AKARI Architecture Design Project in Japan

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Today's Internet Has Many Problems

- No sufficient capacity (700Gbps → x1000 in year 2020)
- Huge power consumption (13kW for 640Gbps → 2000 kW? for 1Pbps)
- No bandwidth-guarantee mechanism (best effort)
- Difficulty in fast and long distance transfer (TCP → new transport)
- No multi-homing (ID is also locator → ID/locator separation)
- Slow reroute (routing → bandwidth-dependent routing)
- ...
- Too much complicated structure (incremental → disruptive)
Internet – Too Much Complicated

- Cannot add new functions
- Cannot provide services for future society

Adding Functions
- Universal communication?
- Small devices?
- Authentication?
- Guaranteed service?
- Hierarchical addressing
- Local addressing
- Anycast
- IPsec
- Complicated routing
- Mobility

Original Internet Architecture

Increasing Layers
- L2: Datalink Layer
- L2.5: MPLS
- L3: Internet Layer
  - L3.5: Mobile IP
  - L3.5: Mobile IP
- L4: Transport Layer
  - L4.5: Platform
  - L4.5: Bundle
- L5: Overlay

Entrust network with your life & living? (tele-medicine, ITS & anticrime, finance)
Rich life? (connecting sensor, RFID)
Safe? Secure? (spam, DDoS)
Never broken? how long? (sustainable society)
Flexible to future change? (nobody knows future)

Individual optimum but NOT global optimum
Design from scratch has come!
AKARI Architecture Design Project
Toward New Generation Network
Designing the future, diverse, new generation network beyond 2015
- pick up techniques for the future under the principles
- integrate & simplify them with design methods

http://akari-project.nict.go.jp/
http://www.akari-project.jp/
How to get to “New Generation Network” or NWGN?

1) Unconstrained design (Clean-slate approach)

2) Incremental development with a future direction
How to get to “New Generation Network” or NWGN?

1) Unconstraint design (Clean-slate approach)

2) Incremental development with a future direction

AKARI... a small light in the dark pointing to the future
AKARI's Start Point: 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
- proof-of-concept
- Testbed (Overlay Network)

Network Architecture

Future requirements from diverse users and society

Evolving, future fundamental technologies

- all optical
- software radio
- theoretical limits

- Grand-Designing a New Generation Network beyond 2015 -
New Generation Social & Design
Requirements in 2015

Social Requirements
- Peta-bps backbone, 10G-bps FTTH, e-Science
- 100-billion devices, M2M, 1-Mega stations
- Competitive industry and user-oriented services
- Medical care, traffic control, emergency, four-nine
- Privacy, financing, food tracking, anti-disaster
- Rich society, handicapped, aged support
- Earth & human monitoring
- Broadcasting & communication, web 2.0
- Economic Incentive (Business-cost model)
- Ecology, sustainable society
- Human possibility, universal communication

Design Requirements
- Capacity
- Quantity
- Openness
- Robustness
- Safety & Security
- Diversity (Long-tail)
- Ubiquity (Pervasive)
- Converge & Simplify
- Network Model
- Energy-saving
- Evolvability

New Generation Network
Designed by the Architecture

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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 authentication
   - Traceability

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

Capacity for Quality

Reliable Network Space

For Future Diverse Society
(1) AKARI Optical Switching - Path / Packet Integration -

**QoS Guaranteed**

- Handle different types of traffic
- Peta-bps switching capacity
- Tera-bps link speed (40G x 100)
- 100 billion tiny terminals

**Parallel Optical Packet Transmission**

- Scalable
- Energy-Saving

**Sustainable in Capacity**

**Sustainable in Usage**

- Allow Usage Diversity

**Requirements:**

**Optical Circuit Switch**

**Optical Packet Switch (with Fiber Delay Line)**

**Optical Wave Sharing**

Keep Both QoS Assuredness & Best Effort Efficiency

=> OPS + OCS (Not OPS over OCS)
(2) Layered identifier and locator (Concept)

Transport layer
(Node ID as identifier)

Node ID

Mapping function
(Node ID ⇔ Locator)

Locator

Network layer
(IP address as locator)

Diversity in Networks
Reliable network space

your-pc#yournetwork.com
my-pc#mynetwork.com

Identifier

- Authenticated, but privacy protected

Local Name

+ HIS Name

Global Name

(Hash Function)

ID

Home Network

Global Network

Foreign Network

GW

GW

GW

HIS

FIS

Local Node

Visiting Node

GW

GW

GW
(3) Self-organizing Control (Concept)

- PDMA (Packet Division Multiple Access)
  - Base Stations
  - Static Channel Allocation
  - User a, b, c
  - CSMA/CA (packet)
  - Wide Shared Channel

Free from:
- Frequency Channel Allocations
- Cell Design

Sustainable in Management and Capacity

- Self-Organizing Mesh Network

Manageable
Fast Recovery

Simultaneous failures
Bad provisioning
Chain reaction
Software bug
Efficient
Optimum
Robust
Adapted
(4) Network Virtualization (Concept)

(a) Isolated Virtual Networks

VN₁  VN₂  ...  Real TestBed Network

(b) Transitive Virtual Networks

VN₁  VN₂  ...  Self-evolvable  Real Operational Network

(C) Overlaid Virtual Networks

VN₂
VN₁
Real Operational Network
Questions?

AKARI Architecture Design Project Major Members:

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