HITACHI
Inspire the Next

Technology Development for beyond 100Gbps LAN/Metro NW

2012/01/19

Central Research Lab., Hitachi Ltd.
Network Systems Dept.

Nobuhiko Kikuchi and Hidehiro Toyoda

Outline

1. Introduction
2. Current 100-Gbit/s interface
3. Realization of >100-G interface

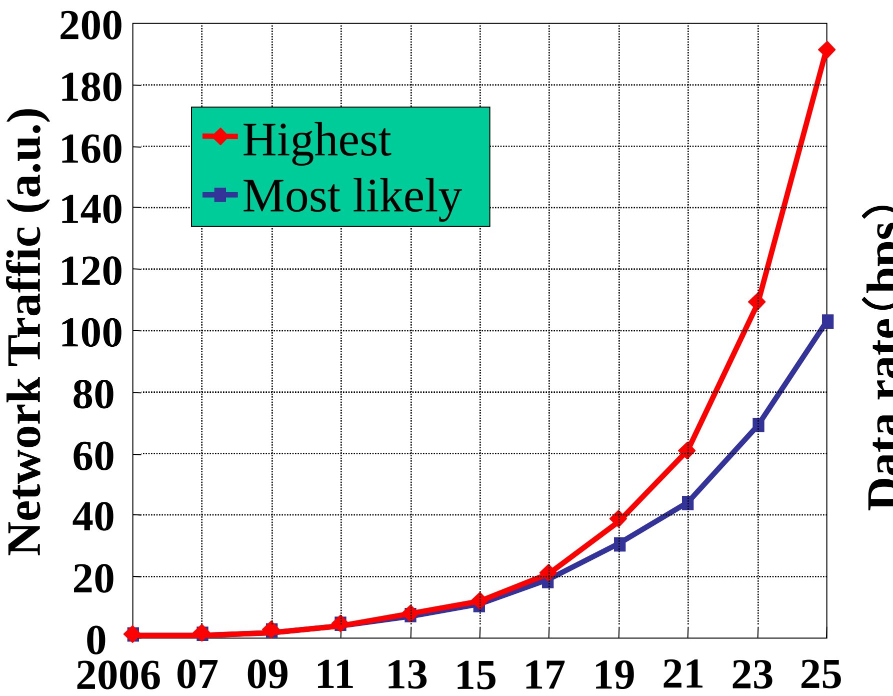
4. Low-cost multilevel interface
5. Use of multi-core fiber
6. Traffic-adaptive power saving
7. Cross-layer convergence with MPLS-TP

8. Summary

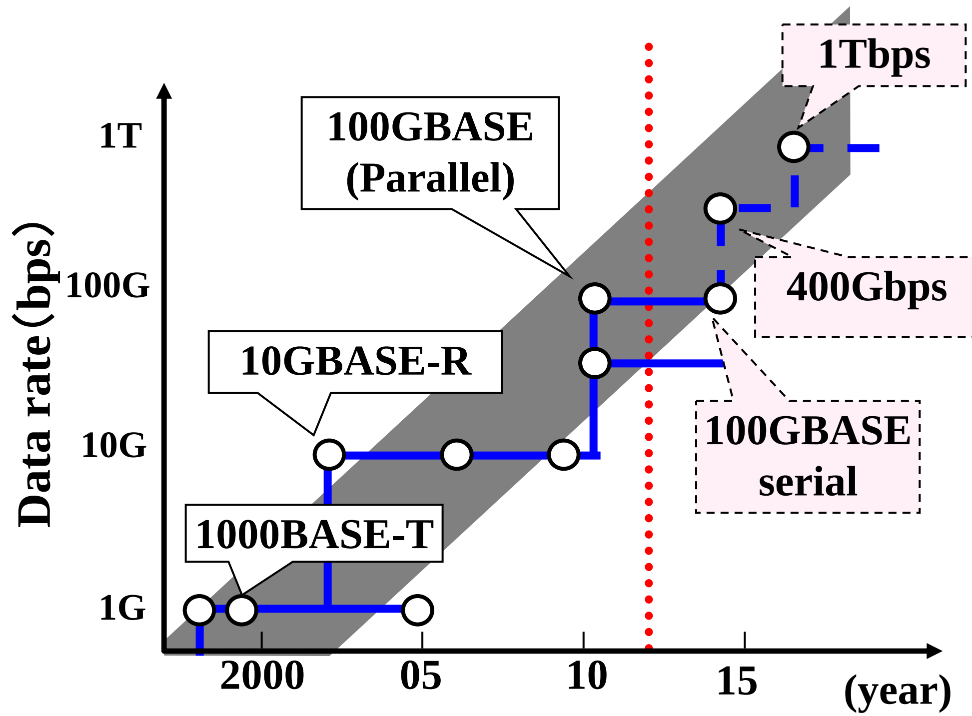
1. Introduction

HITACHI
Inspire the Next

- Smart phones, cloud computing and large-scale data centers drive steady increase of Network traffic.
- 40-G and 100-Gbps Ethernet standardization (IEEE 802.3ba) were completed in Jun. 2010.
- Optical/electrical interface speed must be increased beyond 100 Gbps.



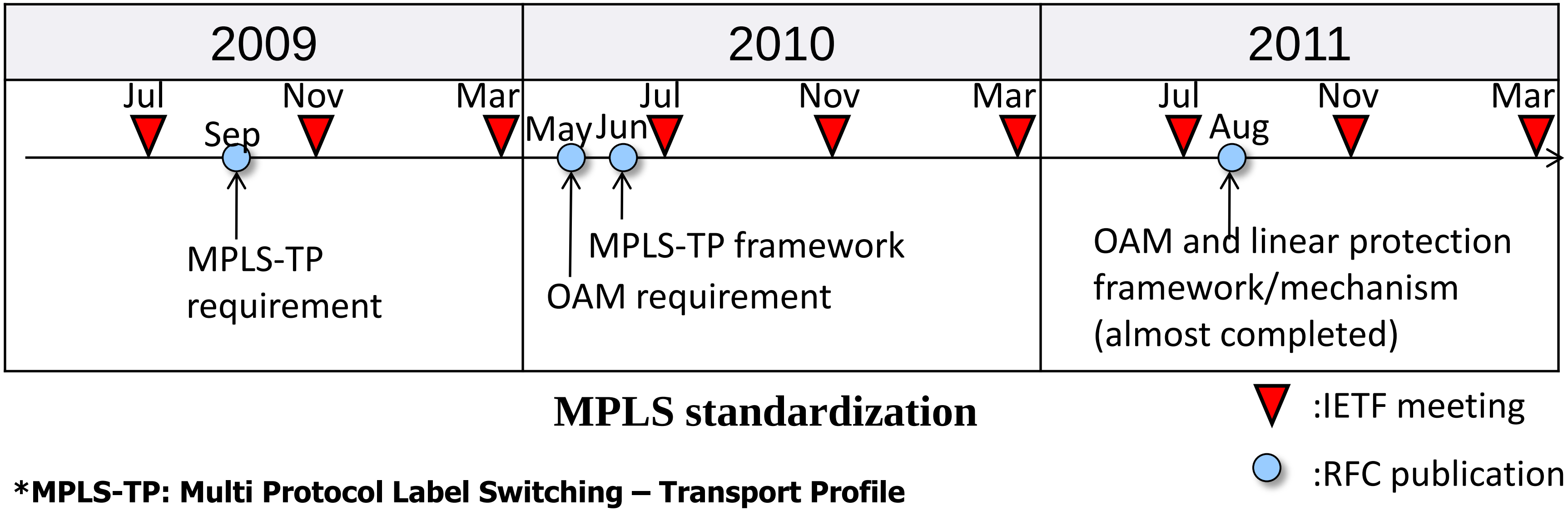
Internet traffic in Japan



Ethernet standardization

1. Introduction

- High-capacity LAN/Metro Network require higher reliability and resiliency.
- MPLS-TP is the key to build a reliable and flexible service-oriented network.
- MPLS-TP standardization is driven by IETF and ITU-T.
  – Hitachi and other Japanese companies contributed both of them.
  – OAM requirement and linear protection standardization was almost finished.



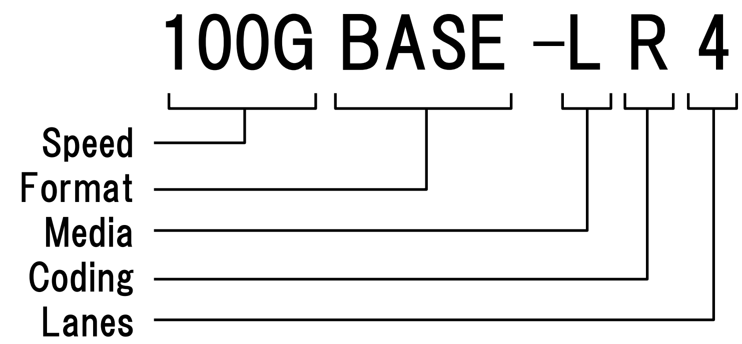
MPLS standardization

***MPLS-TP: Multi Protocol Label Switching – Transport Profile**

2. Current 100-Gbit/s interface (Ethernet)

HITACHI
Inspire the Next

- **Speed**
  - 40G = 40Gbps, 100G = 100Gbps
- **Format**
  - BASE : Baseband modulation
- **Transmission media**
  - Electrical
    - K = bacKplane
    - C = Copper (or Cable)
  - Optical
    - S = Short Reach (100m)
    - L = Long Reach (10km)
    - E = Extended Long Reach (40km)
    - F = Fiber? (2km)
- **Coding**
  - R = 64B/66B
- **Lanes**
  - Number of physical lanes (Number of)
  - n = 1(omitted), 4, 10



Type	Name
40G backplane	40GBASE-KR4
40G Cupper cable 100G Cupper cable	40GBASE-CR4 100GBASE-CR10
40G MMF* 100m 100G MMF* 100m	40GBASE-SR4 100GBASE-SR10
40G SMF 2km	40GBASE-FR
40G SMF 10km 100G SMF 10km	40GBASE-LR4 100GBASE-LR4
100G SMF 40km	100GBASE-ER4

*OM3-grade MMF (Core diameter 50um, Bandwidth 2000MHz･km)

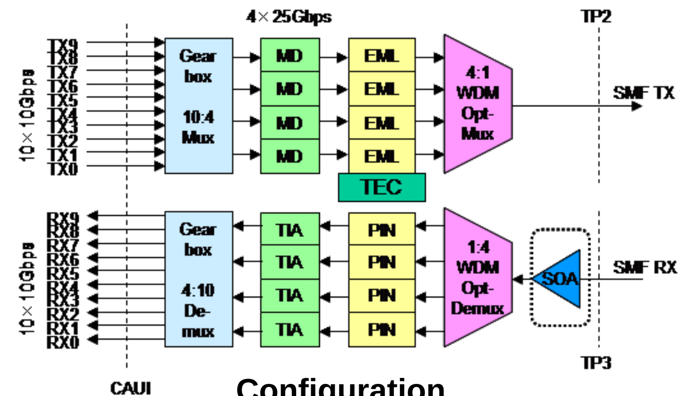
Example of current 100-Gbit/s optical interface

HITACHI
Inspire the Next

100GBASE-LR4/-ER4

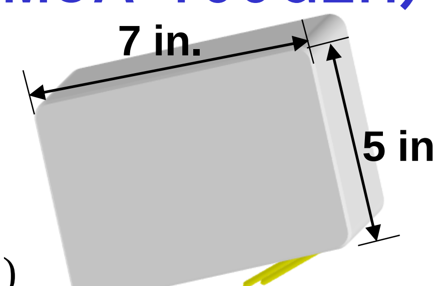
- CFP: 145 mm x 82 mm
- Power consumption: 20~30W
- 25 Gbps x 4 λ LAN-WDM (1.3um, 4.5 nm spacing)

- Tx : 4 x 25-G MD+EML > LAN-WDM Mux
- Rx : (SOA) >LAN-WDM DeMux > 4 x 25-G PIN+TIA

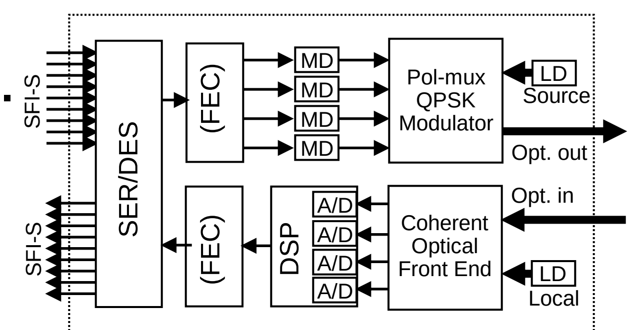


Configuration

OIF 100G-coherent (MSA-100GLH)



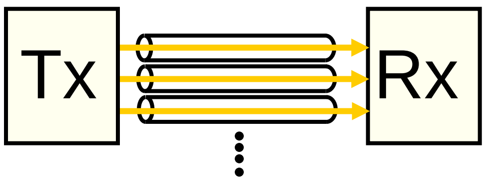
- 5 in. x 7 in. (177 mm x 127 mm)
- Power consumption: Max. 80W
- 100 Gbps x 1 λ
- Format: Dual Pol.-QPSK, 25 GSymbol/sec



Configuration

3. Realization of >100-G interface

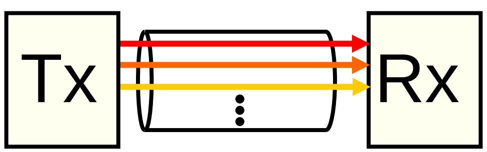
Parallel



Ex: 400 GbE by 25 Gbps x 16 lanes

Pros. Simple TRx. Low TRx cost.
Cons. High fiber cost.
... Only for very short reach (< a few km).

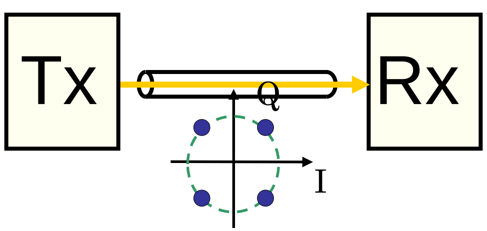
WDM



Ex: 400 GbE by 25 Gbps x 16 λ (DWDM)

Pros. Simple TRx.
Cons. Narrow ch. spacing (<2 nm with SOA).
Precice wavelength control required.
Extra loss from WDM coupler/splitter.
Device integration preffered.

Multilevel



Ex: 400 GbE by 100 Gbps x 4 λ

Pros. Higher performance by the use of DSP.
Reduced number of TRx/λ.
Cons. Complicated and bulky TRx.
High cost and power consumption.

... In the long run, combined use of Parallel/WDM/Multilevel transmission will be required.

Requirement and approaches for >100 Gbit/s

HITACHI Inspire the Next

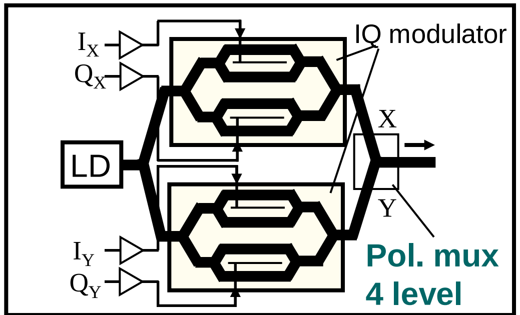
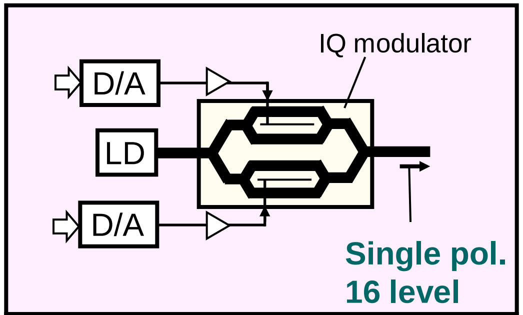
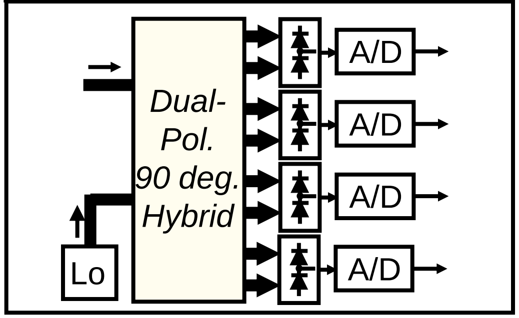
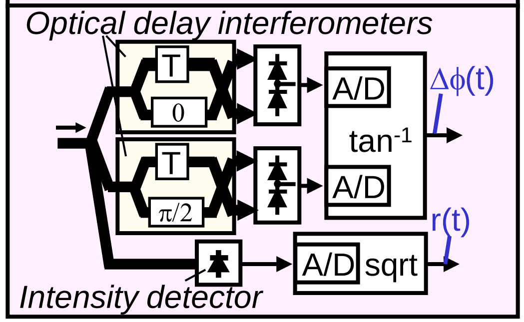
Requirements:

- *Limited electrical signaling speed (25 ~ 30 GHz)*
- *Limited optical bandwidth (~30 nm)*
- *Power consumption (30W / CFP)*
- *Improved reliability / efficient service*

Approaches:

- *Low-cost multilevel tranceiver (>100 G/λ)*
- *Use of multi-core fiber*
- *Traffic-adaptive power saving*
- *Cross-layer convergence with MPLS-TP*

4. Low-cost multilevel interface

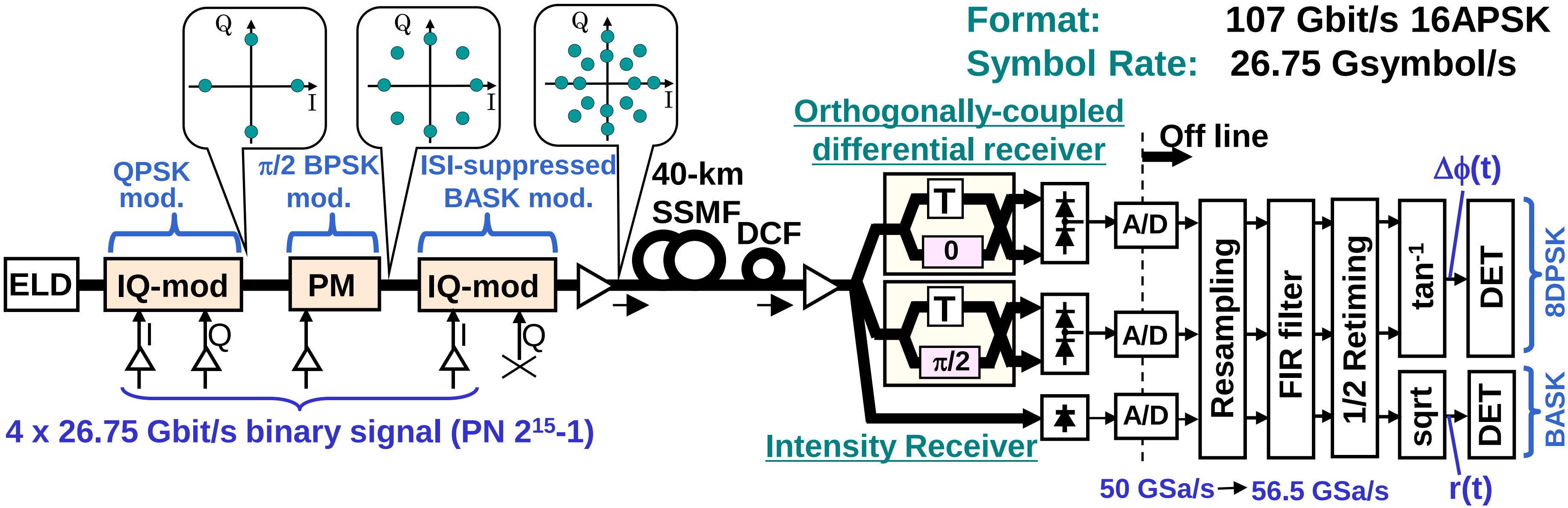
	100-G Coherent	Proposal(Delay detection)
Tx Configuration		
Rx Configuration		
Sensitivity	✓✓ Nearly ideal	✓ 1~2 dB worse
CD tolerance	✓✓ Digital at Rx.	✓ Digital at Tx.
Simplicity	With Pol-mux and Lo-LD	✓ Without pol-mux nor Lo-LD
LD linewidth tolerance	✓ ~3 MHz/LD	✓✓ ~ 20 MHz

Ex.: 107 Gbit/s 16APSK experiment

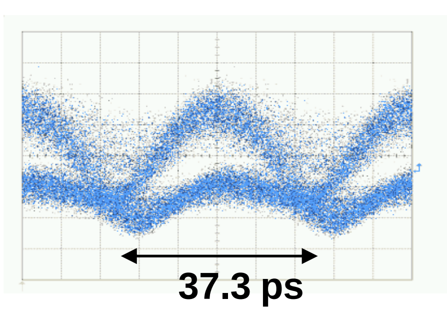
Hitachi
OECC 2010

HITACHI
Inspire the Next

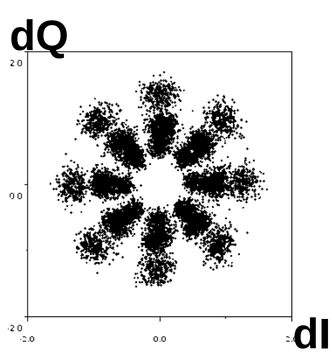
- 16-level 100 Gbit/s single-pol. incoherent signaling.
- Comparable mod. speed with 100-G coherent systems.



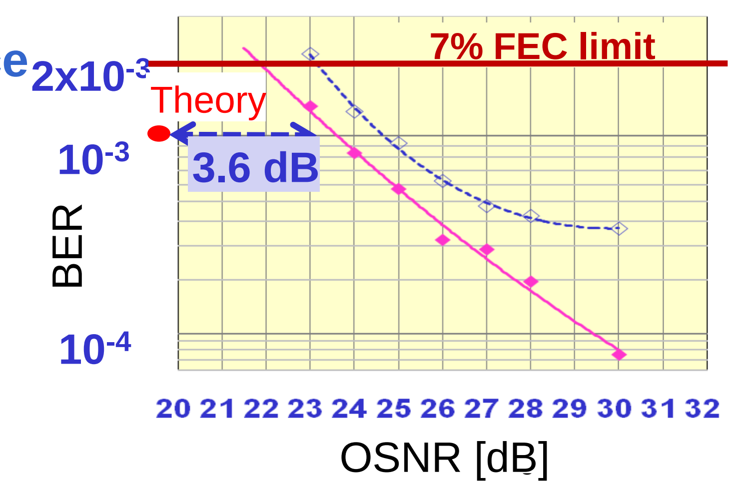
Intensity eye-pattern



Differential constellation

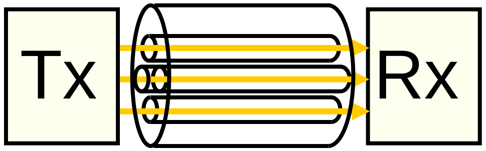


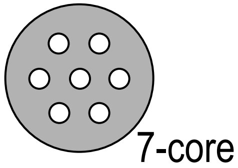
BER performance



ELD: external cavity laser diode(1552nm, Lw=100kHz)

5. Use of multi-core fiber





Advantages:

- *Cost and space effective than bulky array fiber.*
- *Easy handling, low deployment cost.*
- *Compatible with WDM/multilevel modulation.*

... Especially usefull for short-/medium-reach applications.
(board-to-board, data center LAN and Metro NW).

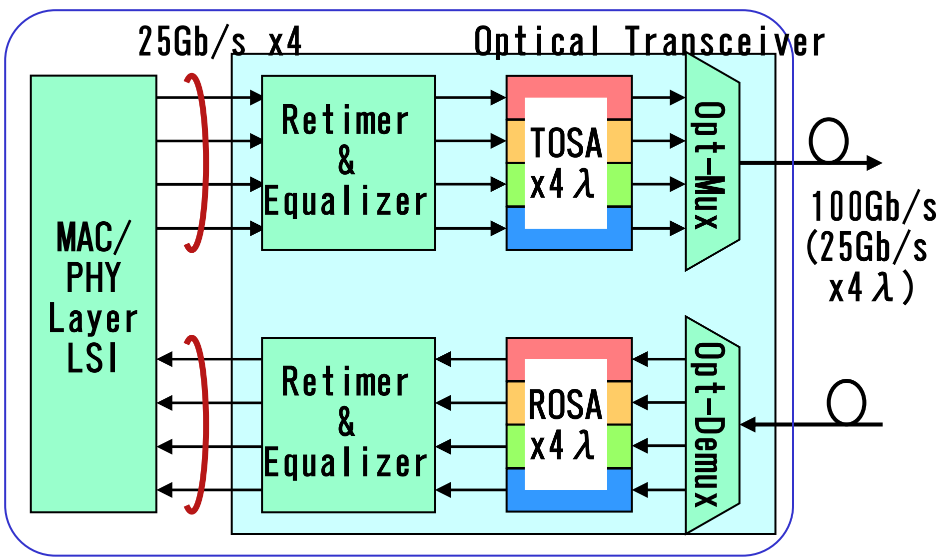
Issues:

- *Development of Small-size and low-loss multi-core couplers/splitters.*
- *Development of connector and amplifier.*
- *Fiber improvement (loss, isolation, bending tolerance etc).*

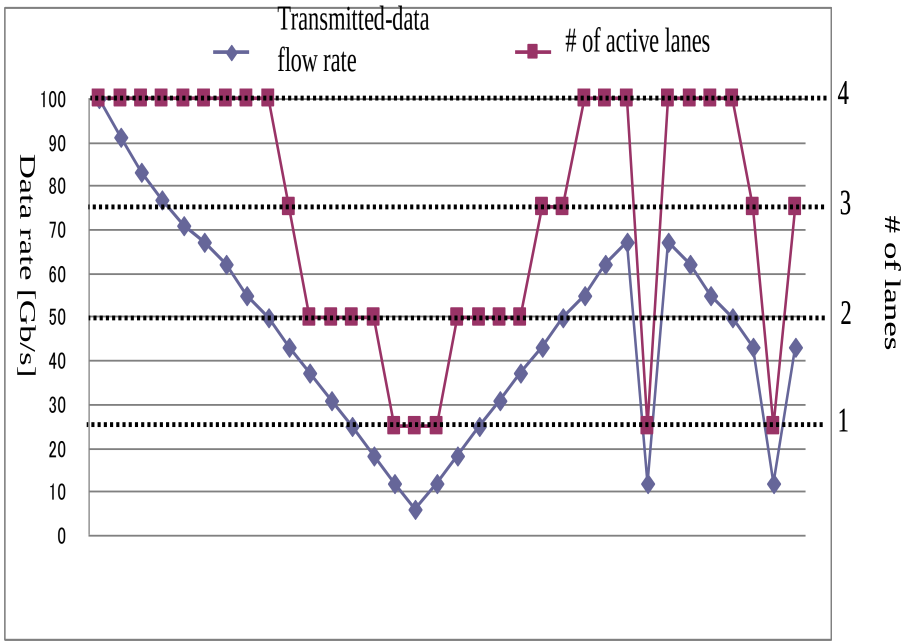
6. Traffic-adaptive power saving

- 100Gb/s Ethernet utilizes multi-lane transmission.
- Our proposal
  - Power saving by adaptively changing the number of active lanes depending on the amount of data traffic.
- Future issues
  - Development of effective control method and protocol.
  - Reduction of transition time by quick stabilization of optical and electrical devices at power up stage.

Network Interface



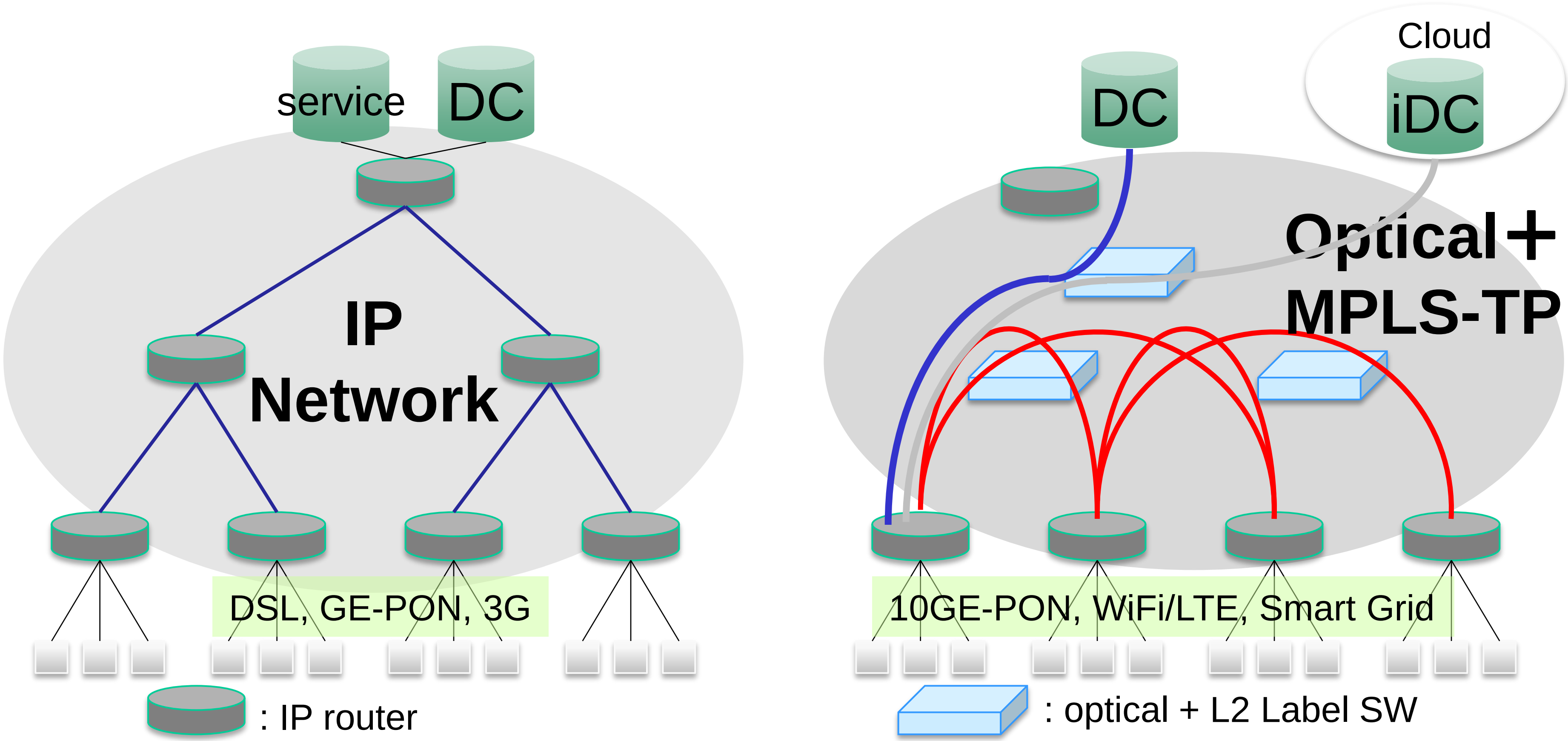
TOSA: Transmitter Optical Sub-assembly
ROSA: Receiver Optical Sub-assembly



7. Cross-layer convergence with MPLS-TP

HITACHI
Inspire the Next

- Currently, IP-routed network provides all the connectivity.
- Combining optical path and MPLS-TP packet switching path for the diversifying service environment
  - Utilizing big and long wavelength path with statistical multiplexing

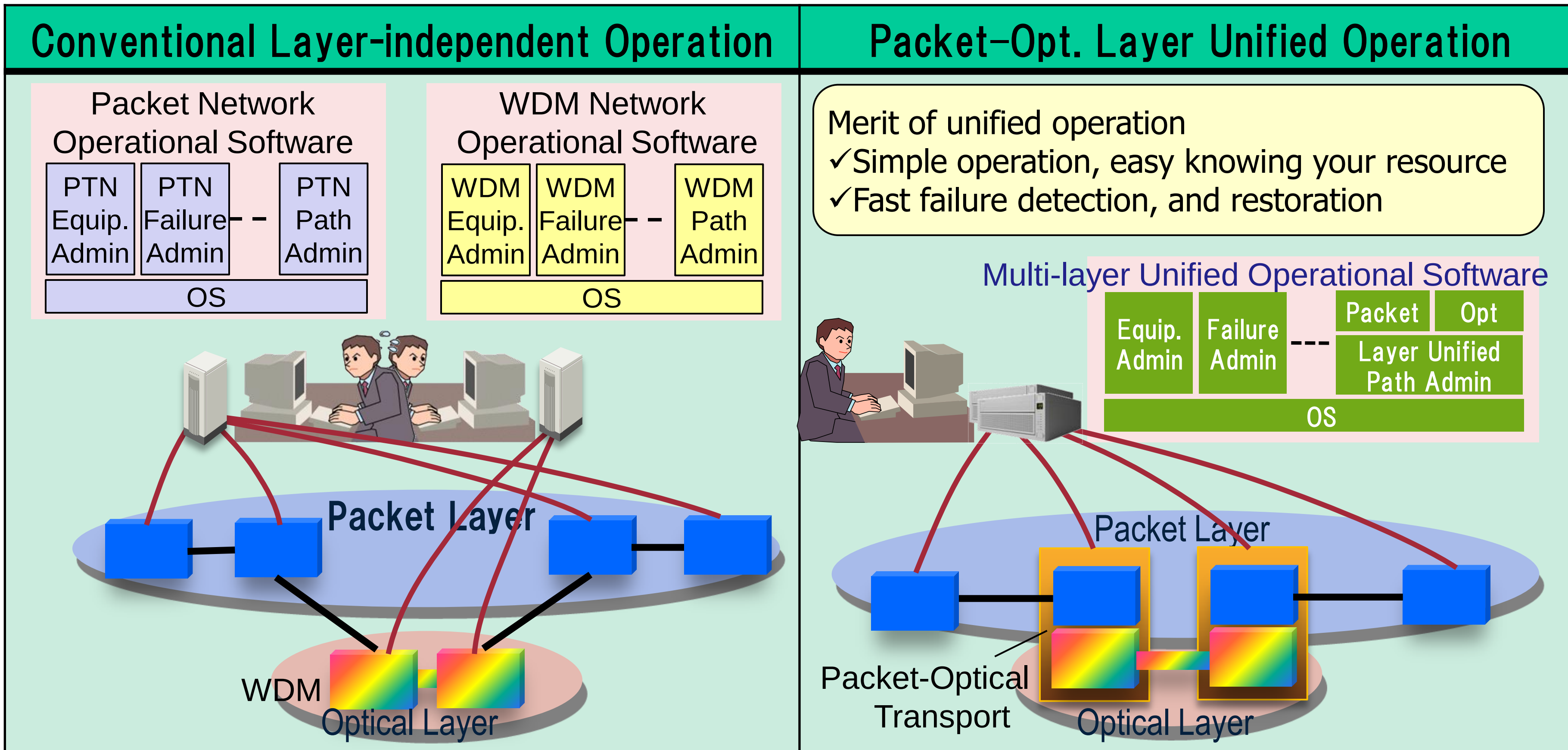


7. Cross-layer convergence with MPLS-TP

Issues:

- Realization of "**unified operation**" for the efficient use of optical and packet path.

  ... Conventional Operation Software (OpS) is independently utilized in packet and optical layers.



8. Summary

- Current 100-G standardization and interface
- Requirement and issues for >100 Gbps
- Related research activities
  - Low-cost multilevel interface
  - Use of multi-core fiber
  - Traffic-adaptive power saving
  - Cross-layer convergence with MPLS-TP