

# Next-generation metro area networks

This questionnaire seeks to obtain data about the current portfolio of physical and link layer technologies, as well as their organizing architectures, in the metro area of telecommunications networks.

It also seeks to identify the direction in which these portfolios and architectures are evolving.

\* Indicates required question

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Graphical overview of questionnaire



## 1. Demographics

1. Please specify the type of network operator you work for (select all relevant categories). \*

*Check all that apply.*

- ☐ Fixed-line telecommunications operator (classical telco)
- ☐ Mobile network operator (MNO)
- ☐ Cable operator (or multiple system operator - MSO)
- ☐ Wireless Internet Service Provider (WISP)
- ☐ Other: \_\_\_\_\_

2. In what region is your company headquartered? \*

*Mark only one oval.*

- ☐ North America
- ☐ Europe
- ☐ Central and South America
- ☐ Asia/Pacific
- ☐ Africa
- ☐ Middle East

3. Please identify your role in your organization. \*

*Check all that apply.*

- ☐ Chief Technical Officer
- ☐ Network Architect
- ☐ Network Engineering
- ☐ Operations: transmission
- ☐ Operations: services
- ☐ Other: \_\_\_\_\_

4. Which of the following best describes your responsibility and involvement in the metro area of telecommunications networks that you work with? \*

*Mark only one oval.*

- ☐ I make the decision, solely or jointly, regarding the metro areas network in my organisation
- ☐ I have significant influence over the metro areas network in my organization.
- ☐ I have some influence over the metro areas network in my organisation
- ☐ I have no influence at all
- ☐ I do not know

The following classifiers regard the number of metro areas which you are able to describe in the subsequent sections.

5. Subscribers in metro areas: North America \*

*Mark only one oval per row.*

	None	1 - 10 metro areas	10 - 100	More than 100
<b>1,000 - 100,000 subscribers</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>100,001 - 500,000 subscribers</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>More than 500,000 subscribers</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

6. Subscribers in metro areas: Europe \*

Mark only one oval per row.

	None	1 - 10 metro areas	10 - 100	More than 100
1,000 - 100,000 subscribers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
100,001 - 500,000 subscribers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
More than 500,000 subscribers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. Subscribers in metro areas: Central and South America \*

Mark only one oval per row.

	None	1 - 10 metro areas	10 - 100	More than 100
1,000 - 100,000 subscribers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
100,001 - 500,000 subscribers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
More than 500,000 subscribers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8.   Subscribers in metro areas: Asia-Pacific \*

Mark only one oval per row.

	None	1 - 10 metro areas	10 - 100	More than 100
<b>1,000 - 100,000 subscribers</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>100,001 - 500,000 subscribers</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>More than 500,000 subscribers</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

9.   Subscribers in metro areas: Africa \*

Mark only one oval per row.

	None	1 - 10 metro areas	10 - 100	More than 100
<b>1,000 - 100,000 subscribers</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>100,001 - 500,000 subscribers</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>More than 500,000 subscribers</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## 10. Subscribers in metro areas: Middle East \*

*Mark only one oval per row.*

	None	1 - 10 metro areas	10 - 100	More than 100
<b>1,000 - 100,000 subscribers</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>100,001 - 500,000 subscribers</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>More than 500,000 subscribers</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## 2. Metro-area Residential Access Subscriptions

## 11. In the metro area, at present, which of the following technologies do you use to serve subscribers?

*Check all that apply.*

- ☐ ADSL2+ (G.992.5)
- ☐ VDSL (G.993.1)
- ☐ VDSL2 (G.993.2)
- ☐ G.fast
- ☐ GPON (ITU-T G.984.1)
- ☐ EPON (IEEE 802.3ah-2004)
- ☐ XG-PON (ITU-T G.987.1)
- ☐ XGS-PON (ITU-T G.9807.1)
- ☐ NG-PON2 (ITU-T G.989)
- ☐ DOCSIS 3.1 & Node + N
- ☐ DOCSIS 3.1 & Fiber Deep
- ☐ DOCSIS 3.1 & + Remote PHY(CM-SP-R-PHY) Node
- ☐ RFoG
- ☐ Active Ethernet (point-to-point (P2P)), less than 1G
- ☐ Active Ethernet (point-to-point (P2P)), 1G
- ☐ Active Ethernet (point-to-point (P2P)), higher than 1G
- ☐ Other: \_\_\_\_\_



12. In the metro area, at present, which of the following serves the largest number of subscribers ?

*Mark only one oval.*

- ☐ ADSL2+ (G.992.5)
- ☐ VDSL (G.993.1)
- ☐ VDSL2 (G.993.2)
- ☐ G.fast
- ☐ GPON (ITU-T G.984.1)
- ☐ EPON (IEEE 802.3ah-2004)
- ☐ XG-PON (ITU-T G.987.1)
- ☐ XGS-PON (ITU-T G.9807.1)
- ☐ NG-PON2 (ITU-T G.989)
- ☐ DOCSIS 3.1 & Node + N
- ☐ DOCSIS 3.1 & Fiber Deep
- ☐ DOCSIS 3.1 & + Remote PHY(CM-SP-R-PHY) Node
- ☐ RFoG
- ☐ Active Ethernet (point-to-point (P2P)), less than 1G
- ☐ Active Ethernet (point-to-point (P2P)), 1G
- ☐ Active Ethernet (point-to-point (P2P)), higher than 1G
- ☐ Other: \_\_\_\_\_

13. In the metro area, which of the following is gaining subscribers at the fastest rate?

*Mark only one oval.*

- ☐ ADSL2+ (G.992.5)
- ☐ VDSL (G.993.1)
- ☐ VDSL2 (G.993.2)
- ☐ G.fast
- ☐ GPON (ITU-T G.984.1)
- ☐ EPON (IEEE 802.3ah-2004)
- ☐ XG-PON (ITU-T G.987.1)
- ☐ XGS-PON (ITU-T G.9807.1)
- ☐ NG-PON2 (ITU-T G.989)
- ☐ DOCSIS 3.1 & Node + N
- ☐ DOCSIS 3.1 & Fiber Deep
- ☐ DOCSIS 3.1 + Remote PHY(CM-SP-R-PHY) Node
- ☐ RFoG
- ☐ Active Ethernet (point-to-point (P2P)), less than 1G
- ☐ Active Ethernet (point-to-point (P2P)), 1G
- ☐ Active Ethernet (point-to-point (P2P)), higher than 1G
- ☐ Other: \_\_\_\_\_

### 3. Metro-Area Commercial Access Subscriptions

14. "Service Providers are deploying Carrier Ethernet services around the globe, in large part, because Carrier Ethernet has compelling capabilities such as standardized service definitions as well as improved scalability, reliability, QoS, and manageability." (BBF TR-224). In terms of number of installed UNIs subject to QoS SLA (non-best-effort), is Carrier Ethernet your most adopted service?

*Mark only one oval.*

- ☐ Yes
- ☐ No

15. If you have answered "no" to the previous question, please indicate what your most adopted access service subject to SLA is.
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#### 4. Access Architecture

16. What is the time range within which you plan to virtualize all your access nodes (vOLT vs OLT, vCMTS vs CMTS) and/or cell-site access devices (disaggregated cell site gateway (DCSG) vs cell-site router (CSR)) ?

*Mark only one oval.*

- ☐ Already virtualized
- ☐ Within 1 year
- ☐ Within 5 years
- ☐ No plans to fully virtualize
- ☐ Other: \_\_\_\_\_

The following question on DAA concerns classical telcos as well as MSOs

17. Which distributed access architecture (DAA) option(s) are you planning for new deployments and replacement deployments?

*Check all that apply.*

- ☐ Remote OLT
- ☐ Depends on several factors, but leaning towards Remote OLT where possible
- ☐ Remote MACPHY Node (RMN)
- ☐ Depends on several factors, but leaning toward RMN where possible
- ☐ Remote PHY Node (RPN)
- ☐ Depends on several factors, but leaning toward RPN where possible
- ☐ Currently comparing options, but plan to deploy within five years
- ☐ Not planning to deploy any DAA option
- ☐ Other: \_\_\_\_\_

The following question on DAA concerns classical telcos as well as MSOs

18. Do you plan DAA to serve the majority of your households passed (when compared with centralized access forms such as centralized OLT and integrated CCAP)?

*Mark only one oval.*

- ☐ Yes, within 2 years
- ☐ Yes, within 5 years
- ☐ Only in greenfield deployments
- ☐ No, not planning to make DAA the majority access architecture
- ☐ Other: \_\_\_\_\_

19. Do you consider use of DOCSIS 4.0 in conjunction with DAA to be a step in migration towards PON?

*Mark only one oval.*

- ☐ Yes
- ☐ No
- ☐ Other: \_\_\_\_\_

20. Has support for N+5 distributions in DOCSIS 4.0 FDX influenced your plan to phase out N+3 and N+5 distributions?

*Mark only one oval.*

- ☐ Yes
- ☐ No
- ☐ Undecided
- ☐ Other: \_\_\_\_\_

21. Availability of electrical power in the DOCSIS portion of the access network supports the implementation of MEC nodes. Is this motive a significant factor in favour of retaining DOCSIS and DAA instead of migrating towards PON ?

*Mark only one oval.*

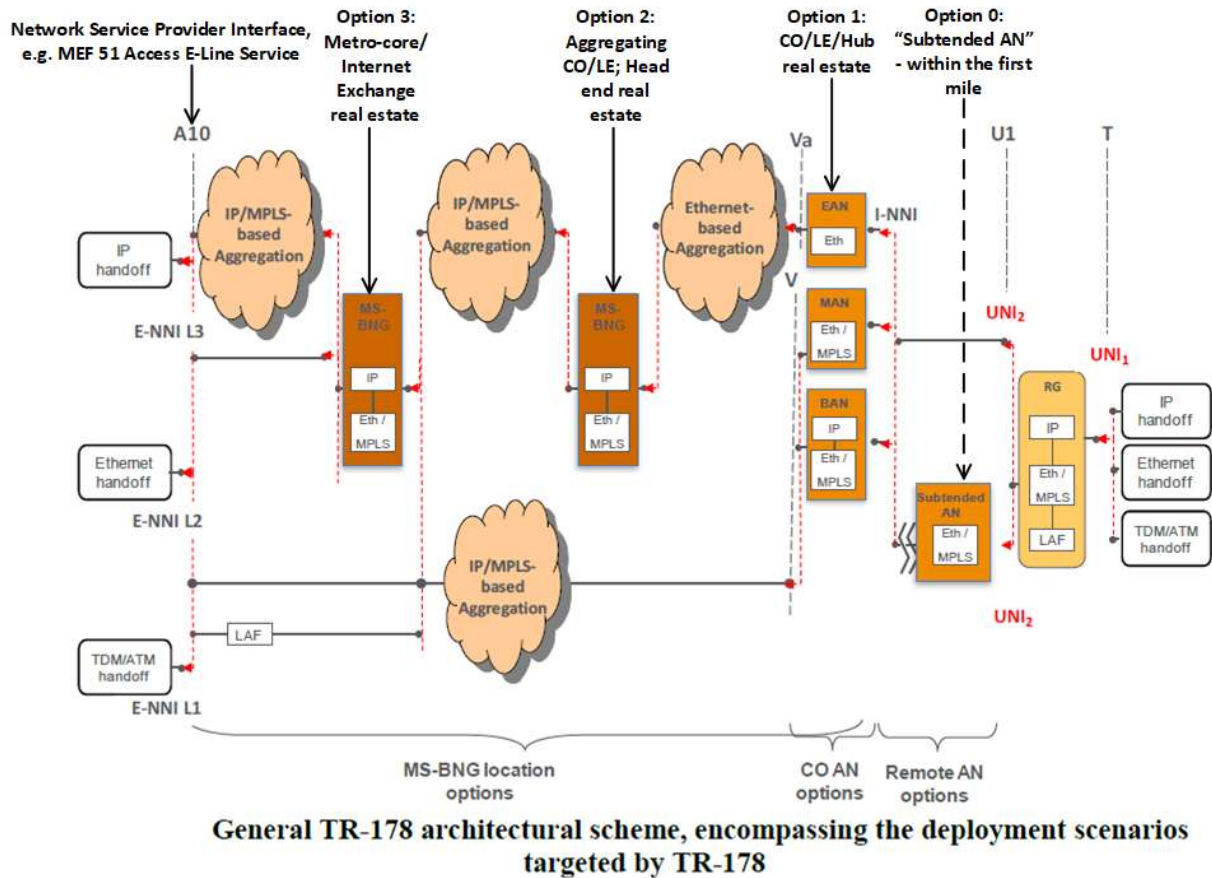
- ☐ Yes
- ☐ No
- ☐ Other: \_\_\_\_\_

22. "Active [(powered)] access nodes are good candidates for locating MEC nodes". In particular, remote access nodes (close to the subscriber - see Option 0 in Fig. 1 below) enable lower latency, lower jitter communication with compute and storage facilities. Do you plan to deploy remote access nodes to enable MEC services?

*Mark only one oval.*

- ☐ Already deployed and plan to keep on deploying
- ☐ Within 1 year
- ☐ Within 5 years
- ☐ No plans to deploy remote access nodes
- ☐ Other: \_\_\_\_\_

Fig. 1: Service edge deployment options, laid over TR-178 general architectural scheme



23. Currently, where do you see scope for deployment of Active Ethernet (P2P) ?

Check all that apply.

- ☐ For cellular xHaul
- ☐ For enterprise subscribers
- ☐ In multi-dwelling units, office parks and other similar dense serving areas
- ☐ Other: \_\_\_\_\_

## 5. 5G RAN deployment and slicing

24. For x-haul at macro cell sites, what type of network service have you deployed/purchased most commonly?

*Mark only one oval per row.*

	MEF service (EPL, EVPL, EP- Tree, EVP- Tree, EP- LAN, EVP- LAN)	MPLS service (VPWS, VPLS, BGP- based EVPN)	PON ONU	Wavelength	Dark fibre	Wireless	Other
<b>Fronthaul</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Midhaul</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

25. If you have indicated "other" in the previous question, please indicate the type of network service.

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26. For fronthaul at small cell sites/fixed wireless access, what type of network service have you deployed most commonly?

*Mark only one oval.*

- ☐ MEF service, (EPL, EVPL, EP-Tree, EVP-Tree, EP-LAN, EVP-LAN)
- ☐ MPLS service (VPWS, VPLS, BGP-based EVPN)
- ☐ PON ONU
- ☐ Wavelength
- ☐ Dark fibre
- ☐ Other: \_\_\_\_\_

27. In your role as a carrier (if applicable), have you deployed disaggregated cell-site gateways (DCSGs)?

*Mark only one oval.*

- ☐ Yes, to support RAN sharing for mobile virtual network operators (MVNOs)
- ☐ Yes, for network slicing
- ☐ Yes, for both RAN sharing and network slicing
- ☐ No
- ☐ Not applicable

28. In your role as an MNO (if applicable), have you used disaggregated cell-site gateways (DCSGs)?

*Check all that apply.*

- ☐ Yes, owned them, to provide RAN sharing to mobile virtual network operators (MVNOs)
- ☐ Yes, as a service provided by a carrier, to provide RAN sharing to MVNOs
- ☐ Yes, owned them, to support network slicing in tandem with the x-haul operator
- ☐ Yes, owned them, as L3VPN endpoints for front- / mid- / back- haul.
- ☐ Yes, as a service provided by a carrier, as L3VPN endpoints for front- / mid- / back-haul.
- ☐ Other: \_\_\_\_\_

## 6. Aggregation

The next four questions are concerned with understanding current and future dominant forms of packet aggregation (layer 2 and layer 2.5).



29. At present, which form of layer 2 (or greater) aggregation of customer traffic from access node (V reference point) to service edges dominates?

*Mark only one oval.*

- ☐ Provider Bridging (PB) Q-in-Q (service and customer tags), without MPLS
- ☐ Seamless MPLS transport
- ☐ Segmented (as opposed to seamless) MPLS transport
- ☐ PB Q-in-Q closer to the access, with MPLS transport rest of the way back to the service edge
- ☐ Other: \_\_\_\_\_

30. For aggregation of customer traffic from access node (V reference point) to service edges, which form would you tend to prefer for current and future deployments?

*Mark only one oval.*

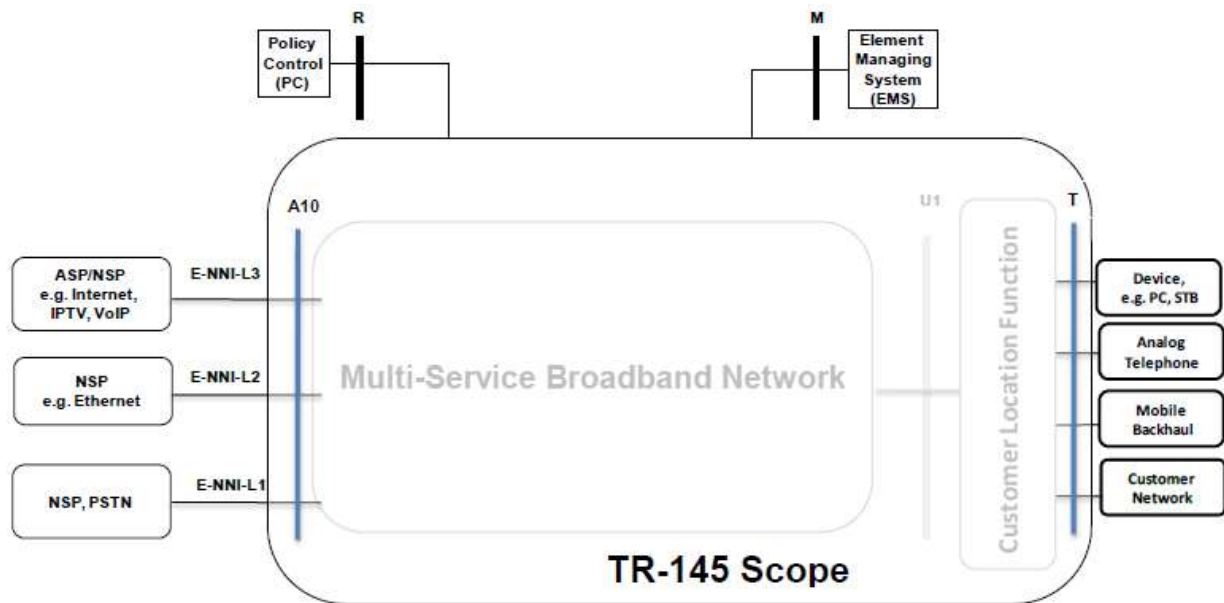
- ☐ Provider Bridging (PB) Q-in-Q (service and customer tags), without MPLS
- ☐ Seamless MPLS transport
- ☐ Segmented (as opposed to seamless) MPLS transport
- ☐ PB Q-in-Q closer to the access, with MPLS transport rest of the way back to the service edge
- ☐ Other: \_\_\_\_\_

31. Do you support the Ethernet Service Layer between the U1 and A10 reference points (see Fig. 2, below) ?

*Mark only one oval.*

- ☐ Yes
- ☐ No
- ☐ Other: \_\_\_\_\_

Fig. 2: BBF TR-145 - scope of reference architecture for multi-service broadband networks



32. If you answered yes to the previous question, is the Ethernet Service Layer your preferred means of layer 2 aggregation (see Fig. 3, below) ?

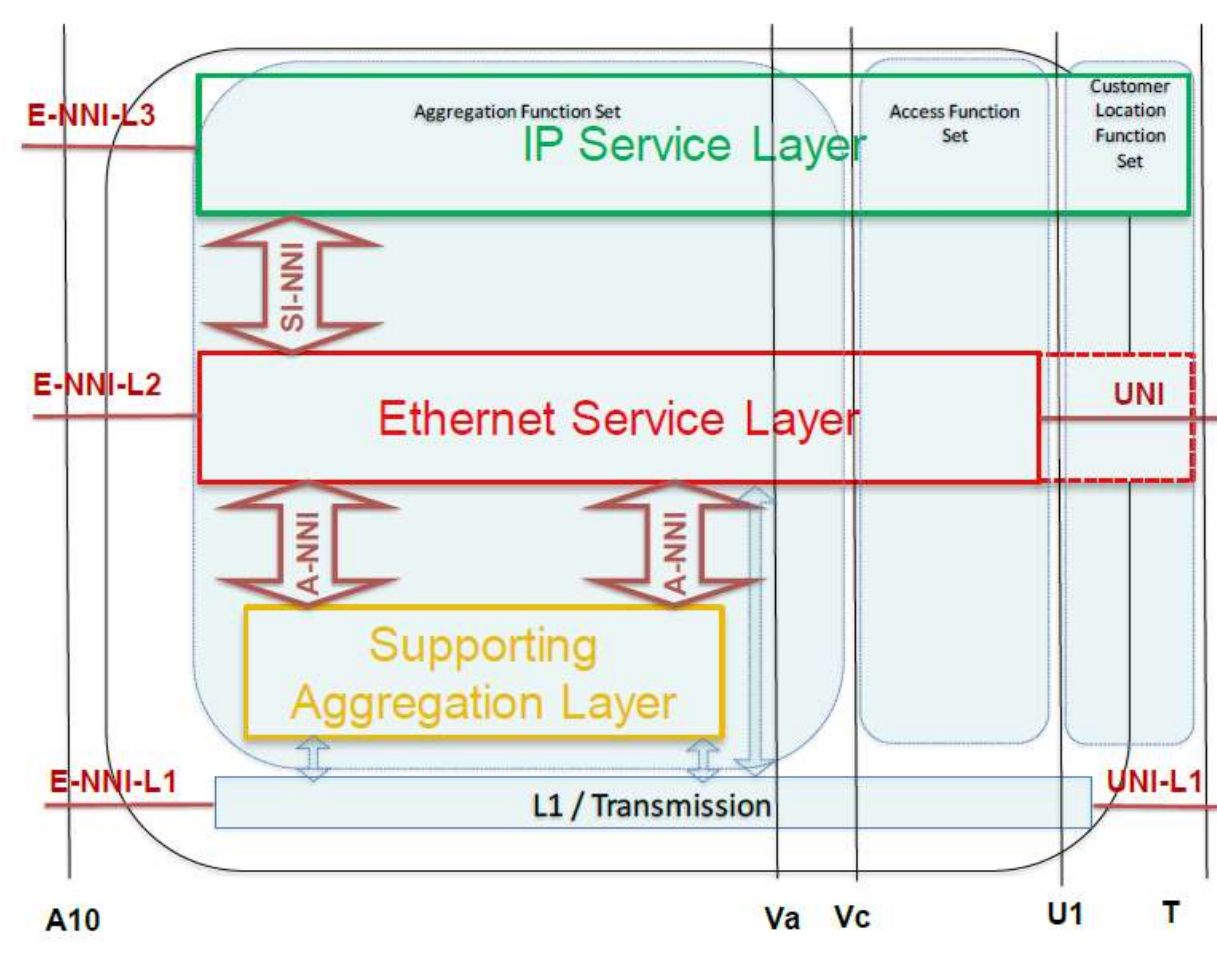
Mark only one oval.

☐ Yes

☐ No

☐ Other: \_\_\_\_\_

Fig. 3: BBF TR-145 - division of aggregation functionality into three distinct functional sets



The following eight questions are concerned with understanding current and future dominant forms of layer 1 and layer 0 aggregation.

33. The following statements describe motivation for migration towards transport systems with integrated DWDM pluggable optics (and away from separate transponder/muxponder devices) and open optical line systems (and away from proprietary systems). For each motivation stated below, choose one response that best describes your opinion on its relevance as a motive for migration.

Mark only one oval per row.

	Mostly irrelevant	Somewhat irrelevant	Somewhat relevant	Highly relevant
<b>DWDM optics can now be packed into switching and routing infrastructure face plates with the same density as client (grey) optics.</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>A line card can now carry a mix of grey optics and DWDM optics</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>400ZR and 400ZR+ standardize the physical layer for metro area networks.</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Open line systems facilitate use of interoperable pluggable DWDM transceivers.</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<b>Open line systems facilitate</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

facilitate  
integration  
with existing  
management  
platforms.

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34. Do you have any further comments to make with regard to the previous question?
- 

35. XR optics ([refer to Open XR forum](#)) enable a new point-to-multipoint network architecture. Do you plan to deploy this technology in your metro aggregation network ?

*Mark only one oval.*

- ☐ Currently investigating
- ☐ Already deployed.
- ☐ By the end of 2022
- ☐ By the end of 2023
- ☐ By the end of 2025
- ☐ No plans.

36. Claim: "XR optics' ([refer to Open XR forum](#)) point-to-multipoint network architecture will replace all other network architectures in metro aggregation".

*Mark only one oval.*

- ☐ Fully disagree
- ☐ Somewhat disagree
- ☐ Somewhat agree
- ☐ Fully agree
- ☐ Haven't considered XR optics

37. Claim: "Existing OTN aggregation will stay in my network but I won't choose OTN for any expansion of my aggregation network."

*Mark only one oval.*

- ☐ Fully disagree
- ☐ Somewhat disagree
- ☐ Somewhat agree
- ☐ Fully agree
- ☐ Other: \_\_\_\_\_

38. If you chose "somewhat agree" or "fully agree" that OTN won't be included in expansion of your aggregation network, please indicate the reasons driving your choice.

*Check all that apply.*

- ☐ Granularity of bandwidth allocation.
- ☐ Cost compared to other aggregation options.
- ☐ Inability to meet 5G's ultra low latency application class requirements
- ☐ Other: \_\_\_\_\_

39. Claim: "Packet-based networks that share link capacities using soft slicing and/or hard slicing will fully displace OTN from metro area networks. The exception is in data-centre interconnect, where capacity allocations are stable."

*Mark only one oval.*

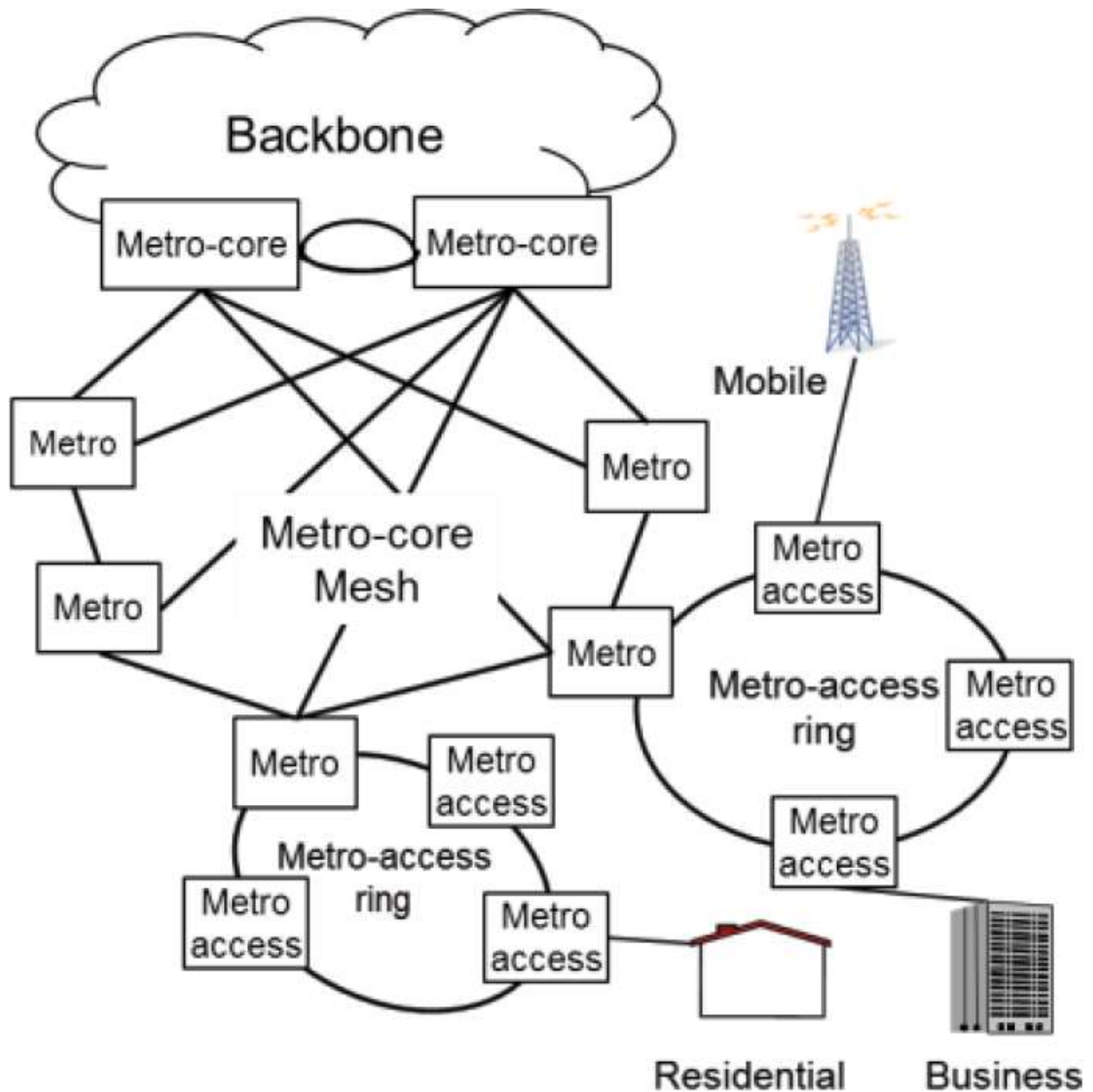
- ☐ Fully disagree
- ☐ Somewhat disagree
- ☐ Somewhat agree
- ☐ Fully agree
- ☐ Other: \_\_\_\_\_

40. Claim: "In the future, a mesh network will likely replace the metro-core ring at least in urban area with challenging capacity and resilience requirements." (see Fig. 4, which shows the proposed metro-core mesh instead of a metro-core ring) (doi: 10.1364/OFC.2015.W3J.4)

*Mark only one oval.*

- ☐ Fully disagree
- ☐ Somewhat disagree
- ☐ Somewhat agree
- ☐ Fully agree
- ☐ Other: \_\_\_\_\_

Fig. 4: Moving towards a metro-core mesh (doi: 10.1364/OFC.2015.W3J.4)



The remaining questions concern the stack of layers used in metro aggregation and metro core.



41. Which of the following best describes your current dominant form of metro-aggregation?

*Mark only one oval.*

- ☐ DWDM + SDH/SONET + Ethernet + IP/MPLS
- ☐ DWDM + ROADM (for node bypass) + OTN + Ethernet + IP/MPLS
- ☐ DWDM + ROADM (for node bypass) + Ethernet + IP/MPLS
- ☐ DWDM + ROADM (for node bypass) + IP over Ethernet
- ☐ Routed optical networks over Ethernet, without ROADMs
- ☐ Other: \_\_\_\_\_

42. For greenfield metro-aggregation deployment, how would you choose to implement an infrastructure based on DWDM optics?

*Mark only one oval.*

- ☐ IP/MPLS over Ethernet over DWDM, with ROADMs for node bypass
- ☐ IP/MPLS over Ethernet over OTN over DWDM, with ROADMs for node bypass
- ☐ IP over Ethernet over DWDM, with ROADMs for node bypass
- ☐ Routed optical networks over Ethernet, without ROADMs
- ☐ Other: \_\_\_\_\_

43. For greenfield metro-core deployment, how would you choose to implement an infrastructure based on DWDM optics?

*Mark only one oval.*

- ☐ IP over Ethernet over DWDM, with ROADMs for router bypass
- ☐ IP over Ethernet over OTN over DWDM, with ROADMs for router bypass
- ☐ Routed optical networks over Ethernet, without ROADMs
- ☐ Other: \_\_\_\_\_

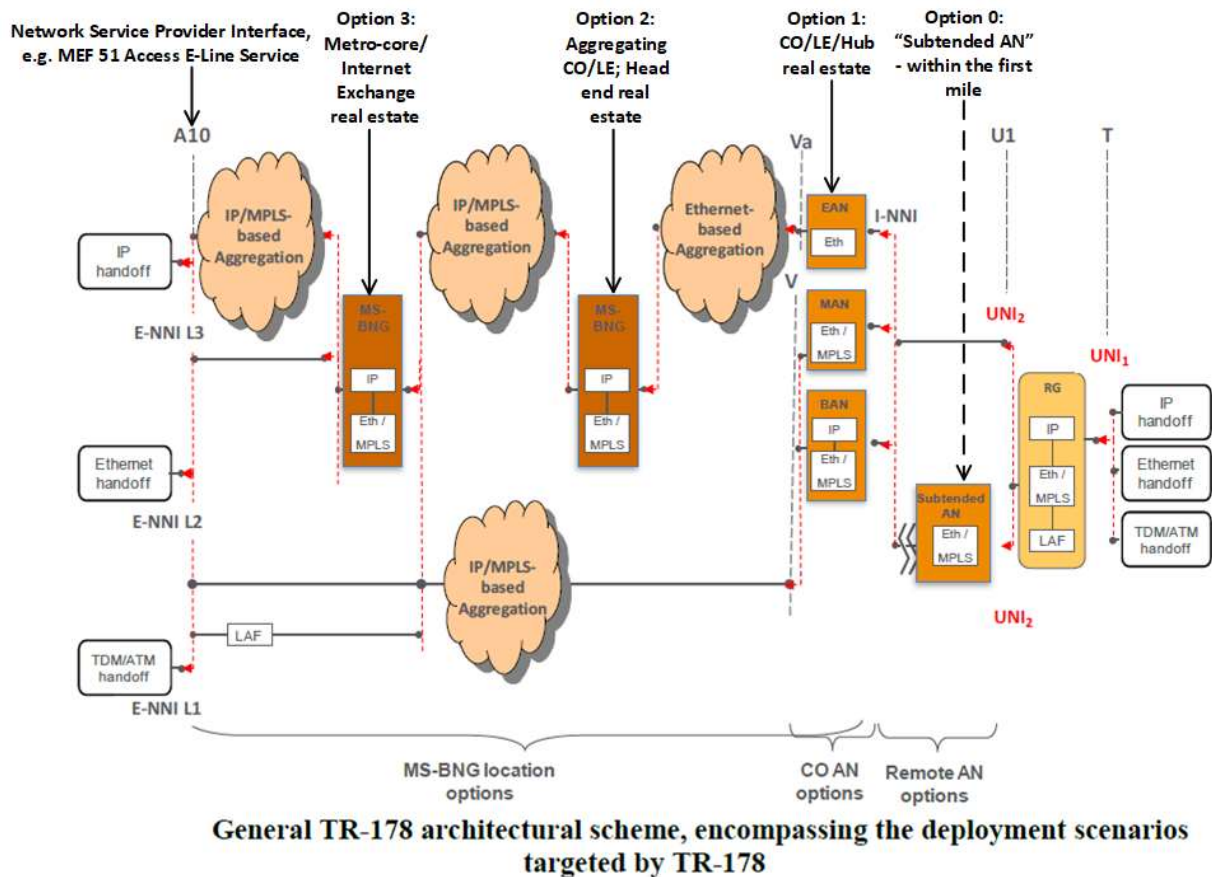
## 7. Service Edge

44. BBF TR-178 identifies several locations for the service edge (see Fig. 5). Which of these locations do you currently employ for Internet Broadband Network Gateway (BNG) ?

Check all that apply.

- ☐ Option 0
- ☐ Option 1
- ☐ Option 2
- ☐ Option 3
- ☐ At A10
- ☐ Other: \_\_\_\_\_

Fig. 5: Service edge deployment options, laid over TR-178 general architectural scheme



45. BBF TR-178 identifies several locations for the service edge (see Fig. 4). Which of these locations do you currently employ for Video BNG?

*Check all that apply.*

- ☐ Option 0  
☐ Option 1  
☐ Option 2  
☐ Option 3  
☐ At A10  
☐ Other: \_\_\_\_\_

46. Support for enhanced mobile broadband (eMBB) is improved by adding video BNGs closer to the end user.

*Mark only one oval.*

- ☐ Fully disagree  
☐ Somewhat disagree  
☐ Somewhat agree  
☐ Fully agree  
☐ Other: \_\_\_\_\_

47. I would consider adding video BNGs closer to the end user to improve energy efficiency of video delivery.

*Mark only one oval.*

- ☐ Fully disagree  
☐ Somewhat disagree  
☐ Somewhat agree  
☐ Fully agree  
☐ Other: \_\_\_\_\_

# Google Forms

