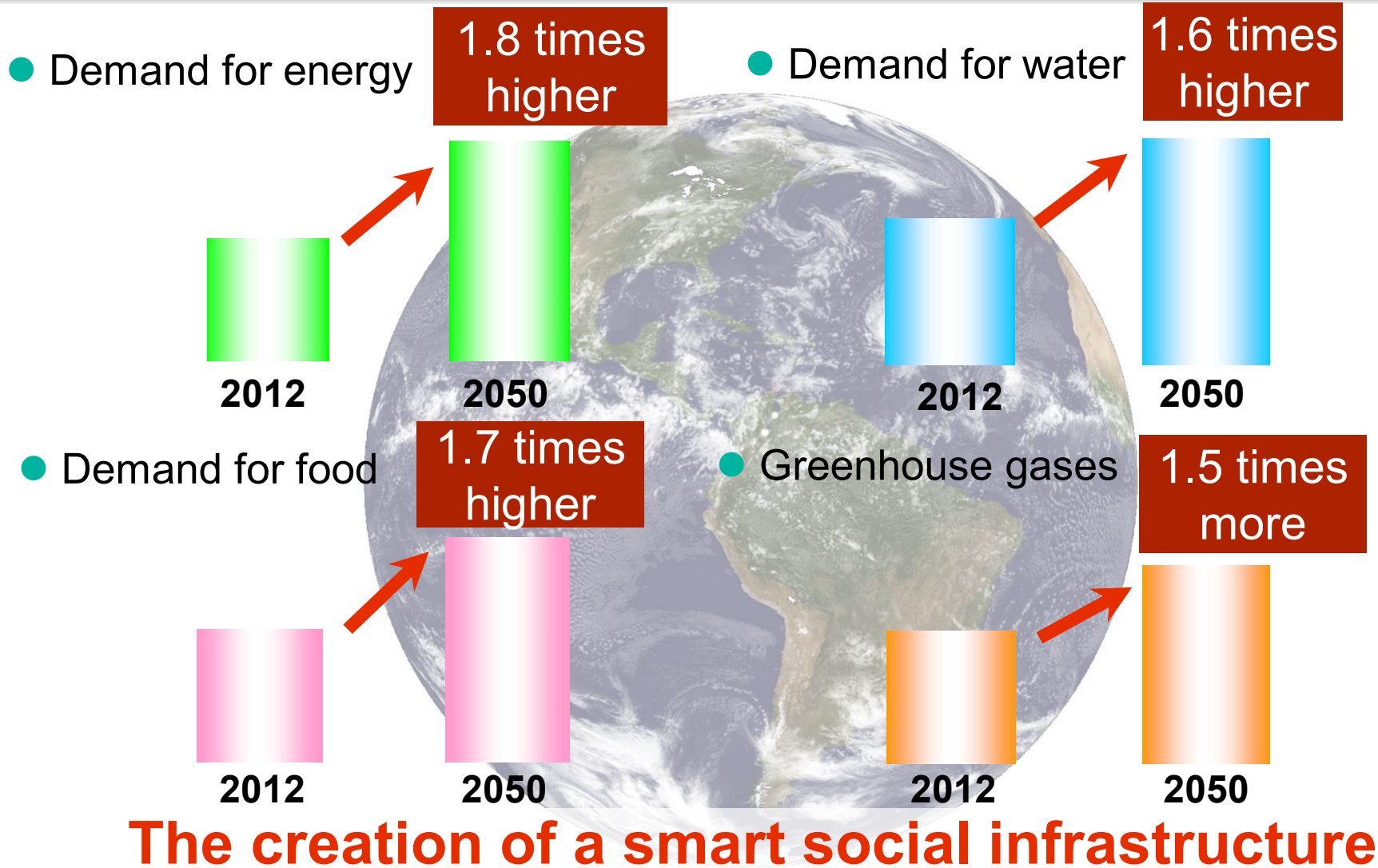
Major Environmental Changes:
Rapid Rise in the Global Population and Growth of Urbanization

The global population is expected to reach 9 billion in 2050.



Sources: UN; Ministry of Economy, Trade and Industry (METI)

Global Issues in 2050

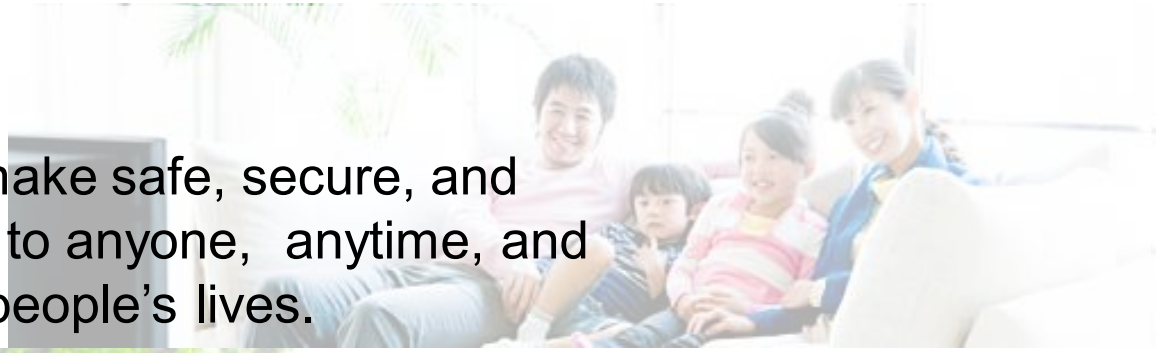


The creation of a smart social infrastructure based on ICT is imperative.

Sources: FAO, OECD

NEC Group Vision 2017

To be a leading global company
leveraging the power of innovation
to realize an information society
friendly to humans and the earth



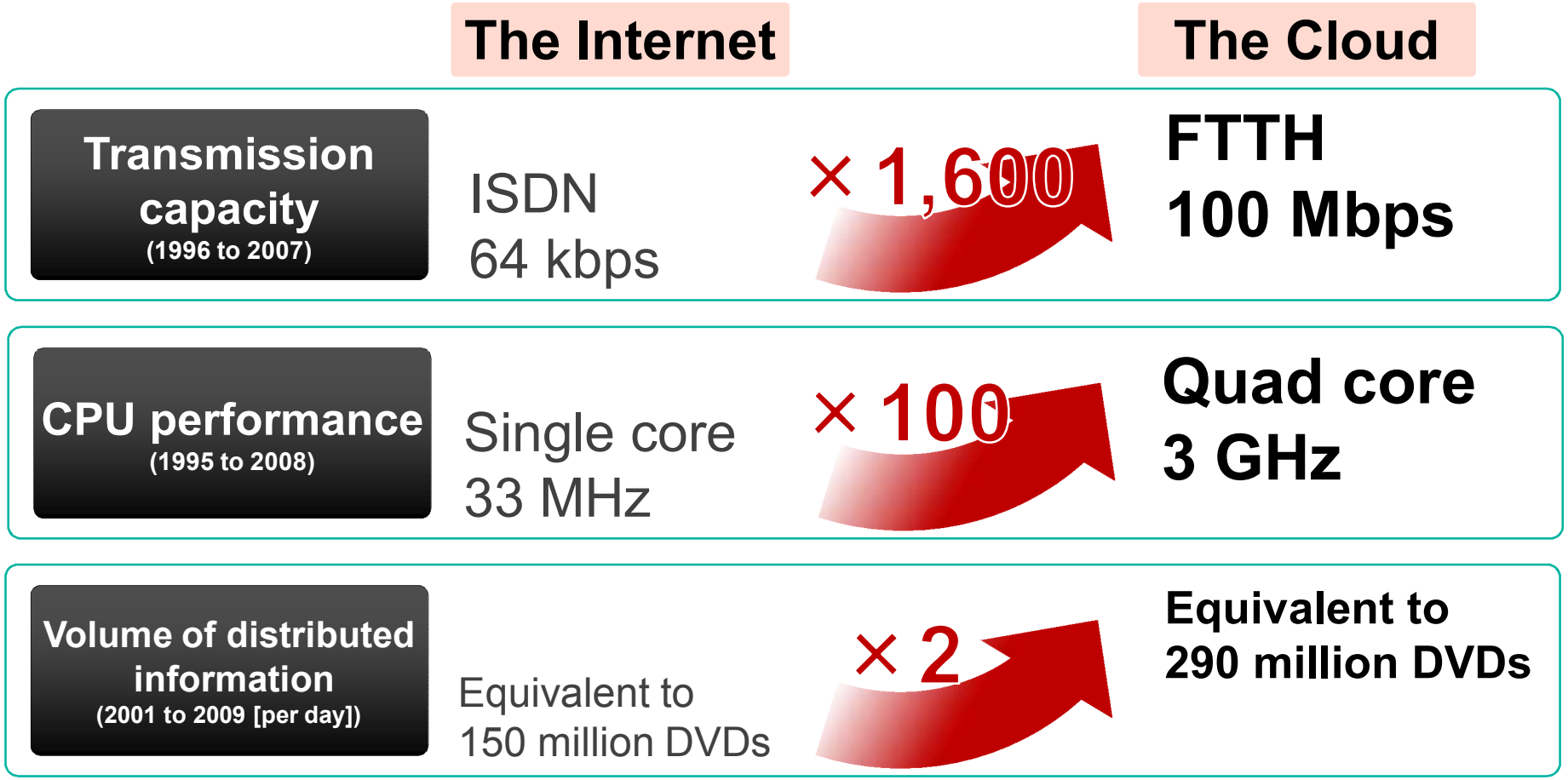
Friendly to humans

The power of ICT is used to make safe, secure, and convenient services available to anyone, anytime, and anywhere, thereby enriching people's lives.

Friendly to the earth

The power of ICT is used to enable efficient utilization of limited resources, co-existence with the global environment, and sustainable development.

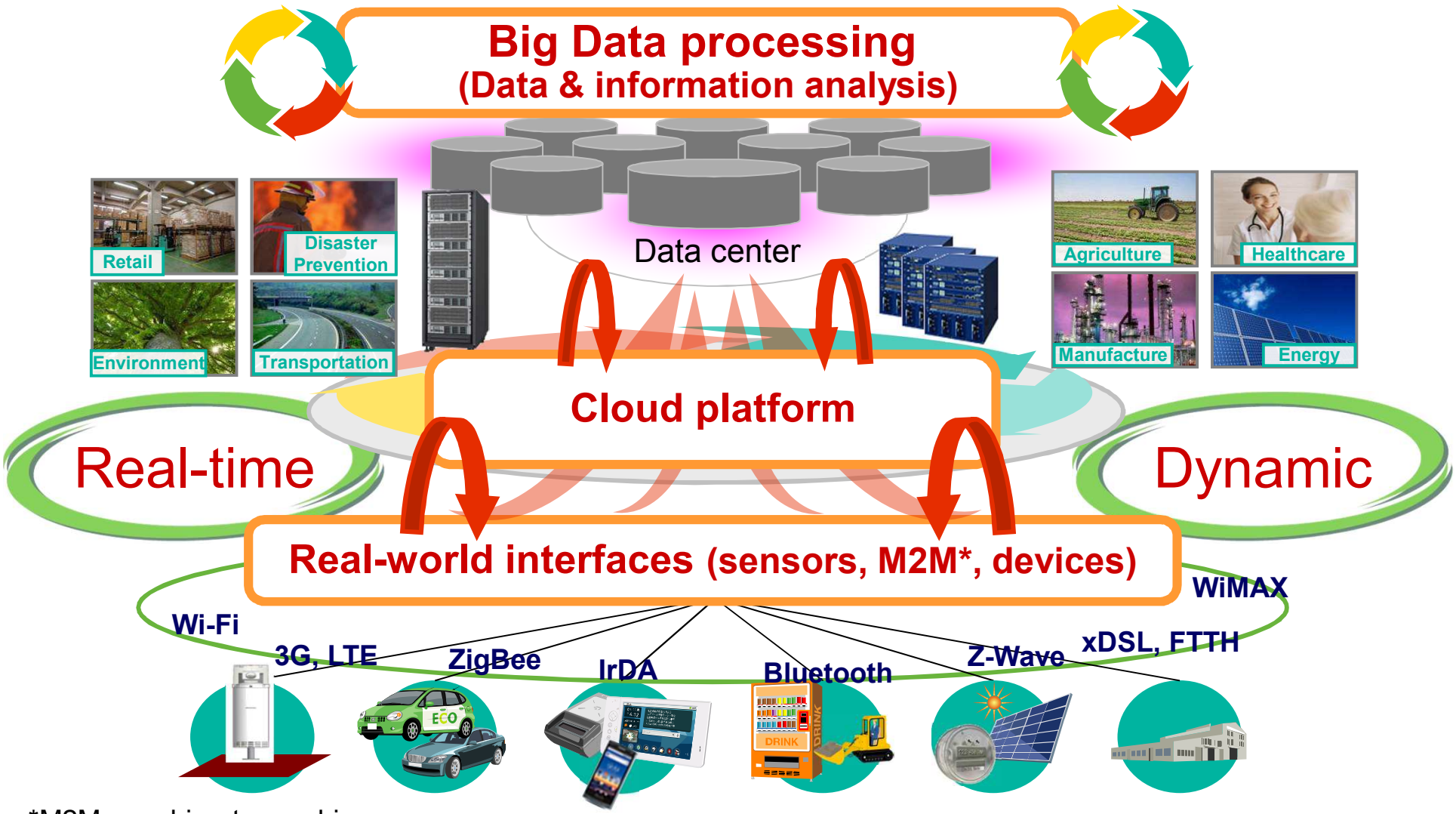
ICT Development and Information Explosion



The volume of information distributed over systems rapidly increased with the advancement and enhancement of ICT infrastructure.

⇒ An environment for creating value through Big Data was established.

Our Vision: The C&C Cloud (Next-Generation ICT Systems)



*M2M: machine-to-machine

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Central Research Labs' Mission, Operating Policy, and Vision

Mission

As a key growth engine for the NEC Group…

We create technological innovations to generate future business.

We continue to create innovations for significant expansion of current business.

Operation policy & vision

Leading-edge research achievements

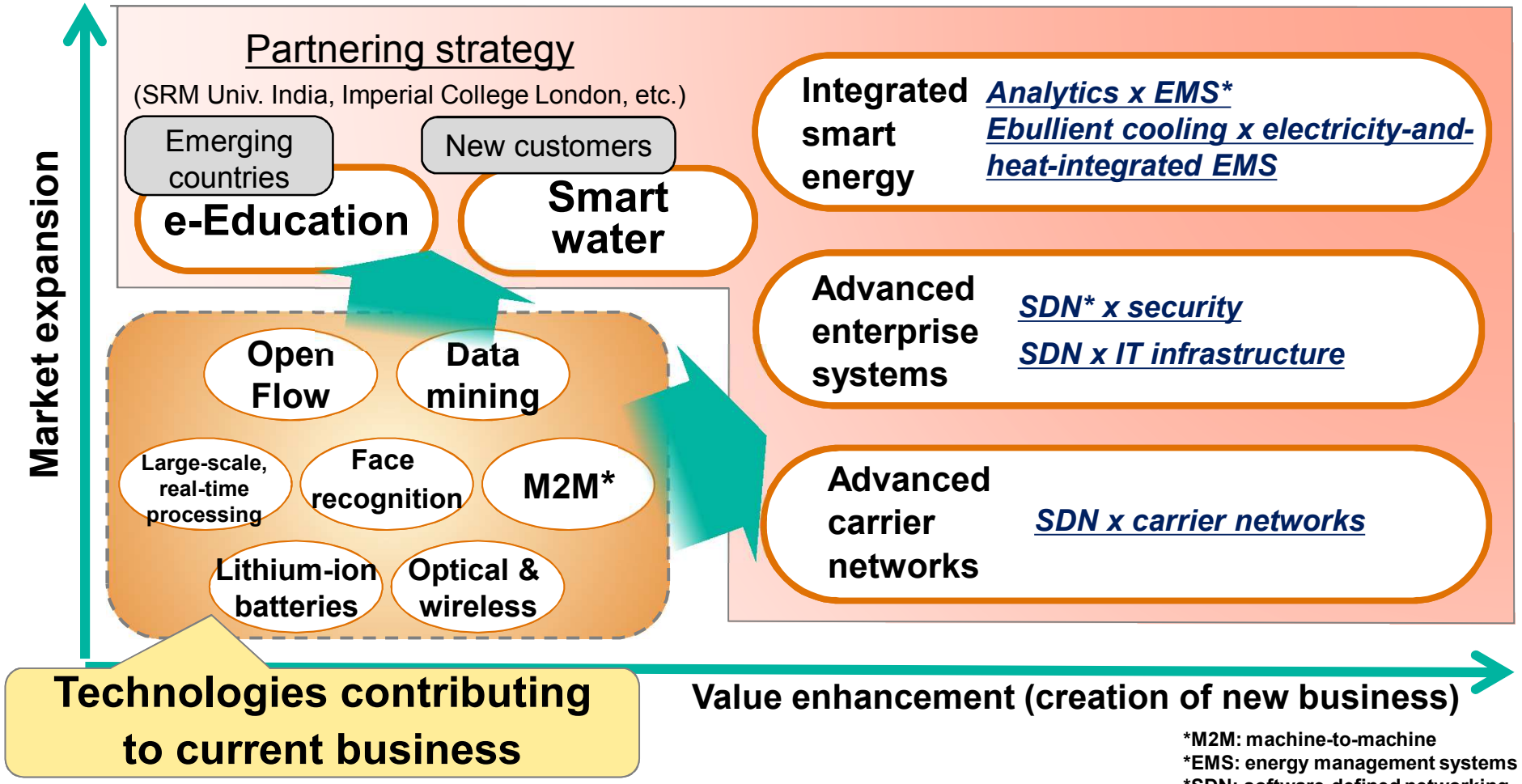
- Big Data processing
- Cloud platforms
- Real-world interfaces

Create new value with customers.

Contribute to new business creation and global business development.

Contributing to Business Growth

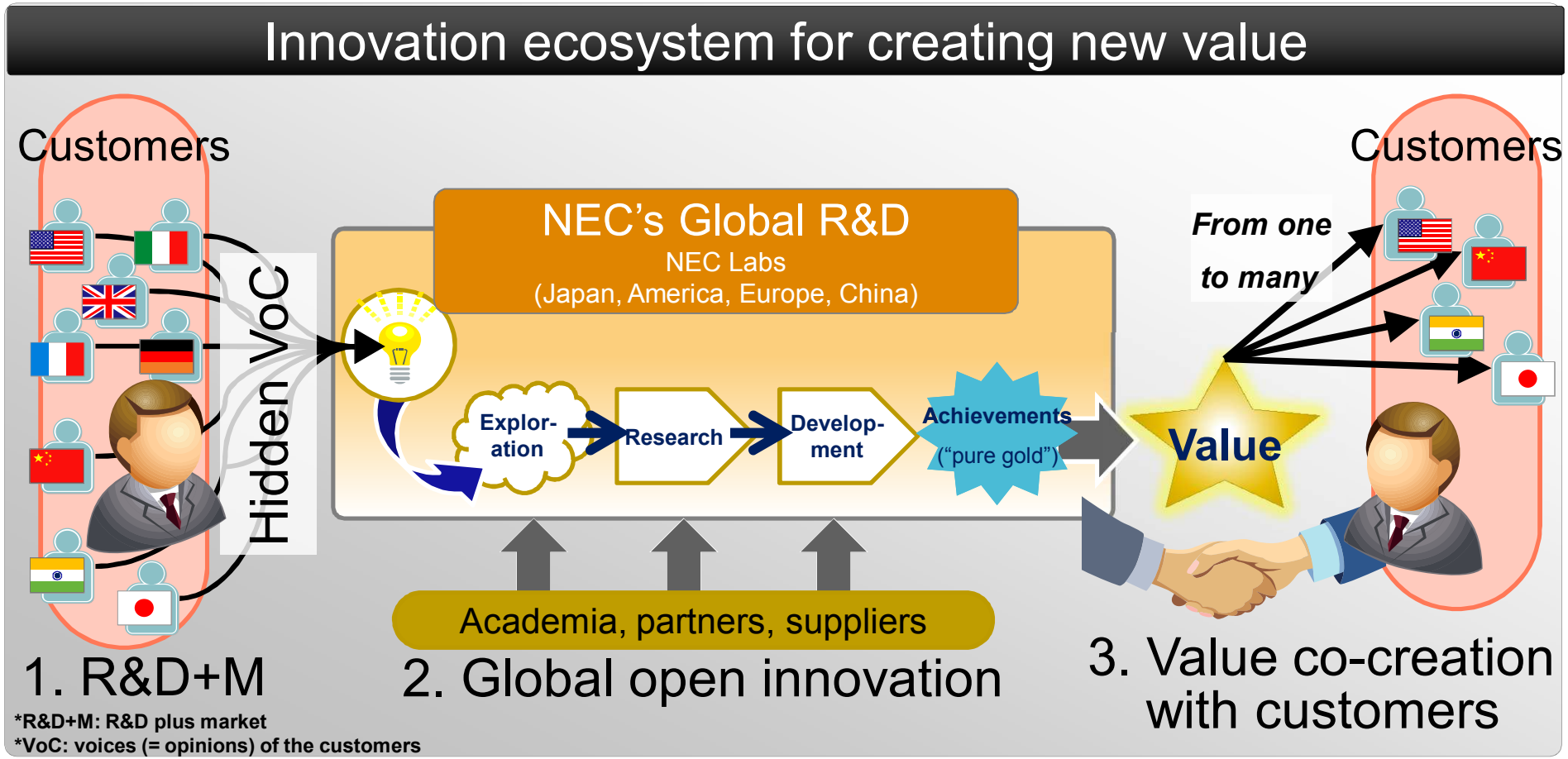
- **Value enhancement:** Generating new business by creating value through R&D strengths nurtured through experience combined with excellent applications
- Using R&D for global business development



*M2M: machine-to-machine
*EMS: energy management systems
*SDN: software-defined networking

Creating New Value with Customers

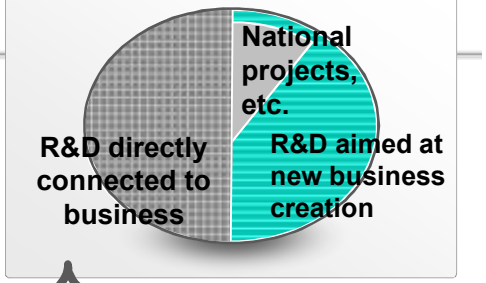
1. R&D+M*: Decide on R&D using the hidden VoC*.
2. Global open innovation: Accelerate R&D and complement resources.
3. Value co-creation with customers: Maximize customers' value.



Strengthening R&D That Contributes Business

Continuing to strengthen technologies that contribute to company-wide strategic business areas

Central Research Labs' R&D funds



Strengthening R&D areas	R&D directly connected to current business	R&D for new business creation
Big Data analytics	**Processing and analysis of large-scale complex information** Technologies for text mining & textual-entailment recognition	**Creation of customer value through prediction and forecasting** Heterogeneous-mixture learning, SIAT
SDN **(software-defined networking)**	**Development and efficient use of enterprise ICT infrastructure** OpenFlow technologies	**Advanced enterprise systems and carrier networks** ExpEther x SDN, BRAS
Real-world data & processing	**Sensing and recognition of data from real-world information** Face recognition, subject recognition	**Optimization of the real world through deep understanding and approaches** Behavior analysis, large-scale video surveillance
Security	**Minimization of system security risks** Encryption technologies, autonomous security	**Maximization of value through safe data leveraging** Data anonymity, concealment processing
Smart energy	**Efficient use of electric power** Lithium-ion batteries, energy management systems (EMS) such as BMU, PCS	**Balance between efficient use of energy and quality of life** Electricity-and-heat-integrated EMS, forecasting & control technologies
Smart business	**Reduction in system integration (SI) costs** Model-based SI	**Optimization of customer business through analytics** Data-store sizing, battery-capacity sizing

Leading Technology That Contributes Current and Future Business:

SDN (Software-Defined Networking)

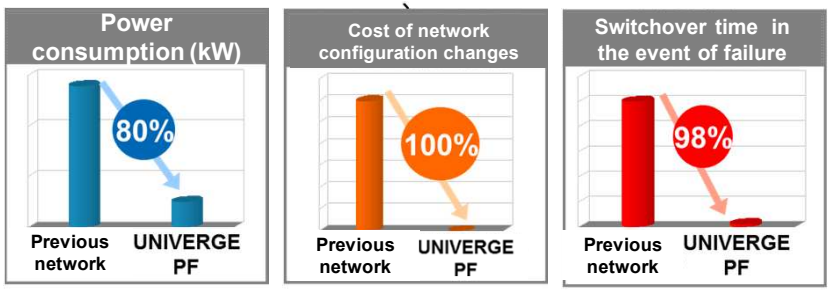
Enabling flexible and speedy launches of new services to ensure that no business opportunities are lost, because SDN allows flexible control of large-scale and complex enterprise systems and carrier networks using software

Current business applications

NEC was the first to commercialize a product using OpenFlow technology (March 2011). It was an SDN switch that has since been adopted by major corporations and organizations.

World's first
SDN switch:
"UNIVERGE PF"

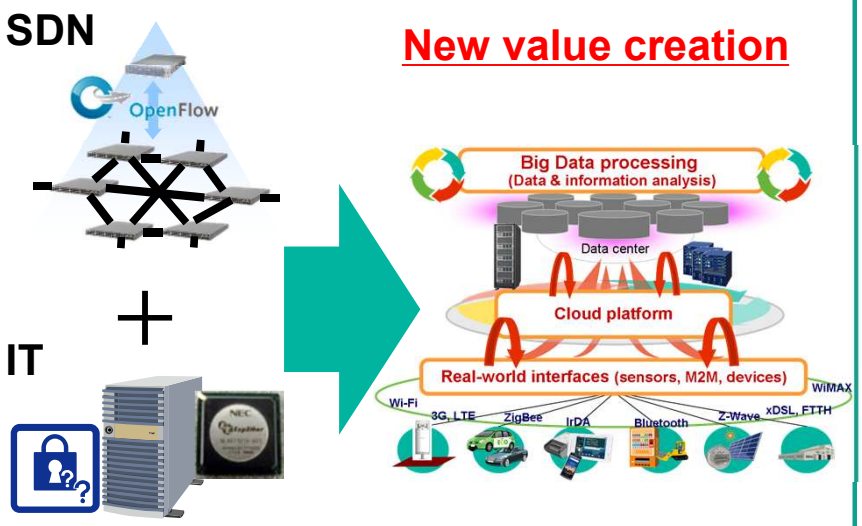
Improvements after installation（Nippon Express）



Other clients: Kanazawa University Hospital, Genesis Hosting, NTT Communications, etc.

For business growth, new business creation

We create new value for enterprise systems and carrier networks through the integration of SDN and IT technologies.



Face Recognition

Achieving safe and secure environments through low-cost and accurate face recognition using commercial camera imaging

Current business applications

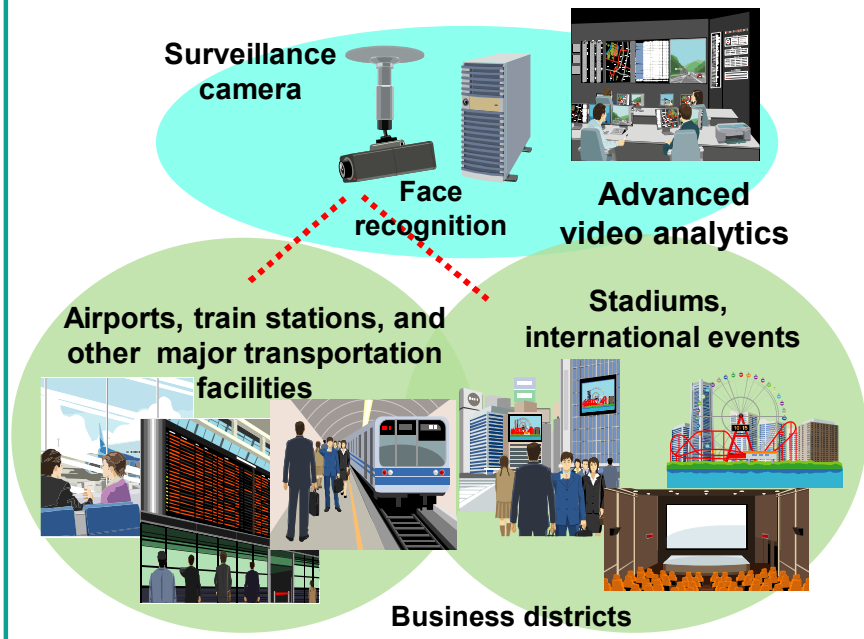
NEC is expanding immigration, gate control, and personal identification business using NeoFace® products based on face-recognition technology.

Hong Kong government

Universal Studios Japan®

For business growth, new business creation

We offer public safety solutions for critical infrastructure by providing core technologies enabling large-scale video surveillance.



Note: NEC is the official marketing partner of Universal Studios Japan®.

Energy

Expanding the range of energy-source choices and improving customer satisfaction through safe, cost-competitive, and high-capacity energy storage systems and energy management systems (EMSs)

Current business applications

NEC has smart-energy business using rechargeable lithium-ion batteries as the core technology.

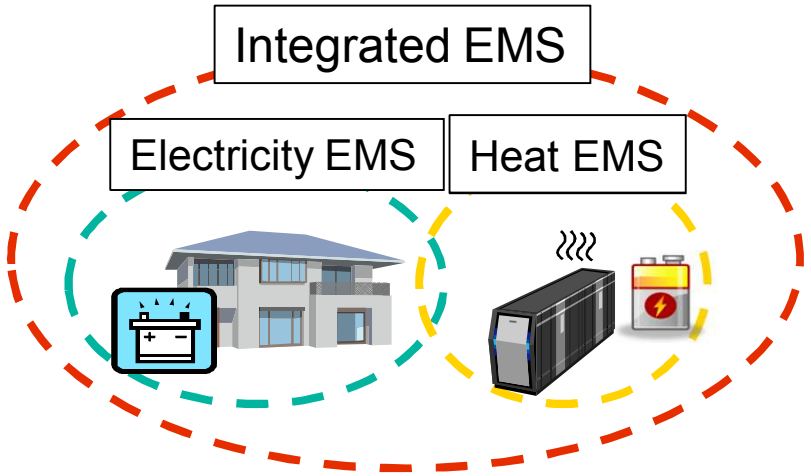
Rechargeable lithium-ion battery

Used in electric vehicles (EVs)

Home-energy storage systems linked to HEMS* and the Cloud

For business growth, new business creation

We create new business through integrated EMSs that include electricity and energy from heat.



*HEMS: home-energy management system

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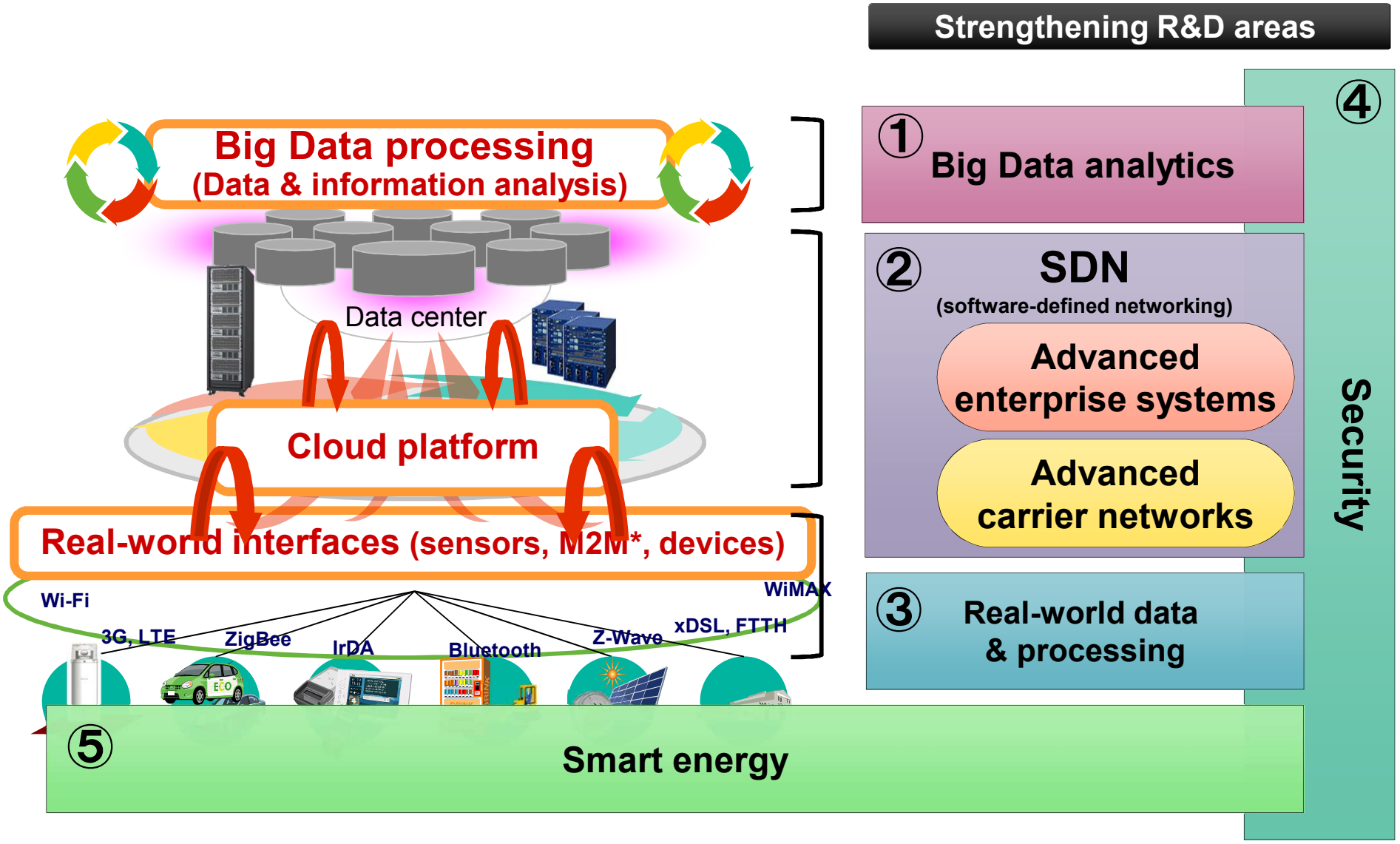
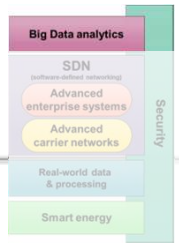
R&D Activities Contributing to the C&C Cloud (Next-Generation ICT Systems)

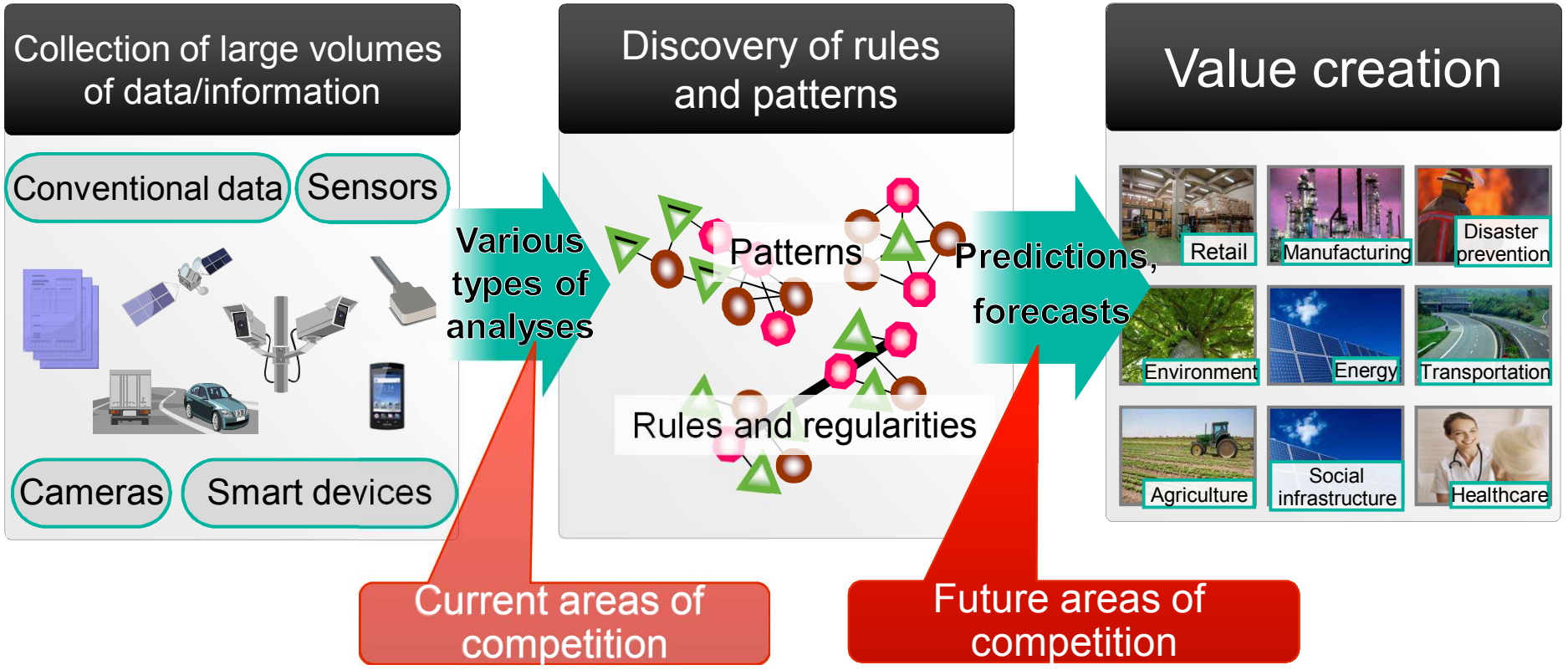


*M2M: machine-to-machine

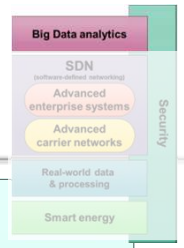
1. Big Data Analytics: Basic Outlook and Trends



- Discovering regularities and rules that are undetectable by humans: using automatic and accurate analysis of large volumes of data
- Offering new value to customers and aiming to maximize the efficiency of the entire social system through predictions and forecasts of real-world events based on Big Data analysis.



1. Big Data Analytics: Research Goals and Leading Technologies



Developing data-mining technologies and engines for extracting value-laden information from large volumes of data

Customer value (examples)		NEC's leading analytical technologies/engines
Forecasting	▪Electric-power forecasting ▪Financial-risk forecasting	Invariant analysis — World's only
Detection of anomalies/ deterioration	• Monitoring large-scale physical systems • Detecting signs of failure • Healthcare	Heterogeneous-mixture learning — World's only
Trend utilization	• Agricultural management based on the use of target values	Face-image analysis — No. 1*
Video surveillance	▪Large-scale integrated surveillance using a number of outdoor cameras	Behavior analysis — World's only Textual-entailment recognition — No. 1*

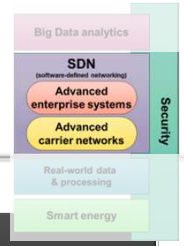
*NEC's technologies were ranked No.1 by the National Institute of Standards and Technology (NIST).

Leading technologies

- Heterogeneous-mixture learning technology that enables automatic and highly accurate analysis of more complex data
- Invariant analysis that enables monitoring of large-scale physical systems without detailed knowledge about the system (System Invariant Analysis Technology: SIAT)

2. SDN*: Basic Outlook and Trends

(*Software-Defined Networking)



Enterprise systems

- Performance bottlenecks in computer systems
- Increases in security costs and risks due to changes in work styles

Essential to develop flexible and secure systems through the integration of IT and networks

Carrier networks

- Weakened revenue models due to greater telecommunications traffic
- High cost of system changes and delay in installation of new services due to inflexible network architecture

Need for fundamental changes in network architecture

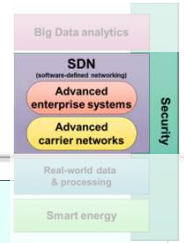
Quick development and flexible operation of systems through SDN

NEC's strengths

- ✓ World's first commercialized product using OpenFlow technology: numerous deployments that include collaboration with major corporations
  - Better performance compared with that of competitors in terms of scalability and flexibility
- ✓ Rich global R&D collaboration experience: participation in ONRC* as core member

*ONRC: Open Network Research Center

2-1. Advanced Enterprise Systems: Research Goals and Leading Technologies



Linking network control to IT-resource control using software-defined networking (SDN) to enable the flexible development and operation of scalable and secure systems

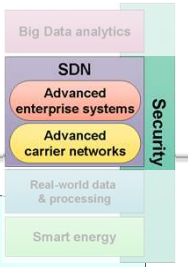
	Conventional systems	NEC's strengths	Additional NEC strengths
Application	**Inflexible enterprise systems**	Automatic development of flexible enterprise systems	**Flexible & secure integrated IT & network systems**
Service infrastructure	**Operator-mediated access control**	Secure access control (automated system configuration) + **IAM***	
Network infrastructure	**Inflexible networks**	Flexible network configuration control + **SDN**	
Computer infrastructure	**Computers with local hardware resources**	Innovative computers (speed and bandwidth guarantees) + **Networked ExpEther**	**Scaled-up computer systems**

*IAM: integrated access management

Leading technologies

- IAM + SDN: Enable flexible system changes while ensuring security
- Networked ExpEther + SDN: A new computer architecture that enables scalability

2-2. Advanced Carrier Networks: Research Goals and Leading Technologies

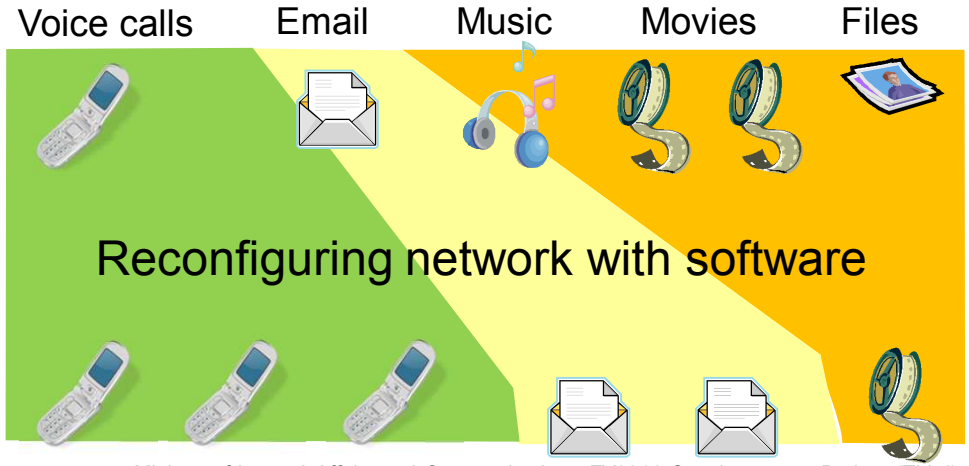


New paradigms for the development of carrier networks
- enabling flexible system development and reductions in OPEX and CAPEX by implementing network functions with software on general-purpose hardware -

Resource allocation during ordinary times

Flexibly allocation of resources to priority services during emergencies

Resource allocation during emergencies



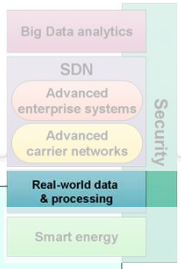
Ministry of Internal Affairs and Communications FY2011 Supplementary Budget (Third):
"R&D of dynamic communication control technologies for mobile communication networks at times of large-scale disasters"

Leading technologies

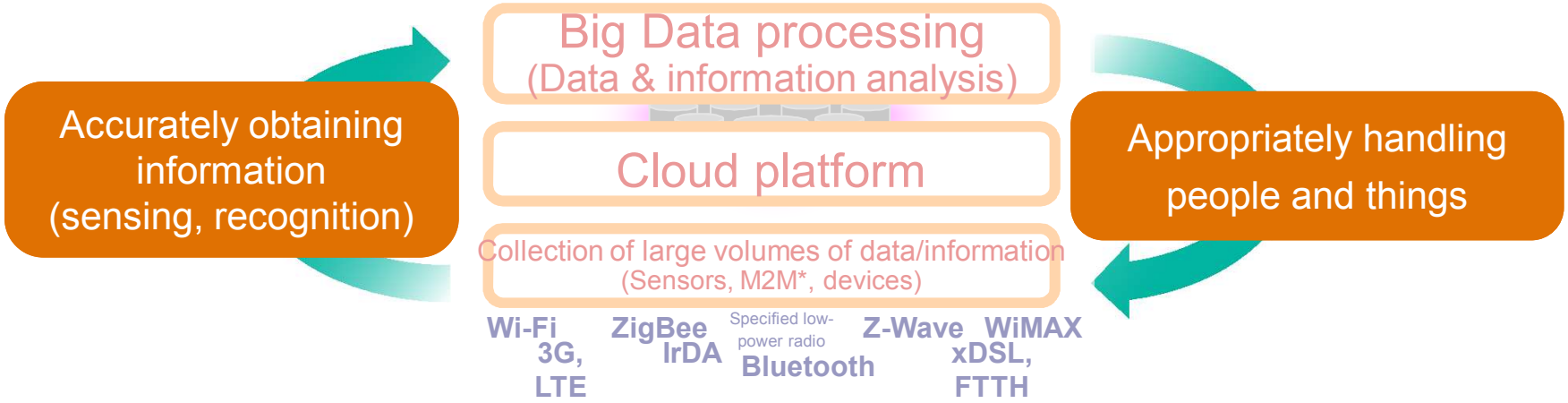
- BRAS*, which offers various types of access services to users at carrier scale using general-purpose devices
- Virtualization technology that enables prioritized allocation of resources for critical services
- Optical-IP integrated transport technology that enables a reduction in both operation costs and energy consumption

*BRAS: Broadband Remote Access Server

3. Real-World Data Processing: Basic Outlook, Research Goals, and Leading Technologies



Making the real world smarter by accurately obtaining information on, analyzing, and understanding real-word situations and approaches for people and things

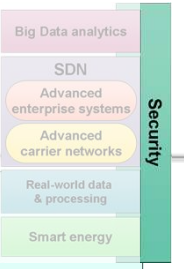


Leading technologies

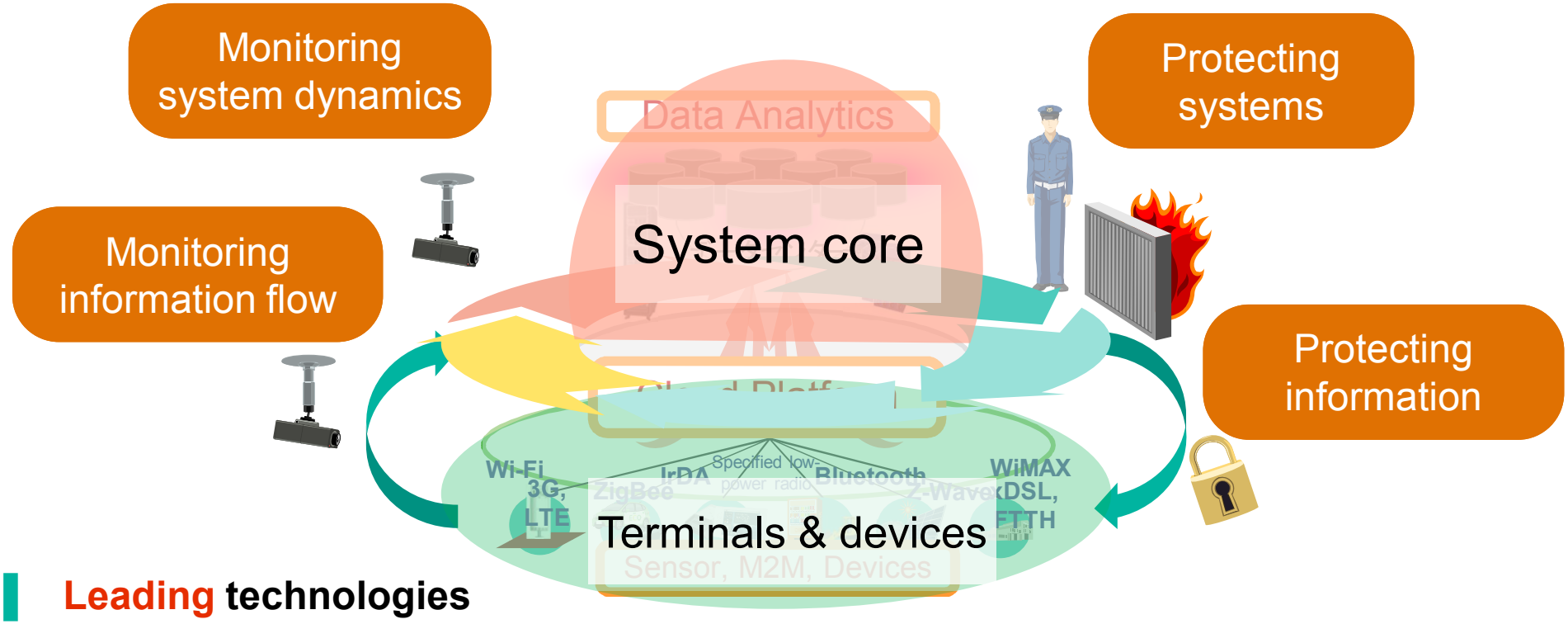
- Technology for the recognition of images under all kinds of indoor and outdoor environments
- Object-sensing solutions that facilitate the customization of store operations
- Vibration-sensing that enables the detection of weak vibrations and the monitoring of water leaks and building deterioration

*M2M: machine-to-machine

4. Security:
Basic Outlook, Research Goals, and Leading Technologies



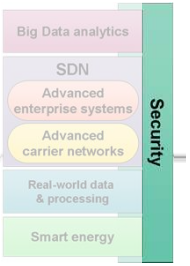
Creating security-risk-free systems and services through technologies for monitoring and protecting entire systems —from the core to the terminals and devices.



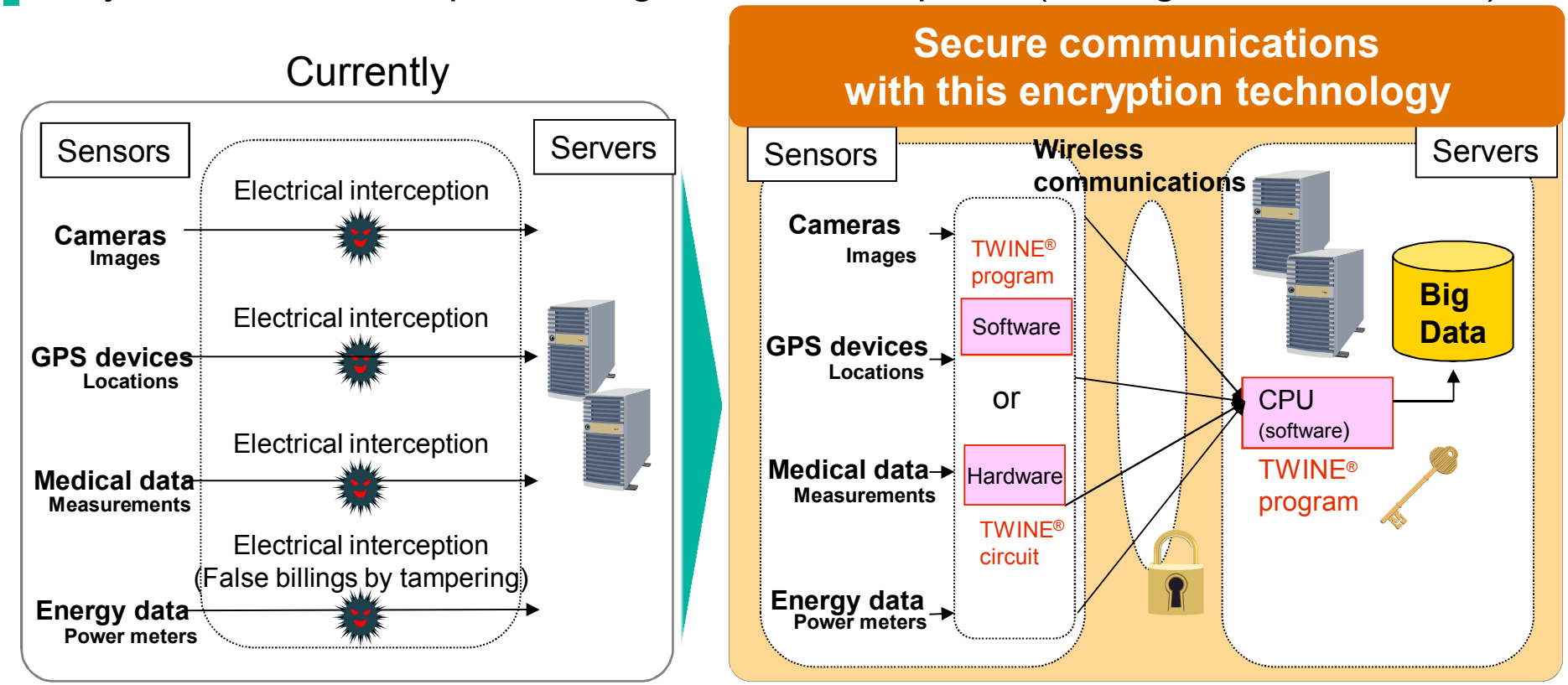
Leading technologies

- TWINE®, which enables safe and lightweight encryption, even in sensors and other small devices
- Integrated system settings that eliminate careless security setting errors

TWINE®: A Secure, Lightweight Encryption Algorithm

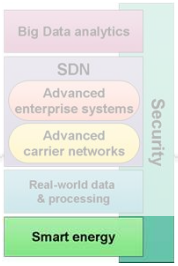


- High-speed encryption in all environments, including small devices, microcomputers, and servers
- Very small amount of processing resources required (among the world's best)

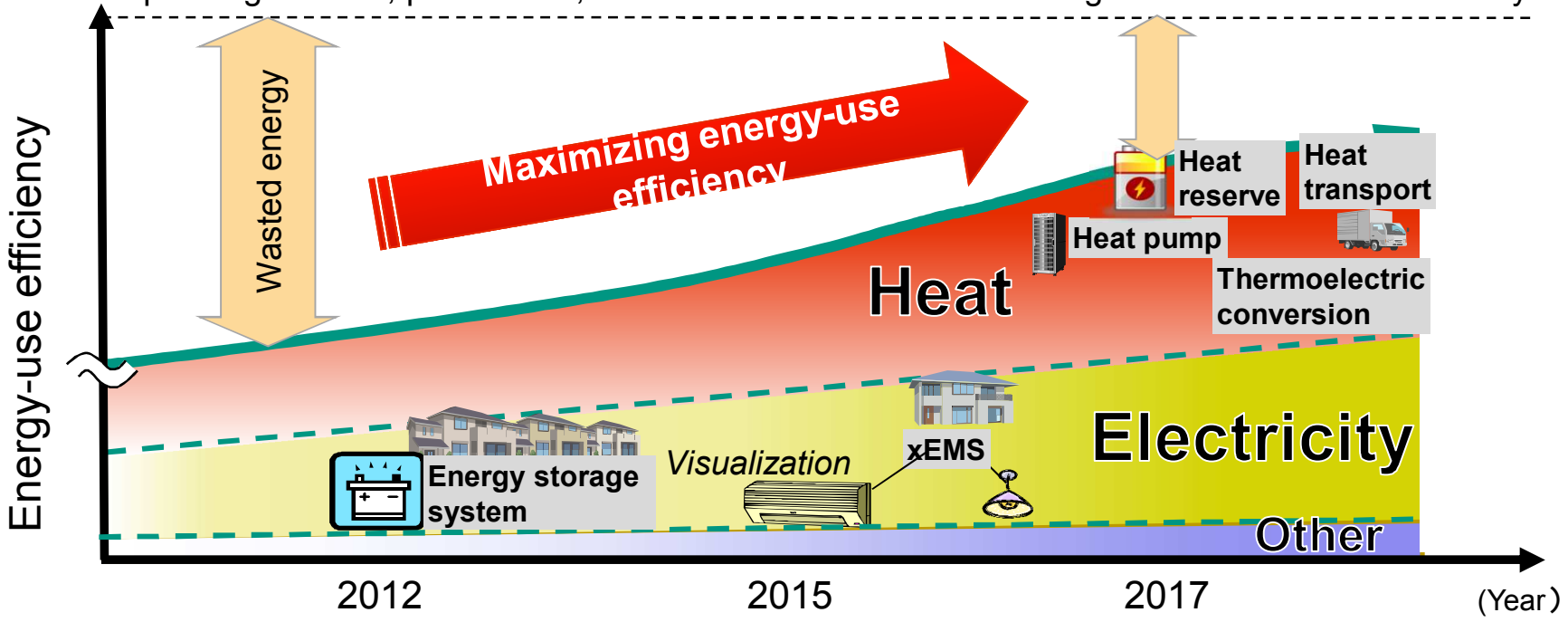


Preventing tampering and eavesdropping with guaranteed confidentiality and integrity through encryption to protect your privacy and security and allow the transmission of information from a variety of sensors

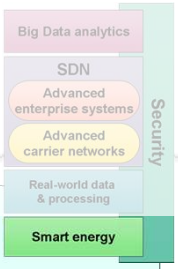
5. Smart Energy: Basic Outlook and Trends



- Maximizing the efficiency of energy use:
  imperative for sustainably responding to the global increase in population
- Necessary to maximize efficiency through energy management with increased scope of control
  - Expanding devices, parameters, and areas for control. And utilizing heat in addition to electricity.

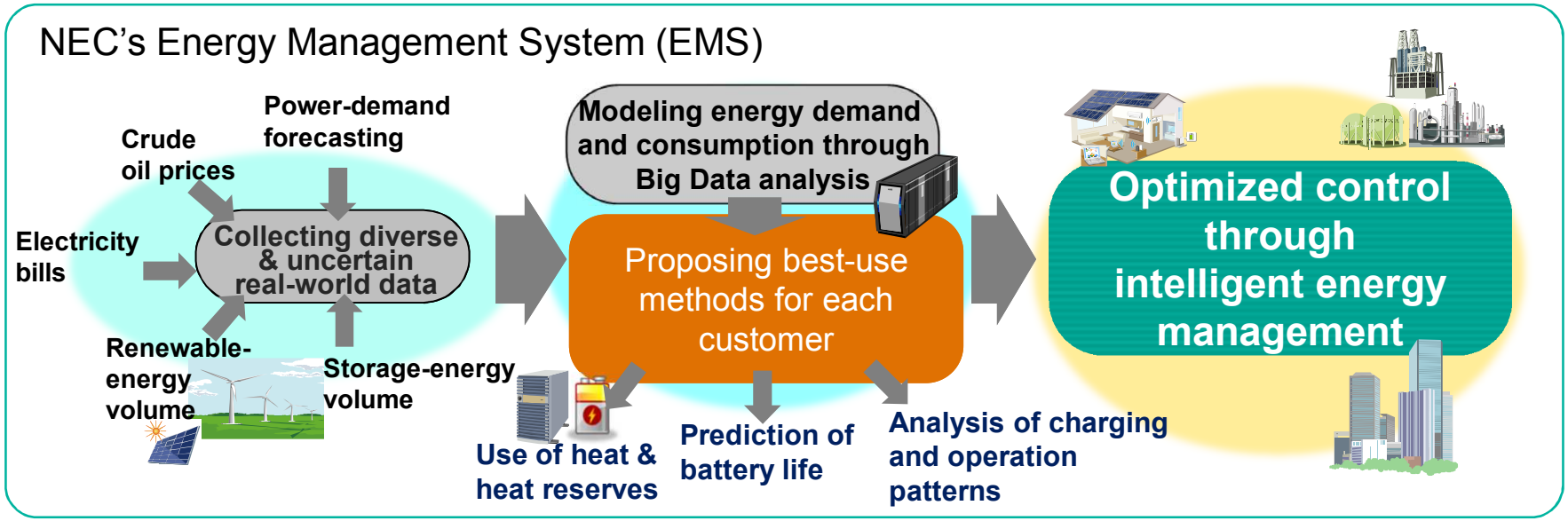


5. Smart Energy: Research Goals and Leading Technologies



Shifting from the "visualization of electricity use" and "device energy-savings" to a "balance between efficiency and convenient lifestyles" through the use of analysis and prediction technologies.

Further improving power-use efficiency through electricity-and-heat-integrated EMS*.
–Reusing energy waste as a heat source or electricity by efficiently collecting and recycling energy–



Leading technologies

- Heat EMS technology for highly efficient recycling of low-temperature heat-energy waste (heat collection and transport technology, spin-current thermoelectric devices)
- 5-V lithium-ion-battery that balances safety and high-voltage applicability through newly developed cathodes and electrolytes

*EMS: energy management systems

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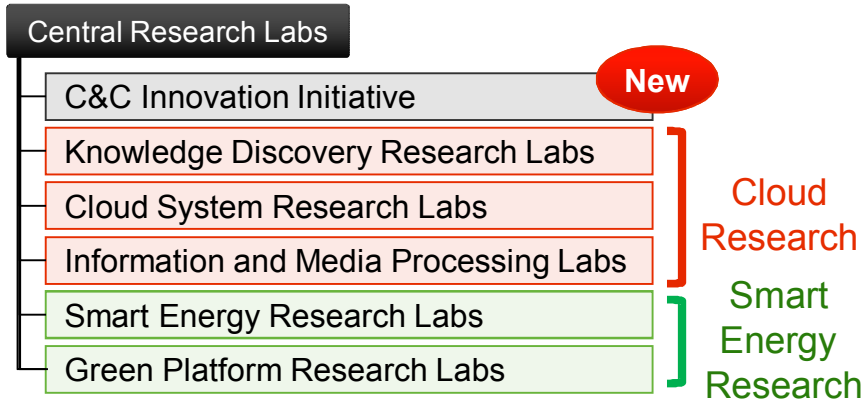
- **Promoting R&D Activities to Contribute to NEC's Growth**

Maximizing R&D Investment Efficiency for Bigger Business Contributions

Reorganization of Central Research Labs (April 2012)

- Established the "C&C Innovation Initiative," which is tasked with matching NEC's R&D seeds with customers' future needs and creating new value
- Reorganized previous categories into two research categories based on our focus areas to maximize results from the coordination of several technologies



Creation of new business by converting research achievements into appropriate customer value with appropriate timing

- Holding bimonthly meetings with the president, CSO*, CMO*, and BU* heads to discuss the creation of value from research results and the establishment of new business projects
- Expanding the scope of research lab activities to maximize R&D investment efficiency; strengthening investments in open innovation and actively promoting proof-of-concept with customers

Strengthening global collaboration that leverages overseas R&D centers

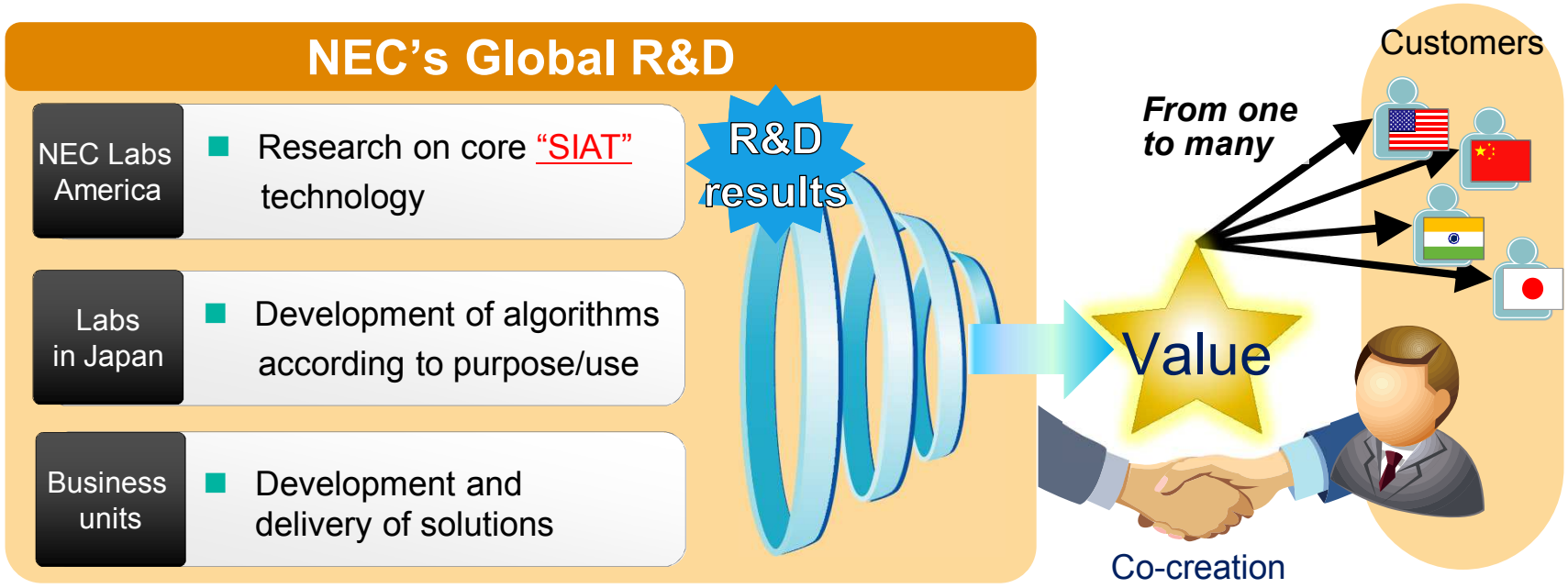
- Enhancing inter-laboratory collaboration and personnel exchanges
- Promoting early adoption of state-of-the-art technologies and problem-solving locally through global open innovation that leverages regional and institutional characteristics

***CSO: chief strategy officer**
***CMO: chief marketing officer**
***BU: business unit**

Global Business Development of Complex Physical System Analysis

- Creating solutions to detect anomalies, optimize maintenance inspection processes, improve quality control, etc., in large factories, vehicles, and aircraft using System Invariant Analysis Technology (SIAT), which was developed by NEC Labs America
- Determining actual solutions to problems at customer locations through cooperation among researchers at NEC Labs America and the Central Research Labs in Japan; providing more solutions for customers through closer cooperation with business units

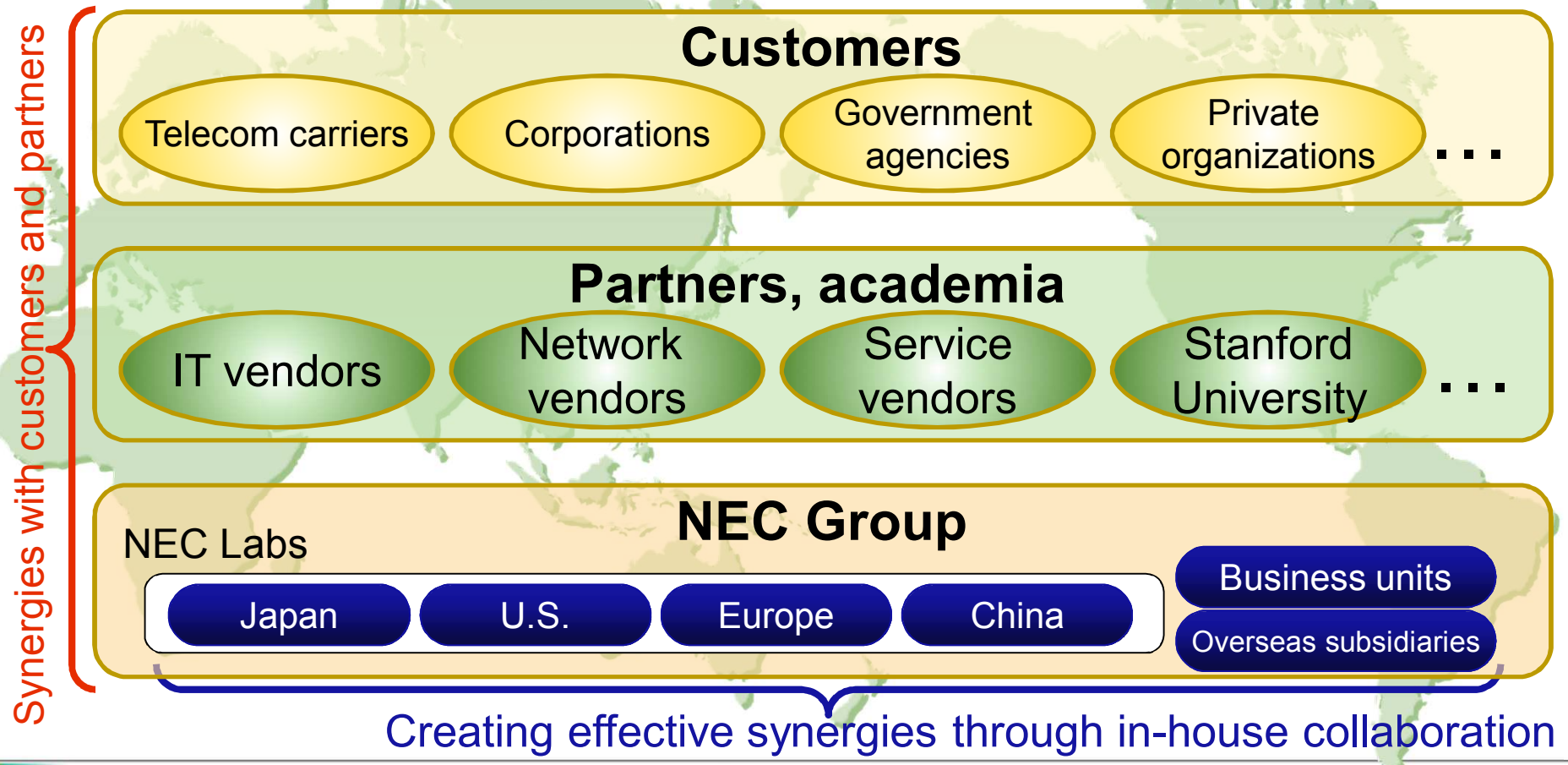
Value co-creation with customers



SDN* Research Aiming for Global Expansion (1/3)

*SDN: Software-Defined Networking

- Strengthening R&D and commercialization efforts by creating synergies through global in-house collaboration
- Implementing field trials and standardization activities by promoting external collaboration in Japan, the U.S., and Europe

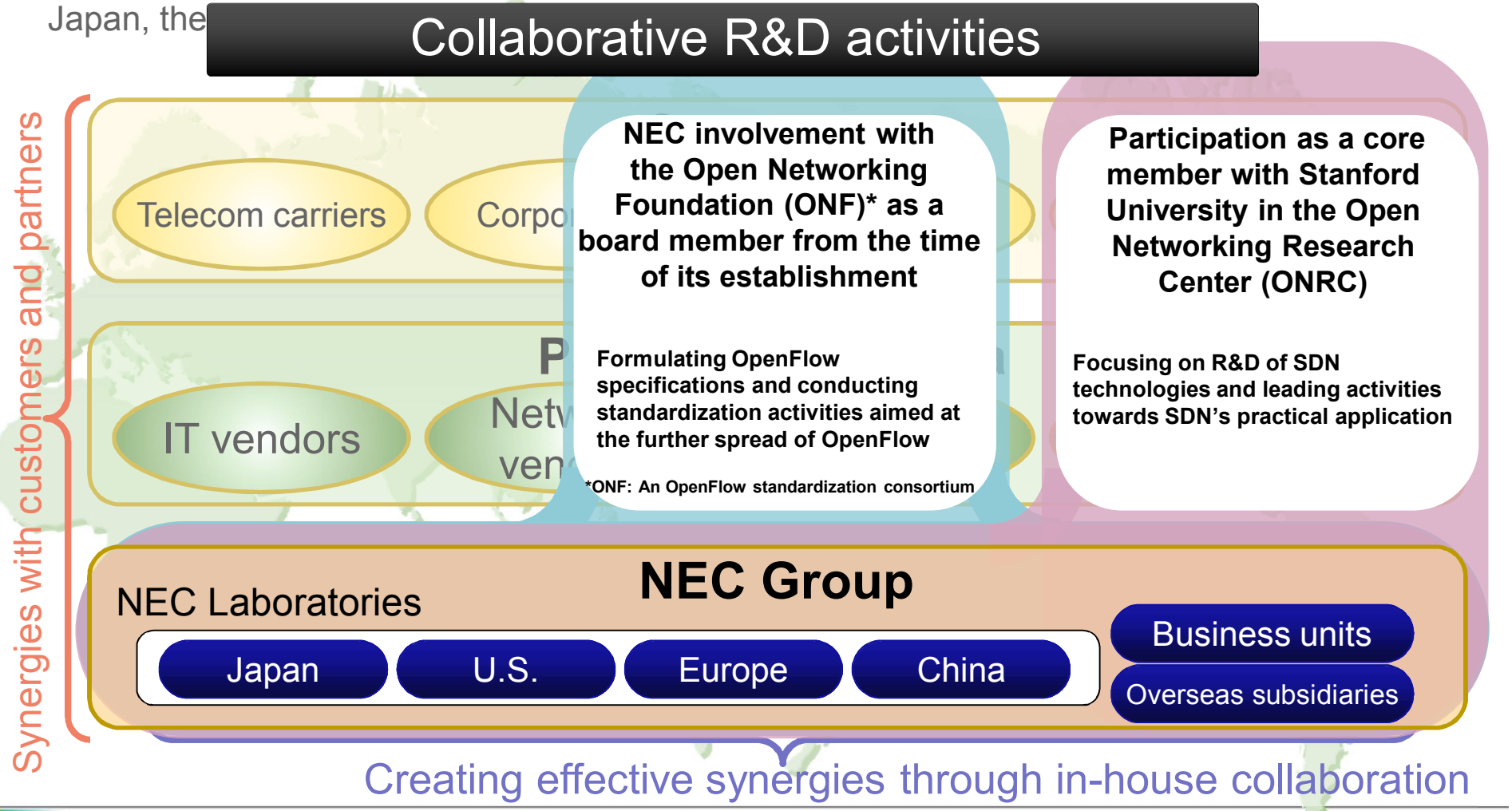


Strengthening Global Collaboration That Leverages Overseas R&D Centers:

SDN* Research Aiming for Global Expansion (2/3)

*SDN: Software-Defined Networking

- Strengthening R&D and commercialization efforts by creating synergies through global in-house collaboration
- Implementing field trials and standardization activities by promoting external collaboration in Japan, the



Strengthening Global Collaboration That Leverages Overseas R&D Centers:

SDN* Research Aiming for Global Expansion (3/3)

*SDN: Software-Defined Networking

- Strengthening R&D and commercialization efforts by creating synergies through global in-house collaboration
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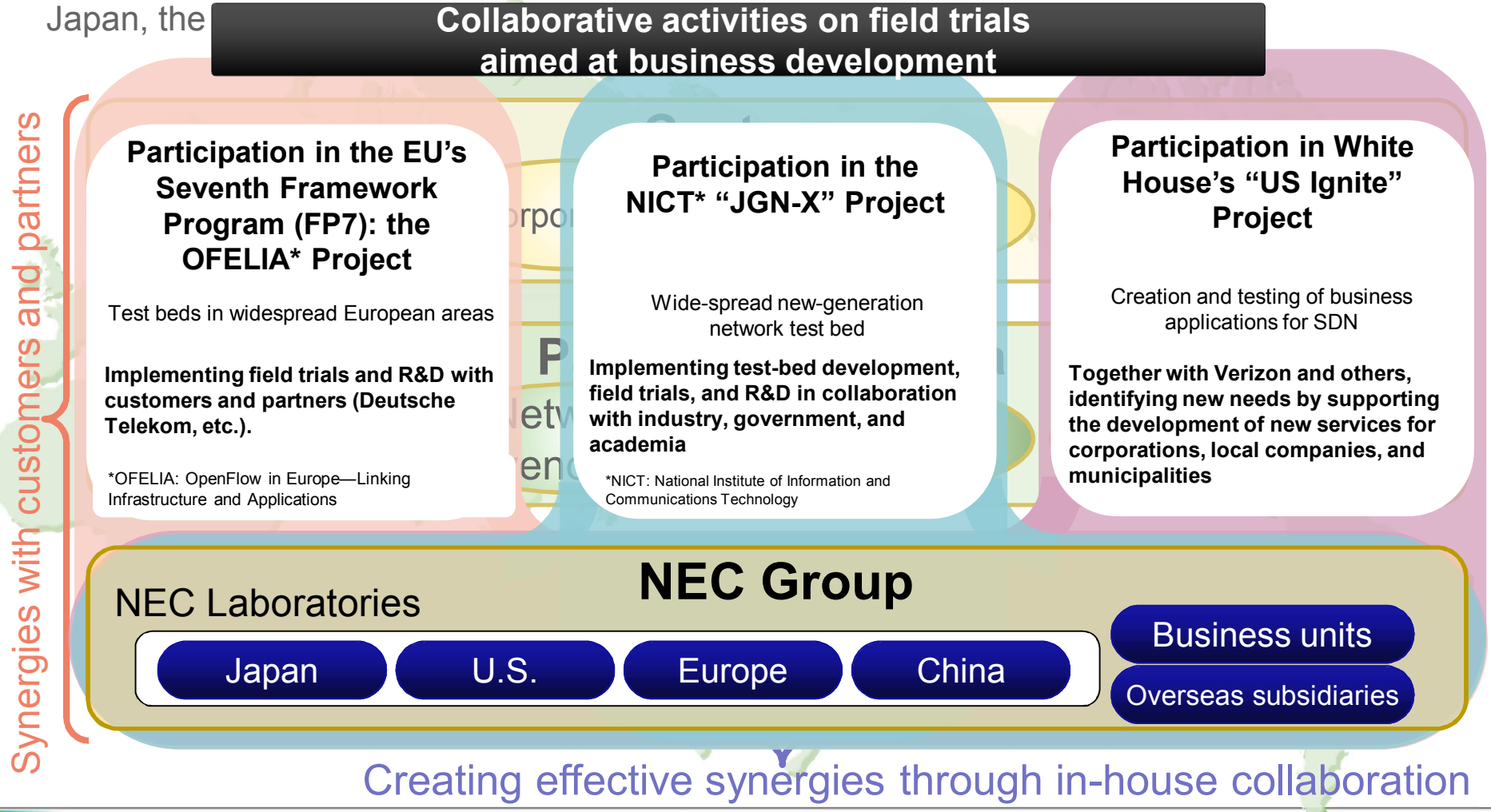


Strengthening Global Collaboration That Leverages Overseas R&D Centers:

Joint Research on Smart Water Management with Imperial College London

Challenges surrounding water resources

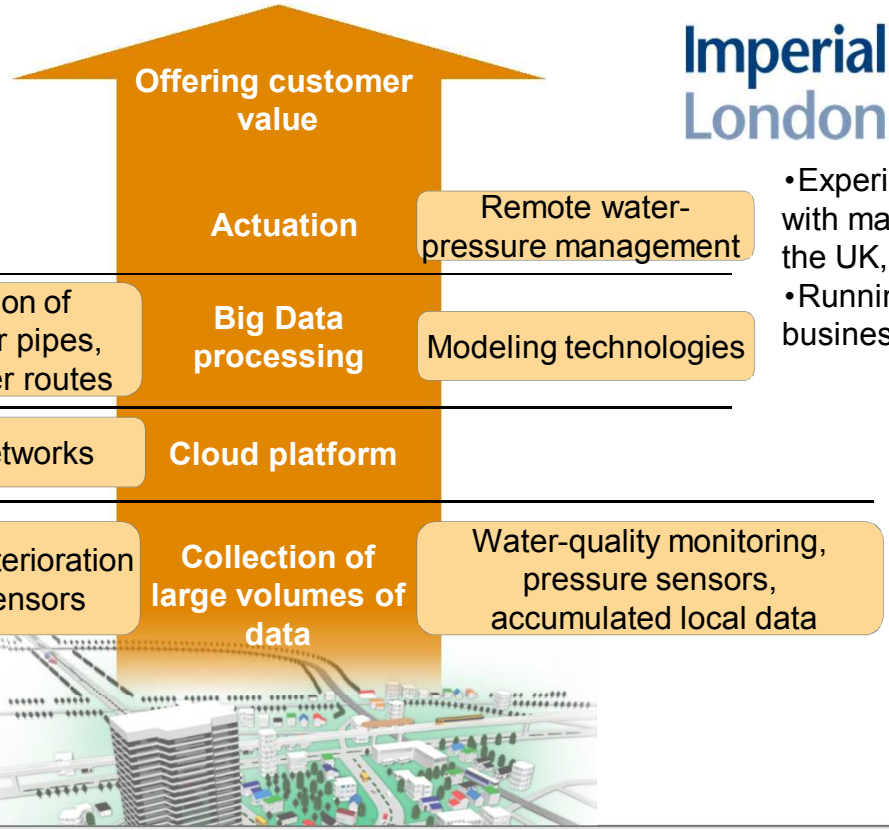
- Social issue: Large resource losses due to leakage from pipes (London = 27%; Tokyo = 3%)*
- Smart water business market: ¥86 trillion by 2025*

*Ministry of Economy, Trade and Industry (METI) estimate

Global expansion of smart water management business

NEC strengths:

- Big Data processing, analysis, and prediction technologies
- Global business expansion by collaborating with Gutermann of Switzerland



Imperial College London strengths:

- Experience in collaboration with major water companies in the UK, e.g., Thames Water
- Running a world-leading business school

NEC's cost-competitive and ultra-sensitive vibration sensors

R&D for Solving Problems Particular to Emerging Countries On-Site

- Selecting research by identifying local problems and needs based on opinions of local customers
- Implementing research that relates closely to local needs through collaboration with SRM University* in India.

*A leading private university for science and technology

Local challenges

- 6-to-8-hour blackouts per day due to unbalanced electricity supply and demand
- Weak power grids with large losses
- Many houses and facilities forced to use diesel generators as backup

Local center

NEC

- Providing electricity-control technologies
- Dispatching researchers
- Establishing local research centers

NEC ✕ **SRM UNIVERSITY** (Under section 3 of UGC Act 1956) ⇒ **Developing solutions for the efficient utilization of limited power resources**

- Energy management technologies
- Energy storage systems
- Lithium-ion batteries
- Machine-to-machine (M2M) networking technology

- Provision of environment for field trials
- Relations with government, clients' industrial organizations

Empowered by Innovation

NEC

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