# Photonic Network Research Institute

Architecture, Systems and ICT hardware

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National Institute of
Information and Communications Technology

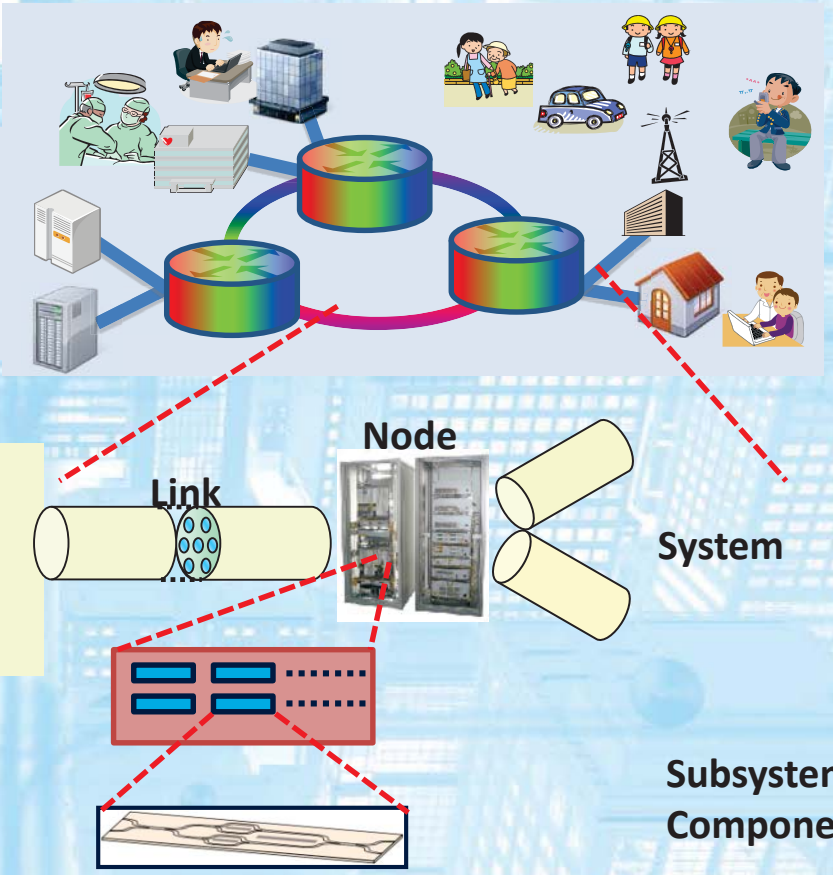
# Photonic Network Research Institute

We promote R&D to realize sustainable future networks that can accommodate explosively growing information traffic, while also reduce excessive power consumption and maintain availability.

**Network Architecture Lab.**
**Dr. Hiroaki Harai**
NWGN to support the society of 2020
Demonstration of NWGN technologies

**Photonic Network System Lab.**
**Dr. Naoya Wada**
Creating hardware system beyond conventional technical limitations

**Lightwave Devices lab.**
**Dr. Tetsuya Kawanishi**
Leading edge network ICT hardware
Convergence of Optical & Wireless



# PNRI Global Alliance & Research Outcomes

## 1. Internship Students (MOU)

- 48 (incl. 9 from oversea, Univ. of Aveiro, Telecom Bretagne, Chiang Mai Univ., )

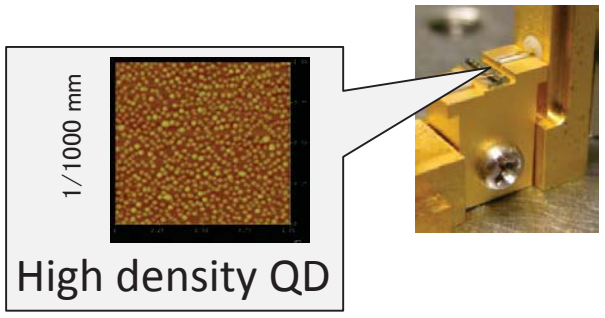
## 2. International Collaboration (CRA)

- NW Architecture : Univ. Bristol, Univ. Murcia, Univ. Massachusetts, NCSU, Seoul Univ., etc.
- Photonic NW sys. : Rome Tre Univ., Heriot-Watt Univ., BME, Avairo Univ., Tsinghua Univ., KAIST., etc.
- Lightwave Devices: Duisburg Essen Univ., Alcatel Lucent Bell Lab., UCSD, UC Davis, Chulalongkorn Univ., Chiang Mai Univ., PTIT, etc.

## 3. Research Outcomes

- Technical Transfer Product (recent example)

Integrated high speed lightwave modulator




High density QD

Low distortion optical amplifier for burst-mode optical signal

# Collaborations with ASEAN countries

**Thailand**

| | |
|---|---|
| Chulalongkorn Univ.（CU） | Evaluation of integrated photonic circuits |
| Chiang-Mai Univ.（CMU） | Techniques for ICT measurements |
| Suranaree Univ. Technol.（SUT） | Photonic signal processing |
| Airport of Thailand(AOT） | Application of imaging tech. to airport |

**Vietnam**

| | |
|---|---|
| Post&Telecom Institute of Technol. | Application of RoF to transport |
| Hanoi Univ. Science and Technol. | Application of RoF to transport |

**Malaysia**

| | |
|---|---|
| Telekom Malaysia R&D | RoF for access network |
| Universiti Teknologi Malaysia | Stable RoF signal generation |

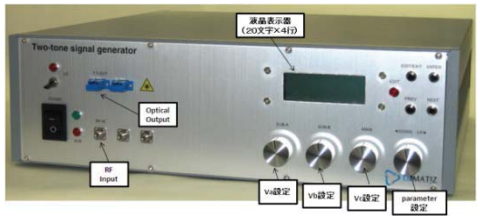
**Singapore**

| | |
|---|---|
| Institute of Infocomm Research（I2R） | Optical switch for datacenter interconnect |

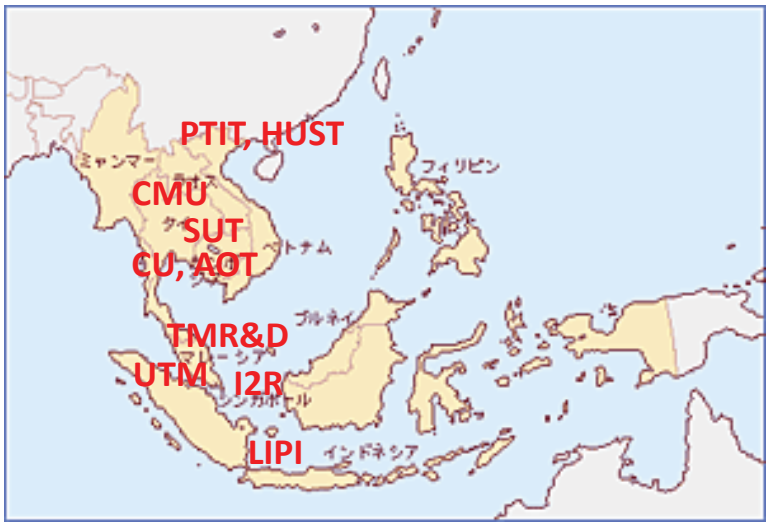
**Indonesia**

Institute Technology of Science (LIPI) Sensing by RoF

**Frequency response meas. system**




ASEAN countries has many big industries of photonics components.




**Standardization activities in APT**
**(APT: Asia Pacific Telecommunity)**

**ASTAP (APT Standardization Program)** CMU TMR&D
Millimeter-wave RoF, ICT measurments

**AWG (APT Wireless Group)**
Fixed wireless system

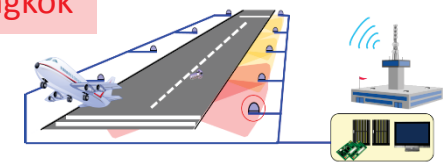
# CRO Workshop

## (Workshop on Convergence of radio and optical technologies)

The workshop focuses on hardware-oriented technology in every a half year.

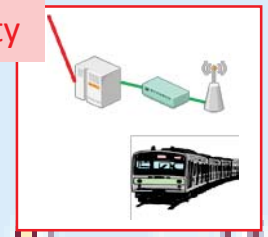
1st CRO Workshop
Aug. 22 2014, Bangkok

**Imaging technology for surveillance of airport runways**



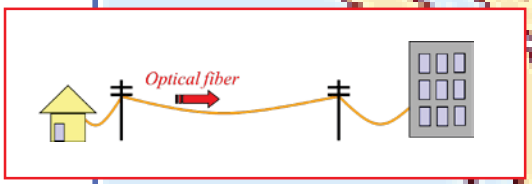

[Left]Chulalongkorn Univ. (former NBTC president)
Prof. Prasit Prapinmonkolkarn
[Right] Airport of Thailand
Leader, Somchanok Tiamtiabrat

**Broadband services for mass transportation**



3rd CRO Workshop
Sept. 15 2015, Ho Chi Minh City

2nd CRO Workshop
Jan. 15 2015, Kuala Lumpur

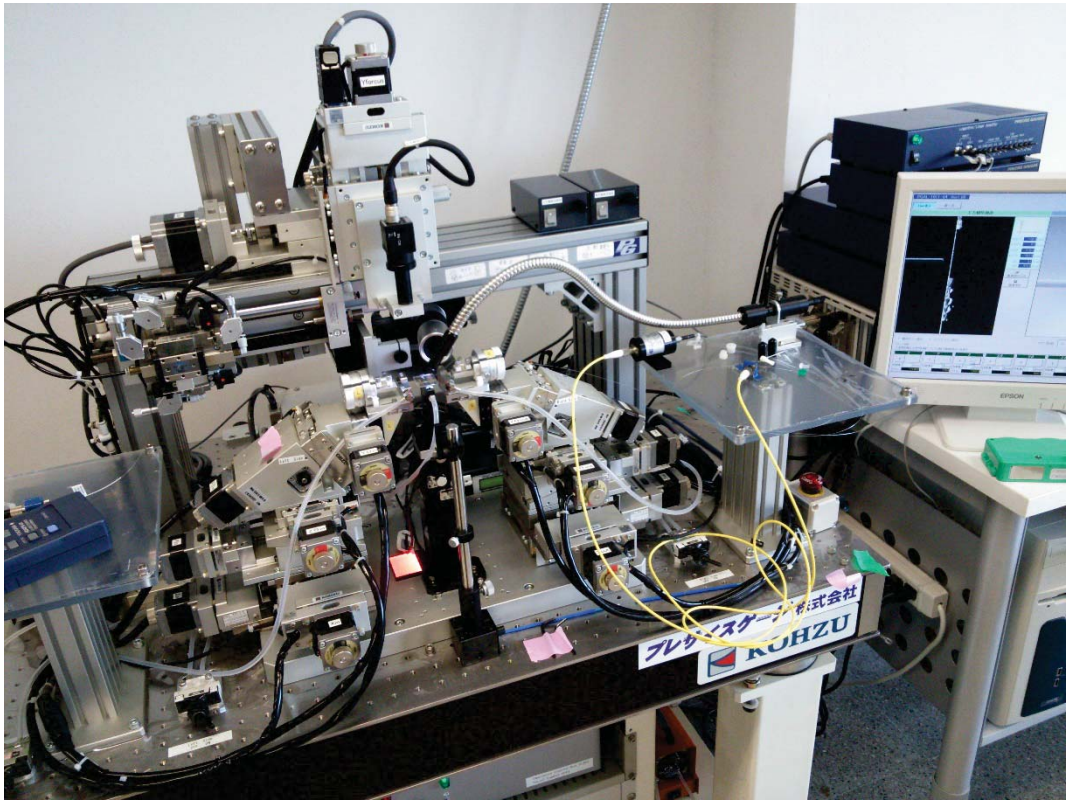



**Radio over fiber tech. for access network**

4th CRO Workshop
Jan. 2016 Jakarta

# NICT-Chulalongkorn Joint Photonic Laboratory

7th Floor of 100 years anniversary Building of EE
Chulalongkorn University

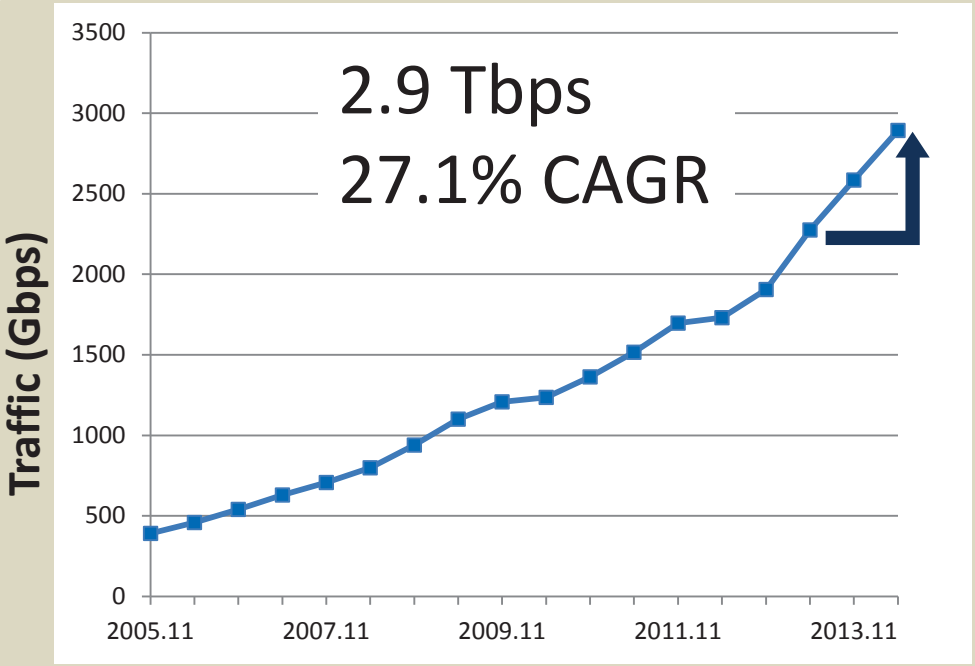



Optical fiber coupling automatic alighner
For various sample device

# Growth of Traffic and Power of ICT equipment

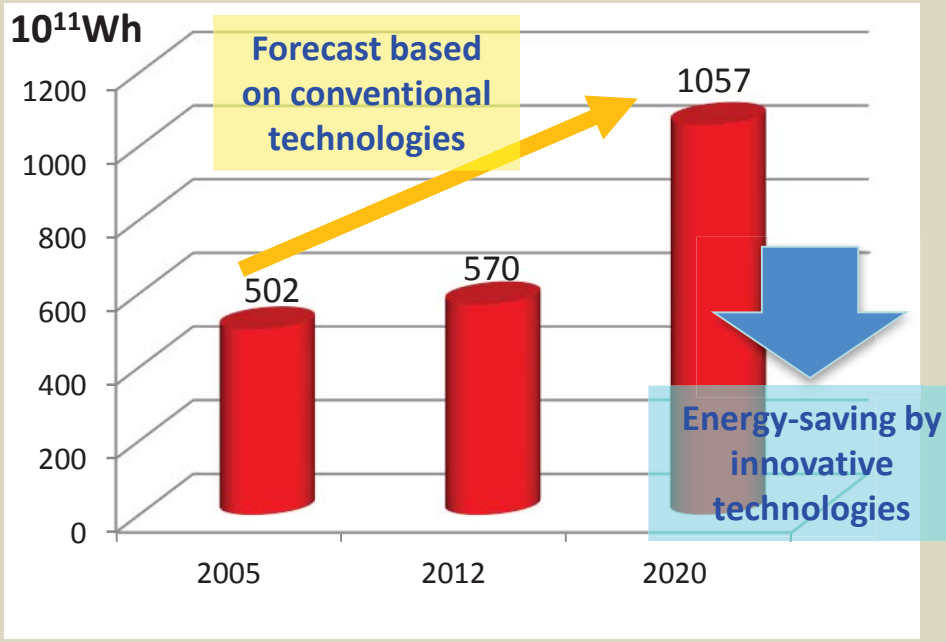
- In Japan, 2.9 T bit/s in downstream traffic (May 2014). Tera: $10^{12}$ , Peta : $10^{15}$
- Explosive growth of LTE subscriber number 20 Mill. by few yrs. (cf. FTTH 24 Mill. by 10 yrs)
- Power consumption is predicted to increase about 2 times if conventional technologies go on.

## Downstream Internet Traffic in Japan




Surveys by Ministry of Internal Affairs and Communications, Japan
Oct., 2014

## Power of ICT equipment in Japan



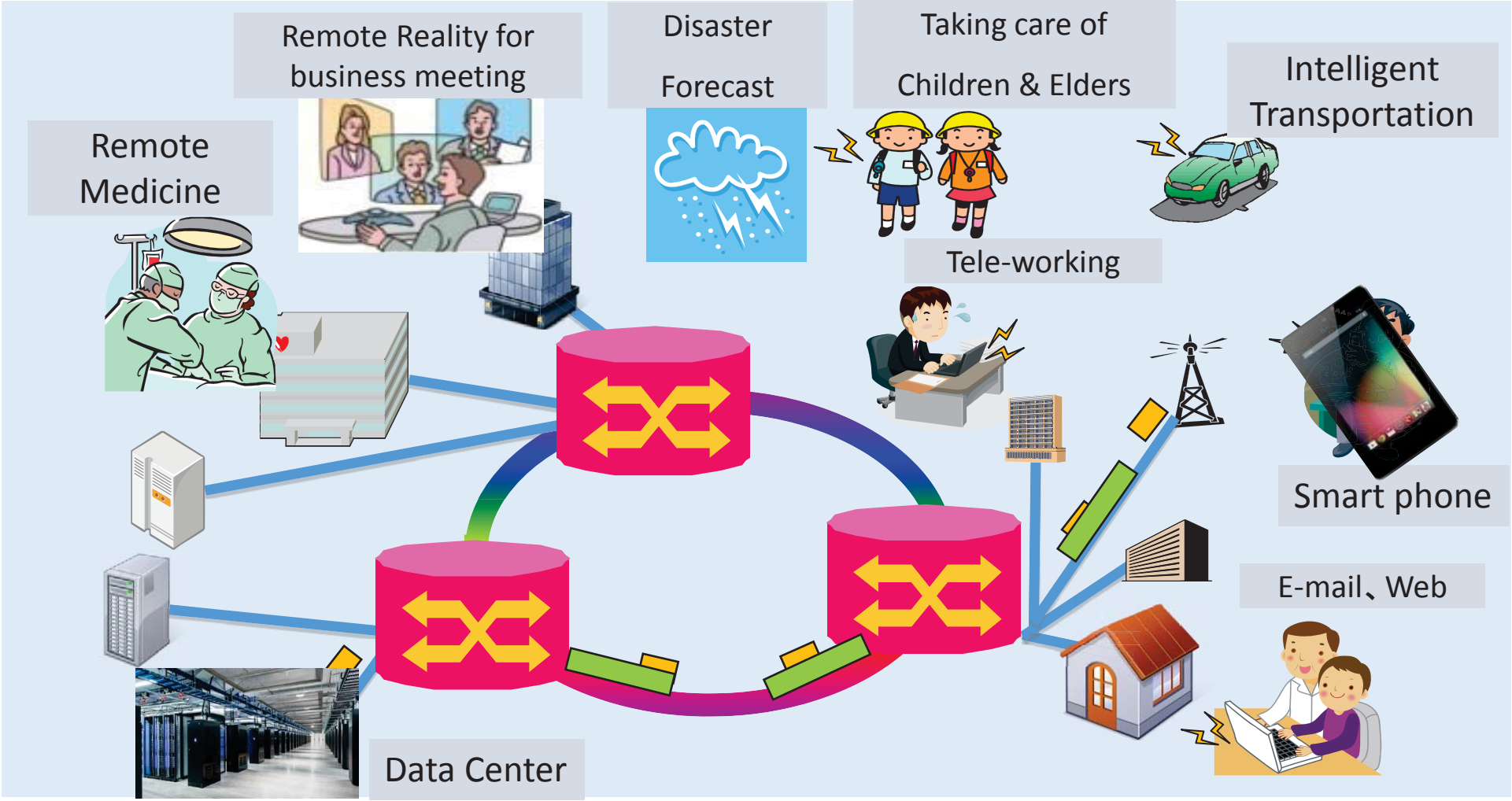

http://www.soumu.go.jp/main_content/000065258.pdf
Surveys by Ministry of Internal Affairs and Communications, Japan

R&D of high capacity & energy efficient network technology is indispensable.

T(Tera) : 1,000,000,000,000 = $10^{12}$ (Trillion)

# Expanding Variety of Network Services

**Optical Network supports various services behind the scenes.**



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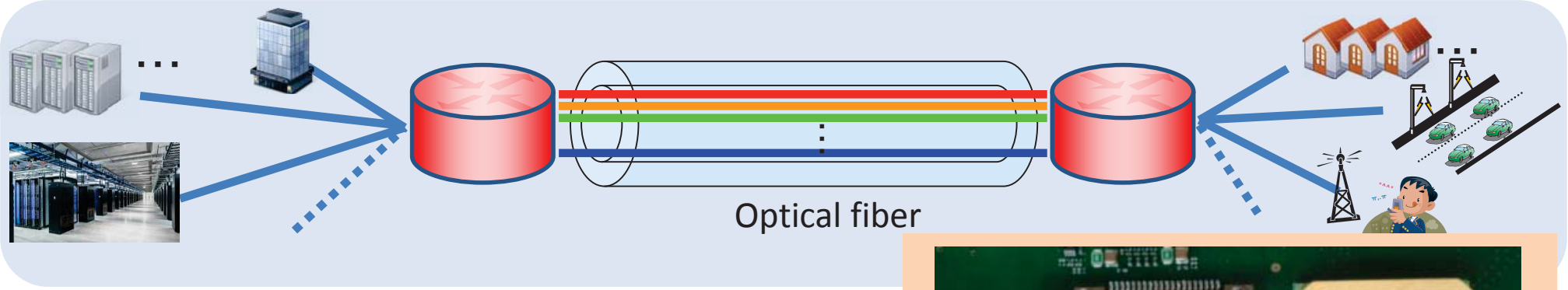
# Optical Fiber Transmission Technology

**1. Current technology :** Wavelength Division Multiplexing (WDM) Transmission

Transmission of multiplexed various channel information on multiple wavelengths over a fiber





**100G digital coherent signal processing chip**

**2. Commercially deployed WDM system in Tokyo-Os**

| Year | 2003 | 2007 | |
|---|---|---|---|
| **Total Capacity** | 800 Giga bit/s | 1.6 Tera b | |
| WDM | IMDD<br>10G ⋮ 80 waves | DQPSK<br>40G ⋮ 40 waves | Dual Pol. QPSK<br>100G ⋮ 80 waves |

NICT Funding R&D
⇒ MIC Funding R&D ⇒ Commercialized

**Giga(G) : $10^9$(Billion), Tera : $10^{12}$ (Trillion)**

**MIC : Ministry of Internal Affairs and Communications**

# Dr. Tetsuya Kawanishi won IEEE Photonics Society Fellow Awards of 2013

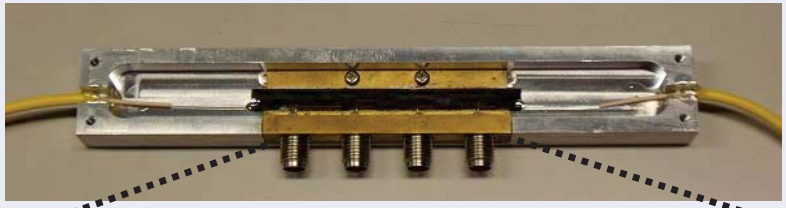

**Exceptionally young recipient in Japanese, only 6-years IEEE member activity**

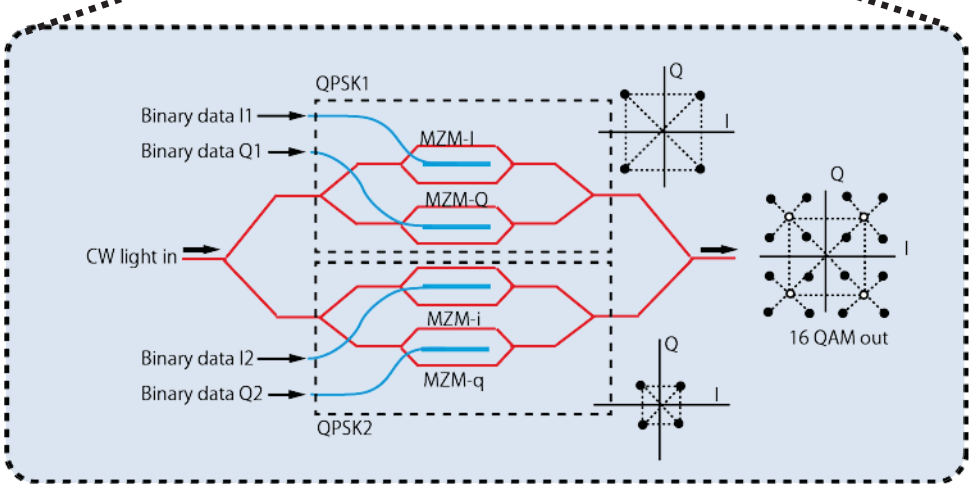
**Achievement : high-speed and precise lightwave modulation technologies**

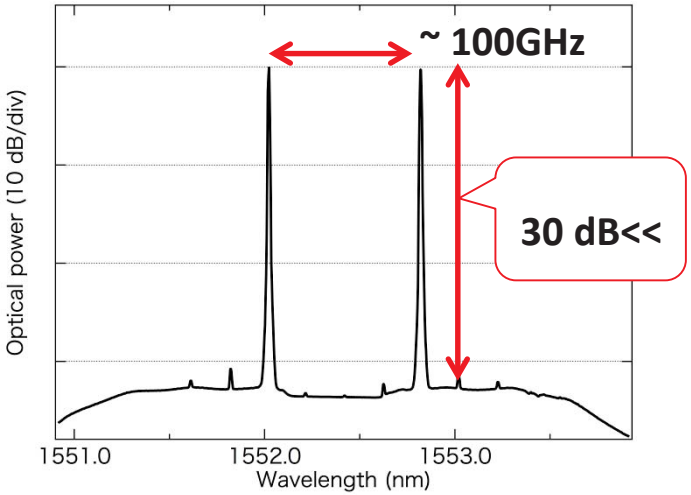
He is involved in precise control of lightwave phase, frequency and amplitude technique for fiber optical communication.

2007 : High-capacity transmission record demonstrated, collaboration with Bell Labs
2010 : This technology has been widely used in commercial optical backbone fiber networks. It was also applied to radio wave astronomy, to generate standard signal (103.97 GHz) in the Atacama Large Millimeter/submillimeter Array (ALMA) Project.

Integrated device for precise modulation





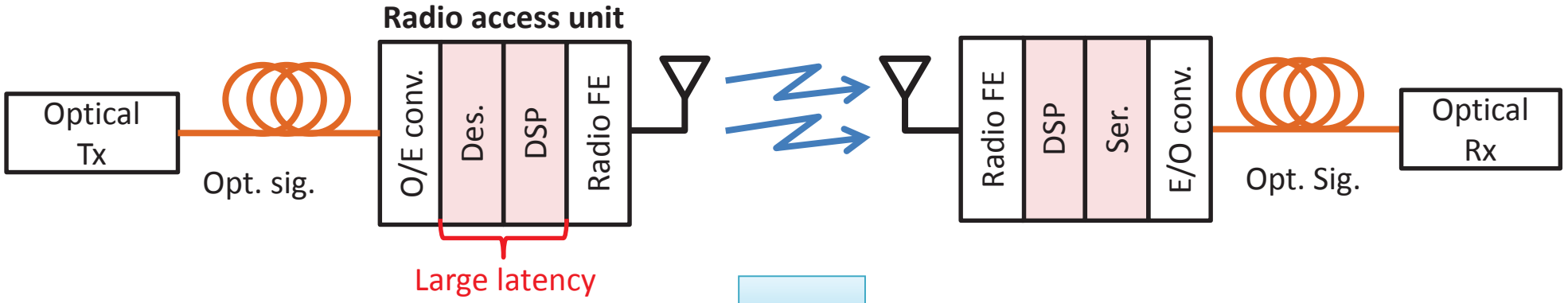




Stable, clean, standard signal of 103.97 GHz by precise Lightwave modulation

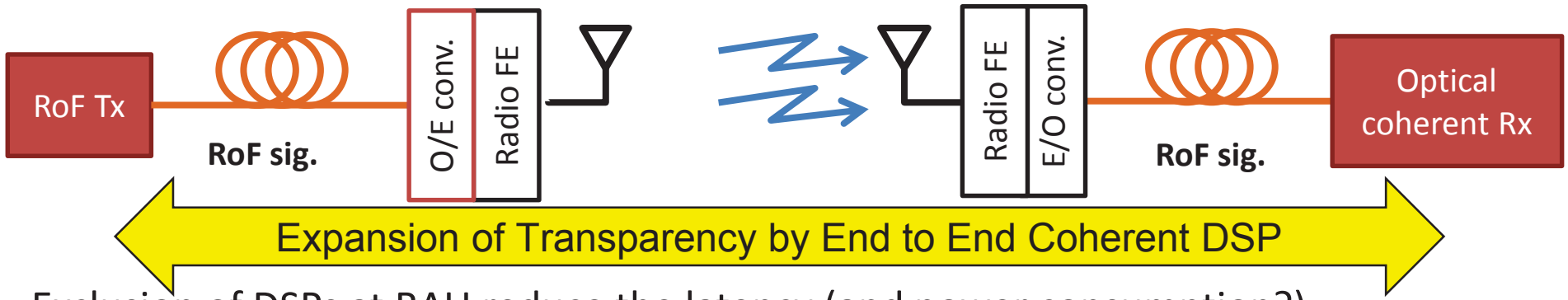
**Atacama Large Millimeter Array (ALMA) Project**

# Coherent Optical & Radio Seamless Transmission on DSP-aided Radio-over-Fiber (RoF) Technology

Conventional Optical-Radio-Optical system




RoF-based O-R-O system **74.4Gb/s mm-wave radio MIMO transmission was demonstrated.**

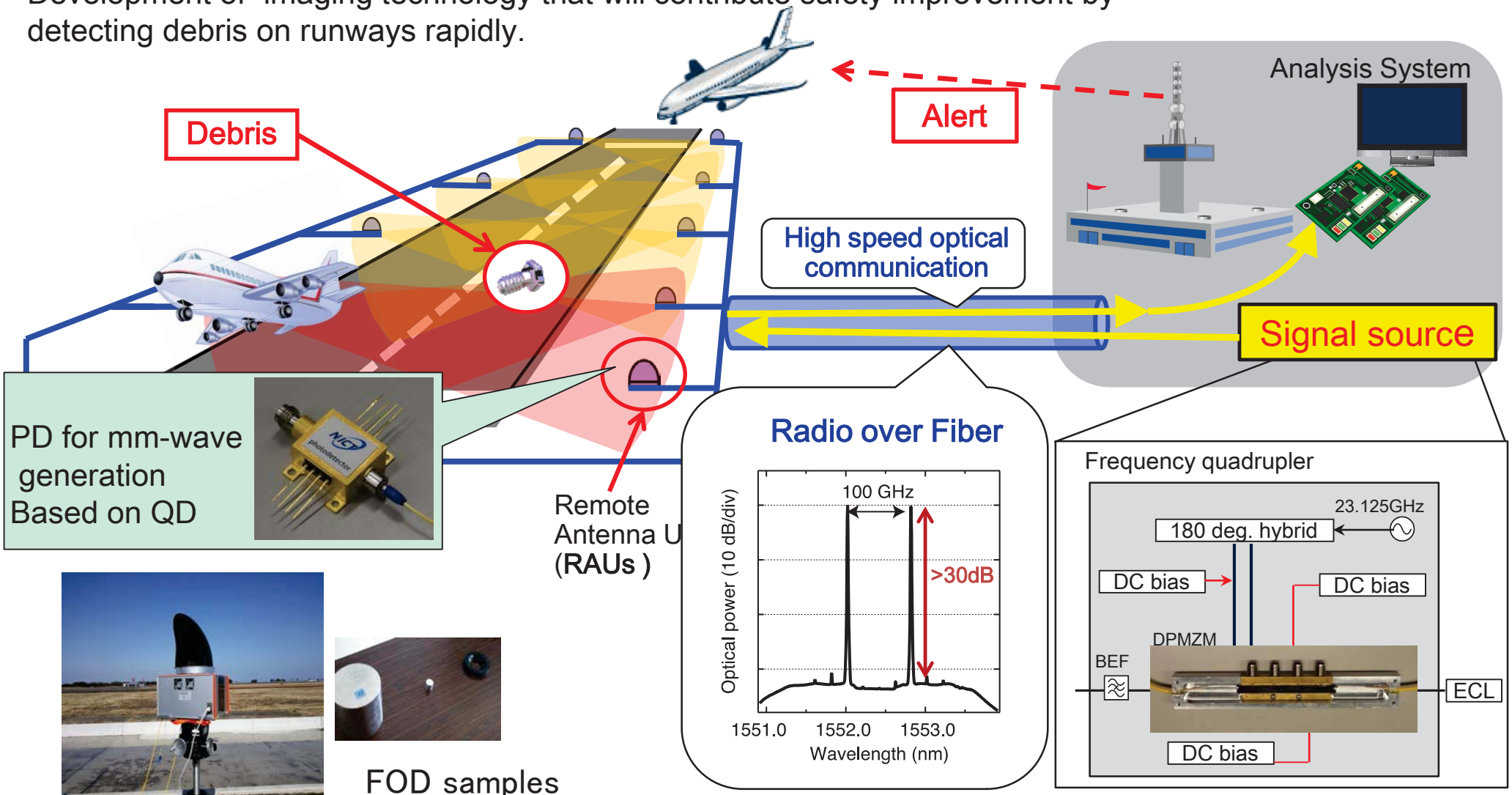



- Exclusion of DSPs at RAU reduce the latency (and power consumption?)
- Transmission impairments can be compensated by End to End Coherent DSP Tx/Rx.


**A. Kanno et al., OTu3D, OFC 2013.**
**A. Kanno et al., Opt. Express, 20, 29395 (2012).**

# High-precision imaging technology using 90GHz band linear cells

Development of imaging technology that will contribute safety improvement by detecting debris on runways rapidly.






mm-wave RAU



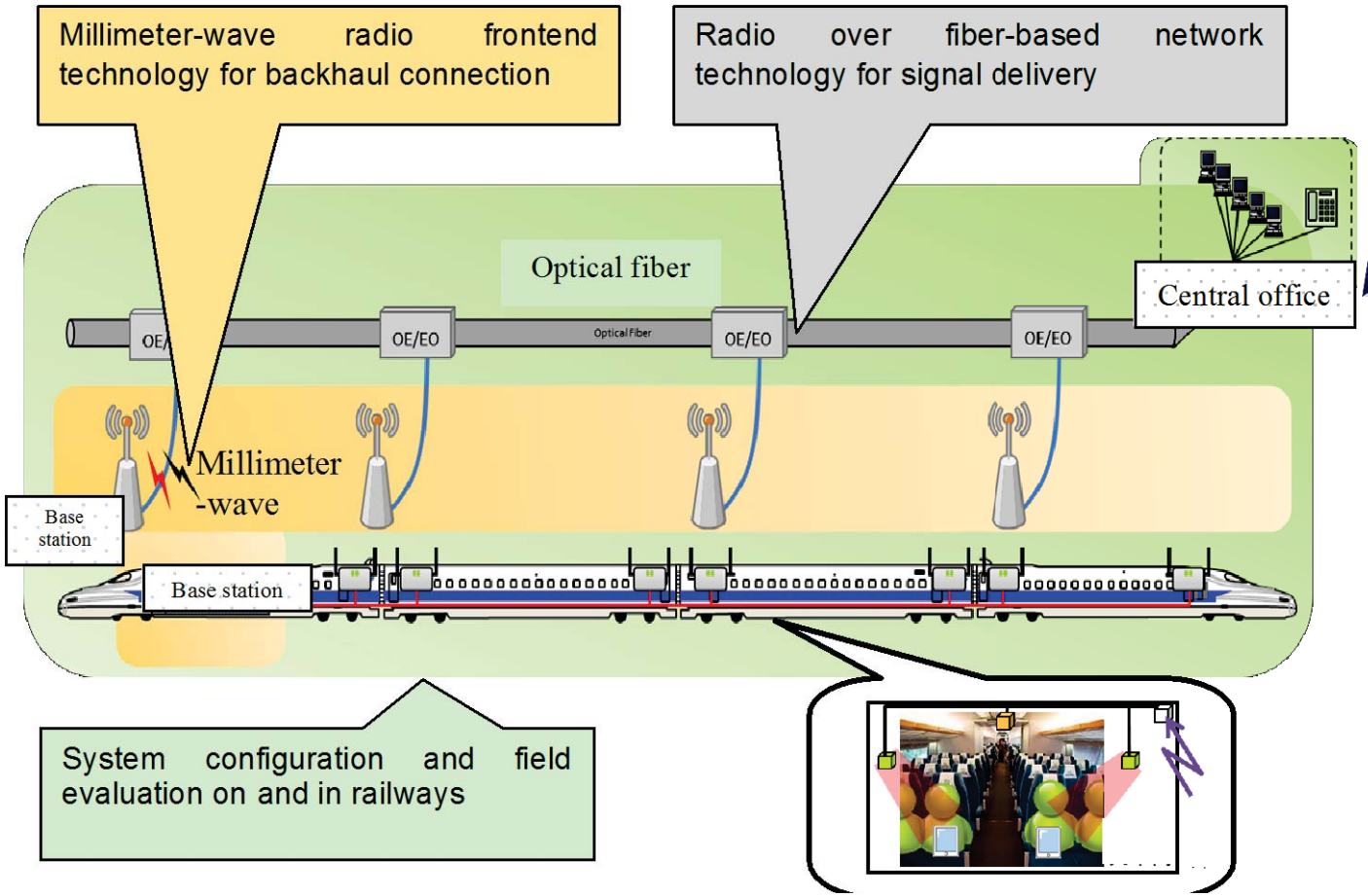
FOD samples

Demonstration in Sendai Airport on Feb. 21, 2015

HITACHI Inspire the Next

# R&D of millimeter-wave backhaul technology for high-speed vehicles（FY2014—FY2019）

“Research and Development to Expand Radio Frequency Resources” program funded by Ministry of Internal Affairs and Communications, Japan.




HITACHI Inspire the Next

JR ENRI

KDDI NICT

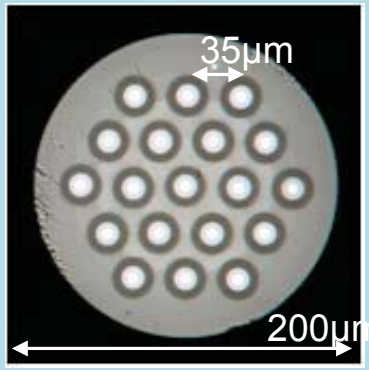
Target: hand-over-free 1 Gbit/s link to the bullet train with a speed >200 km/h by 90-GHz millimeter-wave radio.

NICT

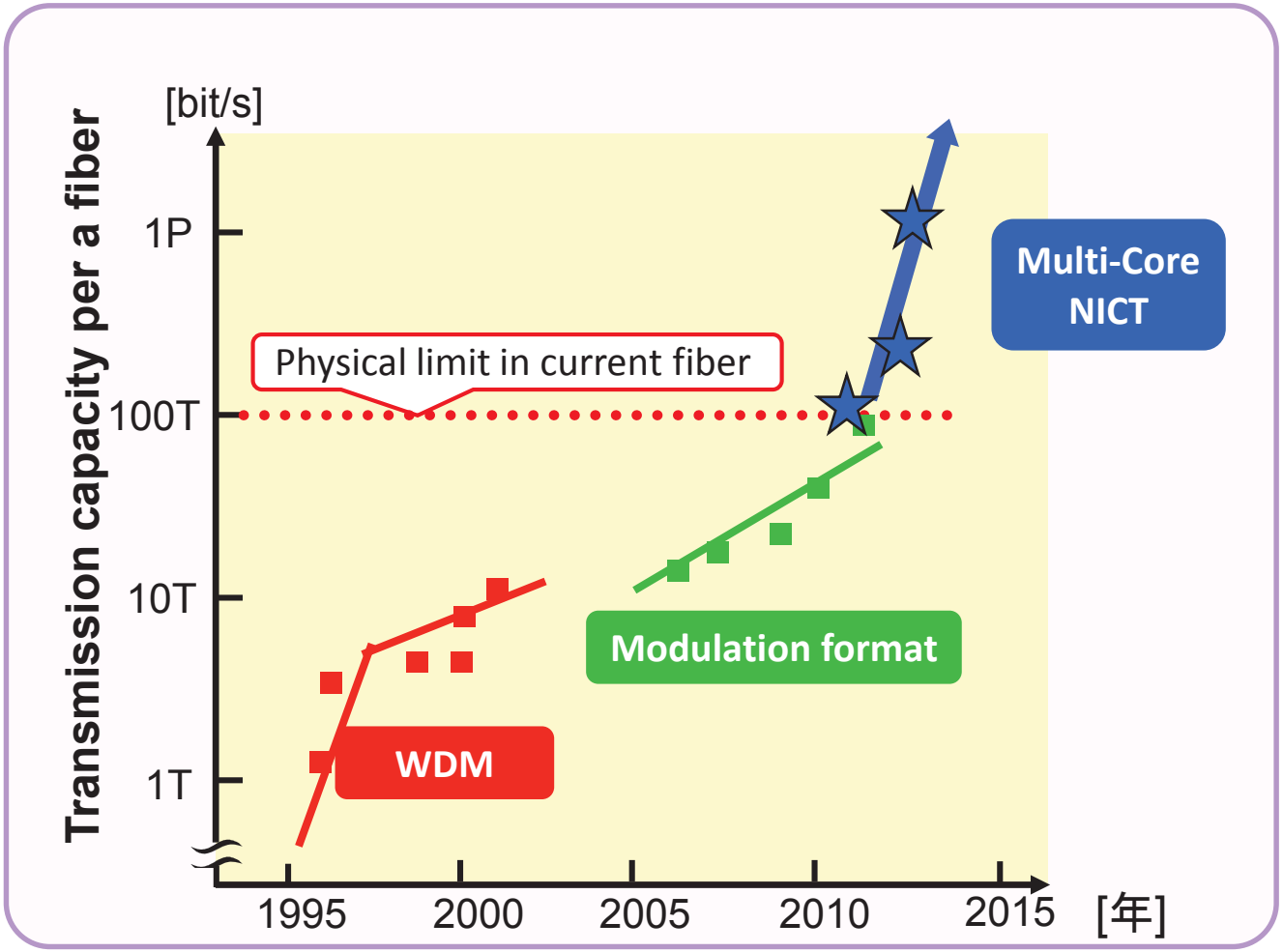
# NICT Japan team leads capacity per a fiber competition by multi-core optical fiber (SDM) transmission technology.

1000 trillion (1 Peta) bit per second per fiber in 2012

19-core fiber




Dr. Yoshinari Awaji

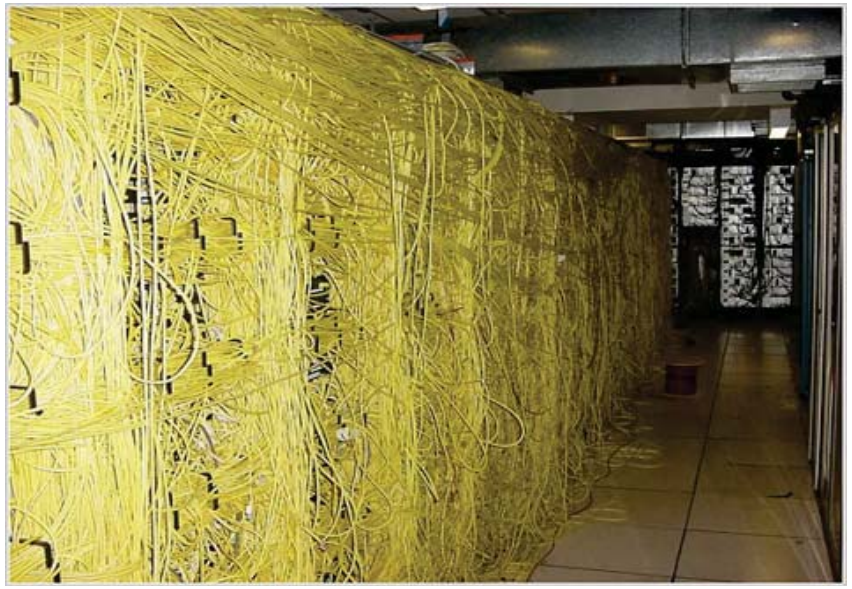



P(Peta) : Quadrillion=1000 T (Trillion)

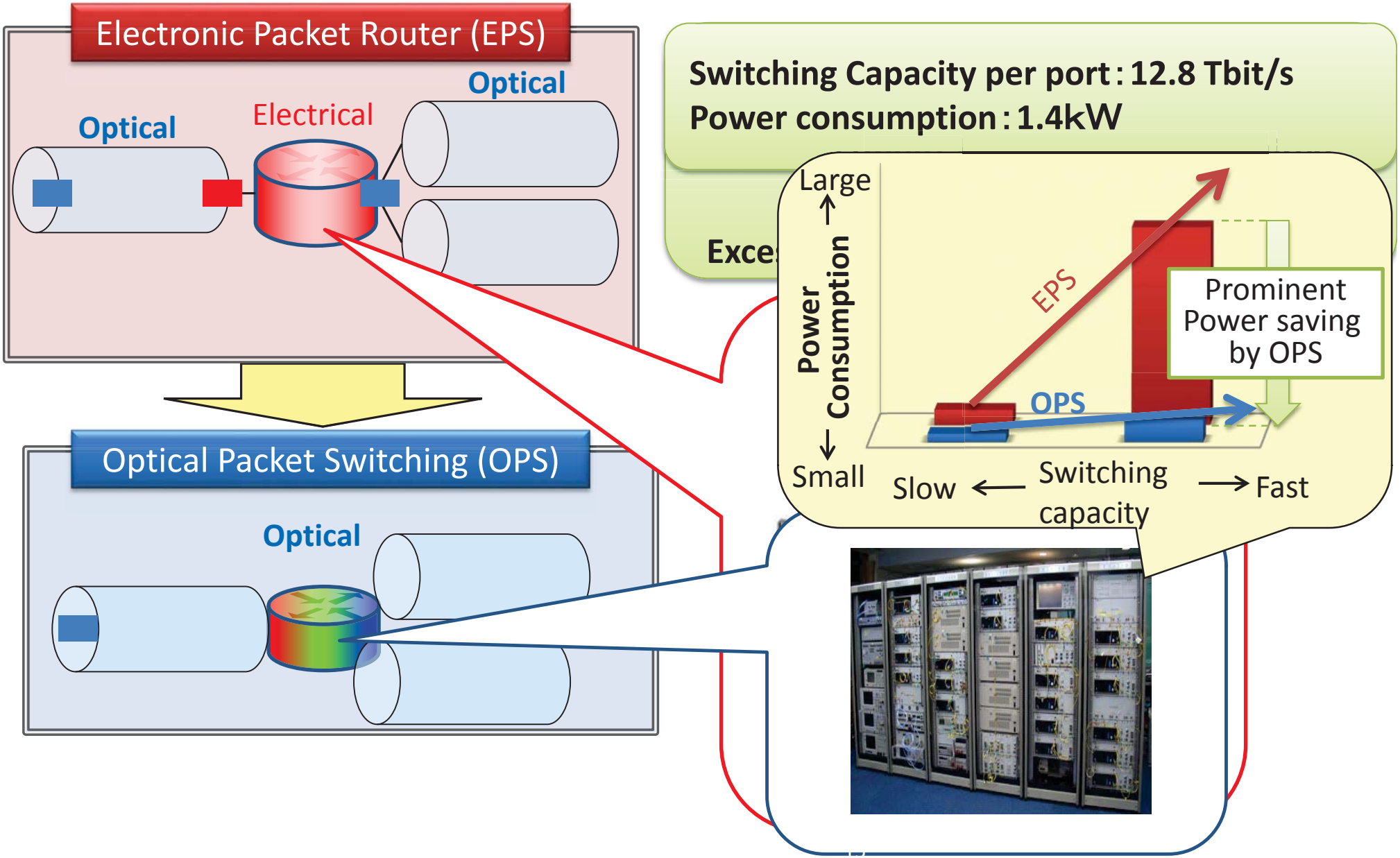
# Data Center -Power Consumption Problem-


**MIC project : "Multi-Core Fiber Inter Connection in Data Center (2012-14)"**

- **Simplified backplane connection**
- **Much easier daily management and faster disaster/ failure recovery**
- **Improved cooling efficiency**



# Towards all optical packet switching



# Integration of developed technologies by partner ship with Industory & Universities

**Ultrafast optical switch (~ns)**


**Burst-mode TX/RX**

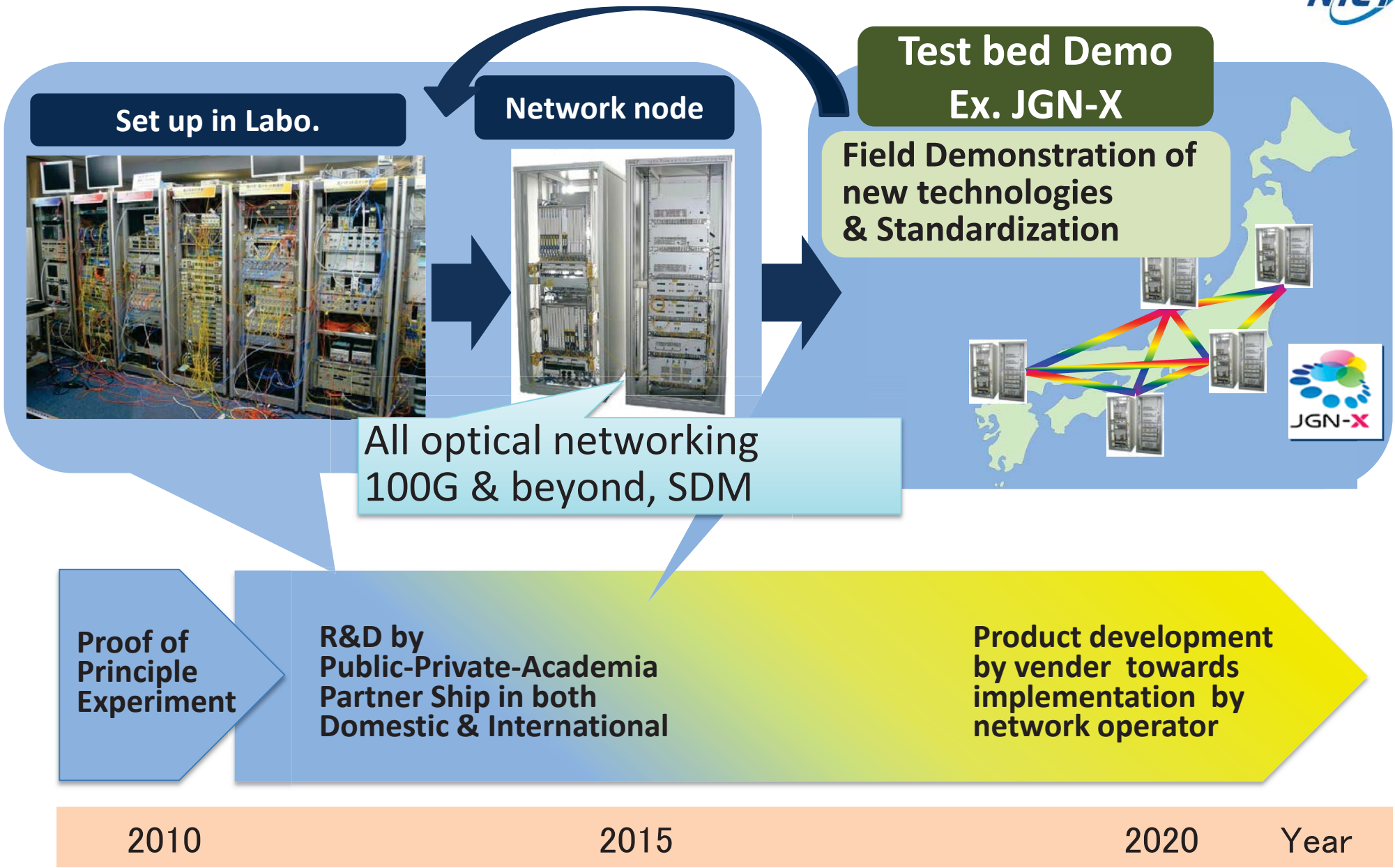
**Optical Packet & Path Network node**

**Burst-mode optical amplifier**

Before optical amplification



**Conventional : Serious distortio**


**Global alliance** is indispensable to promote commercial use of research outcomes (ex. standardization).