Toward 100 Tera b/s Router

ONT3 WS

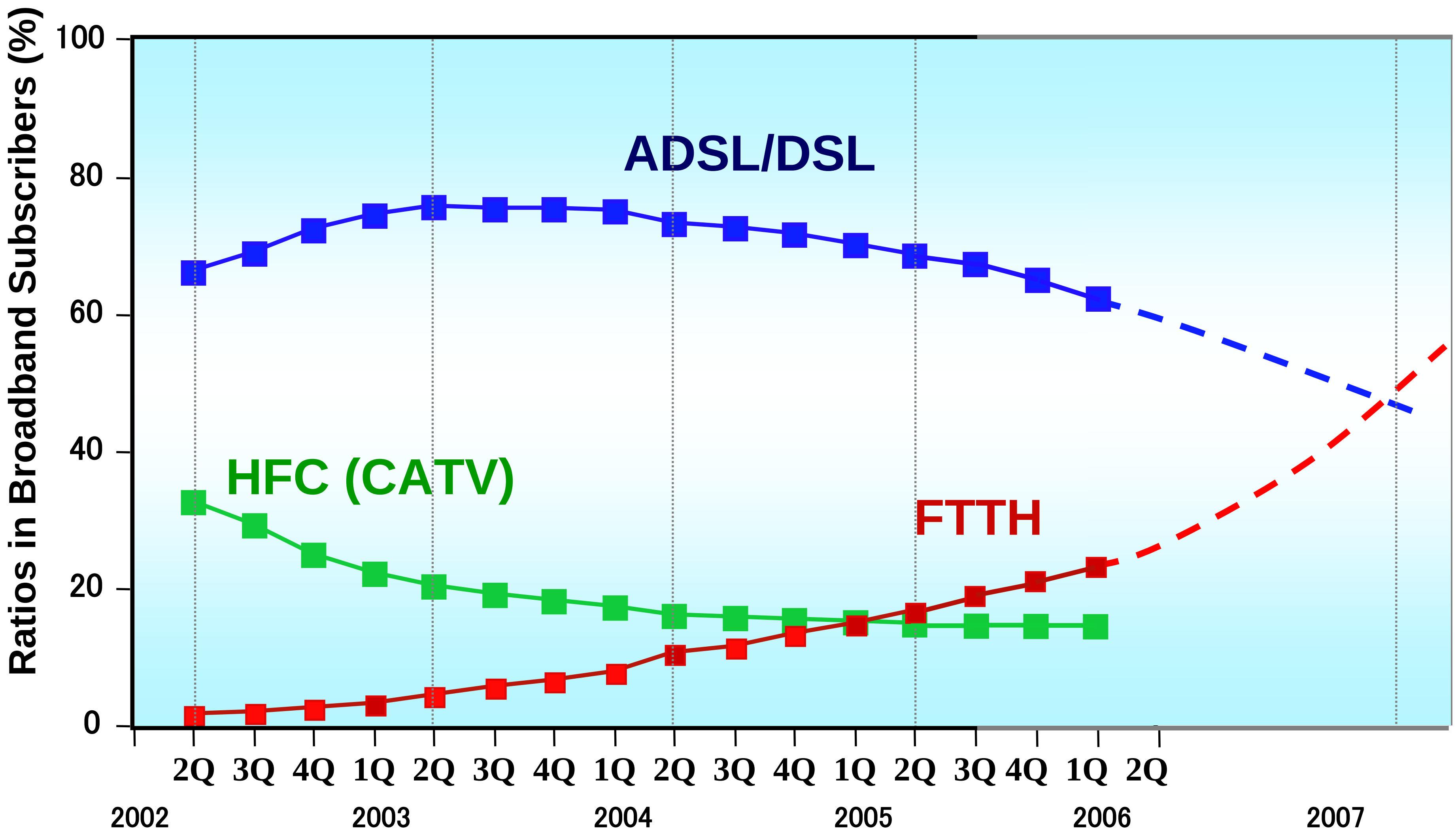
2006. 9. 8.

Nagoya University

NTT R&D Fellow

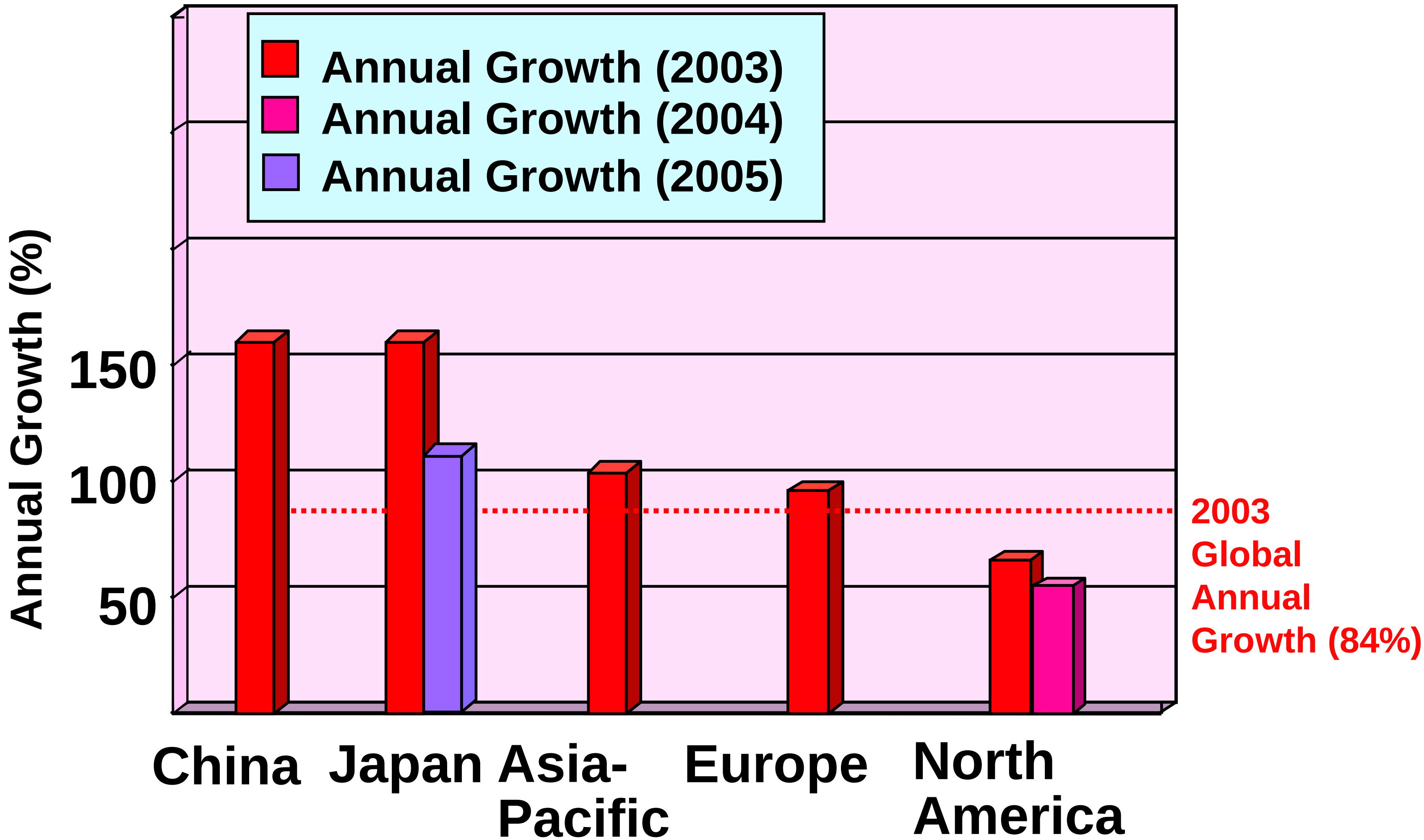
Ken-ichi Sato

Ratios in Broadband Subscribers in Japan



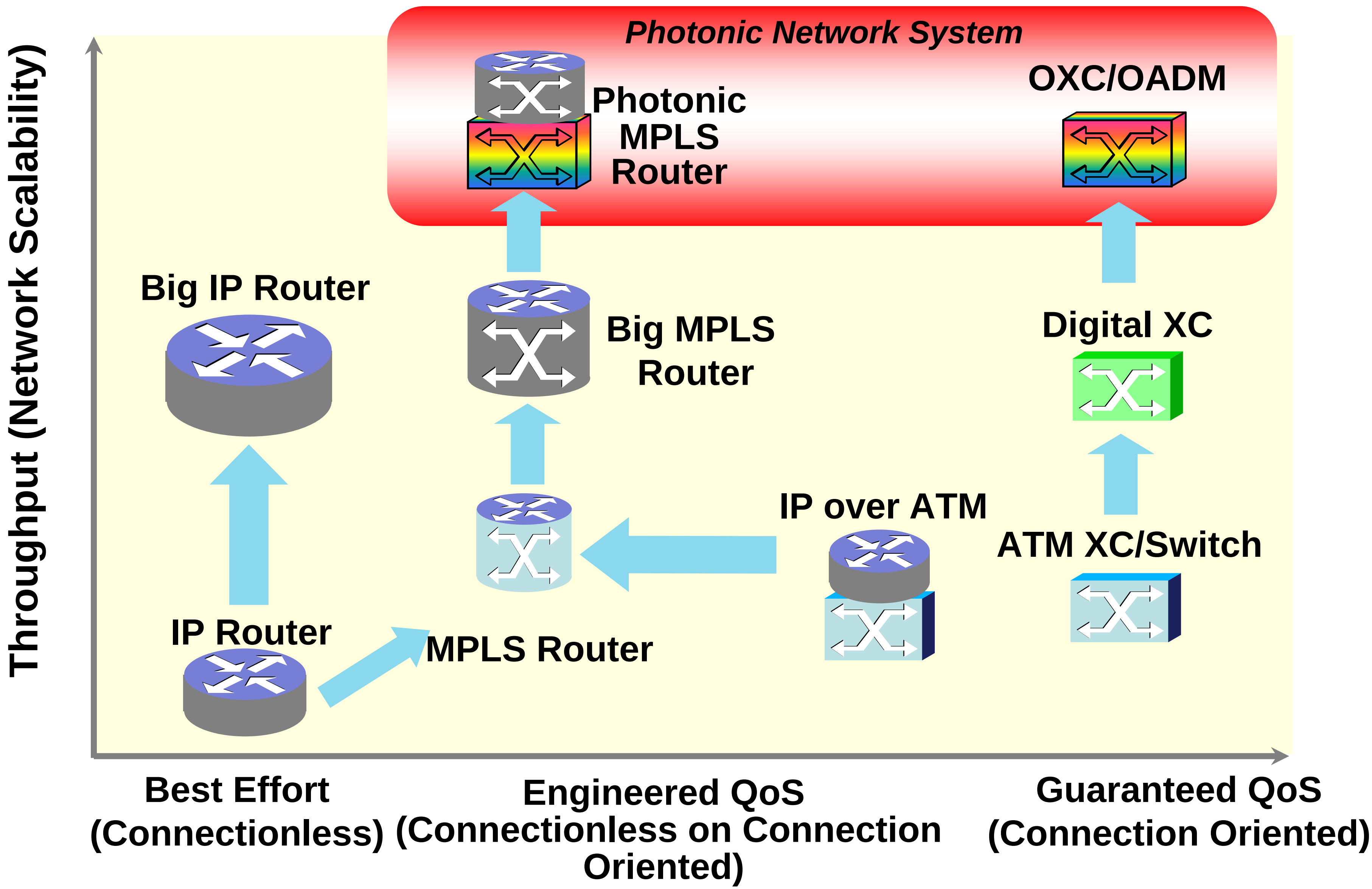
Source: Ministry of Internal Affairs and Communications

Traffic Increase in Regions



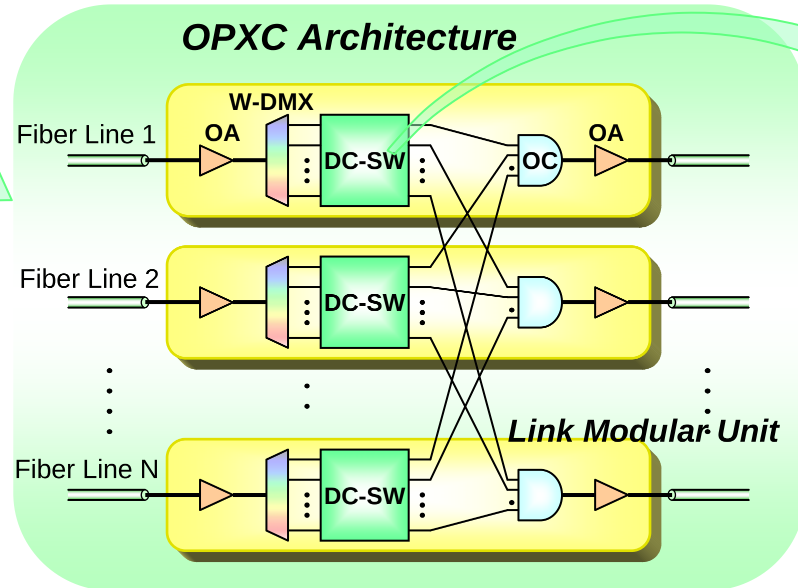
China's Data From: Wu Hequan, Japan-China Photonic Network symposium, June 6, 2004, Tokyo
Other Data From RHK.

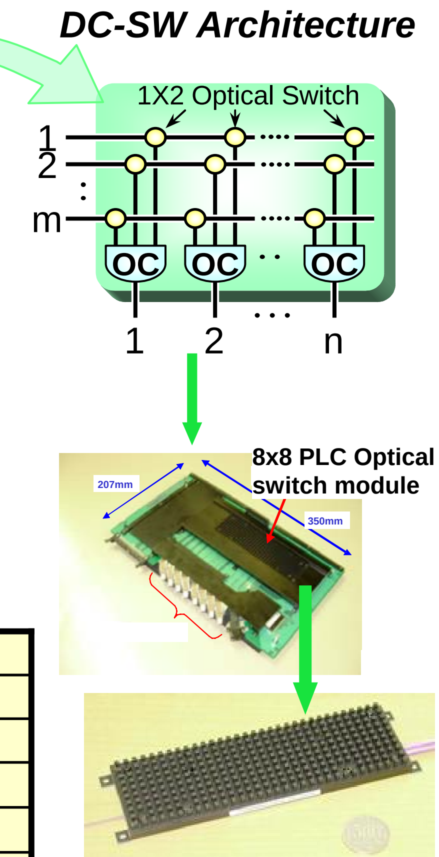
Network node system and QoS.



OXC System Developed by NTT

OXC System
(2,130 mm × 795 mm × 600 mm)

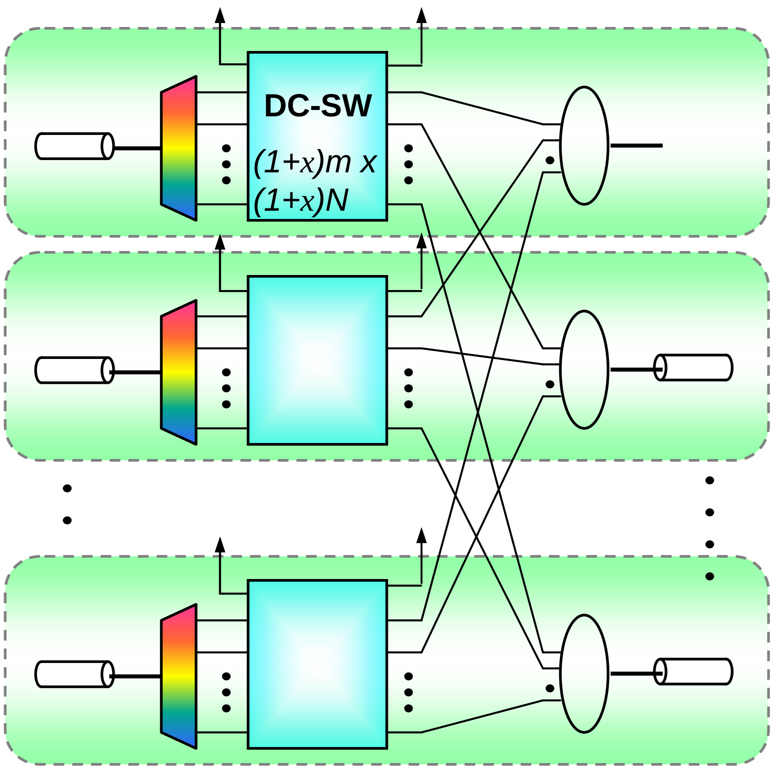




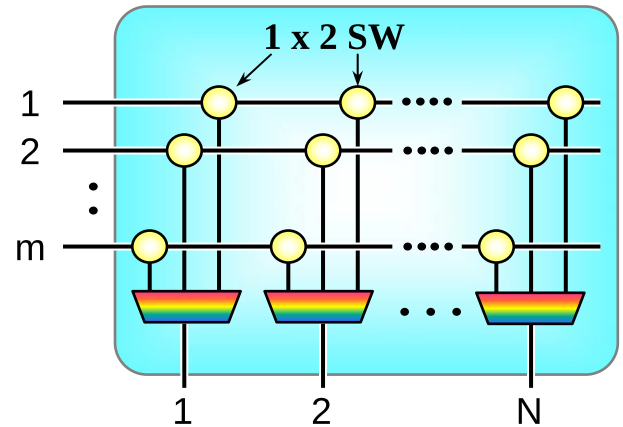
Item		Specifications
OXC Switch	SW Architecture	DC-SW
	SW Component	PLC-TO SW
	Switch Scale	64 × 64
	Modular Increment Unit	8 × 8
	Cross-Connect Function	1:1（Normal） 1:2（Drop and Continue）
Interface (UNI/NNI)	Channel Speed	9953.28Mbit/s（10Gbit/s）
	Frame Structure	ITU-T G.707 STM-64 ANSI T1.105 OC-192
	Optical Specification	ITU-T G.691 S-64.2a/S-64.2b
	Optical Fiber	ITU-T G.652（SMF）/G.653（DSF）
Opt. Path Protection	Protection	1+1
	Protection Time	Less than 50 ms

OXC using Delivery and Coupling Switches

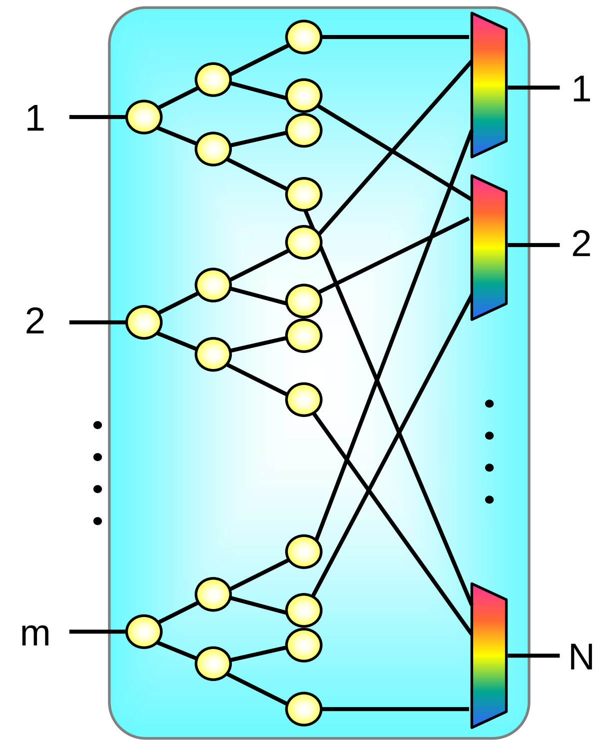
Single layer OXC architecture that uses DC-SWs



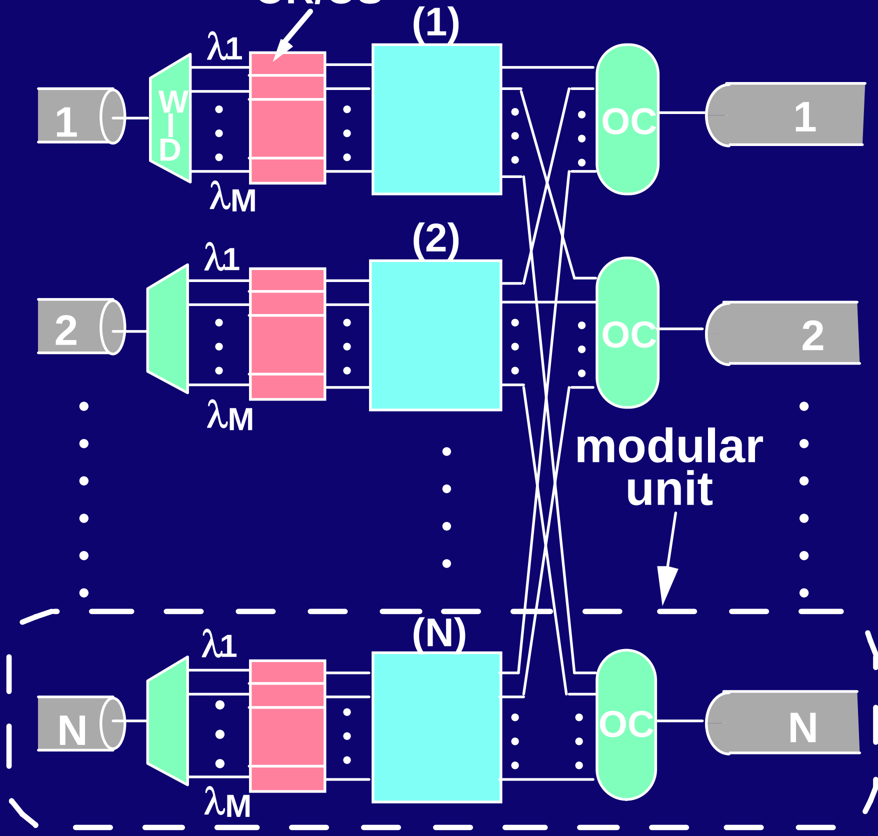
Matrix type *m* x *N* DC-SW



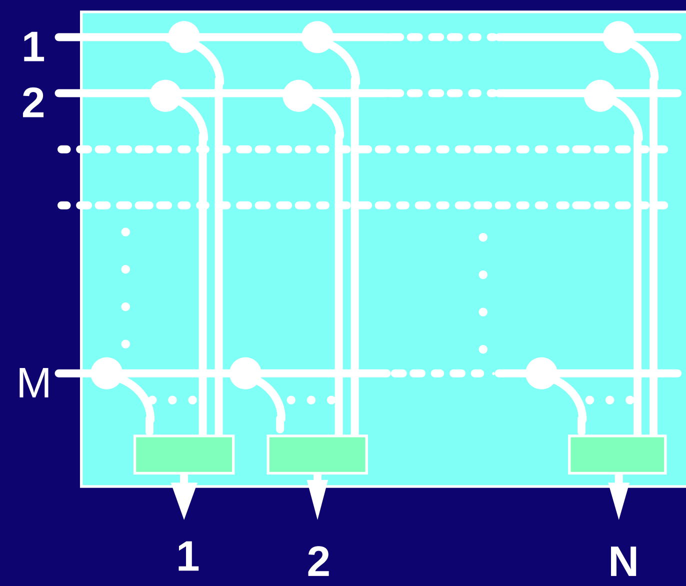
Tree type *m* x *N* DC-SW



Proposed WP/VWP Cross-Connect Switch Architecture



Generic Configuration of M X N Junction Type Matrix Switch



OR : Optical Receiver

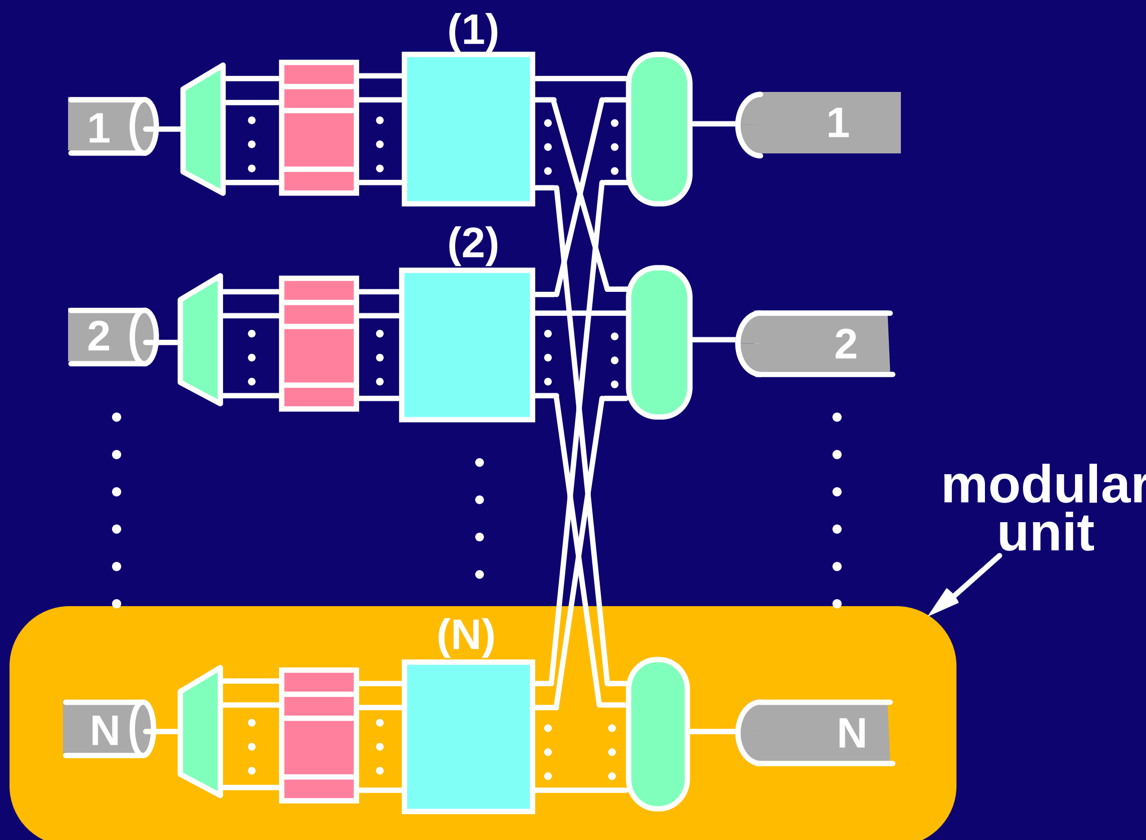
OS : Optical Sender (fixed wavelength for WP, tunable wavelength for VWP)

● : 1 X 2 Switch

▭ : OC for WP/VWP (can be Wavelength Multiplexer for WP)

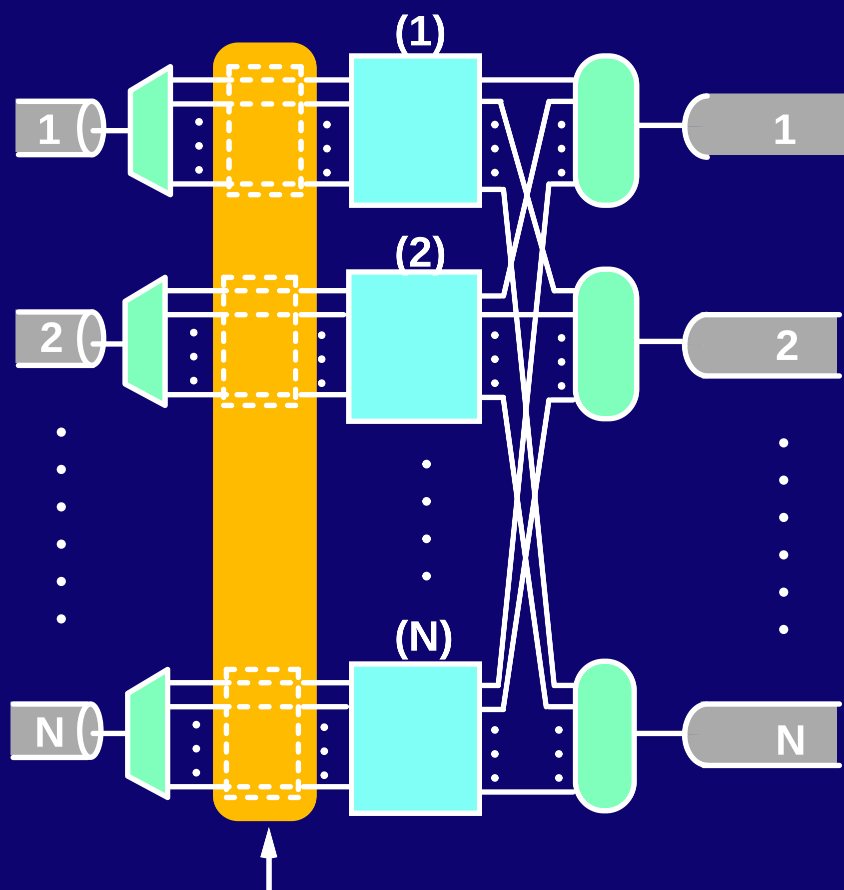
K. Sato, presented at ECOC '94, Transport Network Evolution with Optical Paths, 1994.

HIghly Modular Growth Capability



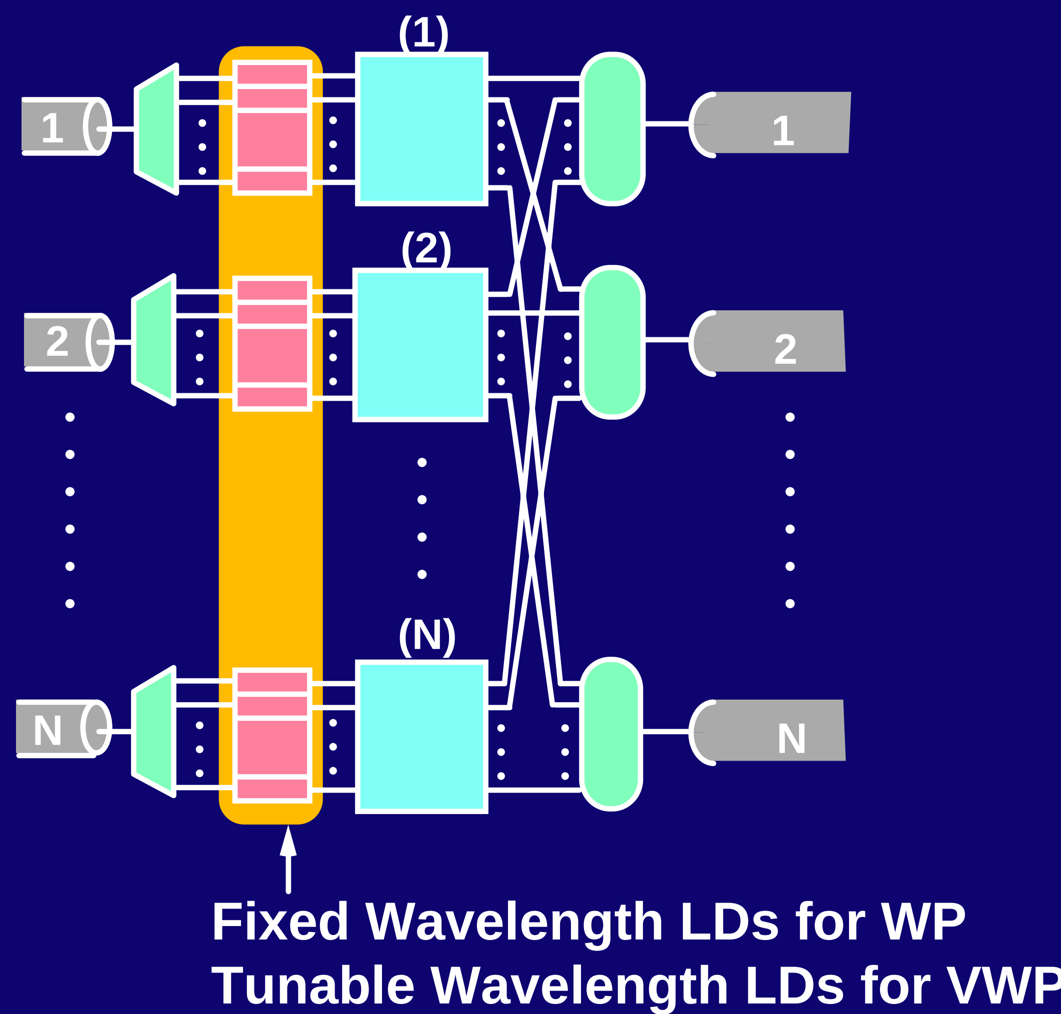
K. Sato, presented at ECOC '94, Transport Network Evolution with Optical Paths, 1994.

Regenerative or Non-Regenerative Repeater Configuration



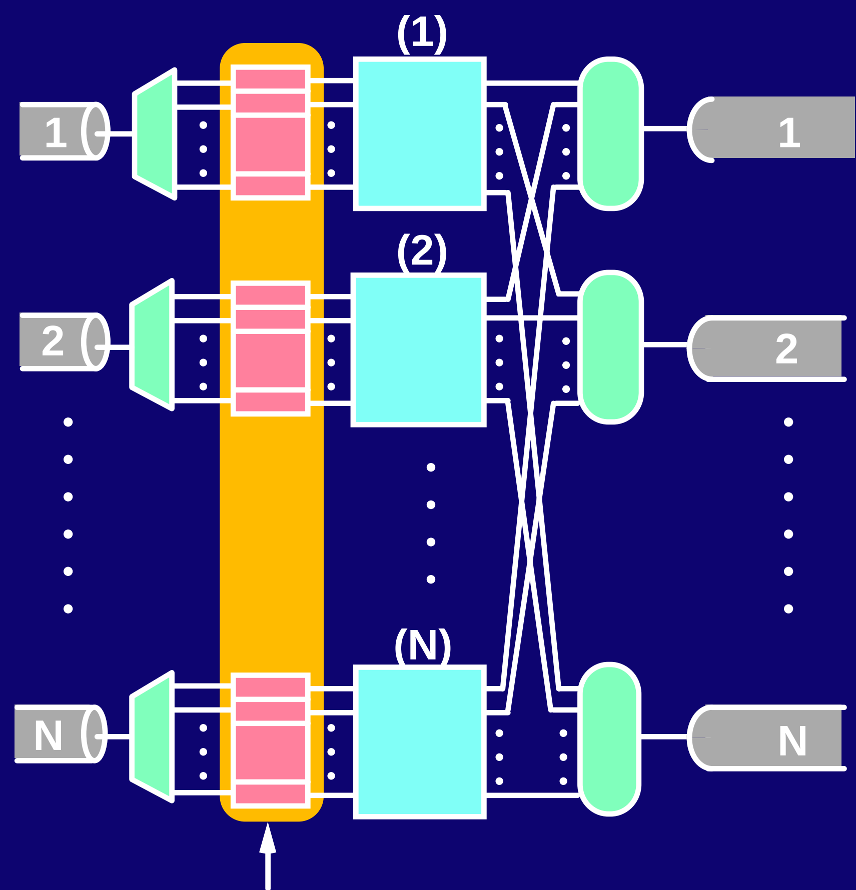
K. Sato, presented at ECOC '94, Transport Network Evolution with Optical Paths, 1994.

WP to WVP XC Up-Gradability



K. Sato, presented at ECOC ‘94, Transport Network Evolution with Optical Paths, 1994.

Transmission Bit-Rate Up-Gradability

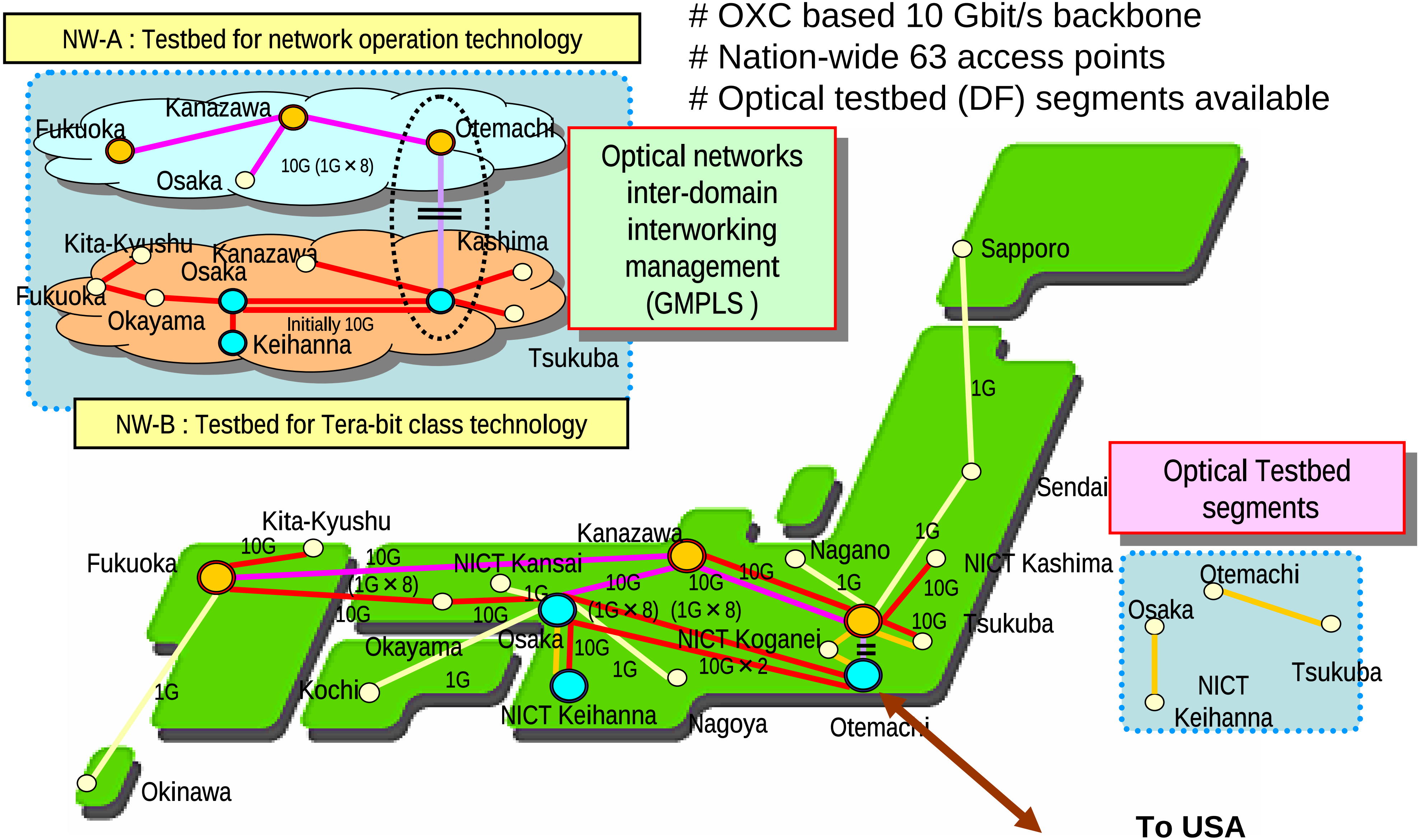


From 2.5 Gb/s OR/OS to 10 Gb/s OR/OS

K. Sato, presented at ECOC ‘94, Transport Network Evolution with Optical Paths, 1994.

Photonic networking R&Ds in JGN-II

- # OXC based 10 Gbit/s backbone
- # Nation-wide 63 access points
- # Optical testbed (DF) segments available



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 ）

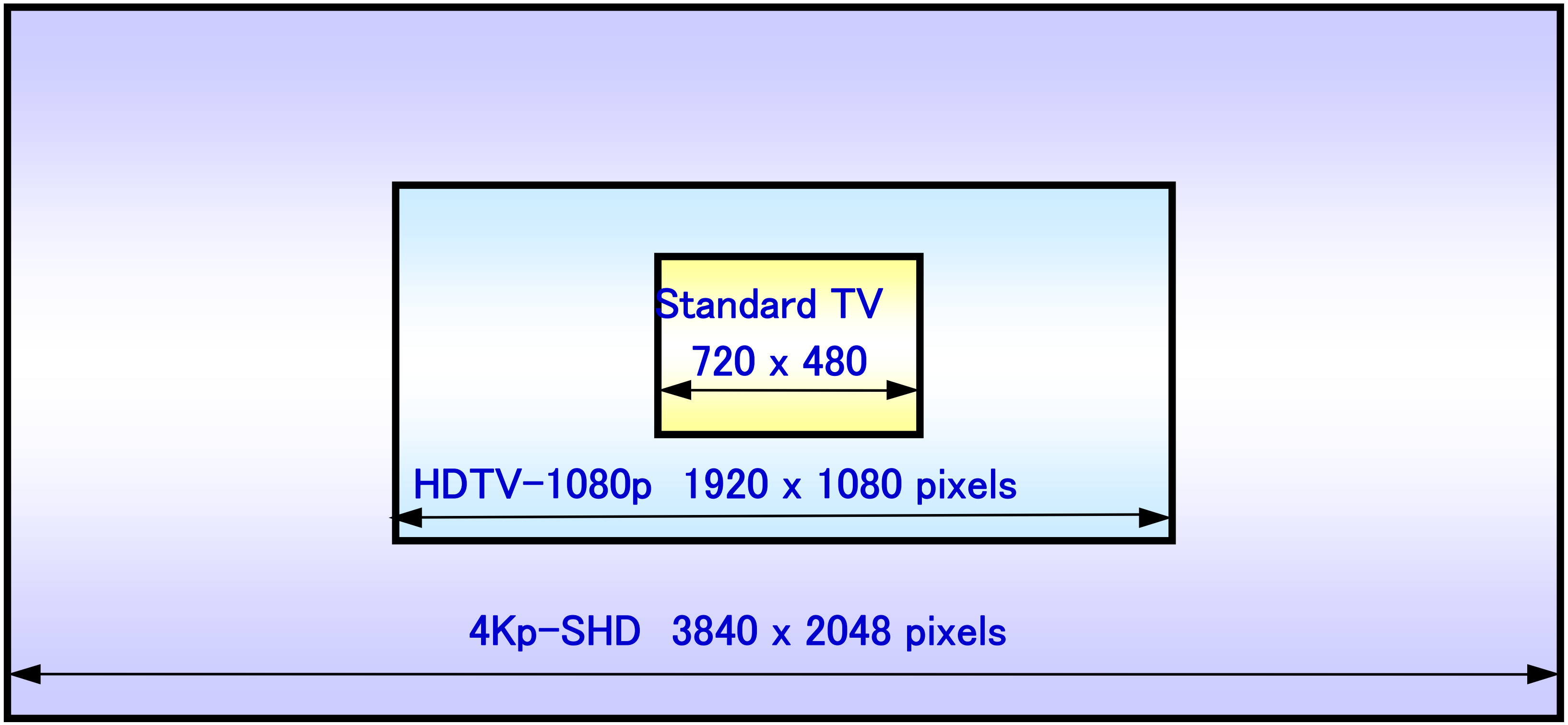
λ Access（2006〜2010)

λ Utility（2006〜2010)

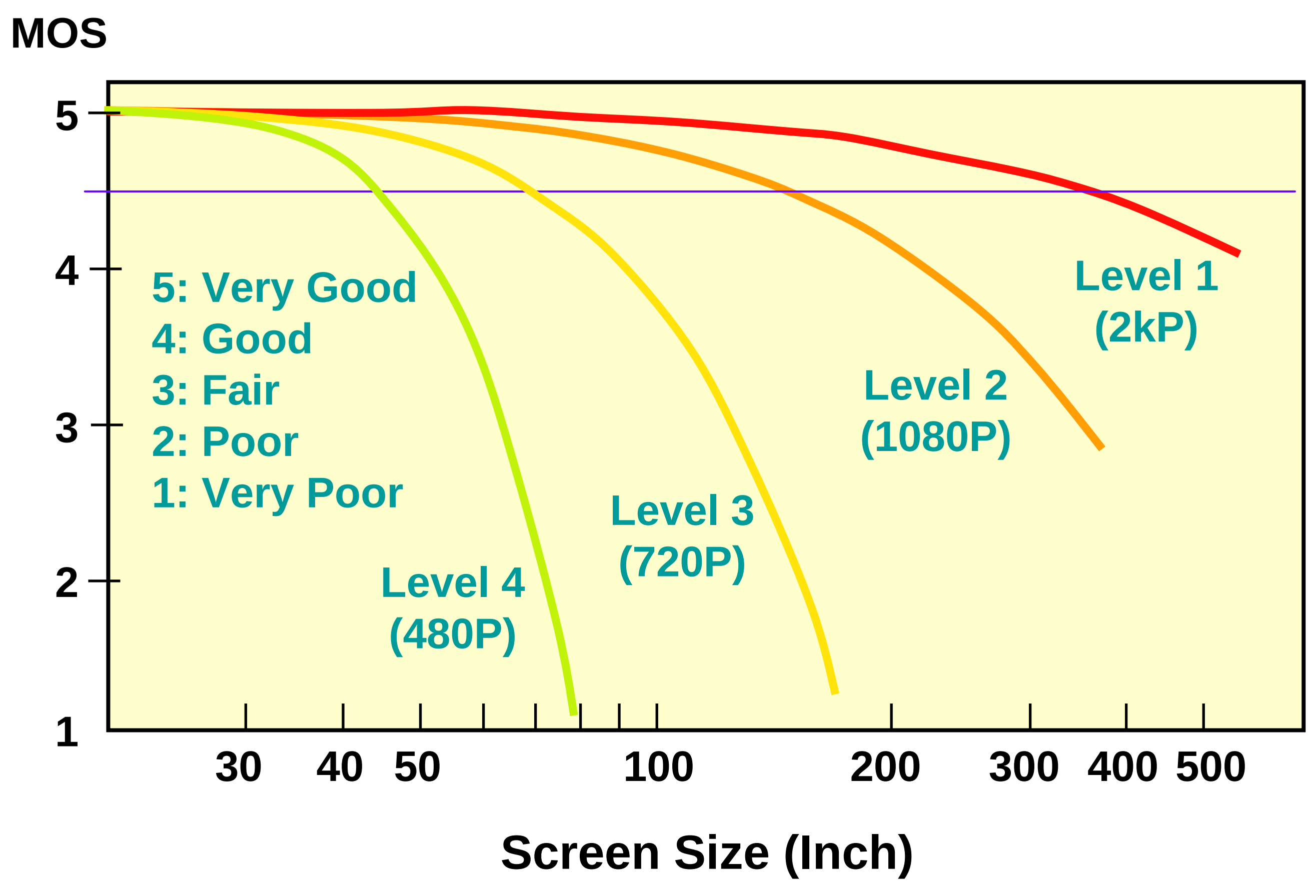
Photonic RAM（2006〜2010 ）

Resolution comparison

HDTV-1080p/24 vs. 4K-SHD Digital Cinema with 8M pixels

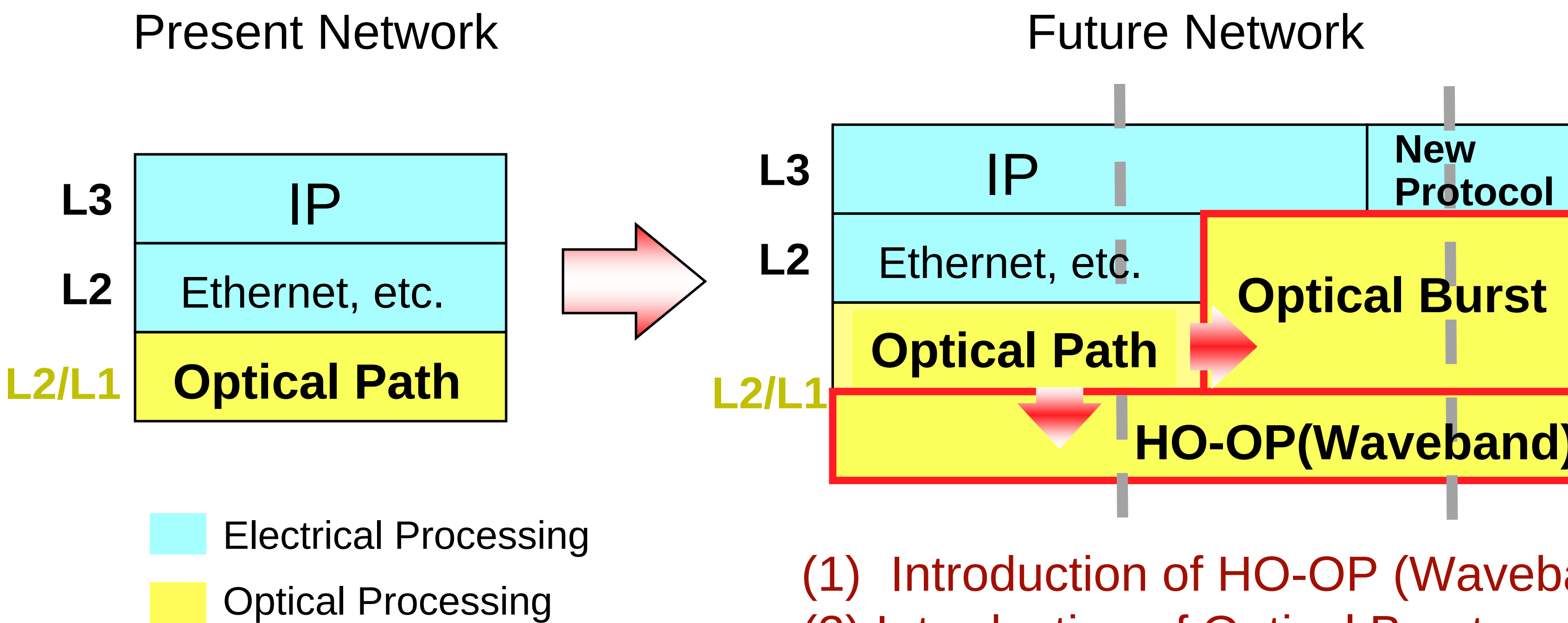


Screen Size and Available Quality



New 360-Degree Display : The SeeLinder

Different Paths to Network Throughput Expansion

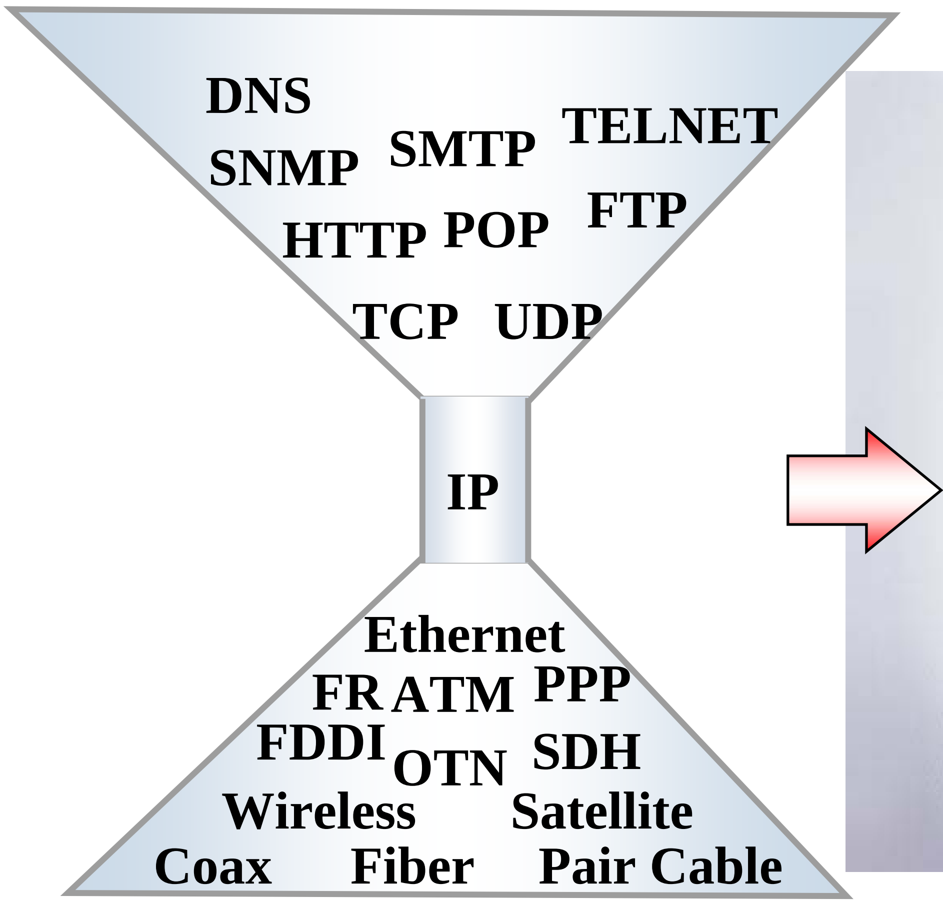


(1) Introduction of HO-OP (Waveband)
(2) Introduction of Optical Burst

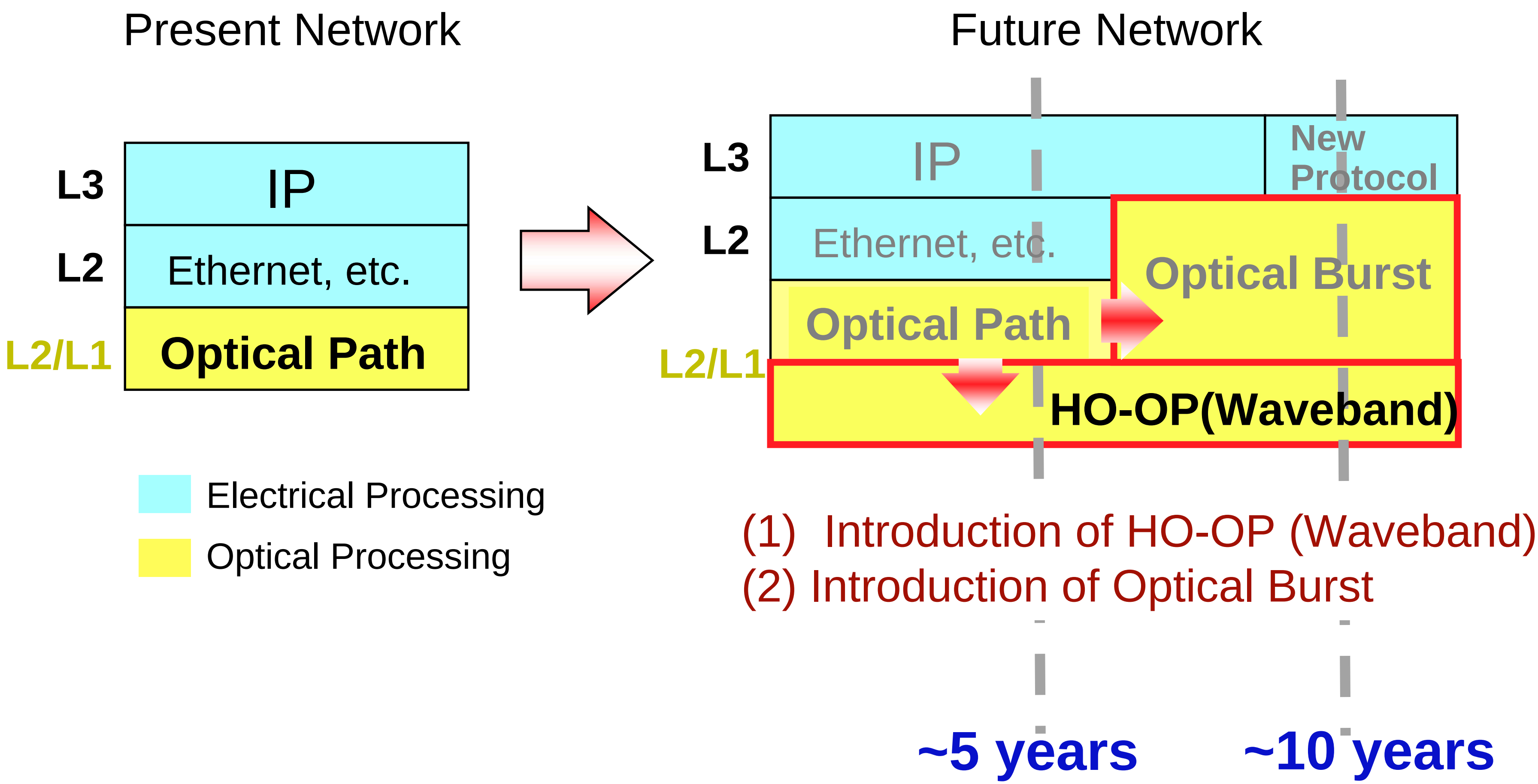
~5 years ~10 years

1~10 Tb/s Electrical Router → ~ 100 Tb/s Photonic Router

Introduction of OBS - Solving IP Bottleneck? -



Different Paths to Network Throughput Expansion

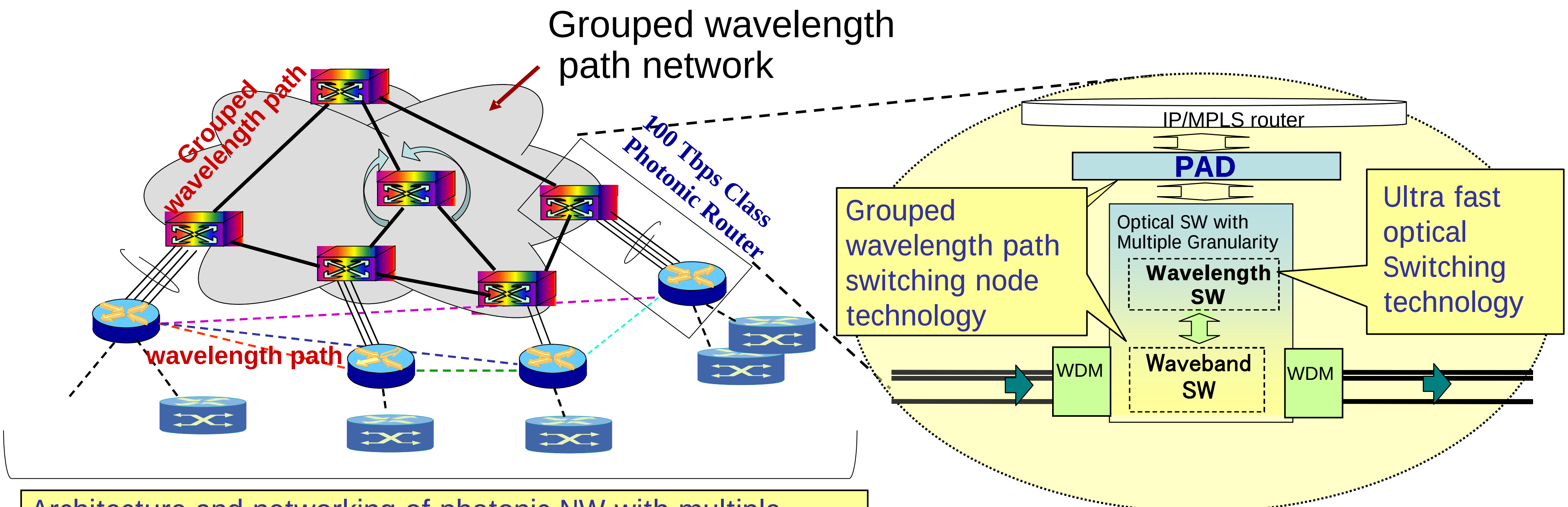


1~10 Tb/s Electrical Router → ~ 100 Tb/s Photonic Router

R&D of High Performance Photonic Node Technology

100Tbps-Class photonic node with multiple switching granularity

- Ultra-fast Switching technology with nsec time region for optical burst handling.
- Node technology with switching granularity up to waveband for throughput expansion.
- Architecture and networking of Photonic NW with multiple switching granularity.



Architecture and networking of photonic NW with multiple granularity nodes.

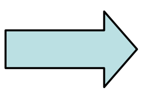
PAD: Payload Assembly Disassembly

Hierarchical Optical Path Networks

■ WaveBand：
Grouped optical path to be treated as a higher order path

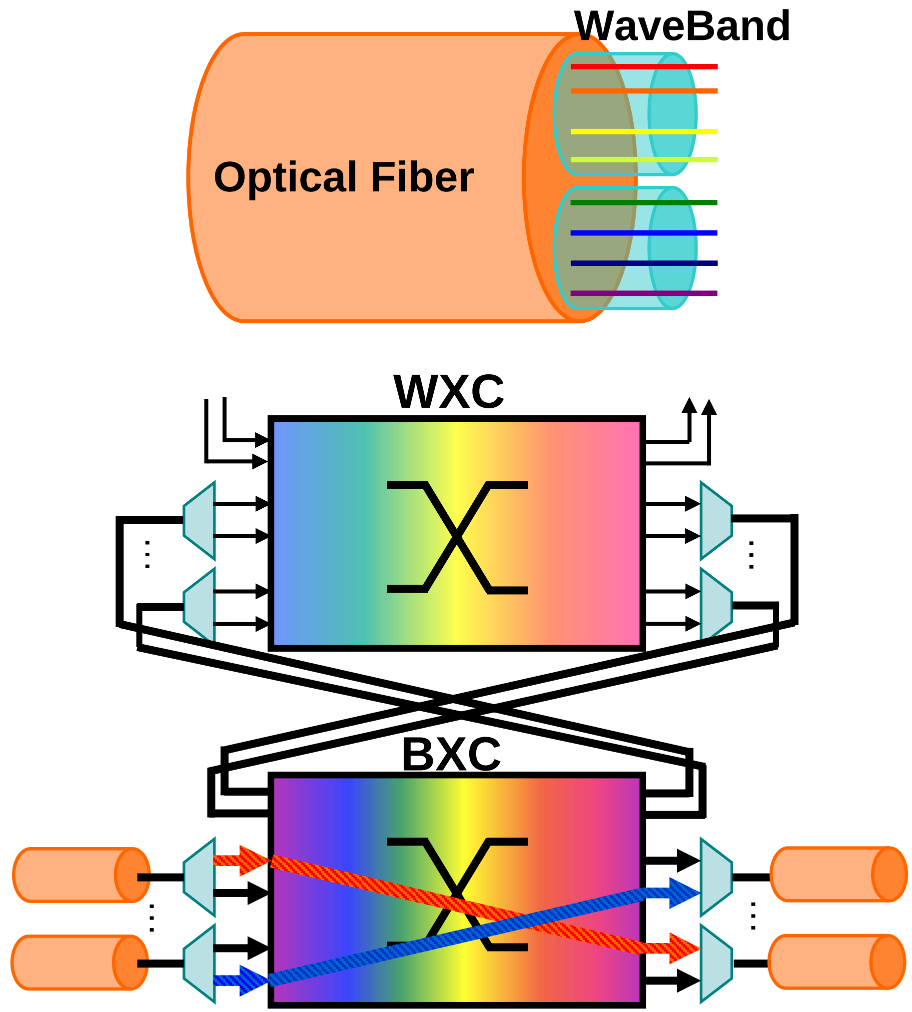
Merits

- Large Capacity Optical Path is Realized by Multiplexing Multiple Optical Paths
- Routing is done as a WaveBand; cut through of wavelength level routing processing



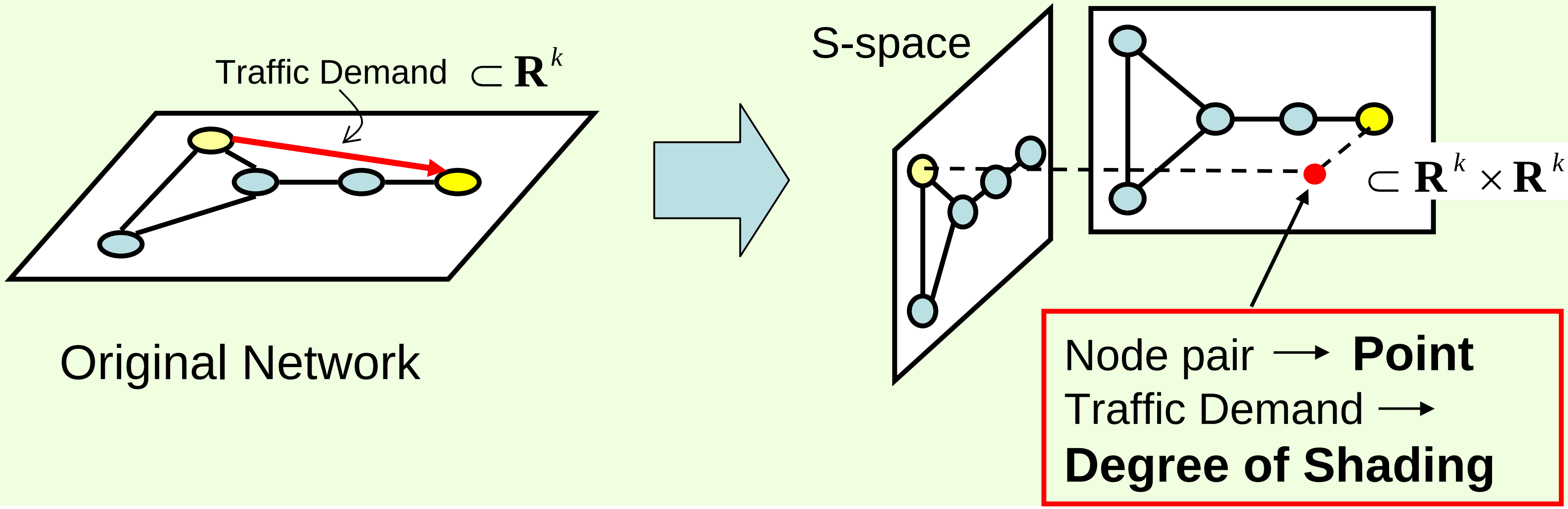
- **Reduction of necessary number of switch ports**
- **Reduction of switch size**

Node cost reduction



Introduction of S-D Cartesian Product Space

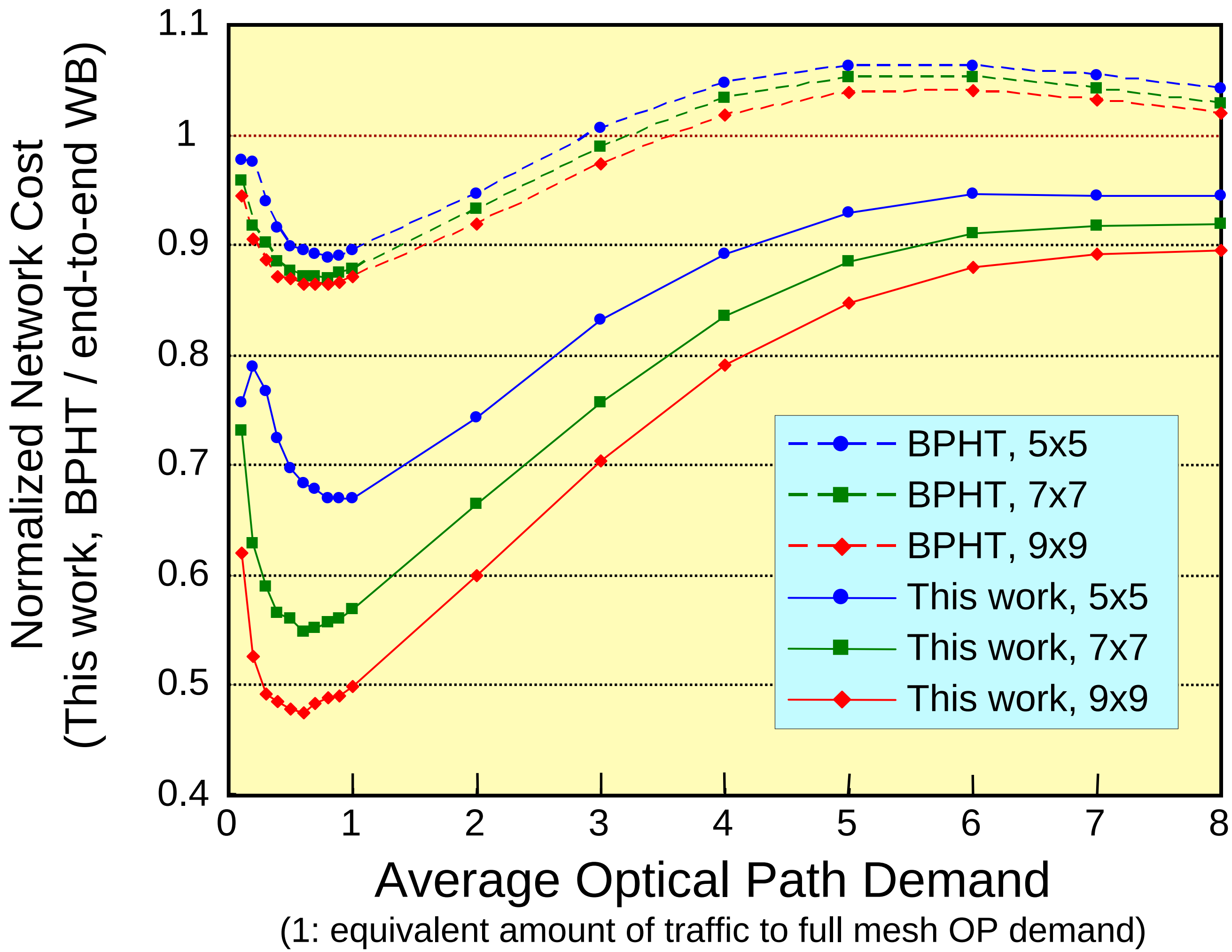
S-D Cartesian product space



- A Cartesian product space is introduces, in which nearby traffic demands are classfied as clusters of points.
- The proposed method searches for the clusters in the space and places them into wavebands.

I. Yagyu, H. Hasegawa, and K. Sato, "An Efficient Hierarchical Optical Path Network Design Algorithm based on a Traffic Demand Expression in a Cartesian Product Space," ECOC 2006, Cannes, September 2006.

Total Network Cost Obtained with Newly Developed Algorithm

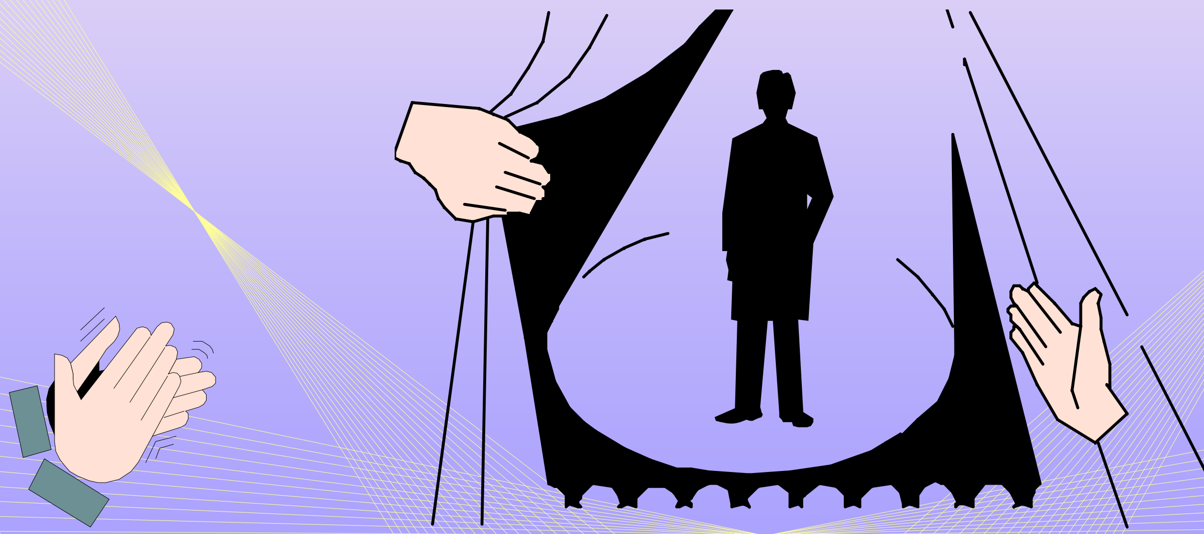


I. Yagyu, H. Hasegawa, and K. Sato, "An Efficient Hierarchical Optical Path Network Design Algorithm based on a Traffic Demand Expression in a Cartesian Product Space," ECOC 2006, Cannes, September 2006.

Conclusions

- Until ten years ago, we looked at N-ISDN and SONET/SDH as the next step technologies on which to base the development of access and core networks, respectively; the agreement was universal.
- The advent and penetration of IP, new technical developments including WDM and photonic network technologies, rapid advances in access technologies, the emergence of IP-based control protocols such as MPLS and GMPLS, provide powerful tools for creating the next generation networks that support IP convergence.
- The technology alternatives are extremely varied and this allows us to develop optimized networks that match each country's or region's or carrier's situation -the divergence in technology and architecture.
- To create next generation photonic networks, hierarchical optical path network and node technologies, network design algorithms that can adapt to unknown traffics, network architectures that maximize electrical layer cut-through are important technologies to be fully developed soon.

Thank you.



Part of this work is supported by NICT (National Institute of Information and Communications Technology)