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Transport Network Slicing

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IEEE 1914.1 TF

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

Transport Network Slicing			
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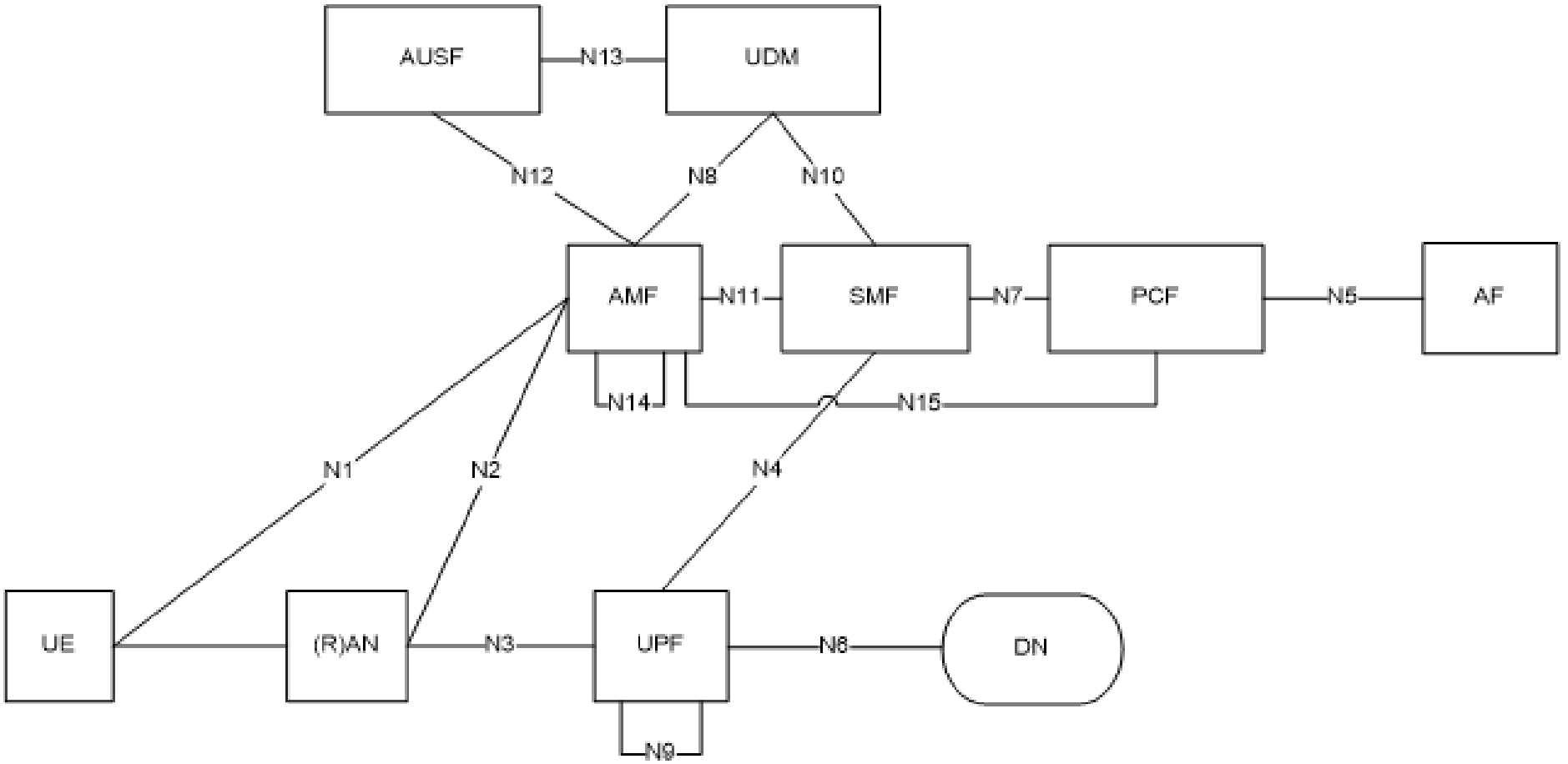
Agenda

- 3GPP Network Architecture and Network Slicing
- E-2-E Network Slicing Across Mobile (UE-RAN-Core) and Transport Network
- Transport Network Slicing – Requirements and Architecture

5G System Architecture



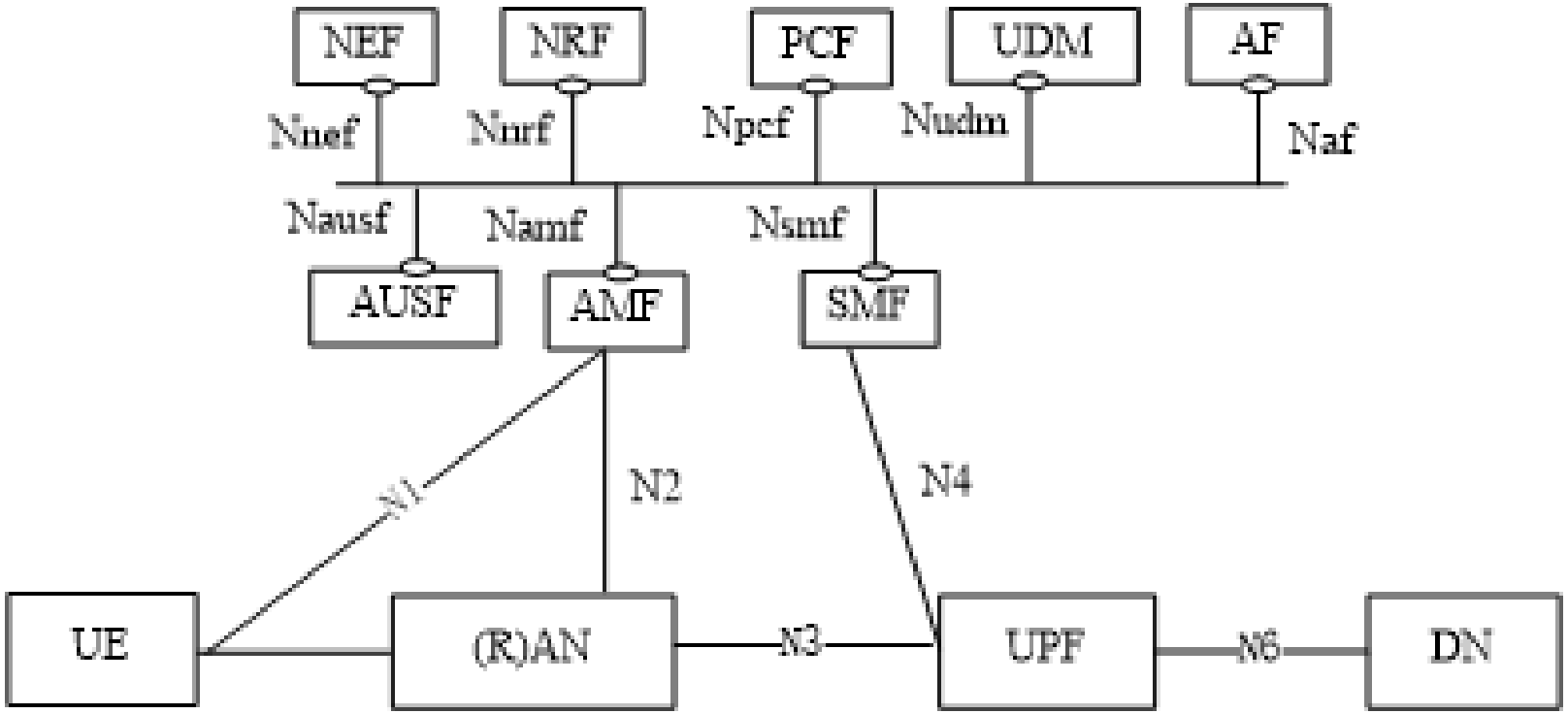
3GPP TS 23.501

5G System Architecture Terms

- Authentication Server Function (AUSF)
- Core Access and Mobility Management Function (AMF)
- Data network (DN), e.g. operator services, Internet access or 3rd party services
- Structured Data Storage network function (SDSF)
- Unstructured Data Storage network function (UDSF)
- Network Exposure Function (NEF)
- NF Repository Function (NRF)
- Policy Control function (PCF)
- Session Management Function (SMF)
- Unified Data Management (UDM)
- User plane Function (UPF)
- Application Function (AF)
- User Equipment (UE)
- (Radio) Access Network ((R)AN)

3GPP TS 23.501

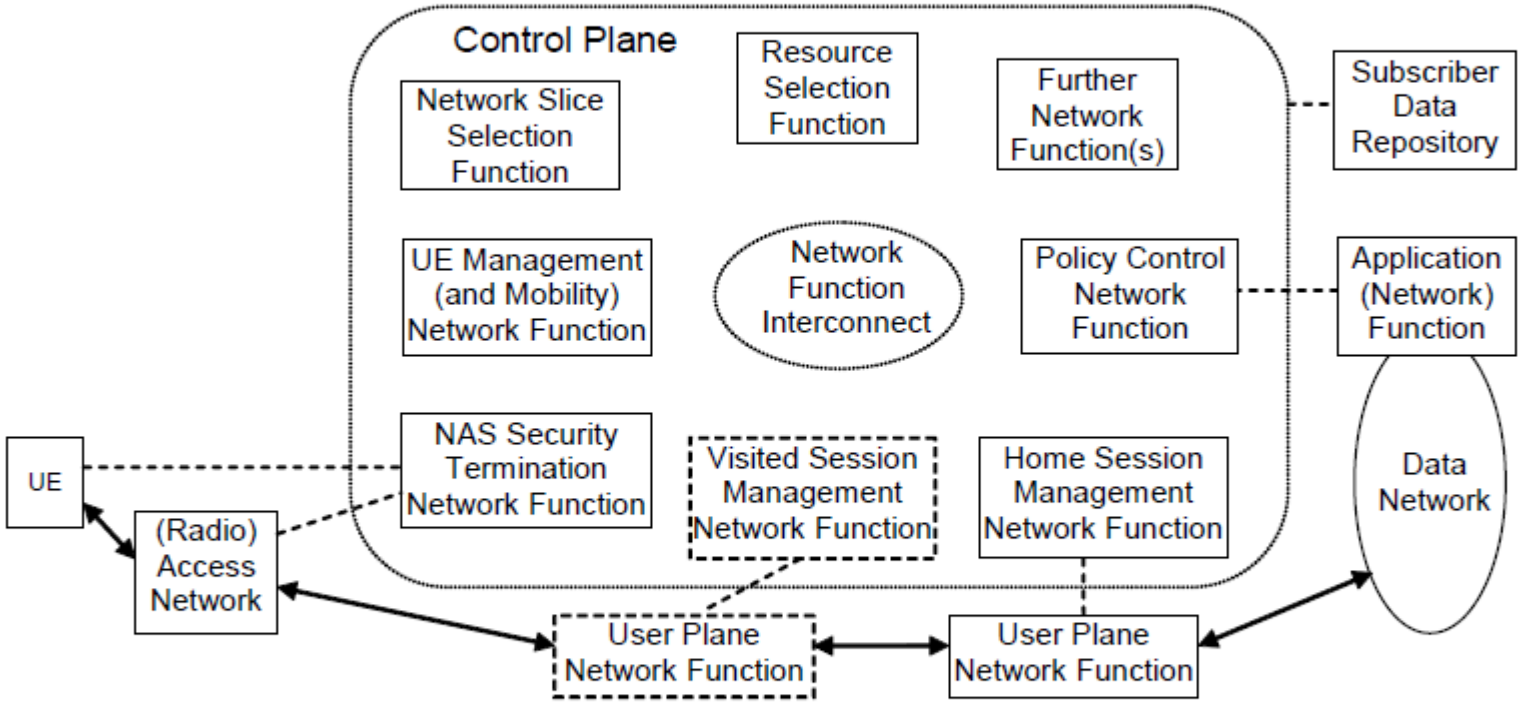
5G System Service-Based Architecture



3GPP TS 23.501

5G Functional Network Architecture

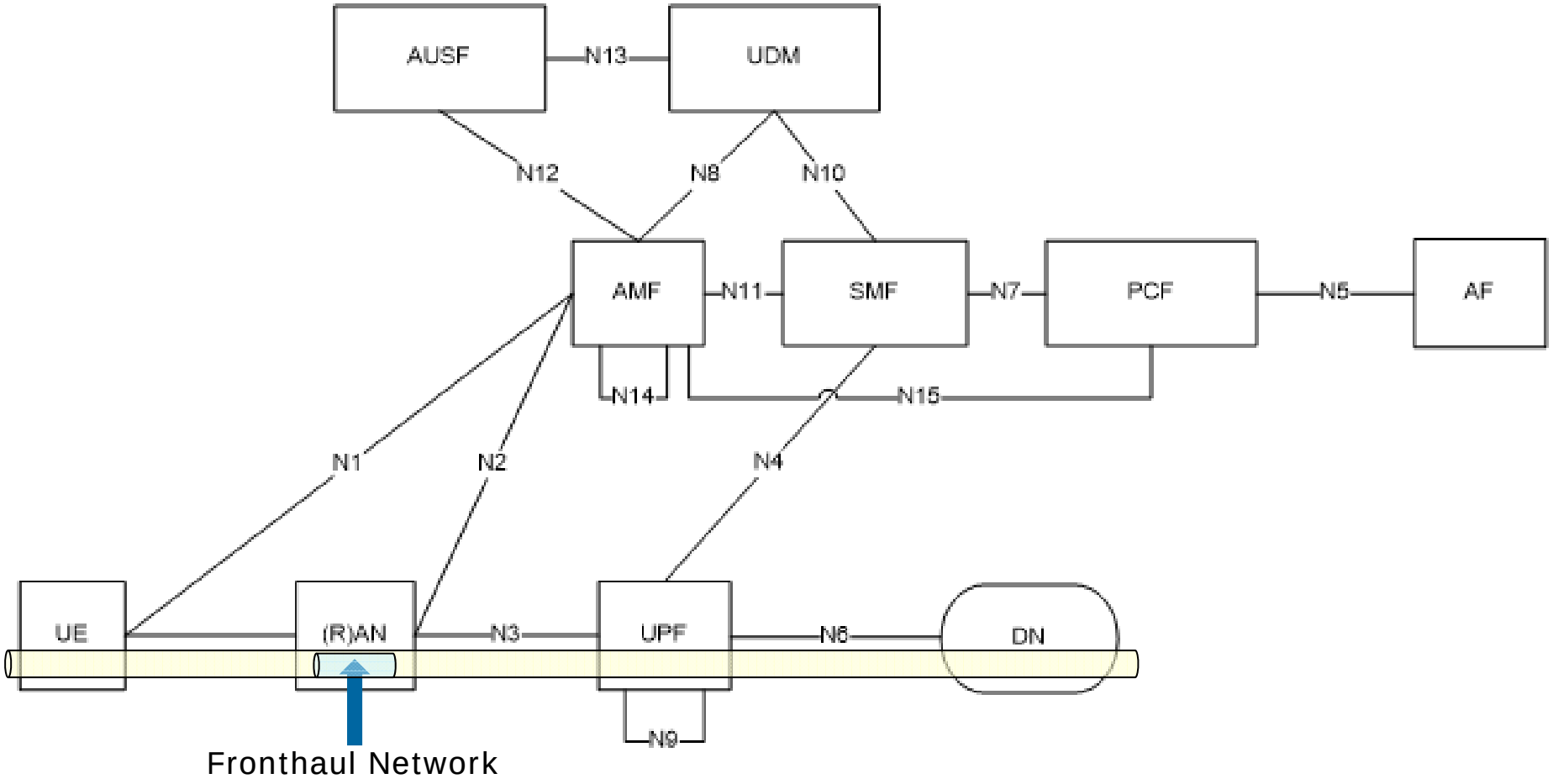
Functional Network Architecture



This is **NOT** (yet?) the 3GPP 5G System Architecture.

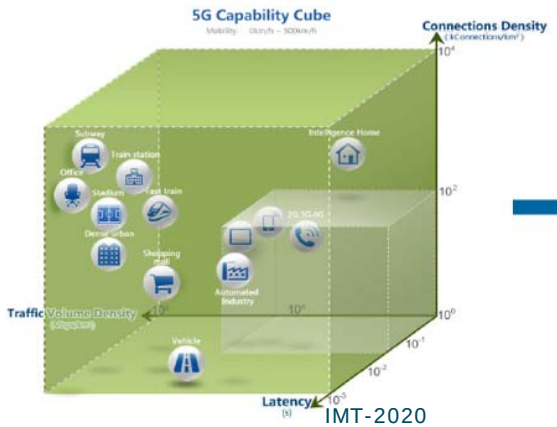
This is a snapshot of the ongoing work where the here shown and other principles and network functions are under discussion.

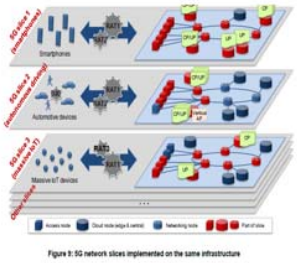
5G System Architecture – Fronthaul Network



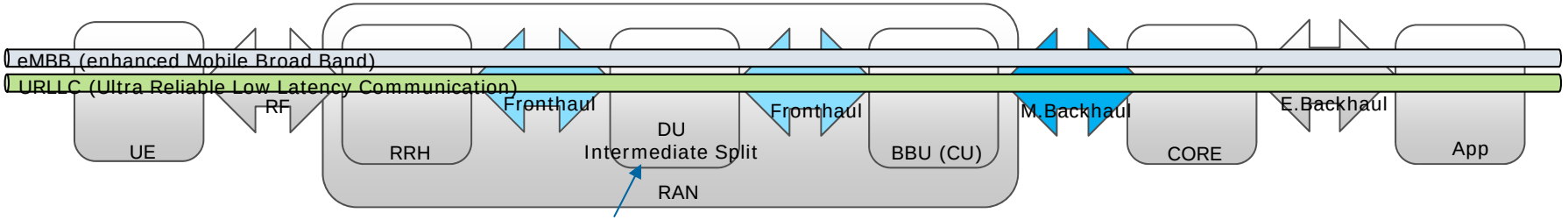
3GPP TS 23.501

5G E-2-E Network Slicing





Network Slicing
Customized for EACH

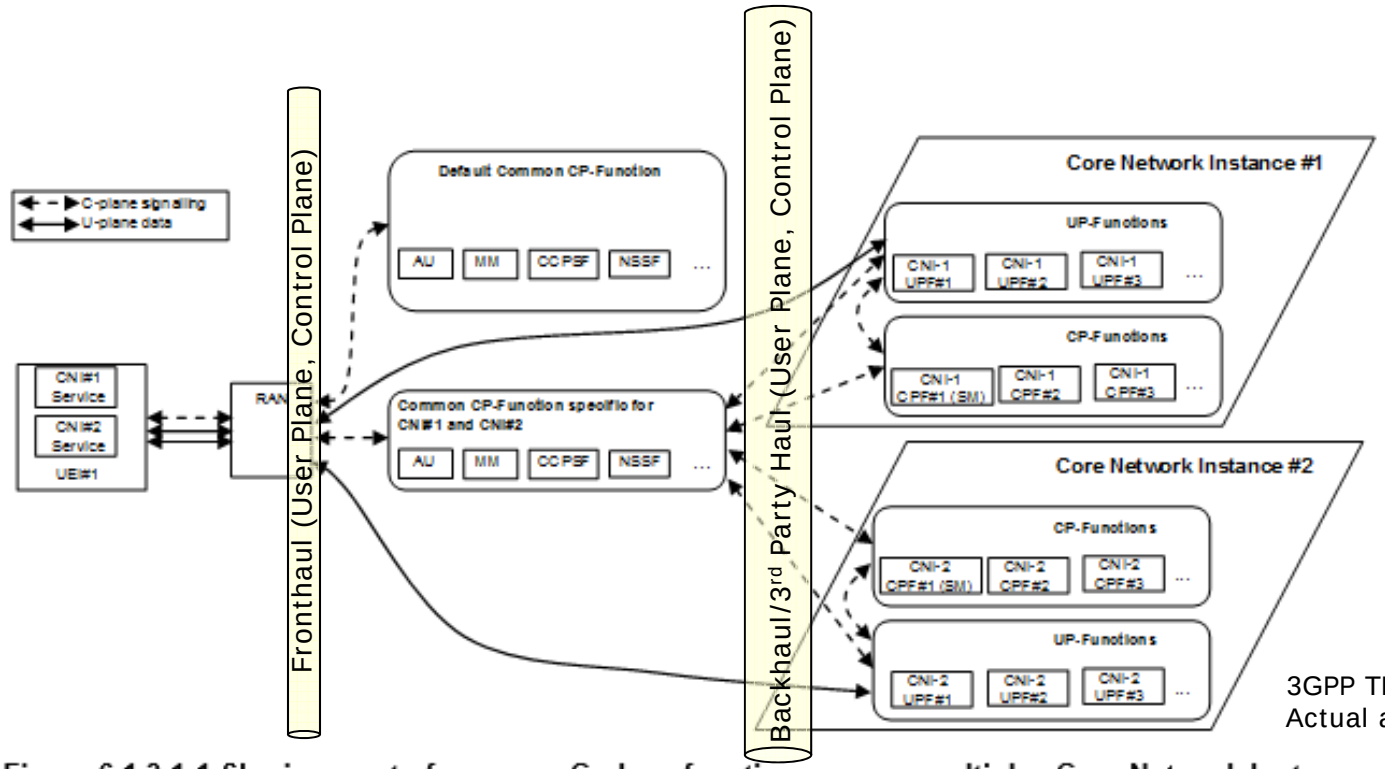


Might exist in reality
But not yet in 3GPP spec

- E-2-E Network Slicing is a Team Work and a coherent one including Mobile Fronthaul and Backhaul
- Fronthual is intertwined within RAN

5G 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

- Mobile Slice (UE-RAN-CORE) and *Transport* Network Slice Creation/Composition, Modification, Deletion and Selection
- Mobile (UE-RAN-CORE) Control Plane and User Plane Separation and Separate Transport Channels

5G E-2-E Network Slicing

Time Sensitive Ethernet Session

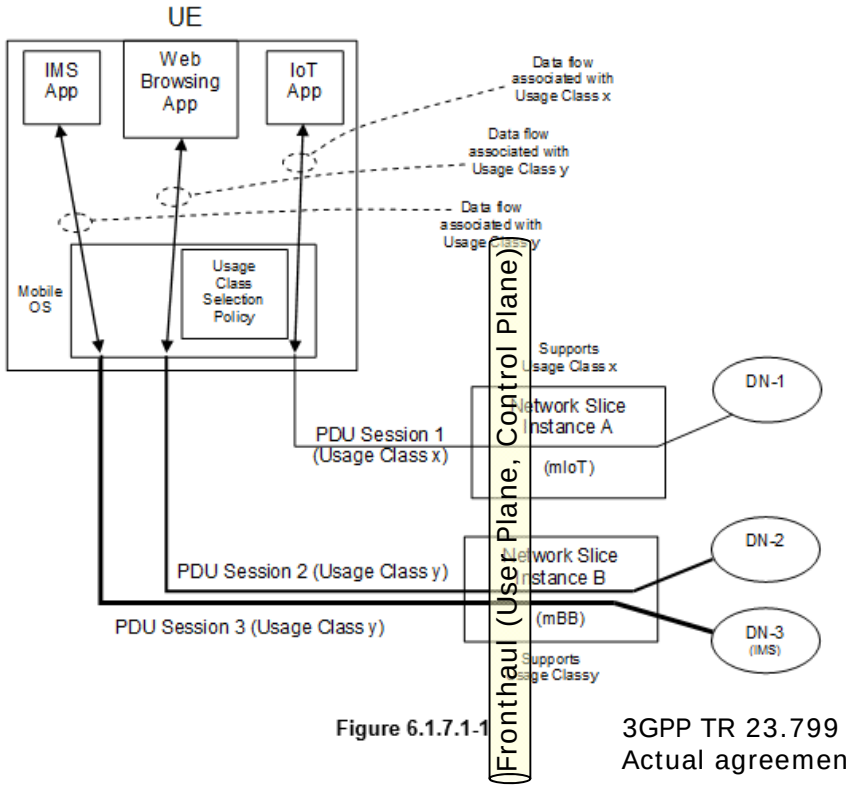


Figure 6.1.7.1-1

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
- Connection Oriented Session and Connectionless Session

5G E-2-E Network Slicing

Time Sensitive Ethernet KPIs

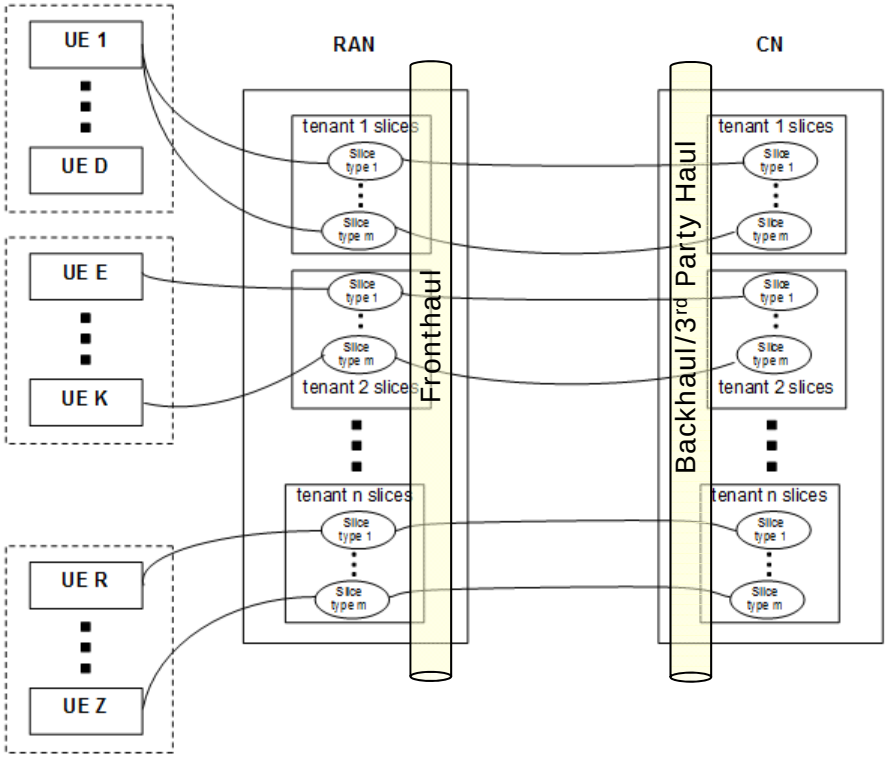


Figure 6.1.2.1.1-1: Network with n Tenants and m possible Slice Types (with UEs which can only access a single tenant slices)

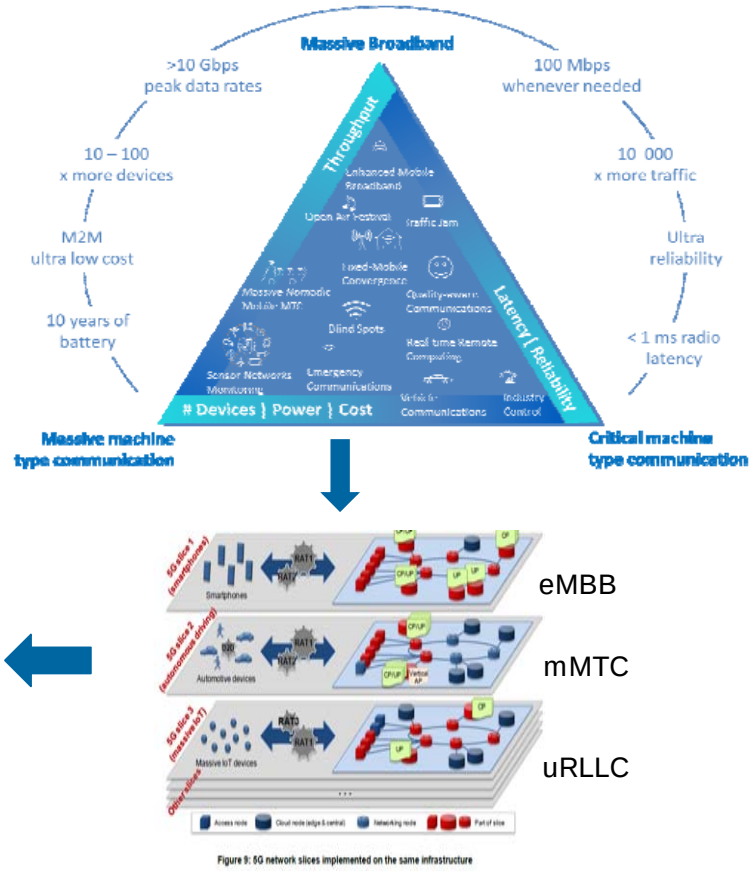
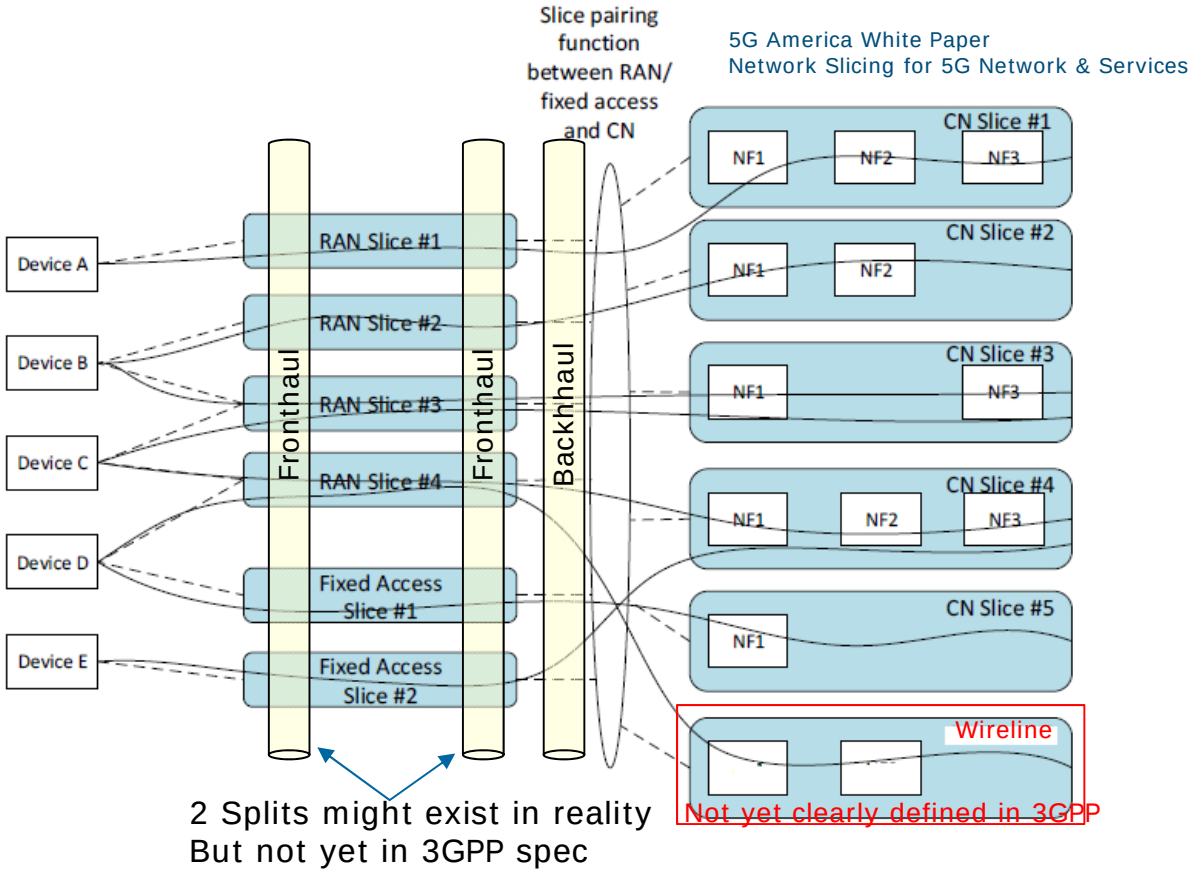


Figure 9: 5G network slices implemented on the same infrastructure

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

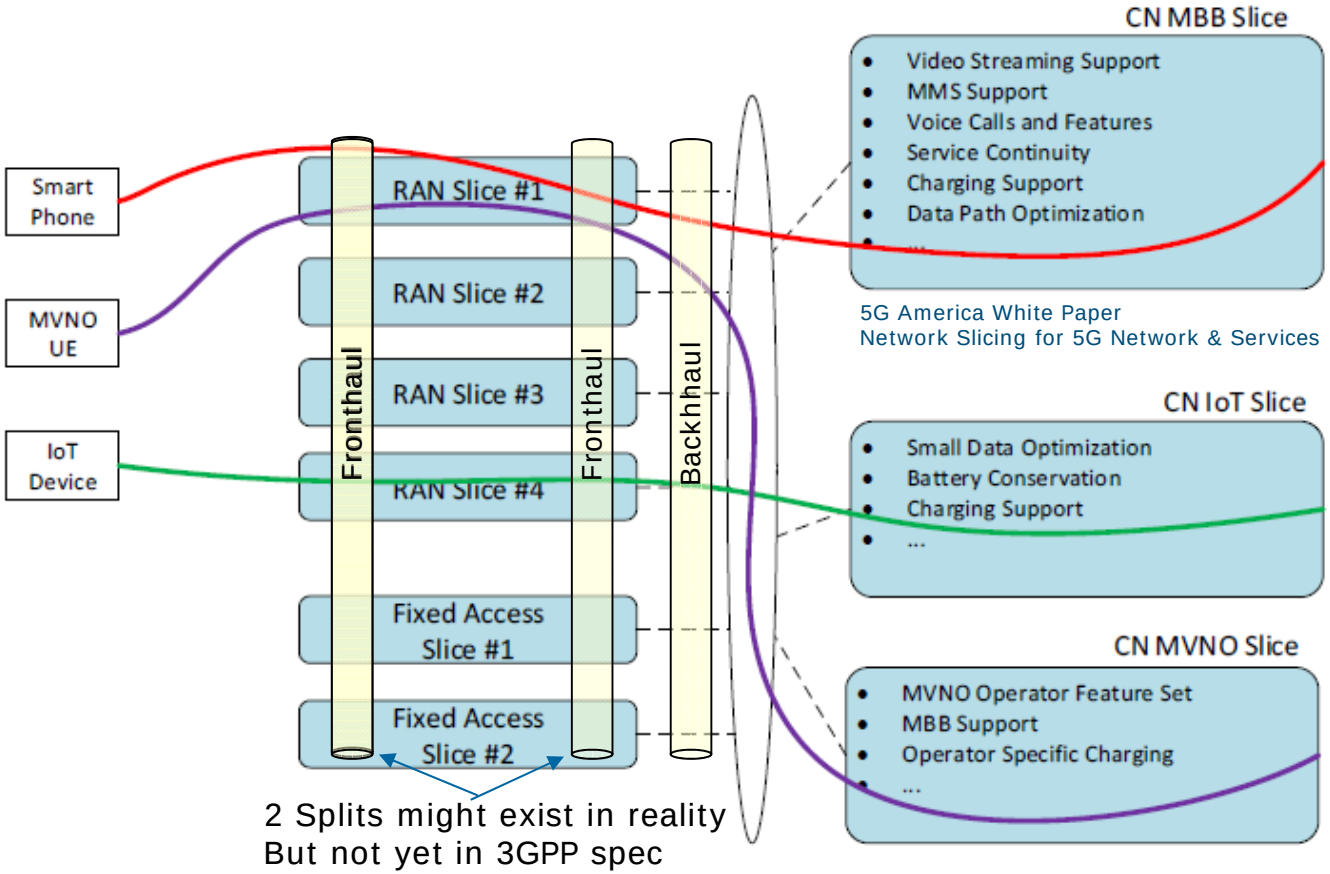
- Time Sensitive Ethernet KPIs across Mobile (UE-RAN-Core) Slice and Transport Slice
- E-2-E KPI budget allocation across Mobile (UE-RAN-Core) Slice and Transport Slice
- Currently not yet addressed by any SDOs
- 3GPP SA5 group proposing to work with outside groups for the Transport Network

5G E-2-E Network Slicing Architecture



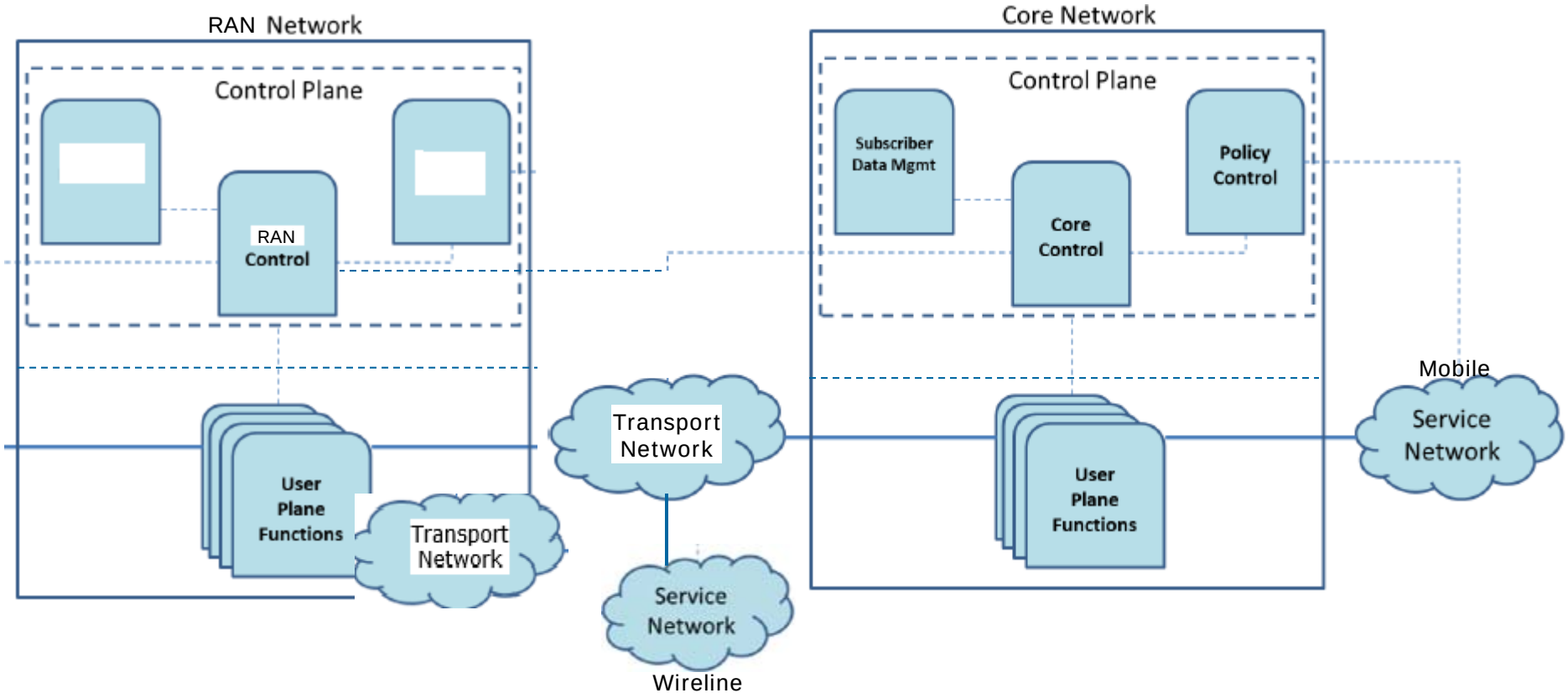
- Fronthaul is inside the RAN Slice between RRH and BBU or between RRH & DU and DU and CU(BBU)
- Backhaul is between RAN and Mobile Core Network or between RAN and Wireline Network for Wireline Services

5G E-2-E Network Slicing Examples



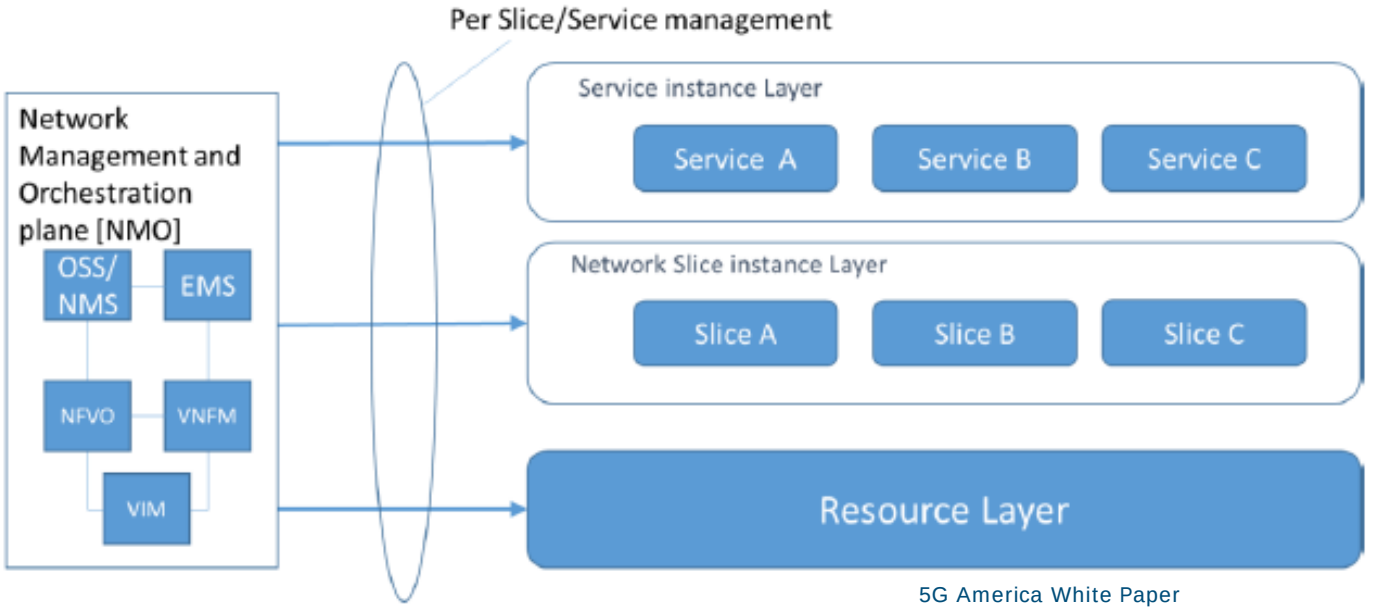
- Each Slice has its own requirements and KPIs
- Transport Network shall have corresponding slice to meet the Mobile Slice E-2-E requirements and KPIs

Network Slicing Architecture– Control & User Plane



- 5G Network supports separation of Control Plane and User Plane
- Separate Transport Network for Control Plane and User Plane with different requirements and KPIs
- User Plane to Mobile Core Network for Mobile Services or to Wireline Network for Wireline Services

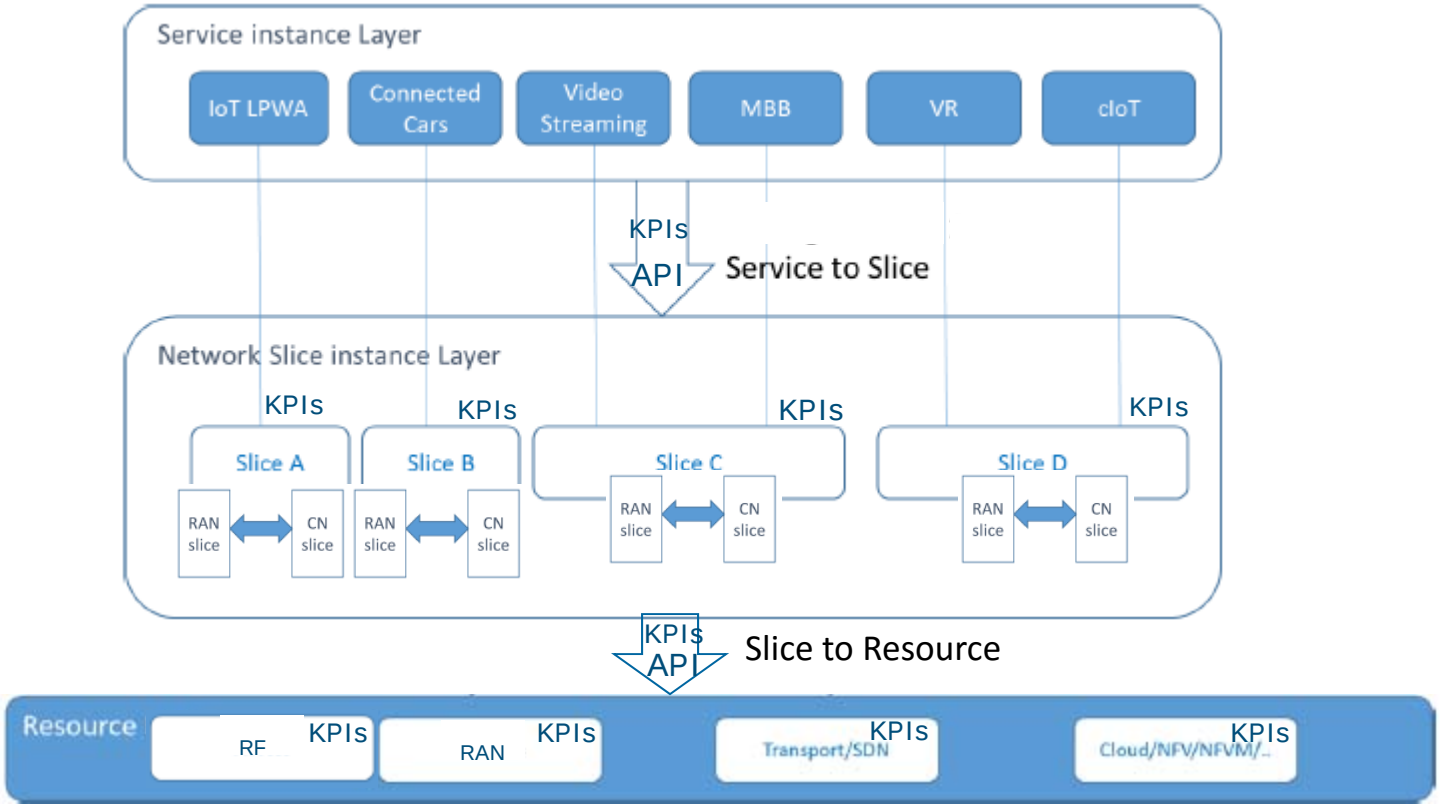
Network Slicing Architecture - Layers



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

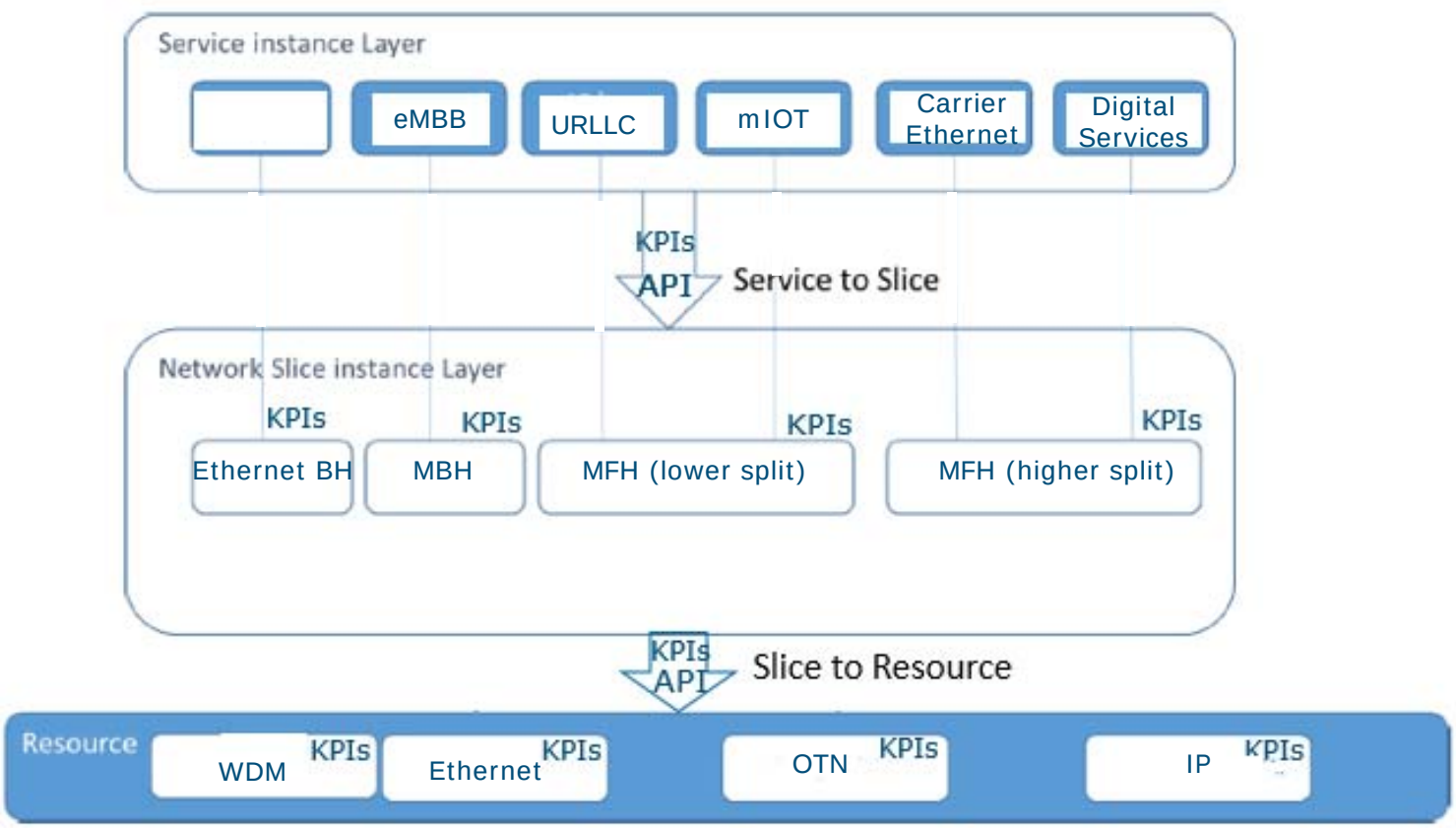
- Network Slicing Layers – Services Layer, Network Slice Layer and Resource Layer
- Network Management and Orchestration Plane – The Conductor
- Transport Network shall have the same Service, Network Slice and Resource Layers
- Network Management and Orchestration Directs both Mobile Network Slices and Transport Network Slices

Network Slicing Architecture - Instances



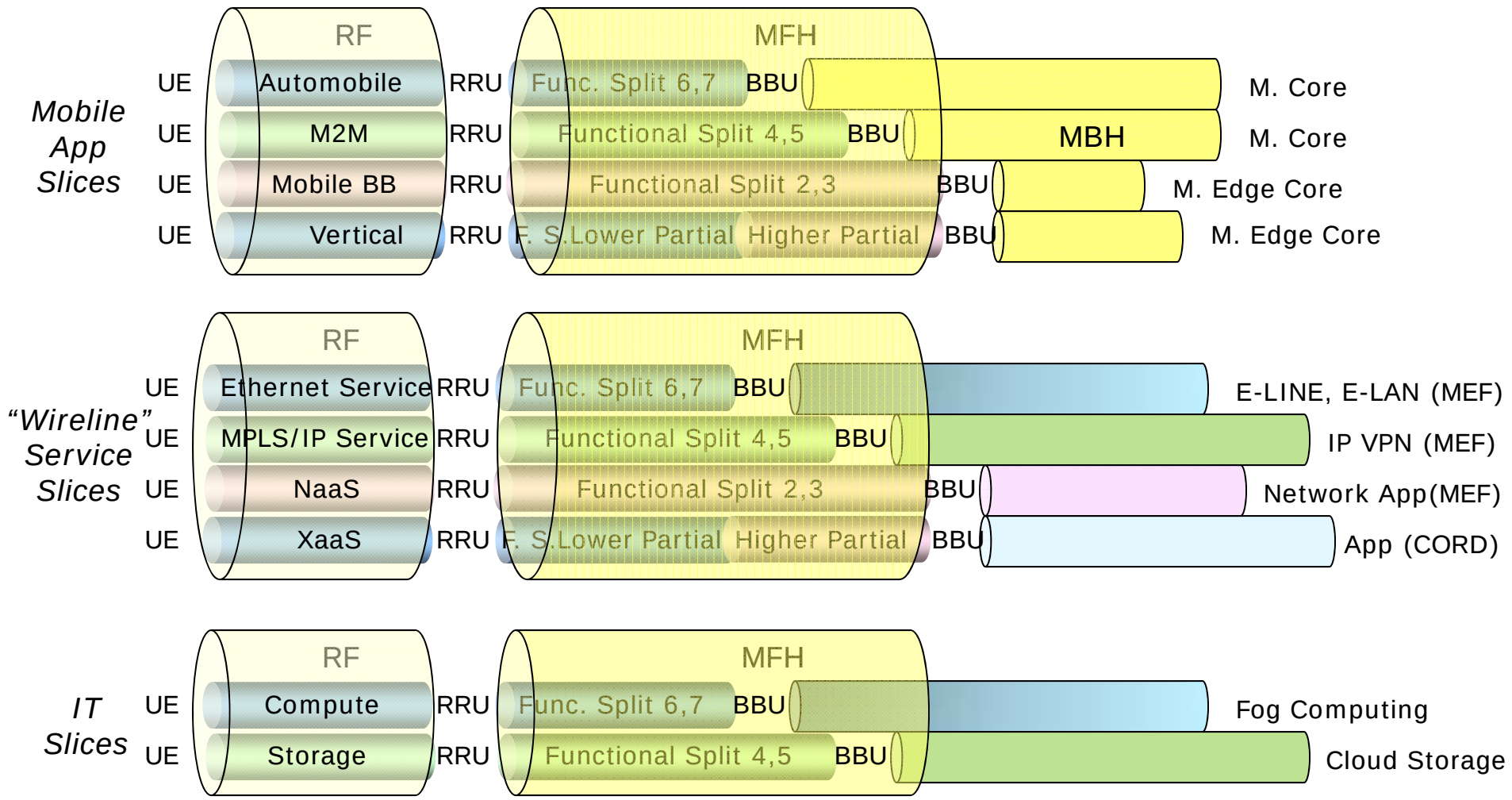
- Network Slicing Layers – Services Layer, Network Slice Layer and Resource Layer
- Transport Network Management and Orchestration Plane – The Conductor
- Transport Network shall have the same Service, Network Slice and Resource Layers
- Transport Network Management and Orchestration Directs Transport Network Slice

Network Slicing Architecture - Transport



- Network Slicing Layers – Services Layer, Network Slice Layer and Resource Layer
- Network Management and Orchestration Plane – The Conductor
- Transport Network shall have the same Service, Network Slice and Resource Layers
- Network Management and Orchestration Directs both Mobile Network Slices and Transport Network Slice

Network Slicing - Services



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

Network Slicing - KPIs

MEF 22.2 Performance Tier (PT) objectives

One way CPOs across PT 1 (metro) for Point-to-Point Mobile Backhaul service

CoS Name	Ingress Bandwidth Profile*(2)*	One Way CPO for Mobile Backhaul Service {S, CoS ID, PT}									
		FD	**MFD**	**IFDV**	**FDR**	**FLR**	**A**	**L**	**B**	**FPP**	**CPM**
Very High *(H^+)*	*CIR>0 EIR=0*	*≤10 ms*	*≤7 ms*	*N/S*	A_{FDR}	*≤.01 % (i.e., 10^{-4})*	$\geq A_{Avail}$	$\leq A_{HLI}$	$\leq A_{CHLI}$	*(3)*	*(4)*
High *(H)*	*CIR>0 EIR≥0*	*≤10 ms*	*≤7 ms*	*≤3 ms*	*≤5 ms*	*≤.01 % (i.e., 10^{-4})*	TBD	TBD	TBD	*(3)*	*(4)*
Medium *(M)*	*CIR>0 EIR≥0*	*≤20 ms*	*≤13 ms*	*≤8 ms or N/S*	*≤10 ms or N/S*	*≤.01 % (i.e., 10^{-4})*	TBD	TBD	TBD	*N/S*	*N/S*
Low *(L)*	*CIR≥0 EIR≥0(1)*	*≤37 ms*	*≤28 ms*	*N/S*	*N/S*	*≤.1 % (i.e., 10^{-3})*	TBD	TBD	TBD	*N/S*	*N/S*

- Build on MEF 22.2 PT objectives framework for 5G Transport and Transport Slice KPIs
- Adding Slice Layer

Network Slicing - KPIs

MEF 22.2 One Way CPO for Mobile Backhaul Service
with Tight Radio Coordination – constrained PT1 {S, CoS ID, PT}

CoS Name	Ingress Bandwidth Profile**	One Way CPO for Mobile Backhaul Service with tight radio coordination {S, CoS ID, PT}							
		FD	MFD	IFDV	FDR	FLR	Availability	L	B
High *(H)*	*CIR>0 EIR≥0*	*≤1 ms*	*≤0.7 ms*	*≤0.3 ms*	*≤0.5 ms*	*≤.01 % (i.e., 10^{-4})*	*TBD* $\geq A_{Avail}$	*TBD* $\geq A_{HLI}$	*TBD* $\geq A_{CHLI}$
Medium *(M)*	*CIR>0 EIR≥0*	*≤2.9 ms*	*≤2 ms*	*≤0.9 ms or N/S*	*≤1 ms or N/S*	*≤.01 % (i.e., 10^{-4})*	*TBD* $\geq A_{Avail}$	*TBD* $\geq A_{HLI}$	*TBD* $\geq A_{CHLI}$
Low *(L)*	*CIR≥0 EIR≥0**	*≤10 ms*	*≤8 ms*	*≤2.8 ms or N/S*	*≤2.9 ms or N/S*	*≤.1 % (i.e., 10^{-3})*	*TBD* $\geq A_{Avail}$	*TBD* $\geq A_{HLI}$	*TBD* $\geq A_{CHLI}$

- Build on MEF 22.2 PT objectives framework for 5G Transport and Transport Slice KPIs
- Adding Slice Layer

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

- Adding Slicing Layer

Network Slicing Lifecycle Management

Requirements

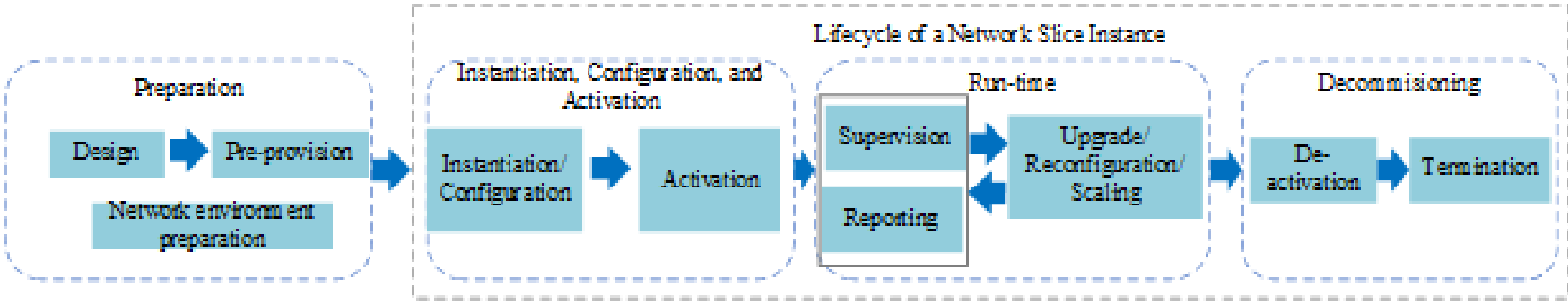
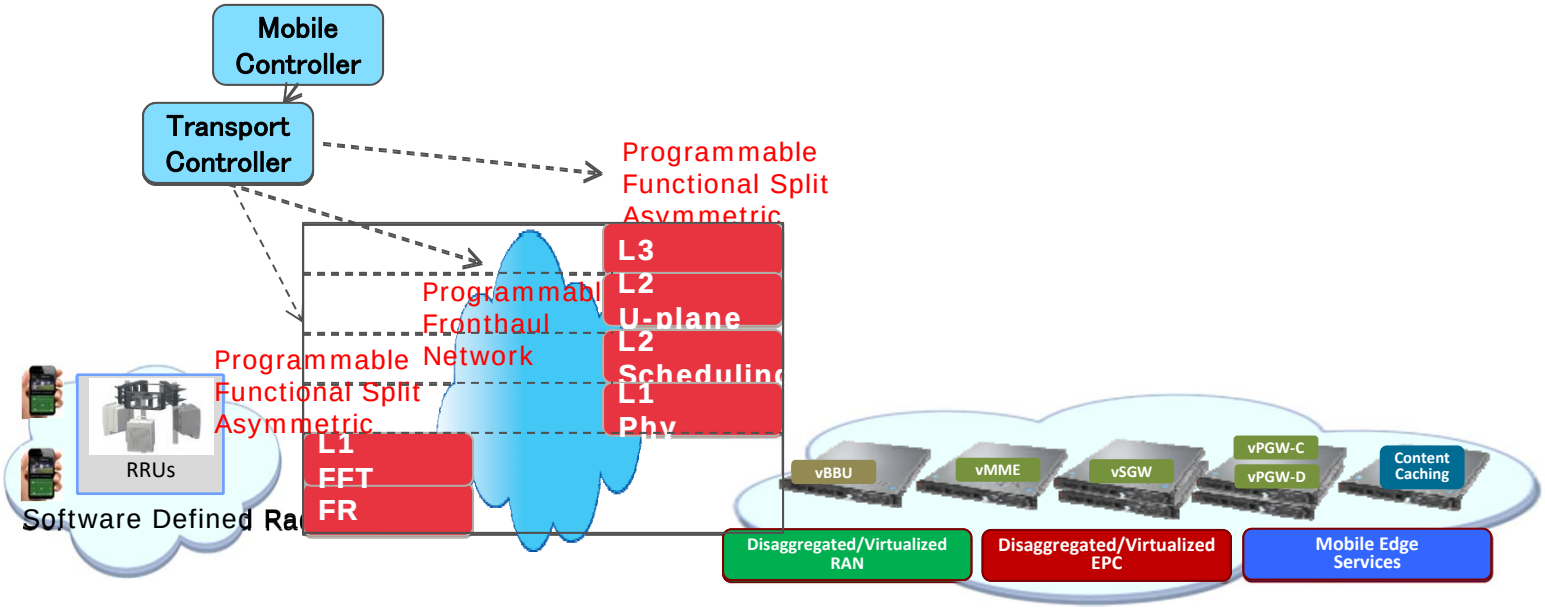


Figure 4.1-1: Lifecycle phases of a NSI 3GPP TR 28.801

- 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

Network Slicing Reconfiguration

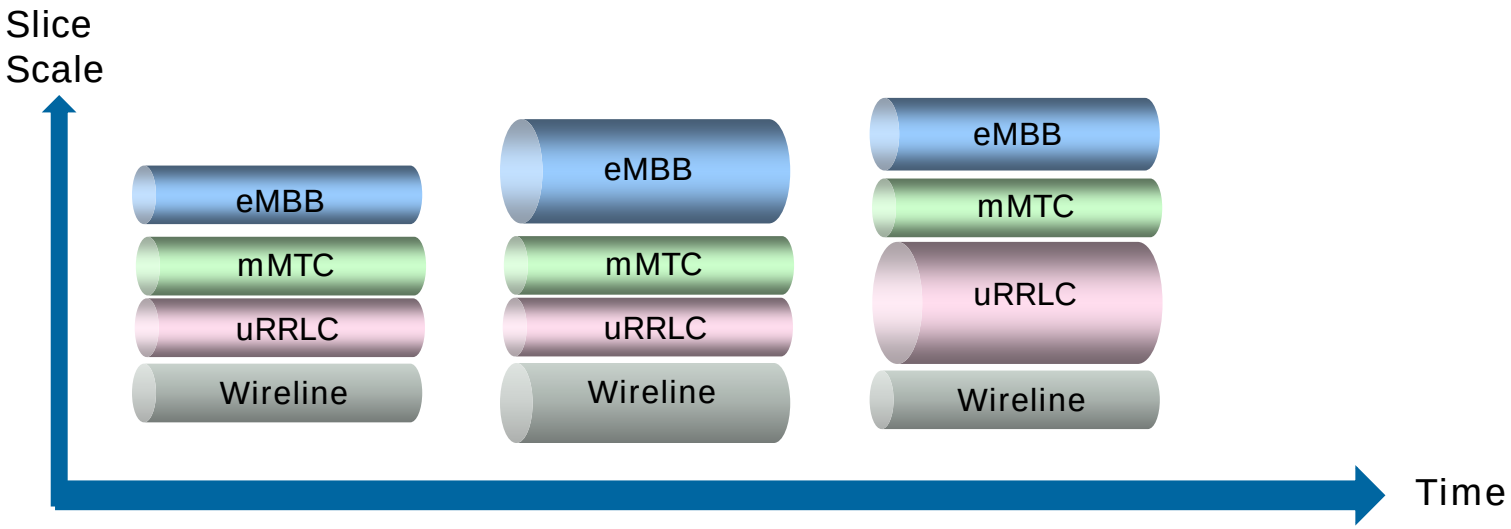
Requirements – Dynamic and On-Demand



- Mobile Network Reconfiguration needed as Applications and Traffic Pattern changes due to Event/Time
- Mobile Fronthaul Network Reconfiguration needed as RRH/BBU functional split adapted to Applications and Traffic Pattern Changes
- Network Slicing Reconfiguration can be dynamic and on-demand

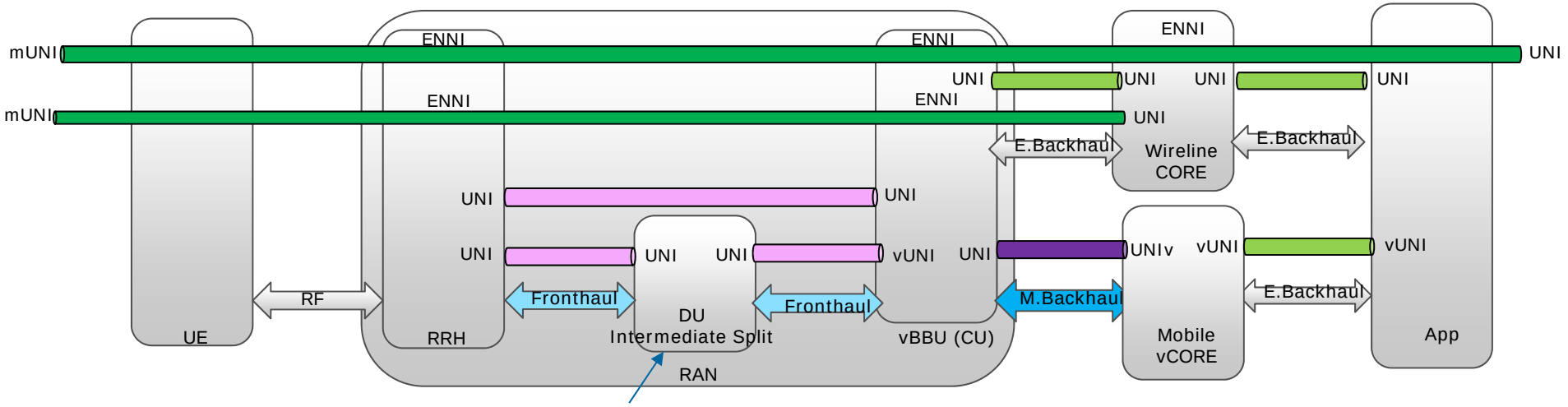
Network Slicing Scaling

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

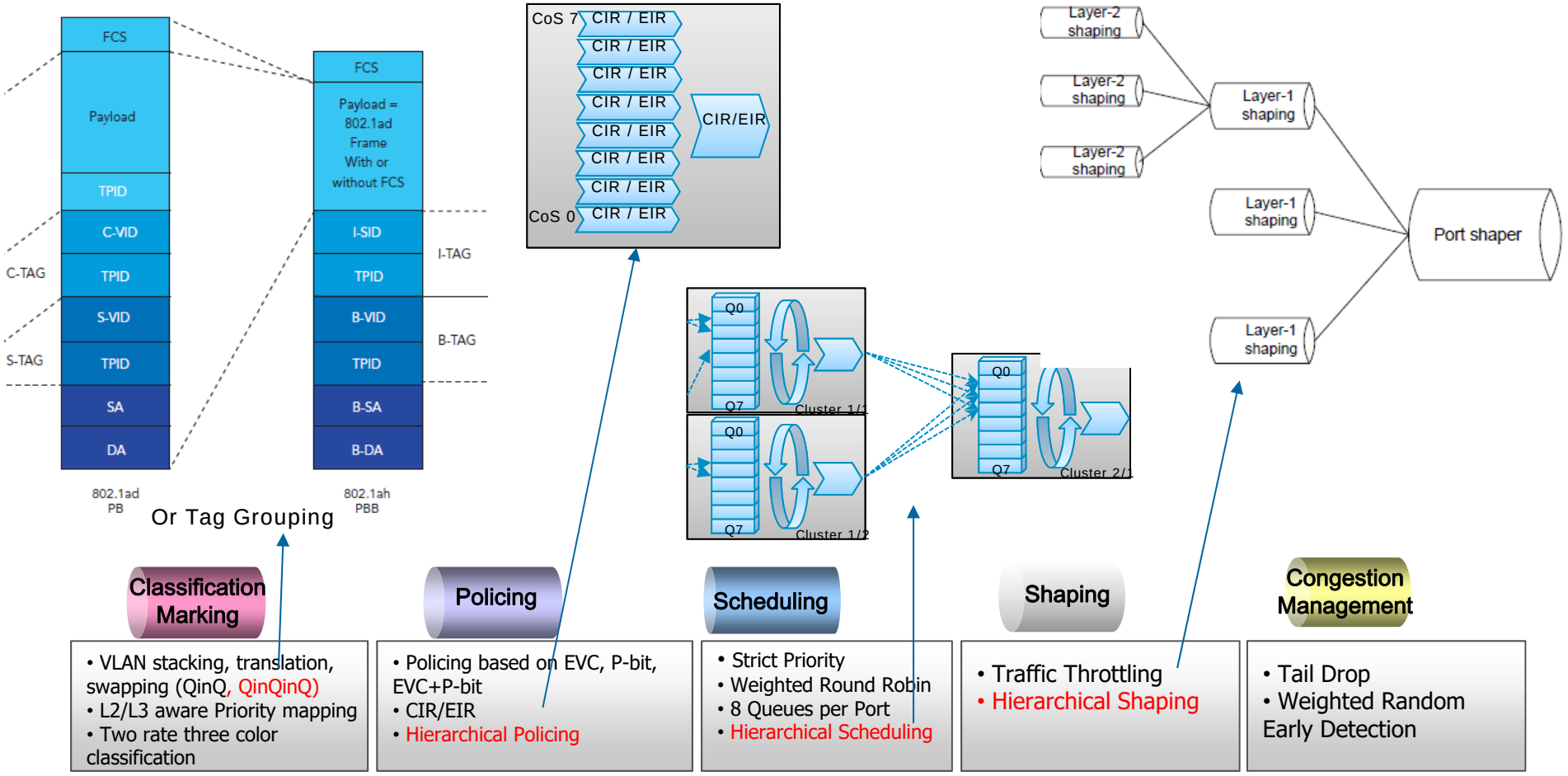
Network Slicing Architecture– Transport Path



Might exist in reality
But not yet in 3GPP spec

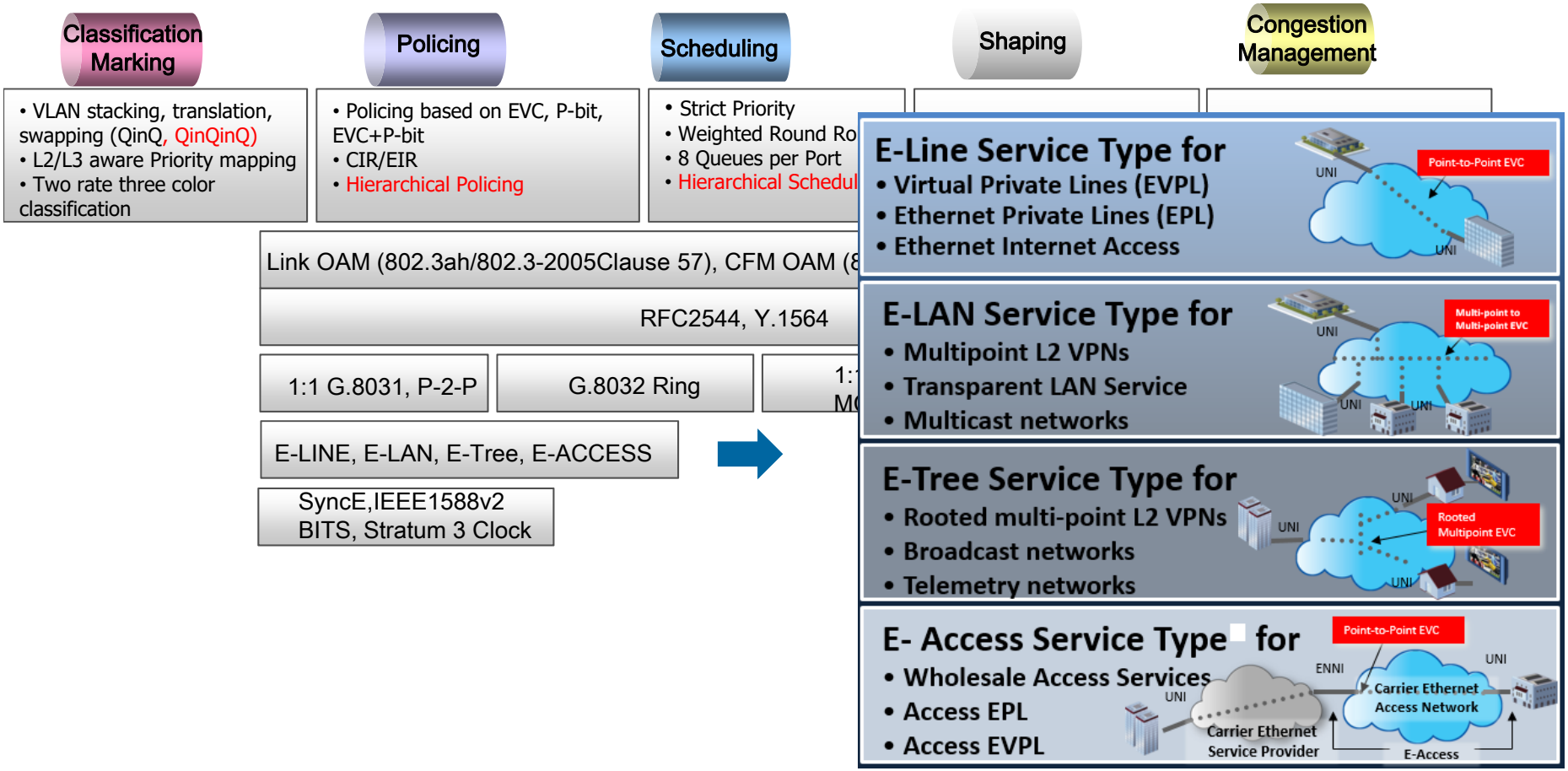
- Variety of Transport Network Paths at different parts of the Network
- Some are self contain without crossing multiple parts of the Network: UNI-UNI
- Some are cross multiple parts of the Network: UNI-ENNI-UNI
- Some UNIs are Mobile UNI (mUNI) and some are Virtual UNI (vUNI) due to vBBU and vCORE
-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

Network Slicing - Carrier Ethernet



- Transport Slice – Carrier Ethernet Traffic Engineering Requirements – Adding Slice Layer

Network Slicing – Ethernet Services



- Adding Slice Service types (A group of EVCs ?)

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

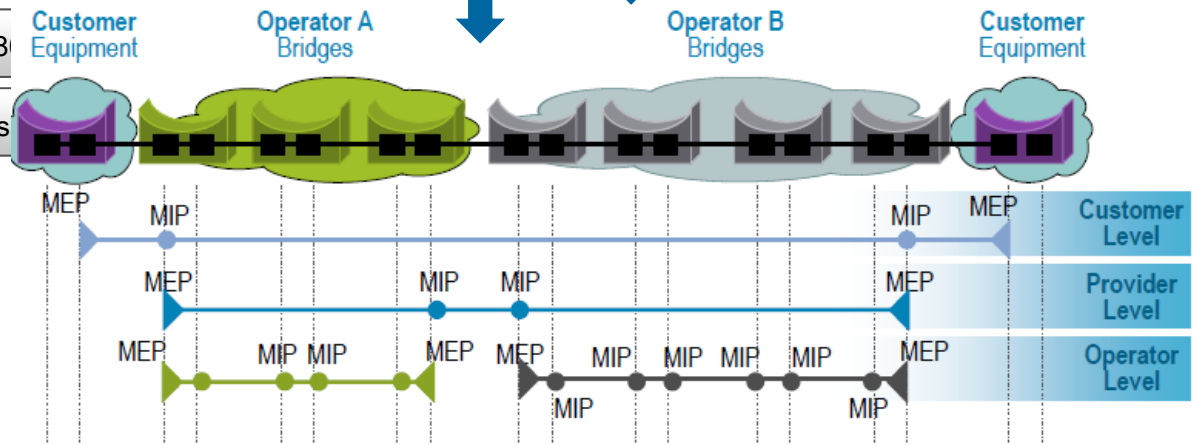
Link OAM (802.3ah/802.3-2005Clause 57), CFM OAM (802.1ag), Service OAM (Y.1731)

RFC2544, Y.1564

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

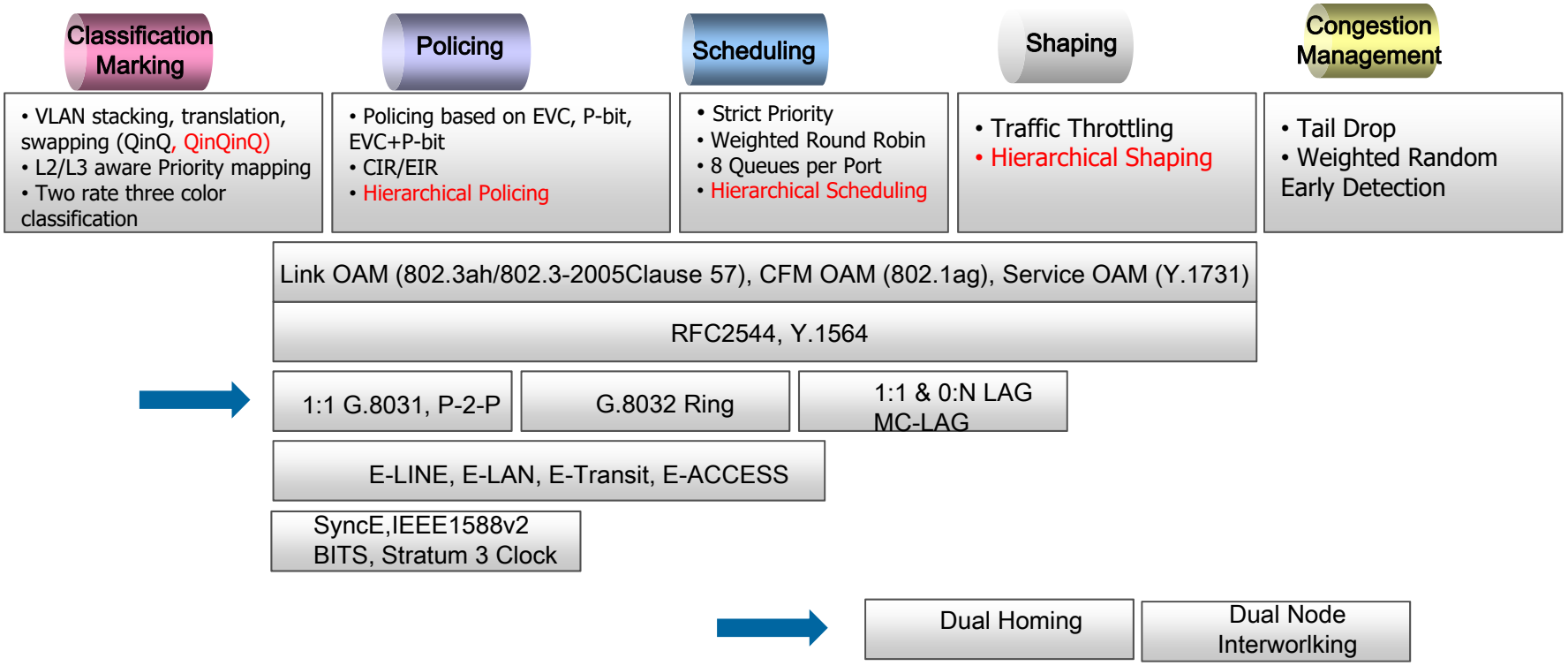
E-LINE, E-LAN, E-Trans

SyncE,IEEE1588v2
BITS, Stratum 3 Clock



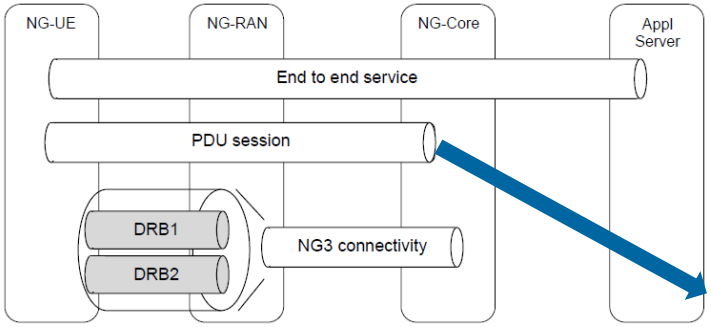
- Transport Slice – Ethernet OAM – Adding Slice Layer (A group of EVCs?)

Network Slicing – Network Protection



- Transport Slice – Packet Network Protection Requirements – Adding Slice Layer

Network Slicing Mobile Protocol I/F Requirements User Plane



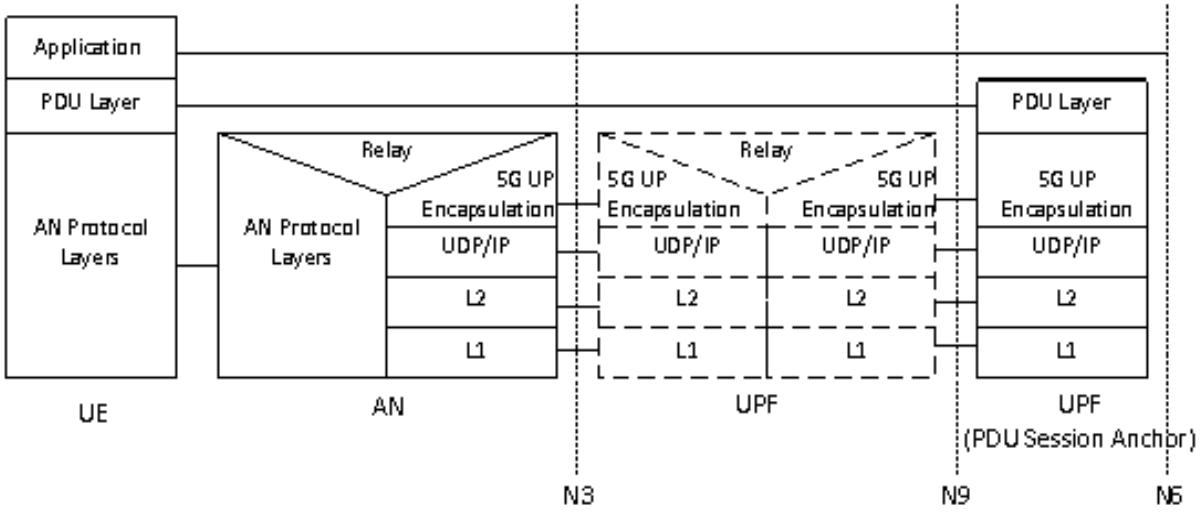


Figure 8.3.1-1: User Plane Protocol Stack 3GPP TS 23.501

- 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)

Network Slicing Mobile Protocol I/F Requirements Control Plane

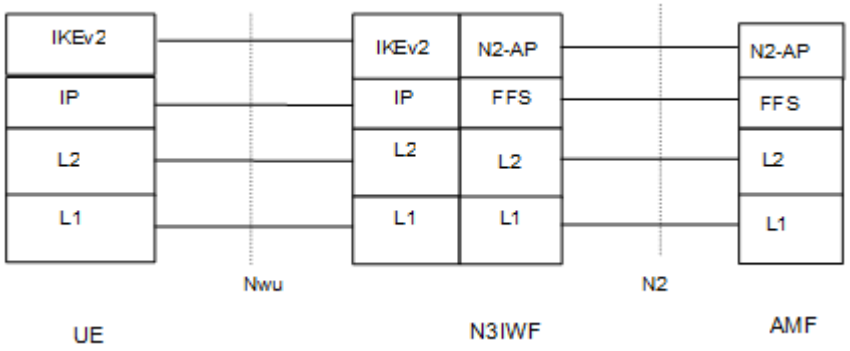


Figure 8.2.x-3: Control Plane for user plane establishment via N3IWF

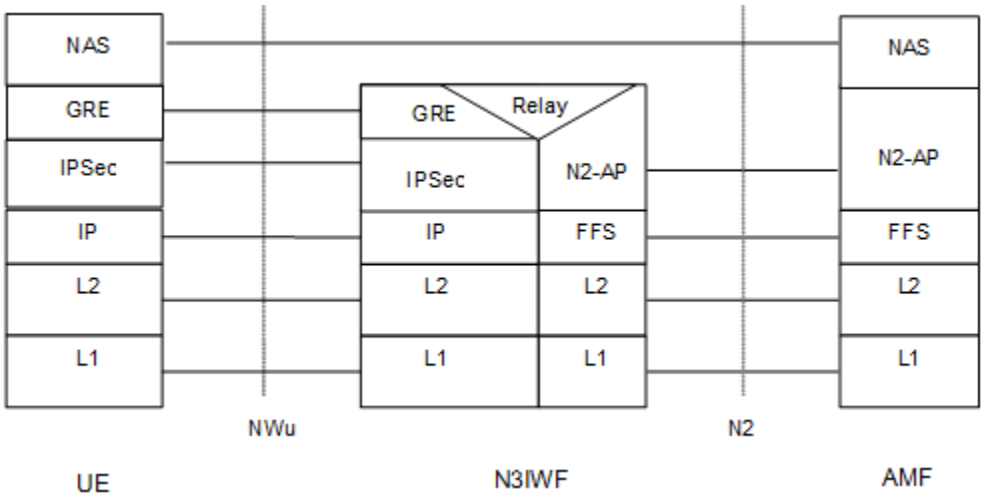


Figure 8.2.x-2: Control Plane for NAS when CP IPsec SA is established

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)