New Generation Networks and Optical Network Testbeds

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Review of ONT2
- From Executive Summary –

The Vision

Layer 1/ Layer 2 networking is going to create entirely new kind of network for real applications. Underlay and overlay taken together can provide new layered services

Immediate Need to Buy Dark Fiber

Changes Needed at Campus Level

GLIF

GENI
Generation and Paradigm

Generation

- Fundamental concept and structure of the systems, are maintained, and functions and performances are improved.
- Mainframe computer: 1G, 2G, 3G, 4G, but no 5G
- Telephone: Analog, Digital, ISDN, but no B-ISDN
- Cellular phone: 1G, 2G, 3G, and 4G
- Internet: IPv4, IPv6, and ?
Generation and Paradigm

Paradigm

- The fundamental concept and structure in the system are completely changed.
- Telegraph ⇒ Telephone ⇒ Internet ⇒ ?
  Mainframe C ⇒ PC ⇒ Ubiquitous C
  ?
- Paradigm shift changes the structure of the industry.
- What makes the paradigm shift in networks?
  ⇒ Majority terminal connected
NXGN and NWGN

- NXGN (Next Generation Network)
  The fundamental structure of IP networking is maintained and the Quadruple-play services are to be provided.

- NWGN (New Generation Network)
  Network architectures and service conditions are different from IP networks, and it may be a new paradigm.

NPW: New Paradigm Network
Next Generation Network and New Generation Network

Variety of Appliances

- Ubiquitous Appliances
- Quadruple Play
- Triple Play

Year

2010
2020

NWGN / (IP + α) or post-IP

NXGN / IP
Objectives of NXGN

- Integration of services over IP networks
  Triple-play Services
  Quadruple-play Services
- Solution for the issues in the Internet
  Application-oriented QoS control
  Mobility support
  Security
- Maintaining the safety and reliability of telephone services
  Meet the requirements for the social infrastructure
  Communication capability for emergence
Internet Concept

- Packet-based Network
- Uniform user community with good will
- End-to-end Argument
  - Intelligent Terminal + Stupid Network
  - Connection-less IP Network
  - Best Effort Networking
- Congestion Avoidance
  - TCP based end-to-end confirmation of data and congestion control
- Open Interface & Transparency
  - Users can use new applications installing software in to users’ PC
- Global Connectivity
  - Global Unique IP Address
- Standardization
  - Rough Concensus + Running Code
Issues in the Internet

- Conditions miss-matching the Internet Concept
  Versatile users $\Rightarrow$ Security issues
  Limited network transparency
    NAT, Firewall, Proxy, Cache, · · · ·
  Supporting mobile terminals
- Issues derived from rapid expansion of traffic
  Unfair feeling among users
  Unfair feeling among providers
- QoS issues
  Difficulty to provide QoS controlled services
  Lack of safety functions for the social infrastructure
Two approaches for NXGN

A  NXGN can be realized by extending IPv6 based Internet to include VoIP and IP multicasting for video distribution

B  Introduction of a new IP-based network keeping the Internet service as it is
Various types of business should be competitive each other.
- SP with specific layer functions such as authentication, billing, etc.
- SP renting other layer functions to provide one stop service to users.
The Internet and NXGN (B)

【Internet】
- No overall network planning
- TCP/IP Protocol is the only common rule
- Best effort based network and no clear responsibility and control rule exist among networks
- User can have freedom to install applications

【NGN】
- IP based network with network control function and with clear responsibility for the control
- Qos control and security functions are installed
- Maintain the Internet connection function

Best effort bearer function to interconnect multiple router based network

QoS controlled bearer function to interconnect multiple networks with clear responsibility
Discussion Points for NXGN

• Issue for A
  - How to compromise between transparency and security
  - How to provide QoS, User Authentication, and Fairness
• Issue for B
  - How to introduce open and transparent IP networking
  - How to keep fair competition among stakeholders
NXGN is entering into the deployment phase.

- Carriers and vendors are investing their resources to the deployment of NXGN.

- Standards for NXGN are being established in the standard bodies.

- Actual services over NXGN may start around 2010.
New Generation Network (NWGN)
or
New Paradigm Network (NPN)
Next Generation Network and New Generation Network

Variety of Appliances

Ubiquitous Appliances

Quadruple Play

Triple Play

NXGN / IP

NWGN // (IP + α) or post-IP

Year

2010

2020
What factors determine NWGN architecture?

Application

Appliance

NWGN Architecture

Physical Layer
NWGN as post-NXGN

New NW paradigm is determined by the major appliances connected and information transferred.

- RFID, Sensor, Cellular phone, Large Screen Home Theater Display, Grid Computing, Ultra high definition tiled display, ----------
- From 100b data from sensors to G Byte, even T Byte information contents

Scale-free Network
Contents in the ubiquitous society
From tiny to huge ⇒ Scale free

- B2B
- IP TV
- Cine-grid
- e-Commerce
- P2P
- Web content
- Sensor & RF ID
- S2M

Capacity of content
- [bit]
- P T G M K
- Web ~ 10kB/page
- Digital Cinema > 100GB
- DVD > GB
- MP3 > MB/music

Access frequency [page/day]
- K M G
- Yahoo: 300M page/day
- InternetTVガイド: 11M page/day
- "S2M"
Key issues for NWGN

Discussion points for architecture of NWGN

- Layered Structure → Multi-layered/Non-layered
- Role of overlay network
- Impact from underlay network: Optical & Wireless Network
- Layer 3: IP → IP + α or Post IP
- Identification, Location and Naming/Discovery
- Transparency → Controlled Transparency
- Requirements from Long Tail Applications
- Network testbed for R&D on New Generation Network
Identification, Location & Naming

• IP Address: Convergence of Identification & Location

• Roles of identification and location are different each other
  – Identity: association layer
  – Location: network layer

• Separation of Identification & Location
  Mobility support
  Multi-homing
  Easy change of network operator

• Naming and discovery of objects
  Object: Appliances, Contents
  Attribute: Identification, Location, Context
  Authentication
Optical Networking Technologies

Key technology for NWGN
Photonic Internet Forum (PIF)

http://www.scat.or.jp/photonic/english/index.html (in English)
Photonic Internet Forum (PIF)

Missions
- Promotion of R&D activities of *photonic networks*
- Proposal of R&D programs of *photonic networks*

Organization etc.
- NPO suponsored by SCAT
- 84 members:
  - Private sectors
  - National research institutes
  - Universities
- Established: Feb. 28, 2001

http://www.scat.or.jp/photonic/english/index.html
PIF (Photonic Internet Forum), OIFC (Optical Internet Forum of China) and KOIF (Korea Optical Internet Forum) have just signed the MoU for collaboration on September 1st, 2006 in Beijing.
R & D on Optical Networking Technologies in Japan

Government funded Projects

NICT-funded Projects: 4 projects, K. Sato

NICT Research Projects, H. Harai, T. Morioka
M. Hirabaru, T. Miyazaki

NEDO or METI related Projects, T. Kudoh: AIST

Research in Universities funded by Ministry of Education

R & D in Industry, T. Otani: KDDI, T. Yamamoto: Fujitsu
K. Nashimoto: Nozomi Photonics

Network Testbed, A. Toyoda: JGN II
H. Esaki: WIDE, A. Kato: T-LEX
J. Matsukata: SINET
Successful launching of R&D programs

**PHASE I**

- All-optical transport (1996〜2005)
- Photonic node enabling broadband access (2000〜2005)
- Optical burst switching network (2001〜2005)
- Control plane for terabit-class network (2001〜2005)

**PHASE II**

- Photonic node with multi-granularity switching capability (2005〜2009)
- λ Access (2006〜2010)
- λ Utility (2005〜2009)
- Photonic RAM (2005〜2009)

PIF proposed 4 projects to MIC as the phase II program
Photonic node with multiple granularity switching capability

100Tbps-Class photonic node with multiple granularity switching

- Nano-second switching capability for optical burst handling
- Multiple granularity switching node up to waveband for throughput expansion
- Architecture and networking of photonic NW with multiple switching granularity

Grouped wavelength path network

Architecture and networking of photonic NW with multiple granularity nodes
λ Access

- Access-to-backbone seamless networking
- All-optical terabit-class LAN

WAN/MAN

Ether-frame aggregation
- Aggregation sw interface
- Aggregation sw engine

>100Gbps transmission
- 100Gb/s Tx & Rx
- Dispersion tolerance

User

Seamless networking
- Dynamic λ/μ-band
- Signalling

User

Opt. IF

NG Ethernet protocol
- Carrier-class network manage.
- Standardization activities

User

Opt. IF

Opt. IF

Megabyte-frame switching
- Megabyte buffering
- MAC protocol

User

Multi-gigabit streaming
- Dynamic multi-lane trans.

User

Opt. IF

Figure 2 – Historical development of Ethernet speeds
λ Utility

Establishing customer-initiated end-to-end 100Gbps optical path and QoS service provisioning between terabit-class LANs

Optical path
ISP network A

Optical path
ISP network B

Optical path
ISP network C

Tx
Rx

Optical peer-to-peer connection

>100Gbps

Dark fiber

>100Gbps optical 3R

Terabit-class optical LAN

Super-computer

Optical service gateway

Borderless NW control & management for optical path provisioning between terabit-class LANs
Optical RAM for all-optical packet switching

- Electric router
  - Cisco CRS-1
  - 1000 kW
  - 80 shelves

- Optoelectric packet router
  - 13 kW
  - 10 shelves

- All-optical packet router
  - 3 kW
  - 2 shelves

Figure of Merit

- Data transparency
- Power consumption
- Size

Scheduler

- Label Proc.
- Buffer
- Switch

Photonic crystal bit memory

Pwr consumption of telecom: 7.4億teraWh, Growth rate: +5%/yr.
Light Path

- Wavelength
- Optical Burst
- Optical Packet

Merit and Demerit

Requirements for optical devices

Replace or Co-exist?
What factors determine NWGN architecture?
Two kinds of Long Tail
Long tail for Business
Long tail for R & D

Long tail is important!
What factors determine NWGN architecture?
Examples of long tail applications for optical networking

- Grid Computing over optical networks  T. Kudoh
- Connection of tailed display for visualization of e-science  T. DeFanti
- Connection of entertainment contents with ultra high quality such as digital cinema & ODS*
  Cine-grid project is now starting.

ODS* : Other Digital Stuff
Dynamic Light Path Experiment over JGN II

- OXC is controlled by GMPLS to provide optical path when required
- Lower latency and higher quality networking than router networking

January, 2006
Multi layer control by GMPLS

- Introduction of Control Plane for multi layer control
- Autonomous routing control function by GMPLS on Control Plane

Control for Packet, Burst Flow, SDH Frame, Wavelength, Fiber

- Path protection & restoration over multi layer
  - Reliable connection
- Autonomous routing by multi layer control
  - High speed path setting for IP Networking
- Automatic path provisioning
  - Reduction of Operation Cost
Network testbeds for NWGN / NPN

Capability

Endo-to-end Optical Networking
Mobile and Ubiquitous Networking
Multi-layer Control Capability
User Control Capability
QoS control Capability
Authentication Function
Large scale with Global Connectivity

Testbeds over Dark fiber is needed.

Long term Support is essential.
Japan Gigabit Network

JGN  1999-2003
1Gbit/s
IP over ATM
IPv6 (a part of JGN)

JGN II  2003-2008
10 Gbit/s
IPv6
WDM + OXC

JGN III or JTN ( ? )  2008-
for NWGN/NPN
NICT has started the new 5-year Research Program

- 7 Research Centers & 4 Management Sections
- 6 Program Directors were invited from outside.
- New Generation Network Research Center concentrates on R&D on NWGN technologies.

Akari Project M. Hirabaru

- NICT is making a plan for JGN III.
Conclusion

- NXGN is now being deployed, standardized, invested toward the service start in 2010. Both users and operators/vendors should get benefit from NXGN.

- NWGN is in the research phase. Network architecture should be studied based on requirements for ubiquitous networking and new networking technologies such as advanced optical networking technologies. Prototype of NWGN and the standard will be realized in 2015-2020 time frame.

Network Testbeds are essential for R&D on NWGN. Global collaboration among universities, industry and government is important supported by governmental research fund.
Thank you for your attention!