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: Hirabar 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:
- Cell Phones: 2G > 3G > 4G?
- Internet: IPv4 > IPv6 > IPv?

Past Network

Present Network

Next Generation Network (NXGN)

Revised NXGN

New Generation Network (NWGN)

1) clean-slate
2) modification

2005 2010 2015
AKARI Architecture Design Plan
- Grand-Designing a New Generation Network beyond 2015 -

2006

NWGN Workshop (Open)
AKARI Camp (Invite Only)

2011

Concept & Principles
Design (Now)
Proof of Concept
NWGN Blueprint
Testbed Construction
Field Trial
Innovation

10+ Researchers (NAG)

Prototyping
JGN2plus
Overlay Network
Testbed Design

English version in Fall, 2007.
AKARI’s Current Focus: Network Architecture

Role

Flexible to adopt a new user requirement
No vertical division. Common infrastructure
Enjoy fundamental technology advances

Process

Design Principles
Select, integrate and simplify
Feedback
proof-of-concept
Testbed (Overlay Network)

Future requirements from diverse users and society
Evolving, future fundamental technologies

Network Architecture

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

All Optical
Software Radio
Theoretical Limits

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

- Grand-Designing a New Generation Network beyond 2015 -
AKARI Sustainable Architecture Principles

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 authentications
   - Traceability

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

Capacity for Quality

For Future Diverse Society

Reliable Network Space
AKARI Architecture Components (I) – Optical & Wireless

(1) Parallel Optical Packet Transmission
- Power Spectrum
- Wavelength
- Header
- Payload
- Sustainable in Capacity

(2) All-Optical Path / Packet Switching
- Forwarding table
- Look-up
- RE
- Sustainable in Usage
- OPS
- Buffer
- OCS
- Sustainable in Management and Capacity
- Energy Saving – All optical

(3) PDMA (Packet Division Multiple Access)
- Packet (CSMA/CA) Only
- Free from:
  - Frequency Band Allocations
  - Cell Design

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

Sustainable in Capacity
Sustainable in Usage
Sustainable in Management and Capacity
Sustainable in Mobility & Security
(5) Overlay Network / Network Virtualization

(6) Self-organizing Control

- Simultaneous failures
- Bad provisioning
- Chain reaction
- Software bug

- Efficient
- Robust
- Optimum
- Adapted

Manageable Fast Recovery
CORE: Collaborative Overlay Research Environment

Private Overlay network over JGN2, WIDE, and SINET

Led by Prof. Aki Nakao

Joint project with:

• 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
- Evolitional nature of overlay network to incorporate into the design
AKARI NWGN (New Generation Network) R&D Plan

CLEAN-SLATE APPROACH

Cooperative & Competitive Projects

AKARI Architecture Design

Overlay (Network Virtualization)

NWGN Community
- Alternative Design
- Network Security
- Applications, etc.

Social Requirements & Global Policy

AKARI
Field Trials & Deployments

Innovation

JGN2 JGN2+ JGN X (NWGN Testbed)

Collaborative Projects

Optical Packet Switch
Cognitive Radio

Photonic Network Phase I & II
NGN Fundamental Technologies
Dynamic Network

Funded by NICT

http://akari-project.nict.go.jp
Structure of Advancement of R&D for New Generation Network (NWGN)

- **Strategic Headquarter for NWGN R&D**
  - Strategy Working Group (R&D strategy planning)
  - Concentration of intelligence among Industry, Academia and Government

- **NWGN Advisory Committee**
  - Input suggestion from industrial perspective to R&D strategy planning

- **Collaborative Research Dept.**
  - Research Center
  - Join
  - Active Participation, Taking lead
  - Knowledge from different field
  - Strategy oriented R&D

- **Company, University, etc.**
  - Join
  - Testbed
  - Commissioned Research
  - Strategy Promotion
  - Join

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

- **Knowledge from different field**
  - Active Participation, Taking lead

- **Join**
  - Strategy Promotion
  - Join

- **Company, University, etc.**
  - Join

**NICT**

**NWGN Promotion Forum**
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 Nationwide 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
## Major changes from JGN2 to JGN2plus

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>R&amp;D Structure</strong></td>
<td>R&amp;D by seven research centers (Research on specific topics under 4-year plan)</td>
<td><strong>Service Platform Architecture Research Center</strong></td>
</tr>
<tr>
<td><strong>NW Operation</strong></td>
<td>Network Operation Center (NOC) (Stable operation of L2/L3 service)</td>
<td>Operation</td>
</tr>
<tr>
<td><strong>NW Services</strong></td>
<td>-Optical Testbed Service -Nation-wide access points (64 APs) -International circuits (US, TH, SG)</td>
<td>R&amp;D</td>
</tr>
<tr>
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<td>Advancement of NWGN testbed R&amp;D</td>
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### Service Platform Architecture Research Center (SPARC)

- Uniting operation and research as one structure to advance R&D for operation / management technology in NWGN
# JGN2plus Services Available

## Network Services

<table>
<thead>
<tr>
<th><strong>L3: IP connection</strong></th>
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<tbody>
<tr>
<td>- IP interconnection among JGN2plus users, or among JGN2plus users and other research networks</td>
</tr>
<tr>
<td>✓ IPv4/v6 dual stack, IPv6 Native (Full route), Core routers on main APs</td>
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<thead>
<tr>
<th><strong>L2: Ethernet connection</strong></th>
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<tr>
<td>- Point-to-point connection service: VLAN-based L2 point-to-point interconnection</td>
</tr>
<tr>
<td>- Multi-point connection service: VLAN-based L2 multi-point interconnection</td>
</tr>
<tr>
<td>✓ Jumbo-frame support (over 1G, 10G lines)</td>
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<tr>
<th><strong>Optical Testbed</strong></th>
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<tr>
<td>- Hakusan – (8 fibers) – Otemachi – (16 fibers) – Koganei</td>
</tr>
<tr>
<td>- for experiments of optical-level transmission</td>
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</tbody>
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<tr>
<th><strong>International circuits</strong></th>
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<tbody>
<tr>
<td>US</td>
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<thead>
<tr>
<th><strong>Operation Service + R&amp;D</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Operation / management of circuits, equipments on APs</td>
</tr>
<tr>
<td>- Service Platform Provisioning</td>
</tr>
<tr>
<td>- Technical supports</td>
</tr>
</tbody>
</table>
JGN2plus Services
(1) JGN2plus Network Outline

Hokkaido
- Sapporo (Sapporo)

Tohoku
- Tohoku (Sendai)
- Tohoku Univ. (Sendai)
- Iwate Pref. Univ. (Takizawa)
- Univ. of Aizu (Aizu Wakamatsu)
- Akita Regional IX *2 (Akita)
- Hachinohe Institute of Technology (Hachinohe)
- Yamagata Prefecture (Yamagata)

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

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

Chugoku
- Chugoku (Okayama)
- Hiroshima Motomachi (Hiroshima)
- Techno Arc Shimane (Shimane)
- New Media Plaza Yamaguchi (Yamaguchi)
- Hiroshima Univ. (Higashi Hiroshima) *3

Kyushu
- Fukuoka (Fukuoka)
- Kita Kyushu AIM Bldg. (Kita Kyushu)
- Kyushu Univ. (Fukuoka)
- NetCom Saga (Saga)
- Nagasaki Univ. (Nagasaki)
- Toyonokuni Hyper NW AP *1 (Oita)
- Miyazaki Univ. (Miyazaki)
- Kagoshima Univ. (Kagoshima)

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

Shikoku
- Kochi (Kochi)
- Kochi Univ. of Technology *3
- Ehime Univ. (Matsuyama)
- Kagawa Univ. (Kida-gun)
- Univ. of Tokushima (Tokushima)

Tokai
- Tokai (Nagoya)
- Nagoya Univ. (Nagoya)
- Softopia Japan (Gifu)
- Univ. of Shizuoka (Shizuoka)
- Mie Pref. College of Nursing (Tsu)

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

Optical Testbed
Koganei – Otemachi – Hakusan

JGN2plus / APII Circuit

*(1G): Access Point
*(2): Internet Exchange
*(3): Partnership Access Point

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

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 Gnd
- Light Path Integration

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

JGN2plus SPARC (at Otemachi)

Research Topic 1
R&D on NWGN Service Platform Fundamental Technology (Shimojo)
- Distributed Data Fusion Technology
- Structured / Adaptive Overlay Technology

Research Topic 2
R&D on NWGN Service Testbed federation technology (Nakayama)
- Multi-layer Overlay NW Integration / Evaluation Technology

Research Topic 3
R&D on middleware and Application of Light Path NW (Otsuki)
- Cutting-Edge Application
- Interoperability Test / Standardization

Research Topic 4
Establishment of Component Technologies for NWGN Operation (Esaki)
- Network Monitoring
- Traffic Management
- P2P Traffic Engineering
- NGN / IMS-SIP Operation Technology

Research Topic 5
Verification of Technologies for International NW Operation (Kitamura)
- 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)

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
International Collaboration

- **Japan-US Link**
  - 10Gbps (Tokyo-Los Angeles-Chicago)
  - Interconnection with Pacific wave (Los Angeles), 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 experiments / demonstrations

III. Construction of “Network for Network Experiment” (JGN2 → JGN2plus)
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).

Research Activities about JGN2plus and NWGN

- **Improvement of international competitiveness**
- **Strategic advancement of R&D by collaboration of industry, academia and government**
- **Activities toward NWGN**
- **Re-design of NWGN from scratch**

**Research Activity in JGN2plus research center (plan)**

- **R&D of NWGN Operation / Management Technology**

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

**Social requirements for network**

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

**Limit of existing technology**

- Complexity by added functions
- Limit of performance improvement

**Collaboration of Industry, Academia and Government**

US (FIND, etc.)
EU (FP7, etc.)
Asia

**International Competition and Collaboration**

- Lead
- Collaboration

**NWGN Promotion Forum**

**New Testbed**

**New Generation NW (NWGN)**

**Now Before**

- JGN2plus
- NWGN Promotion Forum

**Before**

- Current Network
- Next Generation Network (NXGN)

**Y2010 (Next Generation)**

- JGN2plus
- Next Generation Network (NXGN)

**Y2015 (New Generation)**

- New Testbed
- New Generation Network (NWGN)
Activities on NWGN Research and Testbed in US / EU / Japan/…

**GENI Initiative**
- 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.

**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

**JGN2 → JGN2plus**
- 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.

**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.

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.