AKARI and JGN2plus
- for new generation network and it's testbed -

GEC   Mar 3, 2008

Hideki Otsuki
Network Architecture Group
New Generation Network Research Center
NICT

What is AKARI

- A research project for new generation network.
    - Clean slate approach
    - Started from small group studying for Architecture design. (an initial AKARI project)

        … 　AKARI Architecture Design Project

    - Movement for the new generation network promoted by NICT

- "AKARI" is a small light in a dark.
    - To be a light **pointing to the future** .

AKARI Architecture Design Project Members:

Network Architecture Group Leader: Hirabaru
Harai (Photonic switching), Xu (Light Path), Miyazawa (Opt. Access),
Morioka (Optical Transmission), Otsuki (Control), Jumpot,
Inoue (Univ. Access), Nakauchi (Overlay), Kafle (Addressing), and
Ohnishi.

Network science by Prof. Murata (Osaka U.)
Ubiquitous by Prof. Morikawa (U. Tokyo)
Mobility by Prof. Teraoka (Keio U.)
Packet switching by Prof. Ohta (Tokyo Inst. Tech.)
Network Virtualization by Prof. Aki Nakao (Univ. of Tokyo)

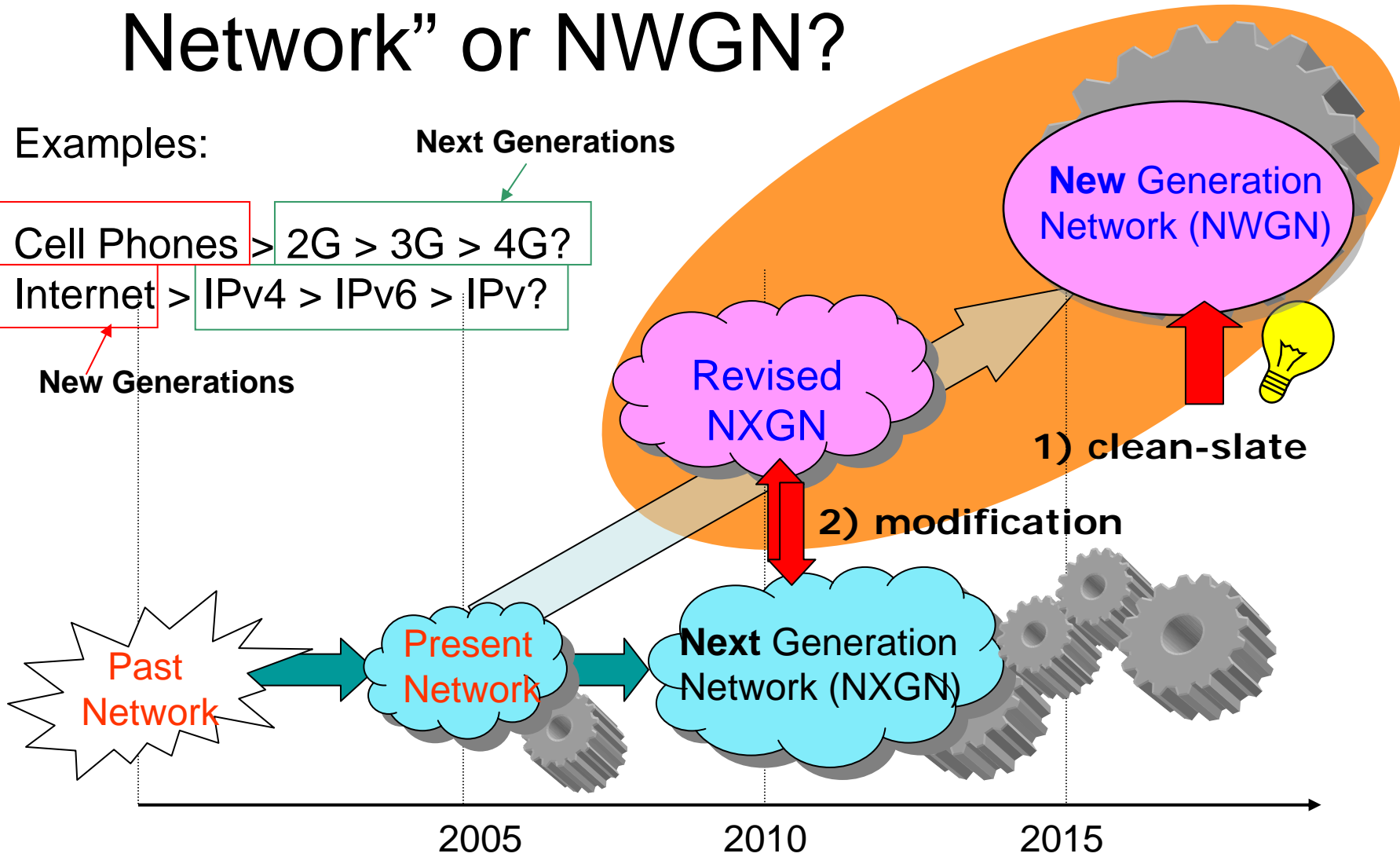**Advisory: Program Director Prof. Aoyama, Executive Director Dr. Kubota**

What's "New Generation Network" or NWGN?

Examples:

Next Generations

Cell Phones > 2G > 3G > 4G?

Internet > IPv4 > IPv6 > IPv?

New Generations

New Generation Network (NWGN)

Revised NXGN

1) clean-slate

2) modification

Past Network

Present Network

Next Generation Network (NXGN)

2005   2010   2015

AKARI   NiCT   JGN2 plus

AKARI Architecture Design Plan

- Grand-Designing a New Generation Network beyond 2015 -

2006   2011   2016～

NWGN Workshop (Open)
AKARI Camp (Invite Only)

10+ Researchers (NAG)

Concept & Principles

Design (Now)

Proof of Concept

NWGN Blueprint

Testbed Construction

Field Trial

Innovation

Prototyping

JGN2plus

Overlay Network

Testbed Design

JGN X

Service & Operations

Standardization
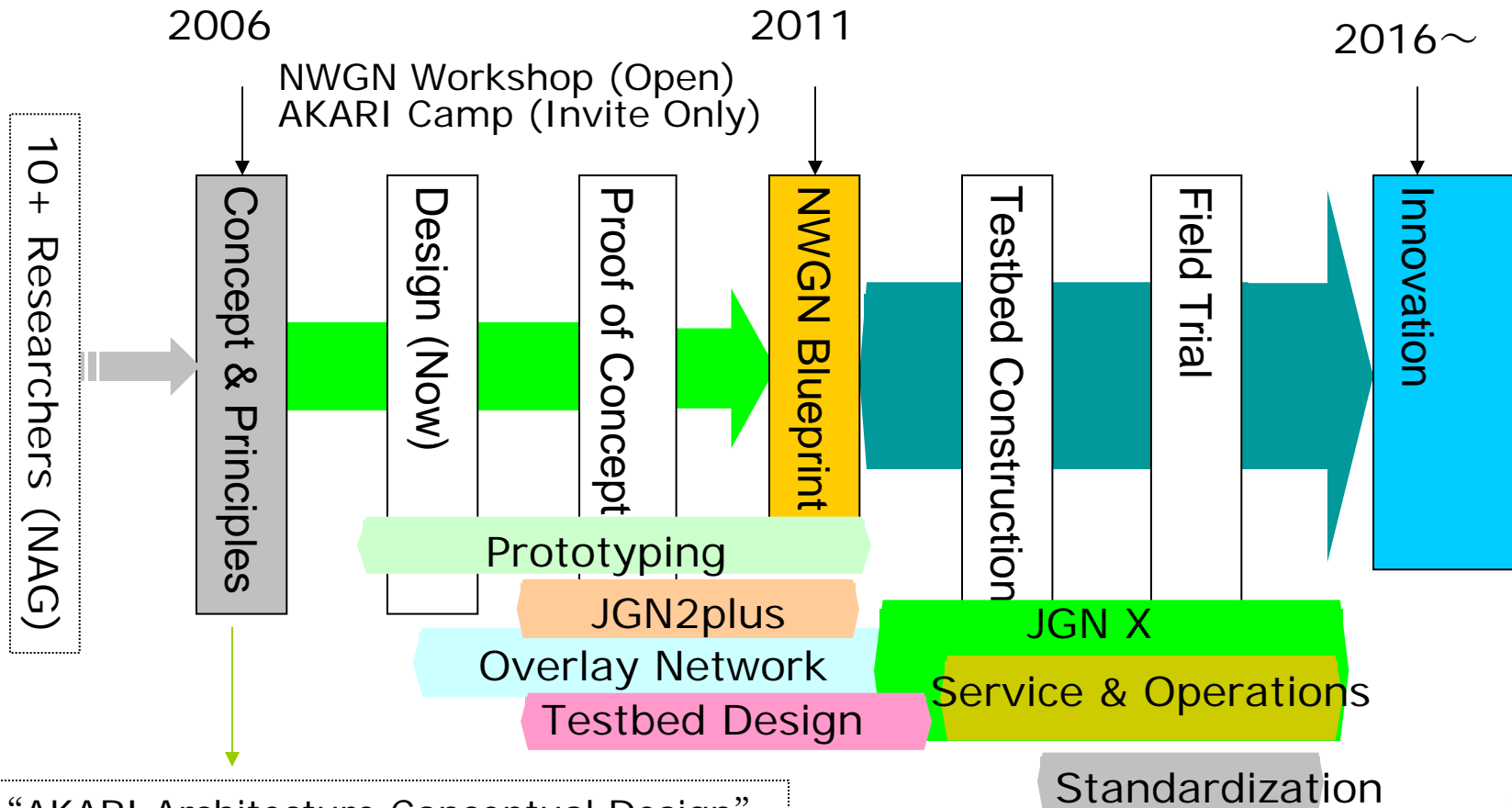
"AKARI Architecture Conceptual Design" released in April 2007.
English version in Fall, 2007.

AKARI

NICT

JGN2 plus

AKARI's Current Focus: Network Architecture

Role

Safety & Security	Capacity (Peta)	Ubiquity
	Energy-Saving	Diversity

Process

Future requirements from diverse users and society

Flexible to adopt a new user requirement

Network Architecture

No vertical division. Common infrastructure

Enjoy fundamental technology advances

Evolving, future fundamental technologies

All Optical	Software Radio	Theoretical Limits

Design Principles

Select, integrate and simplify

Feedback

proof-of-concept

Testbed (Overlay Network)

NETWORK SCIENCE

- Optimal Integration of many components
- Stable enough to rely on for a long time

- Grand-Designing a New Generation Network beyond 2015 -

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AKARI **Sustainable** Architecture Principles

Capacity for Quality

1. KISS (Keep It Simple, Stupid)
   - Crystal synthesis (select, integrate, simplify)
   - Common layer (layer degeneracy)
   - End-to-end (original Internet)

2. Reality Connected
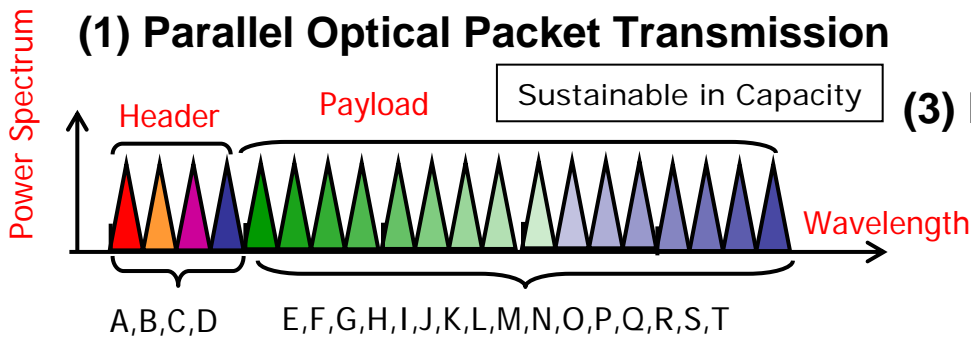- ID-Locator separation
- Bi-directional authentica
- Traceability

3. Sustainable & Evolutional
- Self-* properties (emergent)
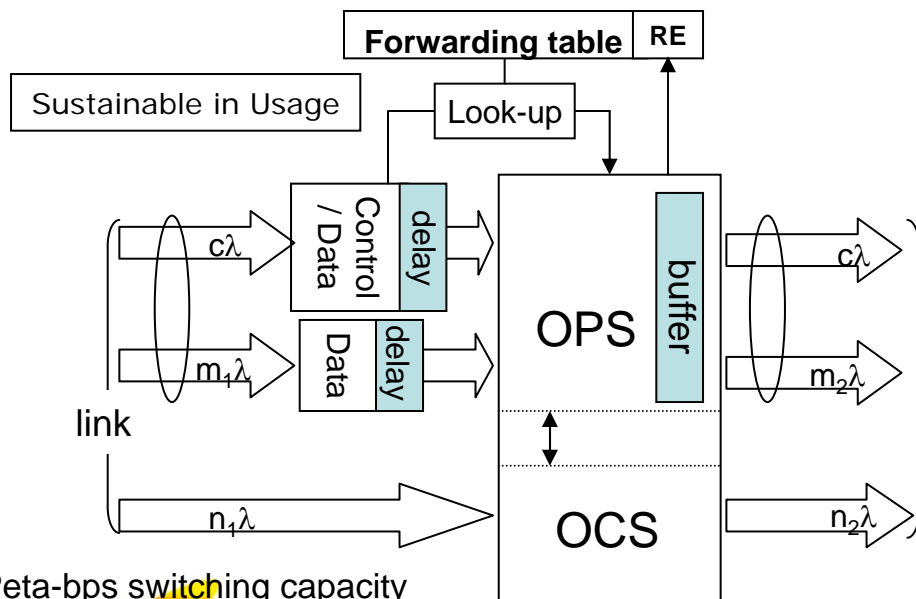- Autonomic distributed control
- Scalable
- Social Selection

Reliable Network Space

For Future Diverse Society

AKARI Architecture Components (I) – Optical & Wireless

(1) Parallel Optical Packet Transmission

Power Spectrum

Header   Payload

| Sustainable in Capacity |

Wavelength

A,B,C,D   E,F,G,H,I,J,K,L,M,N,O,P,Q,R,S,T

(2) All-Optical Path / Packet Switching

Forwarding table   RE

| Sustainable in Usage |

Look-up

Control /Data   delay $c\lambda$ OPS   buffer $c\lambda$

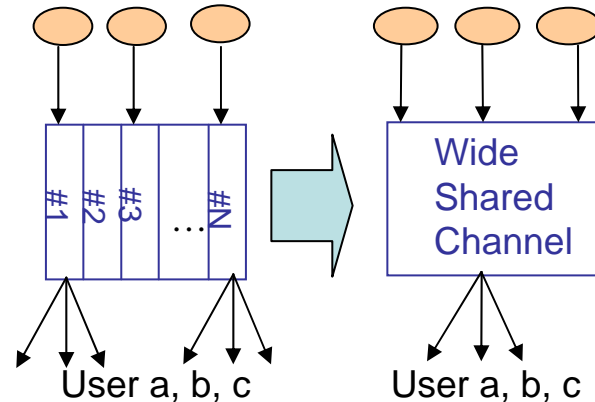Data   delay $m_1\lambda$ $m_2\lambda$

link

$n_1\lambda$ OCS $n_2\lambda$

Peta-bps switching capacity
Tera-bps link speed (40G x 100)
100 billion tiny terminals

Energy Saving – All optical

AKARI

(3) PDMA (Packet Division Multiple Access)

| Sustainable in Management and Capacity |

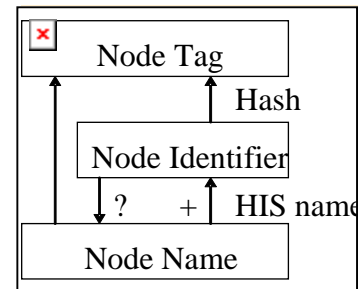#1 #2 #3 …#N → Wide Shared Channel

User a, b, c   User a, b, c

Packet (CSMA/CA) Only
Free from:
Frequency Band Allocations
Cell Design

(4) ID / Locator Separation
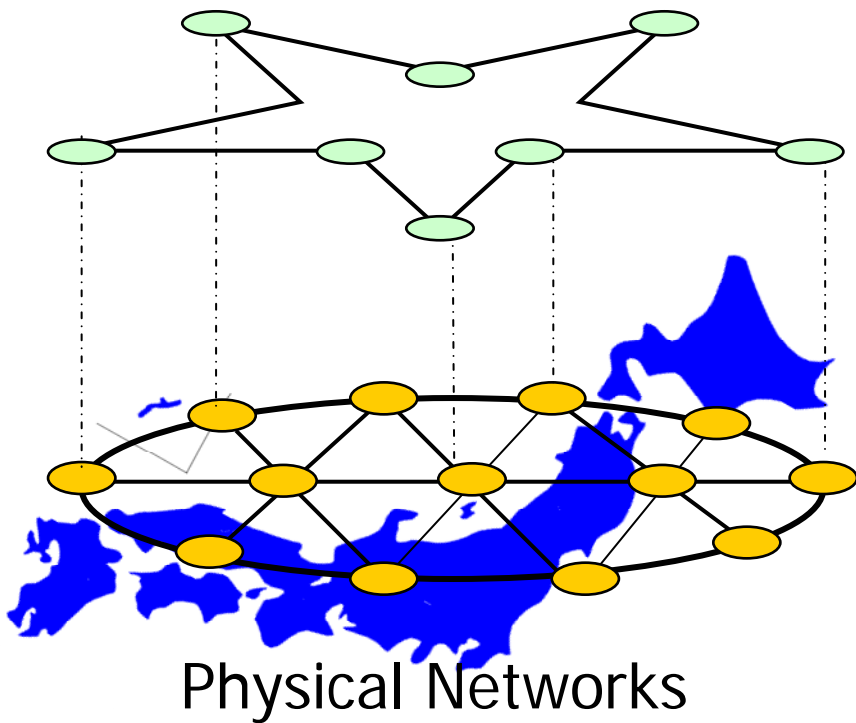
- Generic ID Space
- Authenticated, but
- Keep privacy

| Sustainable in Mobility & Security |

Node Tag

Hash

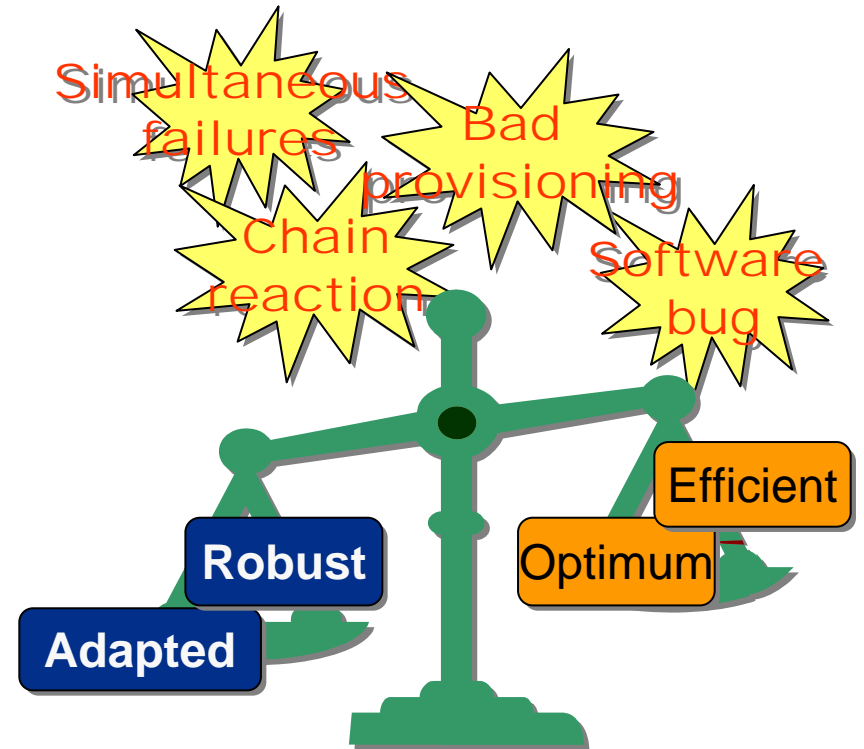Node Identifier

?   +   HIS name

Node Name

NiCT

AKARI Architecture Components (II) - New concepts -

(5) Overlay Network / Network Virtualization

Physical Networks

(6) Self-organizing Control

Simultaneous failures

Bad provisioning

Chain reaction

Software bug

Robust

Adapted

Optimum

Efficient

Manageable
Fast Recovery

AKARI   NiCT   JGN2 plus

CORE: Collaborative Overlay Research Environment

Private Overlay network over JGN2, WIDE, and SINET

Led by Prof. Aki Nakao

Joint project with: THE UNIVERSITY OF TOKYO

- 10 sites, 52 servers
- Multi-Homed
- Testbed Federation
- JGN2+ NOC Coop.

Sapporo
Sapporo Medical U.

Hakusan Network Virtulization Lab.

Tohoku U.

Hiroshima U.

Sendai

Kanazawa
Nagano
Tsukuba

NII

Kyutech

Nagoya
Tokyo

Okayama

U. Tokyo

Kitakyushu
Osaka Keihanna

Fukuoka

NICT Otemachi

Kochi-tech

Osaka U.

NICT Koganei

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CORE Concept

- Collaborative Overlay Research Environment
  - Overlay test-bed based on "Private PlanetLab"
  - Provision resources for mission critical services
- Features we would like to have…
  - Custom hardware to optimize overlay forwarding
  - PoP/Core collocation (nodes "inside" network)
  - Custom hardware to optimize overlay forwarding
- Wireless/Sensors/Photonic capability in future
- Federation (e.g. PlanetLab, OneLab)
- Target overlay research
  - Not just on distributed system apps
  - More on network core architectures
- Utilize both private & public environments
  - Local v.s. Global / Provisioned v.s. Best-Effort

New Generation Perspectives to Overlay Network

- Testbed for prototype and evaluate a new generation network design
- Evolutional nature of overlay network to incorporate into the design

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AKARI NWGN (New Generation Network) R&D Plan
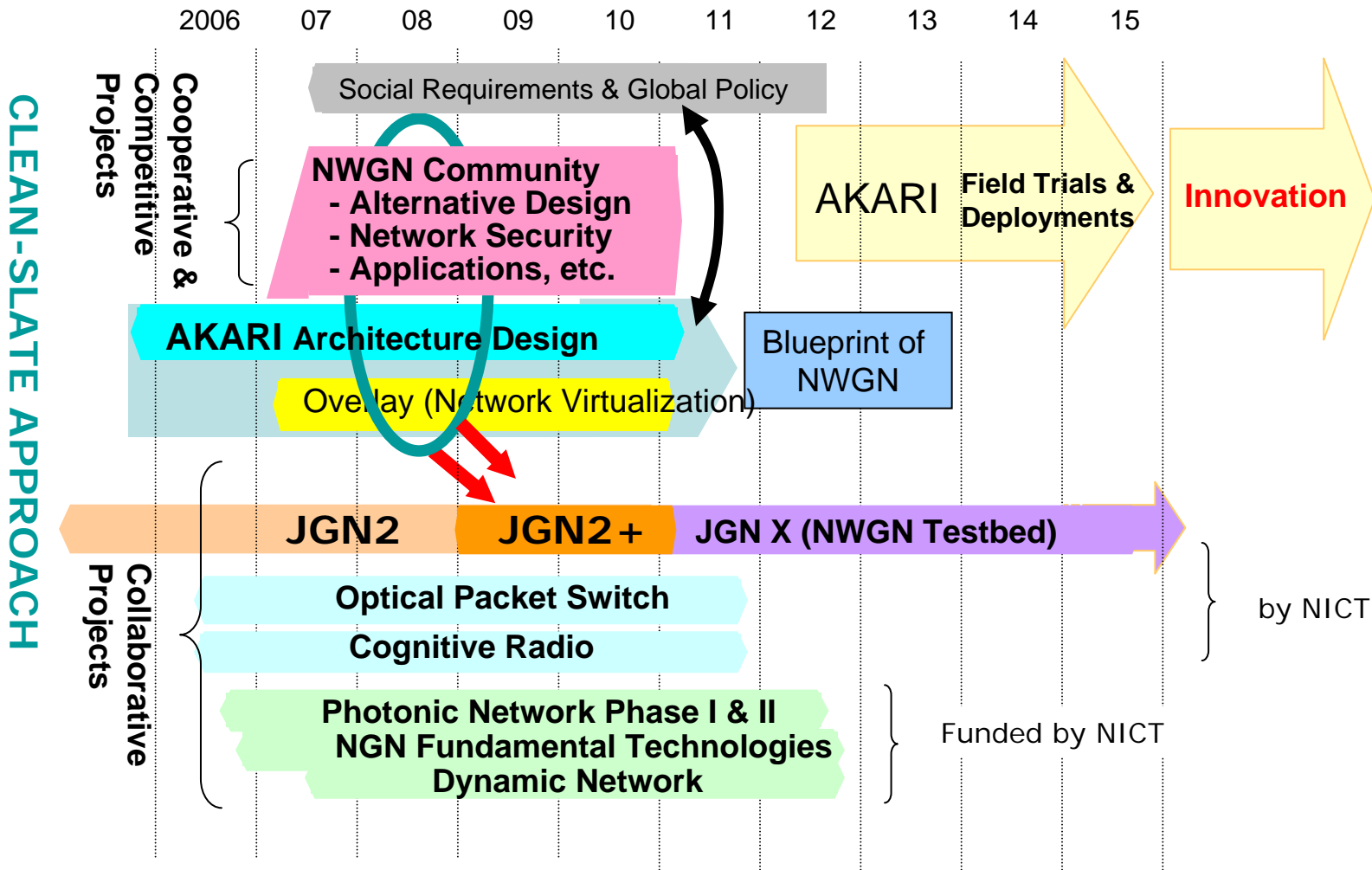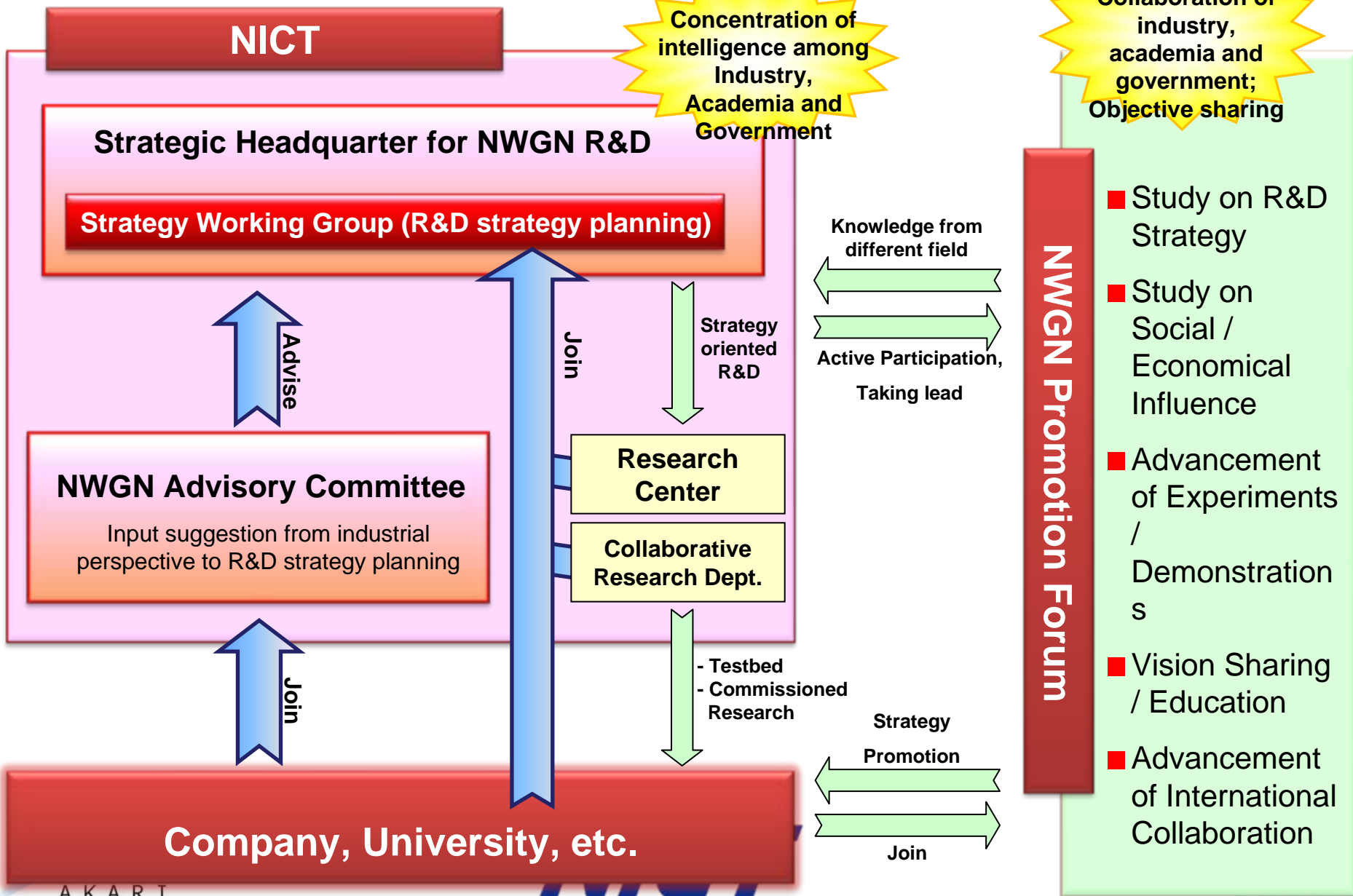

"AKARI Architecture Conceptual Design" English version released in Fall, 2007.
http://akari-project.nict.go.jp

Structure of Advancement of R&D for New Generation Network (NWGN)

NICT

Strategic Headquarter for NWGN R&D

Strategy Working Group (R&D strategy planning)

Concentration of intelligence among Industry, Academia and Government

Collaboration of industry, academia and government; Objective sharing

Advise

Join

Strategy oriented R&D

Knowledge from different field

Active Participation, Taking lead

NWGN Advisory Committee

Input suggestion from industrial perspective to R&D strategy planning

Research Center

Collaborative Research Dept.

NWGN Promotion Forum

- ■ Study on R&D Strategy
- ■ Study on Social / Economical Influence
- ■ Advancement of Experiments / Demonstrations
- ■ Vision Sharing / Education
- ■ Advancement of International Collaboration

Join

- Testbed
- Commissioned Research

Strategy Promotion

Company, University, etc.

Join

AKARI

What is JGN2plus

- A new R&D network testbed
  - Post JGN2
  - Nation wide network
  - L3, L2 and photonic fiber

  - Testbed for network
  - Testbed for application

Mission of JGN2plus from a Viewpoint of Research

- Backbone for new R&D activities in network technology
  - Grid, Broadcasting applications
    - Advanced network service (ex. Light path, GMPLS)
    - Collaboration with SINET and other Grid projects, etc.
  - Ubiquitous, Sensor, P2P
    - Need New communication paradigm by overlay network
      - Planet Lab, PIAX
    - Collaboration with ubiquitous projects, specially appointed ubiquitous area, information explosion project, Live-E, etc.
  - Define Operation model for and migration path to new generation network
- Vehicle for Global Collaboration
  - International collaboration on E-science and NWGN research
  - International education, human resource development
  - Standardization, footprint for development of Service Platform
- Regional Collaboration
  - promotion of U-Japan
- Collaboration with other activities in NICT
  - Security, Starbed(Internet Realscale simulator) , Universal communication, Quantum communication, Space weather, e-VLBI

Target of JGN2plus

- Toward Nation-wide
  deployment of
  broadband network

- Popularization of
  IPv6 technology

- Toward Implementation of
  Next Generation Internet (NGN / IPv6)
- R&D of Optical NW
- Application Development
- International Community

- Toward Implementation of
  New Generation Network
- R&D of Service Platform
- International Experiments

JGN2plus

JGN

JGNII

JGN JGNII JGN2plus

09 2000 2001 2002 2003 2004 2005 2006 2007 2008

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JGN2 plus

Major changes from JGN2 to JGN2plus

	JGN2 (2004.4 - 2008.3)	JGN2plus (2008.4 – 2011.3)
R&D Structure	R&D by seven research centers (Research on specific topics under 4-year plan)	*Service Platform Architecture Research Center* *SPARC* Operation Uniting operation and research as one structure to advance R&D for operation / management technology in NWGN
NW Operation	Network Operation Center (NOC) (Stable operation of L2/L3 service)	R&D Advancement of NWGN testbed R&D
NW Services	-Optical Testbed Service -Nation-wide access points (64 APs) -International circuits (US, TH, SG	-Optical Testbed Service -Nation-wide access points -International circuits (US, TH, SG, CN, KR) -Overlay service platform provisioning.

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JGN2 plus

JGN2plus Services Available

Network Services

L3: IP connection
- IP interconnection among JGN2plus users, or among JGN2plus users and other research networks
✓ IPv4/v6 dual stack, IPv6 Native (Full route), Core routers on main APs

L2: Ethernet connection
- Point-to-point connection service: VLAN-based L2 point-to-point interconnection
- Multi-point connection service: VLAN-based L2 multi-point interconnection
✓ Jumbo-frame support (over 1G, 10G lines)

Optical Testbed
- Hakusan – (8 fibers) – Otemachi – (16 fibers) – Koganei
- for experiments of optical-level transmission

International circuits

| US | TH | SG | CN | KR |

Operation X R&D

Operation Service + R&D
- Operation / management of circuits, equipments on APs
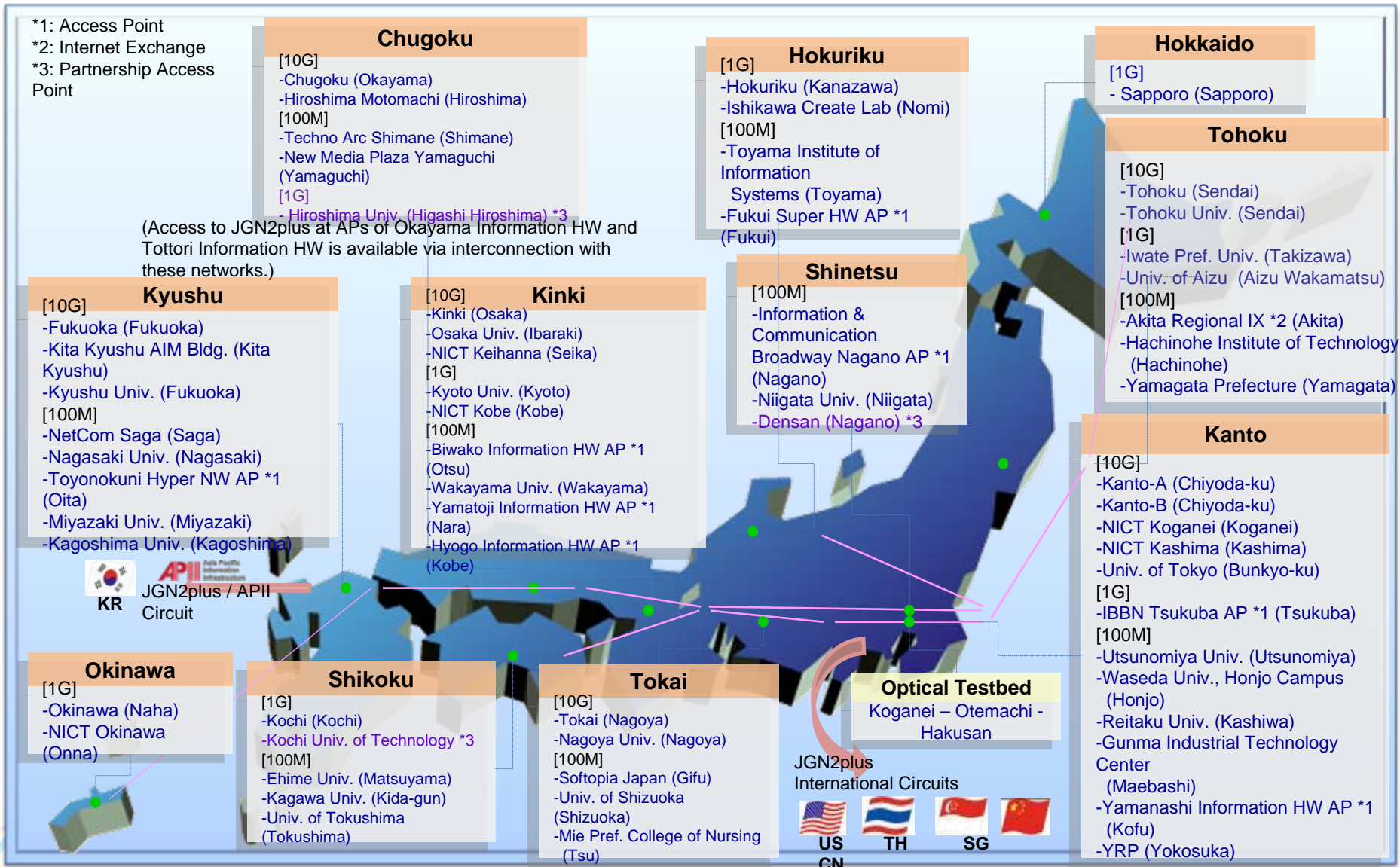- Service Platform Provisioning
- Technical supports

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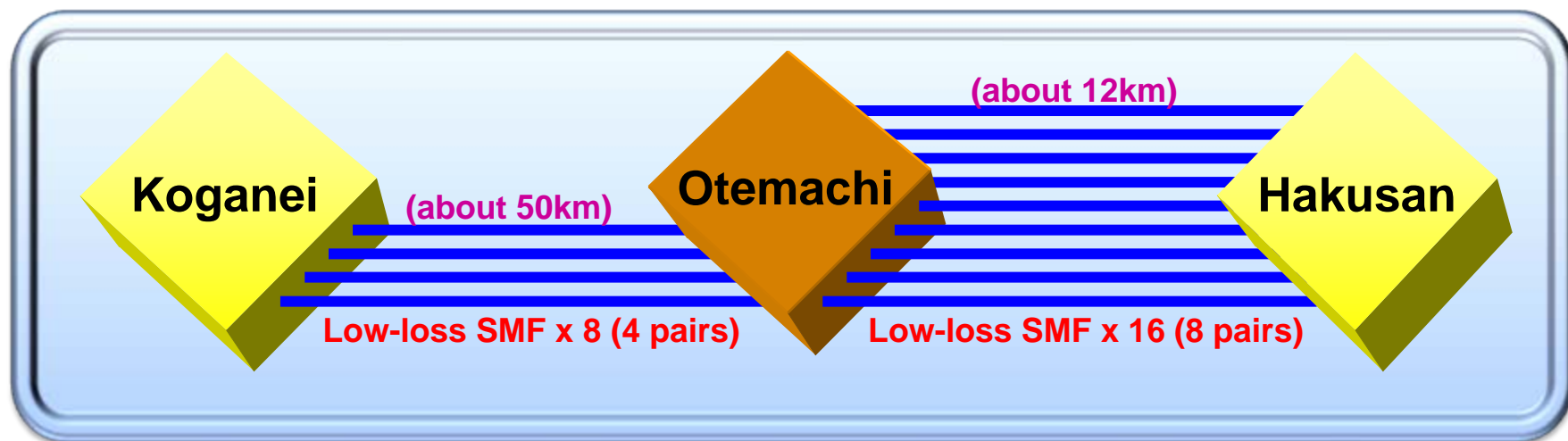JGN2 plus

JGN2plus Services
(1) JGN2plus Network Outline

*1: Access Point
*2: Internet Exchange
*3: Partnership Access Point

Chugoku
[10G]
-Chugoku (Okayama)
-Hiroshima Motomachi (Hiroshima)
[100M]
-Techno Arc Shimane (Shimane)
-New Media Plaza Yamaguchi (Yamaguchi)
[1G]
- Hiroshima Univ. (Higashi Hiroshima) *3

(Access to JGN2plus at APs of Okayama Information HW and Tottori Information HW is available via interconnection with these networks.)

Hokuriku
[1G]
-Hokuriku (Kanazawa)
-Ishikawa Create Lab (Nomi)
[100M]
-Toyama Institute of Information
  Systems (Toyama)
-Fukui Super HW AP *1 (Fukui)

Hokkaido
[1G]
- Sapporo (Sapporo)

Tohoku
[10G]
-Tohoku (Sendai)
-Tohoku Univ. (Sendai)
[1G]
-Iwate Pref. Univ. (Takizawa)
-Univ. of Aizu (Aizu Wakamatsu)
[100M]
-Akita Regional IX *2 (Akita)
-Hachinohe Institute of Technology (Hachinohe)
-Yamagata Prefecture (Yamagata)

Kyushu
[10G]
-Fukuoka (Fukuoka)
-Kita Kyushu AIM Bldg. (Kita Kyushu)
-Kyushu Univ. (Fukuoka)
[100M]
-NetCom Saga (Saga)
-Nagasaki Univ. (Nagasaki)
-Toyonokuni Hyper NW AP *1 (Oita)
-Miyazaki Univ. (Miyazaki)
-Kagoshima Univ. (Kagoshima)

Kinki
[10G]
-Kinki (Osaka)
-Osaka Univ. (Ibaraki)
-NICT Keihanna (Seika)
[1G]
-Kyoto Univ. (Kyoto)
-NICT Kobe (Kobe)
[100M]
-Biwako Information HW AP *1 (Otsu)
-Wakayama Univ. (Wakayama)
-Yamatoji Information HW AP *1 (Nara)
-Hyogo Information HW AP *1 (Kobe)

Shinetsu
[100M]
-Information & Communication Broadway Nagano AP *1 (Nagano)
-Niigata Univ. (Niigata)
-Densan (Nagano) *3

Kanto
[10G]
-Kanto-A (Chiyoda-ku)
-Kanto-B (Chiyoda-ku)
-NICT Koganei (Koganei)
-NICT Kashima (Kashima)
-Univ. of Tokyo (Bunkyo-ku)
[1G]
-IBBN Tsukuba AP *1 (Tsukuba)
[100M]
-Utsunomiya Univ. (Utsunomiya)
-Waseda Univ., Honjo Campus (Honjo)
-Reitaku Univ. (Kashiwa)
-Gunma Industrial Technology Center (Maebashi)
-Yamanashi Information HW AP *1 (Kofu)
-YRP (Yokosuka)

KR
JGN2plus / APII Circuit

Okinawa
[1G]
-Okinawa (Naha)
-NICT Okinawa (Onna)

Shikoku
[1G]
-Kochi (Kochi)
-Kochi Univ. of Technology *3
[100M]
-Ehime Univ. (Matsuyama)
-Kagawa Univ. (Kida-gun)
-Univ. of Tokushima (Tokushima)

Tokai
[10G]
-Tokai (Nagoya)
-Nagoya Univ. (Nagoya)
[100M]
-Softopia Japan (Gifu)
-Univ. of Shizuoka (Shizuoka)
-Mie Pref. College of Nursing (Tsu)

Optical Testbed
Koganei – Otemachi - Hakusan

JGN2plus International Circuits

US
CN
TH
SG

JGN2plus Services
(2) Optical Testbed Service

- JGN2plus Optical Testbed Service
  - ➢ Koganei-Otemachi Section
    - about 50km
    - Single mode optical fiber (ITU-T G.652) x 8
    - Low-loss SMF (within 20dB loss at 1550nm band, without any transponders / amplifiers)
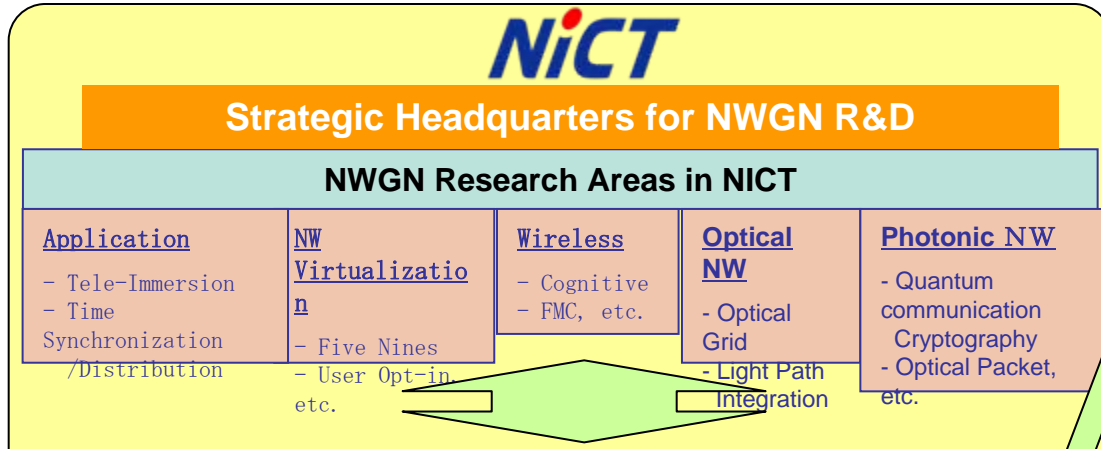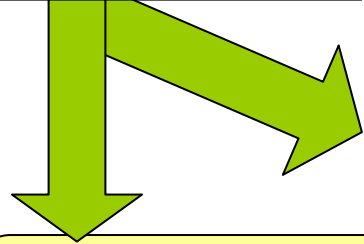 - ➢ Otemachi-Hakusan Section
    - About 12km
    - Single mode optical fiber (ITU-T G.652) x 16
    - Low-loss SMF (within 10dB loss at 1550nm band, without any transponders / amplifiers)

R&D in JGN2plus SPARC

MIC / NICT

New Generation Network Promotion Forum

新世代ネットワーク推進フォーラム
New Generation Network Promotion Forum

NiCT

Strategic Headquarters for NWGN R&D

NWGN Research Areas in NICT

Application
- Tele-Immersion
- Time Synchronization /Distribution

NW Virtualization
- Five Nines
- User Opt-in, etc.

Wireless
- Cognitive
- FMC, etc.

Optical NW
- Optical Grid
- Light Path Integration

Photonic NW
- Quantum communication Cryptography
- Optical Packet, etc.

Other R&D activities in Internet / NGN areas

International R&D NWs

NSF · INTERNET2 · APAN · GEANT2 · TransPAC2 · TEIN2

JGN2plus SPARC (at Otemachi)

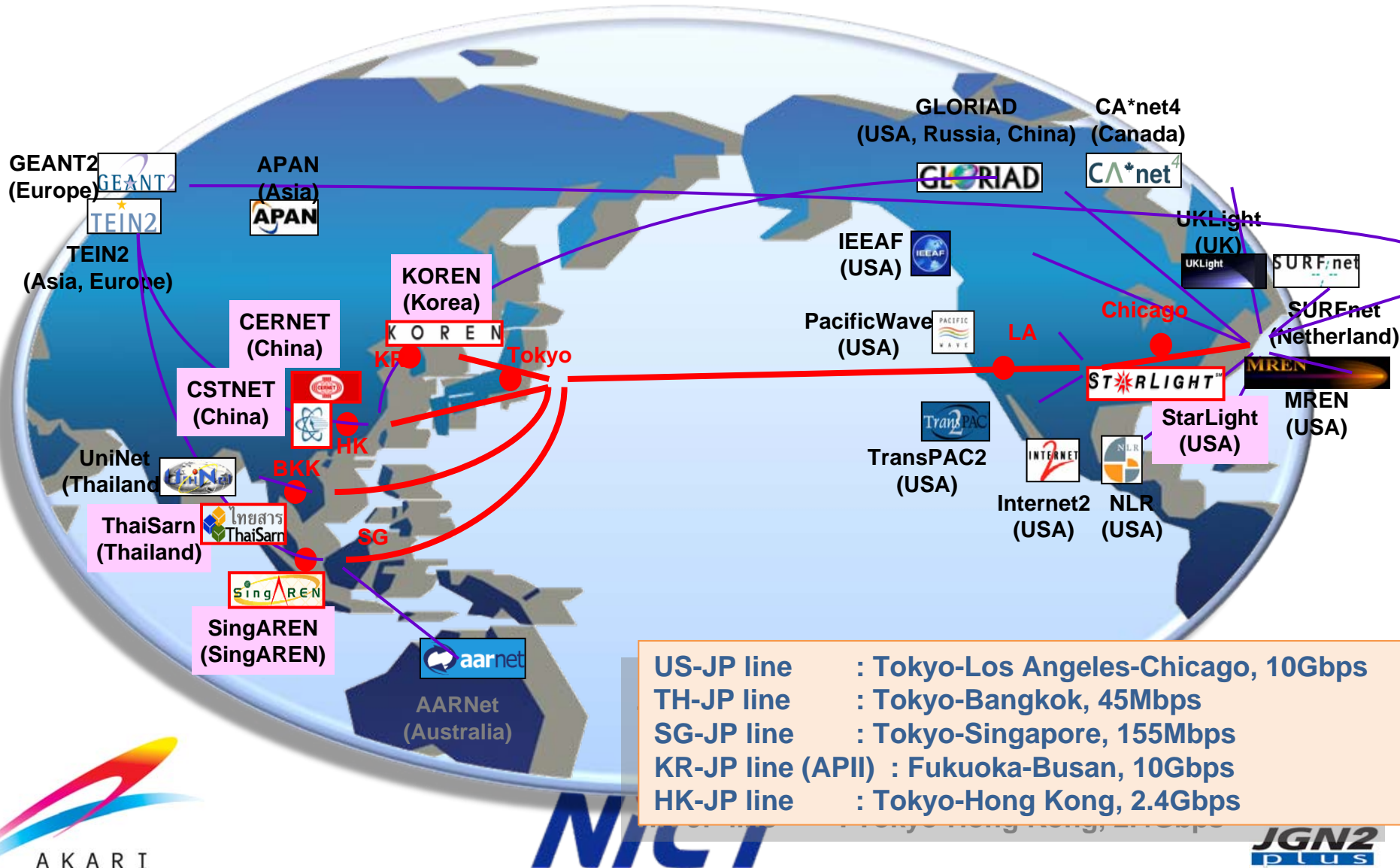| Research Topic 1	Research Topic 2	Research Topic 3	Research Topic 4	Research Topic 5
R&D on NWGN Service Platform Fundamental Technology (Shimojo)	R&D on NWGN Service Testbed federation technology (Nakayama)	R&D on middleware and Application of Light Path NW (Otsuki)	Establishment of Component Technologies for NWGN Operation (Esaki)	Verification of Technologies for International NW Operation (Kitamura)
- Distributed Data Fusion Technology - Structured / Adaptive Overlay Technology	- Multi-layer Overlay NW Integration / Evaluation Technology	- Cutting-Edge Application - Interoperability Test / Standardization	- Network Monitoring - Traffic Management - P2P Traffic Engineering - NGN / IMS-SIP Operation Technology	- Status Monitoring / NW Control - Evaluation of Advanced Domestic / Global NW Systems

Testbed Network Operation (Kobayashi, Yamamoto)

General R&D Projects (150)

Invited R&D Projects (2-3)

JGN2plus Services
(3) JGN2plus International Circuits (L2/L3)

GLORIAD (USA, Russia, China)

CA*net4 (Canada)

GEANT2 (Europe)

APAN (Asia)

TEIN2 (Asia, Europe)

KOREN (Korea)

UKLight (UK)

IEEAF (USA)

CERNET (China)

PacificWave (USA)

Chicago

SURFnet (Netherland)

LA

CSTNET (China)

Tokyo

StarLight (USA)

MREN (USA)

KR

UniNet (Thailand)

HK

TransPAC2 (USA)

BKK

ThaiSarn (Thailand)

SG

Internet2 (USA)

NLR (USA)

SingAREN (SingAREN)

AARNet (Australia)

US-JP line	**: Tokyo-Los Angeles-Chicago, 10Gbps**
TH-JP line	**: Tokyo-Bangkok, 45Mbps**
SG-JP line	**: Tokyo-Singapore, 155Mbps**
KR-JP line (APII)	**: Fukuoka-Busan, 10Gbps**
HK-JP line	**: Tokyo-Hong Kong, 2.4Gbps**

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JGN2plus

International Collaboration

- **Japan-US Link**
  - 10Gbps (Tokyo-Los Angels-Chicago)
  - Interconnection with Pacific wave (Los Angels), and Starlight (Chicago)
- **Japan-Singapore Link**
  - 155Mbps
  - Interconnection with SingAREN
- **Japan-Thailand Link**
  - 45Mbps
  - Interconnection with Thaisarn
- **Japan-Korea link**
  - 10Gbps
  - Interconnection with KOREN
- **Japan-Hong Kong link**
  - 2.5Gbps
  - Interconnection with CSTNET and CERNET
  - Mutual backup with TEIN2

Three Pillars for Advancement of NWGN

By NICT itself

> **I.   Establishment of "Strategic Headquarters for NWGN R&D"**
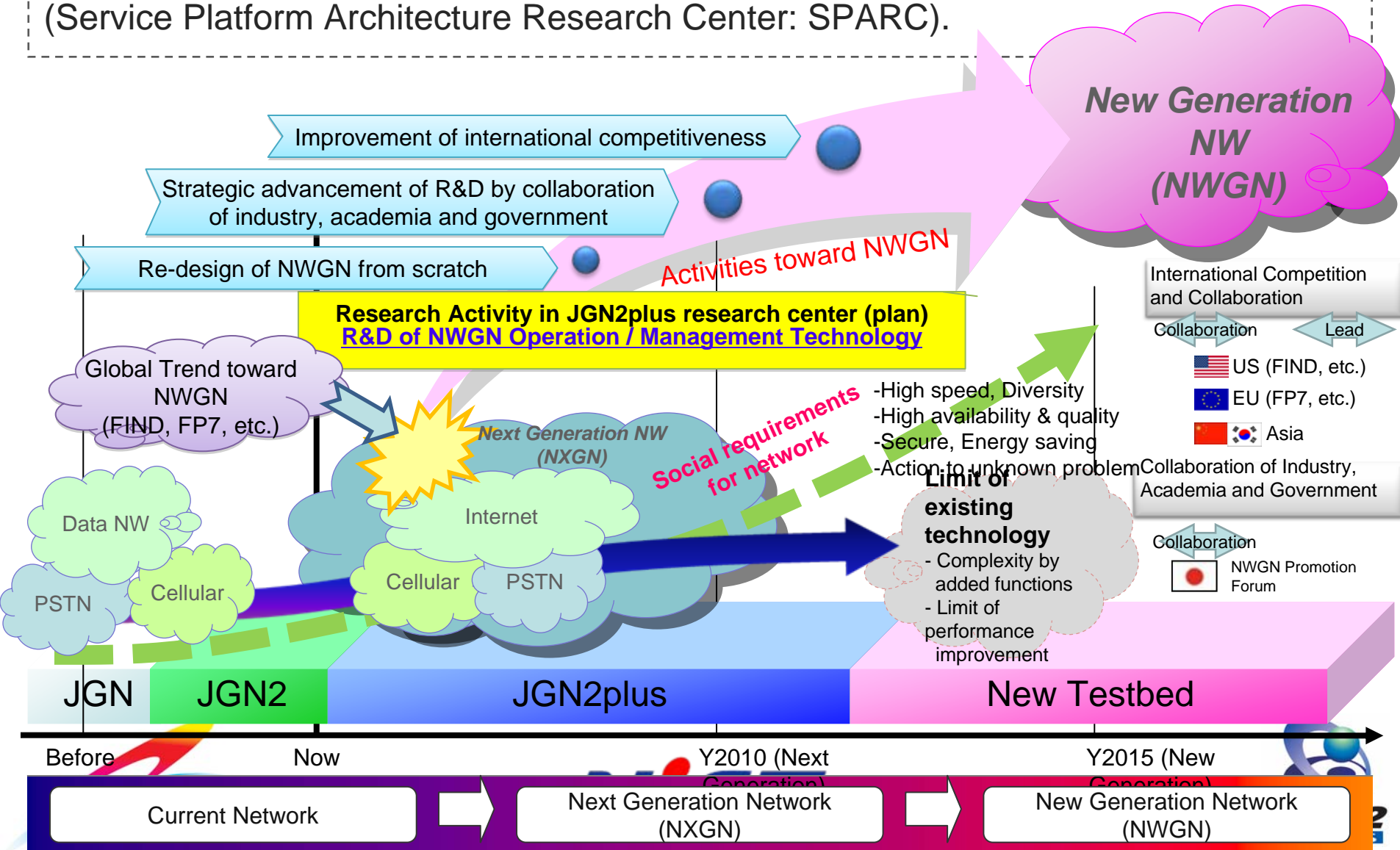> **(Oct 2007)**

As ALL Japan

> **II.   Establishment of "NWGN Promotion Forum" (Oct 2007)**

For advancement of experimetns / demonstrations

> **III. Construction of "Network for Network Experiment"**
> **(JGN2 → JGN2plus)**

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JGN2 plus

Research Activities about JGN2plus and

JGN2plus is a testbed network to support R&D of NWGN promoted by NICT.
It also plays a role of supporting R&D activities in JGN2plus research center
(Service Platform Architecture Research Center: SPARC).

Improvement of international competitiveness

Strategic advancement of R&D by collaboration of industry, academia and government

Re-design of NWGN from scratch

Activities toward NWGN

New Generation NW (NWGN)

Research Activity in JGN2plus research center (plan)
R&D of NWGN Operation / Management Technology

Global Trend toward NWGN
(FIND, FP7, etc.)

Next Generation NW (NXGN)

Social requirements for network

-High speed, Diversity
-High availability & quality
-Secure, Energy saving
-Action to unknown problem

International Competition and Collaboration

Collaboration   Lead

US (FIND, etc.)

EU (FP7, etc.)

Asia

Collaboration of Industry, Academia and Government

Collaboration

NWGN Promotion Forum

Internet

Data NW

PSTN

Cellular

Cellular   PSTN

Limit of existing technology
- Complexity by added functions
- Limit of performance improvement

| JGN | JGN2 | JGN2plus | New Testbed |

Before   Now   Y2010 (Next Generation)   Y2015 (New Generation)

Current Network → Next Generation Network (NXGN) → New Generation Network (NWGN)

Activities on NWGN Research and Testbed in US / EU / Japan/…

US

FIND

- Research funding program aiming at establishing future Internet architecture
- Clean-slate approach
- Focusing on comprehensive research of network architecture design
- Many small projects are adopted and converged to a few full-scale architectures. Those architectures will be examined on GENI infrastructure.

GENI Initiative

- Succeeding to the result of Planet Lab
- Programmable
- Aiming at innovation by fundamental reconsideration of service architecture to overcome problems of current Internet
- Research scopes: Security, Mobile / Wireless, Sensor NW, etc.
- Trying to secure budget from MREFC
- International collaboration is also in a scope.

EU

FP7

- R&D funding program to support to secure
  technological improvement and competitiveness of universities and companies in Europe
< Related projects>
1. The network of the future
2. Service and software architectures, Infrastructures and Engineering
3. Secure, Dependable and Trusted Infrastructure
4. Networked Media

GÉANT2

- Giga-bps R&D network covering all over
  Europe area, funded by EU committee.
- Interconnecting 34 NRENs in EU.
- Over 3,000 research organizations in Europe can share information about research activities.
- Migration to GEANT3 is planned in 2008;
  improving bandwidth and functionality.

Japan

AKARI

NICT promotes NWGN research activity "AKARI Architecture", aiming at implementation of NWGN via establishing new NW architecture / design and experiments. The concept paper of NWGN architecture was published in Apr 2007. NICT established Strategic Headquarter for NWGN R&D in Oct 2007 to build up strategic roadmap of R&D and to promote it.

JGN2 → JGN2plus

R&D testbed network operated by NICT with nation-wide access points, utilized to R&D activities and experiments through collaboration of industry, academia and government.
- Contributing to human resource development in ICT area via experience of practical experiments.
- NICT modifies existing JGN2 network and starts operation of "JGN2plus" from next fiscal year, as a testbed for NWGN researches, R&D of NW technology, etc.

➡ NICT will promote R&D of completely new NW architecture in Y2020 to secure international competitiveness by taking advantage of optical NW technology, ubiquitous NW technology, etc.