IEEE STANDARDS ASSOCIATION

IEEE

Transport Network Slicing Chapter

Part 1 – Key Attributes & Requirements

Tony Tam

Fujitsu Network Communications

June 28-30, 2017

IEEE 1914.1 TF

Compliance with IEEE Standards Policies and Procedures

Subclause 5.2.1 of the *IEEE-SA Standards Board Bylaws* states, "While participating in IEEE standards development activities, all participants...shall act in accordance with all applicable laws (nation-based and international), the IEEE Code of Ethics, and with IEEE Standards policies and procedures."

The contributor acknowledges and accepts that this contribution is subject to

- The IEEE Standards copyright policy as stated in the *IEEE-SA Standards Board Bylaws*, section 7, http://standards.ieee.org/develop/policies/bylaws/sect6-7.html#7, and the *IEEE-SA Standards Board Operations Manual*, section 6.1, http://standards.ieee.org/develop/policies/opman/sect6.html
- The IEEE Standards patent policy as stated in the *IEEE-SA Standards Board Bylaws*, section 6, http://standards.ieee.org/guides/bylaws/sect6-7.html#6, and the *IEEE-SA Standards Board Operations Manual*, section 6.3, http://standards.ieee.org/develop/policies/opman/sect6.html

IEEE 1914
Next Generation Fronthaul Interface
Jingri Huang, Huangjinri@chinamobile.com

Transport Network Slicing			
Date: 2017-06-23			
Author(s):			
Name	**Affiliation**	**Phone [optional]**	**Email [optional]**
Tony Tam	Fujitsu Network Communications		tony.tam@us.fujitsu.com

Agenda

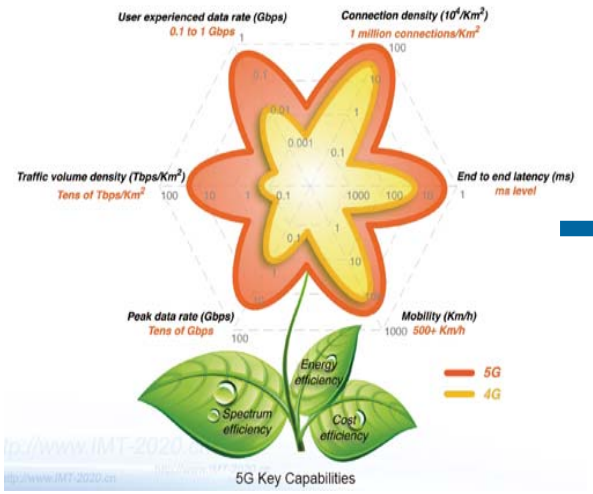
- Network Slicing Chapter Part 1- Key Attributes and Requirements baseline for the text of the document.

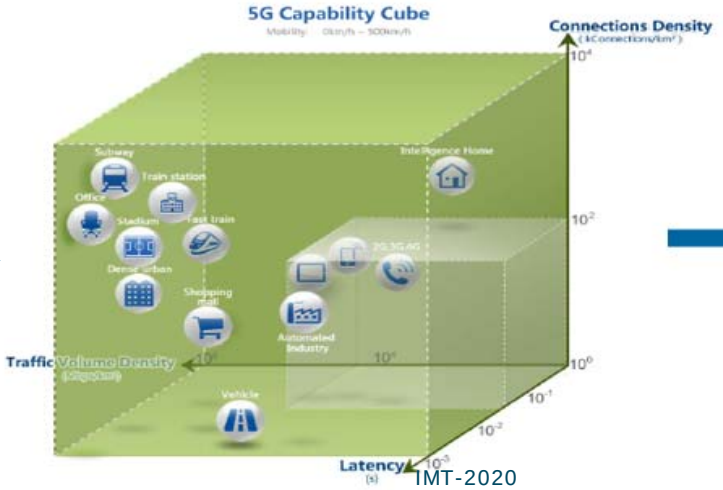
- Serve as the framework for Part 2 - detailed requirements, architecture, and interactions

3GPP Network Slicing Requirements

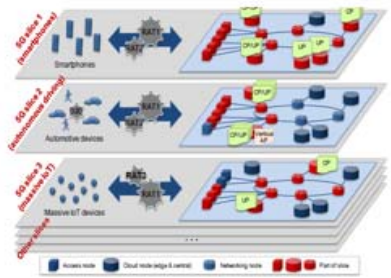
- 3GPP TS 22.261 v15.0.0 requirements related to Transport Network
- Create, modify, and delete
- Define and update the set of services and capabilities
- Configure to associate a service to a network slice
- No impact on traffic and services from one network slice to the other
- No or minimum impact on others during a network slice creation, modification and deletion
- Define Minimum and maximum capacity and adaptation of capacity
- Elasticity of capacity on one has no impact on others on their minimum capacity
- Define priority order as the base for competition of resources
- Means to define policy, functionality and performance
- In a shared network configuration, each operator able to apply all the requirements to their allocated network resources

Network Slicing - Why





Highly Diversified

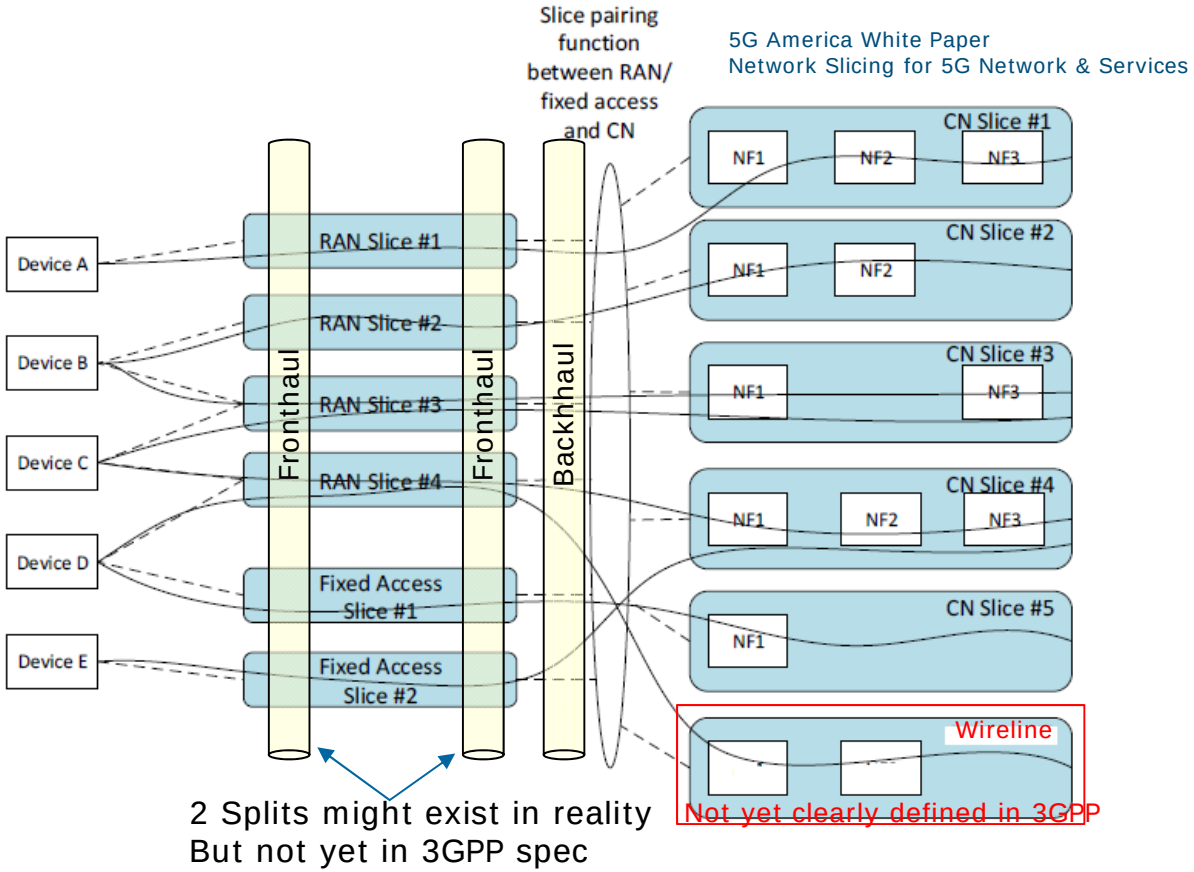


Network Slicing Customized for EACH

- Traffic bandwidth, connection density, and stringent delay has increased up to 3 order of magnitude from 4G network
- The requirements are highly diversified and are sometime at the opposite end of spectrum
- Network Slicing allows operator to provide customized networks to meet each service requirements
- An aggregated Network Slice contains multiple instances sharing the same characteristics and is a group of instances. It can also contains a dedicated instance only
- Furthermore, a Network Slice can be a wholesale slice to 3nd party who will manage the instances within that Network Slice

3GPP TS 23.501

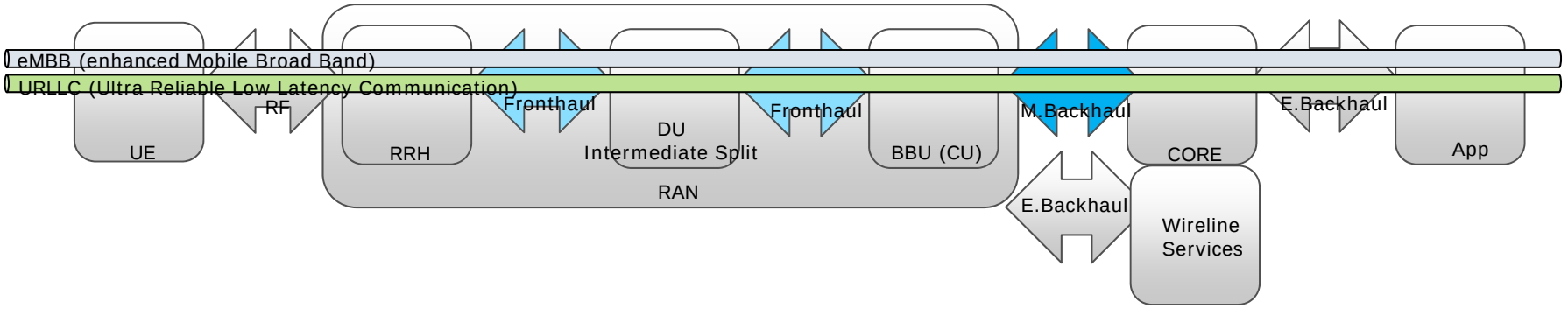
Network Slicing – E-2-E Horizontal



- Fronthaul is inside the RAN Slice between RRH and BBU or between RRH & DU and DU and CU(BBU)
- Backhaul is between RAN and Mobile Core Network or between RAN and Wireline Network for Wireline Services
- There is an East-West association between RAN, Core, and Transport

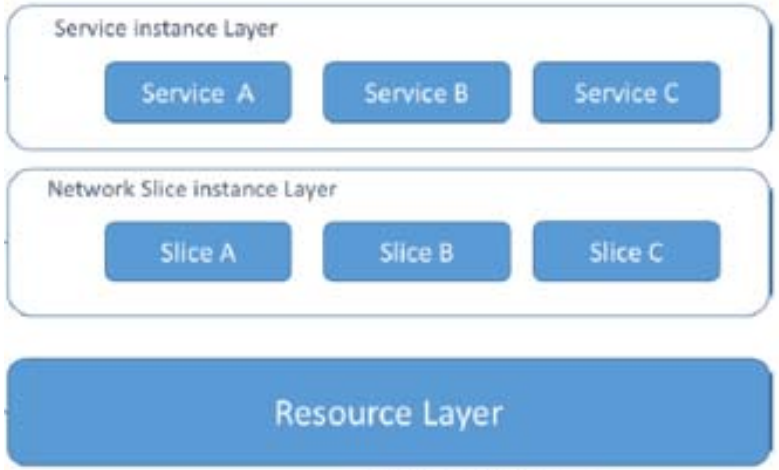
Network Slicing – E-2-E Horizontal Transport

- E-2-E Network Slicing is a Team Work and a coherent one including Mobile Fronthaul & Backhaul and Ethernet Backhaul
- Fronthual is intertwined within RAN
- It will require tightly coordination between Mobile Network Slices and Transport Network Slices either via Central Overall Orchestration (North-South) or In-band (East-West) or both.
- The same may apply to Transport Network Slices belonging to the same path horizontally whatever it makes sense



Network Slicing – Vertical

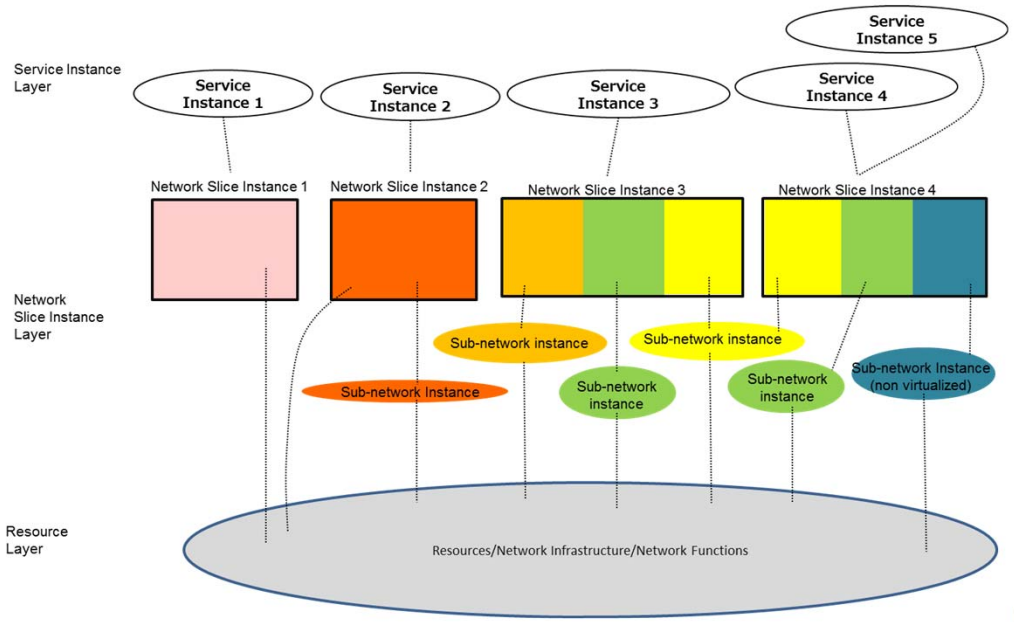
- The Network Slicing for RAN and 5G Core has three layers on each: Service Instance, Network Slice Instance and Resources.
- Within Service and Network Slice layer, it has multiple instances while resource layer is usually shared
- that is realized within or by a Network Slice.
- The Service Instance Layer represents the services (end-user service or business services) that is realized within or by a Network Slice.
- The Network Instance Layer is a set of network functions(e.g., Ethernet switching function, IP routing functions) and resources to run these network functions, forming a complete instantiated logical network to meet certain network characteristics (e.g. ultra-low latency, ultra-reliability, value-added services for enterprises, etc.) required by the Service Instance(s)
- The Resource Layer consists of Physical resource**:** A physical asset for computation, storage or transport including radio access and Logical resource: Partition of a physical resource, or grouping of multiple physical resources dedicated to a Network Function or shared between a set of Network Functions.
- Reference: 3GPP TR 28.801 and Related content in NGMN "Description of Network Slicing Concept"



5G America White Paper
Network Slicing for 5G Network & Services

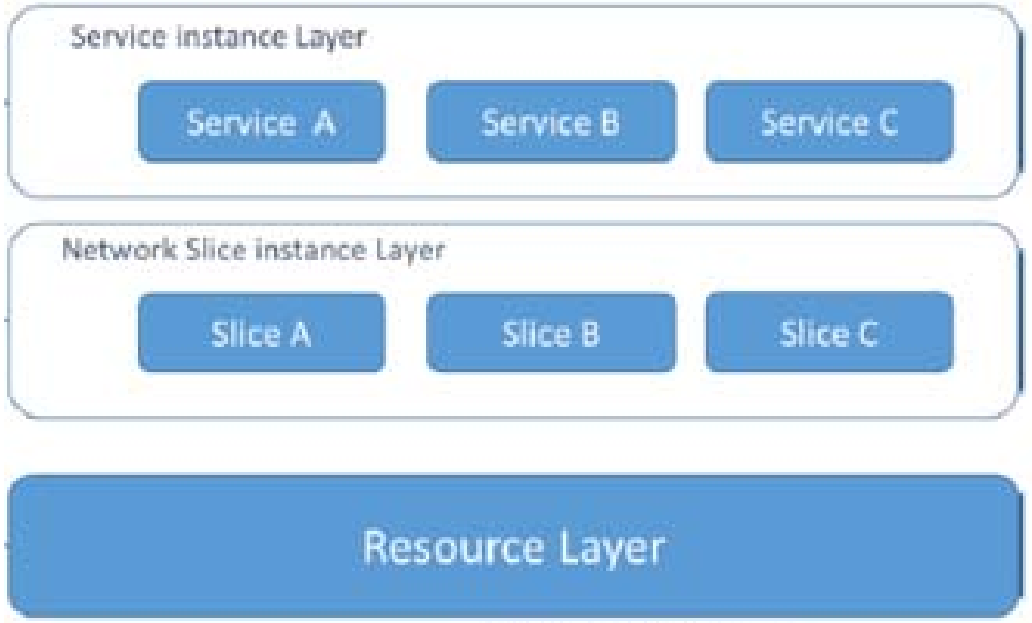
Network Slicing – Vertical

- A network operator uses a Network Slice Blueprint to create a Network Slice Instance. A Network Slice Instance provides the network characteristics (e.g., ultra-low-latency, ultra-reliability etc.) which are required by a Service Instance. A Network Slice Instance may also be shared across multiple Service Instances provided by the network operator.
- The Network Slice Instance may be composed by none, one or more Sub-network Instances, which may be shared by another Network Slice Instance. Similarly, the Sub-network Blueprint is used to create a Sub-network Instance to form a set of Network Functions, which run on the physical/logical resources.
- Network Slice Blueprint: A complete description of the structure, configuration and the plans/work flows for how to instantiate and control the Network Slice Instance during its life cycle. A Network Slice Blueprint enables the instantiation of a Network Slice, which provides certain network. A Network Slice Blueprint refers to required physical and logical resources and/or to Sub-network Blueprint(s).



Network Slicing – Vertical - Transport

- The transport network, mobile fronthaul and Mobile Backhaul shall have the corresponding layers – Service Instance, Network Instance Slice and Resources Layers

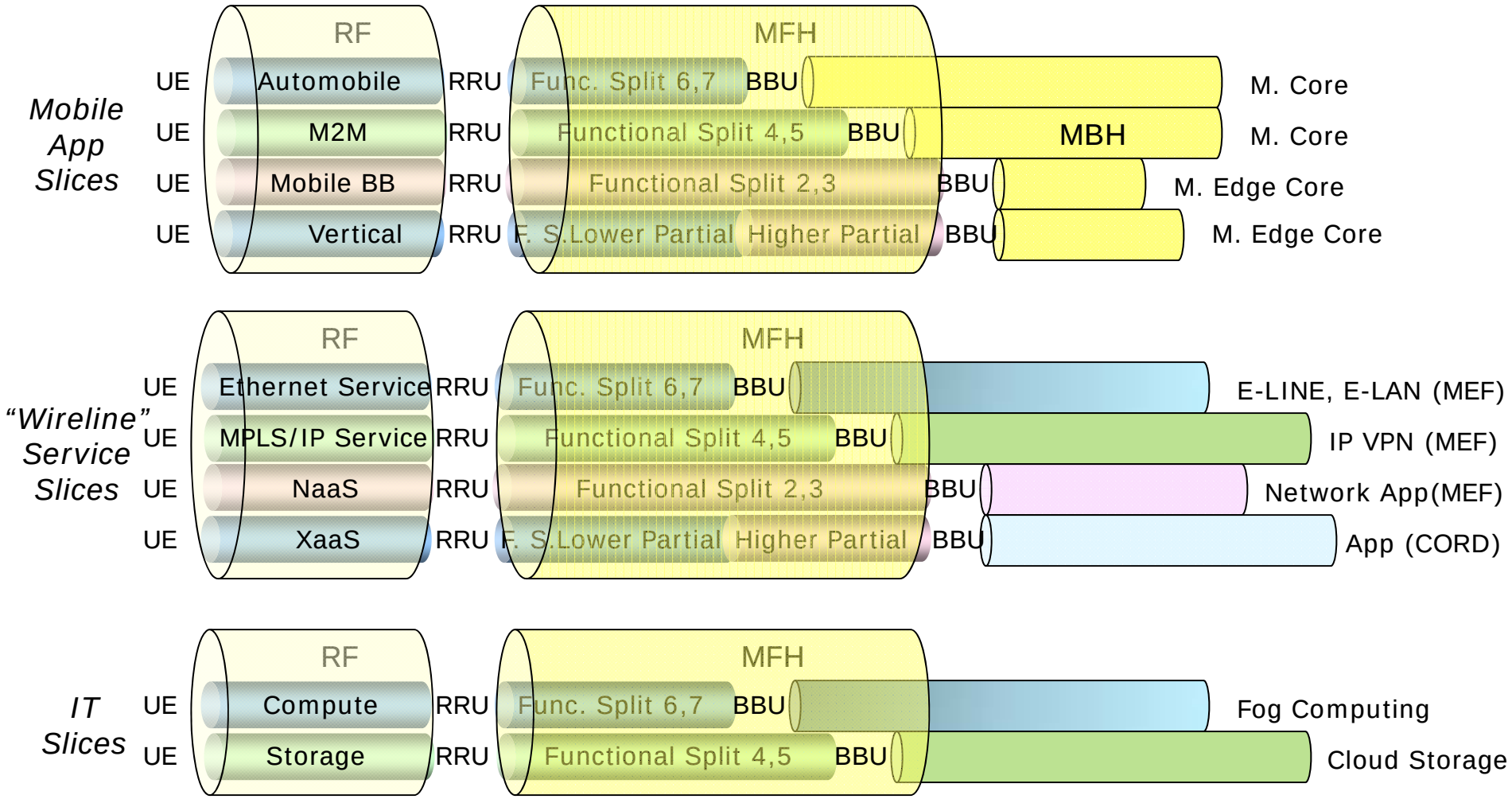


5G America White Paper
Network Slicing for 5G Network & Services

Network Slicing – Service requirements

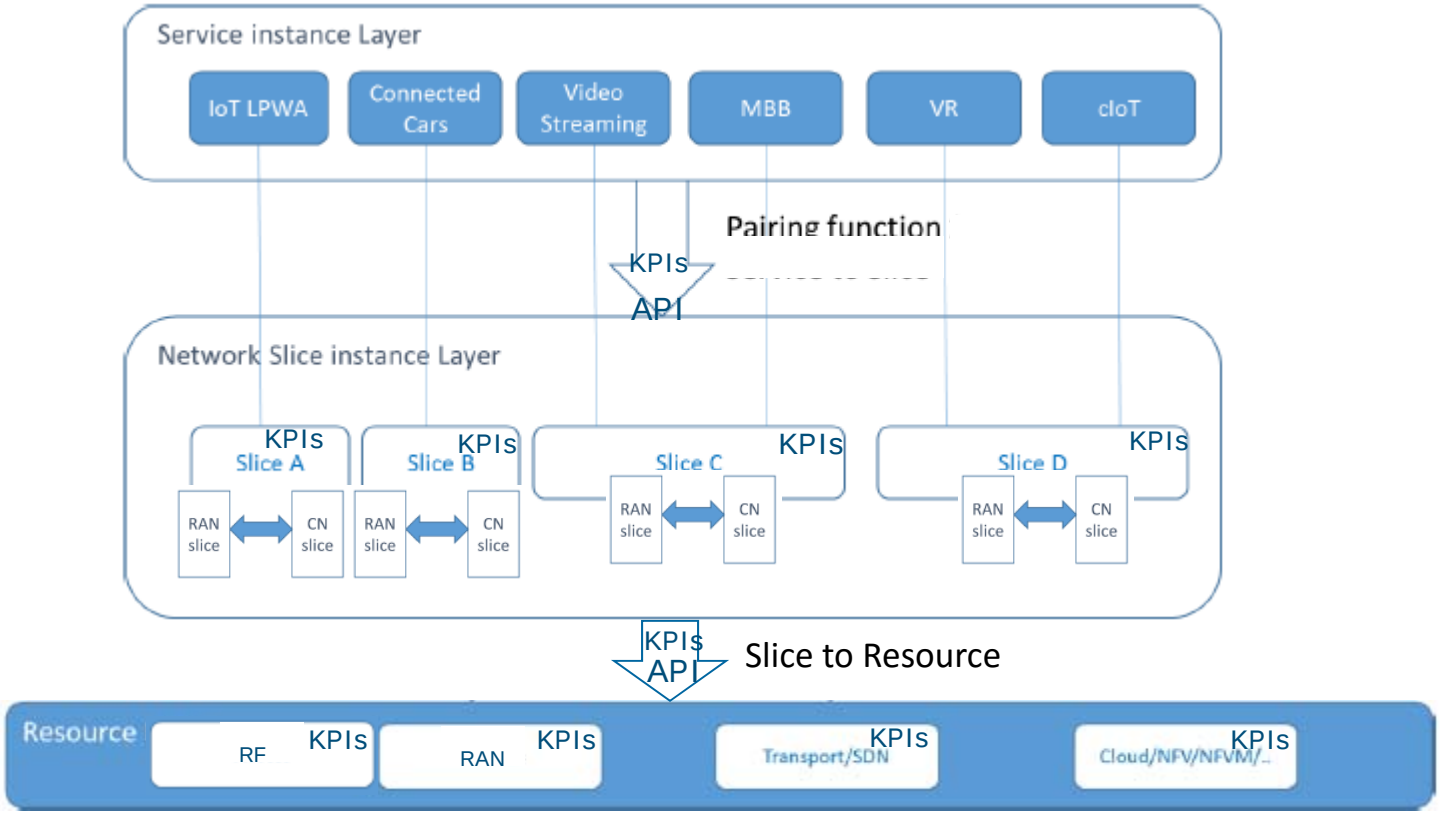
- The service requirements of Network Slicing can be based on
  - Capacity and Bandwidth
  - Functionality - priority, charging, policy, security, mobility, etc.
  - Performance – latency, latency variation, mobility, availability, reliability, throughput, etc.
  - Application catgories – eMBB, uRLLC, mMTC
  - User – consumer, business user, public safety users, roamers, etc.

Network Slicing – Service Examples



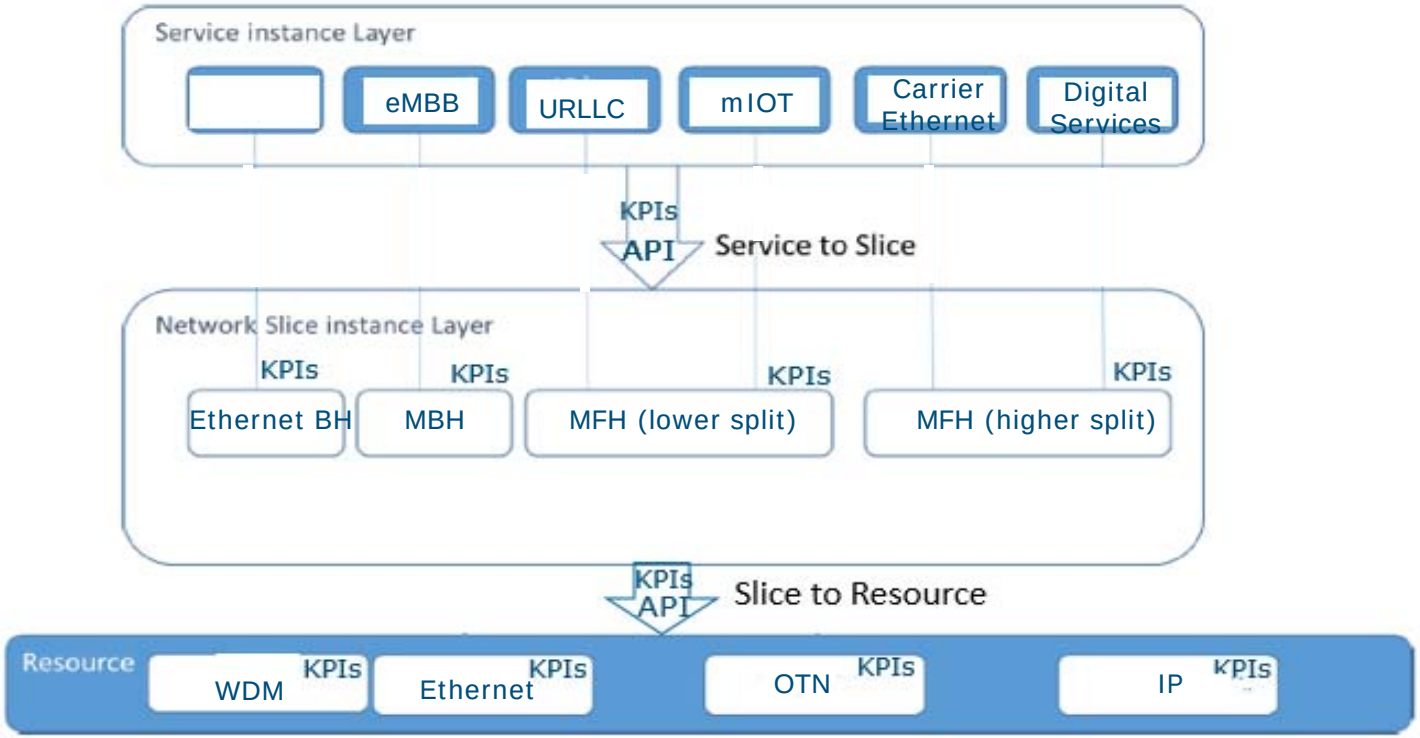
Functional Splits options being discussed in 3GPP, only Option 2 is standardized today

Network Slicing – E-2-E Examples



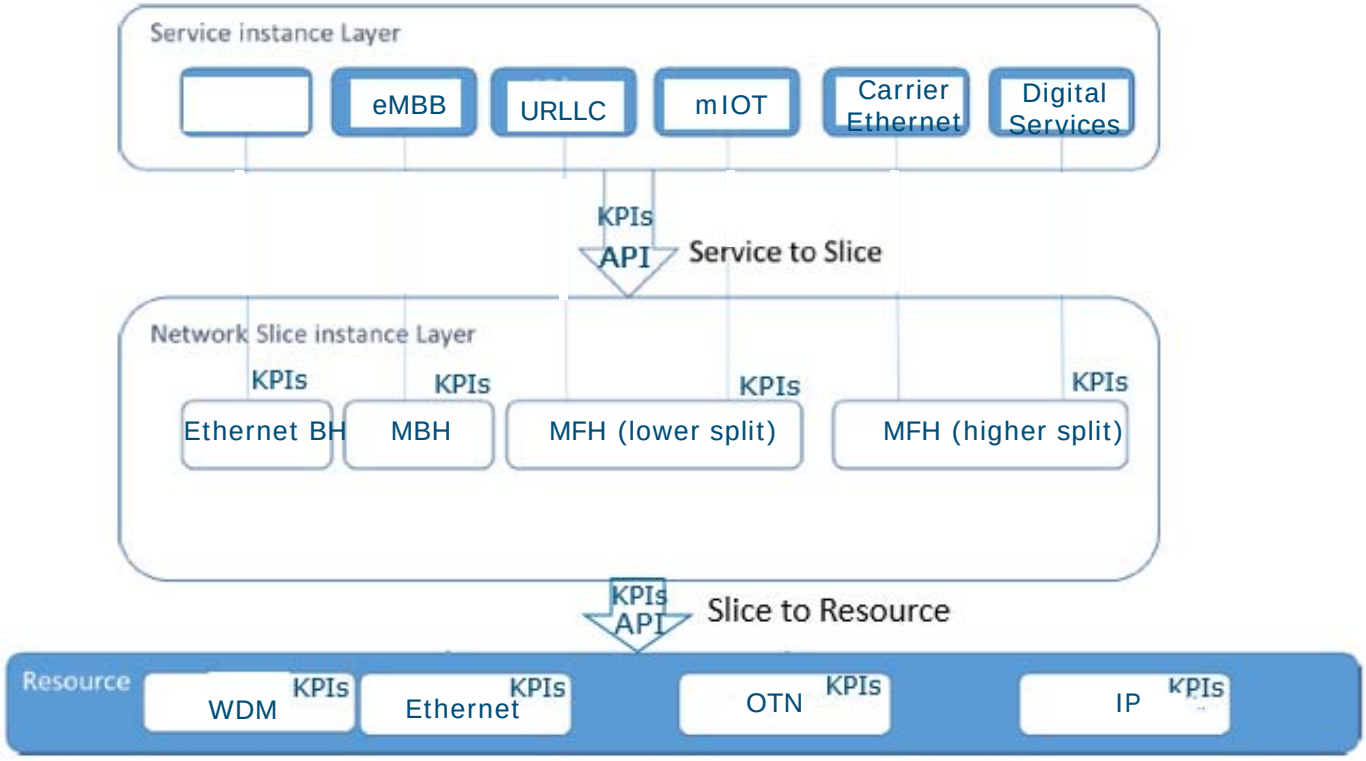
- Inter layer communication via APIs on Service Requirements including KPIs
- Transport Network Slicing instance within RAN for fronthaul and between RAN and Core for backhaul
- It will require Network Slicing association and coordination between Mobile and Transport Network Slicing, possibly via Network Slice ID
- Transport resource in the Resource Layer is dedicated to Transport

Network Slicing – Transport



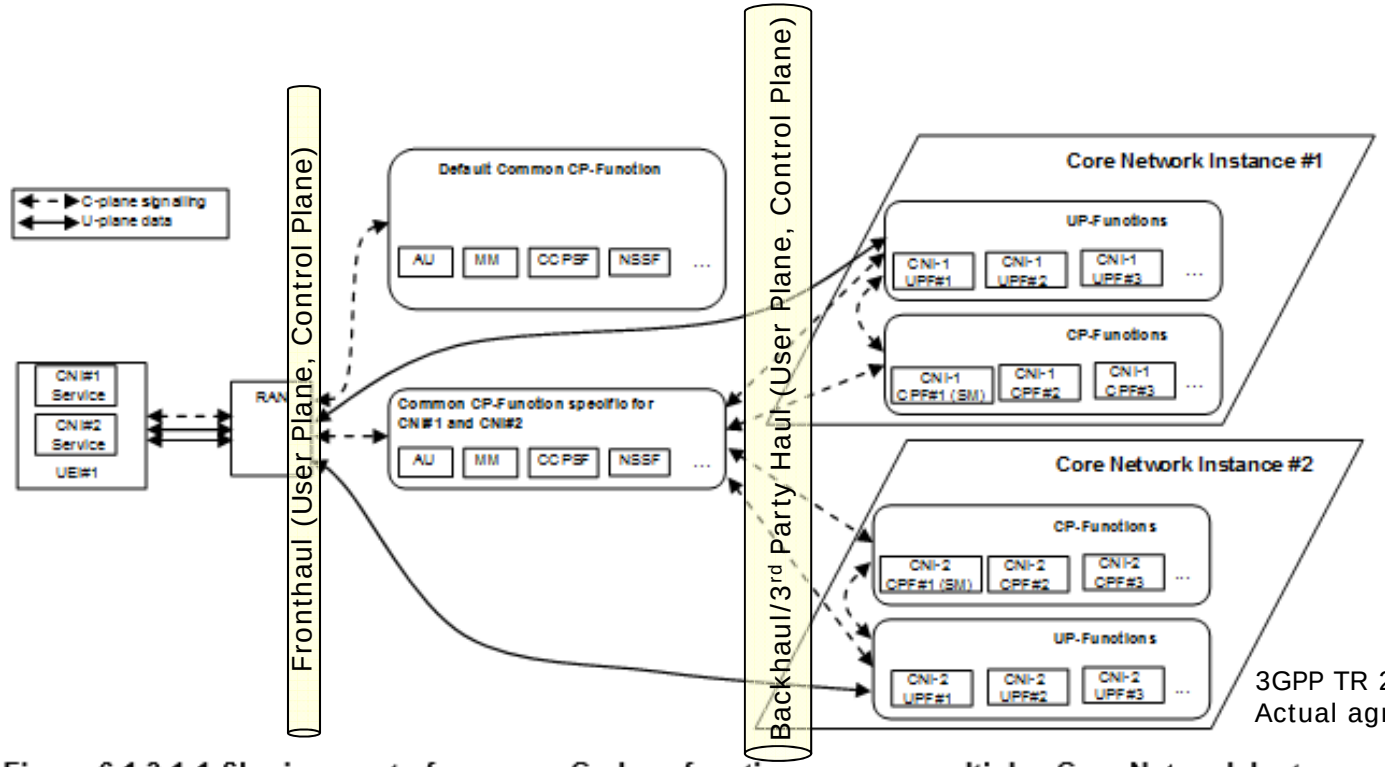
- Transport Network Slicing Instances Category can be based on the location and functions: MFH (lower split), MFH (higher split), MBH and EBH as they serve different purpose with different characteristics and requirements
- Another categories can be based on Service characteristics: eMBB, uRLLC, and mMTC
- Resource Layer Category can be based on Transport Technologies: WDM, OTN, Ethernet, and IP.
- The Transport Technologies can be a sub-network instances within the Network Slice Instance as it can contain multiple sub-network instances (e.g., MFH consists of WDM and Ethernet sub-network instances)
- Some MFH network slice instances may use only WDM sub-network instance for uRLLC while others such as eMBB may use both
- API is the mechanism to communicate requirements from one layer to the next layer in a North-South relationship

Network Slicing – Control and Data Planes



- Transport Network Slicing Instances Category can be based on the location and functions: MFH (lower split), MFH (higher split), MBH and EBH as they serve different purpose with different characteristics and requirements
- Another categories can be based on Service characteristics: eMBB, uRLLC, and mMTC
- Resource Layer Category can be based on Transport Technologies: WDM, OTN, Ethernet, and IP

Network Slicing - Control Plane and User Plane



3GPP TR 23.799
Actual agreements are in section 8 or in TS

Figure 6.1.3.1-1 Sharing a set of common C-plane functions among multiples Core Network Instances

- 5G Network supports the separation of control plane and data plane and applies to Network Slicing
- For a given Network Slice, it has both control plane and data plane instances
- As such, Transport Network will have both control plane and data plane instances
- Both have separate requirements and KPIs

Network Slicing - KPIs

Synchronization

ITU G.8271.1 TAE Budget

Budget Component	Budget	Comment
PRTC	100ns, 30ns for ePRTC	N/A for the most stringent fronthaul TAE target, which is referenced to the last common BC
Holdover and network rearrangements	400ns	N/A if the services requiring finest timing are not offered during rearrangements
Random error of all PTP nodes	200ns	Accumulated low frequency random noise of all nodes (high frequency noise is filtered)
Constant error of all PTP nodes	11 hops x 50ns = 550ns	Could be reduced with better designs
	21 hops x 20ns = 420ns	
Link asymmetries	100ns for 11 hops	Could be reduced with fiber asymmetry measurement techniques
	230ns for 21 hops	
End application	150ns	20ns was specified by CPRI organization for IEEE 802.1CM
Total	**1500ns**	

Standardization Actions

- IEEE 1914 Scope
  - How timing is accomplished is outside the scope of IEEE 1914
  - However, we need to ensure that the mechanisms we define permit the appropriate timing mechanisms to be used
- 3GPP
  - We must continue to liaise with 3GPP to get their TAE, frequency offset, jitter, and other timing requirements

Richard Tse, Synchronization and NGFI
IEEE 1914 April 5, 2017

SyncE,IEEE1588v2
BITS, Stratum 3 Clock → IEEE 1588v2 requires 1ns precision timing

- Synchronization can be another plane in addition to Control Plane, Data Plane and Management Plane
- It may be a separate slice on its own

Network Slicing

Time Sensitive Ethernet Session

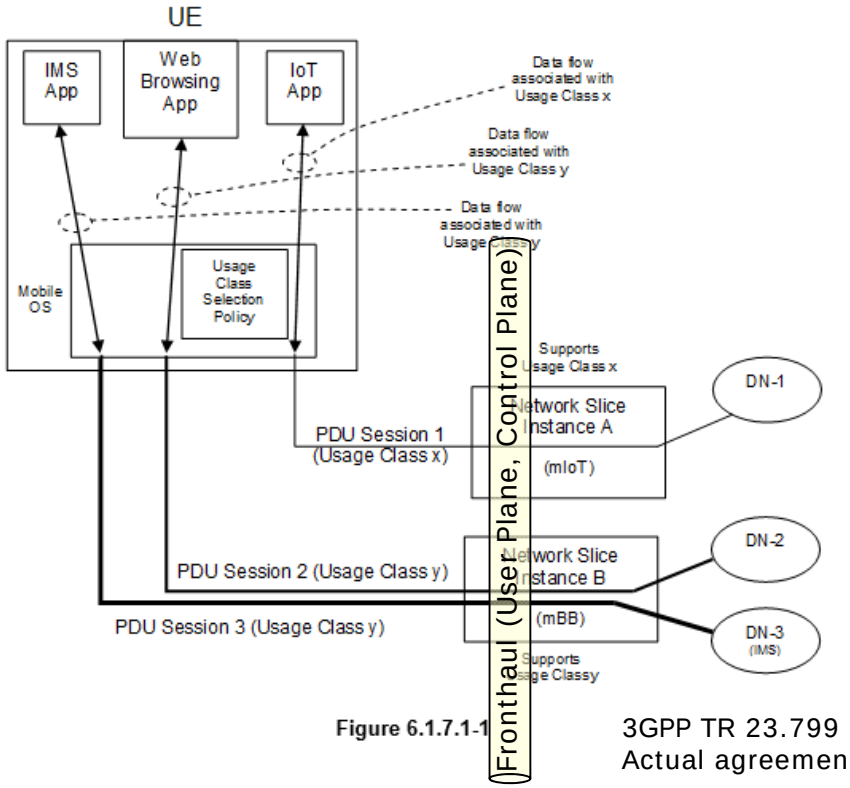


Figure 6.1.7.1-1

Carrier Ethernet Provider

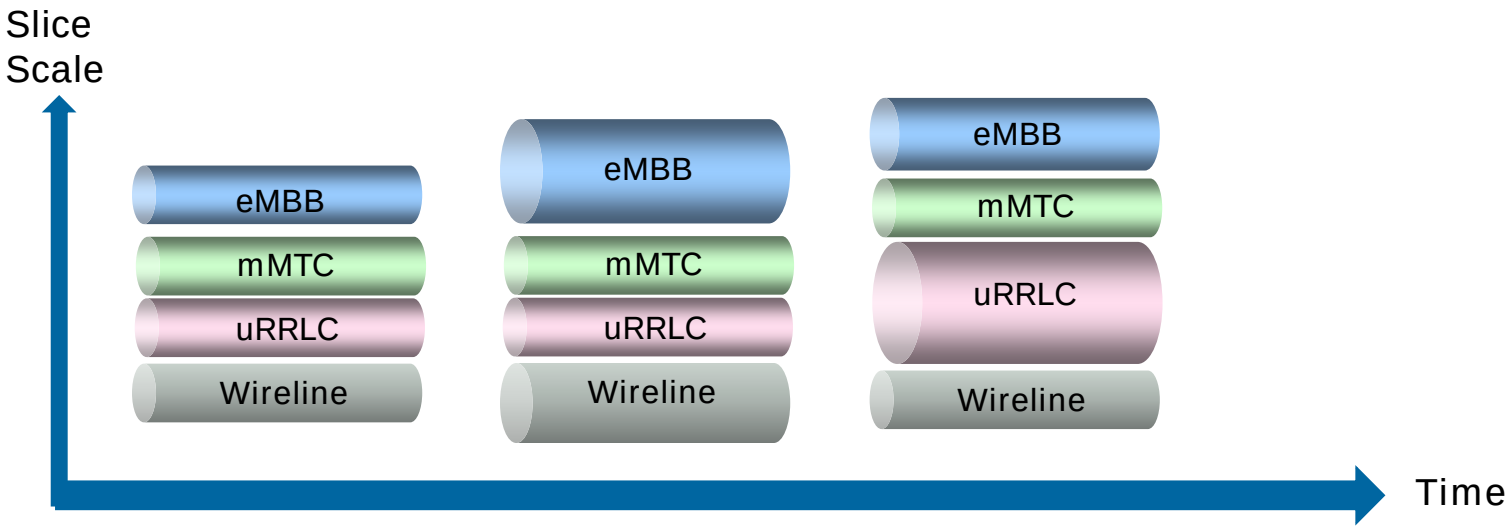
Mobile Operator

3GPP TR 23.799
Actual agreements are in section 8 or in TS

- Time Sensitive Ethernet Session across Mobile (UE-RAN-CORE) Slice and *Transport* Network Slice
- It may be Connection Oriented Session or Connectionless Session
- There is a East-West relationship on each individual session within each slice

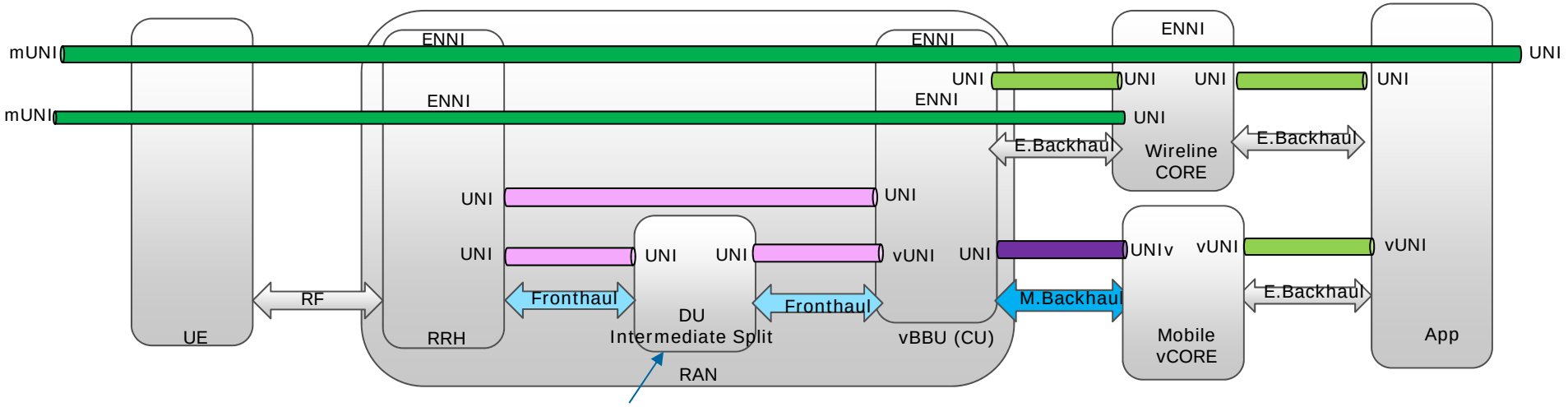
Network Slicing Scaling

Requirements – Scale up & down - Dynamic and On-Demand



- Each Network Slice can scale up & down dynamically and on-demand as Applications and Traffic Load changes
- Each Transport Slice can scale up & down dynamically and on-demand as Applications and Traffic Load changes
- The elasticity of Transport Slice can be based the configured minimum and maximum capacity while dynamically scale up and down within the range
- Furthermore, Ethernet CIR and EIR capability may be needed for Network Slice
- Policy may be communicated when the requested capacity not fully available.

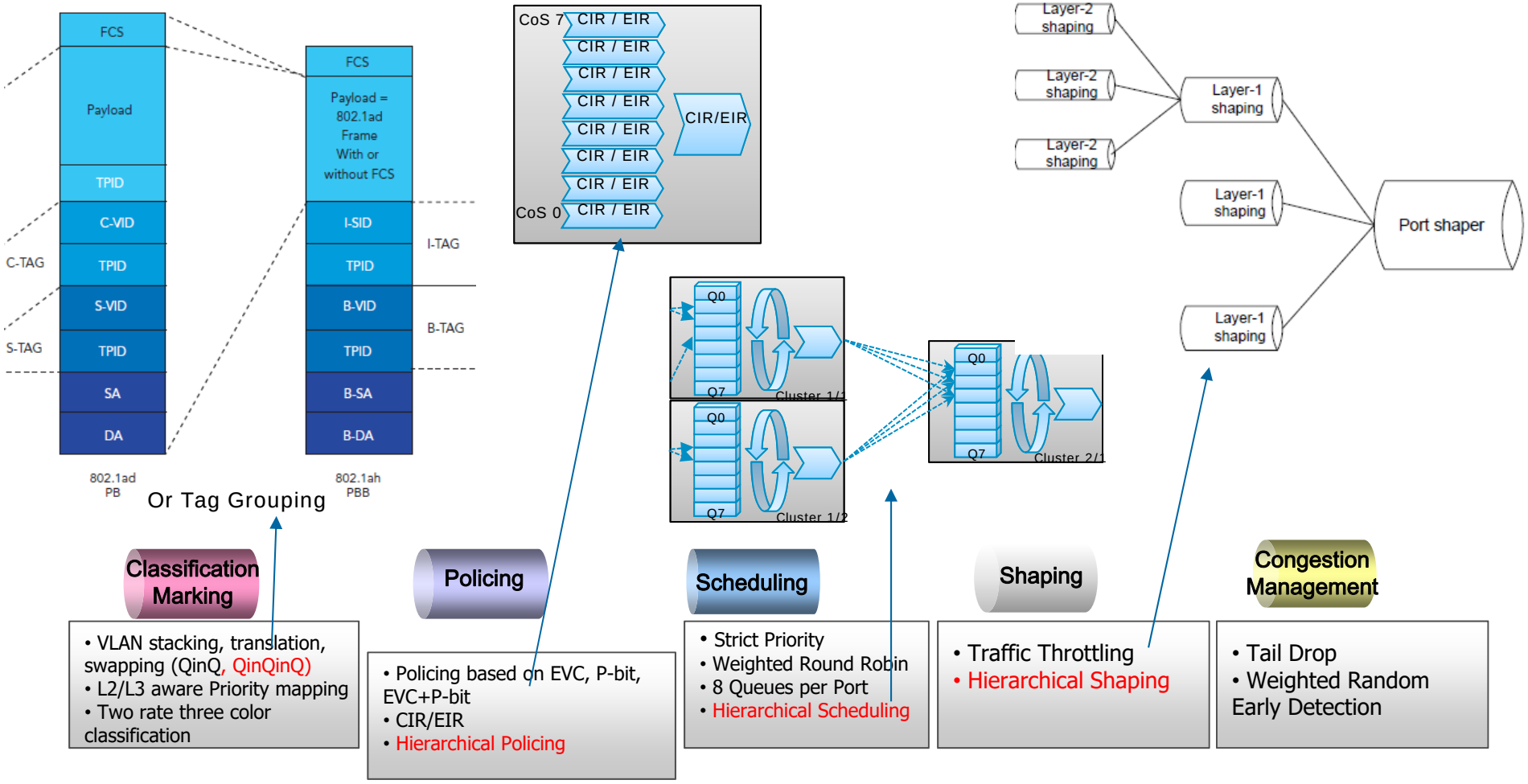
Network Slicing Architecture– Transport Path



Might exist in reality
But not yet in 3GPP spec

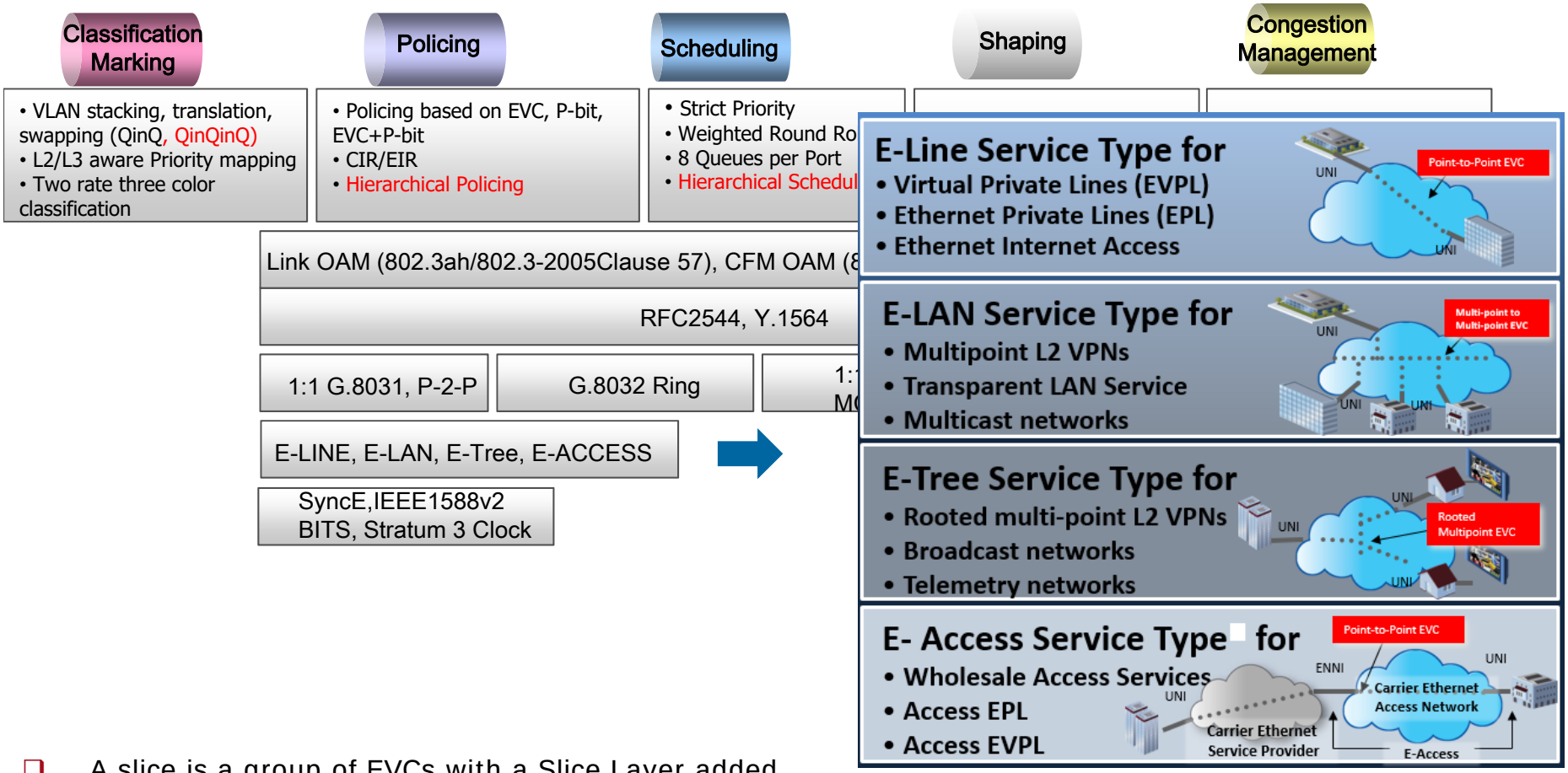
- Variety of Transport Network Paths at different parts of the Network
- Some are self contain without crossing multiple parts of the Network
- Some are cross multiple parts of the Network: UNI-ENNI-UNI
- Some UNIs are Mobile UNI (mUNI) and some are Virtual UNI (vUNI) due to vBBU and vCORE
- Transport Path can span a single transport layer (L0, L1, L2) or multiple layers (L0/1/2)
- Transport network slice is a group of multiple sessions and shall have the same characteristics

Network Slicing - Carrier Ethernet



- Transport Slice – Carrier Ethernet Traffic Engineering Requirements – Adding Slice Layer
- A slice layer may be represented by another tag (two push/pop with one being the slice and the other being individual session), a foundation of a separate layer while maintaining the operations of individual sessions
- The same principal may apply for Policing, Shaping, Scheduling and Congestion Management

Network Slicing – Ethernet Services



- A slice is a group of EVCs with a Slice Layer added
- Ethernet Service type may apply to the Slice layer at least for both E-Line, E-Access, and E-Transit types

Network Slicing – Ethernet OAM

Classification Marking	Policing	Scheduling	Shaping	Congestion Management
• VLAN stacking, translation, swapping (QinQ, QinQinQ) • L2/L3 aware Priority mapping • Two rate three color classification	• Policing based on EVC, P-bit, EVC+P-bit • CIR/EIR • Hierarchical Policing	• Strict Priority • Weighted Round Robin • 8 Queues per Port • Hierarchical Scheduling	• Traffic Throttling • Hierarchical Shaping	• Tail Drop • Weighted Random Early Detection

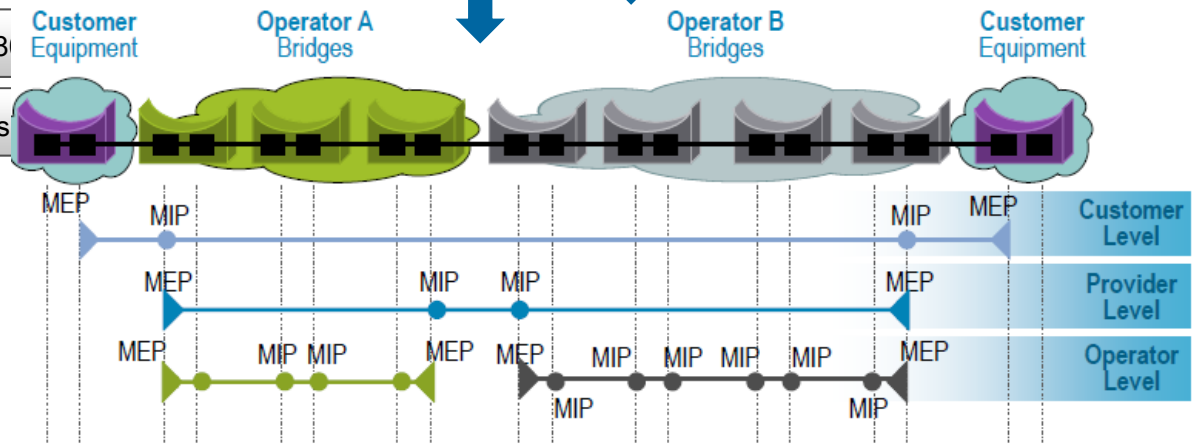
Link OAM (802.3ah/802.3-2005Clause 57), CFM OAM (802.1ag), Service OAM (Y.1731)

RFC2544, Y.1564

1:1 G.8031, P-2-P | G.8

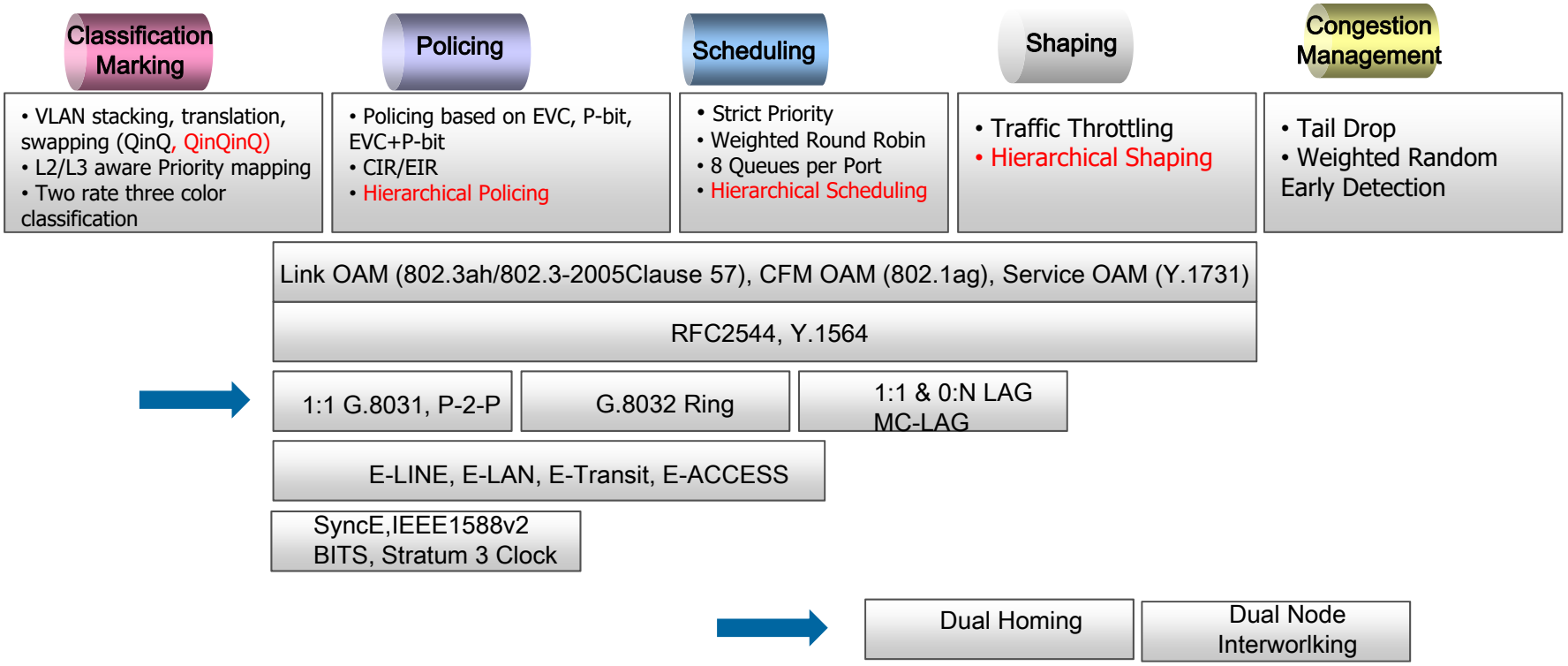
E-LINE, E-LAN, E-Trans

SyncE,IEEE1588v2
BITS, Stratum 3 Clock



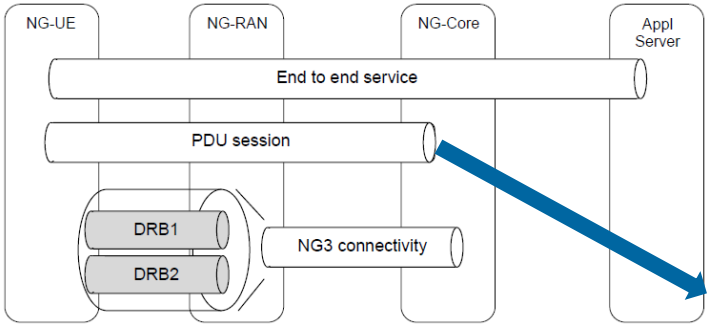
- A slice is a group of EVCs with a Slice Layer added
- The Ethernet OAM can apply to Network Slice Layer

Network Slicing – Network Protection



- A slice is a group of EVCs with a Slice Layer added
- The Ethernet network protection can apply to Network Slice Layer

Network Slicing Mobile Protocol I/F Requirements User Plane



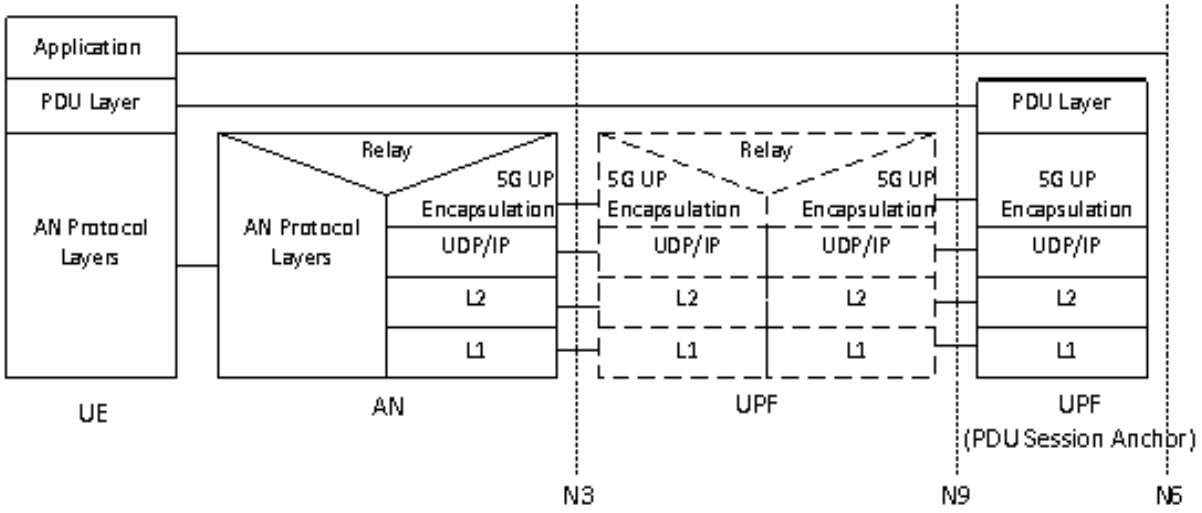


Figure 8.3.1-1: User Plane Protocol Stack 3GPP TS 23.501

- User Plane -> PDU session/layer -> The PDU carried between UE and The DN (Data Network)
- PDU session type – Ipv6 (IPv6 Packets), Ethernet (Ethernet Frames)
- PDU session multiplexing – Multiplexing traffic of different PDN sessions (possibly different session types)
- Each Transport Slice is a collection of PDU sessions sharing the same characteristics
- In the wholesale slice use case, it will need such exposure and management to the buyer of the slice

Network Slicing Mobile Protocol I/F Requirements Control Plane

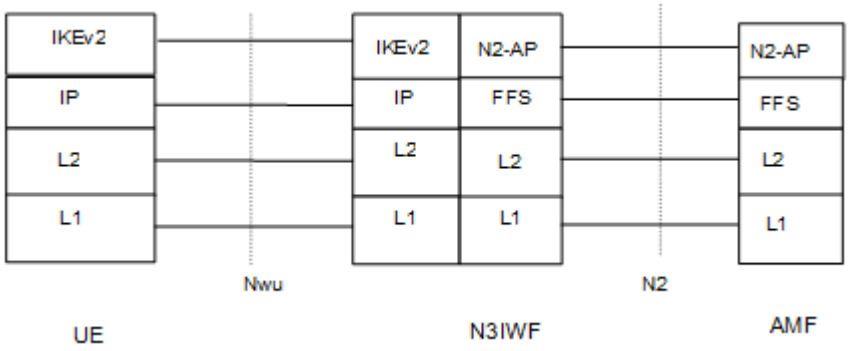


Figure 8.2.x-3: Control Plane for user plane establishment via N3IWF

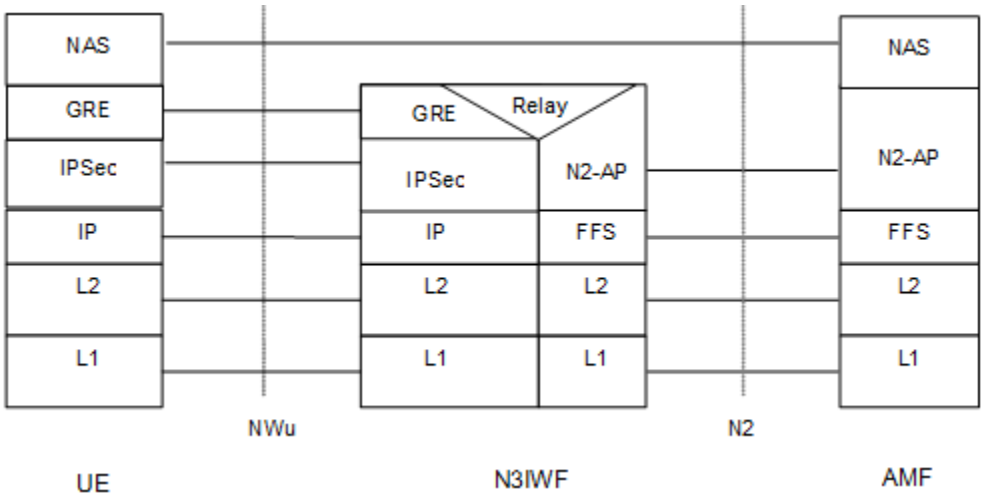


Figure 8.2.x-2: Control Plane for NAS when CP IPsec SA is established

3GPP TS 23.501

- Control Plane -> Control PDU session/layer -> The PDU carried to/from Control Plane – still being defined
- Control PDU session type – Ipv6 (IPv6 Packets), Ethernet (Ethernet Frames)
- Control session multiplexing – Multiplexing traffic of different PDN sessions (possibly different session types)
- In the wholesale slice use case, it will need such exposure and management to the buyer of the slice

Network Slicing Lifecycle Management

Requirements

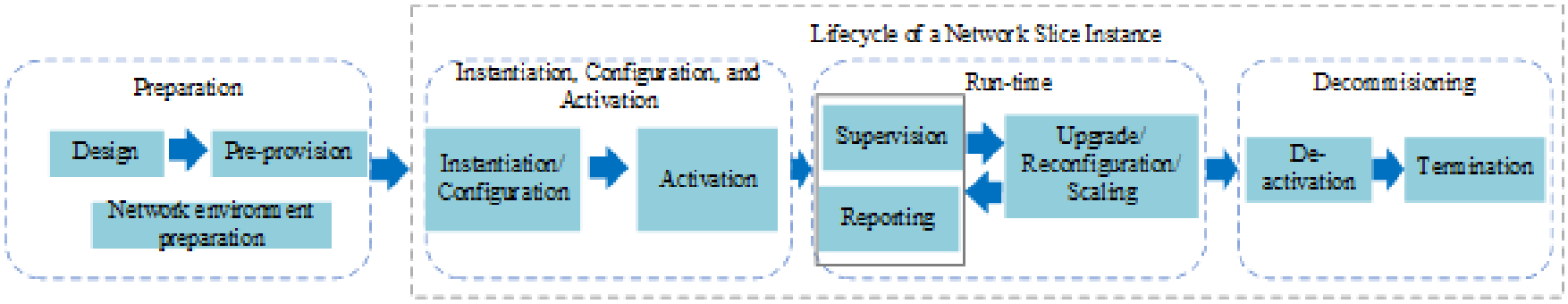


Figure 4.1-1: Lifecycle phases of a NSI 3GPP TR 28.801

- Mobile Network Slicing Lifecycle Management
  - Instantiation/Configuration, Activation, Supervision, Reporting, Upgrade/Reconfiguration/Scaling, Deactivation, Termination
- Corresponding Transport Network Slicing Lifecycle Management
  - Instantiation/Configuration, Activation, Supervision, Reporting, Upgrade/Reconfiguration/Scaling, Deactivation, Termination
- There is an association among RAN, Core and Transport via East-West and/or North-East communication