Faculty of **ENGINEERING** | Chulalongkorn University
Pillar of the Kingdom

Research on Optical Access Network

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And

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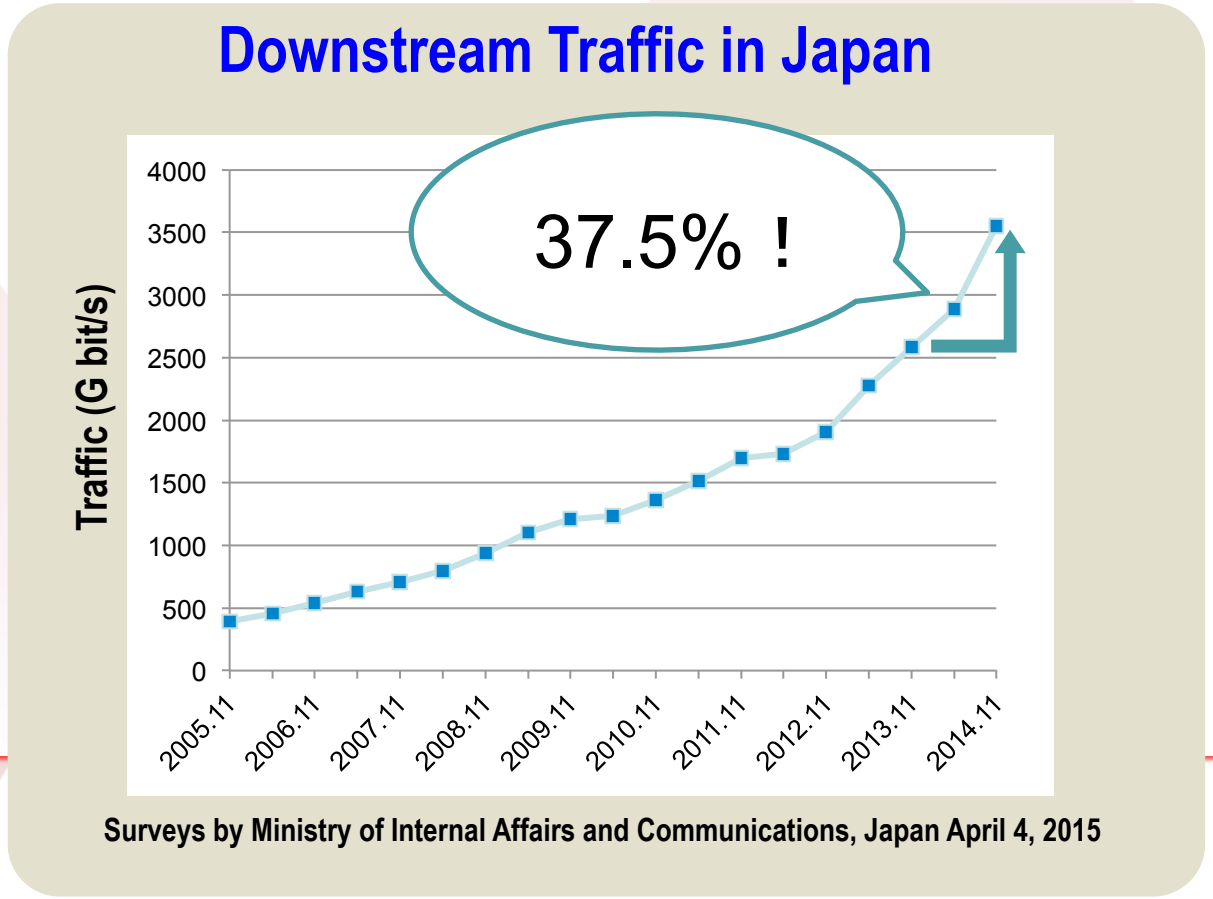
(NICT)

Outline

- Introduction
  - Background and Motivations
  - Research Target
- Current Collaboration Research between Chulalongkorn University and NICT
  - 10 Gb/s Optical Access Network with Long Reach and A Large Number of Subscribers
- Conclusion

Growth of Traffic

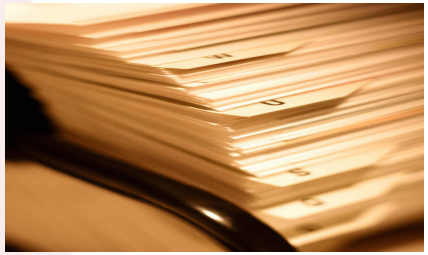
- 3.6 T bit/s in downstream broadband traffic of Japan (Nov 2014).
- 37.5% annual growth rate. 1 P bit/s will be realistic ~2030s.

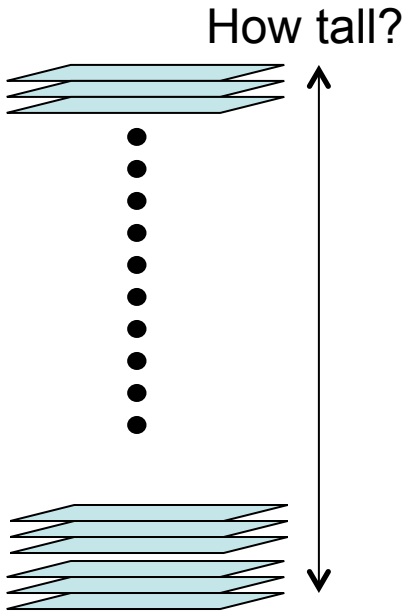


How big is 3.6 T bit/s data?

- 1 character = 8bits, 4000 characters/page
- Question: 3.6 Tera bits is corresponding to …

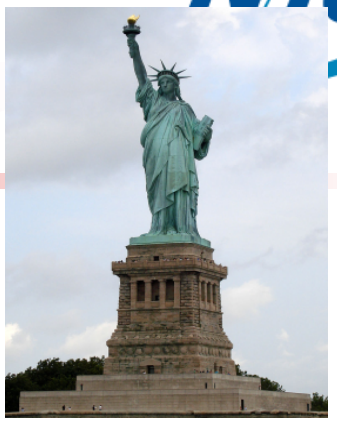
1. 93 m
2. 381 m
3. 3,774 m
4. 6,190 m
5. 9,900 m

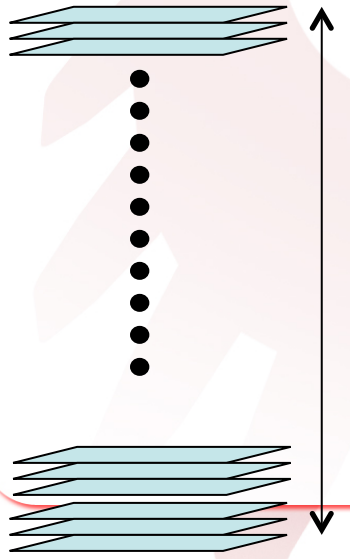




1 char = 8bit, 4,000 chars/page

1. 93 m Statue of Liberty
2. 381 m Empire State Building
3. 3,774 m Mt. Fuji
4. 6,190 m Mt. Denali (Mt. McKinley)
5. 9,900 m 111 million A4 sheets (3.6 Tbits)





9,900 m (111 M pages)

Role of optical access network technology

Almost all data is downloaded via

> Intra and Inter data center network

> Optical access network (PON: passive optical network)

> Wireless access network (Wi-Fi)

> Mobile network (4G, 5G, Beyond 5G)

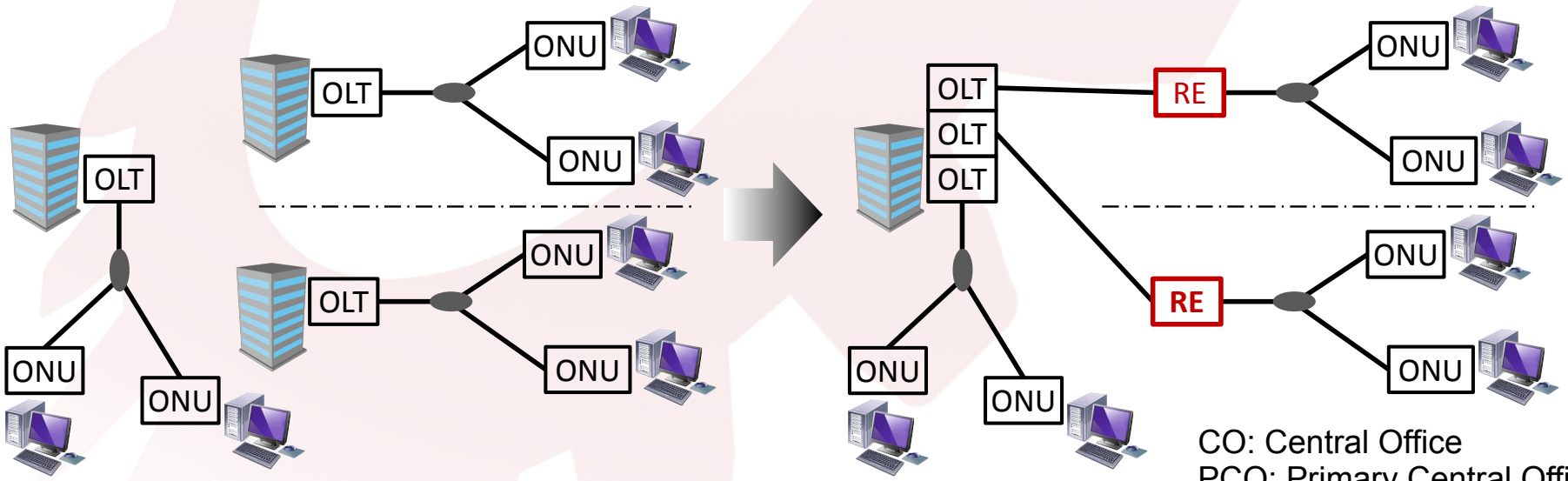
Wi-Fi terminals and Routers are connected by optical fiber

Antennas of mobile network are connected by optical fiber

Optical access network technologies are not only for DC and PON networks, are also useful for Wireless accesses and Mobile networks.

Long-reach PON

Long-reach PONs with reach extenders (REs) are promising for Central Office (CO) consolidation in order to reduce the CAPEX and OPEX.

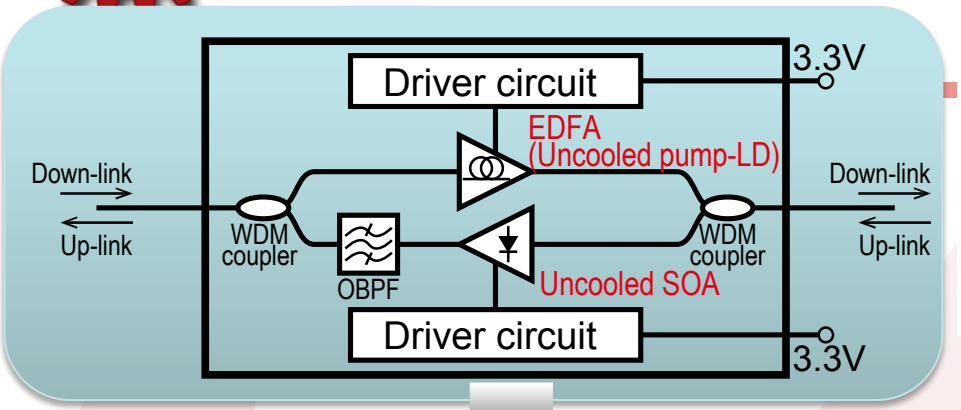


CO: Central Office
PCO: Primary Central Office
RE: Reach Extender
OLT: Optical Line Terminal
ONU: Optical Network Unit

Key technology

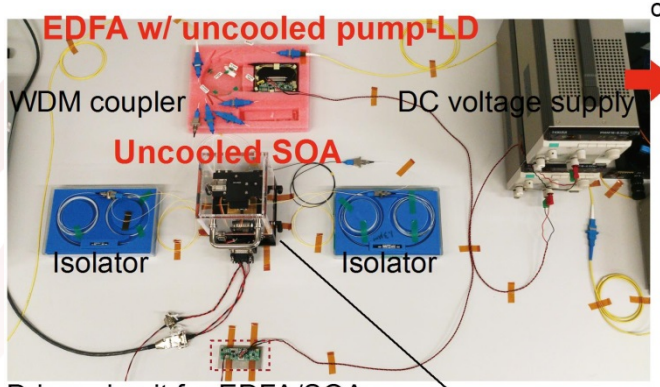
Bidirectional 1-R repeater with low-power consumption and low-cost

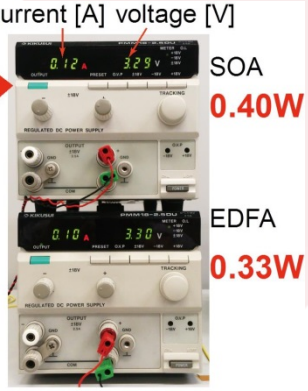
Configuration of 1-R repeater



- Down-link(DL): Erbium-doped fiber amplifier (EDFA)
- Up-link(UL): Semiconductor optical amplifier (SOA)
- The down- and up-link are separated and combined by WDM-couplers.
- Both the EDFA (pump-LD) and SOA operate without any temperature controllers.
  => low power consumption
- Same design driver circuits are used for pump-LD and SOA.

Experimental setup

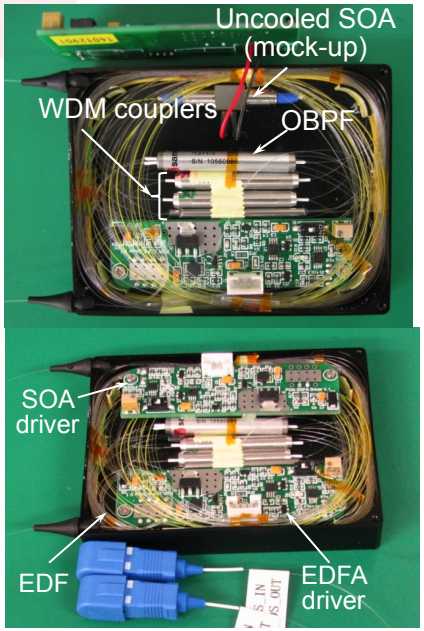




Driver circuit for EDFA/SOA

Power consumption
0.73W

Packaged module



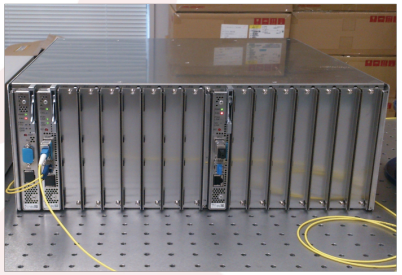
Size: W70 x D90 x H14mm

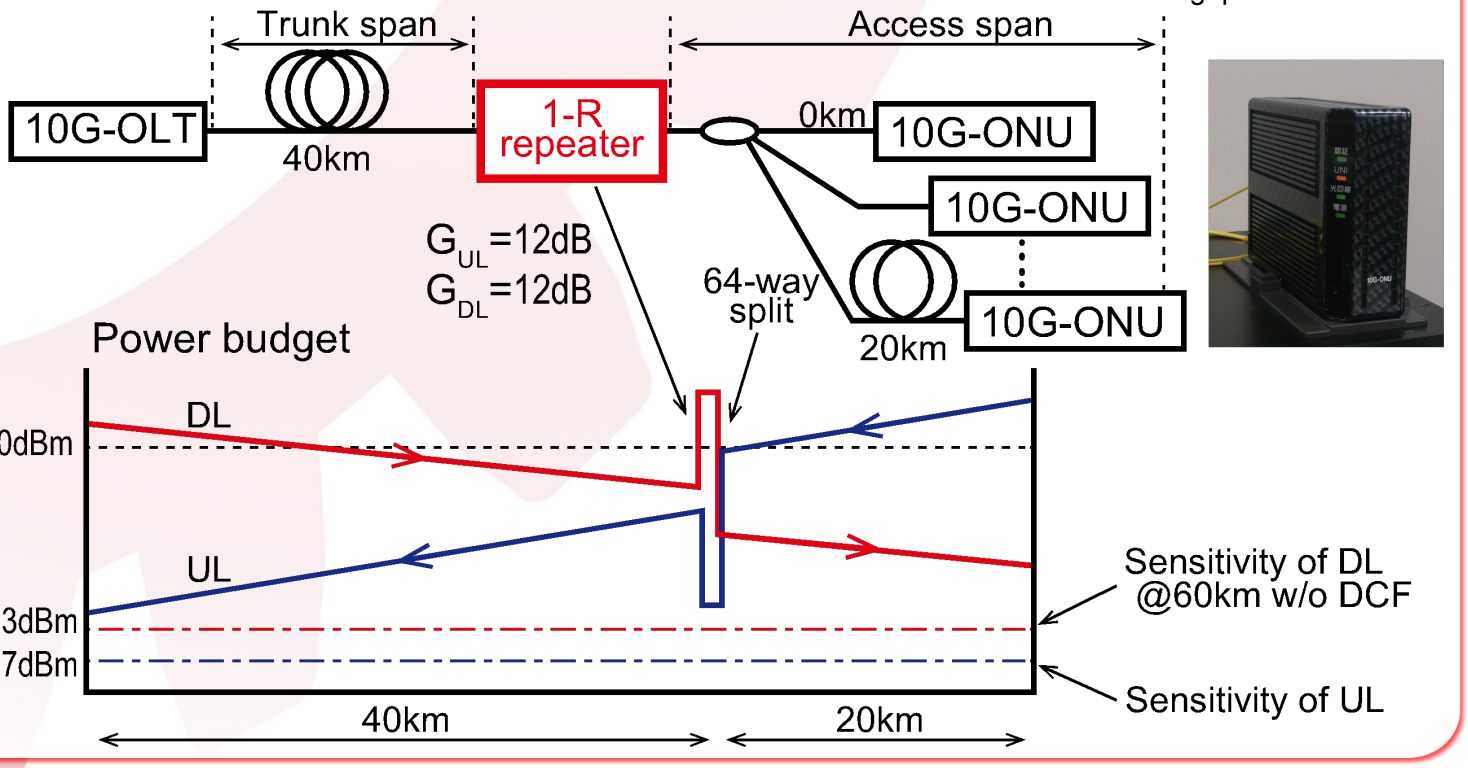
The power consumption is as low as 0.73-W in total !
The devices can be packaged in MSA-size module.

S. Shimizu et al,
P.4.5, ECOC2014.

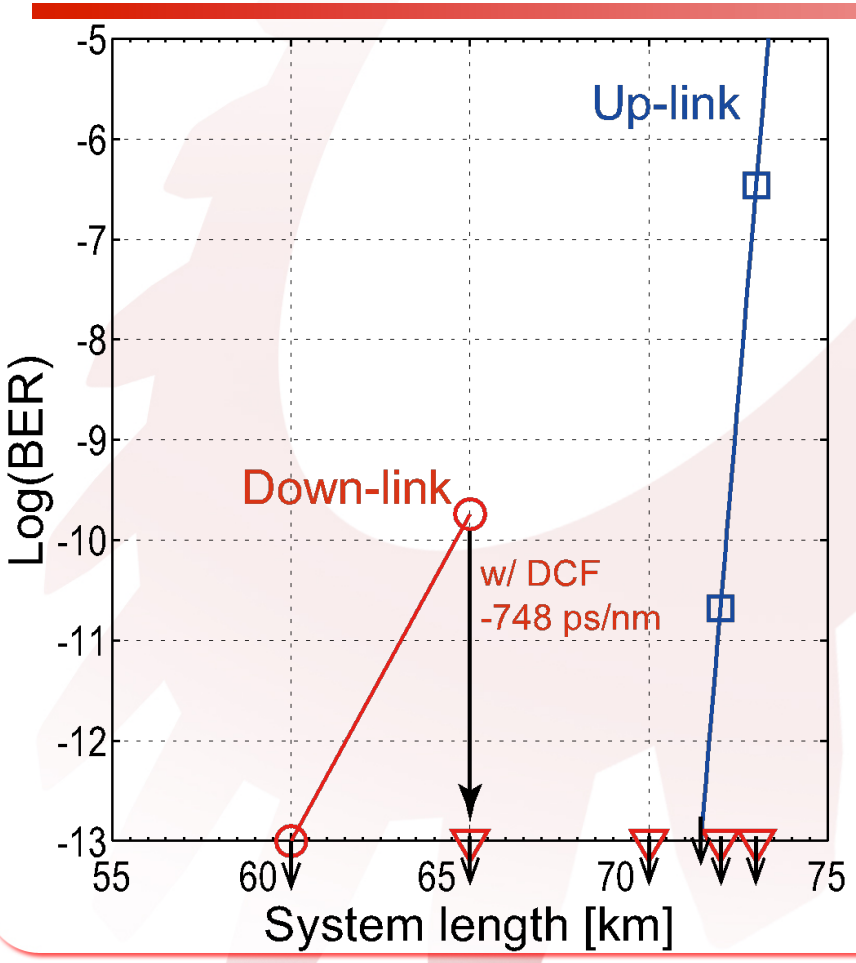
System demonstration setup

λ=1310 nm,
P_{Tx}=+6dBm,
L_{frame}=1522Byte,
L_{gap}=512Byte



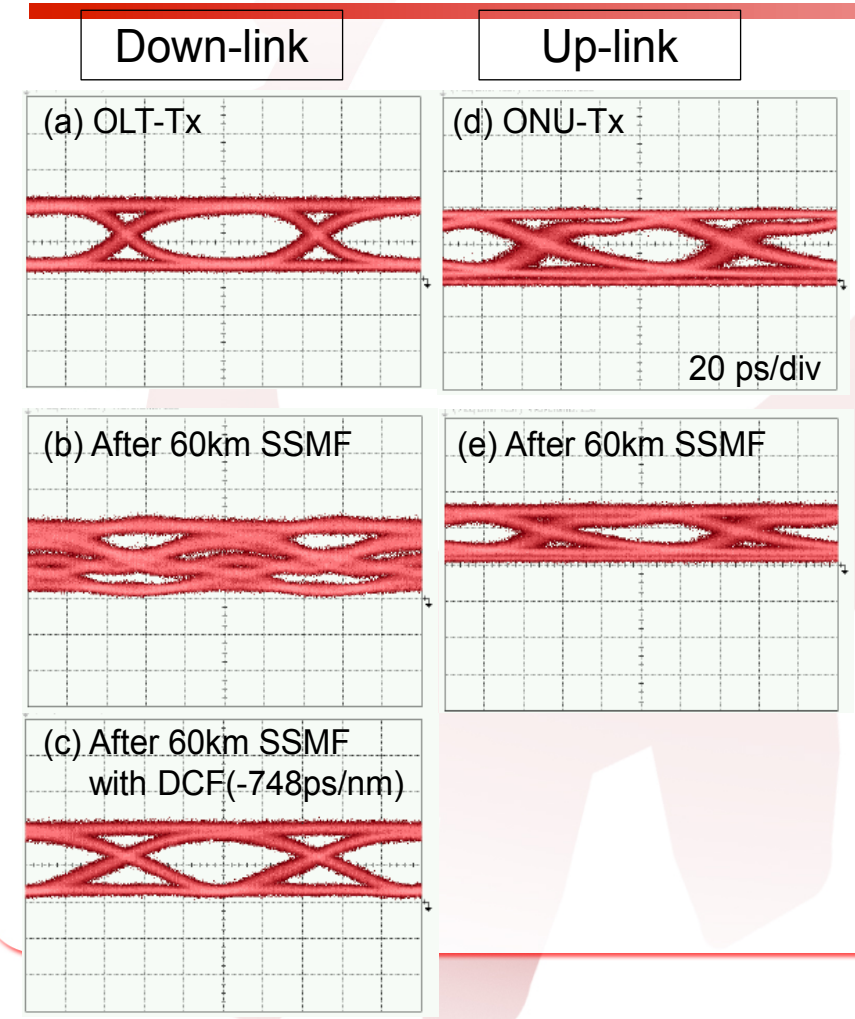


BER measurement



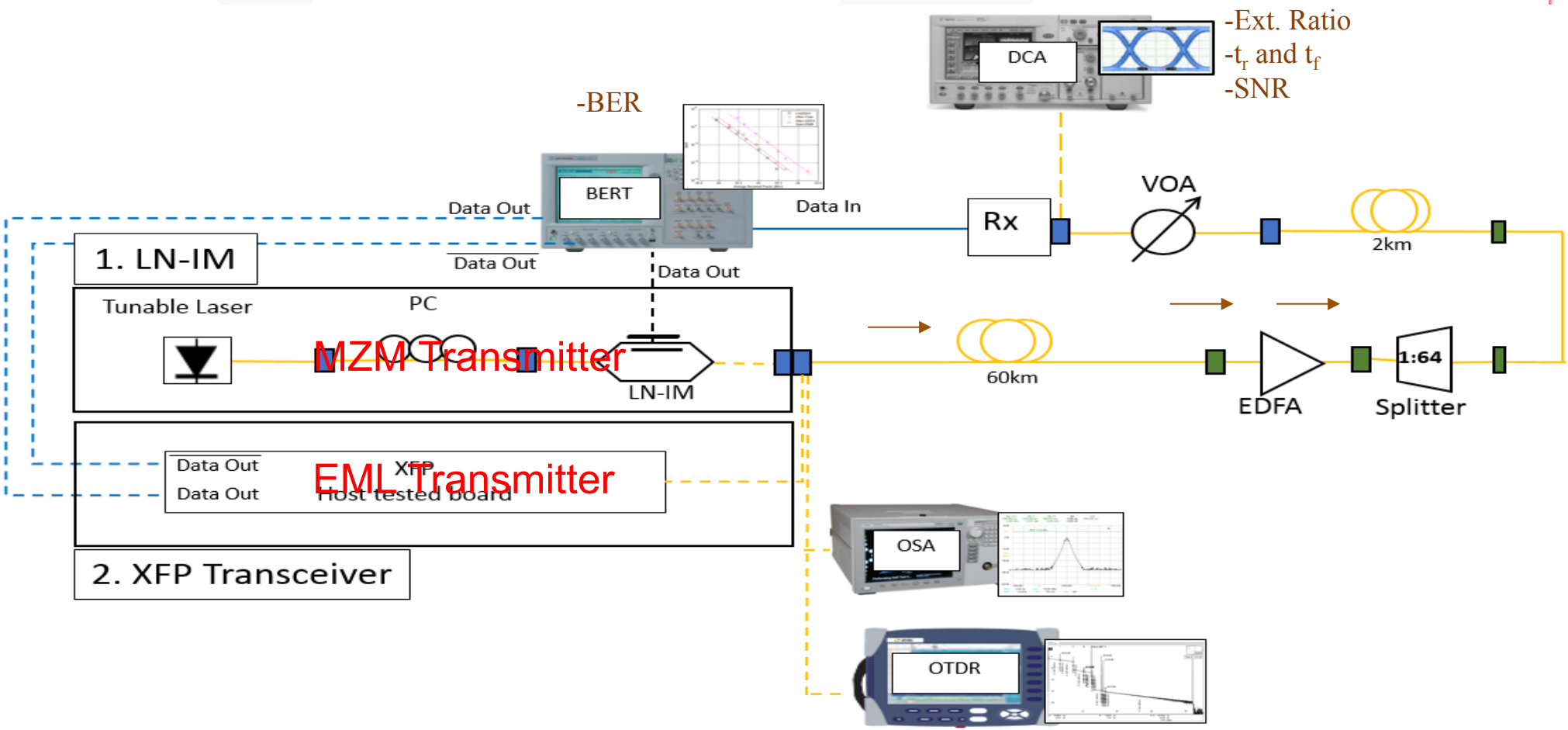
- **Both the UL and DL have achieved error-free (BER<10^{-12}) in 60-km reach.**
- **The reach distance of DL is not limited by the power budget but by the chromatic dispersion (CD); 18ps/nm/km@1579nm.**
- **To extend the reach distance, we put a dispersion compensating fiber (DCF) with D=-748 ps/nm, only for the DL.**
- **An error-free operation has been achieved with over 70-km reach distance.**

Waveforms



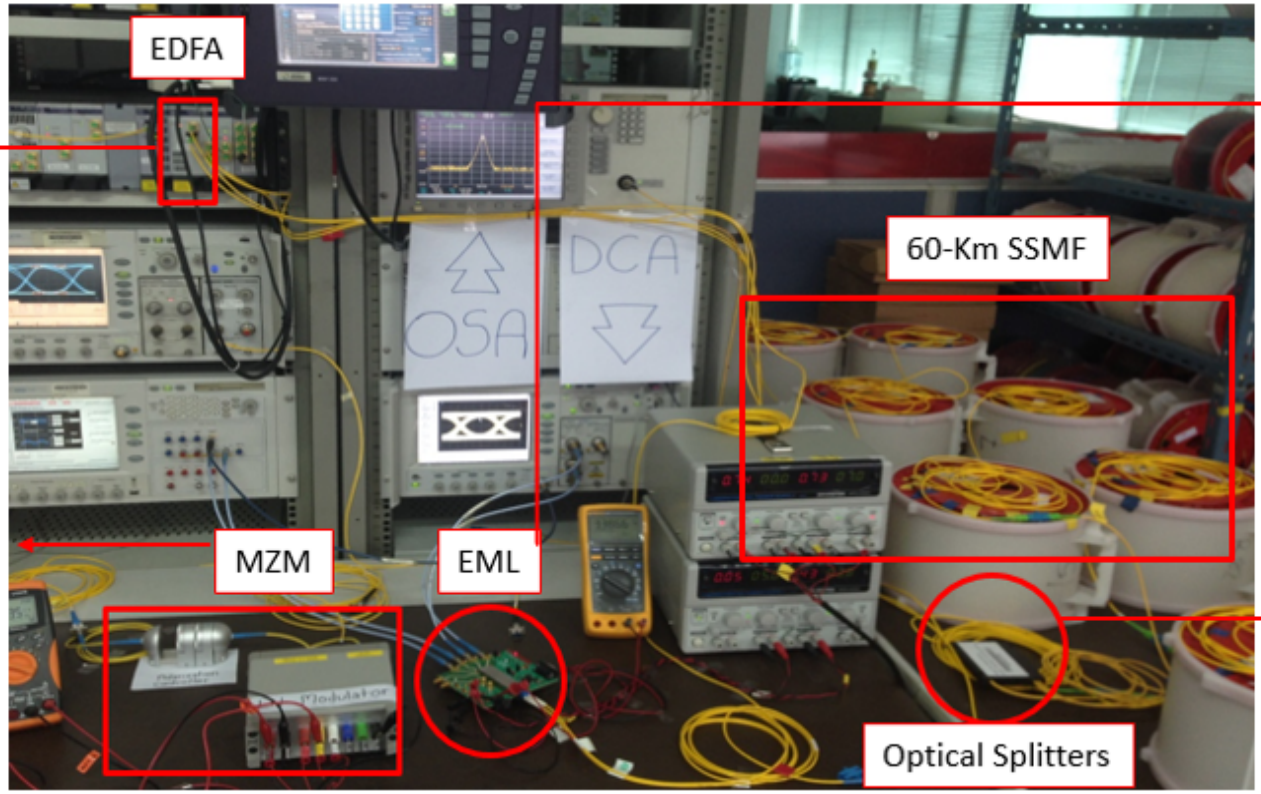
- **For the DL, the signal waveform is distorted due to the CD after 60-km transmission.**
- **For the UL, there is no waveform distortion owing to the zero-dispersion at 1300-nm wavelength. UL = O-band DML**
- **1300-nm signal-waveband with SOA is the good choice for UL of long-reach PON, which allows to use low-cost 10G transmitters (no CD management is required).**

Block Diagram



Experimental Setup @ Electro-Magnetic Research Laboratory CU, Thailand

JDSU-EDFA



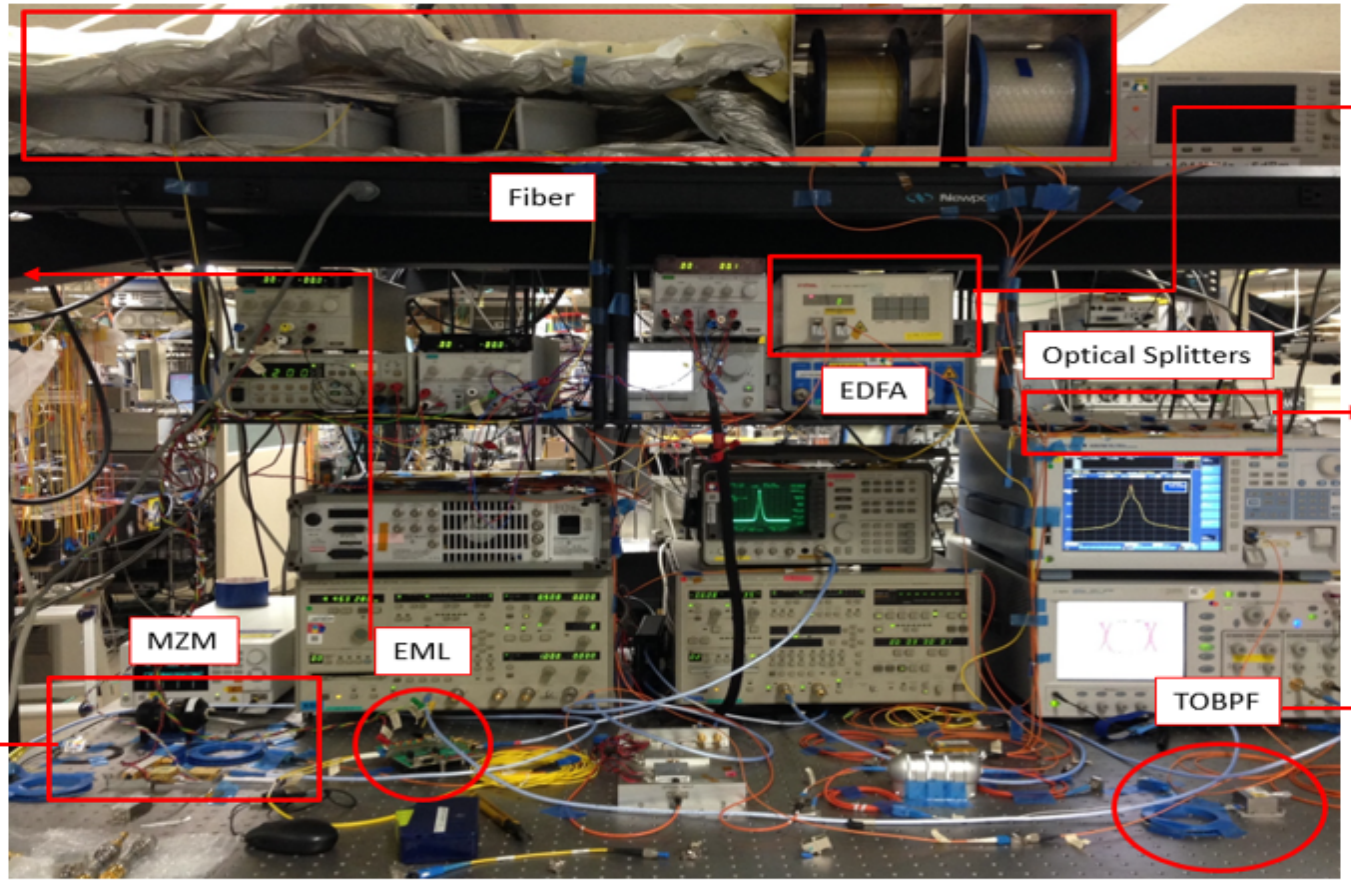
EML Transmitter

MZM Transmitter

Optical Splitter

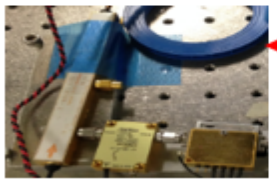
60-Km SSMF & 64 Splitting Ratios

Experimental Setup @ Photonic Network System Lab. NICT, Japan



EML Transmitter

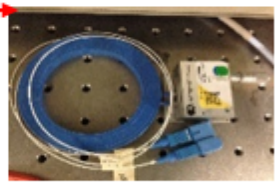
MZM Transmitter



Fitel-EDFA

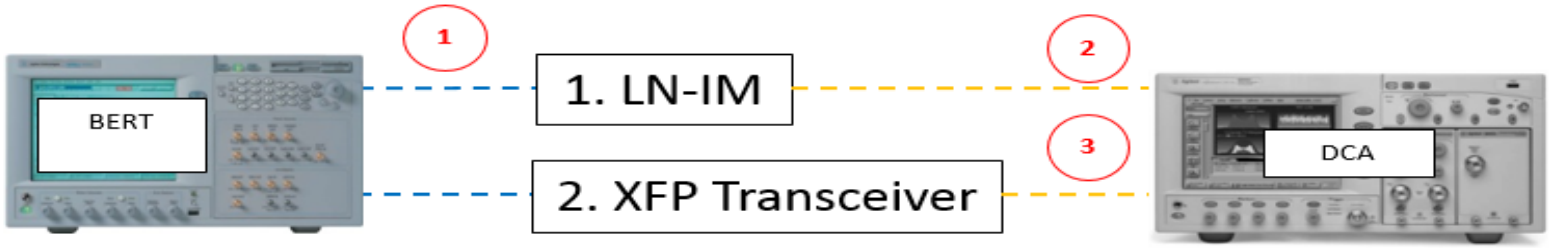
Optical Splitter

TOBPF

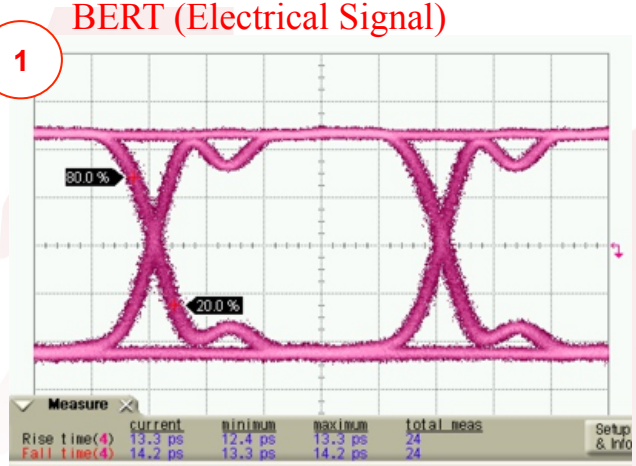


62-Km SSMF & 256 Splitting Ratios

Eye Diagrams

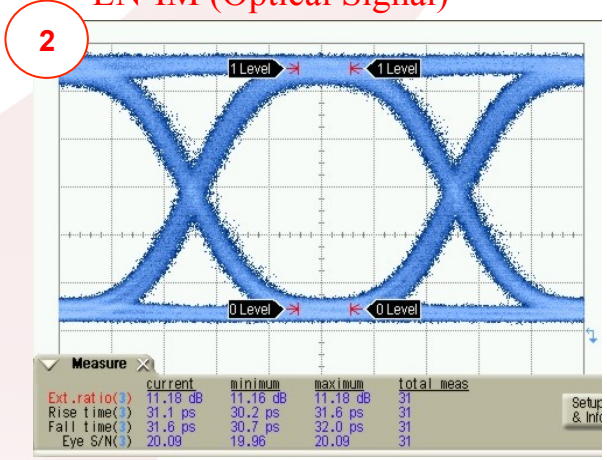


BERT (Electrical Signal)



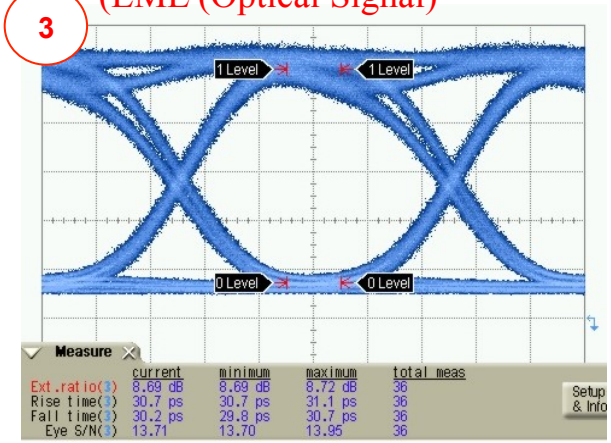
Rise Time 13.3ps
Fall Time 14.2ps

LN-IM (Optical Signal)



Ext. Ratio: 11.18dB
Rise Time 31.1ps
Fall Time 31.6ps

(EML (Optical Signal)



Ext. Ratio: 8.69dB
Rise Time 30.7ps
Fall Time 30.2ps

Conclusion

- **In collaboration between Chulalongkorn University and NICT, we are able to setup the experimental transmission of 10 Gb/s access network using a low-power optical amplifier.**
- **This network can achieve 62 km over standard SMF and 256 subscribers.**
- ***We plan to demonstrate XG-PON with downstream and upstream transmissions at standard wavelengths: 1577-nm Downstream and 1270-nm Upstream.***
- ***In the near future, We also plan to demonstrate NG PON2 and Beyond….***

Research collaboration on access network systems and their applications are welcome!

Thank you

More detail, please contact us!

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