Super-PON CFI

(skeleton version)

Scale Fully Passive Optical Access Networks to Longer Reaches and to a Significantly Higher Number of Subscribers

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CFI Objectives

- Measure the interest in studying Super-PON Ethernet architectures
- We do not need to:
  - Fully explore the problem
  - Debate strengths and weaknesses of solutions
  - Choose a solution
  - Create a PAR or 5 Criteria
  - Create a standard
- Anyone in the room may vote or speak

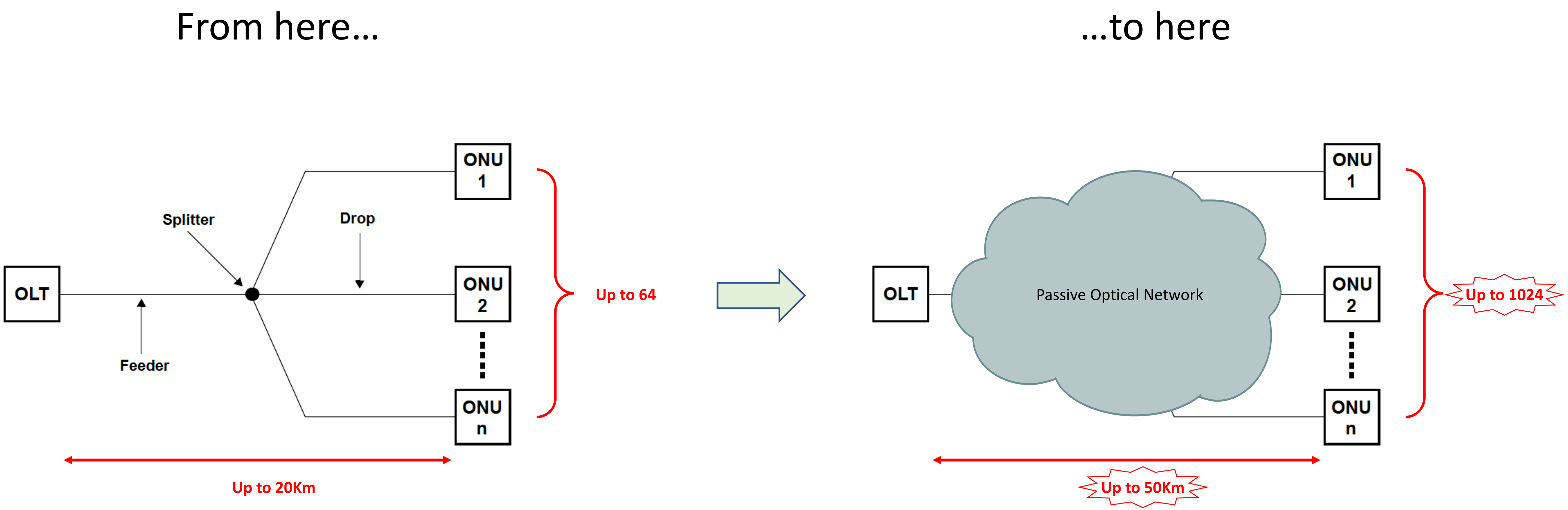
Agenda

- Overview
- Market Need
- Technical Feasibility
- Why Now?
- Straw Polls

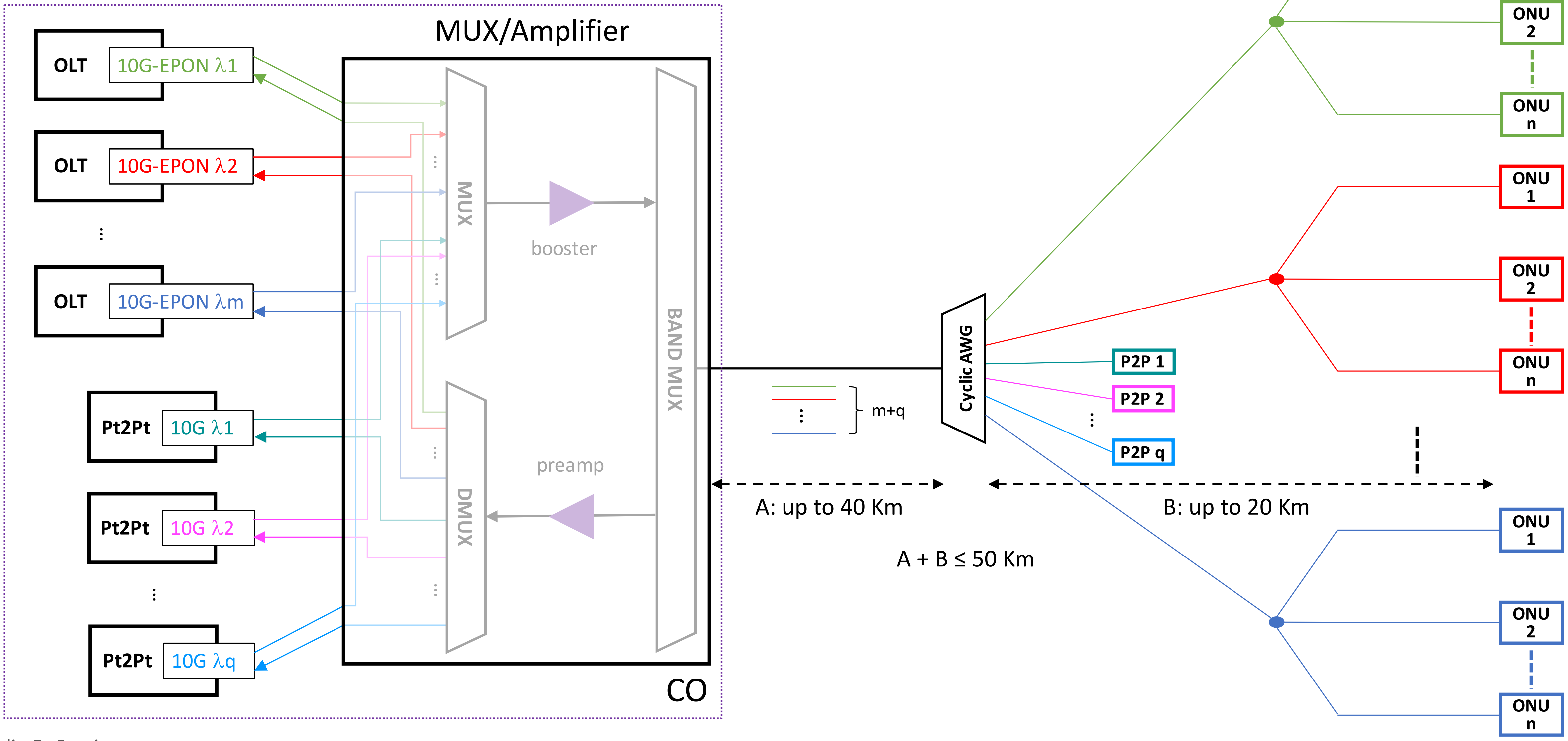
Super-PON: A Different Way to Scale

- Ethernet traditionally scaled (in speed) in powers of 10
- Then 802.3 recognized the need for different scaling factors for different markets/applications
  - And 40Gb/s, 25Gb/s, 50Gb/s, 2.5Gb/s, 5Gb/s, 200Gb/s, 400Gb/s came out
- Super-PON intends to study PON scalability in different dimensions to address different/complementary markets/applications
  - Not in speed (802.3ca is already doing that),
  - But in reach (from ~10-20Km to ~40-50Km) …
  - …and in number of subscribers for fiber strain (from ~64 to ~1024)
- Optimize OSP resources utilization

Super-PON Goal



Super-PON Architecture



Super-PON Summary

- A DWDM system
  - Multiplexes multiple channels over a single feeder fiber
  - Separates the channels with a passive optical router (AWG) in the OSP
  - Supports more (customers) with less (fiber)
- An amplified system
  - Achieves long reach through amplification
  - Single amplifier for all channels to reduce the cost impact
- Supports different types of subscribers
  - Cost effective asymmetric ONUs for residential customers
  - Guaranteed performance symmetric ONUs for business customers

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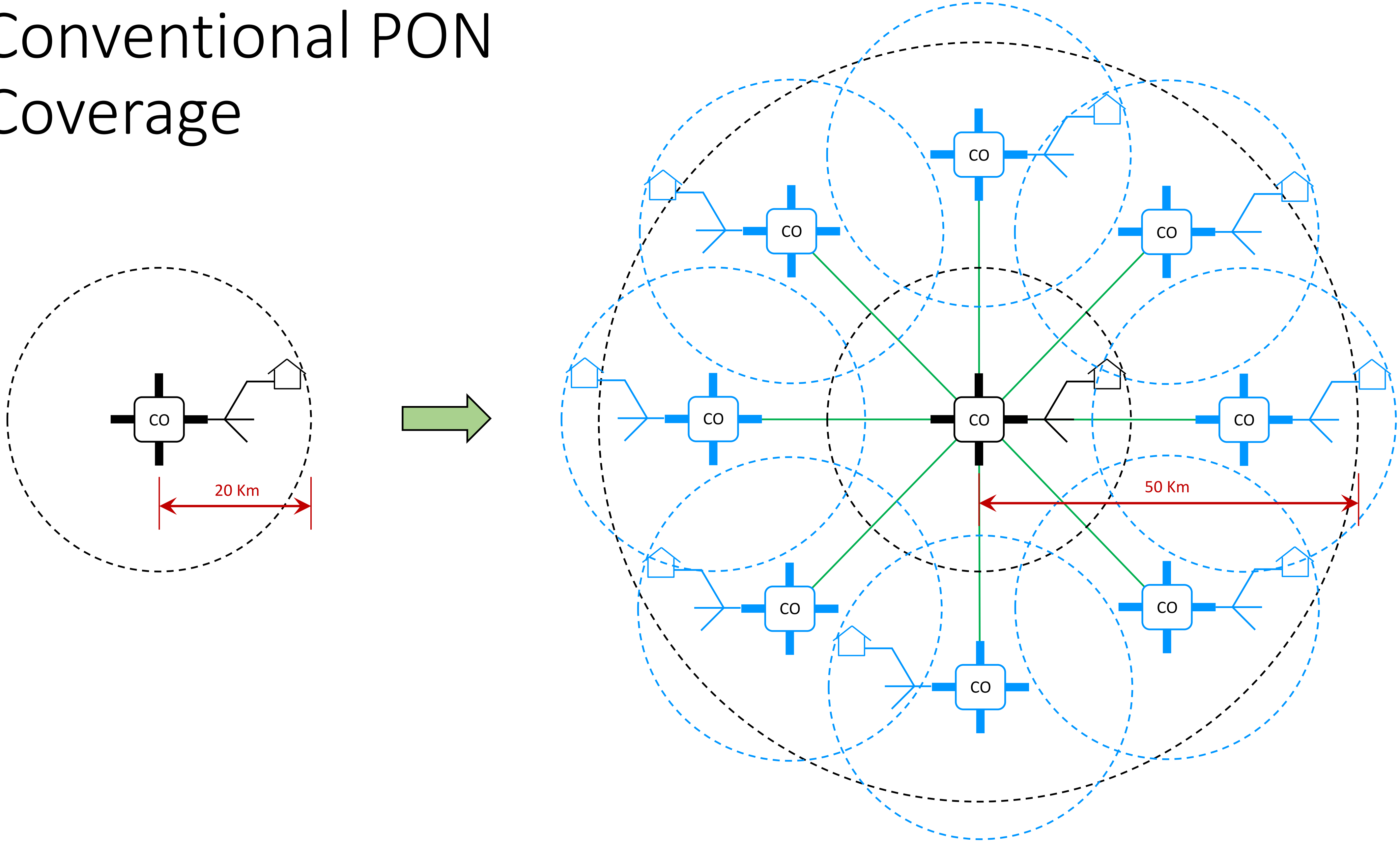
Super-PON Applicability Summary

- Green field:
  - Optical fiber plant build simplification (lower CAPEX and TTM)
  - Support for both residential and point-to-point applications
- Brown field (optical fiber plant already in place):
  - CO consolidation for CORD
  - Re-use existing fiber plant and transform peripheral COs from (managed) active sites to (unmanaged) holders of passive components
  - Increased typical utilization of OLT ports
  - Point-to-Point support for (5G) cellular and specific subscribers
  - OSP expansion (i.e., additional OSP build to complement the existing OSP)

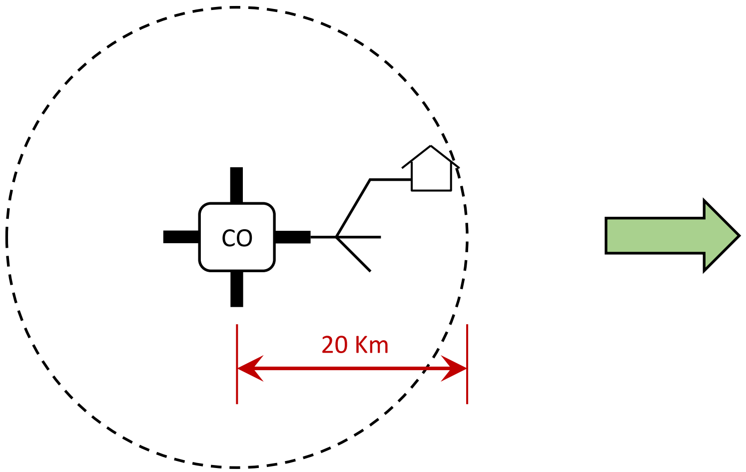
Use Cases

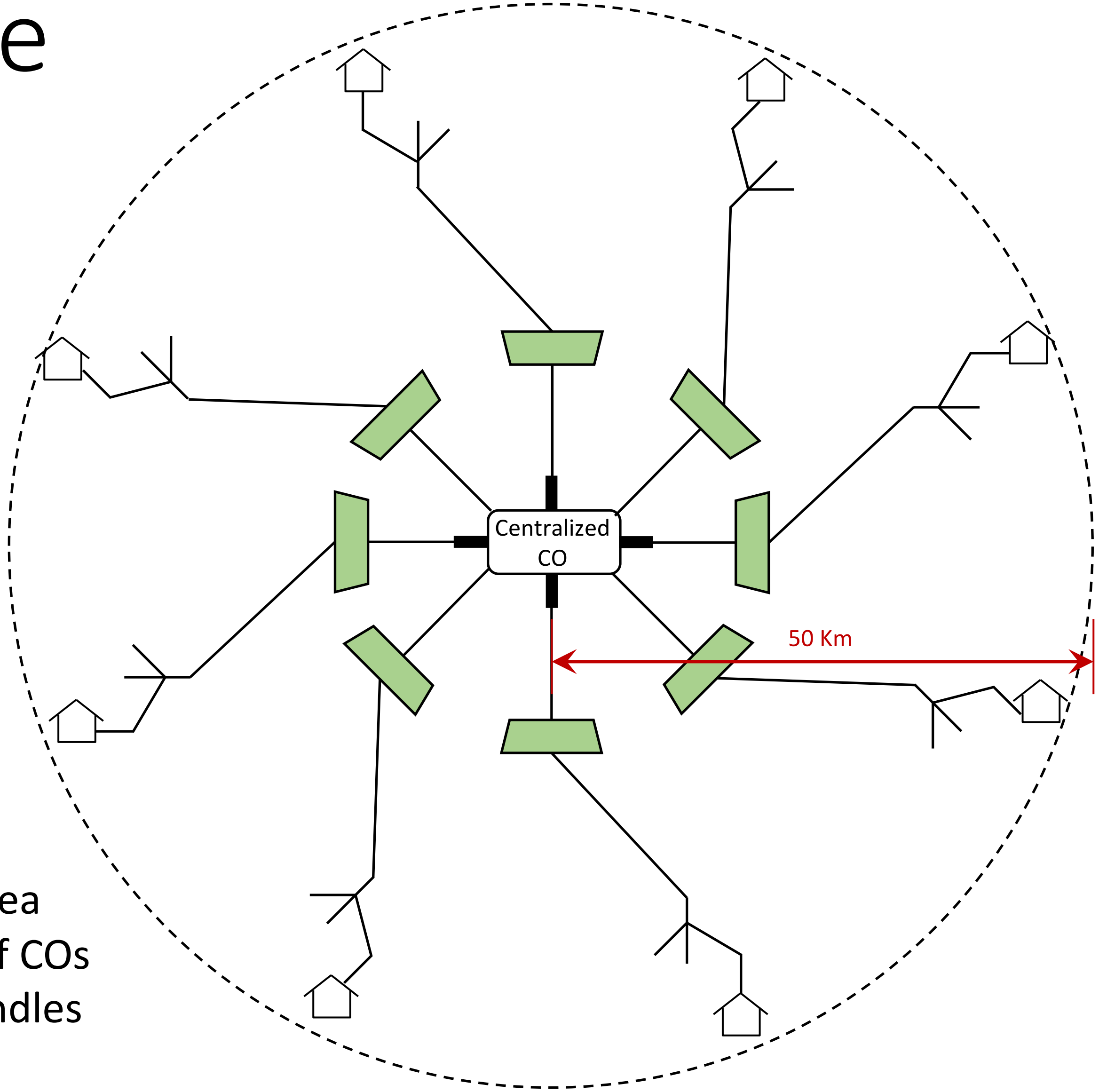
- New optical plants
  - Greenfield case
    - Concentrate active equipment in less central offices
    - Reduce the amount of fiber needed to build an OSP
  - New developments in US
  - Developing countries
- Smart cities
- Support for 5G cellular
- Extended EPON questions
- CO consolidation for CORD deployments
- Fiber shortage

Conventional PON Coverage



Super-PON Coverage

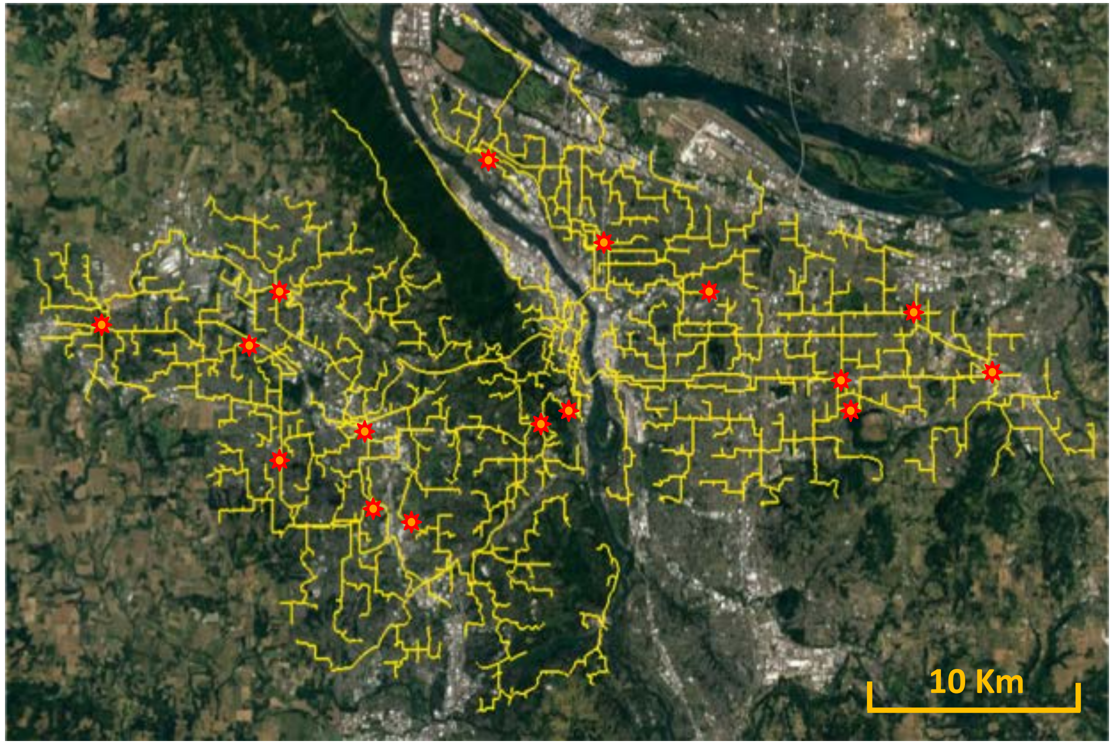




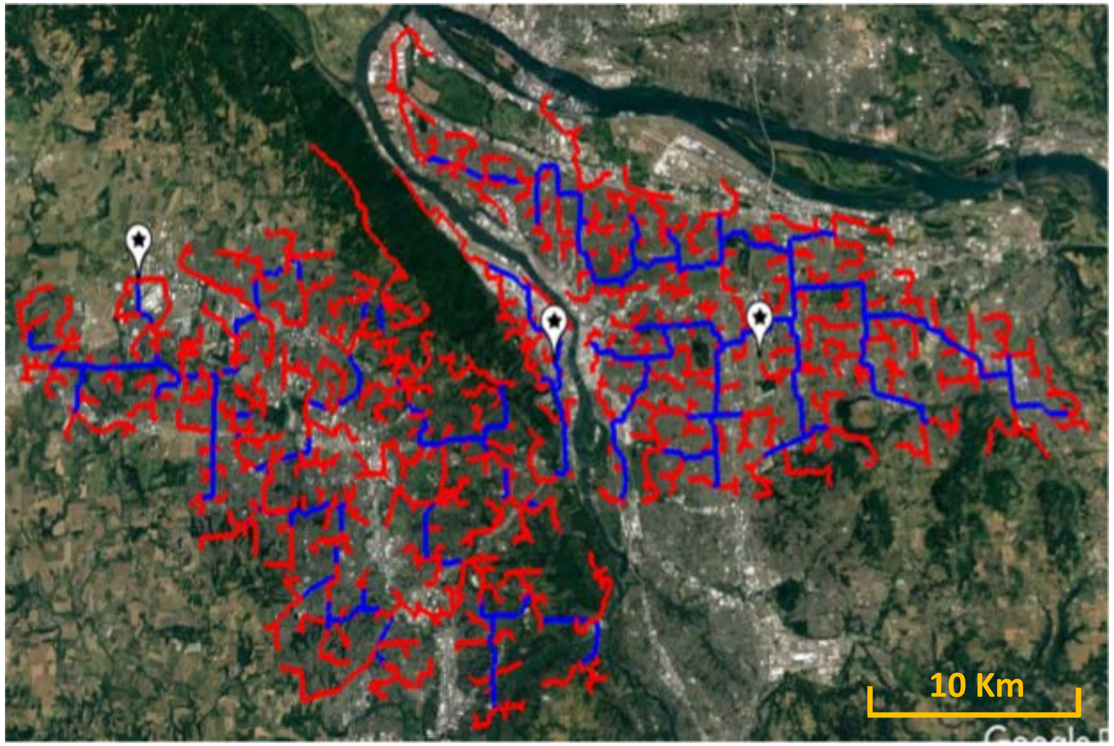
- Larger serving area
- Fewer number of COs
- Smaller fiber bundles

Use Case: Super-PON OSP

Conventional PON: 16 COs



Super-PON: 3 COs



Feeder fiber

CAWG feeder fiber

Splitter feeder fiber

- Significantly smaller number of COs
- Better fiber utilization
  - Much less backbone and feeder fiber
  - Lower OSP building cost

Advantages

- Less fibers needed (DWDM)
  - Enables smaller/fewer cables
    - From 432-fiber cables to 12/48-fiber cables
- Lower OSP building cost
  - Smaller cables can be longer and are easier to bend/handle
  - Allows use of micro-trenching and directional boring techniques
  - Easier to repair
- CO consolidation
  - The same number of feeder fibers can serve a much greater area
  - Less COs → less OPEX

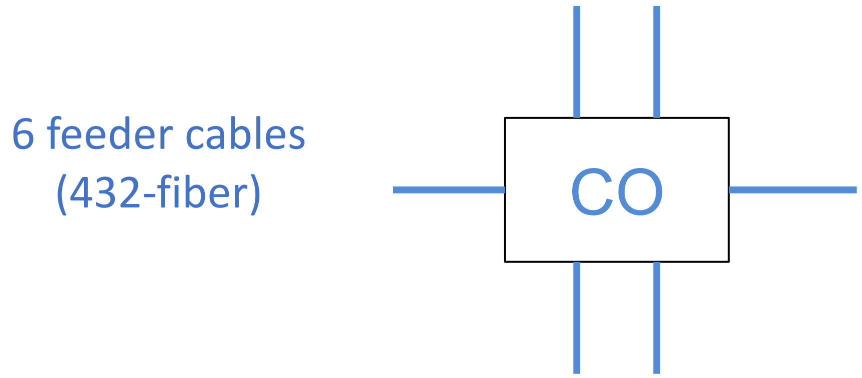
About Trenching…

Traditional Trenching

Micro Trenching

Directional Boring

…and Repairs



A 432-fiber cable:

- Contains 36 ribbons of 12 fibers
- ~10 min to splice a ribbon
- ~6 hours total to splice a broken cable
- Additional ~2 hours for cable manipulation
- Average time to repair a cable damage: ~8 hours

A 24-fiber cable:

- ~40 mins total to splice a broken cable
- Additional ~1 hour for cable manipulation
- Average time to repair a cable damage: ~1 hour 40’

Use Case: US New Real Estate Developments (from Comcast)

- New single family homes are being built now, after the last recession
- This is a greenfield environment where Super-PON is quite interesting

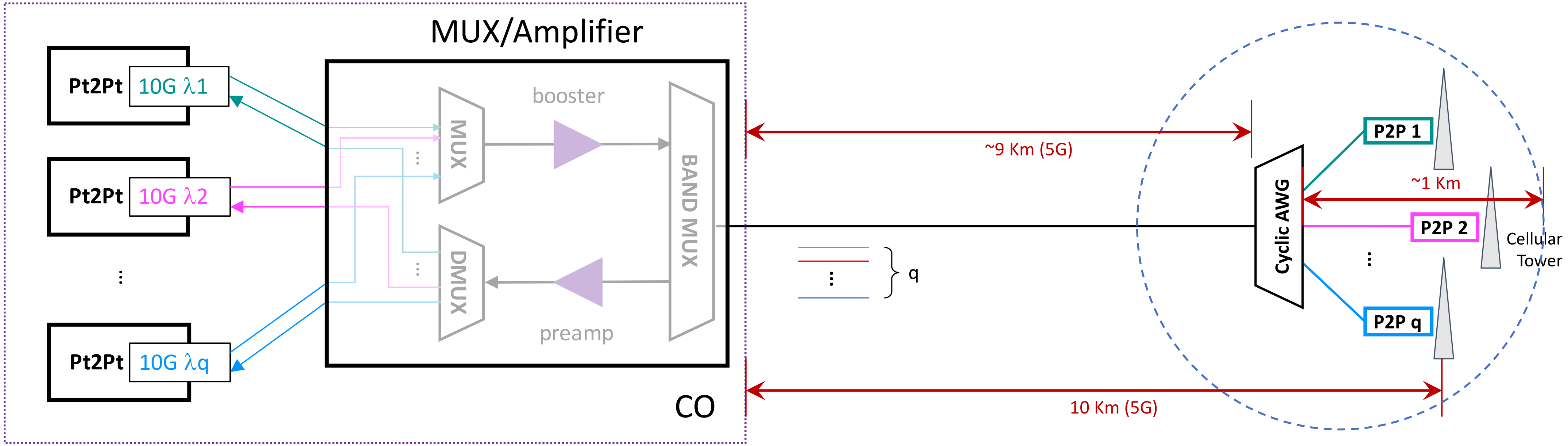
Use Case: Developing Countries

- Developing countries are beginning to plan for fiber access networks
  - E.g., India
- These are greenfield scenarios
  - Super-PON is an interesting option

Use Case: Smart Cities

- Lot and lot of connectivity end-points needed to support the network of sensors and actuators at the basis of:
  - Smart lighting
  - Smart transportation
  - Smart infrastructure
  - Smart IoT devices
  - Smart data
- Need to do more (end-points) with less (fiber strains from the CO)
- Example: Sidewalk Lab project in Toronto, Canada

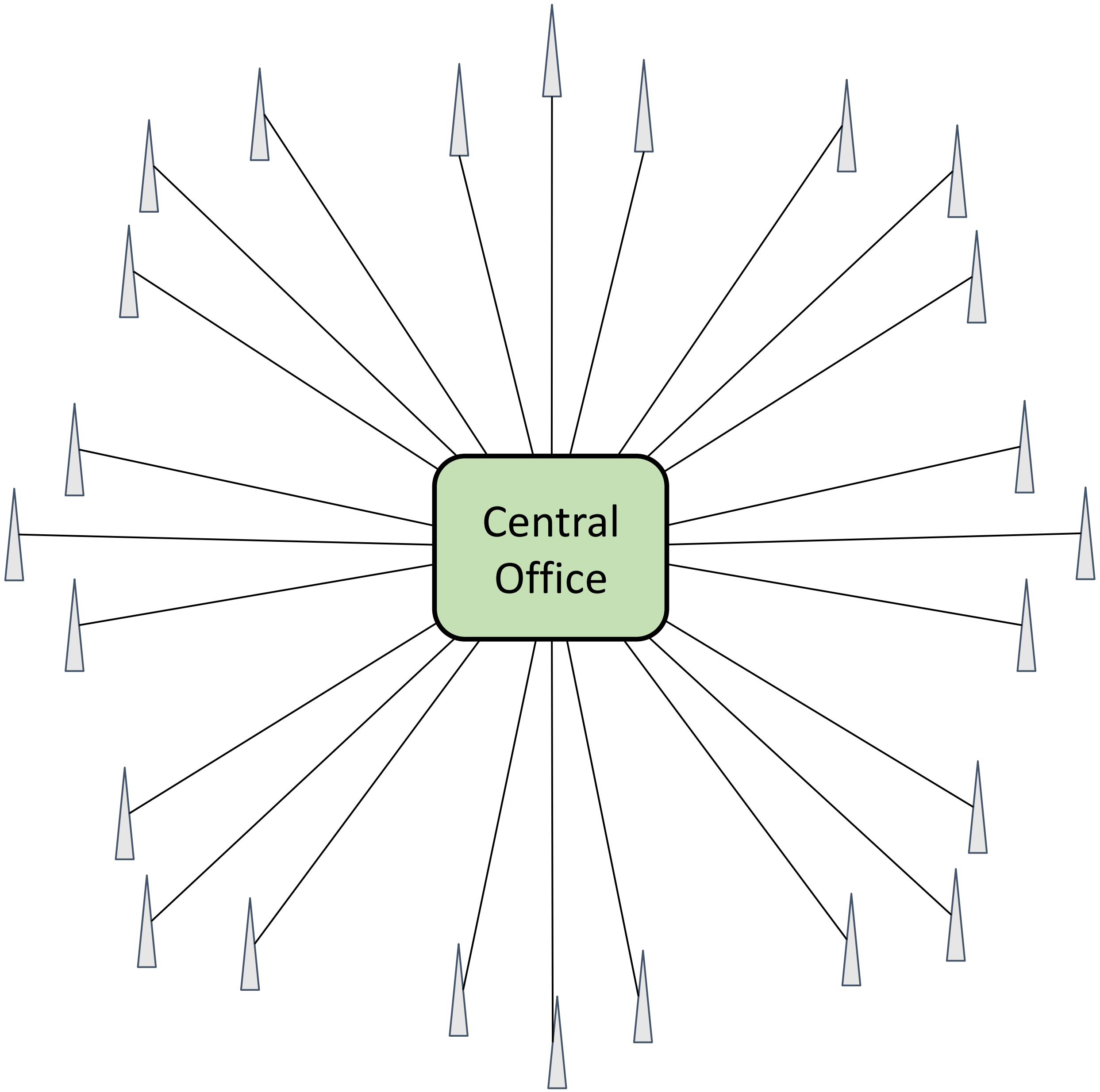
Use Case: 5G Cellular Front-Haul Support



- No 50Km reach (max 10Km for 5G delay requirements)
- Multiplex multiple channels (q) in the CAWG feeder fiber
  - Large deployment radius
- The CAWG serves up to q cellular towers
  - Small deployment radius

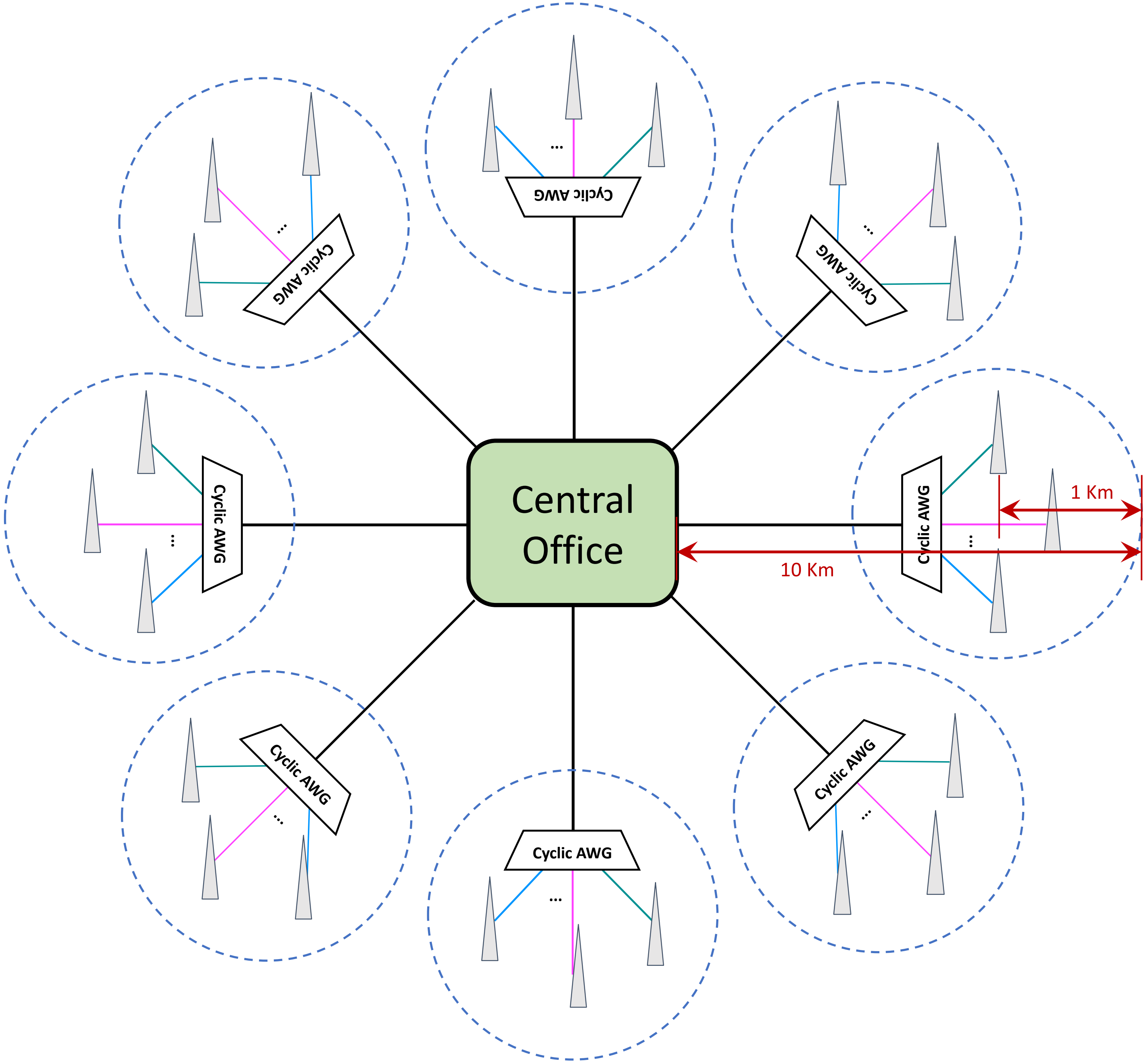
Example of 5G Support

- From here…
  - Each tower needs its own fiber from the central office



Example of 5G Support

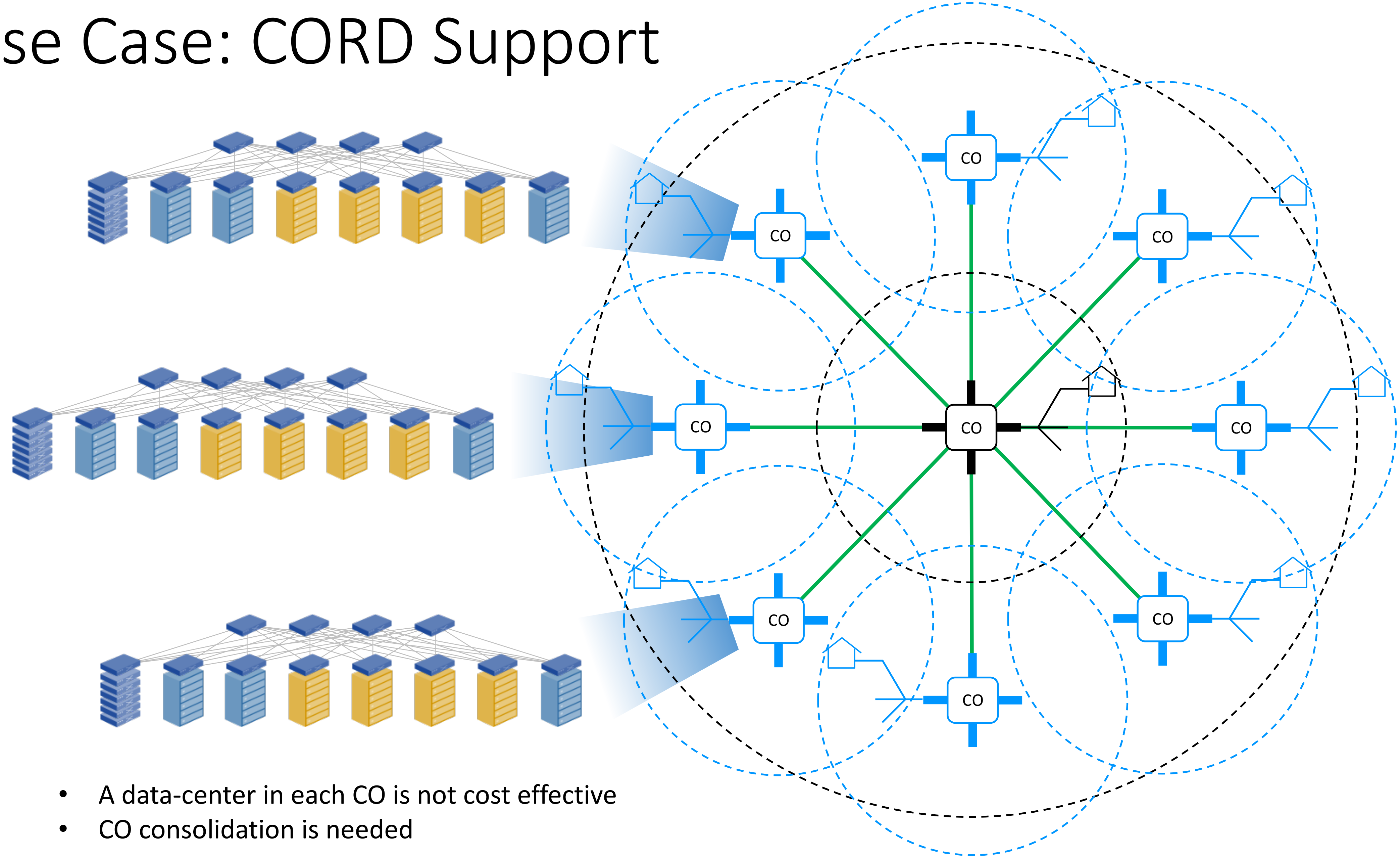
- …to here
  - Leverage Super-PON DWDM to carry multiple channels over one fiber



Extended EPON Questions

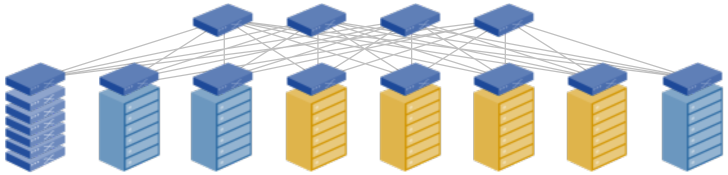
- How to leverage EPON architecture in rural areas
- How to further increase subscriber density in CO
- How to decrease the cost of connection per subscriber
- How to serve more people at larger distance from CO using IEEE 802.3 EPON equipment and avoid proprietary solutions

Use Case: CORD Support

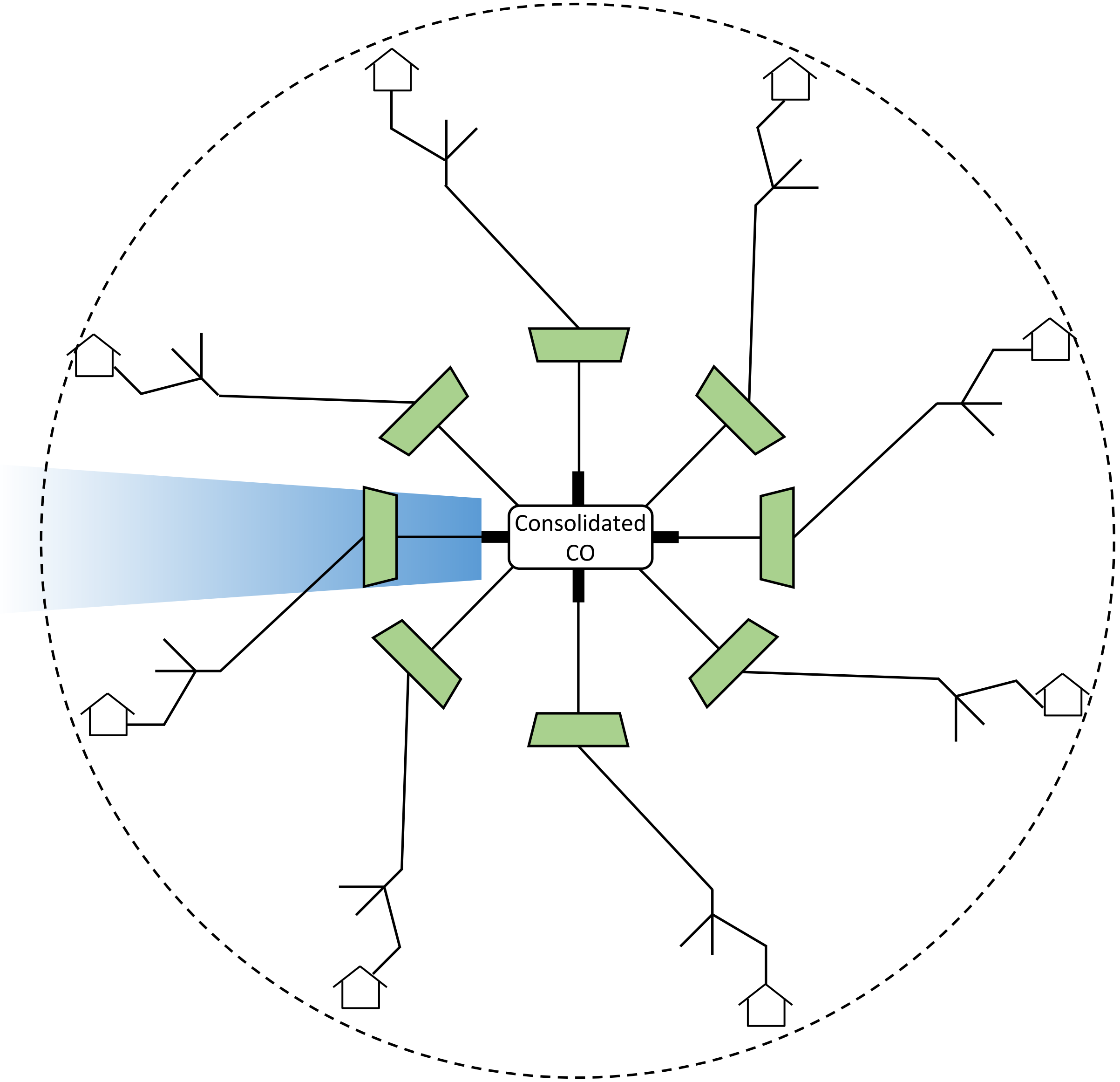


- A data-center in each CO is not cost effective
- CO consolidation is needed

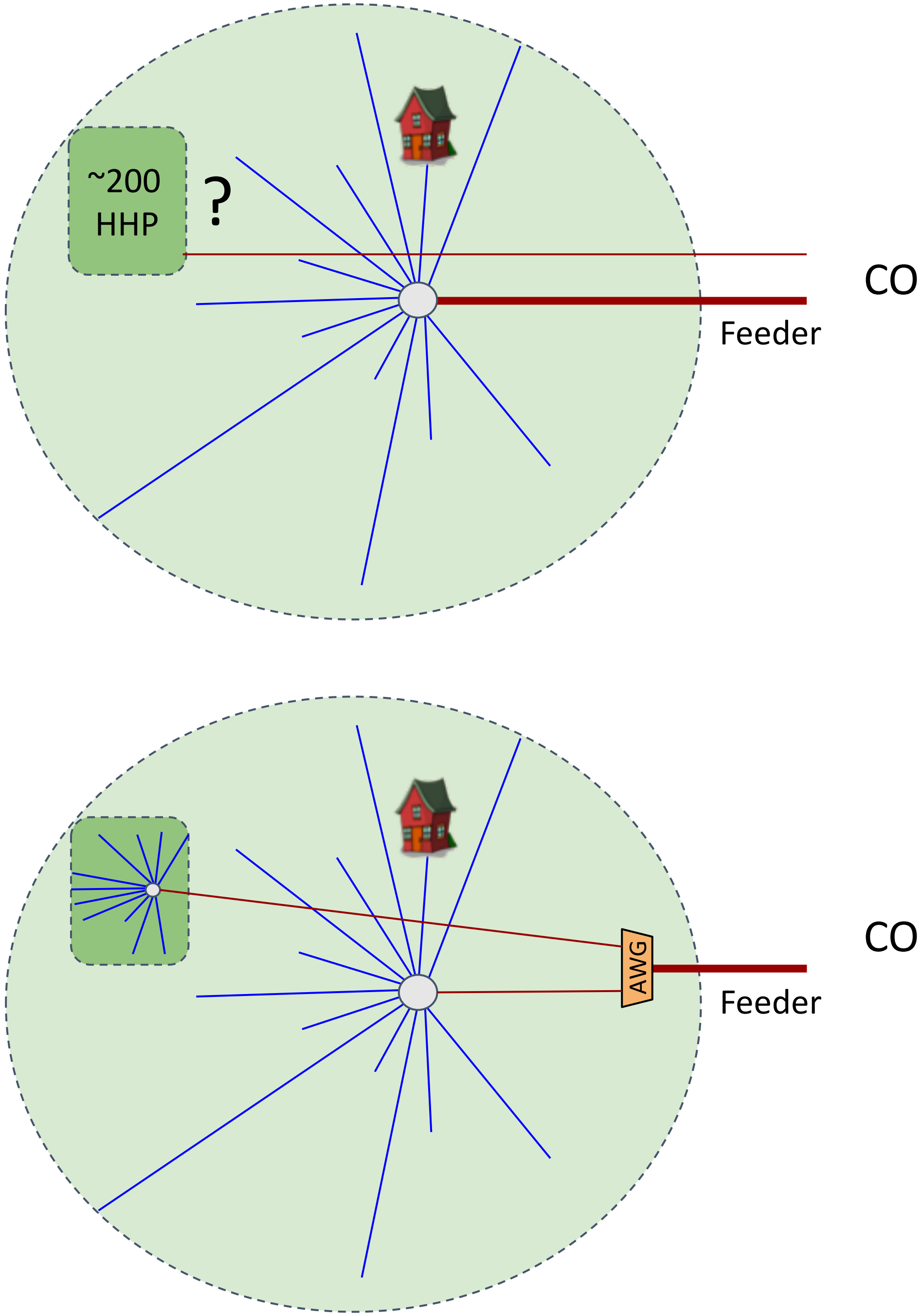
Consolidated CO



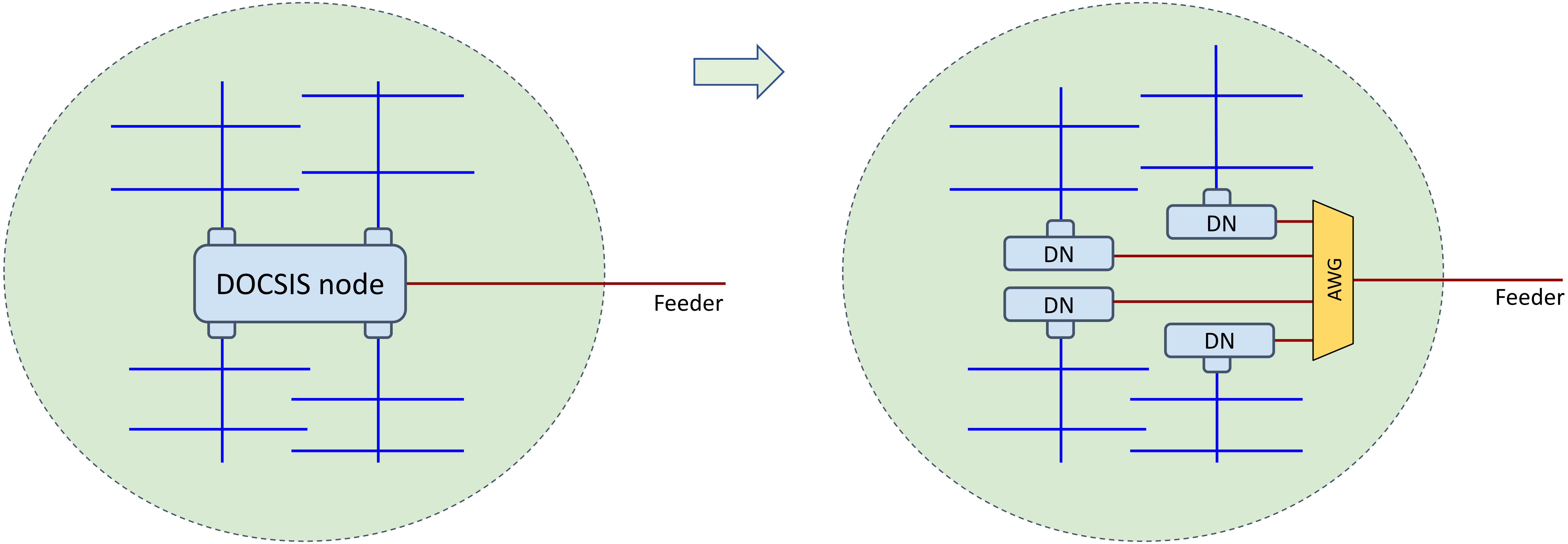
CORD is now cost effective



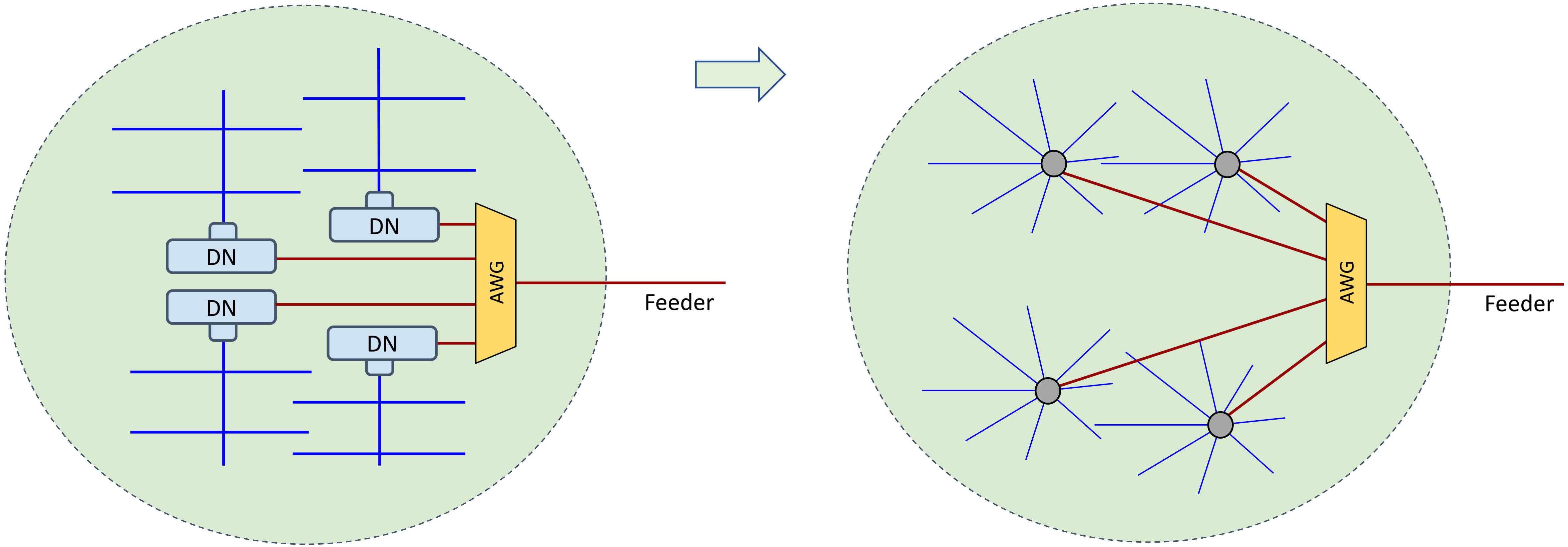
Use Case: Fiber Shortage



Use Case: DOCSIS Node Splitting



Use Case: DOCSIS to FTTH



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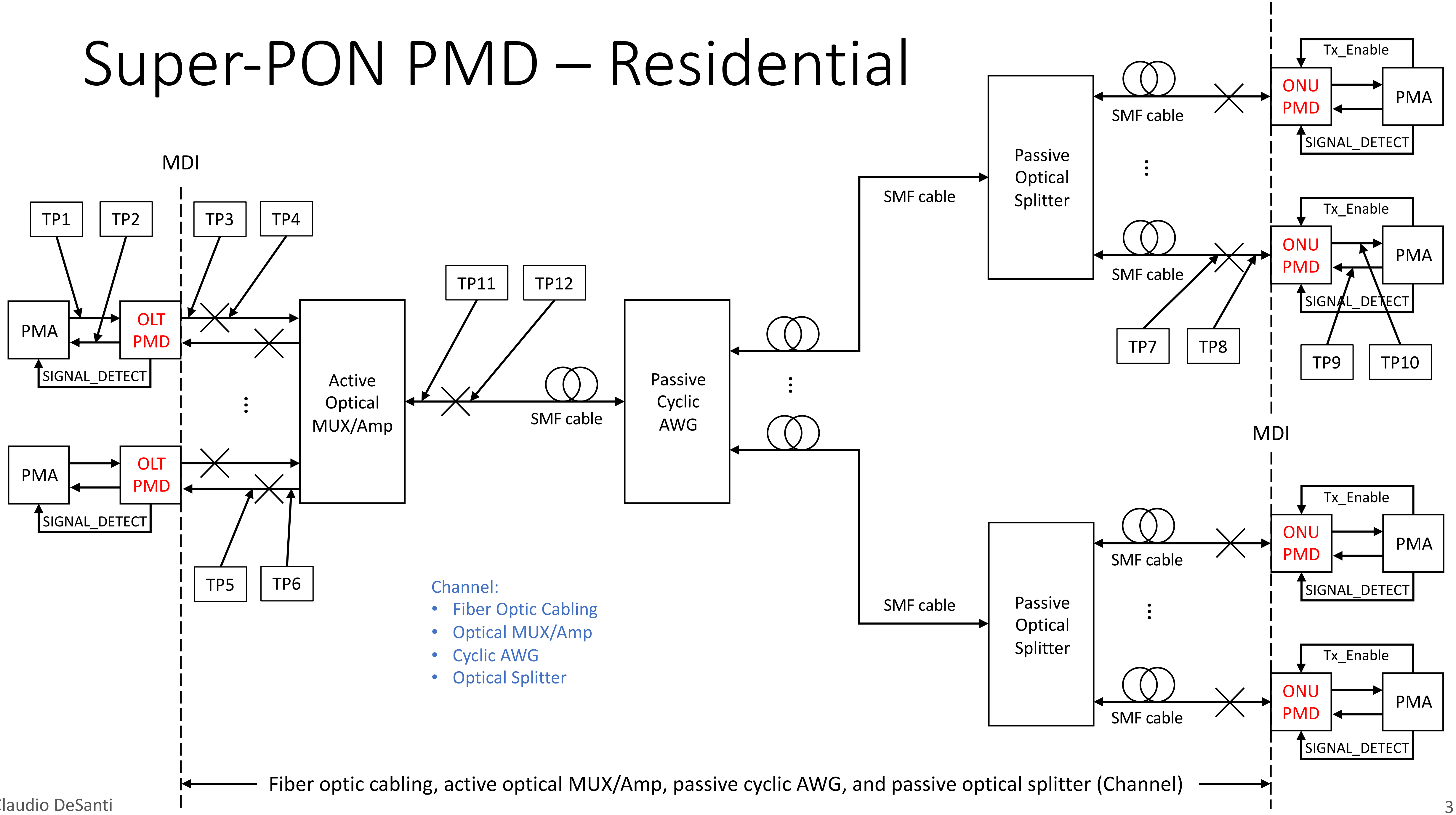
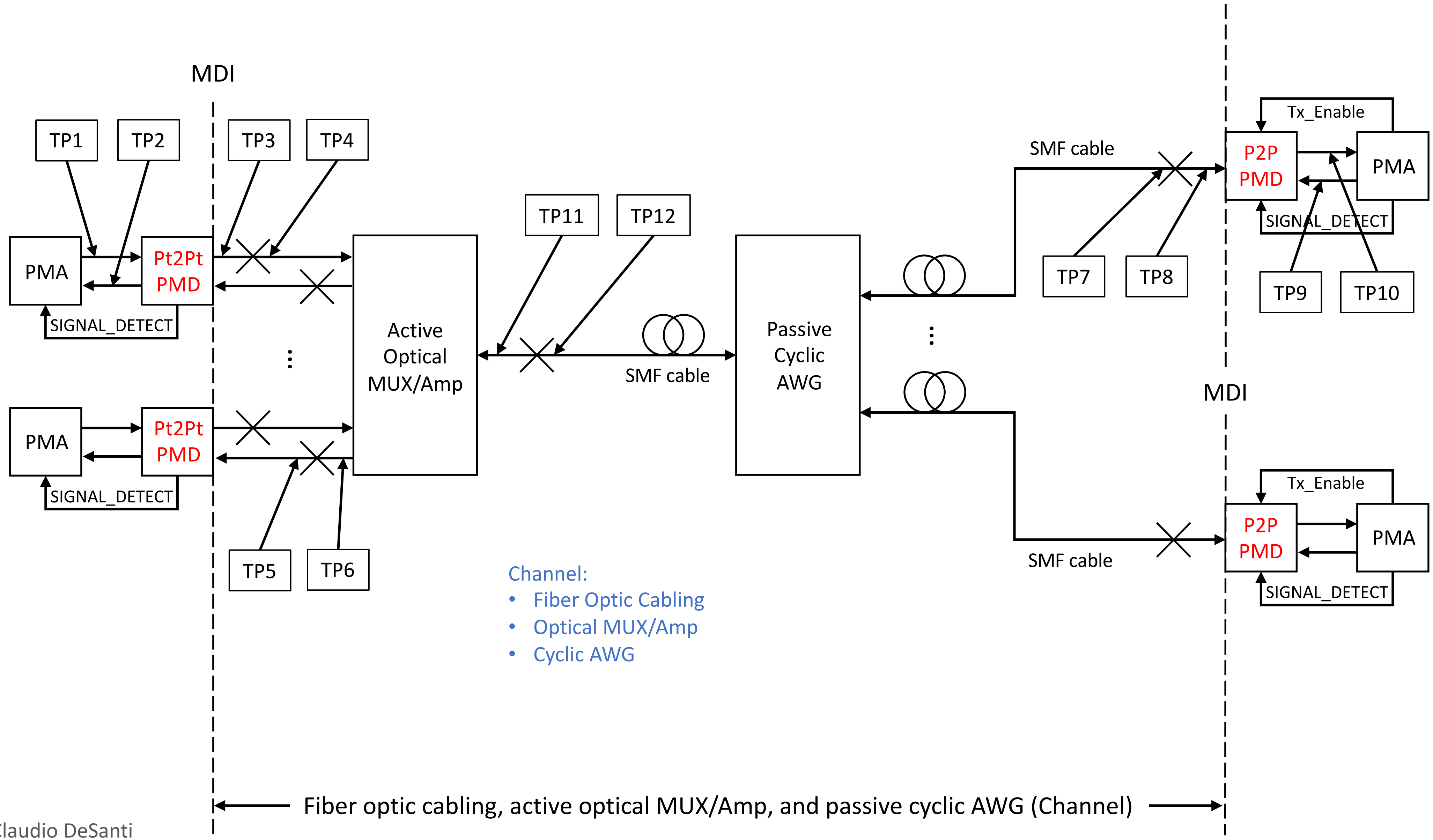
Topics

- Mostly a PMD-only project
  - Similar to 802.3bk
  - The only additional thing could be the possible 2.5G-EPON speed addition
- Low cost tunable lasers
- DWDM (20 channels per fiber)
- MUX/Amp
- Athermal CAWG

Super-PON PMD – Residential



Super-PON PMD – Point to Point



Channel:
- Fiber Optic Cabling
- Optical MUX/Amp
- Cyclic AWG

Speed Considerations

- For residential support, an EML laser in the OLT and a DML laser in the ONU allow:
  - 10Gb/s downstream – 2.5Gb/s upstream
    if the MUX/Amp **does not** contain dispersion compensation
  - 25Gb/s downstream – 10Gb/s upstream
    if the MUX/Amp **does** contain dispersion compensation
- A 10Gb/s downstream – 2.5Gb/s upstream ONU is cost effective for residential users
  - Symmetric point-to-point links allow optimal support for higher speed business users
- Defining 2.5G-EPON upstream is a very doable effort
  - Just downclock 10G-EPON or 25G-EPON
  - Allow XGMII to have different RX_CLK and TX_CLK
  - Assign two bits in the REGISTER_REQ MPCPDU and in the DISCOVERY GATE MPCPDU for discovery
  - Specify the optical PMD parameters
- Enables to leverage for Ethernet the existing 2.5Gb/s GPON optical ecosystem

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Why Now?

- The Software Defined Central Office is getting real
  - CORD is an example
  - Requires CO consolidation to be cost effective
  - Super-PON complements in the access network the consolidation made possible in compute and services by CORD
- Super-PON point-to-point support helps (5G) cellular deployments
- Super-PON is advantageous for new US residential developments
- Developing countries are planning for greenfield fiber networks
- Technology advancements made cooled lasers and tunable cooled lasers more affordable than before
  - Enables narrow DWDM channel bands

Supporters

- …

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Straw Polls

- Should a study group be formed?
- Would I participate in such a Study Group?
- Would my company support participation in such a Study Group?

Thank you