New Generation Network
Its Promises and Challenges

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Euroview 2012
July 23 & 24, 2012
Outline

I  What is NwGN, and Why?
II  What led the Internet to success?
III An End to the End-to-End Design
IV Network virtualization
V  AKARI Architecture and JGN-X
VI  FIA and Testbeds, Activities in the U.S.
VII What should be Japan’s strategies?
What is New Generation Network (NwGN)?

- A flagship of the networking research in Japan
- Design of a new network
  - A “clean slate” approach
- Implement and Verify on a testbed
- Experimentally operational by around 2015.
Why NwGN?

NwGN is called for

Next Generation Network (NGN)

Limit of the Internet

Exploding Traffic

Security Issue

Mobility

Diagram: AKARI Architecture Design
Requirements for NwGN

1. **Scalability** (users, things, “big data”)
2. **Heterogeneity and diversity** (in “clouds”)
3. **Reliability and resilience** (against natural disasters)
4. **Security** (against cyber attacks)
5. **Mobility management**
6. **High performance**
Requirements for NwGN—cont’d

7. Energy and Environment

8. Societal needs

9. Compatibility (with today’s Internet)

10. Extensibility (for the unforeseen and unexpected)
AKARI Architecture

- Cross-layer optimization
- ID/locator split architecture
- Virtualization
- Optical packet & circuit integration
ID and Locator in the Internet

Host

- Application
- Transport
- Network
- Data link
- Physical

Use IP address as ID

Use IP address as Locator

Link

Router

Link

Host

- Application
- Transport
- Network
- Data link
- Physical

Diagram: Ved Kafle
ID/Locator Split Architecture

Diagram: Ved Kafle
Choose a subset of a collection of **physical resources** (routers, end users, links, etc.) and **functionalities** (routing, switching, transport) of one or multiple real networks and form a **logical network**.

Provide a **testbed** for the future network architecture and its protocols.
Virtual Networks and Overlaid Networks

(a) Isolated Virtual Networks

(b) Overlaid Virtual Networks

Diagram: Akihiro Nakao
Configuration of Virtual Node

Diagram: NICT News No. 393
Virtual Node Project and Participating Companies

Figure 6 • Assignments of each company in the Virtual Node Project

Diagram: NICT News No. 393
Optical Packet and Optical Path

Characteristics of Optical Technology

- Broadband
- Memory and operation circuits, not well developed
  - Optical packet switching: translate the header into electric signal
  - Optical path: Optical paths in WDM (wavelength division multiplexing) are equivalent to circuits in circuit switching
  - AKARI Architecture integrates optical packets and optical paths
Integrated System of Optical Packets and Optical Paths

Diagram: Hiroaki Harai, NICT
JGN-X Network Overview

Diagram: Eiji Kawai, NICT
- Can we reach an agreement on the architecture?
  - How to deal with the NIH syndrome
  - Conflict of interest among different stakeholders

- Will backward compatibility be a decisive factor?

- Or should we aim at an “optimal” clean-slate architecture?
  - with a feasible migration path scenario?
  - or with a coexistence scenario (i.e., two virtual networks)
How to evaluate architectures?

- Comparison of different architectures is difficult
- Limited mathematical modeling techniques
- Lack of interest in quantitative arguments among the Internet community
  - its character, culture and history
- Provides only “best effort” services.
- So no need to characterize the network performance quantitatively.
- Very few quantitative discussions in the Internet literature.
- The Internet community is not interested in “theoretical limits” of any sort.
Recall ATM/Broadband ISDN Efforts

- Telecommunication carriers’ effort on B-ISDN in the 1980’s and 1990s.

- Lost the race against the Internet in offering multi-media services

- A “Geankenexperiment”:
  Suppose that the B-ISDN camp had won over the Internet.
  - No pervasive social networks yet?
  - No Lehman Shock or Flash Crash?
  - No cyber attacks that threaten us today?
  - No need for the future network architecture?
Over reliance on Testbed

- Prototyping or testbed
  - Useful for a proof-of-concept or protocol validation.
  - Will not lead to quantitative understanding or to a solution for optimal control.

- The Internet has been successfully running, because of its “overdimensioning.”
  - Cost/performance of the network components have been improving geometrically.
  - No guarantee in the future.
  - Energy consumption of IT systems is a serious issue.
Little attention or effort paid to the performance aspect of a virtual network?

Statistical sharing of limited physical resources by multiple logical networks (or slices).

A network of “processor sharing” servers seems a reasonable mathematical abstraction of a virtual network, where a “processor” is a bottleneck resource (e.g., a router) at a node.
Processor Sharing (PS)

- Originally introduced as the limiting case of round-robin scheduling by L. Kleinrock
- Early work on PS was motivated by its applicability to time-shared computers.
- Renewed interest in the PS scheduling
  - Modeling of statistical multiplexed traffic;
  - Modeling of Web servers;
  - Modeling of links congested with TCP traffic
“Fair scheduling” emulates PS.

The stationary distribution of the number of customers in a PS server is insensitive (or robust) to the distribution of service time (e.g., flow size).

N. Dukkipati et al. [15] compare the performance of TCP/IP algorithms against the theoretical limit implied by a PS model.
Loss network theory is a recent development, see Kelly [16], Kobayashi & Mark [13,14].

- Can characterize a network with resource constraints which supports multiple end-to-end circuits with different resource requirements.

- Can be viewed as a generalization of the classical Erlang or Engset loss models.

- Its insensitivity and robustness against the network traffic or load characteristics make this characterization very powerful.
Blocking probability and call loss rate can be written in terms of the normalization constant $G$ (the partition function).

- Product form solution and computational algorithms

- Asymptotic analysis becomes more accurate and simpler as the network parameters become greater.
Open Loss Network (OLN)

Number of links in the network: $L=5$

Class of a call: $r=(c, \tau)$, $c=$ routing chain, $\tau=$ call type
Generalized Erlang Loss Model

$L$ = Number of the server types

FIGURE 7.3-2: Generalized loss station (GLS) which is equivalent to the OLN.

$$\sum_{r \in R} A_{l,r} n_r \leq m_l,$$
FIGURE 7.3-3: Mixed loss network.
Packet-switch routing and path circuits can coexist.
For further Information

For copies of my slides and text,

Send email to Hisashi@Princeton.EDU

or

See my blog www.HisashiKobayashi.com where the slides and text will be uploaded.

Thanks for your attention!!


http://itu.int/ITU-T/go/sg13

Building New-Generation Networks,” NICT News, June 2010, No. 393,

[8] A. Nakao, A. Takahara, N. Takahashi, A. Motoki, Y. Kanada and K,
Matoba, “VNode: A Deeply Programmable Network Testbed Through

[9] H. Furukawa et al., H. Harai, T. Miyazawa, S. Shinada, W.
Kawasaki, and N. Wada, "Development of Optical Packet and Circuit
