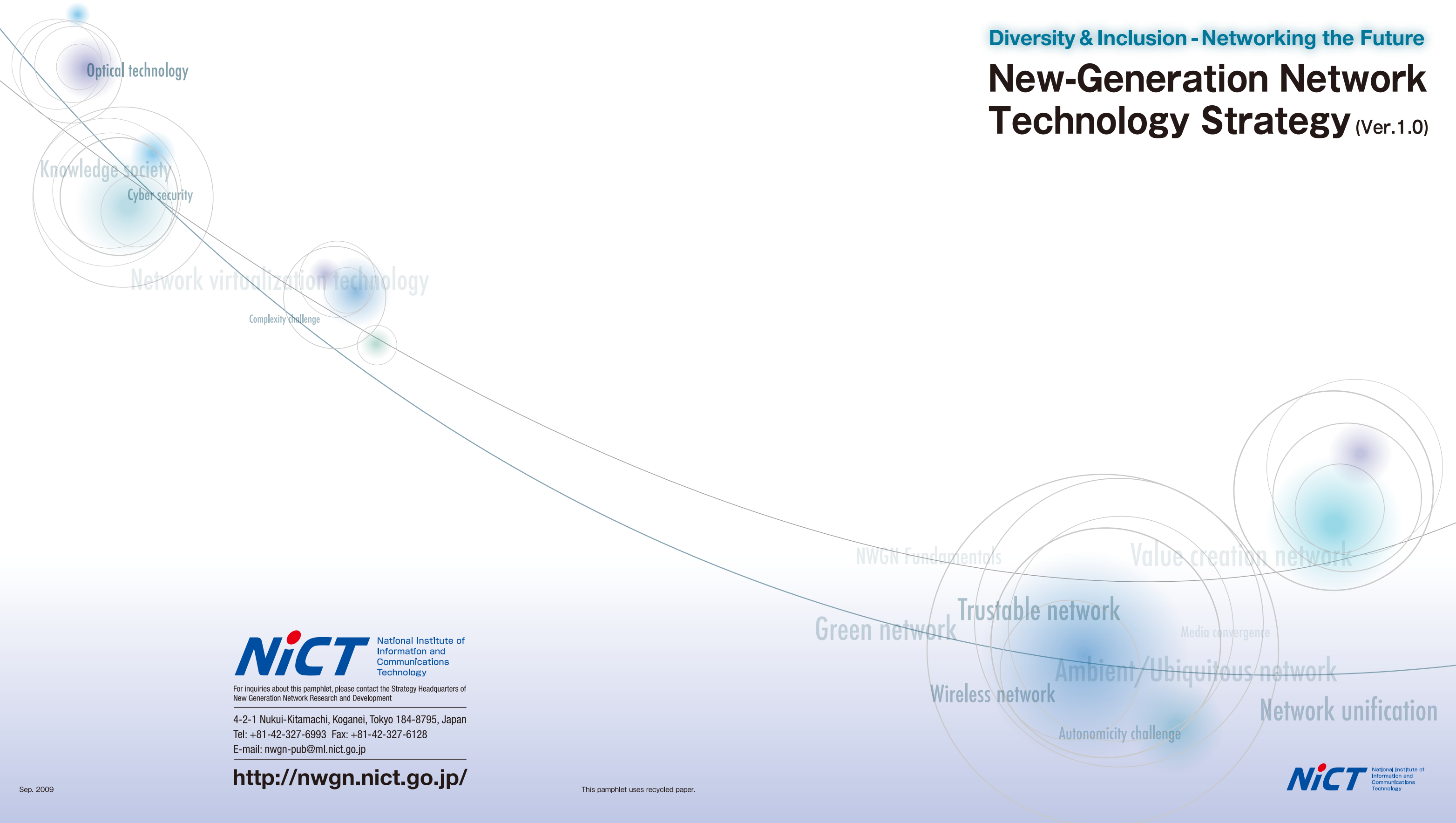


Diversity & Inclusion - Networking the Future  
**New-Generation Network  
Technology Strategy** (Ver.1.0)



**NICT** National Institute of  
Information and  
Communications  
Technology

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Dramatic advances in telecommunications technology in recent years have sparked a new information revolution that ranks alongside the industrial revolution. Today, the Internet is an essential part of our social infrastructure not only in the world of business, but also in our everyday lives. However, innovative developments are needed in order to make networks into infrastructure for building a safe and secure society and for creating new industries.

The National Institute of Information and Communications Technology (NICT) is promoting R&D on the "New-generation network" which should become the ICT infrastructure over the next several decades. The New-generation network looks beyond the Next Generation Network (NGN), aiming for radical solutions to technology issues and limits which are difficult to solve only by improving the Internet, with new designs from a clean slate unconstrained by existing technologies.

The New-generation network must solve various problems faced by today's society, and also contribute to the further development of civilization in the 21st century. The NICT has issued reports on the New-generation network vision on how future society should develop, and the role which the New-generation network should fulfill in future society. Bold and accurate R&D strategy is needed to achieve the network described in this vision. This report recommends a technology strategy towards achieving the New-generation network.

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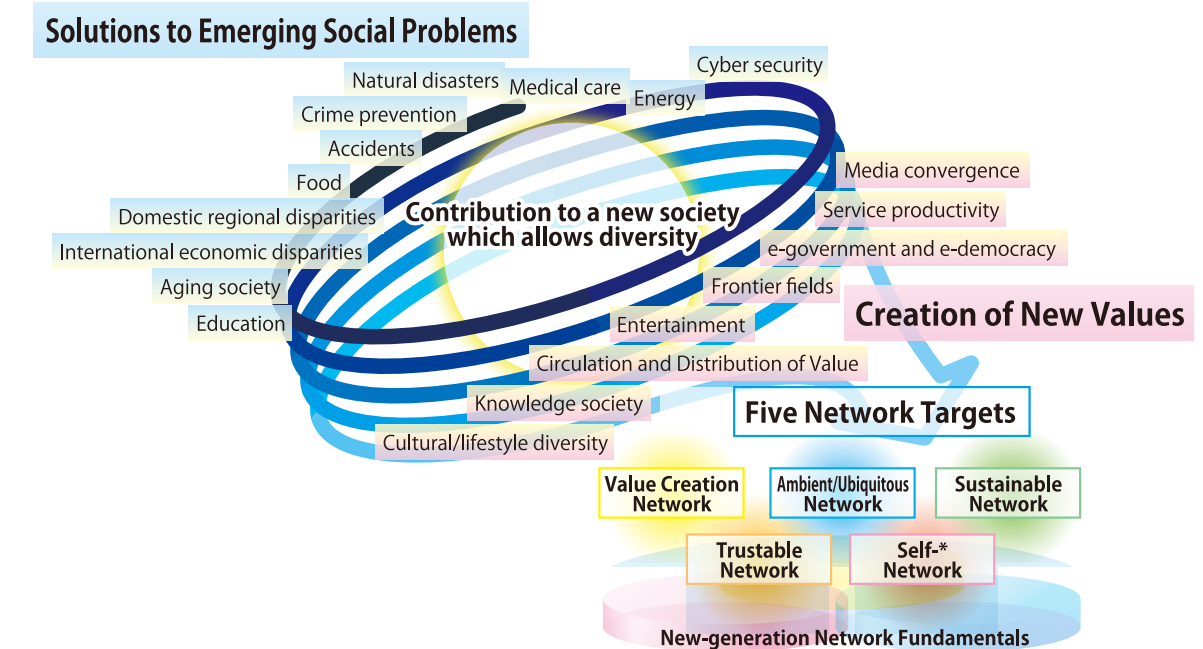
# From New-generation Network Vision to Target

In the New-Generation Network Vision (issued September 2008, revised in March 2009), the Strategy Headquarters of New Generation Network Research and Development analyzed and proposed 20 technology requirements demanded for the New-generation network to solve social issues and create new value in future society.

This time, the Headquarters proceeded further with this investigation, deriving functional requirements which cannot be achieved by extending the existing Internet and Next Generation Network. We closely studied over 100 technology requirements, and grouped them into representative technology categories. In this grouping task, we carefully and deeply reviewed the vision: connections between the network and the world's "things" and people, relationship with the world and sustainable society, trusting and supportive relationships between people and the network society, etc. From this investigation, we summarized the characteristics which the future network should possess. The five network targets shown in the diagram below form a specific image of the New-generation network to achieve in 10 to 15 years.

The technology development items shown in the five network targets are linked to multiple technology requirements which contribute to social issue solutions and the future society outlook. It is also considered important to perform integrated R&D straddling technology fields, towards achieving each target. It is also thought necessary to promote research on network science fields for sustainable network fundamentals common to the five network targets, advanced device development, etc., from the perspective of stronger fundamental research.

These will be discussed in the New Generation Network Promotion Forum, and we will proceed to closely examine and revise network targets, roadmaps and issues concerning R&D on network fundamentals, thereby forming a promotion and implementation strategy to maximize the competitiveness of the New-generation network R&D results.



Network targets derived from social requirement conditions

# Value Creation Network

## Background of Targets

Aim to bring about new services innovation in the network, going beyond services which simply provide connections. Issues are creating new value chains in order to provide services from the user standpoint, and coexistence between diversifying user needs and sharing of service functions. It is also thought that a future network infrastructure must be achieved which gathers services information flowing through the network, and integrates knowledge of businesses and people, generating previously unseen new services.

## Network goals

Network which induces service creation and media creation, creating new value

Network which creates value through the change from an information society to a knowledge society

Network which creates and supports new industries which put ideas into practice

## Technology goals

Service creation network technology

In order to construct infrastructure which creates new value, technology to transmit and distribute knowledge information, and technology to analyze service situation and significance, knowledge database which supports these

Media creation network technology

Network platform technology enabling anyone to transmit huge amounts of information, while enabling people to safely obtain information created which is useful corresponding to their situation

## Major R&D Promotion Strategy

Promotion of services research and its application technology development

Solicit joint research with social economics, human behavior sciences, etc.

Foster talented software human resources and idea generation

Build up know-how concerning services innovation infrastructure

Strengthen support for service venture launches

## Effects

Create new industries which put ideas into practice

Global market of 160 trillion yen in year 2020

Knowledge distribution businesses, knowledge processing service businesses

Anyone will be able to create services, building new value chains and improving service productivity

Deliver services integration technology from Japan to the world

## Priority Technology 1 : Services creation network

1 Technology to modularize network services and make them into platforms

For network services: Shared module technology, module protection technology, and general purpose platform technology

2 Technology to achieve large scale knowledge delivery and distribution

Knowledge collection technology, knowledge delivery technology, knowledge data analysis technology, and knowledge data mining technology

3 Large scale distributed services knowledge database construction technology, network built-in type service process visualization technology

Technology to build extremely large scale databases to store knowledge, support of visualization functions for the network itself to provide services, and provision of its tool group

## Priority Technology 2 : Media creation network

1 Micro media distribution platform technology

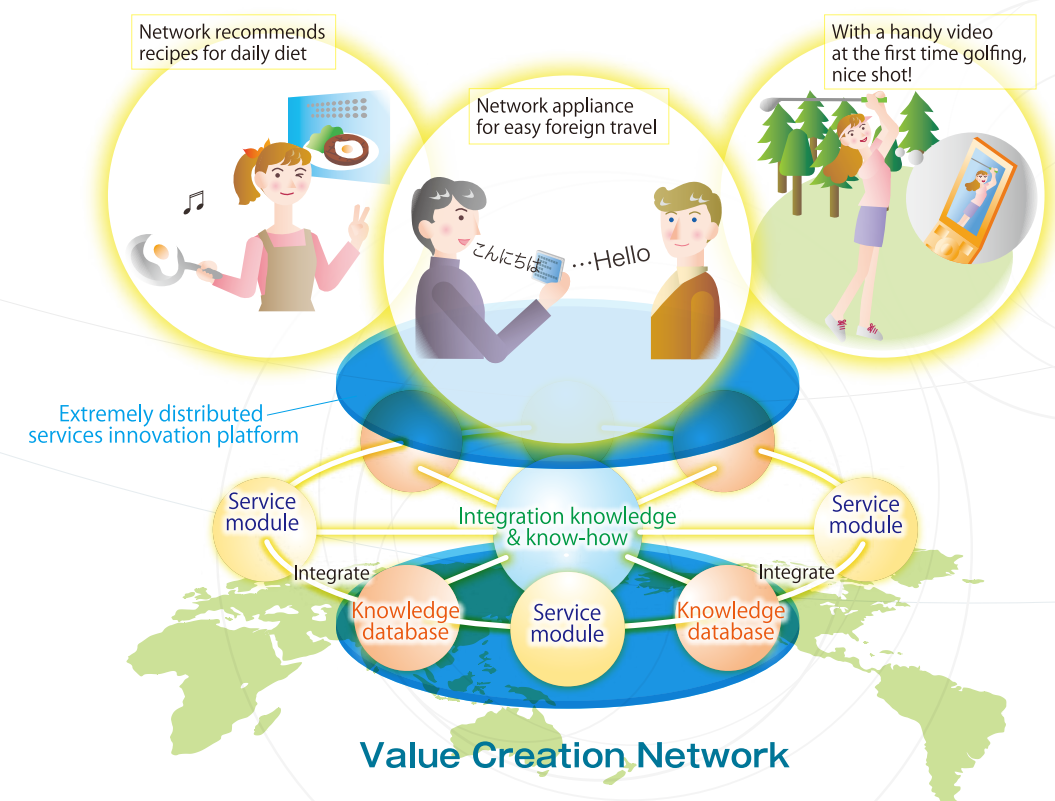
For easy information transmission from each individual, wired and wireless integrated networking technology and compatible terminal technology, enabling anyone to easily transmit information anytime, anywhere, and development of the information distribution environment

2 Information reliability evaluation technology

Information analysis technology and database construction technology, to choose accurate and significant information from among large amounts of information

3 User adapting new media generation technology

To provide information with new value impossible via previous media, technology which understands the user's situation and generates information satisfying user needs





# Trustable Network

## Background of Targets

Information and communication networks are essential in all social activities of individuals and organizations. Stability and trustability of the network itself are important for maintaining continual network functioning. It is thus thought necessary to achieve guaranteed service with advanced failure resistance, fast recovery from failure, and stable operation even when human errors and cyber attacks occur. This new trustable network infrastructure on the scale of the entire society should also achieve a network usage environment with stability and trust secured.

## Network goals

### Highly reliable network

Sustainable and stable network, even considering various threats and failures

Network for coexistence of good usability with safety including privacy protection

## Technology goals

### Trustable network infrastructure

Technology providing total operation reliability, including the network, device and user

### Network to ensure reliability for people and society

Network technology with simple settings to obtain strong privacy protection and reliability of people and society

## Major R&D Promotion Strategy

### More advanced network operation and security countermeasures technology and creation of new industries

Advances in and applications of network operation technology which has been built up in networks until today

Strengthen activities for awareness of securities countermeasures

Create new industry by supporting ventures related to network operation technology and security countermeasures technology

Implement industry/academia/government cooperation, by interdisciplinary work

## Effects

### Achieve safe and secure ICT infrastructure

Resolve sources of psychological anxiety concerning ICT

Achieve social infrastructure which also functions during emergencies and disasters

Minimize leaks of private and secret information

## Priority Technology 1: Trustable network infrastructure

### 1 Trustable terminals and infrastructure service applications

Trustability technology at each level, from devices connected to the network through to infrastructure services

### 2 Trustable application development and verification platform

Elemental technology to detect and remove vulnerabilities, from the service application development stage

### 3 Trustable network management and operation technology

Development of data transmission nodes which have advanced autonomy, and support mechanisms to minimize operations tasks of managers

### 4 Survivable network

Communications technology to secure survivability of network users themselves during emergencies such as natural disasters

## Priority Technology 2: Network to ensure reliability for people and society

### 1 Network device authentication platform technology

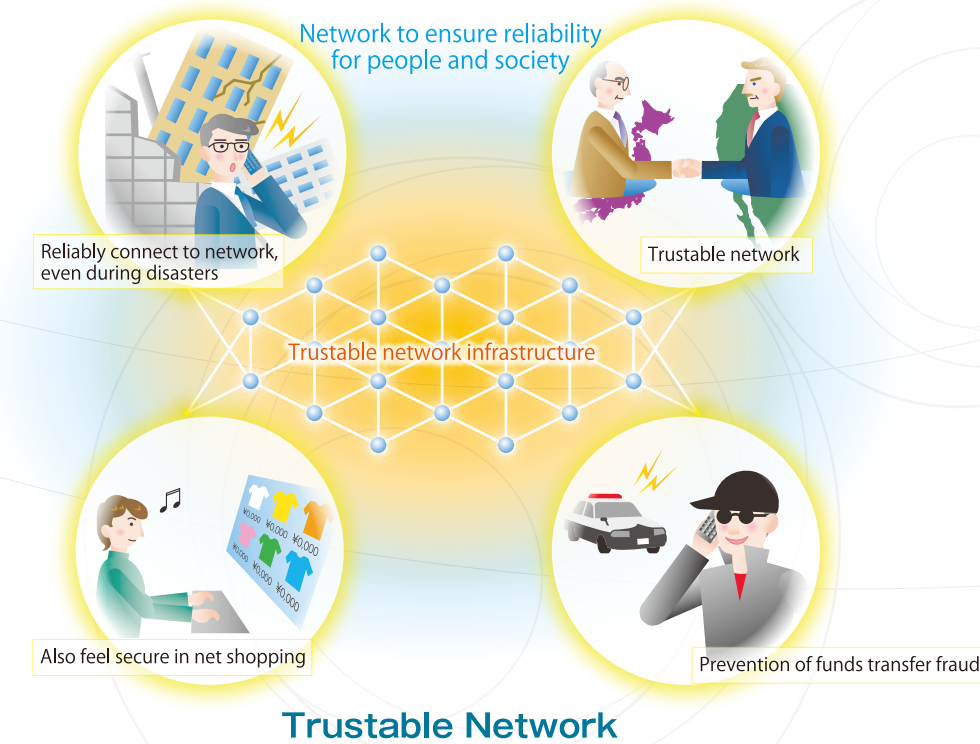
Authentication infrastructure technology which recognizes peer to peer (P2P) type communications, authentication technology incorporated in the operating system (lower layer), and technology for their easy authentication settings

### 2 Network user authentication platform technology

Technology to clearly manage the identities of communications counterparties, and also objectively evaluate their reliability

### 3 Advanced information management technology

Technology for the primary creator to centrally manage private information of individuals and secret information of organizations



# Ambient/Ubiquitous Network

## Background of Targets

Environmental problems, food problems, ageing problems, etc. can be raised as social problems closely related to the social life of humanity that are foreseen in the time of the New-generation network. In such an environment, to achieve a life supporting society in which humans can live decent lives and achieve high quality of life, support is needed from ICT for all living situations. There has been internationalization of distribution and progress in international cooperation, especially for environmental problems and food problems. Thus it is believed that cross-border food distribution management, environmental monitoring, traffic accident prevention using networks, remote health care for senior citizens, support for humans by network robots, etc. can be achieved if it becomes possible to perceive, pursue and as necessary collect and process sensor information generated by humans, things and living environments on a broad global scale, or to drive actuators. It is thought necessary to develop the New-generation network technologies towards solving the social issues mentioned above.

## Network goals

Network of sensors and actuators which support human daily life in all situations

Large scale sensor and actuator infrastructure which connects each other and provides integrated management of the vast number of sensors and actuators in living environments, and using that to form a global scale sensor network with middleware which can dynamically process diverse real-time sensor data

## Technology goals

Global sensor and actuator cloud

Integrated management and control technology which forms the vast number of sensors and actuators in living environments into a cloud

Technology for real-time processing for the vast amount of sensor data in a sensing service which tracks distribution of 10 trillion items/year and live body monitoring of 10 million users, and interaction with the real world

## Major R&D Promotion Strategy

Develop sensor and actuator nodes utilizing the strengths of electronic device technology, and form into open testbed

Promote R&D focusing on wireless sensor and actuator node technology

Construct an open sensor testbed soon. Expand globally to verify node technology and accelerate services development.

Establish de facto actuator API (Application Programming Interface), and foster a service development community

## Effects

Achieve ICT support in all living situations

Achieve safety and security by food resource distribution management and traffic accident prevention

Achieve environmental conservation by environmental monitoring

Achieve aging society with good quality of life, by remote healthcare and living assistance robots

Achieve large scale cloud infrastructure, including embedded devices

## Priority Technology 1 : Network to handle the quantitative explosion

### 1 Sensor and actuator node technology (energy conservation, implementation)

Hardware design technology for sensor and actuator nodes under extreme conditions, such as extreme energy conservation, extreme precision, and extremely light weight

### 2 Sensor and actuator cloud management and control technology

Technology to form a sensor and actuator cloud from diverse nodes, from the level of micro machines in the body, to nodes in the world and extending to extreme distribution in outer space

### 3 Cloud self-organizing technology

Cloud self-organizing technology which autonomously detects and connects connectable networks and adjoining sensors and actuators

## Priority Technology 2 : Life-supporting network

### 1 Environment adaptive sensing technology

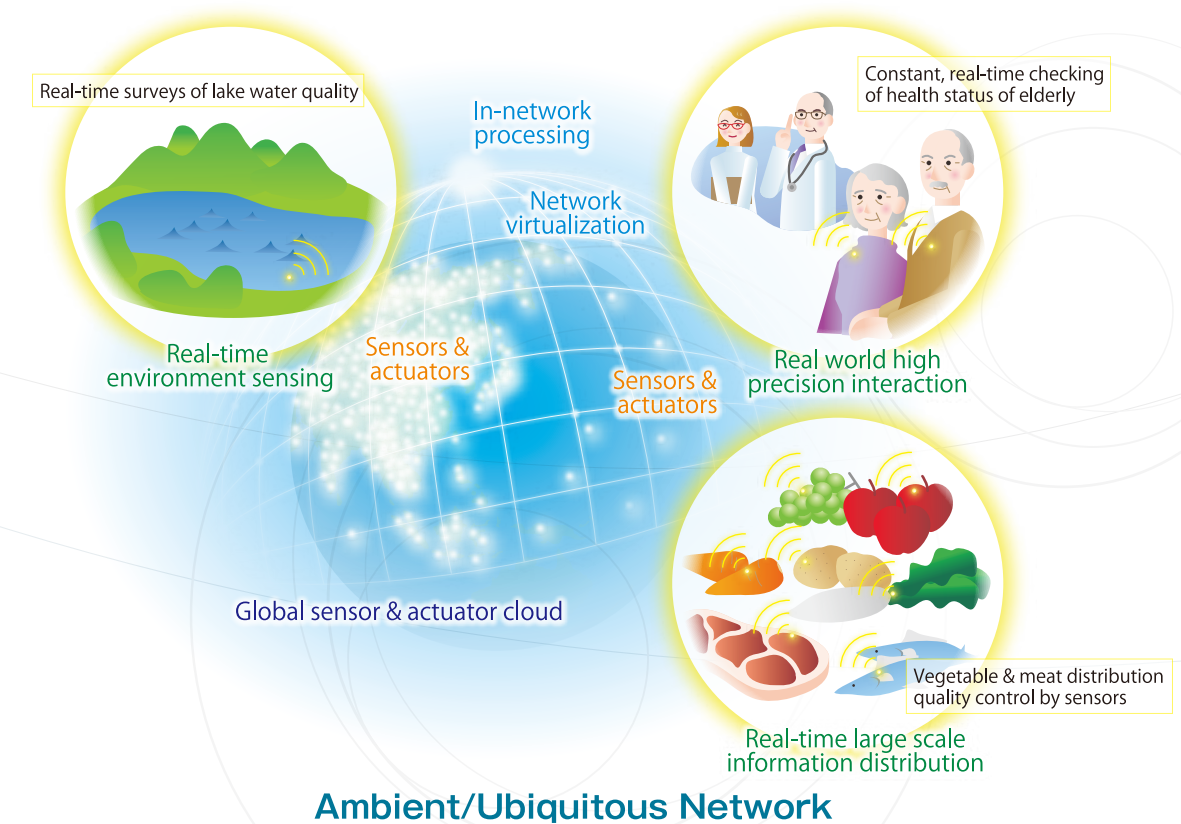
Technology to automatically learn the environment and individual user profiles and context from results of analyses of primary sensor data collected, and based on those, automatically configure sensors and actuators

### 2 In-network processing technology

Technology for real-time and highly flexible reversible data aggregation at intermediate nodes exploiting data oriented network

### 3 Wireless network virtualization technology

Technology to dynamically create on-demand, secure, and highly customizable wireless virtual networks satisfying individual application requirements and user context





# Self-\* Network

## Background of Targets

In recent years, networks are being used for data transfer like Web and email, and also to transfer sensor data and streaming data like voice and video. There is also rapid progress in diversification of services, such as offering applications and platforms through the network, called PaaS (Platform as a Service). On the other hand, though the accompanying conditions required for services are also diversifying, until now it has been difficult to completely provide networks which are customized for each service between sender and receiver, and dramatic problems are foreseen. Thus it is thought necessary to achieve a network that anyone can use without stress, which can respond flexibly to conditions requesting services, etc.

## Network goals

### Pleasant network which can be used without feeling network restrictions

Network which accommodates diversity, able to simultaneously operate different networks matching conditions required

Even in heterogeneous networks, unified network which can provide consistent end-to-end services

"OMOTENASHI"(hospitable) network which can provide services matching user literacy

## Technology goals

### Network technology which can handle diverse requirements

Operation of multiple networks with different specifications, according to each service, etc.

Optimal transmissions end-to-end in a unified network

Use of network services without stress, not requiring complex settings

## Major R&D Promotion Strategy

### Use testbed and accelerate R&D promotion

Strengthen development based on competitive optical/wireless technology

Construct unified network testbed soon

Strengthen federation testbed and integration technology

Fostering of operation managers using testbed

## Effects

### Provide network customized for the individual

Make extremely simple for network operation managers

Automatic network configuration to eliminate user stress

Easier migration, to achieve evolutionary network

Provide infrastructure which solves social problems and achieves the future society

## Priority Technology 1 : Diversity network

### 1 Virtualization of nodes and network resources

To provide virtual networks in multiple layers, technology for virtualization of nodes and network resources including processing functions, in multiple layers

### 2 Virtual networks on physical networks

Technology for network construction, operation and management, in order to map virtual network resources to heterogeneous physical network resources, and build multiple virtual networks

### 3 Adaptive custom network

Technology to launch dynamic functions using appropriate resources, to enable handling of dynamic changes in network composition and traffic, handling of dynamic addition of new functions, etc.

## Priority Technology 2 : Network unification

### 1 Data transmission in unified path/packet network

Network architecture which unifies path/packet networks, and technology to achieve data transmission by route and transmission method according to the flow's characteristics

### 2 Data transmission in wired/wireless unified network

Network architecture which unifies transmissions in rough and precise wireless networks and optical fiber networks, and technology to achieve data transmission by route and transmission method according to the flow's characteristics

### 3 Network which unifies multiple aspects: optical/electronic/wireless and path/packet

Technology for operation, management and data transmission in unified network which integrates wired/wireless, optical/electronic and path/packet networks

## Priority Technology 3 : "OMOTENASHI"(hospitable) network

### 1 Automatic network configuration

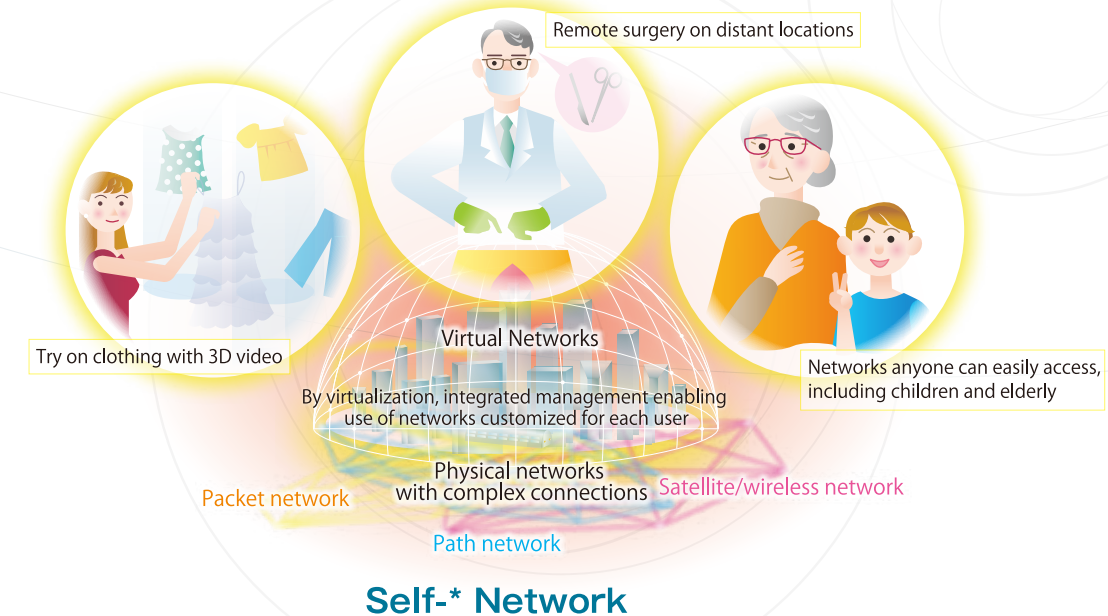
Ease of use technology to enable unburdened use of unified network which integrates wired/wireless, optical/electronic and path/packet

### 2 Network status visualization and autonomous networks

Technology for visualizing network status and various network problems, and for autonomous networks which optimally maintain the network while providing problem solutions corresponding to user intentions

### 3 User data control network

Architecture which finds and manages network user's data, and technology which enables control of user data in the network, according to user desires



# Sustainable Network

## Background of Targets

Information and communications societies have been achieved through synergistic effects of innovative technologies, especially broadband communication technology using optical fibers, Internet technology, mobile telecommunication technology, computer technology, etc. On the other hand, with the rapid innovation and spread of services, this field is now facing many problems that can be called limits of the earth's capacity, and these problems are becoming the constraints for further development of network systems and services.

Among these, today's most important issues are "energy problems" and "frequency resource problems". Efforts have been made on these issues, but considering current forecasts of growth in users, diversification of sensors and other appliances, and traffic growth, these are thought difficult to solve by existing methods. Thus in the New-generation network, it is thought necessary to aim for further sustainable development of the information and communication society, by finding methods for essential solutions to global scale problems.

## Network goals

### Sustainable network

"Green network" enabling information distribution with very little energy

"Highly efficient spectrum use wireless network" which shares limited spectrum among many users and diverse appliances

## Technology goals

### Green network technology (information distribution with very little energy)

Network enabling transfer of information at 1/1000 of current energy levels (1000 times higher energy efficiency. Current technology has a limit of about 10 times higher energy efficiency.)

### Technology for advanced use of frequency resources

Achieve higher spectrum use efficiency, by dynamic frequency sharing technology, frequency use technology comprised of smaller cells, and pioneering of unused sub-millimeter to terahertz frequency bands. Thereby achieve 100 times higher wireless communications volume (traffic capacity).

## Major R&D Promotion Strategy

### Achieve goals by innovation in network architecture and wireless communication methods

R&D on new network architecture aiming for lower power consumption

International standardization to promote industry

Promote spectrum sharing technology verification

Promote development of technology for higher efficiency spectrum use, and accelerate development of technology for its related fixed mobile convergence (FMC) enabling end-to-end quality guarantees

## Effects

### Coexistence of lower global environmental burdens and greater communication volume

Drive the information and communication market, utilizing strengths in energy reducing technology

Allow further communication traffic growth, user growth, and diverse appliances

International contributions utilizing energy conserving network technology

More portability (no cables) for all information home electronics/ appliances, to improve usability and develop new usage situations and business models

## Priority Technology 1 : Green network (Extremely low energy information transmission)

### 1 Low-power oriented network architecture

Technology to create and verify new network architecture with lower power consumption information transfer as the primary objective

### 2 Total power-minimization in ICT overall

Technology to optimize mechanisms for allocation and transfer of distributed contents in the network

### 3 Low power consumption photonic network, optical access, wireless access

Technology for lower power consumption in network equipments

### 4 Technology for lower power consumption in home networks

Lower power consumption technology for in-home communication devices which comprise a large share of power consumption today

### 5 Protocols for low power consumption networks

Communication protocols to handle lower communication bandwidth and temporary appliance disconnection from the network by such as sleep function

### 6 Real-time measurement and methods to calculate power use in network and appliances

Technology for methods to calculate power amounts in network equipments and appliances, and real-time measurement and information distribution to give feedback

## Priority Technology 2 : Advanced efficient spectrum utilization

### 1 New spectrum usage technology

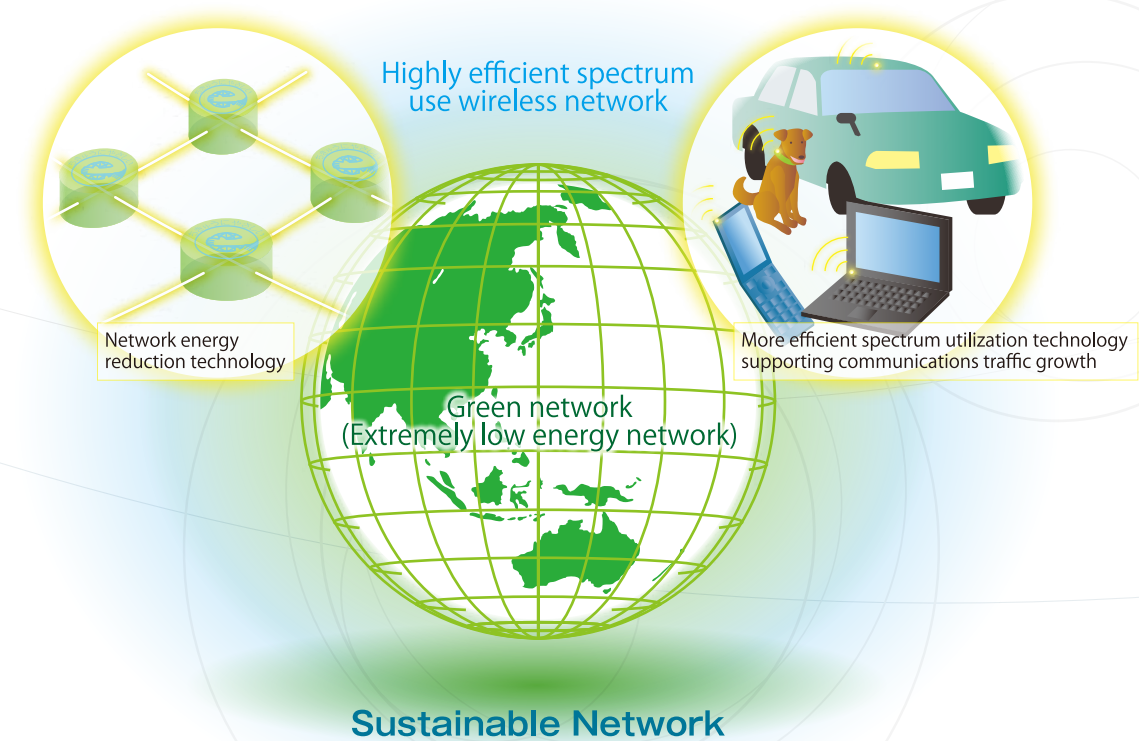
Technology to use unused frequency bands: millimeter-wave, sub-millimeter wave and terahertz wave

### 2 Cognitive wireless technology

Technology to sense spectrum utilization and share such information among systems and users, and to share the same spectrum between multiple systems

### 3 Technology for cooperation between systems, by heterogeneous networking

Technology for mobility protocols which consider aggregation and handover between different systems seamlessly





# New-generation Network Fundamentals

## Fundamentals to Support The Five Network Targets

The most significant attributes in the era of the New-generation of network include the vast scale and complexity of networks. However, it is difficult for traditional network fundamentals to solve quantitative challenges such as the scale and complexity, and to resolve the qualitative requirements posed in the networks. In addition, the network should work in the era of a knowledge-society. The network should also be harmonized with innovations in cutting-edge physical and device science and technology. That is, we need to develop the New-generation network fundamentals in order to break through the limitations of classical technologies, to handle diverse new requirements, and to create emergent value.

## Network goals

Network fundamentals enabling continual values and solving quantitative and qualitative challenges

Fundamentals to handle the tough conditions posed on the New-generation network, such as extremely large-scale complexity and diversity. Fundamentals to create new value and functions in the New-generation network

## Technology goals

Network fundamentals in the era of complexity and interdisciplinary research

Scientific and technological fundamentals to support extremely large and complex network systems

Network fundamentals incorporating complex behavior of terminals, people, and society

Fundamental technology for value creation in a knowledge society

Creating value chain between networks and cutting-edge innovations in physical properties, materials, and devices

## Major R&D Promotion Strategy

Strategic promotion of fundamental research

Foster network architects

Interdisciplinary research promotion scheme

Strategic strengthening of fundamental areas

## Effects

For future and emergent innovations in the network

Diverse impacts from fundamental technologies of the New-generation network

Developing fundamentals in the knowledge-society and value creation

Exploit Japan's strengths in materials and devices for innovation in network systems

## Priority Technology 1 : Network Architecture Fundamentals

### 1 Novel network architecture fundamentals

Deepen and broaden the sciences of networks. Break through the limitation of classical theories for the New-generation network architecture fundamentals

### 2 New network performance and evaluation fundamentals

Fundamentals to handle diverse performance indices and value standards expected in the New-generation network

## Priority Technology 2 : Knowledge-Society Network Fundamentals

### 1 Network fundamentals for a knowledge-society

Fundamental technology for the creation of emergent value by people in a knowledge-society

### 2 Network fundamentals for supporting people

Fundamental technology for supporting people by a network involving information on people's actions, emotions, sensorimotors, and brains

## Priority Technology 3 : Network Physical Architecture Fundamentals

### 1 Harmonize the cutting edge physical layer technologies with functional systems

Exploit Japan's world-leading materials and device technologies for innovations in network systems and applications

### 2 New ICT physical principles for novel network applications

Develop new network principles with innovative physical, photonic, materials, and biology research

