CCDE Practical Scenario-1

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Main Document

This section is used in the main scenario

Background Information

TelecomNet is a Multinational converged telecommunication and technology services provider. It serves its customers with voice, data, TV and value-added consumer and enterprise services on mobile and fixed networks. Since the past 25 years, it has continuously increased the variety of its services based on mobile voice and data communication, as well as on its quality levels, and as a result, its number of subscribers.

TelecomNet's target has been to become an integrated communication and technology services player in the region, operating a converged mobile and fixed network platform and offering a wide range of innovative products and services. For TelecomNet, it is important to offer their consumer and corporate customers the full range of the mobile and fixed broadband services to meet their expectations.

Services:

TelecomNet launched LTE services in its home country. They offer high speed fiber internet with its FTTX services. It also offers DSL (digital subscriber line), Fixed Wireless and also satellite broadband to its customers. With its wide coverage area and diverse range of services abroad, is therefore, able to provide its subscribers with mobile communication services, both in the country and around the world.

TelecomNet currently has the widest coverage 4G mobile technologies in the country. They have established an extensive Fiber-To-The-Home (FTTX) network covering most of the populated area, making the country rank as one of the most fiber-connected countries in the world. TelecomNet FTTX network enables an ultrafast residential Internet network speed of up to 500 Mbps. Around 5 years ago, TelecomNet rolled out the first and currently the region's widest 4G LTE network, providing mobile broadband speeds of up to 300Mbps and covering nearly all of the country's populated area.

Their FTTX design is GPON based. Current FTTX deployment of the company is purely FTTH based as, they think that FTTH is ultimate goal and fulfill the ever-increasing bandwidth demand.

As a DSL service, company provides ADSL and VDSL services. As an ADSL, they only provide ADSL v1 and for VDSL service they provide VDSL 1 and VDSL 2 service, which provides much more bandwidth compare to ADSL.

Current Fixed Network Bandwidth and Supported Distance for each Service

Service	Downstream	Upstream	Max Reach
ADSL	8 Mb/s	1 Mb/s	5.5 km
VDSL 1	50 Mb/s	30 Mb/s	1.5km
VDSL 2	100 Mb/s	30 Mb/s	0.5 km
GPON	2.5 Gb/s	1.25 Gb/s	20 km

TelecomNet was generally selling two basic categories of service, which are ranked below:

- ✓ Residential service, for home users, families, and consumers.
- ✓ Enterprise-class service: The higher reliable and highest-quality option, which they offer higher rate bandwidth and same-day repair response.

TelecomNet has an MPLS network which provides different kind of VPN connectivity services to its customers.

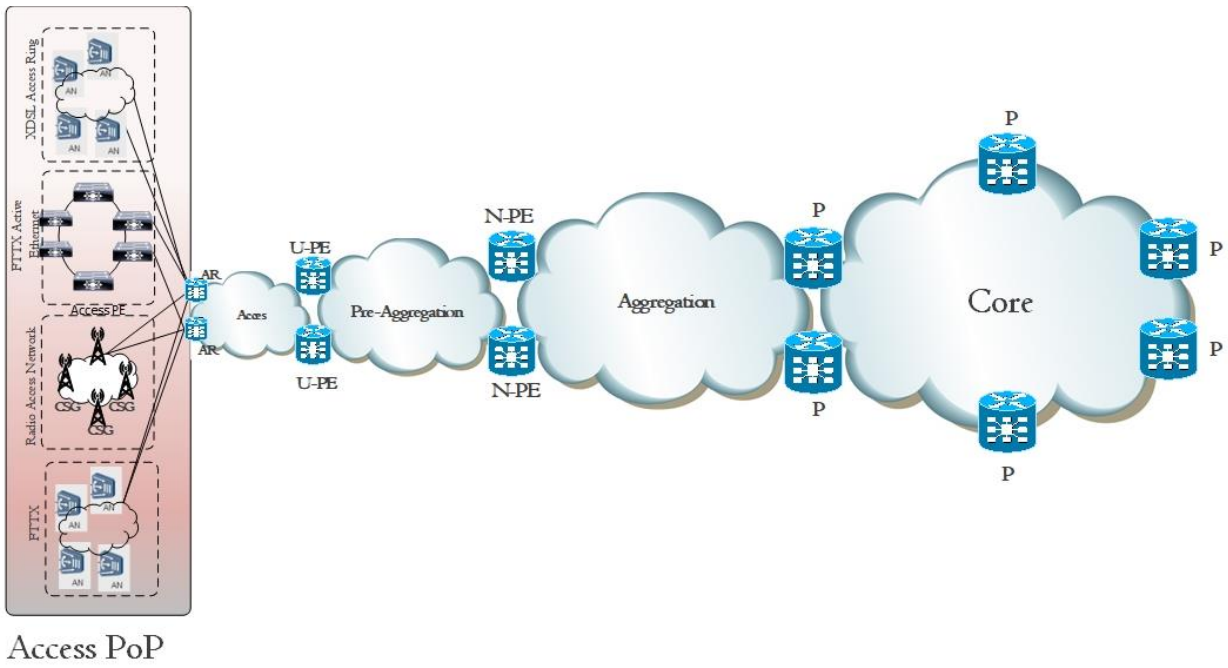
Overall, services such as Internet, Point-to-Point (Pseudowire), Layer 2 MPLS VPN VPWS and VPLS, Layer 3 MPLS VPN over the following connection types:

- ✓ XDSL connection
- ✓ FTTX connection
- ✓ Active Ethernet connection

- ✓ Mobile LTE connection
- ✓ Broadband satellite connection

At the years of 2013, TelecomNet decided to give LTE service to the customers inside the country. The resulting 4G network therefore enabled them to offer new data intensive services at a low cost per bit, but there is a need to deliver these new services while making optimal use of the network and guaranteeing SLAs from any one point in the network to another.

Their end to end network consists of Access, Pre-Aggregation, Aggregation and Core segments.



Pre-Aggregation, Aggregation and the Core Layer of the company carry both Fixed and the Mobile services, all the technologies and the protocols used in these layers, except Access Layer, are the same for both fixed and the mobile services.

But at the access layer, fixed service is Layer 2 based, mobile service access is completely MPLS based.

This is done for scalability as the company has Seamless MPLS design in IP/MPLS Multi Service Network.

Physical Design:

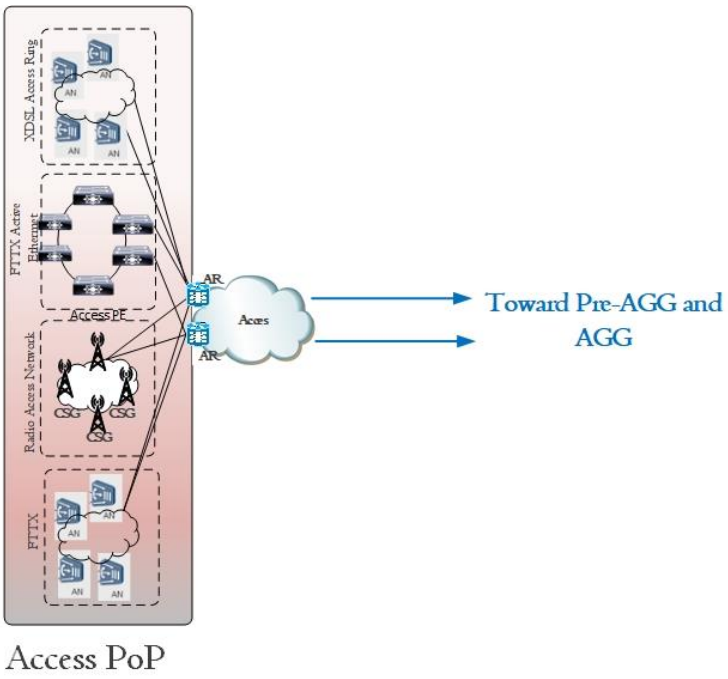
Access PoP's (Access Layer)

This layer consists of customers CPE's that were using different connection types to connect to the Service Provider network, including XDSL Broadband, FTTX and Active Ethernet. Based on each of these services, the customers in each area location were grouped as an Access PoP in each geographic location, connecting to their 1'st Aggregation point which was the Access Routers.

TelecomNET access network is based on Ring topology and it aggregates the customer nodes as a group to connect it to the TelecomNet Backbone network. Access nodes are DSLAM, OLT and Cell Site Routers. There are thousands of cell site routers in their network.

In each access site location, there are several access ring networks that were differentiated by the services:

- Passive fiber GPON customers
- Active Ethernet fiber customers
- LTE customers
- XDSL customers



Pre-Aggregation Layer(A-PE)

Each of the Access ring networks that were in each small location, were aggregated at the A-PE PoP sites. These A-PE (named Access PE) PoP sites, were connected to several Access PoP ring networks. The number of these connections varied based on the population of the customers in that area that the A-PE layer was covering.

The Pre-Aggregation Layer PoP sites were connected in a ring topology around the city, aggregating and connecting to all of the Access PoP sites, to connect them to the Upper layer network which was the U-PE Aggregation layer.

Aggregation Layer (U-PE)

The U-PE Aggregation Layer, consists of routers that are aggregating the Access PE (A-PE) PoP sites.

This layer consists of the U-PE routers that were installed in the PoP sites at the specific locations of each City that were closer to the Access PoP's , covering several A-PE PoP sites that were inside an area in the city. The number of these type of PoP sites were related to the number of A-PE PoP's in the area.

The U-PE Aggregation layer is connected to the Upper layer aggregation which is called the N-PE.

After aggregating the Pre-Aggregation PoP sites, the traffic is send to the N-PE Aggregation layer.

Edge Layer (N-PE)

This Layer consists of routers that are aggregating the U-PE routers. All U-PE routers inside a specific city are aggregated at this layer . The traffic is then send to one of the core sites that is closer to this PoP site. N-PE routers are connected to the P routers that are located at the Core sites.

The Services Layer of TelecomNet's Service Provider Network which consists of CGNAT and other service layer devices connected to the NPE routers at this layer, covering the users in that specific cities.
TelecomNET calls this layer as Edge Layer.

Core

TelecomNet selected 4 cities for its Core Locations, each in one of the North, South, and East & West regions in the country. These 4 cities were the main cities in each region that have been elected based on Technical and Geographical reasons:

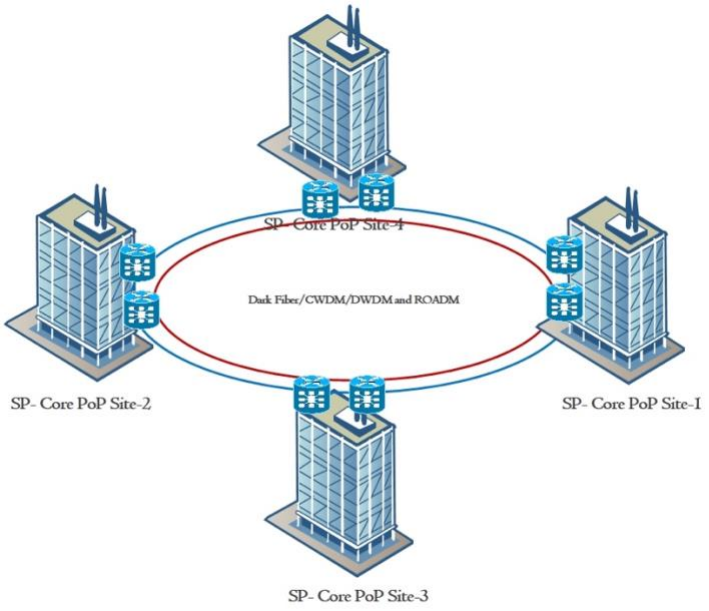
Technical reasons:

1- Telecom infrastructure capability comparing to other cities
2- Closest to the Main locations of the telecommunication central sites in the country
3- Population and users according to other cities in the region

Geographical reasons:

1- Best geographic location based on the connection to Countries PoP sites in other cities
2- Geographic Location based on Connection to Inter Exchange Providers in the Country
3- Geographic Location based on Connection to Transit Providers outside the country
4- Considering Geographic Location based on the less impact of Natural Disasters

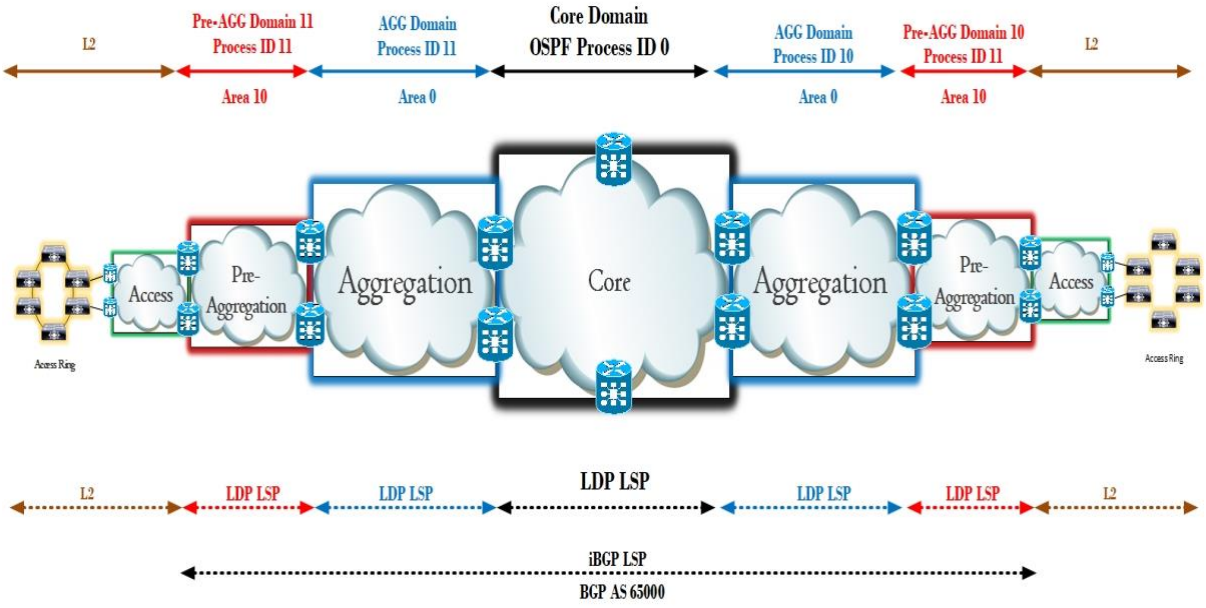
So based on the above reasons, at these 4 main Location's, TelecomNet has selected and Built its Central PoP sites and has installed the Core network Equipment. Each Core site consists of redundant P routers, connecting to the other Core sites with a Multiple Path Protection of DWDM Backbone Optical ring network.



Each of the Core sites, had also NPE routers installed in the site, because they were covering the city that they were located in. Also each of the 4 Core sites had a Data Center for serving multitenant datacenter services to customers.

These 4 Core sites also had an IGW layer (Internet Gateway layer) which had connections to international carrier networks, connecting TelecomNet to its international upstream networks.

Technology and the Protocols:



OSPF is used in IP/MPLS network, Different OSPF Process ID between the Pre-Agg and the Access Layer than Agg and Core layers.

OSPF Router ID is set manually on all the OSPF enabled devices and Loopback 0 IP address will be used as OSPF Router ID on the devices.

Also, in order to provide more scalability in OSPF, they enabled OSPF Prefix-suppression feature and Incremental SPF.

BFD is deployed on the network for OSPF. BFD 'min-rx-interval' and 'min-tx-interval' is set to 50 ms and the detection-multiplier is set to 4.

TelecomNET is considering to deploy IP Fast Reroute Mechanism in Pre-Agg and Aggregation Layer and they have RSVP based Fast Reroute Link and Node Protection in the CORE network for many years. They have currently tuned OSPF timers in the Access rings where it is applicable.

Their OSPF timer configuration is as below:

- LSA Arrival time is 50ms
- LSA Throttling timers: 10 100 2000
- SPF Throttling timers: 10 100 2000
- LSA Retransmission timer is 60 ms

All Loopback interface subnet mask will be configured as /32. Loopback interfaces will be used for the device access and the management, also they are used in many protocols in the network, for example OSPF, BGP, MPLS and LLDP.

LDP is signaling protocol they have been using for many years and they are investigating advantages and the disadvantages of Segment Routing and applicability of Segment Routing to their network.

TelecomNET's IP/MPLS Network has IGP-LDP Synchronization feature enabled to avoid blackholing in case if failure.

They have LDP, extended up to the Access Network nodes all the way to the Access PE (AR) devices for the Mobile service.

Fixed residential network Access connection is purely Layer 2 based, thus there is no LDP, IGP or BGP in the Access part of the Fixed network.

BGP runs for the Mobile service up to the Access domain.

BGP AS 65000 runs on Access, Pre-Agg, Aggregation and Core nodes for the transport of Mobile services.

They have Rosen GRE SSM Multicast deployment for their IP TV service and currently IPTV is provided only to their FTTH customers.

IPTV set top-box is provided and managed by the TelecomNET and all of them are IPv6 capable devices.

Company is using same BRAS/BNG for both FTTX and the XDSL customers. They want to manage as few BNG as possible.

TelecomNet has total number of 4M customers around the country. They have not implemented IPv6 in the network, so all users are using IPv4.

Although in addition to their public IPv4 addresses, they purchased IPv4 addresses from the other companies, they are using Carrier Grade NAT in the network. Currently, TelecomNET assign IPv4 public IP address to the only Business and some of the Mobile customers.

They have bought 3 different subnets in the last 5 years, because of the customer growth in the network. These subnets are not summarized under a specific range. These subnets are as follow:

- 8 * /20 subnets
- 4 * /21 subnets
- 2 * /19 subnets

Question 1: What is the main design reason for TelecomNET for extending MPLS up to the Access network for Mobile service?

A. To reduce the number of points to provision the service
B. To have fast convergence in the Core network
C. To have end to end Quality of Service in the network
D. To reduce number of prefixes in their OSPF network
E. To connect Access and Pre-Aggregation networks to Aggregation network

Answer 1: A

Question 2: What are the advantages of having Multiple layers (Access, Pre-Agg, Agg and Core) in the TelecomNet network? (Choose Three)

A. Provides more scalability
B. Reduces blast radius
C. Fast Convergence

D. Role Based Access Control
E. Having different vendors in each layer

Answer 2: Blast Radius, when there is a failure, how much impact will be.

Role Based Access Control means, allowing different level engineers to different level of routers. Low level engineers to access device, highly technical engineers to the core devices etc. **A, B and D are the correct answers.**

Question 3: TelecomNET has a MPLS Layer 3 VPN between the Cell Site Routers and the LTE Core nodes, how end to end MPLS VPN between these two end points can be deployed?

A. The access, pre-aggregation, aggregation, and core layers are within a single AS. Intra-AS MPLS should be deployed
B. The access and pre-aggregation layers are within a single AS, whereas the aggregation and core layer in another AS, Inter-AS MPLS should be used
C. The access layer within a single AS, whereas the pre-aggregation, aggregation and core layer in another AS, Inter-AS MPLS should be used
D. The access layer, pre-aggregation and aggregation layers are within a single AS, whereas the core layer in another AS, Inter-AS MPLS should be used

Answer 3: Answer is A. Because they have single BGP AS which is 65000 across all domains for Mobile service as it was mentioned in the background document. Reading the document carefully is enough for this question.

Question 4: Based on given information in the scenario, to which routers TelecomNET should connect their BNGs?

A. Access Layer
B. Pre-Aggregation Layer
C. Aggregation Layer
D. Core Layer

Answer 4: In the scenario, it is given that they want to manage as few BNG as possible, if BNGs are connected to the Aggregation Layer, it is the centralized placed to collect all FTTX and XDSL customers. This type of BNG design is called as Centralized BNG design. BNG creates Service Edge Layer design, it is not connected to the Core device directly. Core device functionality is high speed data transfer. Answer is C.

Email – 1

From: TelecomNET Strategy Unit

To: Orhan Ergun Consultancy

Subject: Business Customer Connectivity and BGP design in the network

Dear Consultant,

For our Business customers, we have a Metro Ethernet Service where we deploy our switches at the customer location, if multiple companies share the same building, we place larger devices to accommodate more customers.

Buildings are connected to each other in a ring topology. We have 40Gbps capacity on these rings.

Typically, 6 nodes are used in each business customer ring in our network.

G.8032 is used to provide fast convergence in the business customer rings.

These rings are terminated at the Pre-Agg layer in the network. At the Pre-Agg layer, if the customer is looking for Layer 2 or Layer 3 service, MPLS starts at the Pre-Agg Layer.

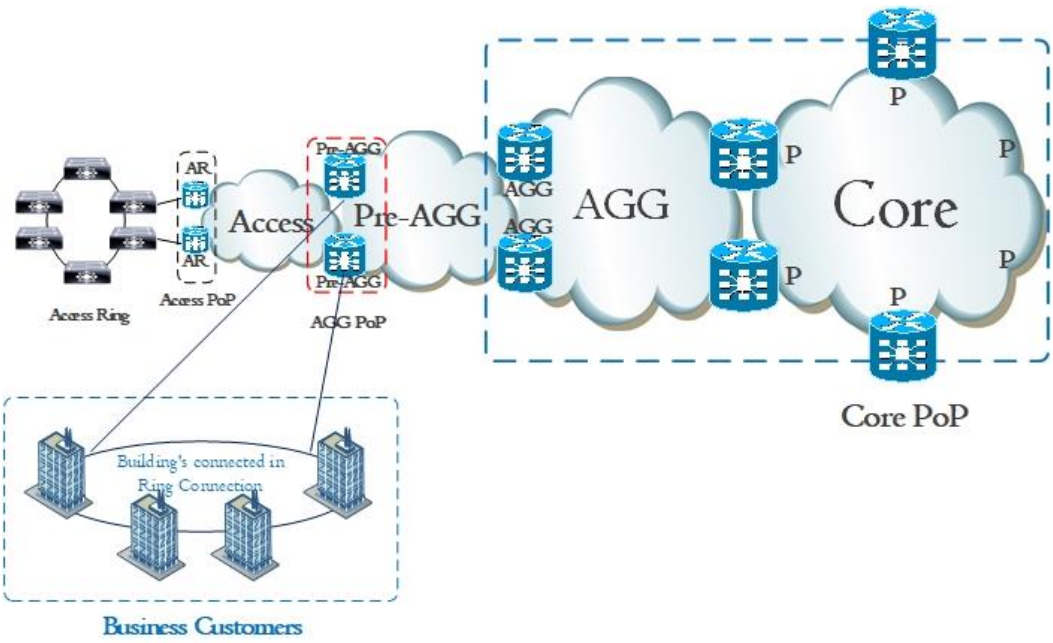


Figure - Business Customers Connectivity

In our network, Pre-Aggregation Layer routers reside in Aggregation POP locations, Aggregation and Core Layer devices reside in Core POP locations.

For the MPLS Layer 2 VPN, We provision Martini based Layer 2 VPN is used.

Customers who require Layer 3 VPN, can run static routing or EBGP with the TelecomNET. We don't provide OSPF, IS-IS, RIP or EIGRP as a PE-CE MPLS Layer 3 VPN routing protocol.

For the EBGP connection with the customers, TelecomNET has BGP Route Limit Policy. According to their policy:

- 1500 prefix is the allowed limit

- If advertised prefix reach to 70% of the allowed limit, NMS system is notified
- If allowed limit is exceeded, session will be teared down and after 300 seconds, router retries to bring the session up.

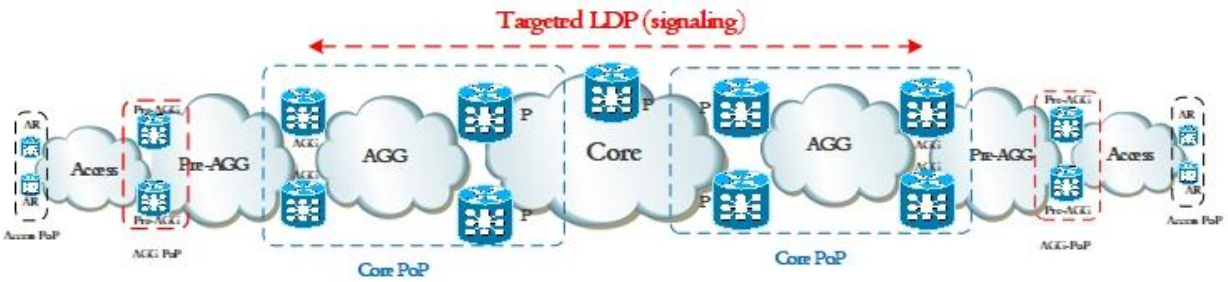
Question 5: Which below options are correct for the Business Customers of TelecomNET? (Choose Two)

A. If the capacity requirement is larger in some customer buildings, number of nodes in the ring can be reduced
B. TelecomNET can provide more optimal routing to the customer with MPLS Layer 2 VPN than MPLS Layer 3 VPN
C. Business users can be connected to Aggregation Layer devices to provide lower latency for the Internet destination traffic
D. 802.1q can be one of the protocols between the switches which deployed at the business buildings and the Pre-Agg Layer devices of TelecomNET

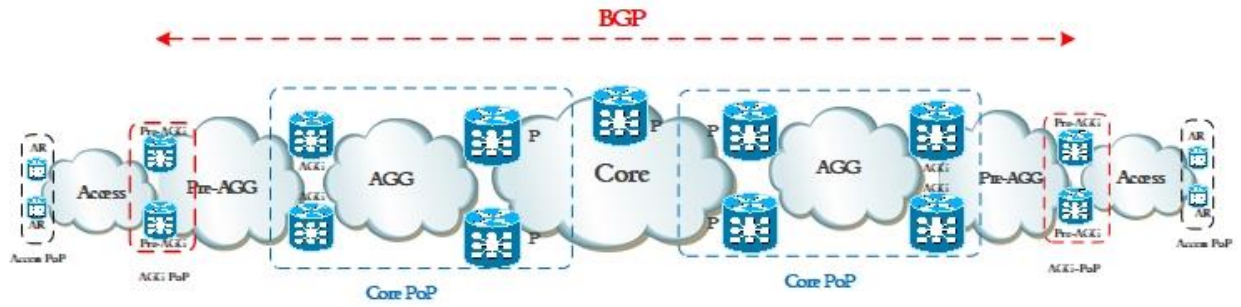
Answer 5: A and D, are the correct answers. C cannot be because; Aggregation Layer devices terminate services devices not the users. B is wrong because Optimal Routing is not related with the type of the service based on this scenario.

Question 6: Which below drawing correctly shows MPLS Layer 2 VPN deployment of TelecomNET?

A.

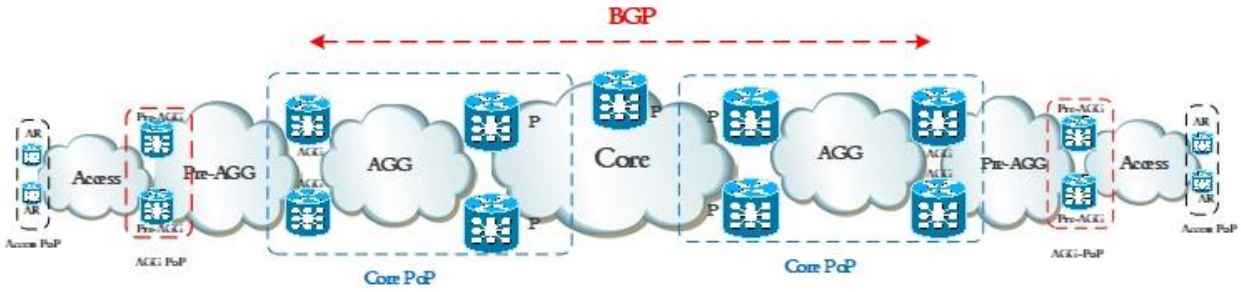


B.



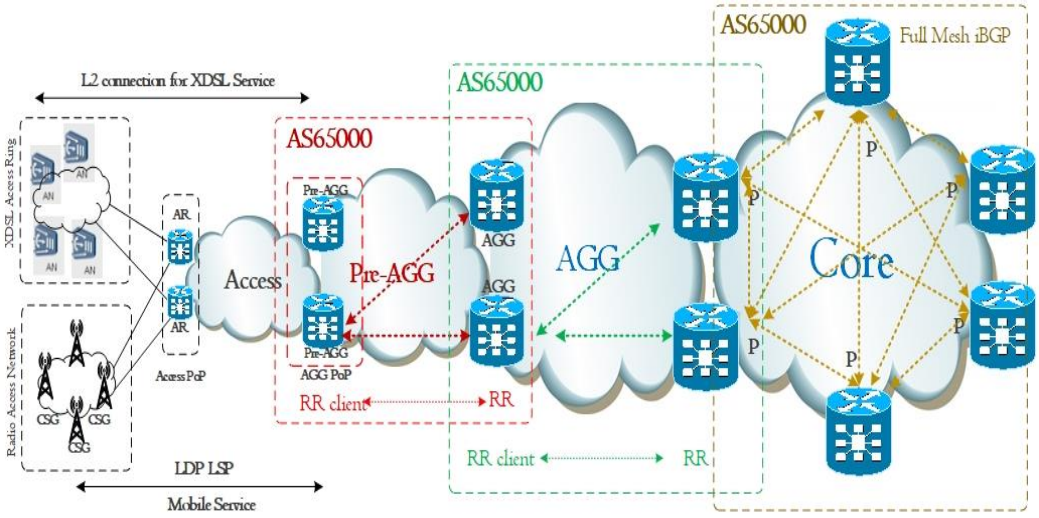
C.

D.



Answer 6. Answer is C

Question 7: TelecomNET is carrying device loopback via BGP. In the below topology, on the Route Reflectors next-hop self is deployed. Which options are correct for TelecomNET BGP design? (Choose Two)

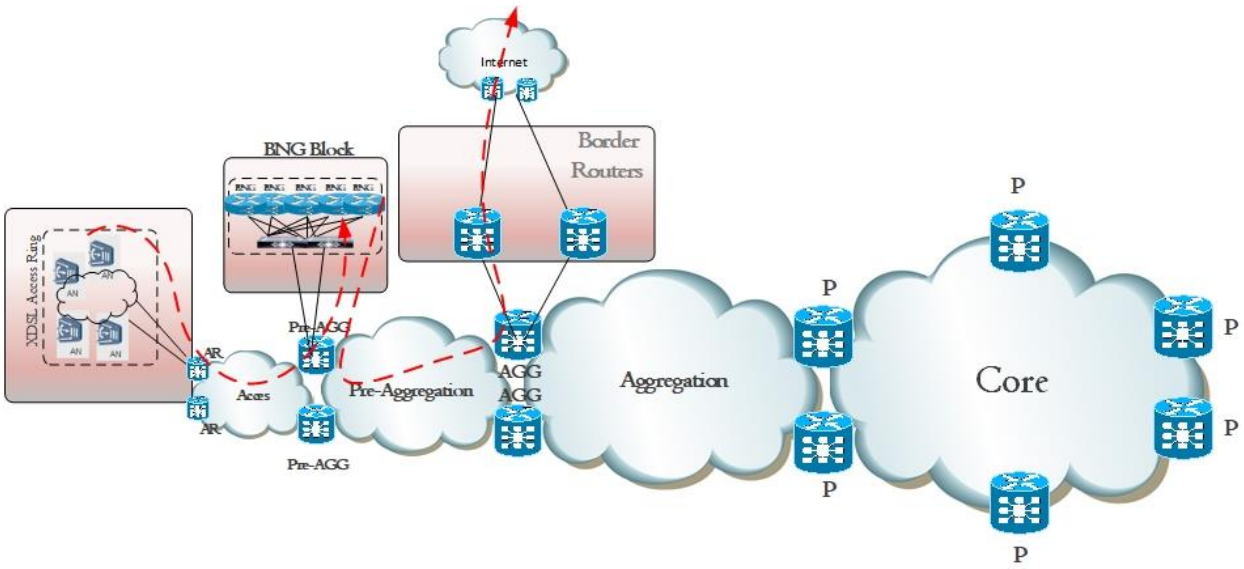


A. BGP runs between Pre-Aggregation and the Access Routers (AR)
B. In order, Pre-Agg routers to use both Agg routers as next hop, BGP Add-path can be used
C. Next-hop self on RR limits the scalability of the design
D. Full-mesh IBGP within the Core needs to be replaced with BGP Route Reflector
E. If both Pre-Aggregation and the Aggregation Layer Routers would be the RR Client of P-Core device, more number of prefixes needed to be known by the Pre-Aggregation Layer Routers OSPF

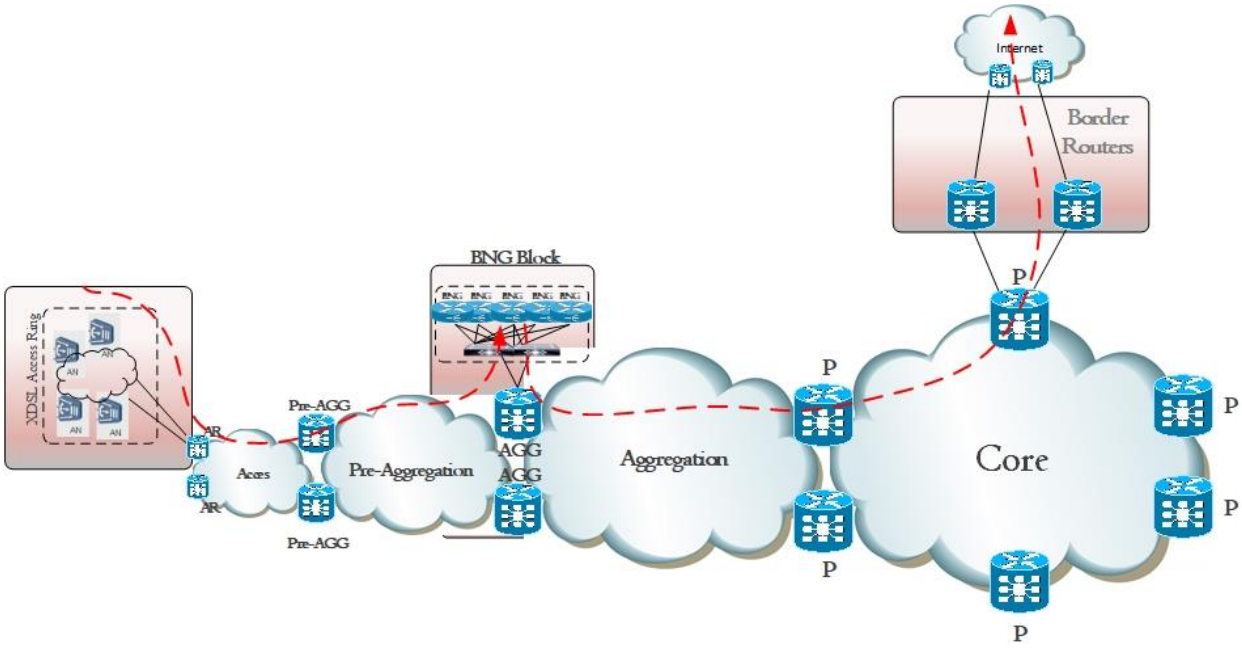
Answer 7: A is wrong. B is Correct, C is wrong, NHS increases scalability, D is wrong because not necessary as per the requirements so far, E is correct, Pre Agg would have to learn P loopbacks and vice versa within IGP. Thus, B and E are the Correct answers.

Question 8: Based on the information so far, please select among the below options, XDSL Internet service traffic flow.

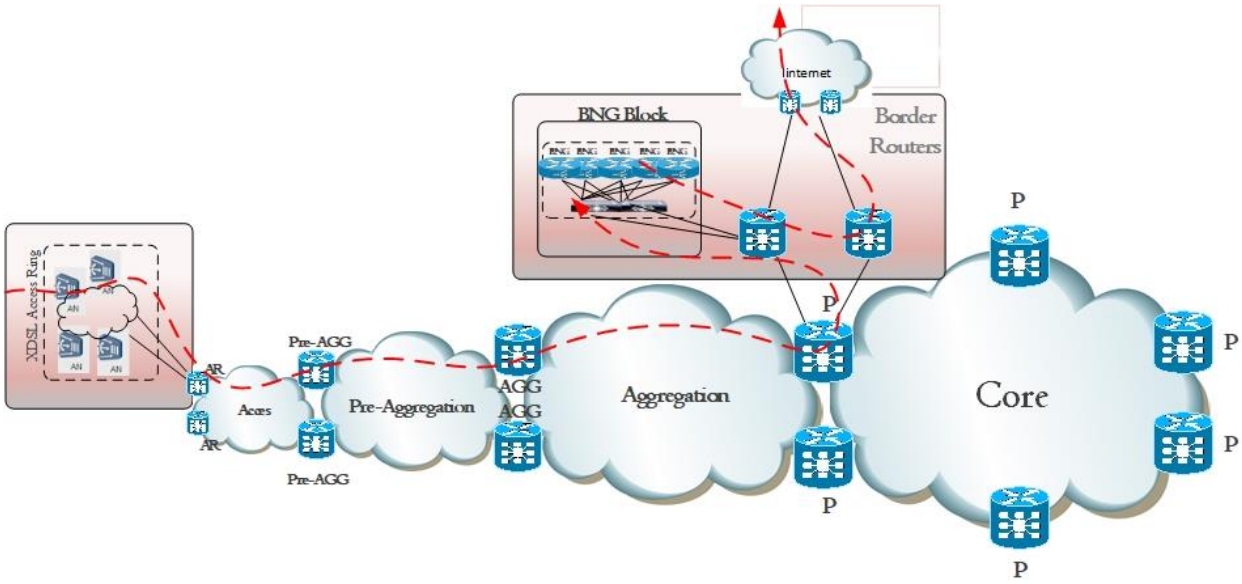
A.



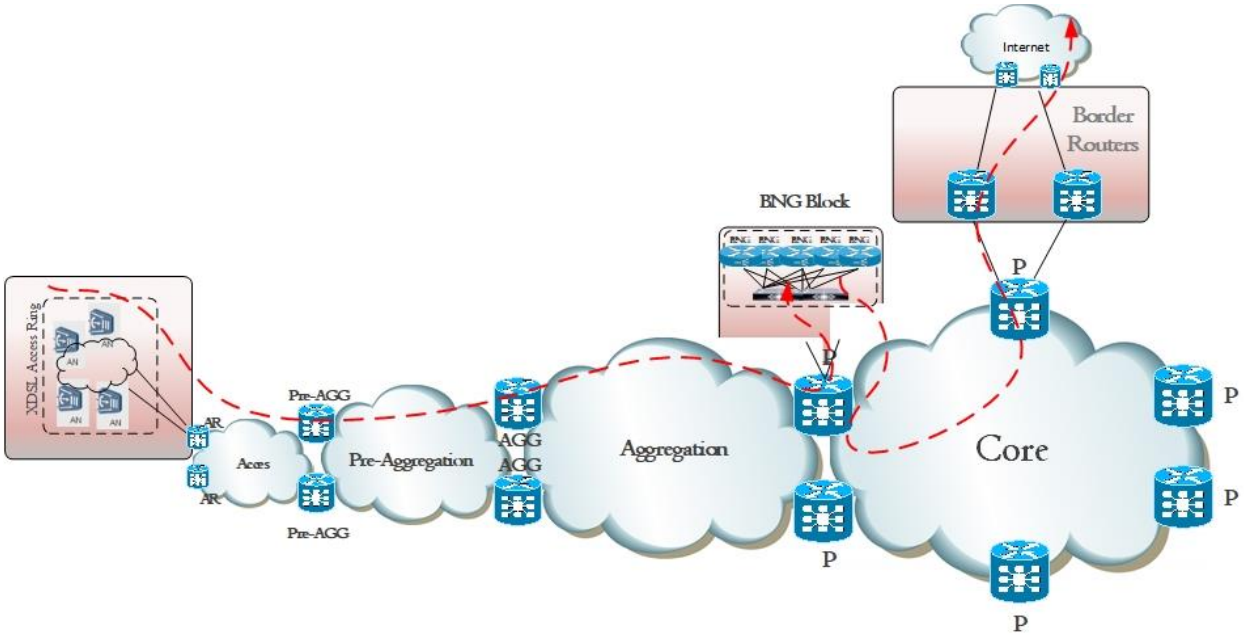
B.



C.



D.



Answer 8: Answer is B

Question 9: Should TelecomNET migrate their OSPF network to IS-IS?

A. Yes
B. No

Answer 9: No need.

Question 10: Which below options are correct for TelecomNET CGNAT design? (Choose Two)

A. Deploying IPv6 can reduce the number of sessions on the CGNAT devices
B. Connecting CGNAT devices along with BNGs to the Aggregation Layer devices provide optimal routing comparing to placing the CGNAT devices at the Pre-Aggregation Layer
C. Blast radius increases if CGNAT boxes are deployed at the Access POP locations
D. If CGNAT devices would be deployed at the Internet Gateway POP locations, rather than Aggregation Layer devices, asymmetrical routing would be bigger issue
E. CGN is stateless function, thus if redundancy is required, NAT Table between redundant equipment need to be synchronized

Answer 10: A and B are the correct ones. CGN is not stateless. E is wrong.

Blast radius decreases if CGN would be distributed, which means deployed at the Access instead of Agg, thus C is wrong.

If CGN would be deployed at the IGW, asymmetrical routing would be less of an issue, thus D is wrong.

Email -2

From: TelecomNET Strategy Unit

To: Orhan Ergun Consultancy

Subject: Segment Routing Design Considerations

Dear Consultant,

As we mentioned during our initial meeting, we are considering to deploy IP Fast Reroute Mechanism in Pre-Agg and Aggregation Layer and we have had RSVP based Fast Reroute Link and Node Protection in the Core network for many years. We have tuned OSPF timers on our network currently.

Their OSPF timer configuration is as below:

- LSA Arrival time is 50ms
- LSA Throttling timers: 10 100 2000
- SPF Throttling timers: 10 100 2000
- LSA Retransmission timer is 60 ms

Before we deploy IP Fast Reroute, we have some questions for you.

Regards,

Customer

TelecomNET Strategy Unit Manager

Question 11: Which below option is correct for the TelecomNET network convergence?

A. Directed LFA will bring most benefit to the Business Customers
B. On the Mobile access network rings, Directed LFA brings immediate benefit
C. Core RSVP Link and Node Protection should be replaced with Remote LFA
D. TI-LFA can provide fast reroute for the Mobile Access ring failure
E. TI-LFA can provide fast reroute to the Business Customers

Answer 11: Business Customer Access Rings are L2 based and G.8032 provides fast reroute already. IP FRR mechanisms such as LFA, Remote LFA, TI-LFA doesn't provide anything for them.

There is no requirement in the scenario to force us migration RSVP to Remote LFA.

Directed LFA cannot provide fast reroute to the Mobile access network, because Directed LFA cannot provide reroute in ring topology. D is the only correct answer.

Question 12: TelecomNet is looking to understand some characteristics of Segment Routing before they decide whether they should deploy it on their network, please fill the below comparison chart between RSVP based Traffic Engineering and Fast Reroute vs. Segment Routing TE and Fast Reroute.

	RSVP TE	Segment Routing – MPLS
Easier troubleshooting		
Less number of Control Plane state		
Needs MP-BGP between PE devices for MPLS L3 VPN		
Standard Based		
Link and Node Protection		
Post Convergence Path with FRR		
ECMP Support		

Answer 12:

	RSVP TE	Segment Routing – MPLS
Easier Troubleshooting		X
Less number of Control Plane State		X
Needs MP-BGP between PE devices for MPLS L3 VPN	X	X
Standard Based	X	X
Link and Node Protection	X	X *
Post Convergence Path with FRR		X
ECMP Support		X

X* = With TI-LFA, it provides 100% topology coverage in case link and node protection

Question 13: Which below options are true for the services that TelecomNet provides? (Choose Two)

A. Among all the available options, FTTH can provide the highest bandwidth per user

B. With DSL, bandwidth decreases by the distance
C. Reliability point of view Satellite is better than Fiber
D. Deploying Fiber to the Rural areas economically viable option for TelecomNET
E. Line of sight is not required in Fixed Wireless deployment as in Satellite

Answer 13: A and B are the answers.

Question 14:

Summary

As all of the above information of the TelecomNet's SP was introduced, the network devices are as follow:

- ✓ **CPE**: Customer Premises Equipment which are the customer's routers/modems/switches/access points connected to TelecomNet's network.
- ✓ **Access PoP**: All Access node CPE's were grouped (per service: XDSL,FTTX,LTE,…) as a star/ring topology and connected to the upper aggregation layer , **A-PE** which is located in that geographic area
- ✓ **A-PE** : PE routers that aggregated the **Access PoP** ring's to connect it to the upper layer network
- ✓ **U-PE**: The Centralized point in each geographic area were aggregates all **A-PE** routers in that area to connect to the Upper layer network
- ✓ **N-PE**: Aggregation Point were connects several **U-PE** routers from different areas to connect to upper layer network. Also, Edge services such as **BNG & CGNAT** for users under the geographic coverage of the **N-PE** are connected to the **N-PE** .
- ✓ **Core P**: These routers were located in the selected 4 main Central PoP sites of the country(based on the 4 regional structure explained before)
- ✓ **DC**: Each of the 4 Main Central PoP sites , had its own Datacenter, that were used as multitenant datacenters for the customers and also international services
- ✓ **IGW**: The Internet Gateway Layer or the Border Layer that's located in each of the 4 main core sites for the World Wide Connectivity Connections

- ✓ **BNG** : For establishing and managing customer sessions, for the customer to access the broadband services provided by TelecomNet BNG's are used and connected to the **N-PE** routers, covering customers in the specific area that the N-PE is located.
- ✓ **CGNAT** : Carrier-grade NAT, as the Carrier NAT service based on the large number of customers of the TelecomNet, that are in the area that the N-PE is covering.

So, based on the description of each of the above modules that are used in TelecomNet's network, the PoP sites are as follow:

- 4 Main Core sites located around the country, consisting of MPLS **P routers** and also **N-PE** routers, which the NPE routers were covering a specific region in the country . Also each Core Site having a Data Center and also IGW layer for the international connections
- Each Main Core site covering several cities , connecting to several NPE routers that were located inside the Largest populated cities
- Service Edge Layer Appliances such as BNG, CGNAT,… connected to NPE Layer
- Each NPE router connected to several UPE routers that were located in medium scale populated cities
- Each UPE router connected to the AGG ring layer which covered a geographic area to collect the Access Ring network
- Each A-PE in the small geographic location actually aggregated the Access PoP rings in that area
- Each Access PoP consists of several access node CPE's connected inside a ring or star topology which were aggregating customer's node CPE's