Remotely Reconfigurable PON Architecture

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Contents

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- **Some applications**

  - Evolution of TDM-PON to WDM-PON

  - Evolution with protection

  - OSP management and protection

- **Summary**

Why Remote Reconfiguration?

- **Outside plant is the most costly part of PON.**
  - Passive OSP implies no flexibility.
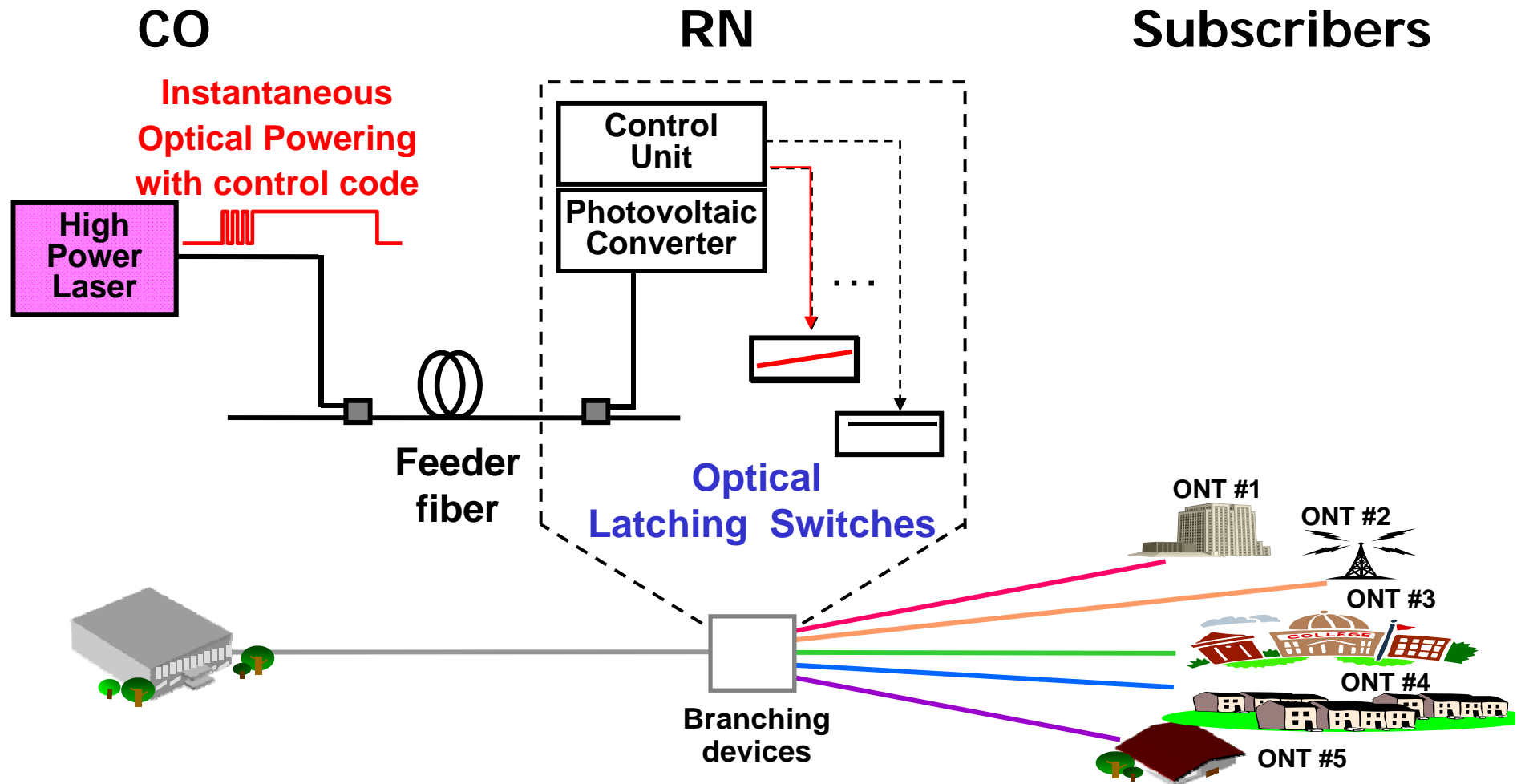 - Needs truck roll for reconfiguration.
- **Reconfiguration of OSP will provide great flexibility.**
  - The passive nature of OSP should be maintained to reconfigure without sending truck roll
- **Needs for reconfiguration**
  - Evolution from TDM-PON to WDM-PON
    - Reuse of video overlay band
  - Evolution with protection
  - Monitoring of OSP using OTDR
  - Optical protection (1:1, 1+1, 1:N)
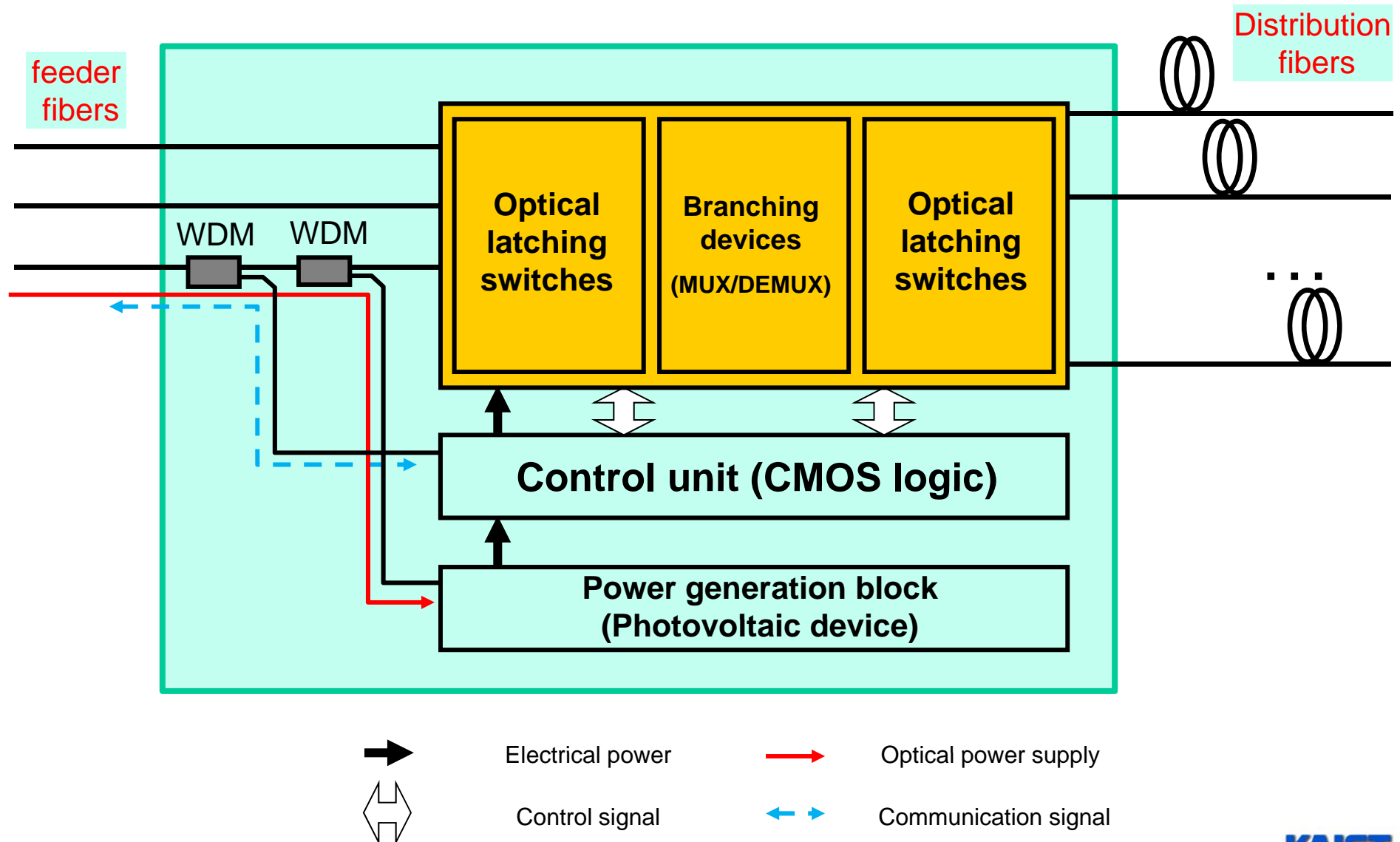 - Change of split ratio
  - New functionalities

Remotely Reconfigurable Remote Node

CO **RN** **Subscribers**

Instantaneous
Optical Powering
with control code

High
Power
Laser

Control
Unit

Photovoltaic
Converter

. . .

Feeder
fiber

Optical
Latching Switches

ONT #1

ONT #2

ONT #3

ONT #4

ONT #5

Branching
devices

- *Reconfigure the optical paths of the RN remotely*
- *Maintaining the RN in the passive state*

* J.H. Lee, K.-M. Choi, and C.-H. Lee, PTL, vol. 20, no. 11, pp. 915-917. 2008.

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Remote Node Details

feeder fibers

Distribution fibers

WDM   WDM

Optical latching switches	Branching devices (MUX/DEMUX)	Optical latching switches

. . .

Control unit (CMOS logic)

Power generation block (Photovoltaic device)

➡ Electrical power   ➡ Optical power supply

⬍ Control signal   ⬌ Communication signal

Enabling Technologies

- **Remote powering**
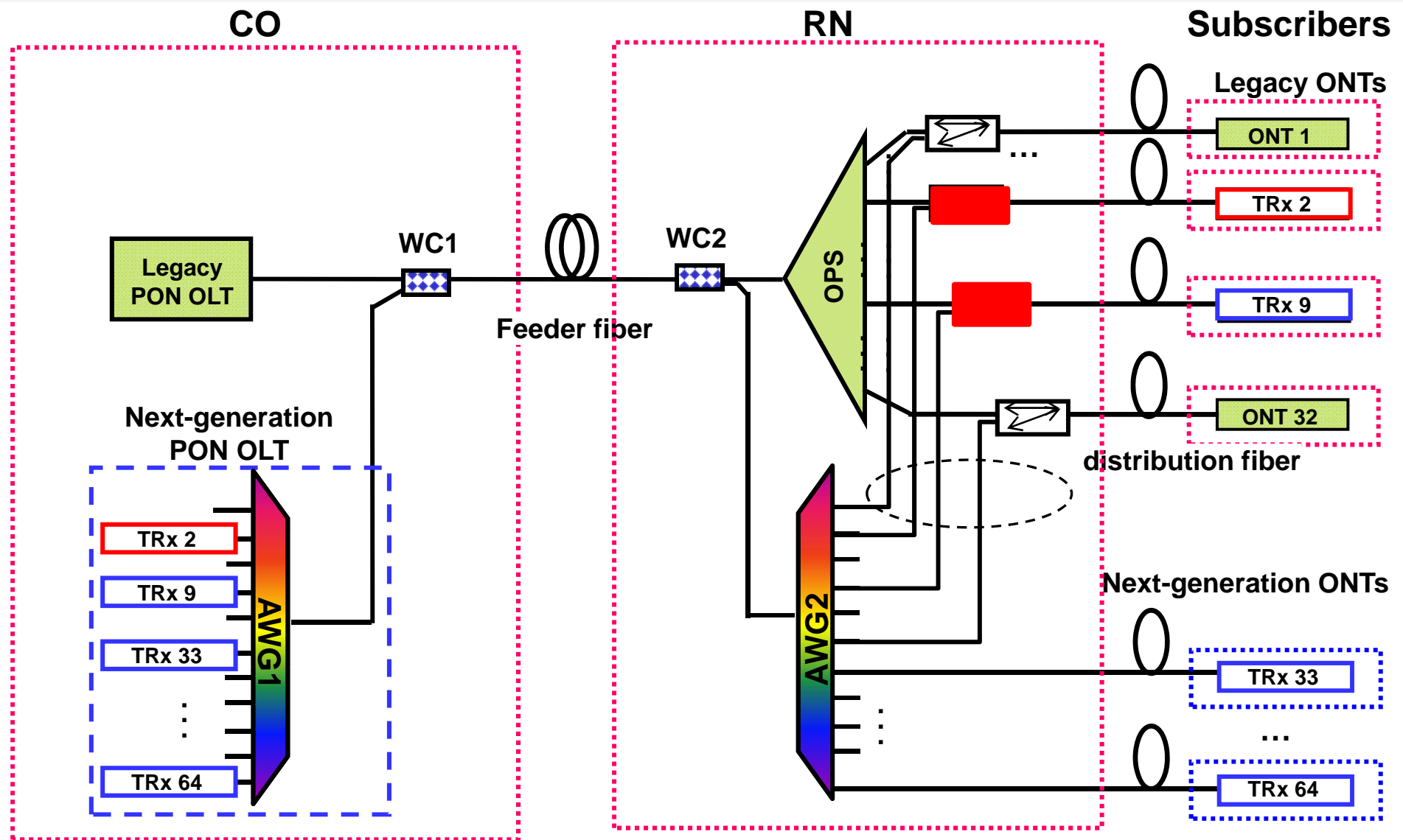 - A single high power laser at a CO

- **High efficiency photovoltaic device**

- **Optical latching switch with a low switching energy**
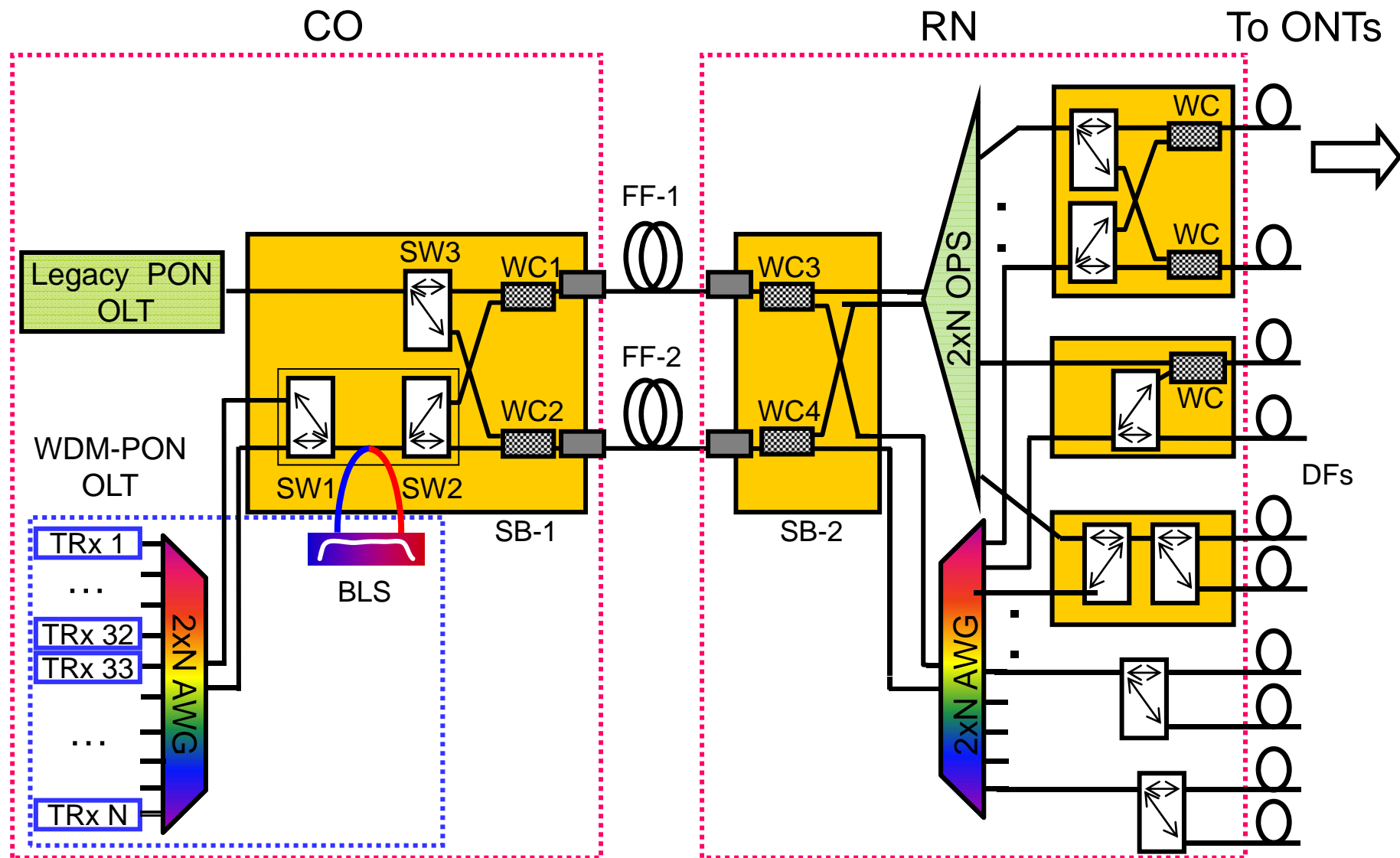 - MEMS based optical latching switch

- **Very low power CMOS logic devices**

Evolution from TDM-PON to WDM-PON

* J.H.Lee, K.-M. Choi, and C.-H. Lee, PTL, vol. 20, no.11, pp.915-917. 2008.
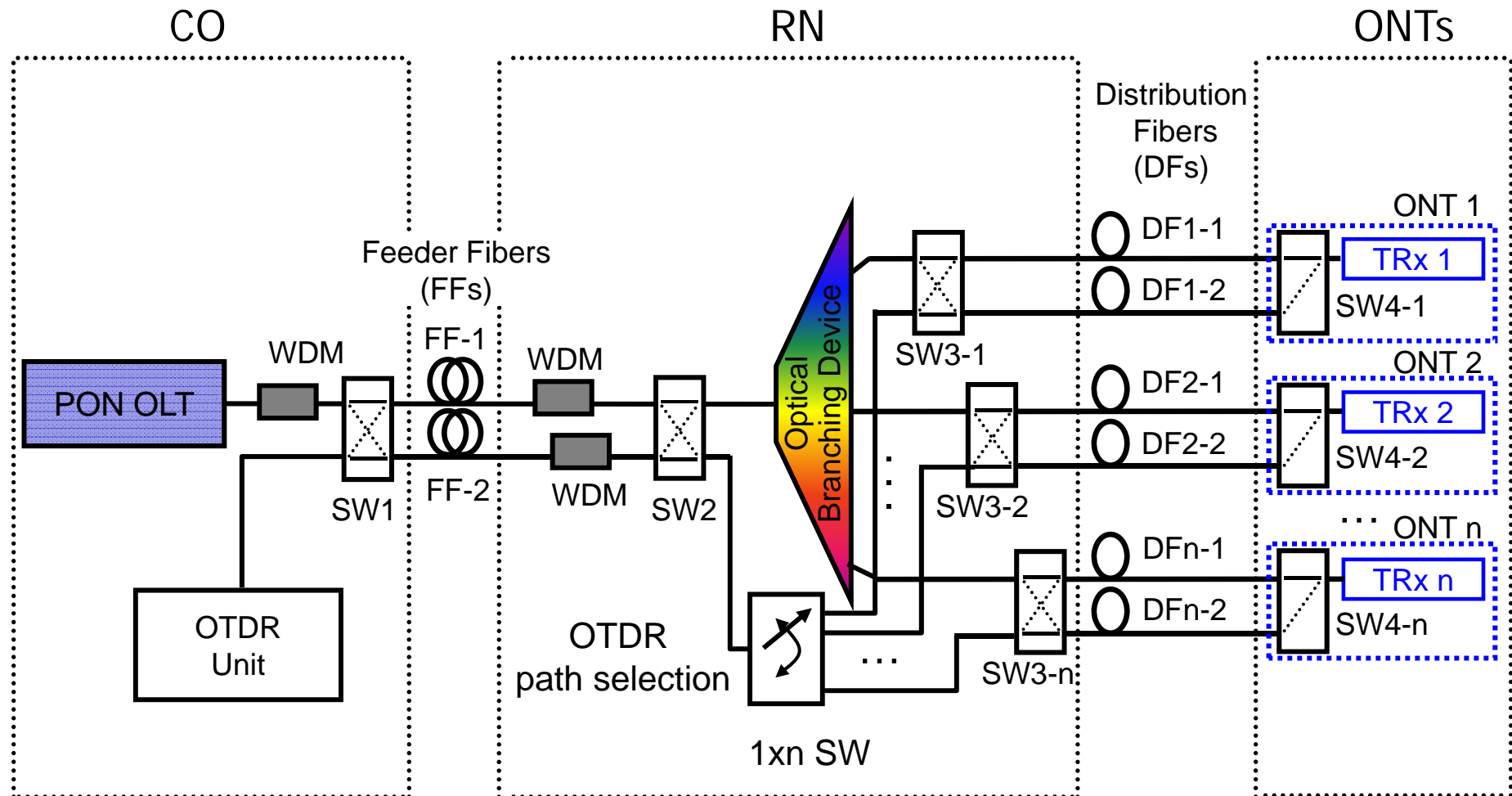
Evolution with Protection Capability

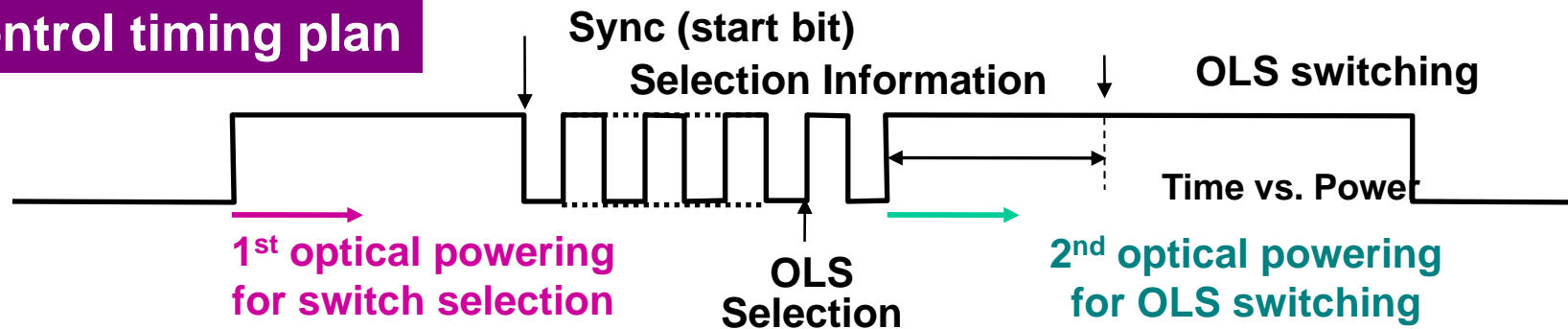* J.H. Lee et. al. accepted for publication in IEEE J. Lightwave Tech.
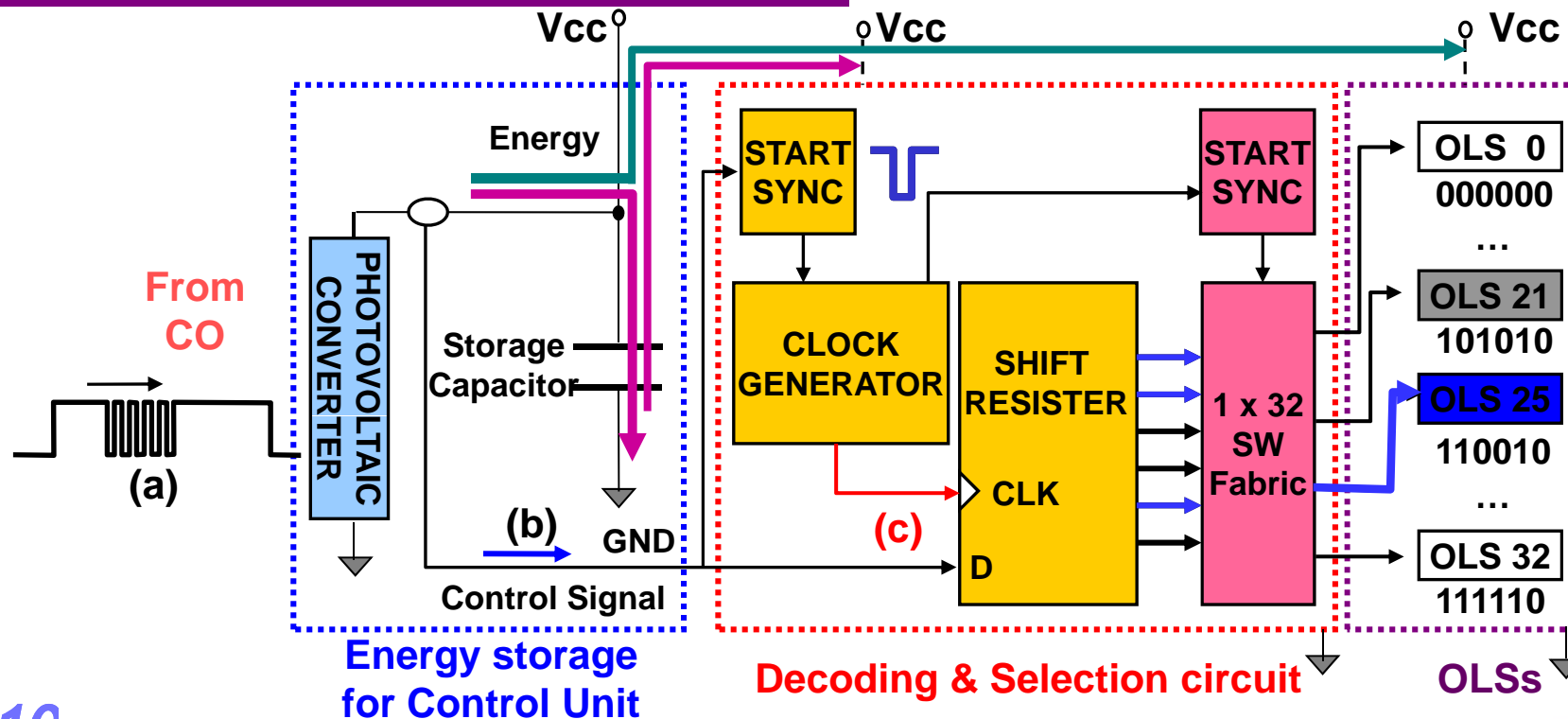
Seamless Maintenance and Protection

* J.H. Lee, K.-M. Choi, and C.-H. Lee, PTL, vol. 21, no. 12, pp. 799-801. 2009.
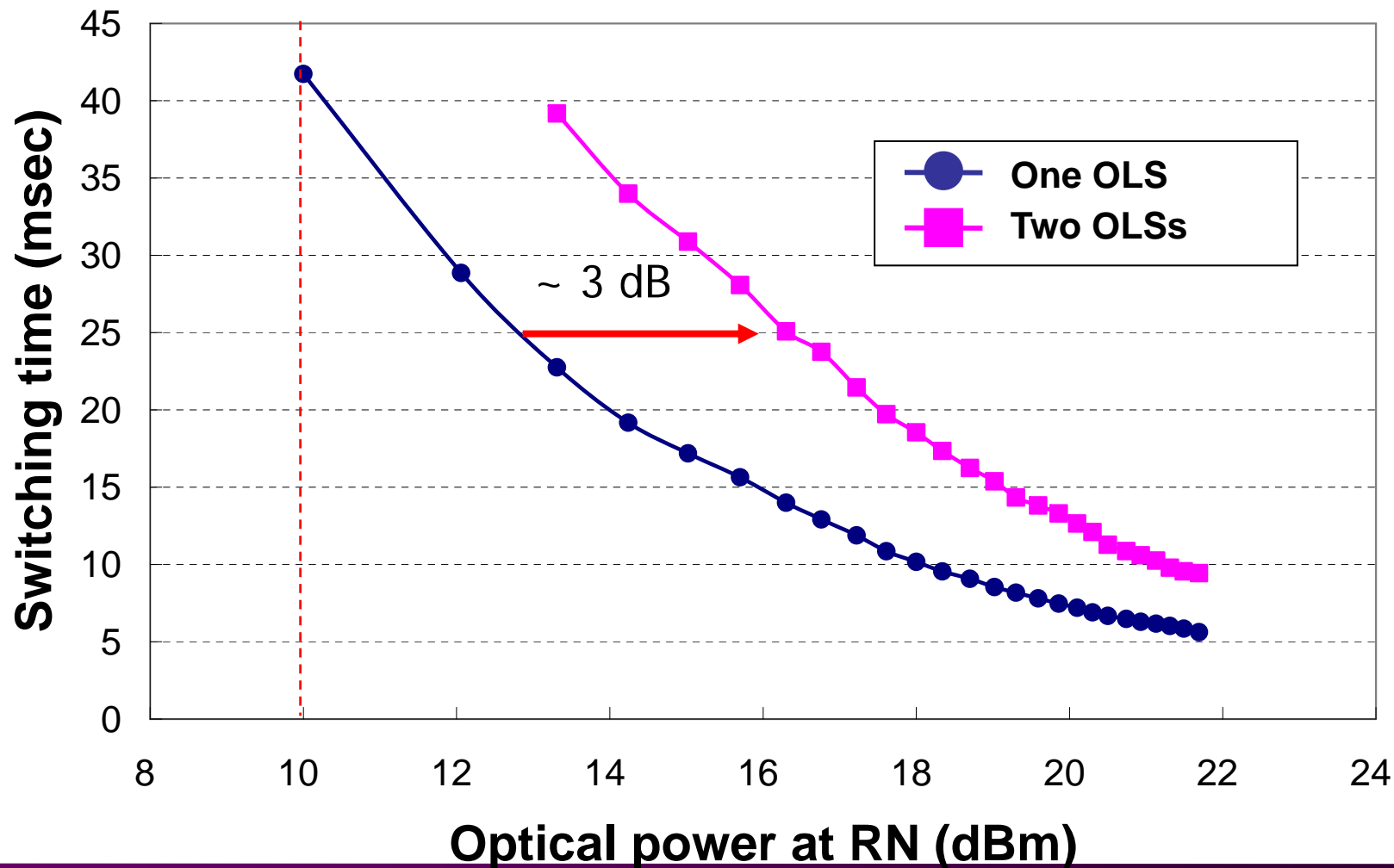
Control Functions

Control timing plan

Sync (start bit)

Selection Information

OLS switching

Time vs. Power

1st optical powering
for switch selection

OLS
Selection

2nd optical powering
for OLS switching

Functional Block of Control Unit

Vcc

Vcc

Vcc

Energy

From CO

PHOTOVOLTAIC CONVERTER

Storage Capacitor

(a)

(b)

GND

Control Signal

START SYNC

CLOCK GENERATOR

SHIFT RESISTER

CLK

D

(c)

1 x 32 SW Fabric

START SYNC

OLS 0
000000

…

OLS 21
101010

OLS 25
110010

…

OLS 32
111110

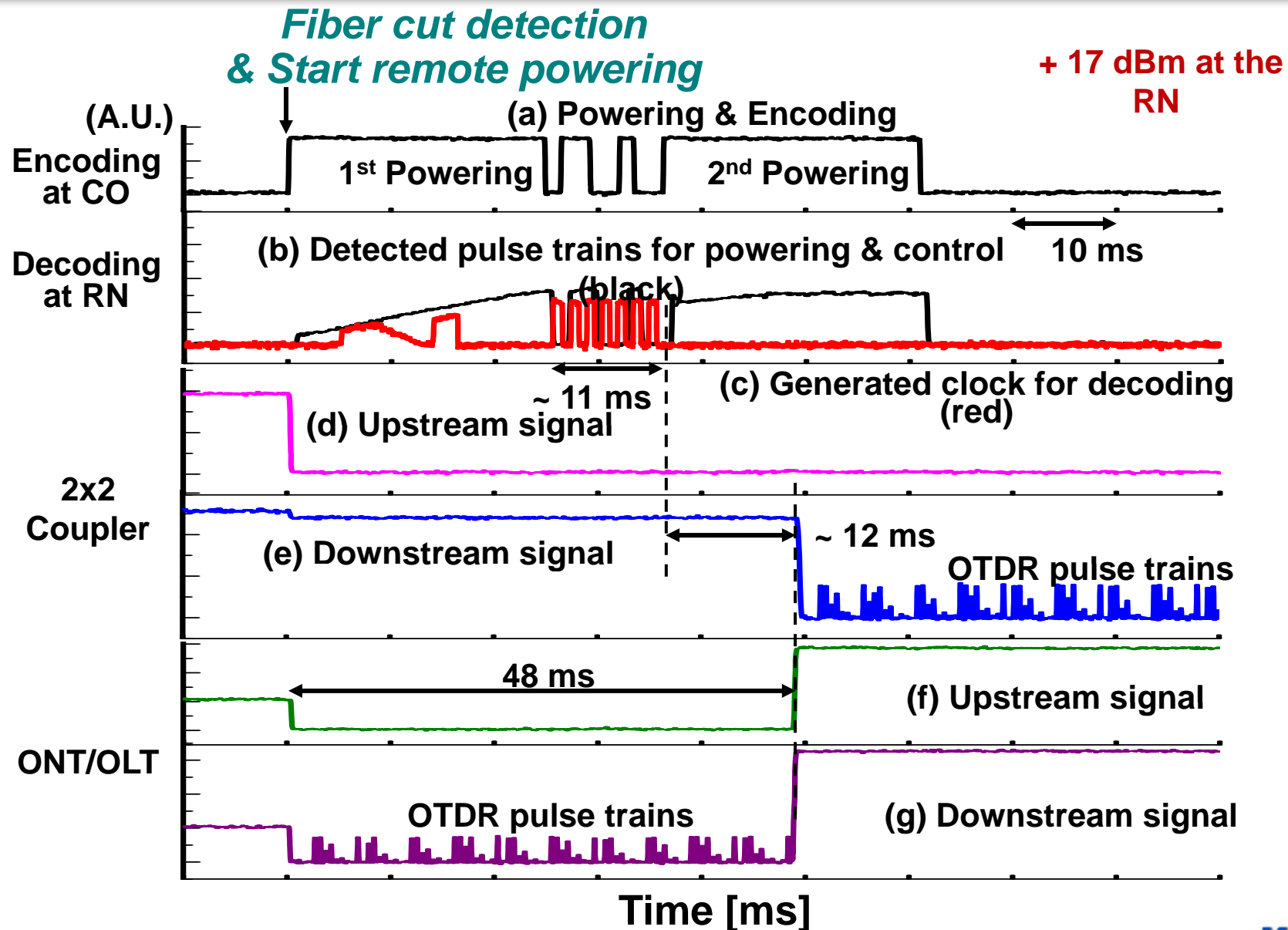Energy storage
for Control Unit

Decoding & Selection circuit

OLSs

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Switching characteristics of OLS

* Minimum optical power for switching one OLS at RN < 10 dBm
* Maximum switching time < 42 msec
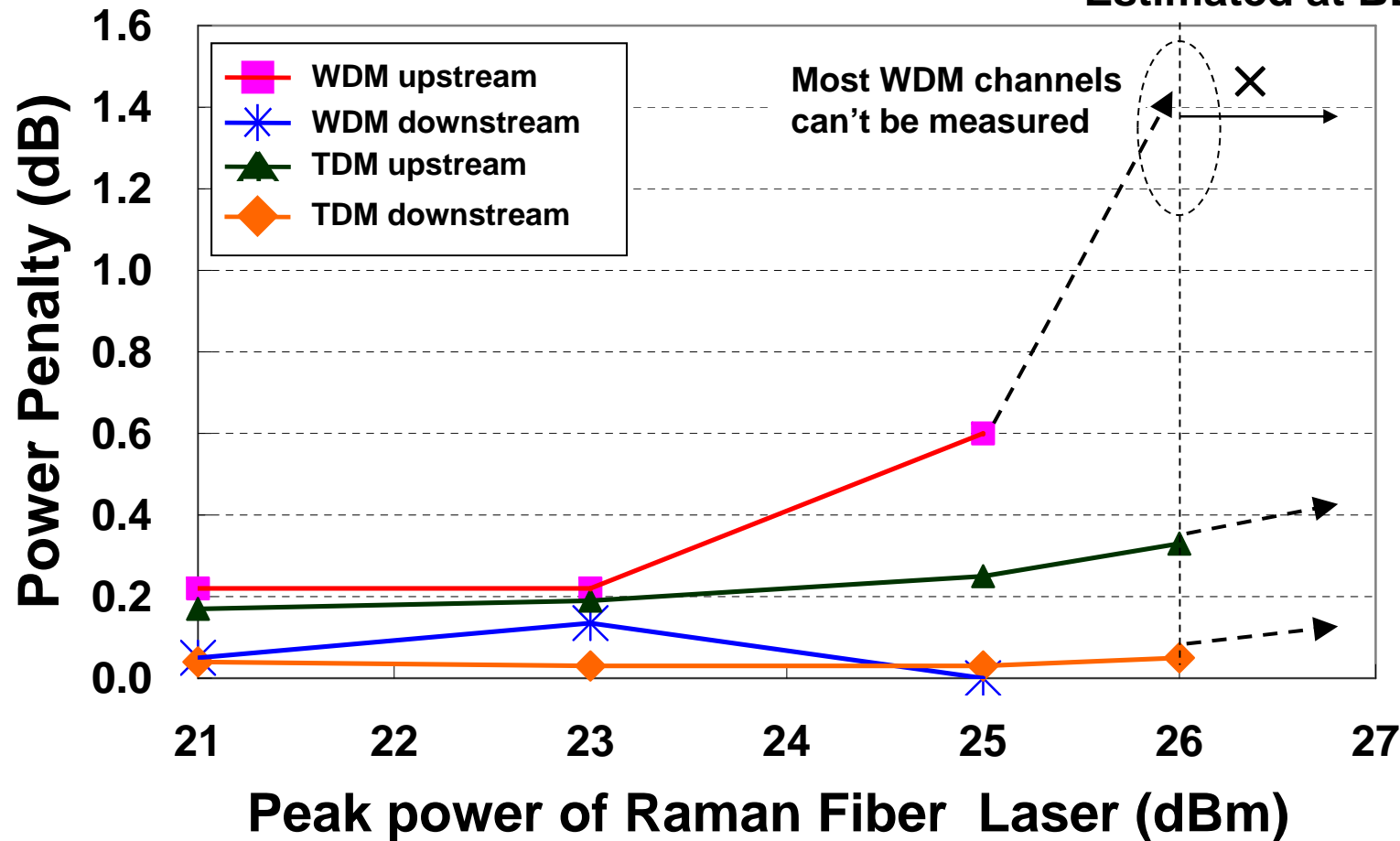
Restoration Characteristics (Distribution Section)

Switching Power Requirements

- **Minimum power for OLS switching ~ 2.5 mW**

- **Power consumption at CMOS logic < 260 μW**

- **Total power for reconfiguration ~ 2.8 mW**

- **Optical power requirement at CO ~ 18.5 dBm**

  - Photovoltaic device conversion efficiency = 25%

  - Optical losses for feeder fiber section: 8 dB

- **The switching power can be reduced further with**

  - High efficiency photovoltaic device > 35 %

  - Low power OLS < 1 mW

Power Penalty due to optical powering

* 40 msec, 5 Hz repetition ratio
* Estimated at BER of 10^{-10}

Most WDM channels can't be measured

Legend:
- WDM upstream
- WDM downstream
- TDM upstream
- TDM downstream

Y-axis: Power Penalty (dB)
X-axis: Peak power of Raman Fiber Laser (dBm)

• *Limits of optical powering due to optical nonlinearity < 25dBm*

Summary

- **Remotely reconfiguration PON will provide great flexibility on architecture of access networks**

- **Remotely reconfigurable nodes were demonstrated with commercial devices (OLS, Photovoltaic device, CMOS logics)**
  - Reconfiguration of remote node without sending truck roll.
  - A single high power laser at a CO.
  - The passive nature of network was maintained.

- **Minimum required optical power at CO ~ 18.5 dBm**
  - This power can be reduced further with advanced devices
  - The maximum power was limited by optical nonlinear interaction.
    - Limits number of switching devices with a single pulse.