

ECOC 2022 Workshop

“Moving from optical components in RAN to optical components for RAN”

# Optical access network for RAN: current state and possible evolution paths

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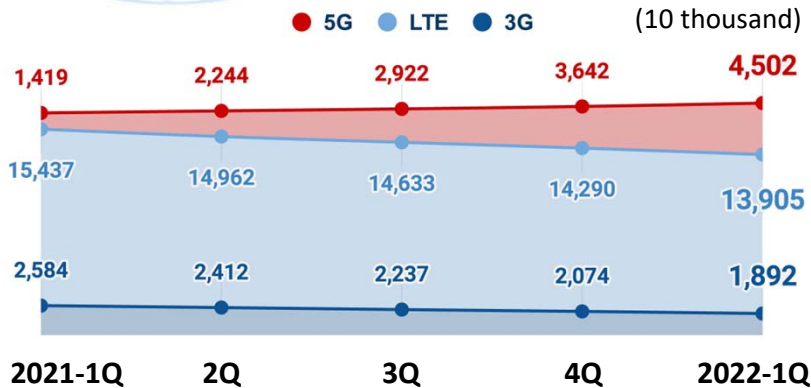
# Outline

- **Current State (Optical Access for 5G RAN)**
  - Status of 5G Services in Japan
  - Mobile fronthaul, backhaul, and midhaul
  - Fiber sharing technologies
- **Possible Evolution Paths (Optical Access for 6G RAN)**
  - 5G Evolution and 6G powered by Innovative Optical and Wireless Network (IOWN)
  - IOWN APN for 6G RAN
  - Optics for the APN-based 6G RAN
- **Summary**

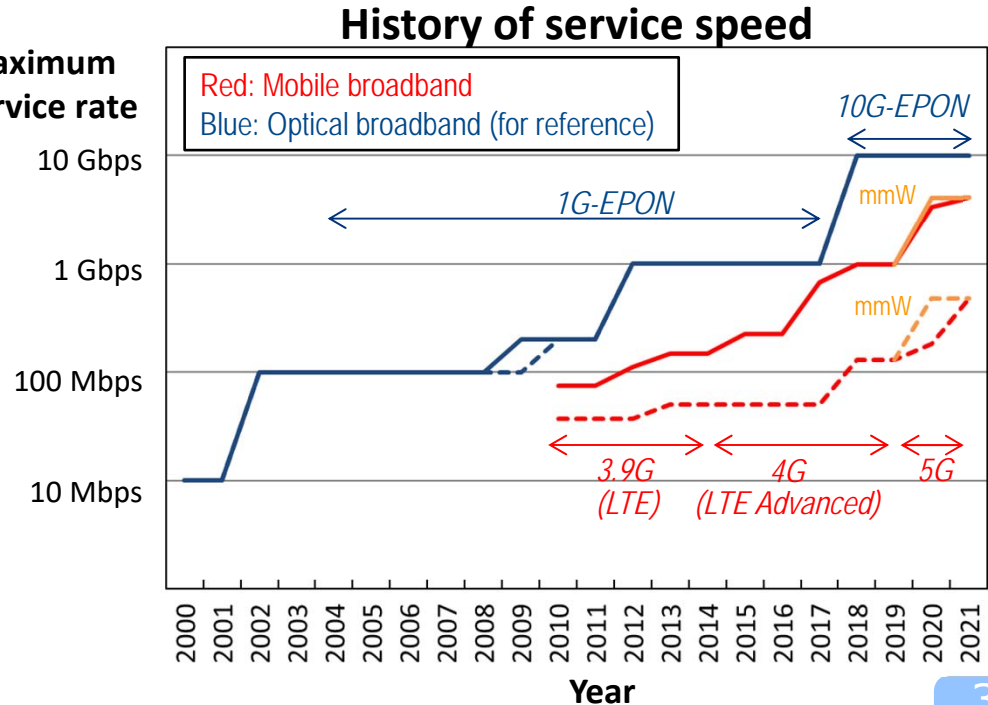
# Status of 5G Services in Japan

- 5G subscribers grow 3.2x per year.
- Maximum service rates are ~480 Mbps (upstream) and ~4.1 Gbps (downstream)
  - For both Sub6 (3.7 GHz & 4.5 GHz\*) and mmW (28 GHz\*) \* in the case of NTT docomo
  - In both 4G and 5G, effective rates become 20~40% (upstream) and 10~20% (downstream) of maximum when crowded.

## Subscribers growth

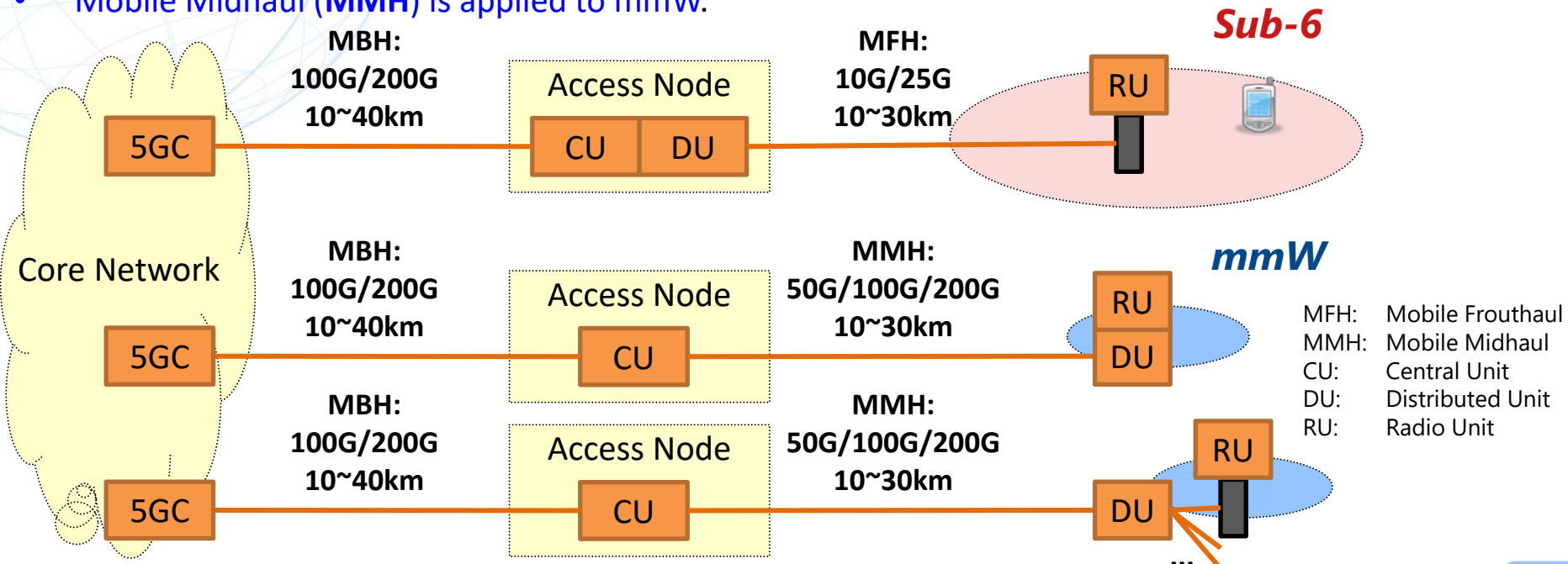


## Maximum service rate



# Mobile backhaul, fronthaul, and midhaul

- C-RAN to consolidate CU/DU into the access node is a major option for Sub-6 in Japan.
  - 10-Gbps to 25-Gbps bidirectional optical links are applied to carry eCPRI in Mobile Fronthaul (MFH).
  - Currently, point-to-point optical access is the most popular; one reason is that the dark fiber is very cheap in Japan.
- Mobile Midhaul (MMH) is applied to mmW.

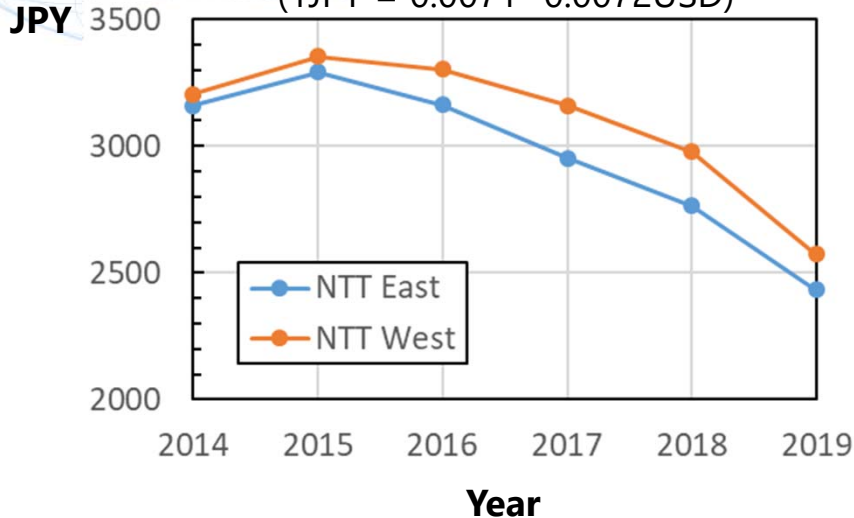


# Fiber sharing technologies for MFH

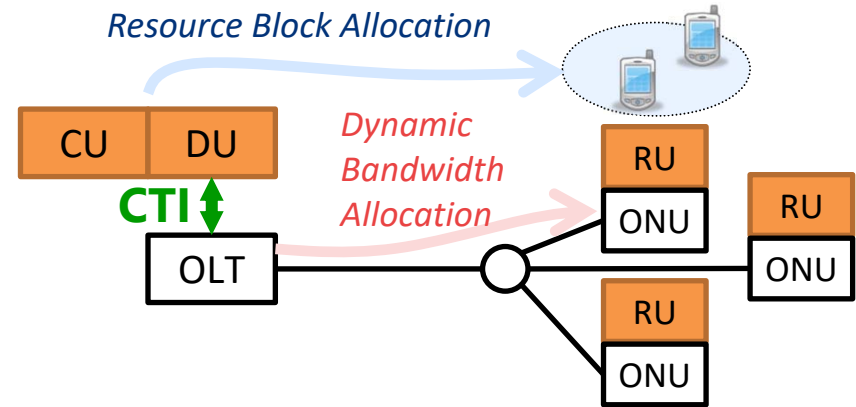
- WDM-PON a candidate but has not been a major solution for MFH so far.
  - The reason is that the dark-fiber price is very cheap (<20 USD per month) in Japan.
- TDM-PON with Cooperative Transport Interface (CTI) seems a good solution in terms of sharing not only the fiber but also the OLT optics.

## Dark-fiber price in Japan

(1JPY = 0.0071~0.0072USD)



## TDM-PON with CTI



- Sharing not only the fiber but also the optics in MFH
- Good solution especially for use cases in which the total bandwidth per OLT is relatively constant (e.g. office floor, department floor).

# 5G evolution and 6G powered by IOWN

- IOWN (Innovative Optical and Wireless Network) is a concept of a new communication platform to realize a smarter world where data, activities and people in different industries will be brought together at around 2030.
  - Innovative network and information processing architecture centered on evolving optical technologies are under study.
- 5G evolution and 6G will be powered by IOWN.

## IOWN Global Forum (IGF) *founded in 2019*

### Key challenges



Lower power consumption by

**100x**



Higher transmission capacity by

**125x**



Lower end-to-end latency by

**200x**

### Founding Members

 intel



 SONY

### Sponsor Members

31 Organizations (Chunghwa Telecom, Orange, Rakuten Mobile, SK Telecom, Ciena, Cisco, Dell Technologies, Ericsson, Fujitsu, Microsoft, NEC, Nokia, etc)

### General Members

57 Organizations

### Academic and Research Members

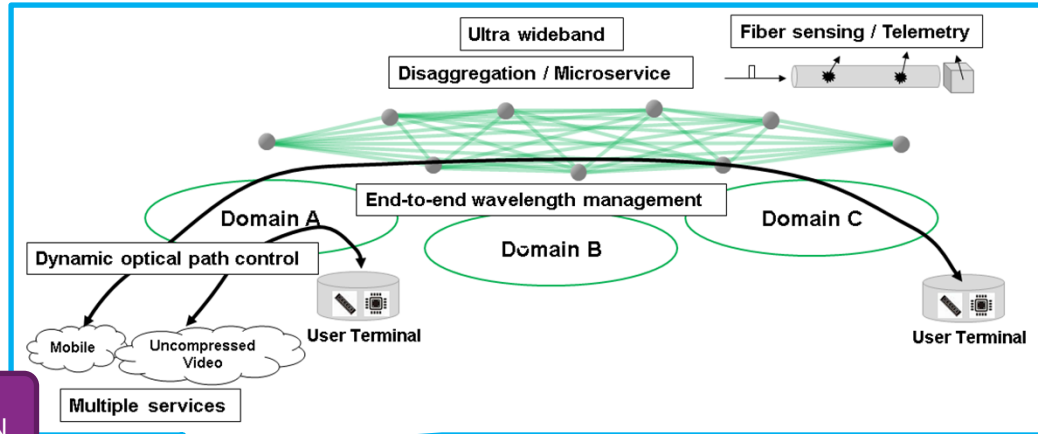
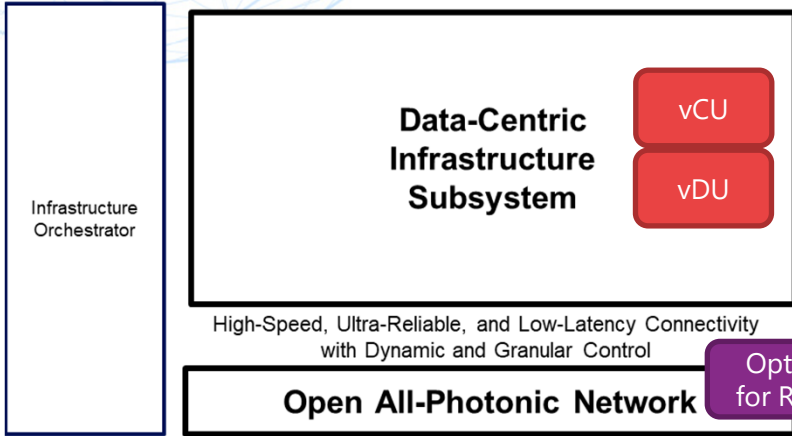
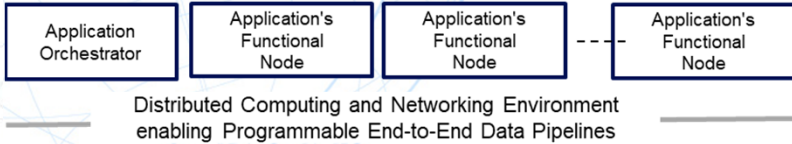
10 Organizations



Ref. Takehiro Nakamura, "5G Evolution and 6G Powered by IOWN," docomo Open House '22, Jan 2022.

# IOWN overall architecture

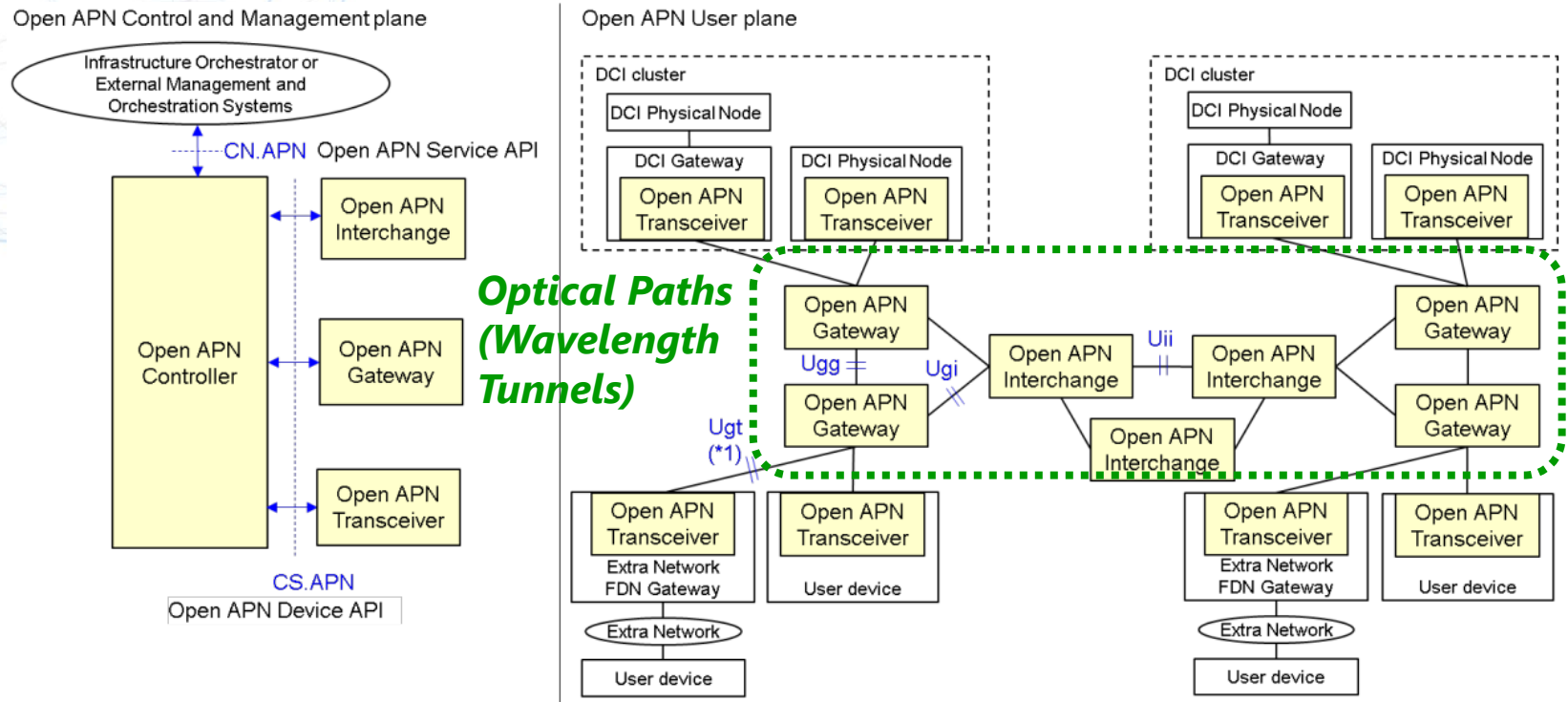
- IOWN Global Forum published “System and Technology Outlook Report” in March 2021, in which the overall architecture comprises **Data-Centric Infrastructure (DCI)** and **Open All-Photonic Network (APN)**.
- Open APN is expected to provide **end-to-end optical connections** through **dynamic control**.



[https://iowngf.org/wp-content/uploads/formidable/21/IOWN-GF-RD-System\\_and\\_Technology\\_Outlook\\_1.0.pdf](https://iowngf.org/wp-content/uploads/formidable/21/IOWN-GF-RD-System_and_Technology_Outlook_1.0.pdf)

# Open APN High-level Reference Architecture

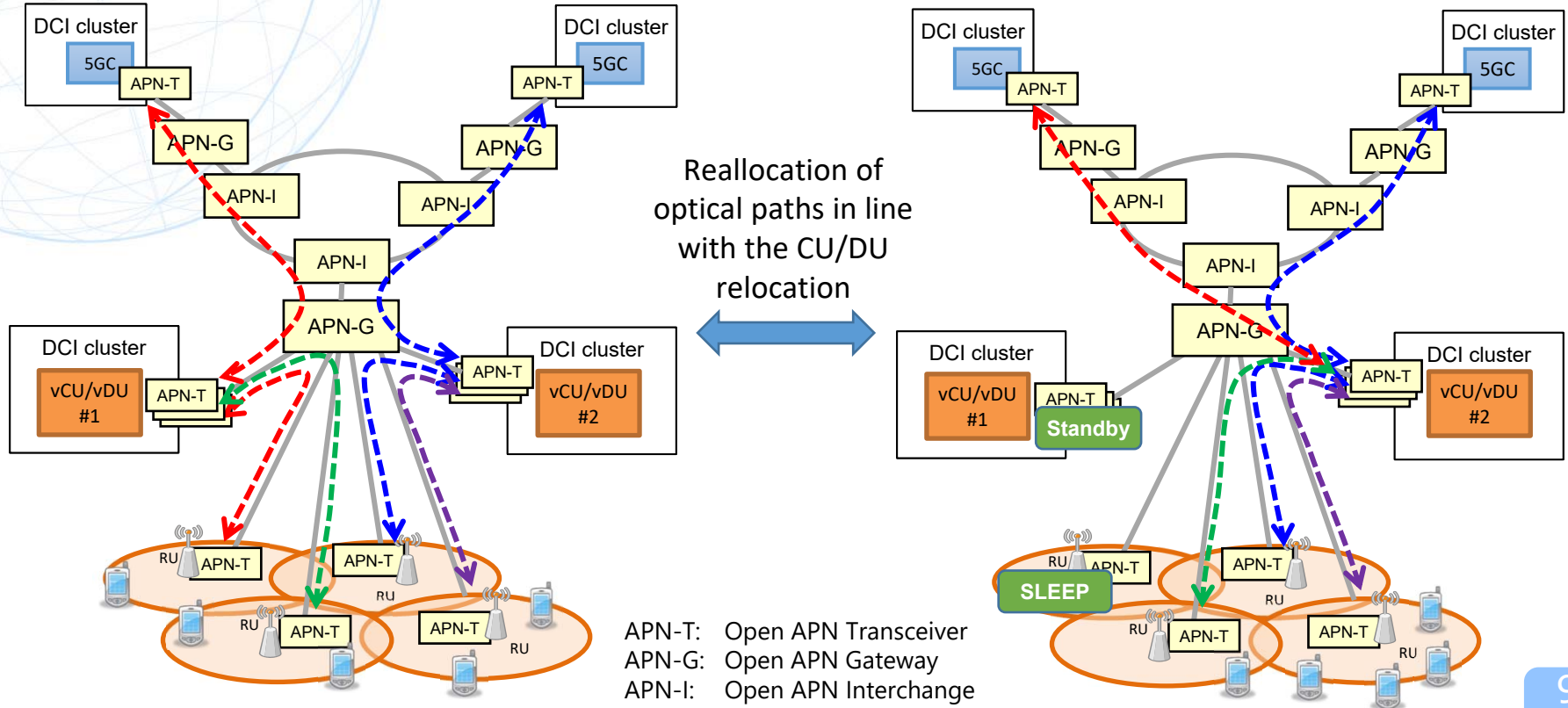
- Open APN comprises Open APN Transceivers (APN-T), Open APN Gateways (APN-G), and Open APN Interchanges (APN-I).
- APN-G and APN-I provides optical paths (i.e. wavelength tunnels)



\*1: Ugt can be a multiple wavelength interface.

# APN for 6G MFH/MBH

- With vCU/vDU, the CU/DU function can be rearranged among multiple sites for various purposes
  - e.g. for performance optimization, energy optimization, and failure protection.
- APN can relocate large-capacity, low-latency optical paths in line with the CU/DU relocation.

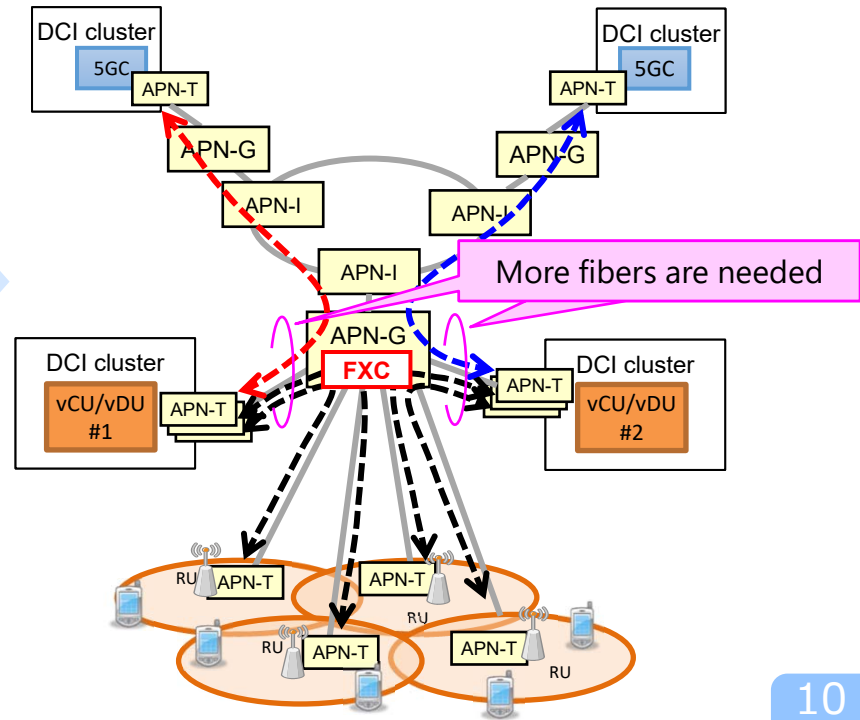
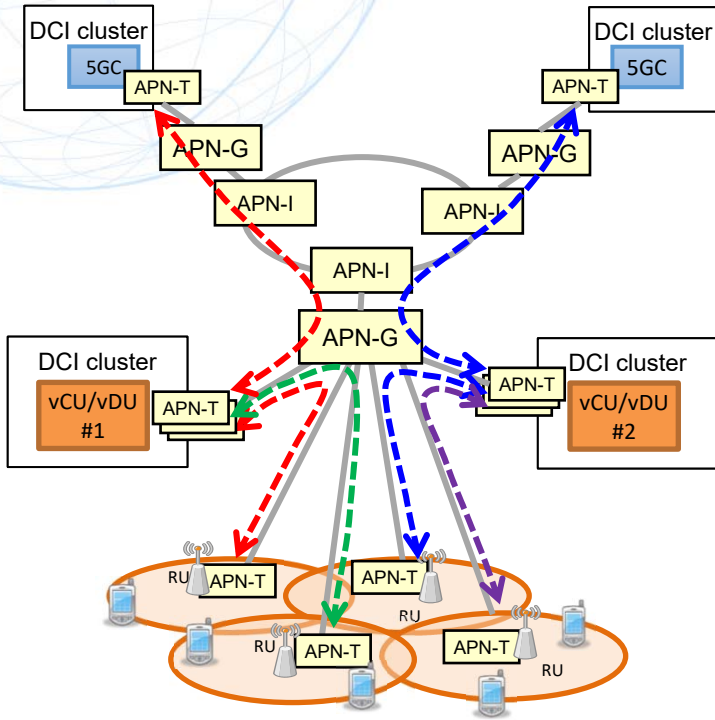


# Introducing Fiber Crossconnect (FXC)

- In the same architecture to allow vCU/vDU reallocation, non-DWDM optics will become available in the MFH sections by introducing a FXC function in (or aside) APN-G.

*K. Honda, et al., "Photonic Gateway for Direct and Protocol-Independent End-to-End User Connections," OFC2021, paper W6A.37.*

- On the other hand, more fibers are needed between APN-G and DCI clusters. Pros and cons depend on the location of DCI clusters.



# Optics for APN-based 6G MFH

- *Discriminator: This is not a consensus of IOWN Global Forum but presenter's personal view.*
- Peak speed: 100 Gbps and over per RU
- Distance: 30 km and over
- Wavelength-tunable (DWDM), or wavelength-fixed (non-DWDM)
- *Single-fiber bidirectional transmission is preferred in access*
  - *For the non-DWDM scenario, BiDi with direct detection seems the most realistic approach*
  - *For the DWDM scenario, how to realize the single-fiber access especially with coherent optics is one of the issues.*
- Point-to-multipoint option to share the wavelength as well as to provide flexibility to adjust the bandwidth
  - XR Optics to share 400 Gbps with the granularity of 25 Gbps seems a good candidate.
  - It may be good to start discussing >100G PON “for RAN” in a relevant industry forum/fora.

Coherent or Direct detection:  
researches needed!

Tunable/DWDM or  
fixed/non-DWDM:  
researches needed!

How to realize PtMP: researches needed!

- **Current State (Optical Access for 5G RAN)**
  - 5G Services using Sub-6 and mmW are growing in Japan.
  - Point-to-point optical access is a major solution for MFH (for Sub-6) and MMH (for mmW) as the dark fiber price is very low in Japan.
- **Possible Evolution Paths (Optical Access for 6G RAN)**
  - 5G Evolution and 6G will be powered by Innovative Optical and Wireless Network (IOWN).
  - IOWN APN will adequately support 6G RAN.
  - Researches are needed for (1) coherent or direct detection, (2) tunable-DWDM or non-DWDM for MFH, and (3) how to realize PtMP.