New Generation Network
Its Promises and Challenges

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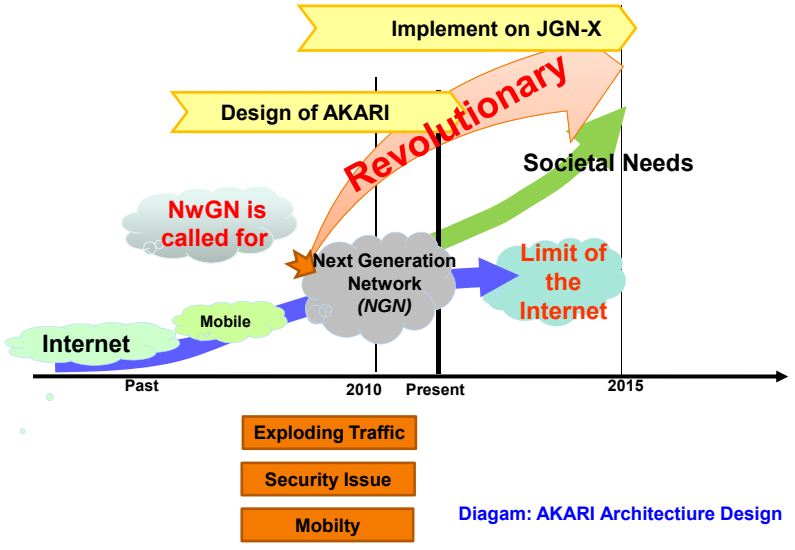
Outline

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, Ativities 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 aound 2015.

Why NwGN



Diagam: AKARI Architectiure 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**

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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

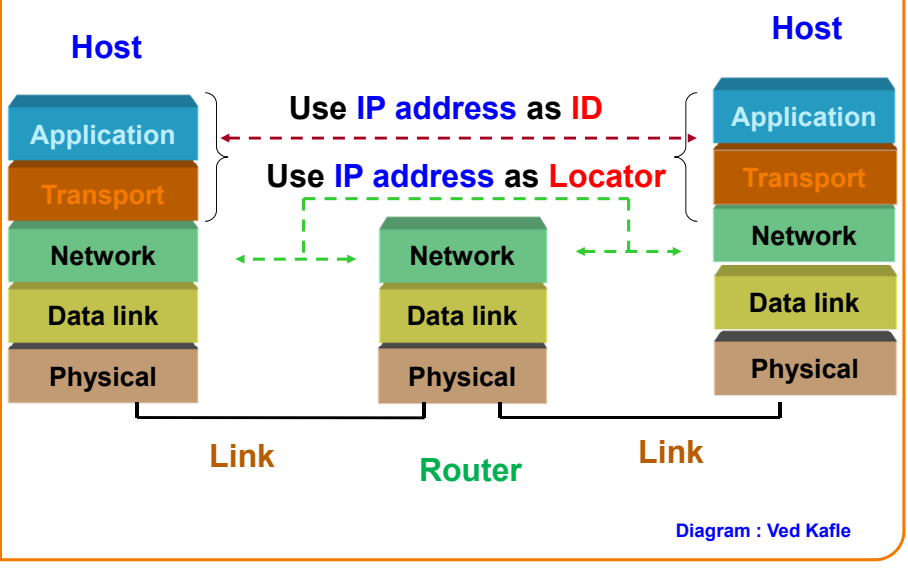

Diagram : Ved Kafle

ID/Locator Split Architecture

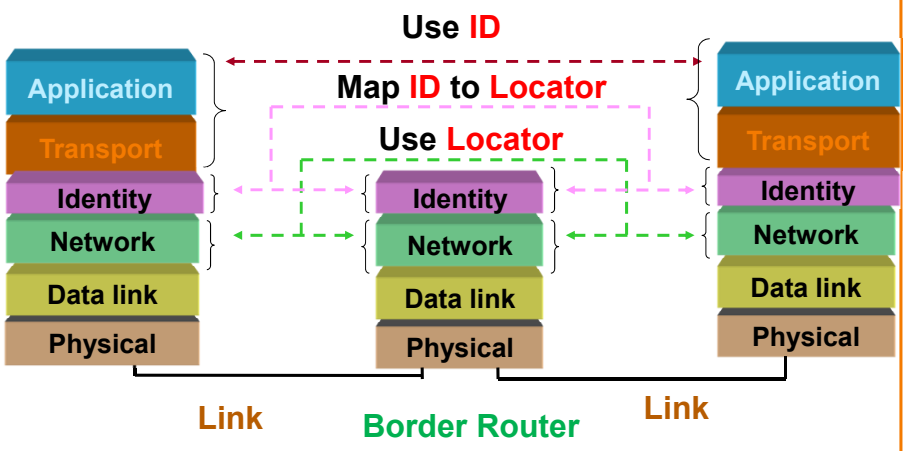

Diagram : Ved Kafle

Network Virtualization

- 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.

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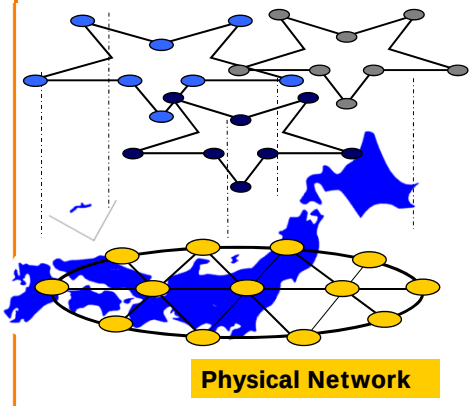
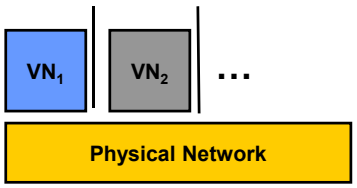
Virtual Networks and Overlaid Networks



(a) Isolated Virtual Networks



(b) Overlaid Virtual Networks

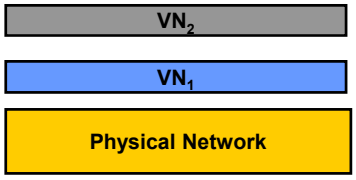


Diagram: Akihiro Nakao

Configuration of Virtual Node

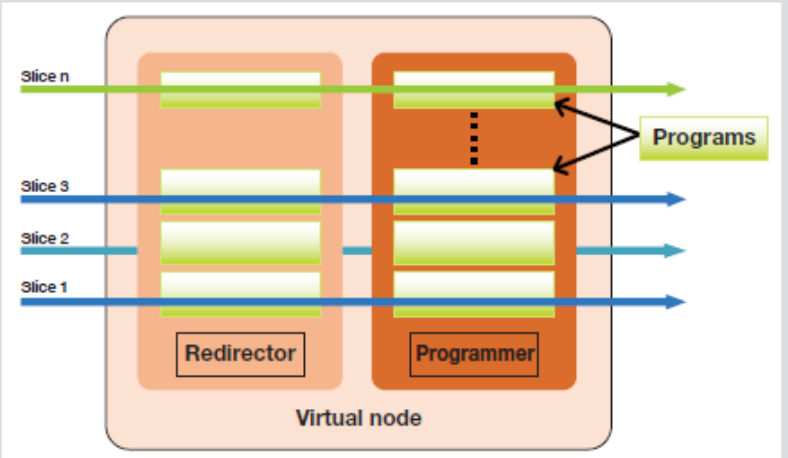


Figure 3 ●The configuration of virtual node (Router)

Diagram: NICT News No. 393

Virtual Node Project and Participating Companies

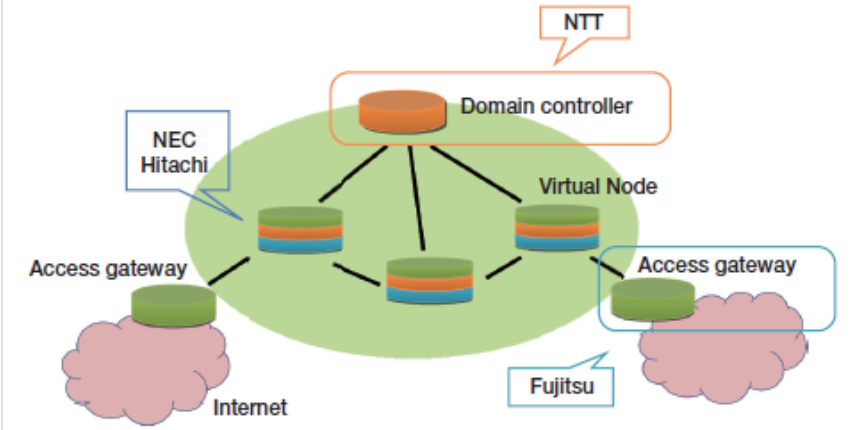


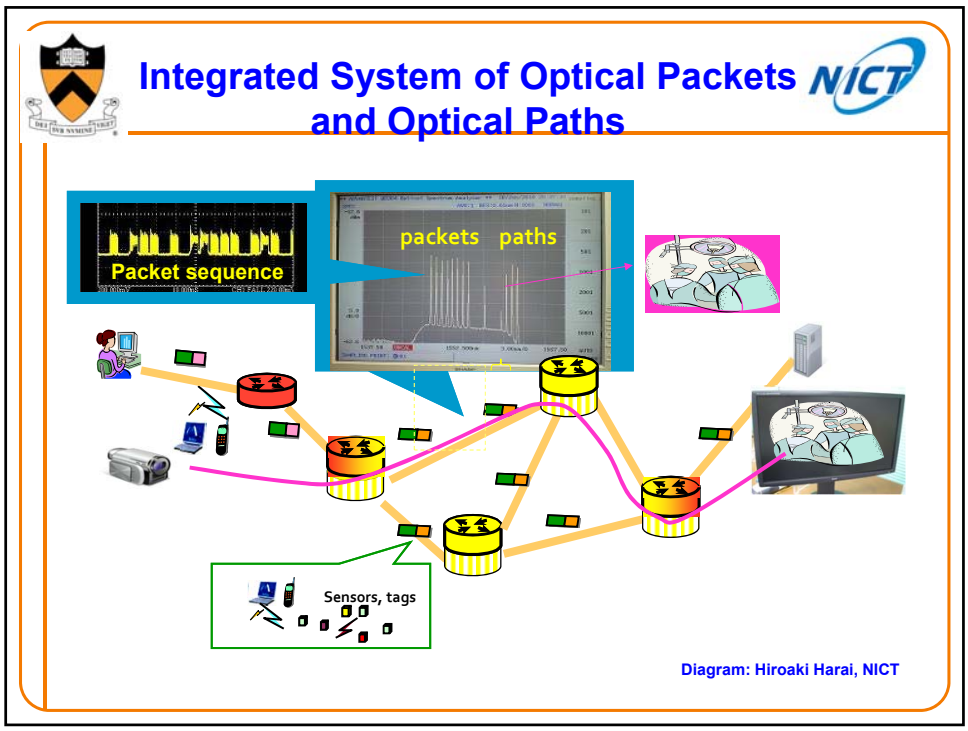
Figure 6 ●Assignments of each company in the Virtual Node Project

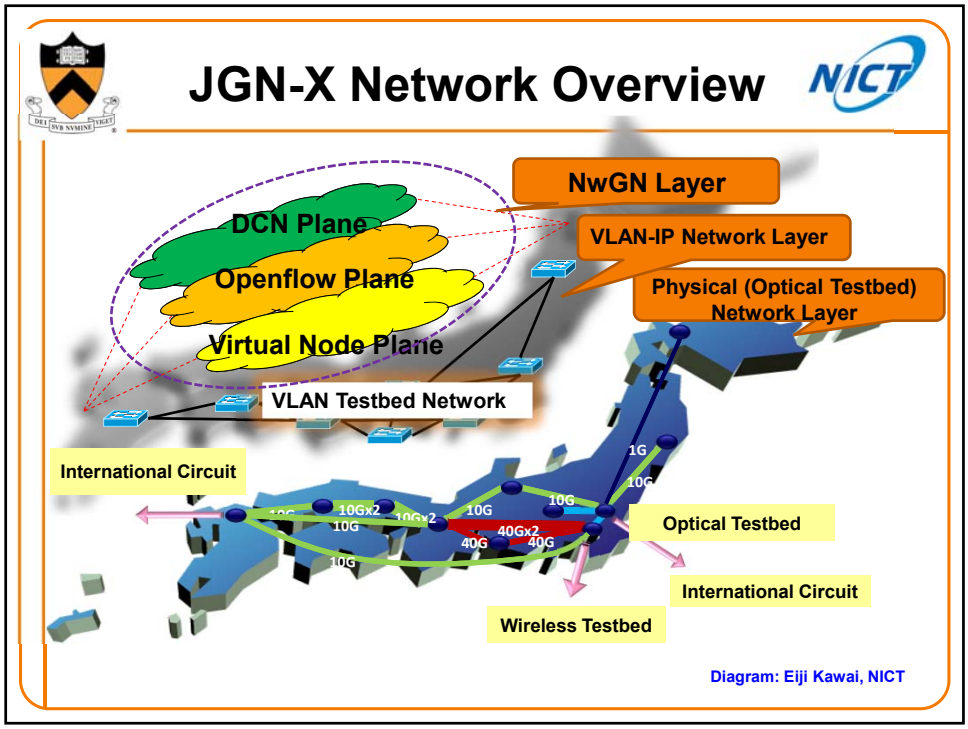
Diagram: NICT News No. 393

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
Packet sequence
packets
paths
Sensors, tags
Diagram: Hiroaki Harai, NICT


JGN-X Network Overview
NwGN Layer
VLAN-IP Network Layer
Physical (Optical Testbed) Network Layer
DCN Plane
Openflow Plane
Virtual Node Plane
VLAN Testbed Network
International Circuit
Optical Testbed
International Circuit
Wireless Testbed
1G
10G
10Gx2
40Gx2
40G
Diagram: Eiji Kawai, NICT

JGN-X International Circuits

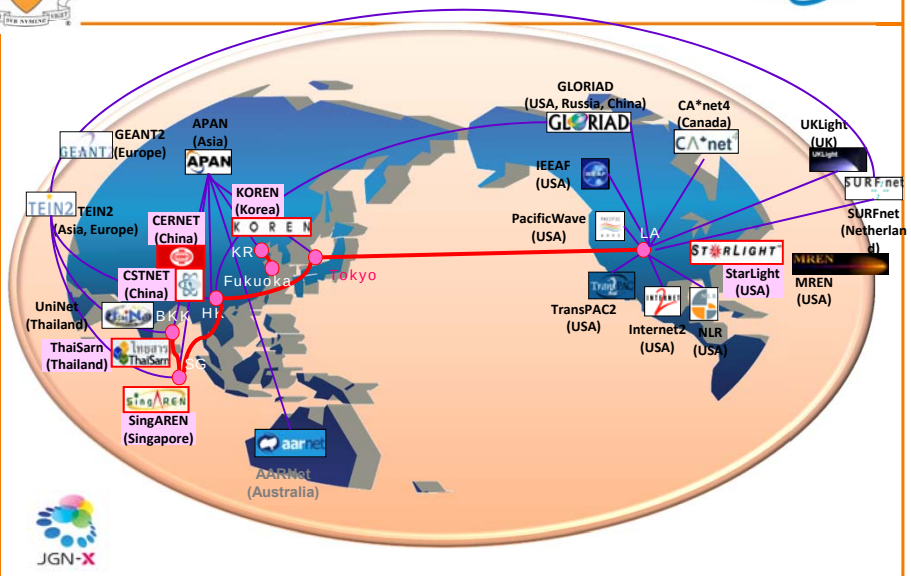


Diagram: Eiji Kawai, NICT

Research around JGN-X

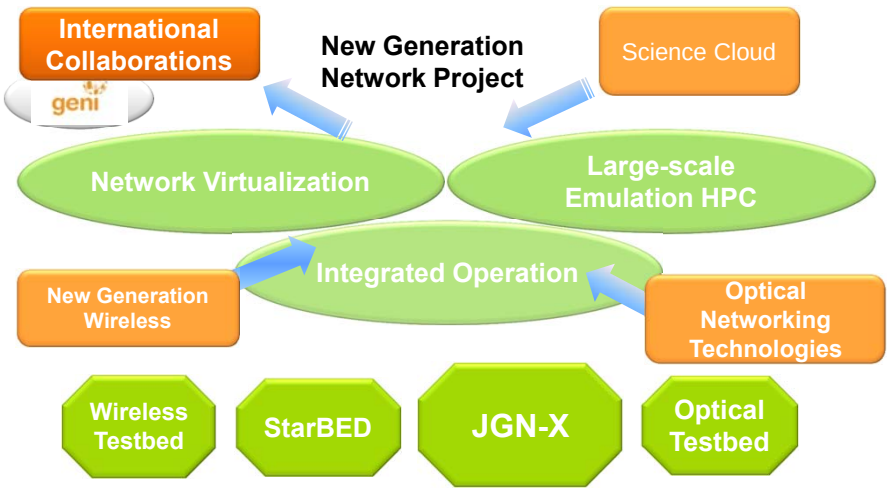


Diagram: Eiji Kawai, NICT

Challenges in the Future Internet Research

- **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

TCP-IP Networks

- 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.

Modeling and Analysis Issues

- 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 it's 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

Processor Sharing (PS) –cont'd

- "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 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.

Performance Analysis

- 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

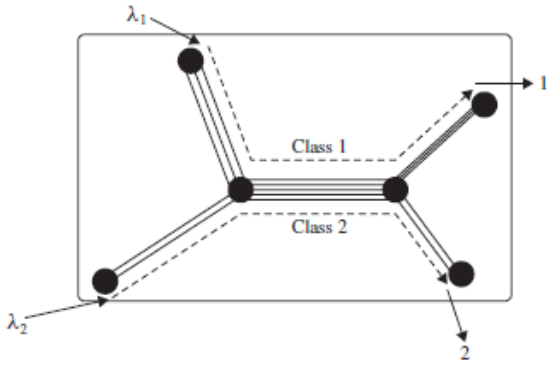


FIGURE 7.3-1: Open loss network (OLN).

Class of a call: r=(c, τ), c=routing chain, τ=call type

Generalized Erlang Loss Model

L=Number of the server types

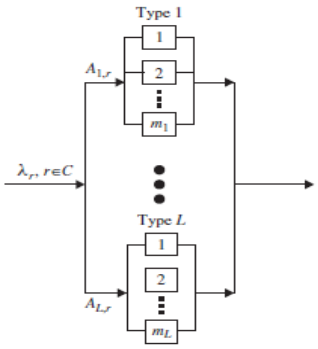


FIGURE 7.3-2: Generalized loss station (GLS) which is equivalent to the OLN.

$$\sum_{r \in \mathcal{R}} A_{\ell,r} n_r \leq m_\ell,$$

Mixed Loss Network (MLN)

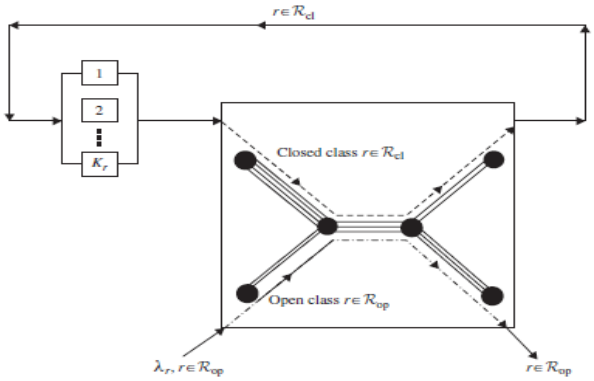


FIGURE 7.3-3: Mixed loss network.

Queuing and Loss Network (QLN)

Packet-switch routing and path circuits can coexist.

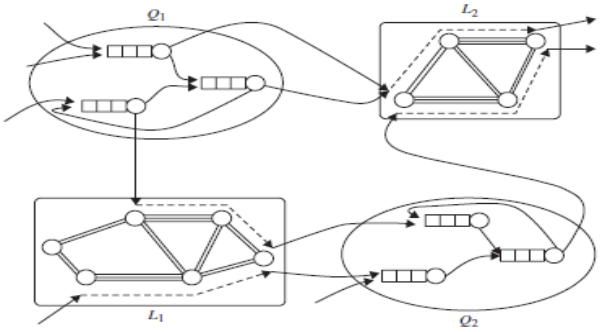


FIGURE 7.4-1: Queueing-loss network (QLN).

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!!

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