NEDO Project on Development of Next-Generation High-Efficiency Network Device Technology
- Project Status Towards Energy Saving -

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Outline

- Introduction and Objectives
- Target Areas of Development
- Photonic I/O Devices for 100GbE and 40GbE
- High Density Optical Backplane
- Dynamic Optical Path Network
- Conclusions
Introduction and Objectives

Router Throughput and Its Energy Efficiency Rating

Throughput (Gbps) vs. Mbits/J

EER in 2020
\[
\frac{\text{EER in 2020}}{\text{EER in 2005}} \approx 5
\]

448-540
Introduction and Objectives
- Evolution of current router technology may fail in 2020

Why so much energy is required to transfer weightless information?

➢ The broadband subscribers in the world = 215M in 2005 (Penetration = 3.35%: WHITE PAPER Information and Communications in Japan).
➢ World Population in 2020 = 7,500M.
➢ Energy consumption per capita = 1/35

Assuming 30% penetration ratio,
Energy consumption per capita in 2020 = 1/10 of that in 2005 (per capita)
Target Areas of Development

- Next Generation Network must be energy efficient!
  - Using Optics is our solution.
  - For the current demands
    - Photonic I/O Devices for 100GbE and 40GbE
  - For the demands in the near future
    - High Density Optical Backplane
  - For the demands in the future
    - Photonic Path Switching
Photonic I/O Devices for 100GbE and 40GbE
- 40Gbit/s chipsets for LAN-WAN -

LAN-WAN Transponder

43.6W (61%)

Next Generation Highly Efficient Network Technology (ICMU 2010)
Photonic I/O Devices for 100GbE and 40GbE
- Highly Integrated 25Gbps - 4ch Optical Transceiver -

- One chip LDD/TIA integrated with 4ch x 25Gbps Serdes
- Low power consumption: 25mW/Gbps (estimated)
- 4ch x 25Gbps LD and PD arrays

LD: laser diode, LDD: LD driver, PD: photo diode, TIA: transimpedance amplifier

25mW/Gbps (63%)
High Density Optical Backplane with 25Gbps-4ch(100Gbps) Transceiver

Overcome the current technological barrier of 6.5Gbps&1m
⇔ Datacenter Scale 100Gbps Backplane

Large-scale edge router
Traffic analyzer
Router retrieval device
Packet I/O device

100-Gbps Internal I/O

25mW/Gbps

Next Generation Highly Efficient Network Technology (ICMU 2010)
Large Scale Dynamic Optical Path Network
- Router Throughput and Its Energy Efficiency Rating -

Next Generation Highly Efficient Network Technology (ICMU 2010)
Large Scale Dynamic Optical Path Network
- Circuit switching better suits real-time video services -

- At 82 Tbps throughput, Optical circuit switch operates almost at four orders of magnitude lower electricity than IP routers.

\[ \text{4x40G-NIC } \times 2 \text{ (240 W)} \]

\[ \text{160G-OTDM NIC (< 100 W)} \]

NIC: Network Interface Card
Large Scale Dynamic Optical Path Network (DOPN)
- Application- and/or User-Driven Switching in Optical Layer -

- Total Capacity: 1,000-10,000 Times Larger
- Energy Consumption: Decrease by 3 digits
- Main Services: High-Def Video Based
- User Connectivity: 10-100Gbps

Ref. VICTORIES Project at AIST supported by MEXT
Large Scale Dynamic Optical Path Network (DOPN) - Integrated 160G OTDM-IC Module -

- Compact 43G Transceiver
- 43G LD/PD
- SOA Array
- Ultrafast All-Optical Gate Array
- 43GHz Optical Clock
- Silicon Photonics /PLC based Platform for Hybrid Integration
- MUX/DEMUX
- 172Gbps OTDM signals

100W

Next Generation Highly Efficient Network Technology (ICMU 2010)
Picosecond cross-phase modulation in integratable ISBT (intersubband transition)

InGaAs/AlAs/AlAsSb coupled double quantum well

Phase modulation spectrum

1ps pulse with 10GHz repetition

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Conclusions

Power (kW) Assuming 9.6Tbps router

- Decreased to 80%
- Decreased to 70%

For further reduction, architectural Innovations are necessary

Existing Technology

Basic Plan (Device Level)

Future Architecture Level

Next Generation Highly Efficient Network Technology (ICMU 2010)