Research on Optical Access Network

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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.

**Downstream Traffic in Japan**

Surveys by Ministry of Internal Affairs and Communications, Japan April 4, 2015
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)
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 PONs with reach extenders (REs) are promising for Central Office (CO) consolidation in order to reduce the CAPEX and OPEX.

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

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

System demonstration setup

\[
\lambda = 1310 \text{ nm}, \quad P_{Tx} = +6 \text{ dBm}, \quad L_{\text{frame}} = 1522 \text{ Byte}, \quad L_{\text{gap}} = 512 \text{ Byte}
\]
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

- Ext. Ratio
- $t_r$ and $t_f$
- SNR

1. LN-IM
   - Tunable Laser
   - PC
   - LN-IM
   - MZM Transmitter
   - EML Transmitter

2. XFP Transceiver

- BERT
- Data Out
- Data In
- Rx
- VOA
- 2km
- EDFA
- 1:64 Splitter
- OSA
- OTDR
Experimental Setup @ Electro-Magnetic Research Laboratory
CU, Thailand

60-Km SSMF & 64 Splitting Ratios
Experimental Setup @ Photonic Network System Lab. NICT, Japan

62-Km SSMF & 256 Splitting Ratios
Eye Diagrams

1. LN-IM
   - BERT (Electrical Signal)
   - Rise Time 13.3ps
   - Fall Time 14.2ps
   - Ext. Ratio: 11.18dB

2. XFP Transceiver
   - LN-IM (Optical Signal)
   - Rise Time 31.1ps
   - Fall Time 31.6ps
   - Ext. Ratio: 8.69dB

3. (EML (Optical Signal)
   - Ext. Ratio: 8.69dB
   - Rise Time 30.7ps
   - Fall Time 30.2ps
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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