

Broadband Network Architectures, WDM-PON Evolution Strategies
and Future Ultra-High-Bandwidth Services

Evolutional Perspective of WDM-PON from NTT's Viewpoint

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Outline

1. Operator's Requirements
2. Migration Scenarios
3. Potentials of WDM in the Access Network
4. Summary

1. Operator's Requirements

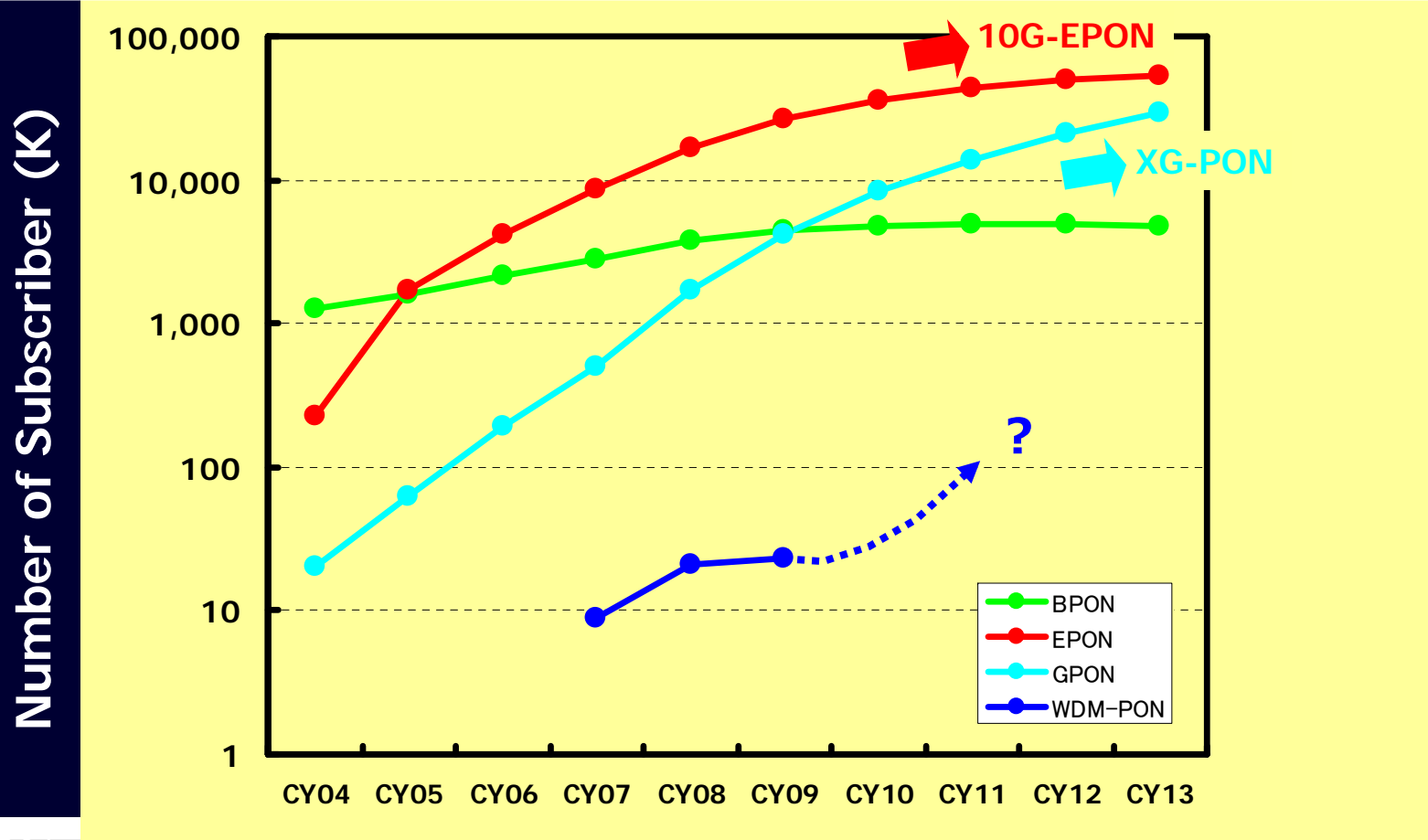
2. Migration Scenarios

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Worldwide PON Market Trend and Forecast

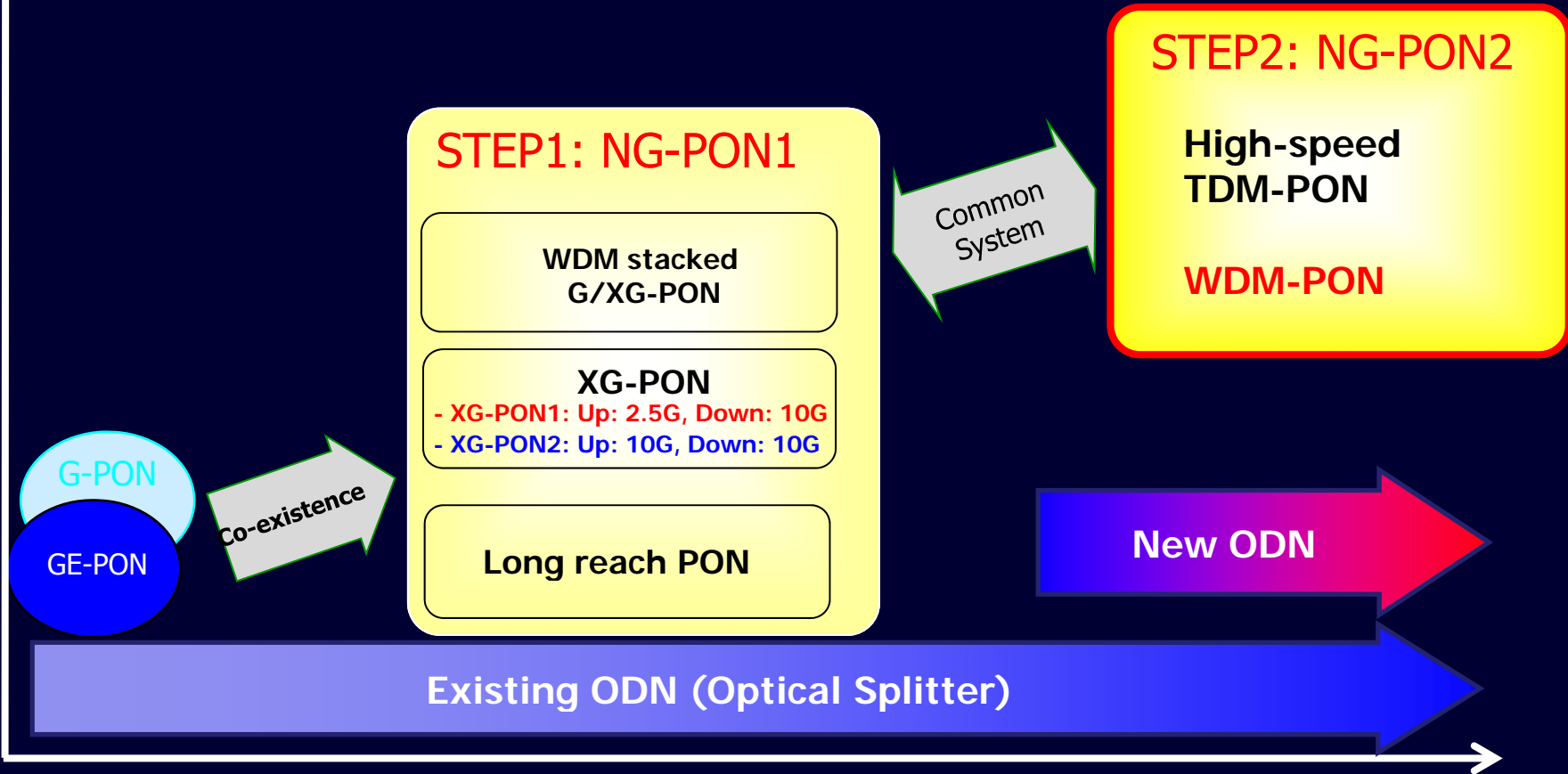
- TDM-based PON (G-PON, 1G-EPON) has steadily increasing
- It is expected to smoothly migrate to XG-PON and 10G-EPON
- WDM-PON deployment has locally started
- TDM-based PON will be the most widespread PON system in the future



Development Scenario towards Future PON

- FSAN plans Two-step scenario towards future PON
- WDM-PON is located at "STEP-2" in which system is free from existing ODN and co-existing with the current deployed system
- However, TDM-based PON has been already massively deployed

Transmission Capacity

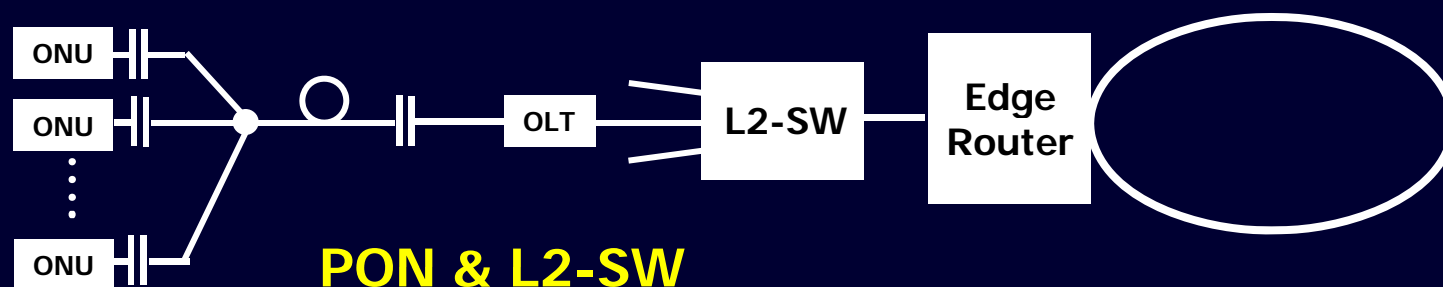


Requirements for NG-PON system

- Reuse the current Optical Distribution Network

Smooth Migration

- Efficient Aggregation Network Architecture



- Wide Flexibility of Bandwidth Requirement

From wide-band to Narrow-band

Priority and Fairness Load balancing

- High Reliability

Redundancy

- **Green Systems**

Power Saving

1. Operator's Requirements

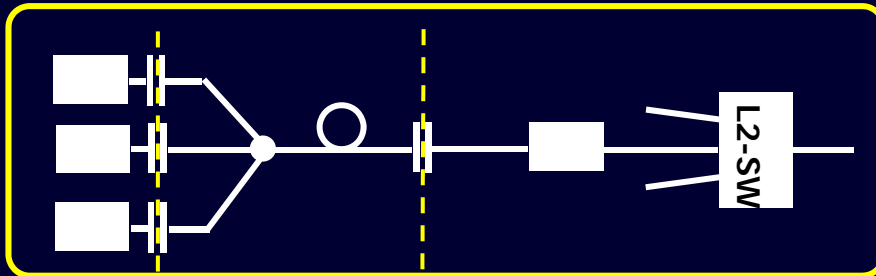
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Access Network Migration Scenarios

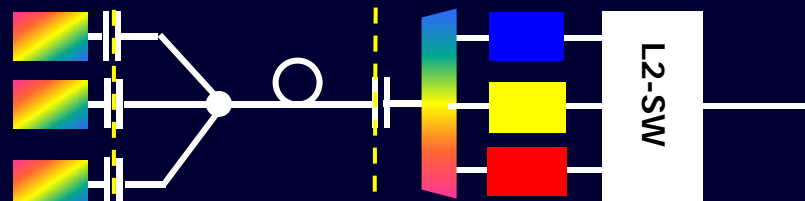
Current TDM based PON



Scenario 1 Reuse ODN

**Continuous Upgrade
TDM-based PON on the same ODN**

Minimum CAPEX
of ODN

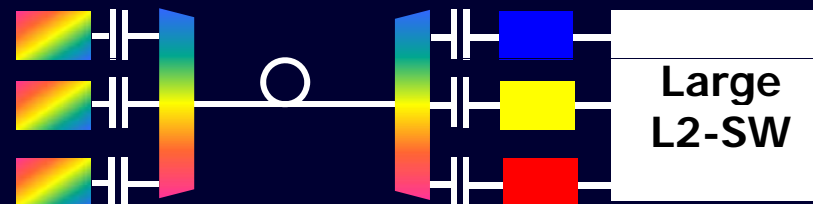


Same ODN

Scenario 2 ODN Reconstruction

**Constructing simple
network architecture**

WDM? Minimum OPEX
of PON operation

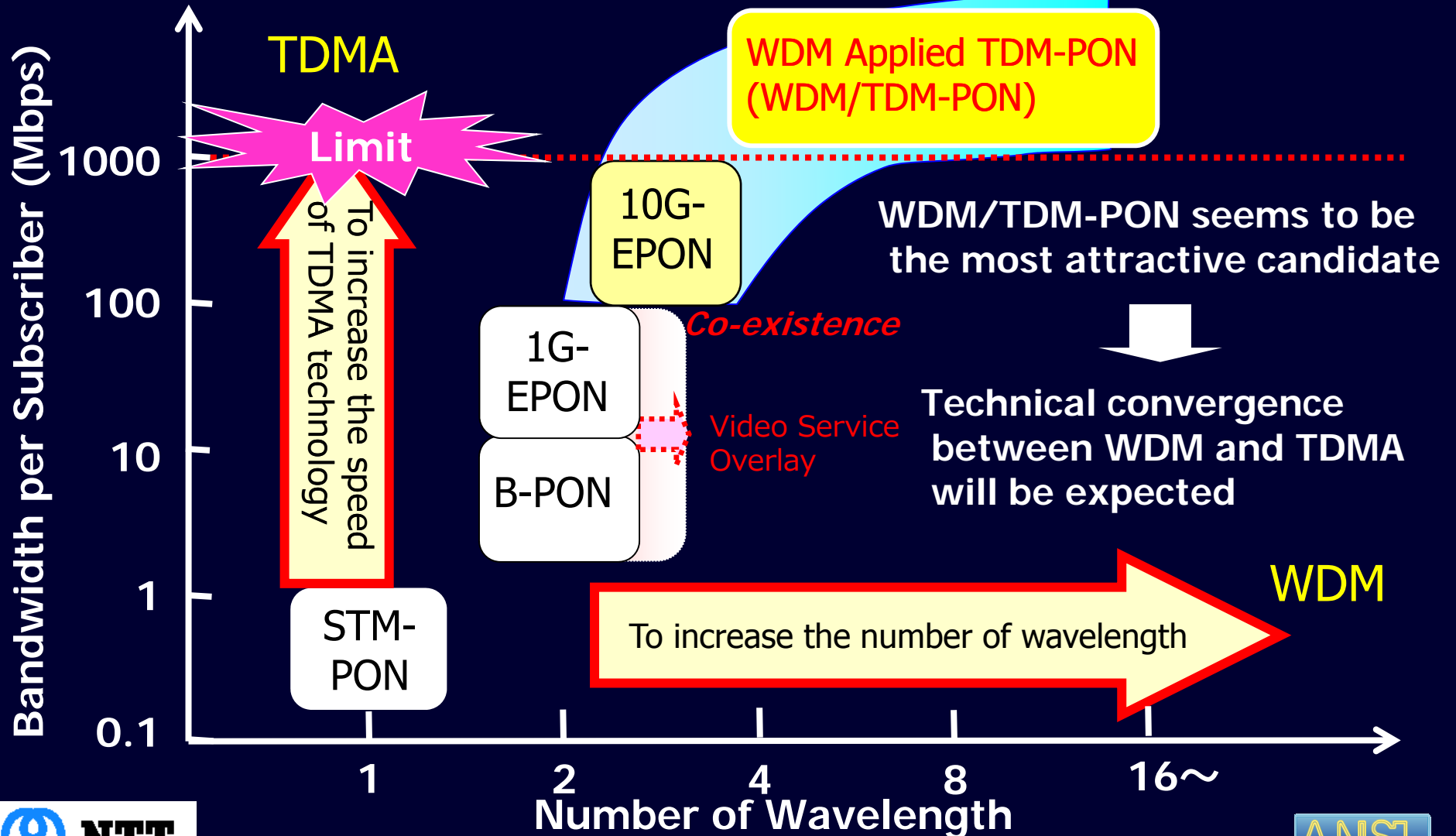


- huge investment
- need highly large-scale L2-SW

How is WDM applied ?

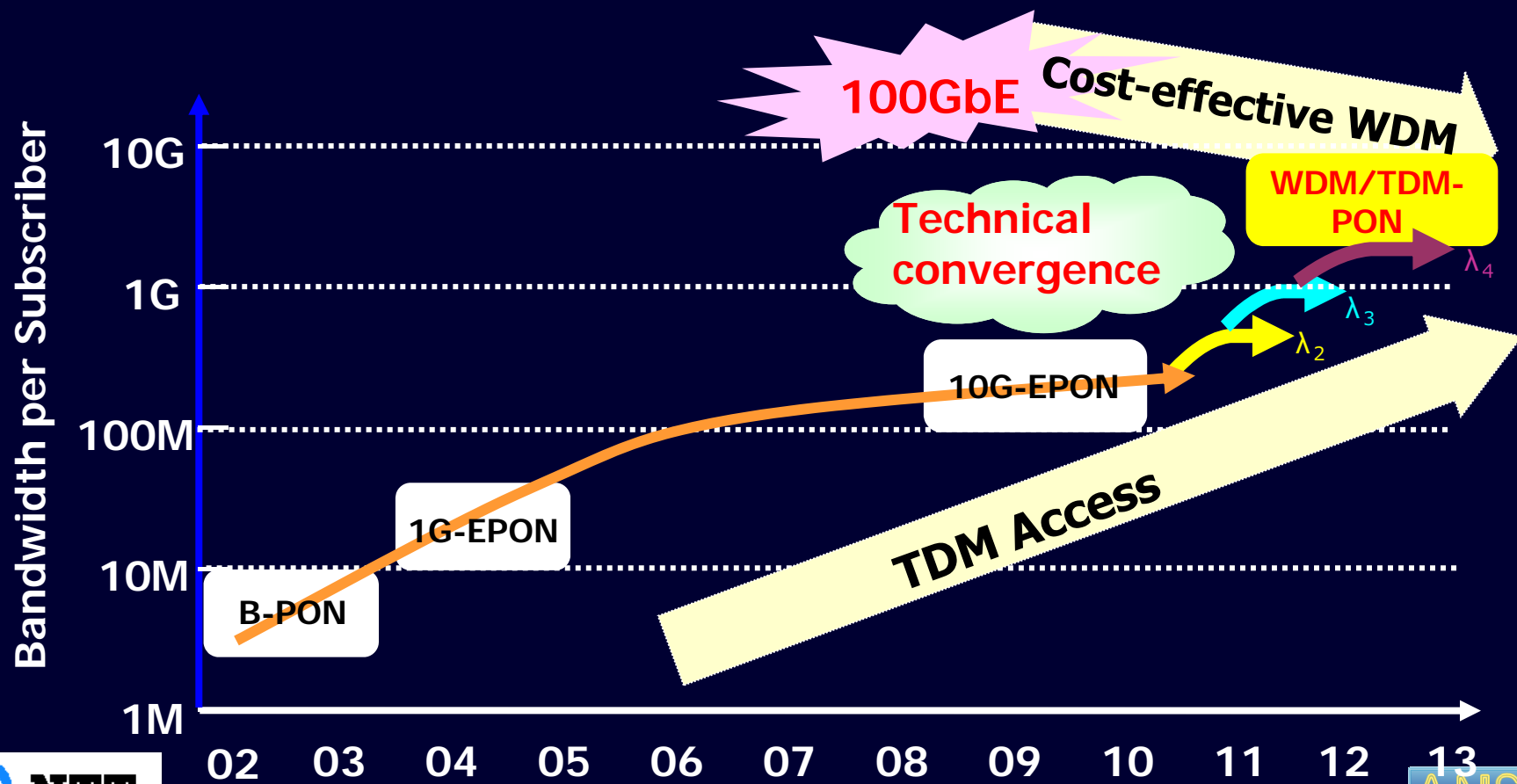
How can we upgrade Bandwidth ?

- TDMA technology will face physical limit of integration circuit
- Wavelength Applied TDM-PON keeps technical continuity with TDMA



Technical Convergence TDMA & WDM

- Fortunately, Ethernet Technology is progressing from 10G to 100G
- 100GbE (4 wavelengths) will trigger cost reduction of WDM components
- This leads to technical convergence of TDMA and Cost effective WDM
- In this way, WDM applied TDM-PON (WDM/TDM-PON) will be developed



1. Operator's Requirements

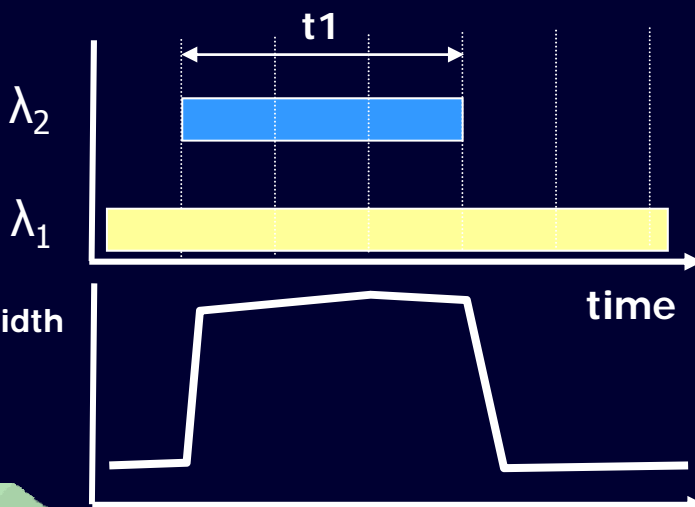
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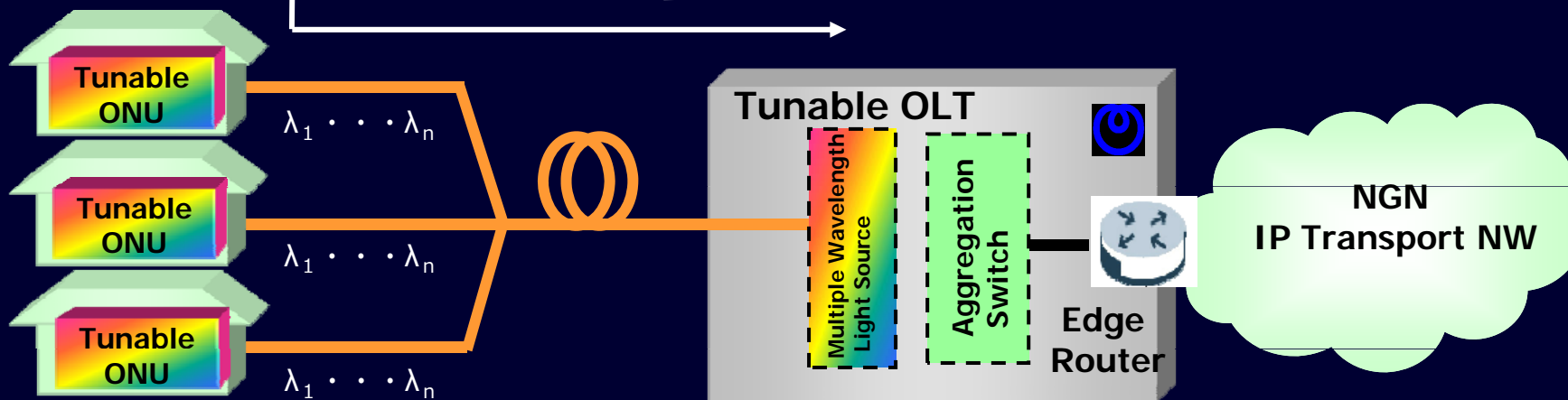
WDM-applied TDM-PON

- If several wavelength can be employed, **flexible bandwidth assignment** can be achieved using not only TDMA but also Wavelength assisted Dynamic Bandwidth Assignment in the same PON branch



A subscriber needs a large bandwidth for some period t_1
 This subscriber is assigned wavelength 2 during t_1

In this case, the practical transmission rate of other subscribers within the same branch is not affected.
 In this way, a more flexible and high-speed optical access system will be provided

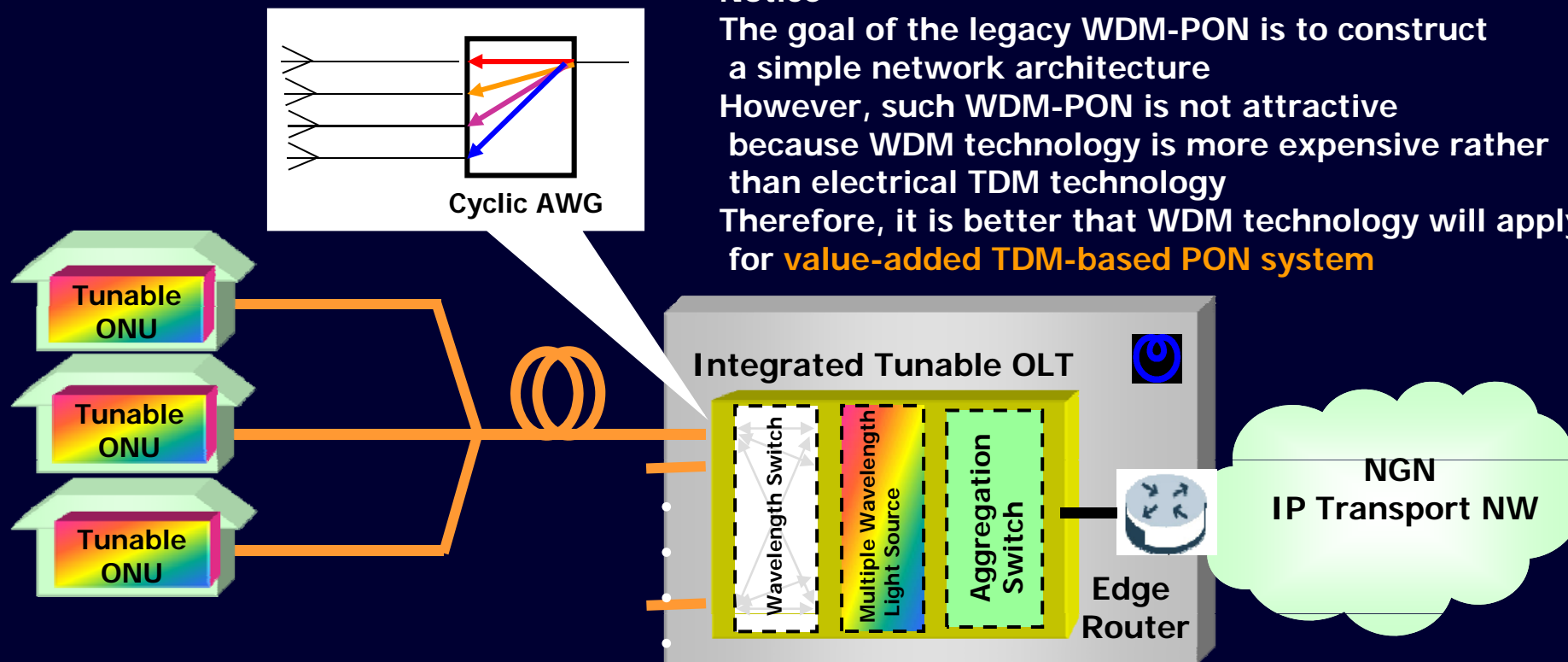


Widely dynamic WDM-PON

- If a wavelength switch can be employed in the OLT, high-grade operation such as **Load balance, Redundancy, and Power Saving** can be achieved among multiple PON branches using wavelength routing technique for example

Notice

The goal of the legacy WDM-PON is to construct a simple network architecture. However, such WDM-PON is not attractive because WDM technology is more expensive rather than electrical TDM technology. Therefore, it is better that WDM technology will apply for **value-added TDM-based PON system**



Issues of Widely Dynamic WDM-PON

Employ Wavelength Control

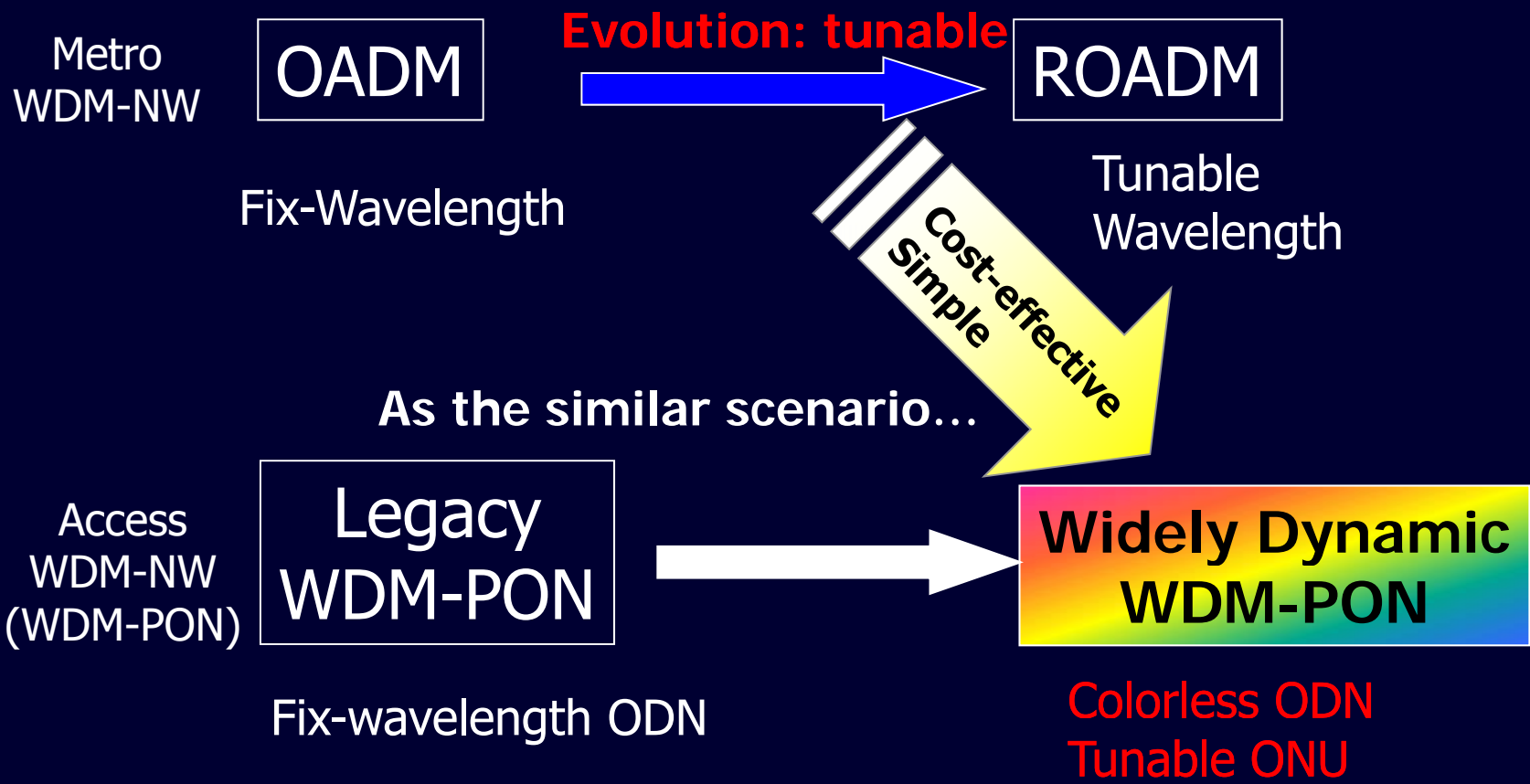
- Dynamic Wavelength Bandwidth Assignment
 - Wide-Range Bandwidth Assignment
"Priority and Fairness"
 - Load balance "Routing Wavelength"
 - Redundancy "Switching Wavelength"
 - Power Saving "Sleep Wavelengths"

Develop Optical Devices

- Wavelength Tunable Light Source and Selector
- Wavelength Switch

Tunable Device Expectation for future Access NW

- Generally, tunable devices are complicated and expensive
- Remind that tunable Light sources trigger the evolution of Metro WDM-NW
From OADM to Reconfigurable OADM
- Cost-effective tunable devices will be a trigger for widely dynamic WDM-PON



Summary

- **TDM-based PON** is suitable for **effective aggregation architecture** of Access NW
- **WDM Technology** will play a key role for constructing **Value-added TDM-PON** from operator's point of view
 - Wide-Range Bandwidth Assignment
"Priority and Fairness" "Load balance"
 - Redundancy
 - Power Saving
- The key issues of **Widely Dynamic WDM-PON** are
 - Flexible Bandwidth Management
 - Cost-effective Wavelength Tunable Devices

Thank you very much

