

Network Slicing

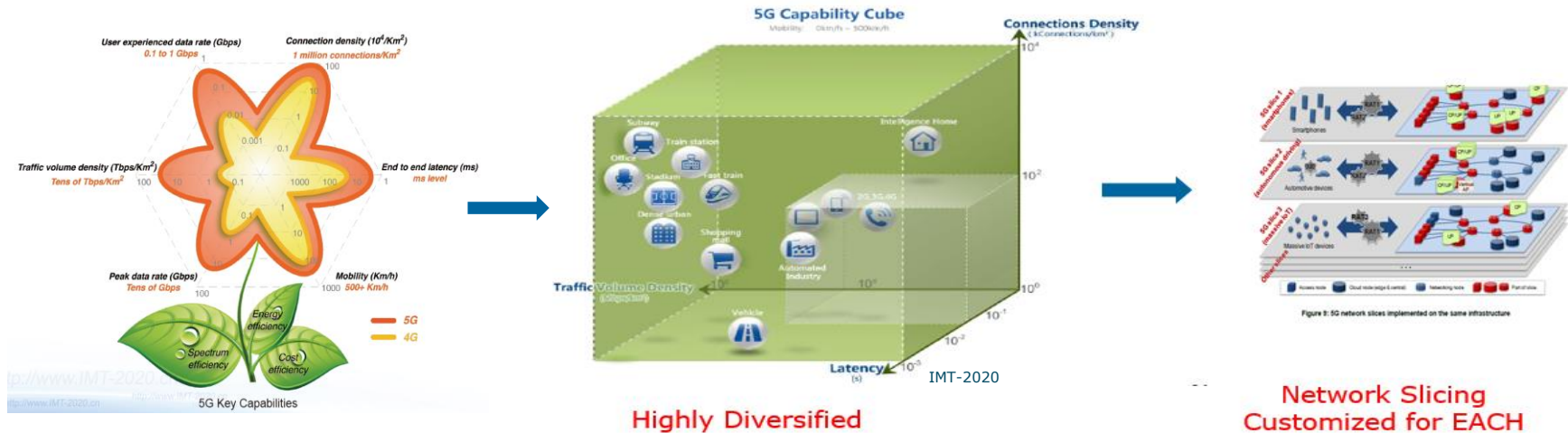
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September 26, 2017

Burnaby, Canada



Network Slicing

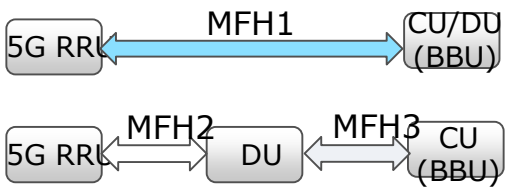


- ❑ Traffic bandwidth, connection density, and stringent delay has increased up to 3 order of magnitude from 4G network
- ❑ The requirements are highly diversified and are sometime at the opposite end of spectrum
- ❑ Network Slicing allows operator to provide customized networks to meet each service 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

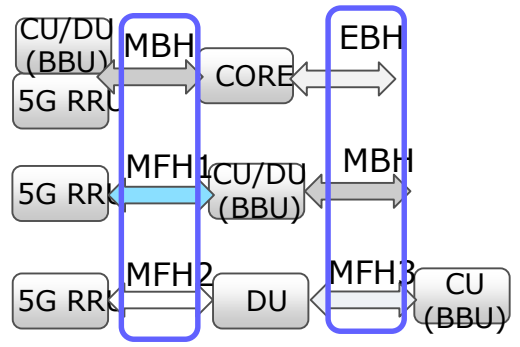
3GPP Network Slicing Requirements

- ❑ 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

5G Transport Network

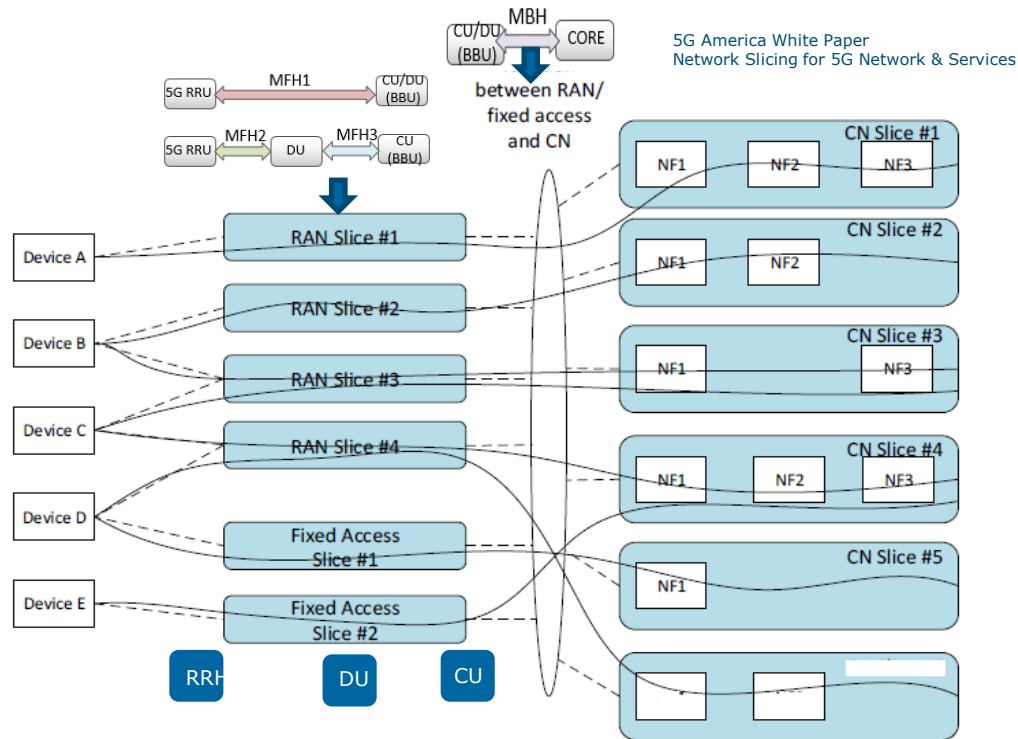


DU Distributed Unit
CU Centralized Unit



- ❑ Functional Splits can be in 1 or 2 stages (RRH-DU-CU)
- ❑ Three types of Fronthaul Networks
- ❑ Each has its own KPIs
- ❑ RRH, CU, DU, and Core distributed based on Service
- ❑ Multiple configurations can be co-located
- ❑ Transport Network can be an Any Hual Network
- ❑ Ethernet Service Types – Mobile Fronthaul 1,2,3, Mobile Backhaul, Ethernet Backhaul
- ❑ Multiple Ethernet Service Types can co-exist

3GPP Network Slicing – E-2-E Service View



- ❑ 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

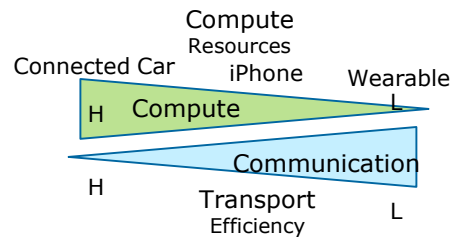
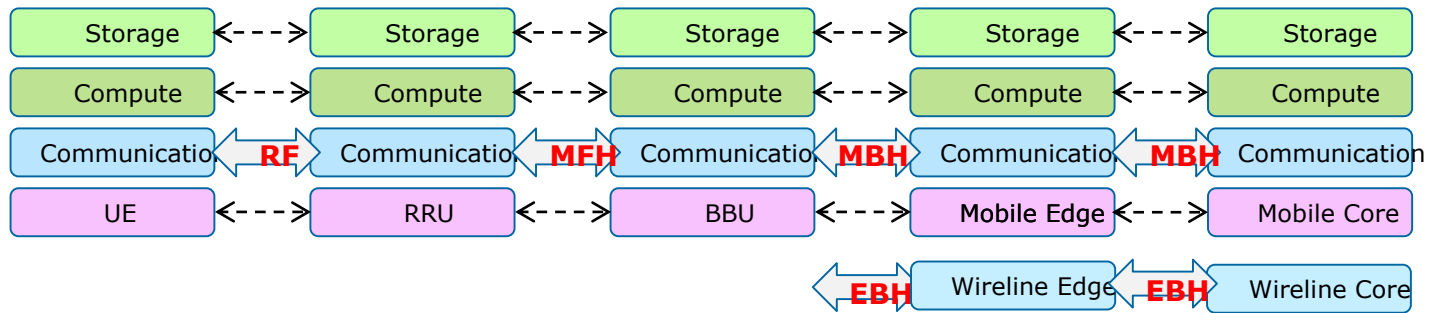
3GPP Network Slicing – System View



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

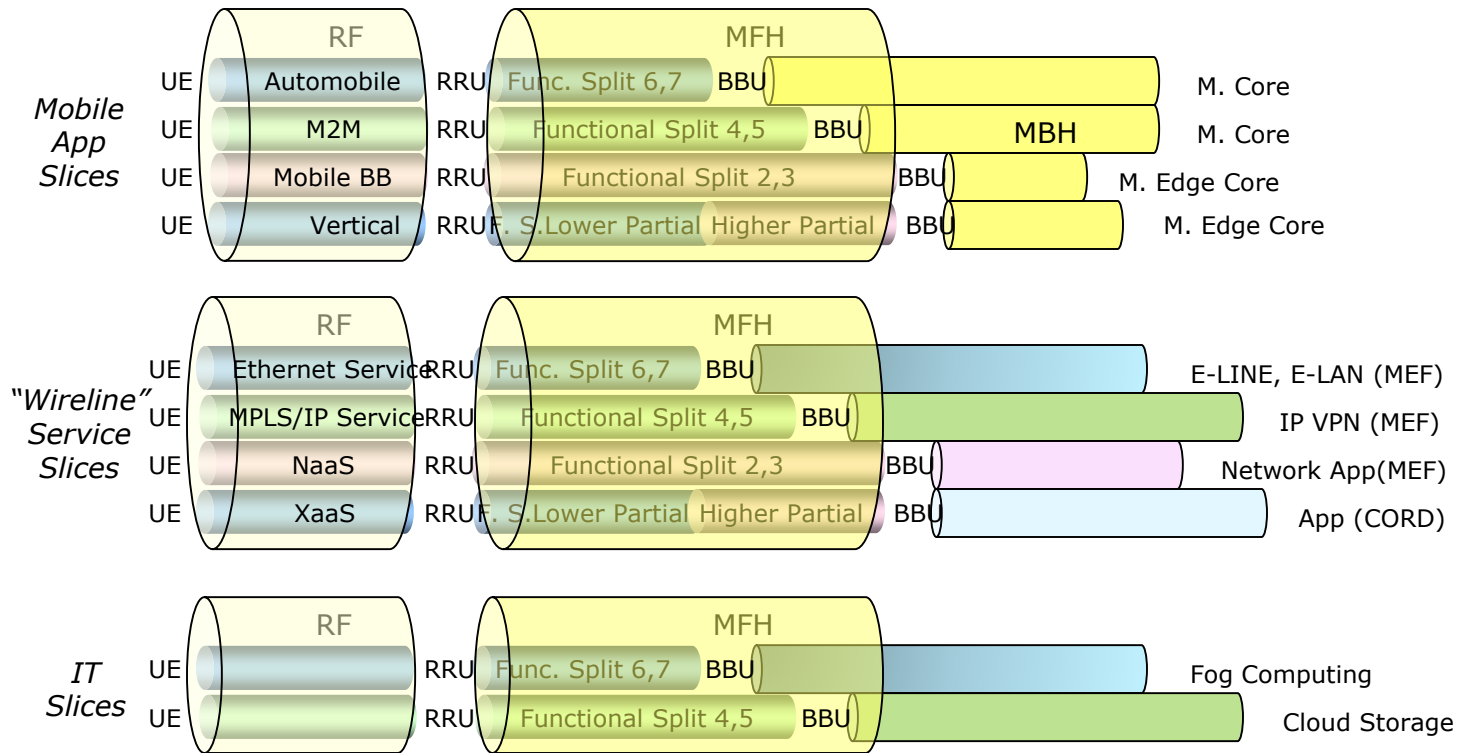
- ❑ The Network Slicing for RAN and 5G Core has three layers on each: Service Instance, Network Slice Instance and Resources.
- ❑ Within Service and Network Slice layer, it has multiple instances while resource layer is a pool
- ❑ The Service Instance Layer represents the services (end-user service or business services or others) that is realized within or by a Network Slice Instance
- ❑ The Network Instance Layer is a set of network 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, massive IoTs)
- ❑ The Resource Layer consists of Physical resource 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"

E-2-E Network Resources Framework



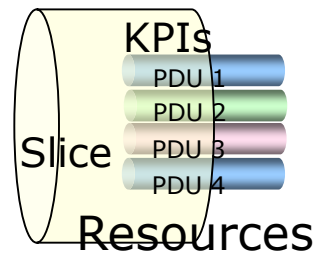
- ❑ Widely Diversified Resources and Capabilities
- ❑ Often Inversed Relationship
- ❑ Customized for EACH

Network Slicing – Service Category



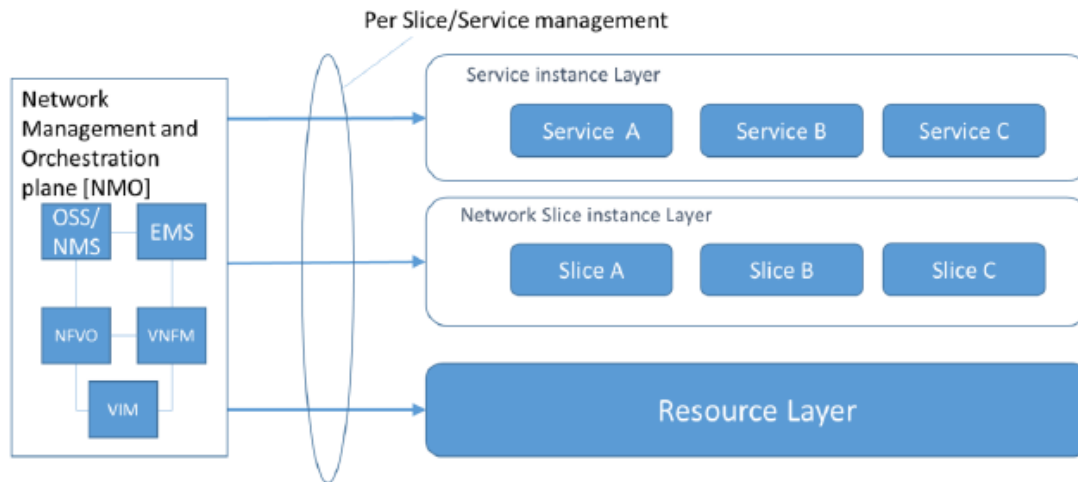
Functional Splits options being discussed in 3GPP, only Option 2 is standardized today

Network Slicing - Basic Constructs



- ❑ Network Slice – A **Group** of Services (PDU sessions in the Transport Network) shares the **same set of KPIs and Resources** (e.g., Bandwidth)
- ❑ Key Parameters – **Group KPIs and Group Resources**
- ❑ Group Resources – **A Reserved Pool of Resources dedicated** to serve all Services belongs to a given slice either active services or services to be activated
- ❑ Group KPIs – **Common set of KPIs required** for all Services belongs to a given slice

Network Slicing Architecture - Layers

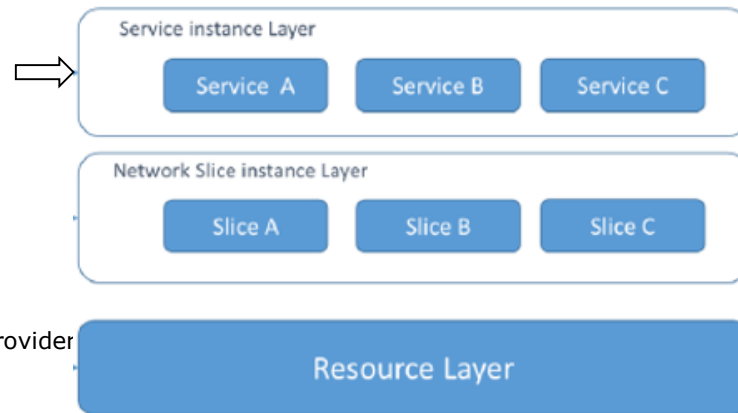


5G America White Paper
Network Slicing for 5G Network & Services

- ❑ 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

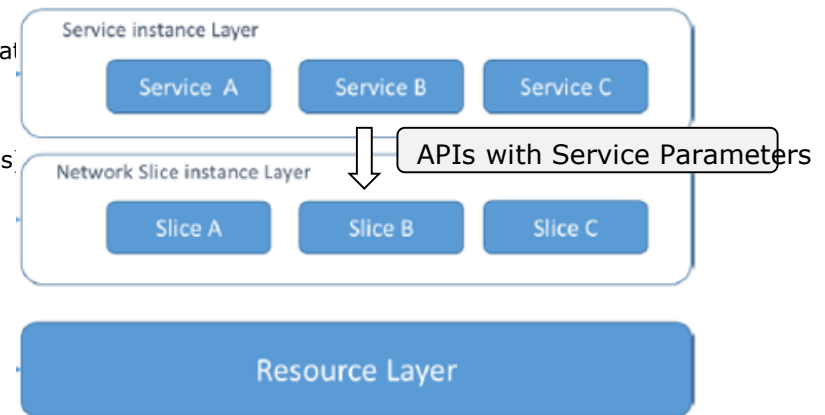
Network Slicing – Services Types

- ❑ Mobile Slices
 - ❑ eMBB, uRLLC, mMTC
- ❑ Wireline Slices
 - ❑ Connectivity Services – Carrier Ethernet, IP, MPLS
 - ❑ Application Services – Digital Services, XaaS
- ❑ IT Transport Slices
 - ❑ Compute, Storage
- ❑ Wholesale Slices
 - ❑ Global Roaming, Enterprise Private 5G Network, App Provider
- ❑ Vertical Slices
 - ❑ Autonomous Driving, Industry 4.0, eHealth, etc
- ❑ User Slices
 - ❑ Business, Consumer, Hybrid
- ❑ Performance Slices
 - ❑ Platinum, Gold, Brown, Best Effort
- ❑ Others
- ❑ Same applies to PDU session within a Slice



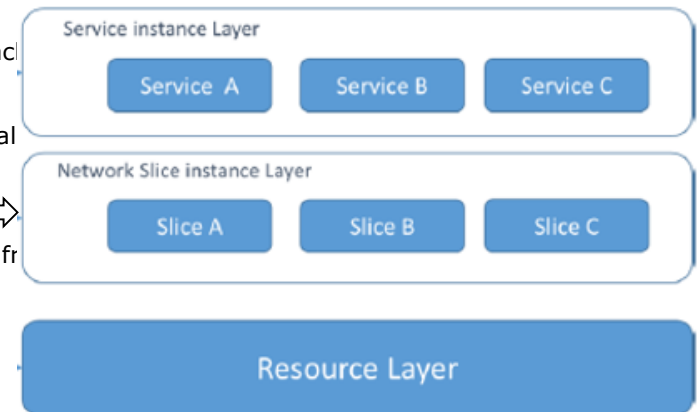
Network Slicing – Services

- ❑ **Bandwidth Profile**
 - ❑ Capacity
 - ❑ CIR (Committed Information Rate), EIR (Excess Information Rate)
 - ❑ Two Rate Three Color – Green, Yellow, and Red Packets
 - ❑ Token/Bandwidth Sharing when not used
 - ❑ Priority – Class of Services (5G QoS 15 levels -> Transport 8 levels)
- ❑ **Performance**
 - ❑ Latency
 - ❑ Latency Variation
 - ❑ Frame Loss Ratio
 - ❑ Availability
 - ❑ Reliability
- ❑ **Security**
- ❑ **Connectivity Types**
 - ❑ E-Line, E-LAN, E-Tree, E-Access, E-Transit
- ❑ **Services to Network Communication**
 - ❑ API Requests and Responses
 - ❑ Asynchronous and Autonomous Responses
- ❑ Same applies to PDU session within a Slice



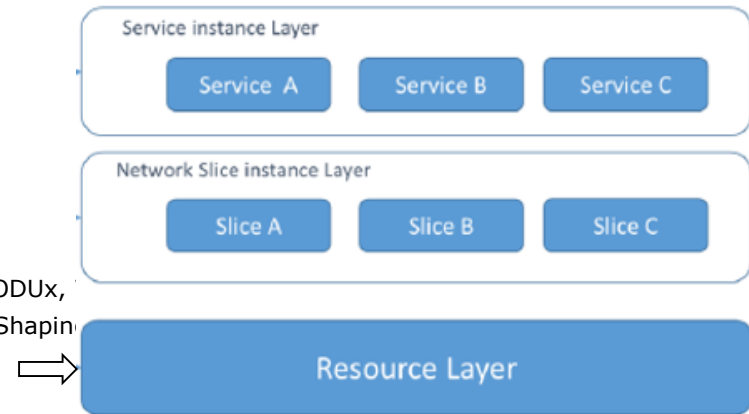
Network Slicing – Network

- ❑ Transport Network Types
 - ❑ Mobile Fronthaul (NGFI-1), Mobile Mid-Haul (NGFI-2), Mobile Backhaul, Ethernet Backhaul
- ❑ Transport Network Connectivity Types
 - ❑ E-Line (P-2-P), E-LAN (MP-2-MP), E-Tree (P-2-MP, E-Access and E-Transit (wholesale))
- ❑ Transport Network Management - FCAPS
 - ❑ CM – Create, Update, Delete Transport via APIs (Slice Infrastructure)
 - ❑ PM – Latency, Latency Variation, and Frame Loss Ratio via Synthetic Ethernet OAM frames
 - ❑ FM – Connectivity Check, Ping, Trace route via Ethernet OAM frames and Alarms
 - ❑ AM – Accounting
 - ❑ SM – Security
- ❑ OAM
 - ❑ Connectivity (802.1ag), Service OAM (ITU-T Y.1731), Service Activation (ITU-T Y.1564)
- ❑ Protection
 - ❑ Ethernet – G.8031, G.8032, LAG, MC-LAG
 - ❑ OTN – 1:1, 1+1, N:1
 - ❑ WDM – 1:1, 1+1
- ❑ Network Slice Taxonomy
 - ❑ Control Plane, Data Plane, Management Plane, Sync Plane
 - ❑ Uplink/Down Link, Unicast/Multi-cast
- ❑ Transport Network Layers
 - ❑ Base Layer – Ethernet
 - ❑ Optional Server Layers – OTN and WDM



Network Slicing – Resources

- ❑ Types
 - ❑ Hard Slice – Dedicated Resources
 - ❑ Soft Slice – Shared Resources competed based on Priority
- ❑ Priority
 - ❑ Priority – 5G 15 QoS -> 8 Ethernet QoS
- ❑ Isolation
 - ❑ Hard Slice – Ethernet: Time Sensitive Networking (Reservation), Flex E, OTN: ODUx,
 - ❑ Soft Slice – Ethernet: CIR/EIR, Token Sharing, Input Queues, Output Queues, Shaping
- ❑ Performance
 - ❑ Base Layer – Ethernet (Fair Performance)
 - ❑ Optional Server Layers – OTN (Better Performance) and WDM (Best Performance)
- ❑ Same applies to PDU session within a Slice



Network Slicing Lifecycle Management

Requirements

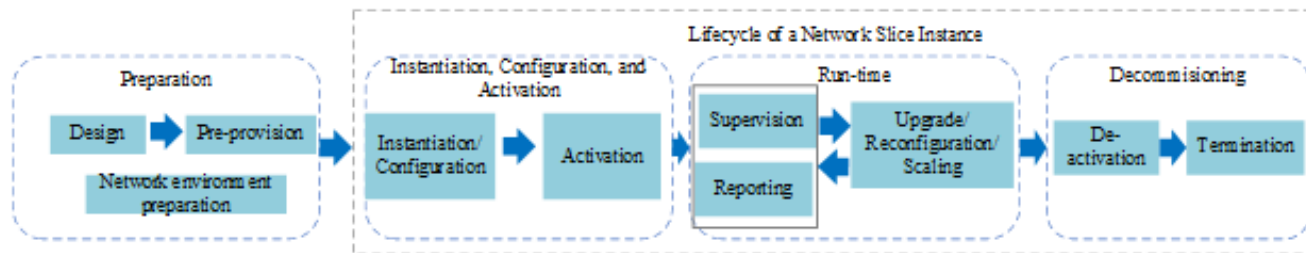


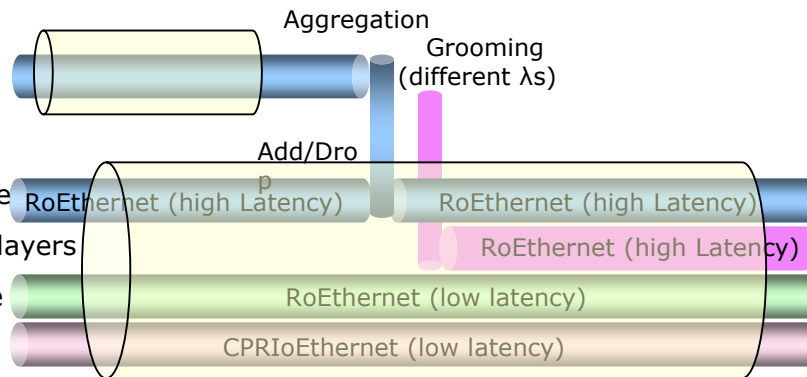
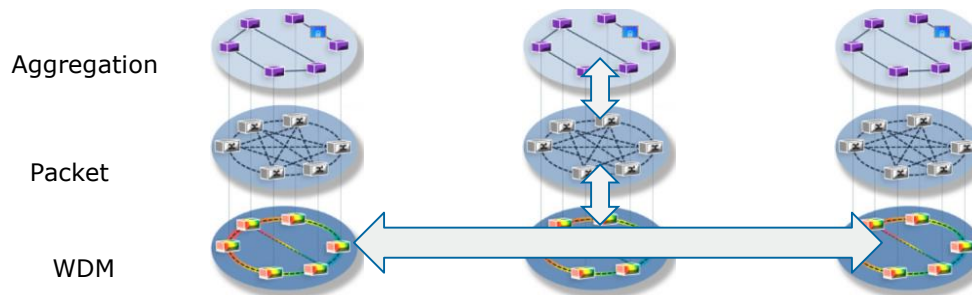
Figure 4.1-1: Lifecycle phases of a NSI 3GPP TR 28.801

- ❑ 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

Network Slicing – Transport Network Architecture

Transport Slice spans two or more Transport Nodes and one or more Transport Layers

Transport Network KPIs = Links + Nodes

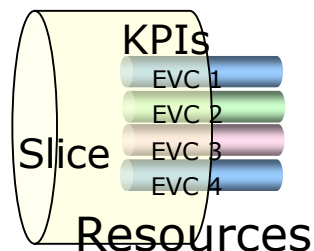


- ❑ PDU sessions over Ethernet or IP
- ❑ Ethernet is the base layer in this example
- ❑ Ethernet may be over OTN and/or WDM layers
- ❑ Ethernet over WDM layer in this example

Separate Fiber (Express & Local) (Packet Layer)
or Separate λ s on same Fiber (Packet & WDM Layer)

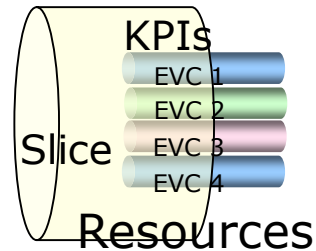
Transport when you can
Switch only if you must

Network Slicing - Basic Constructs - Ethernet



- ❑ Network Slice – **A Group of EVCs** shares the **same set of KPIs and Resources** (e.g., Bandwidth)
- ❑ **Representation of A Group of EVCs – Slice ID**
- ❑ **Group Attributes**
 - ❑ **Capacity** – Minimum and Maximum
 - ❑ **KPIs** – Delay, Delay Variation, Frame Loss Ratio, Availability, Reliency
 - ❑ **OAM** – Connectivity and Services OAM
 - ❑ **Alarms** – LOS, LOF, RDI, AIS, TCA
 - ❑ **Protection** – LAG, G.8031, G.8032
 - ❑ **Security**

Network Slicing - Ethernet Representation



- ❑ **Slice Representation Examples** - A Group of EVCs
 - ❑ Single S-Tag = EVC, Enhanced MEF tools (e.g., Trunk/OVC+, Envelope+) to represent Slice ID
 - ❑ Single S-Tag - Higher order bits=Slice ID, Lower order bits=EVC
 - ❑ Double S-Tag - Inner Tag=EVC, Outer Tag=Slice ID
 - ❑ PBB - S-Tag=EVC, B-Tag+I-Tag=Slice ID
 - ❑ MPLS - S-Tag=EVC, MPLS Label=Slice ID

Network Slicing – Network Correlations

	RAN Slice	RAN PDU	Transport Slice	Transport PDU
Slice/PDU	Slice ID	PDU ID	Slice ID	PDU ID
Slice Aware	Slice ID	PDU ID	Slice CoS	PDU ID
Slice/PDU Aware	Slice ID	PDU ID	Slice CoS	PDU CoS
Slice Agnostic	Slice ID	PDU ID	CoS	CoS

- ❑ Slice/PDU – 1:1 corresponding at both Slice and PDU level
- ❑ Slice Aware – RAN Slice ID translates into Class of Service and map to Transport Slice while PDU still 1:1
- ❑ Slice/PDU Aware – Both RAN Slice ID and PDU ID translates into Class of Service and map to Transport Slice & PDU
- ❑ Slice Agnostic – Both RAN Slice ID and PDU ID translates into Class of Service and map to Transport PDU
- ❑ Each Slide has its own priority. Each PDU session within a slice has its own priority