New-Generation Network Architecture: Its Opportunities and Challenges

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1. Introduction

- MITI's Fifth Generation Computer System (FGCS) project began in 1982.
  - Highly parallel processing computer
  - Massive databases or knowledge bases
  - Logic programming language (Prolog)
  - Prototype of a High performance workstation

- IBM, the U.S. Government and Europe's responses.

Analogy between the FGCS and the AKARI Projects?

- Japan has kept up to the U.S. and others.
- Japan wishes to play a leadership role in the next generation system.
- Prototyping a future system.
- Balancing International competition and cooperation.

2. A Brief History of the Internet

- **1969:** The Defense Advanced Research Project Agency (DARPA) commissioned a wide-area network ARPANET.
- **1973**: Transmission control protocol (TCP) designed by Vinton Cerf and Robert Kahn.
- **1977:** TCP began to replace the original network control protocol (NCP).
- **1978:** Separation of TCP into an inter-network (IP) layer and a transport layer (TCP), whence TCP/IP sprang.

A Brief History of the Internet-cont'd

- **1983:** Every site connected to the ARPANET switched to TCP/IP.
- All *publicly accessible* networks that use TCP/IP are collectively known as the Internet.
- **1985:** ARPANET became the NSFNet.
- **1989:** Commercial email service started, and Internet service providers (ISPs) were introduced.

A Brief History of the Internet-cont'd

- **1989:** World Wide Web (WWW) was invented by Tim-Berners Lee.
- **1990s**: Web browsers Mosaic, Netscape and Intenet Explorer were introduced.
- **1994:**. Amzon.com, Inc. was founded by Jeff Bezos (Then the dot com bubble in late 90s).
- **1997:** BlackBerry introduced by RIM (Research in Motion), a Canadian company.
- **1999**: Google, Inc. was founded by Larry Page and Sergey Brin. In 2004, IPO.
- **2005**: YouTube, LLC. (Utube) was founded and was bought by Google, Inc. in Oct. 2006.

3. The Internet Deployment in Japan

- **1990:** NTT's VI&P B-ISDN Deployment
- **1993**: NTT's FTTH Deployment
- **1999**: DoCoMo introduced i-mode (Internet service).
- **2001-2004**: The MIC's successful "e-Japan" program.
  - DSL (digital subscriber lines)
  - FTTH (fiber to the home)
  - High-speed Internet users

The Internet Deployment in Japan- cont'd

- **2005:** The MIC launched the "u-Japan" program.
- Migration from IPv4 to IPv6.

  - IPv4 uses 32 bits for address:

    $2^{32} \approx 4 \times 10^9$ addresses, where $2^{10}=1024 \approx 10^3$

    (cf. 6.5 billion people on the earth)

  - IPv6 uses 128 bits for address:

    $2^{128} > 3.4 \times 10^{38}$ addresses

  - So once we convert to IPv6, the address space is, practically speaking, infinite!

4. Evolutional changes of the Internet

- When TCP/IP was originally designed,
  - The main purpose was to share files and data among researchers.
  - QoS (quality of service) was not considered, let alone security.
  - No real-time applications assumed.
  - No mobile terminals assumed.

Basic Philosophy behind the original Internet architecture

- A connectionless packet-switching & forwarding "dumb" infrastructure.
- The internet (IP) layer treat all data packets equally, i.e. "fairness" based congestion control.
- A high-level functionality placed at the end system of the network, i.e., the transport or application layer implements end-to-end services.

Recent extensions to the Internet

To Support

- Differentiated services (DiffServ)
- IP Security (IPSEC), Firewalls
- Voice service (VoIP), video-streaming.
- Mobile user service (mobile IP)*
- Mapping of IP addresses (NAT)
- Evolution of inter-domain routing (Border Gateway Protocol)

But, such IP constrained approaches introduce complexity, inconsistency and performance degradation, hence will not be viable forever.

* Mobile IP has not yet seen much deployment in practice.

A "Clean-Slate" Approach: AKARI

- **"New-Generation" Network (NWGN) Architecture**

  - Investigate a new architecture not constrained by IP

  cf. "Next-Generation" Network (NGN):

  - Extension of the IP-based network;

  Int'l standards recommendations formed

Hence, the "new-generation" is newer than the "next-generation".

5.What should the NWGN be like?

- Must support a variety of ubiquitous and different communications.

  - scaling and heterogeneity

- Must support highly dynamic mobility in rapidly changing networks.

  - mobile users and time-varying network resources

- Must be flexible to deliver services envisioned (but not necessarily well defined) for future societies and business.

  - e.g., medical and health service, education, future banking.

What should the NWGN be like? -cont'd

- Must allow energy efficient implementation:
  - All-optical processing, wireless channels,
  - "Virtualization" of network resources
- Must be robust and secure against
  - Network failures, malfunctions and attacks
- Must be flexible and open to support
  - Unforeseen implementation technologies
  - Unforeseen applications

6. Opportunities for the NICT and Japan

- The NICT as a central coordinator for the nation wide effort
  - cf. The U.S. and Europe don't have the NICT equivalent.
- The AKARI Project has started at the opportune time.
  - An excellent vehicle to collaborate with universities and industry worldwide.
- Japan's advanced communication infrastructures and applications.
  - Success of the "e-Japan" and "u-Japan" initiatives

Opportunities for the NICT and Japan-cont'd

- Japan has the most advanced cellular system deployment.
- Japan has developed leading edge applications.
- NWGN will provide great opportunities for Japan's further creativity in wireless core technologies and ubiquitous applications.

Challenges for the NICT and Japan-cont'd

- Technical Issues: How to make the AKARI Project technically successful?

  - The concerted effort at too an early stage may potentially have some danger.

  - Architecture researchers and application developers need to communicate.

  - Communications with outside worlds will be a key to be "collectively creative".

  - How to envision the migration from the current post-Internet to the NWGN?

Challenges for the NICT and Japan-cont'd

- Project Management Issue: How to overcome the problems of the Japanese-style management?

- Where and how to recruit capable researchers and project leaders?

- Ongoing review of project directions both internally and externally.

- How to make the Project recognized in the research community and standard body.

Challenges for the NICT and Japan

- Political Issues: How to balance competition and cooperation with similar efforts abroad?

  - To prove superiority of one architecture over another is difficult

  - How to cope with so-called NIH (not invented here) syndrome?

  - How to play a leadership role in the world scene?

Human Capital Problem for Japan in this competitive world

- How can Japan's IT business compete in the world market?
  - Why isn't DoCoMo's "i-mode" hitting the world market?
- How can Japan recruit and retain foreign brains?
  - Is the language barrier the only problem?
  - We should appoint foreign talents to key positions (professors, managers, board).

Human Capital Problem for Japan in this competitive world-cont'd

- How can Japan strengthen Ph.D. programs in engineering?

  - A lesson to be learned from Singapore's successful program.

- Why isn't Japan attracting women to science and engineering?

  - The U.S., China and Singapore seem doing much better.