5G Network Slicing via XGVela

XGVela Architecture for Network Slicing

A Proposal

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Red Hat

Telco/MNO Strategy

5G The “Enterprise Release”

- ***MNO/Carrier Goals***
  - Increase Revenues
    - 4G and prior were largely consumer-revenue oriented, but ***consumer revenues are declining***
    - 5G is seen as the “***Enterprise Play***”, an opportunity for new revenue streams
  - Reduce OpEx & CapEx
    - Network resources may not be optimally utilized with current practices
    - Legacy RAN network elements are largely proprietary and ASIC-driven & are too expensive and labor intensive to certify, install, maintain
      - Network resource sharing via the VPN/Slicing concept can reduce CapEx over time
      - COTS and virtualization in the RAN is a new opportunity to reduce CapEx (the cellular Core has been virtualized for some time now)
      - Orchestration and Automation is an opportunity to reduce OpEx

Why Network Slicing?

Exploitation of the “Enterprise” Release: 5G

- ***The benefits of Network Slicing with E2E Orchestration***
  - Network Slicing is a strategy for monetizing the network infrastructure by carving the network into VPNs that are dedicated to particular services, in particular Enterprise-focused services
  - Network Slicing also reduces CapEx over time by multiplexing (sharing) network resources
  - E2E Dynamic/Elastic Orchestration and Automation for OpEx reduction & Network Optimization
  - ***Distributed Intelligent Edge in a Network Slice***
    - 5G Adjunct technology (MEC, REC) will advantage native 5G features (e.g., <1ms RTT latency)
    - Enterprise presence in the Telco/MNO data centers
    - Far Edge presence to advantage enterprise work centers for Advanced Use Cases (AUC)
      - E.g., Remote Surgery, Factory Automation, 360-Video & VR Rendering, Drones as gNB (O-RU & O-DU)
    - Federated services and federated management (the “***action is at the edge***”)
  - ***A Network Slice contains RAN Intelligence & Optimization***
    - OpenRAN to stimulate new technology and realize true interoperability
    - New “xApp & rApp Ecosystem” to optimize RAN for new Edge Vertical Services
    - New appliances (RAN Intelligent Controller, RIC) to facilitate & accelerate the (x|r)App Ecosystem
- ***Red Hat technology*** can be used as “Infrastructure” as well as “Middleware” or “Component Parts” of technologies in each of these categories

Software Defined Networks
Network Resource Multiplexor

Red Hat

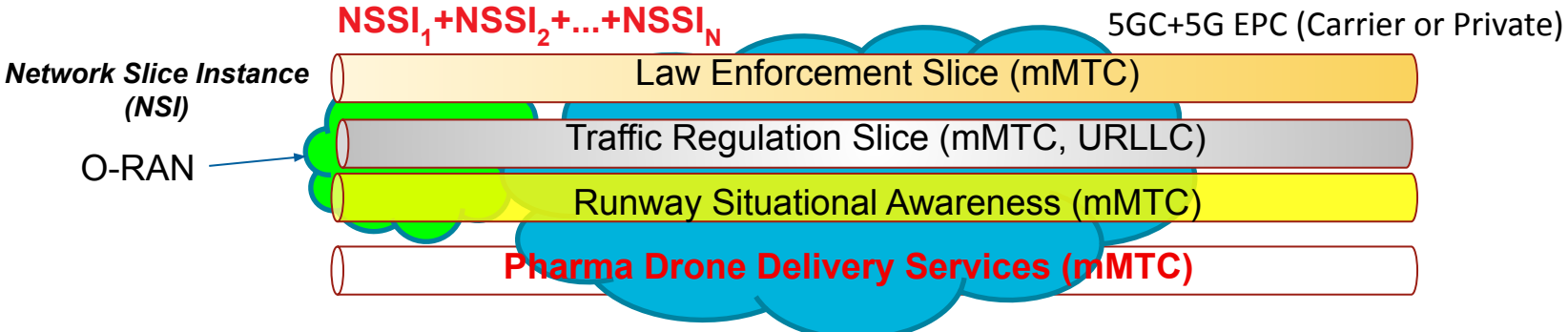
What is a "Network Slice" in 5G?

A software-defined (SDN) "overlay" on the network infrastructure (i.e., a VPN)

- From a ***systems modeling perspective***, a Network Slice per 3GPP is a "***Network Slice Instance***", or NSI
- An NSI model includes modelled subnets, referred to as ***Network Slice Subnet Instances*** (NSSI)
  - NSSI are defined by 3GPP as distributions and allocations of Network Functions (NFs)
  - It has been proposed to use the NSSI construct to model any Compute, Storage, & Network resources
    - Templates for describing NFs, Logical constructs, such as ports & links, microservices, apps
- NSSI and NSI models can be constructed via an OSS and/or an Orchestration system (e.g., ONAP)
- Refer to: https://www.3gpp.org/news-events/1951-sa5_5g for an overview of NSI & NSSI modeling constructs

Each NSI models a network slice with unique SLA/QoS/QoE attributes

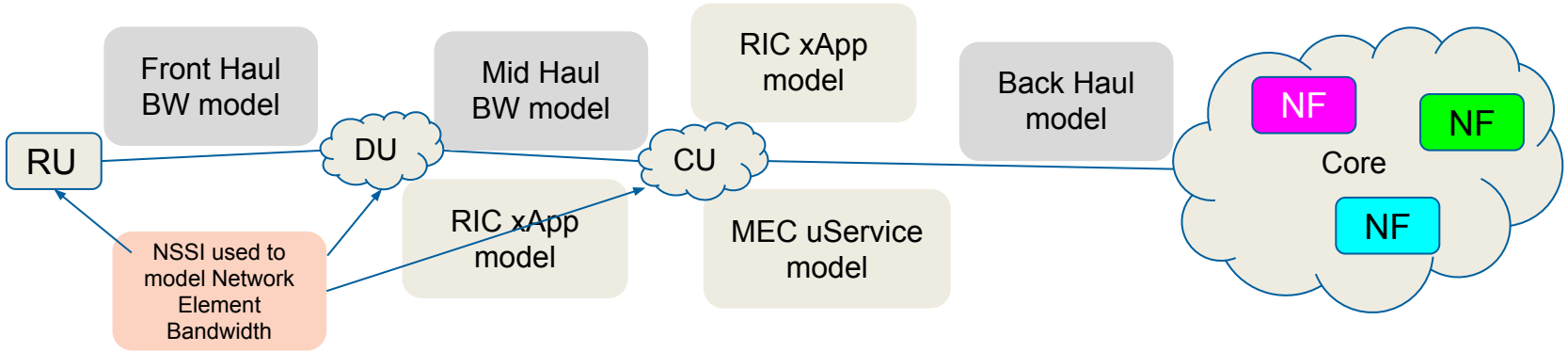
- **Example Network Slices modeled by an NSI construct:**
  - Pharmaceutical - Drone delivery of medicine (UAS/UAV classification)
  - Law Enforcement – City surveillance enhancement via multiple cameras, sensors, IoT worn by officers
  - Traffic Regulation and Policing
    - Change street lights based on actual traffic vs. TOD only
    - Improved throughput on highways via use of intelligent cars (Autonomous Vehicles)
  - FAA – Improved field of vision/situational awareness on runways



S-NSSAI Extensions

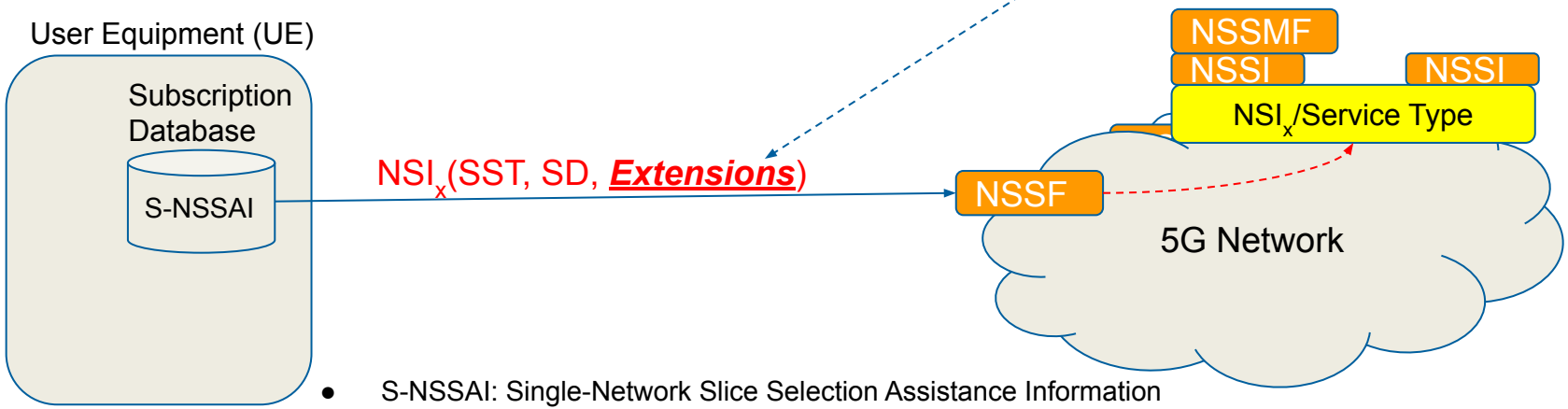
- Current 3GPP S-NSSAI contains 2 parameters (Slice Service Type (SST), Slice Differentiator (SD))
  - MNOs/MVNOs/Enterprises may require additional parameters
    - *Proposed: (SST, SD, **Parameter/Template Extensions,..,..**)*
    - ***Extension templates*** should allow for any NFs, Apps, uSvc, compute, network, or storage resource
      - E.g., Guaranteed Bit Rate Network Slice. Make sure the Back-Haul EVC meets the GBR settings, including Packet Error Rate, likewise for cloud DataPath
        - (GBR, PER=10-6, ***B-Haul EVC=(GBR, PER=10-6***))

  - Early Network Slicing POCs are/were performed with "Orchestration-based" capability
    - NSSI models for RAN, Transport, other subnets, are modeled and "pushed" to the network
    - See AT&T RAN Slicing Framework:
      https://wiki.onap.org/download/attachments/10784151/ONAPNetworkSlicingv3_25Jan2018.pptx?api=v2
      https://wiki.onap.org/display/DW/Use+case+proposal%3A+5G-+RAN+deployment%2C+Slicing%2C+SON



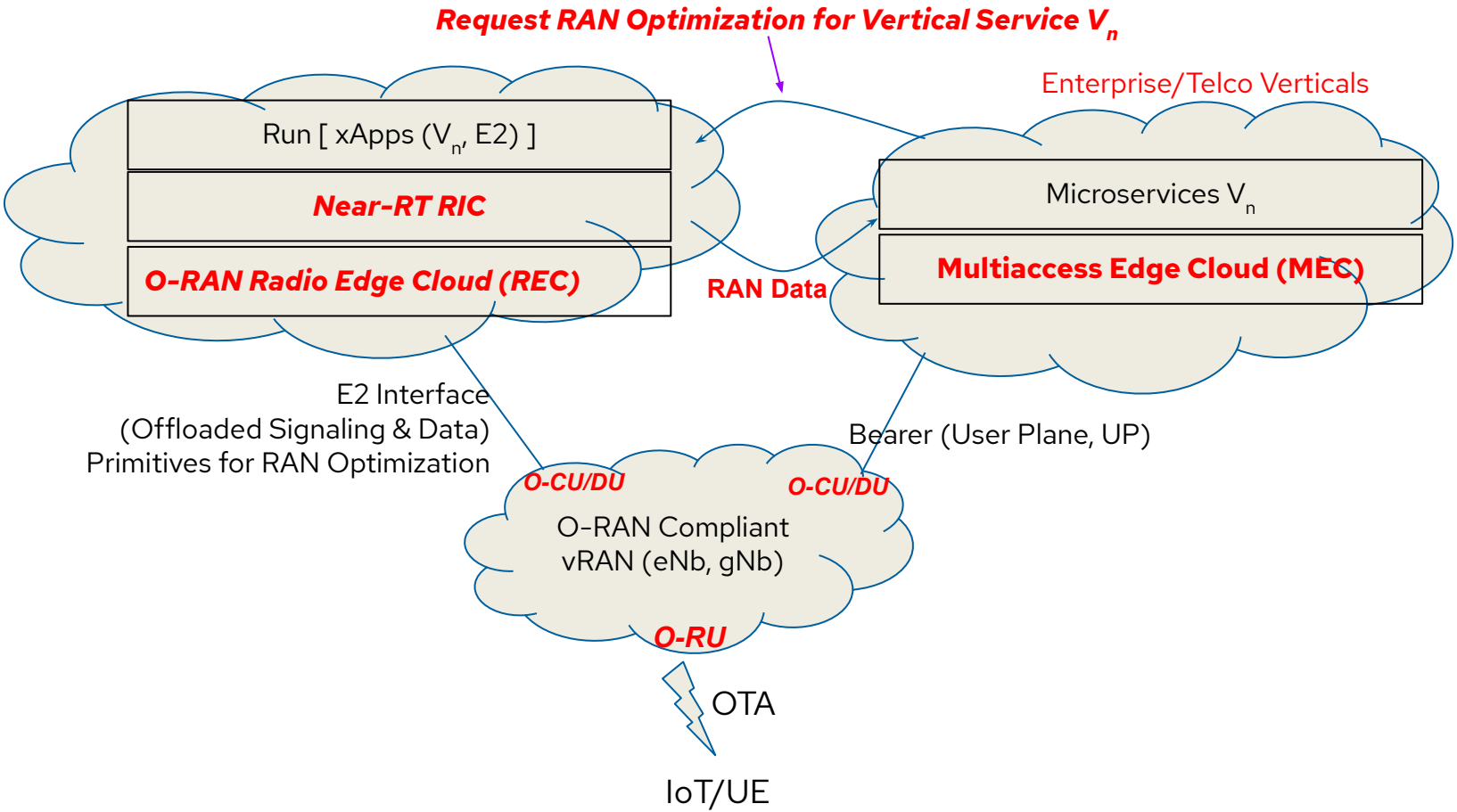
S-NSSAI Parameters

3GPP S-NSSAI currently limited to 2-Tuple (Slice/Service Type (SST), Slice Differentiator (SD))
Proposed parameter extensions: (ServiceType, Differentiator, ***Extensions***)



- S-NSSAI: Single-Network Slice Selection Assistance Information
- NSSF: Network Slice Selection Function
- NSMF: Network Slice Mgmnt Function
- NSSMF: Network Slice Subnet Mgmnt Function
- NSI: Model of a ***Network Slice Instance*** for OSS/Orchestrator use
- NSSI: Model of a ***Network Slice Subnet Instance*** for OSS/Orchestrator use
- Service Type: Defines expected network slice behavior, depending on its specific features and service(s)
  - eMBB, mMTC, URLLC

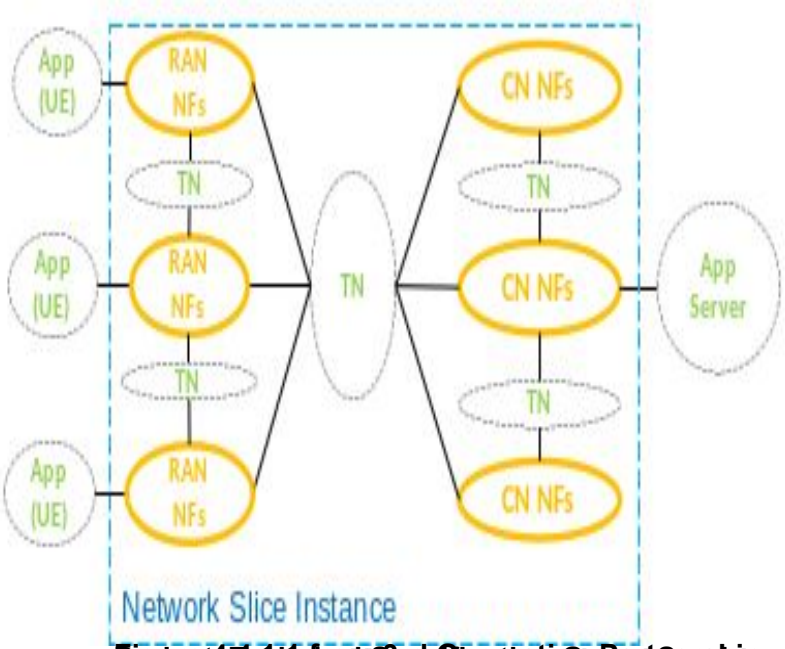
Extensions for MEC and REC uServices



NSI Component Breakdown

An NSI is an SDN with its own service offerings built from NSSI and a particular Service Profile

- NSI = [(NSSI1 || NSSI2 || ….. || NSSIn), Service Profile (CoS[], QoE[], SLA[])]
- Service Type/Profile ()
  - A unique set of services independent of other NSI and the physical network
  - Custom CoS/QoE, Performance and reliability SLAs
  - Requires its own set of FCAPS in addition to the physical network FCAPS
  - Realized via Slice as a Service (SlaaS), Slice as Infrastructure, or defined via a central OSS/Orchestration system
  - Typically managed by an MVNO (Mobile Virtual Network Operator)



NSSI Examples

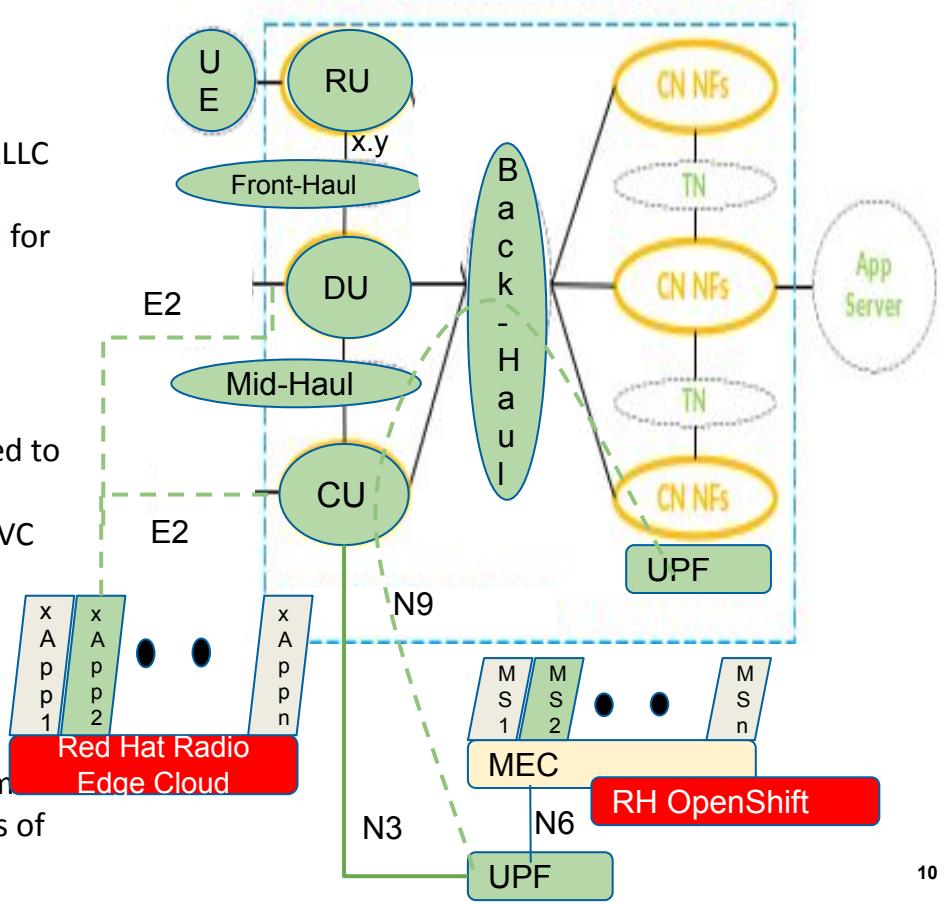
Legend: Network Slice NSSI

Reserved resources from the RAN, vRAN, 5GC, EPC

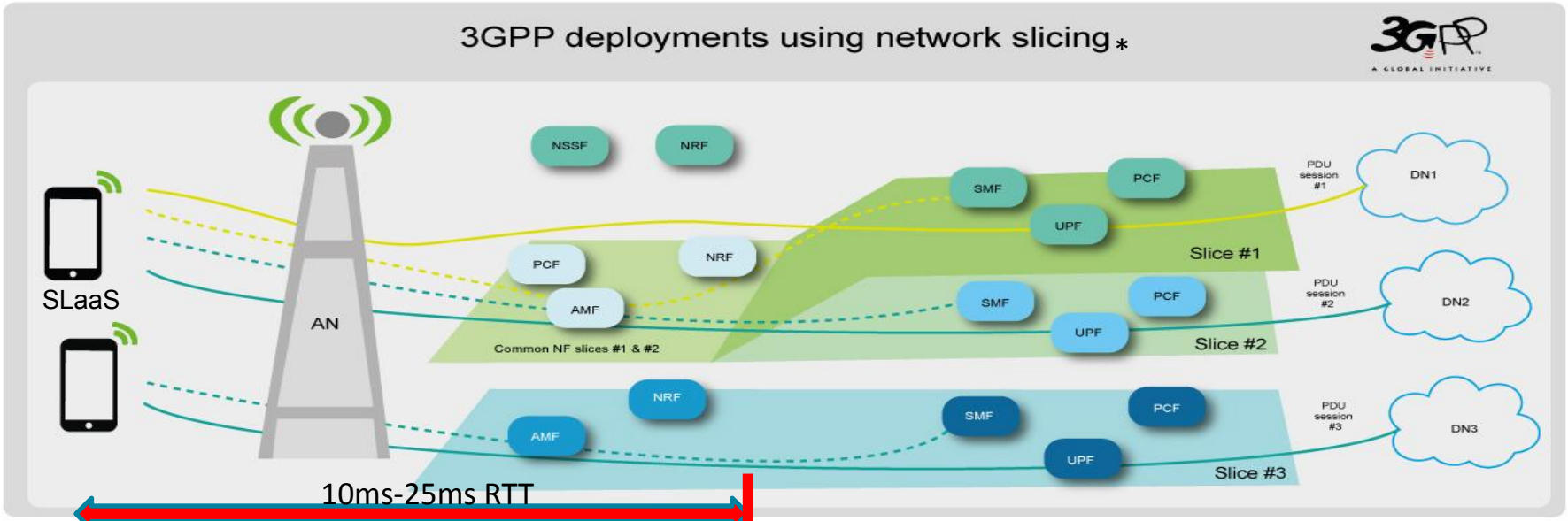
- Examples:
  - A unique UPF instance at an edge location supporting a particular NSI's data plane for URLLC services
  - vRAN logical ports (e.g., x.y, VLAN ID) reserved for an NSI over which that NSI's services flow

Extensions defined by the carrier

- Examples:
  - Backhaul Ethernet Virtual Circuit (EVC) assigned to a particular NSI
    - E.g., a Verizon IEN EVC, an AT&T IPAG EVC
  - A specific MEC microservice used to provide a particular NSI's service(s)
  - A specific RIC xApp designated to provide a particular RAN optimization for a given NSI's service(s)
- Refer to 3GPP TS 22.261 for Network Slicing Requirem and refer to 3GPP TS 28.530 for Management aspects of Network Slicing.



Telco/MNO E2E View of Network Slicing



*Mademann, Frank. (2017). 3GPP System architecture milestone of 5G Phase 1 is achieved", https://www.grandmetric.com/2018/03/02/5g-core-network-functions/

Network Slicing Products & Trials

- ***Sample Orchestration-Based Products for Network Slicing***
  - Ericsson
    - Ericsson 5G RAN Slicing solution
    - Dynamic Orchestration (E2E)
  - ZTE 5G Slice Management Solution
  - Nokia/Cloudstreet Dynamic Profile Controller (NPC)
  - Ciena Blue Planet
  - Viavi (test products for Network Slicing)
  - Amdocs 5G Slice Manager

- Telco/MNO Orchestration Trials
  - AT&T has performed Network Slicing PoCs using ONAP, some in partnership
    - https://events19.linuxfoundation.org/wp-content/uploads/2018/07/ONAP-Based-E2E-Slicing-Demo-ONS-v1a-1.pdf
    - https://wiki.onap.org/download/attachments/10784151/ONAPNetworkSlicingv3_25Jan2018.pptx?api=v2

Network Slicing
Proposed New XGVela Platform Services

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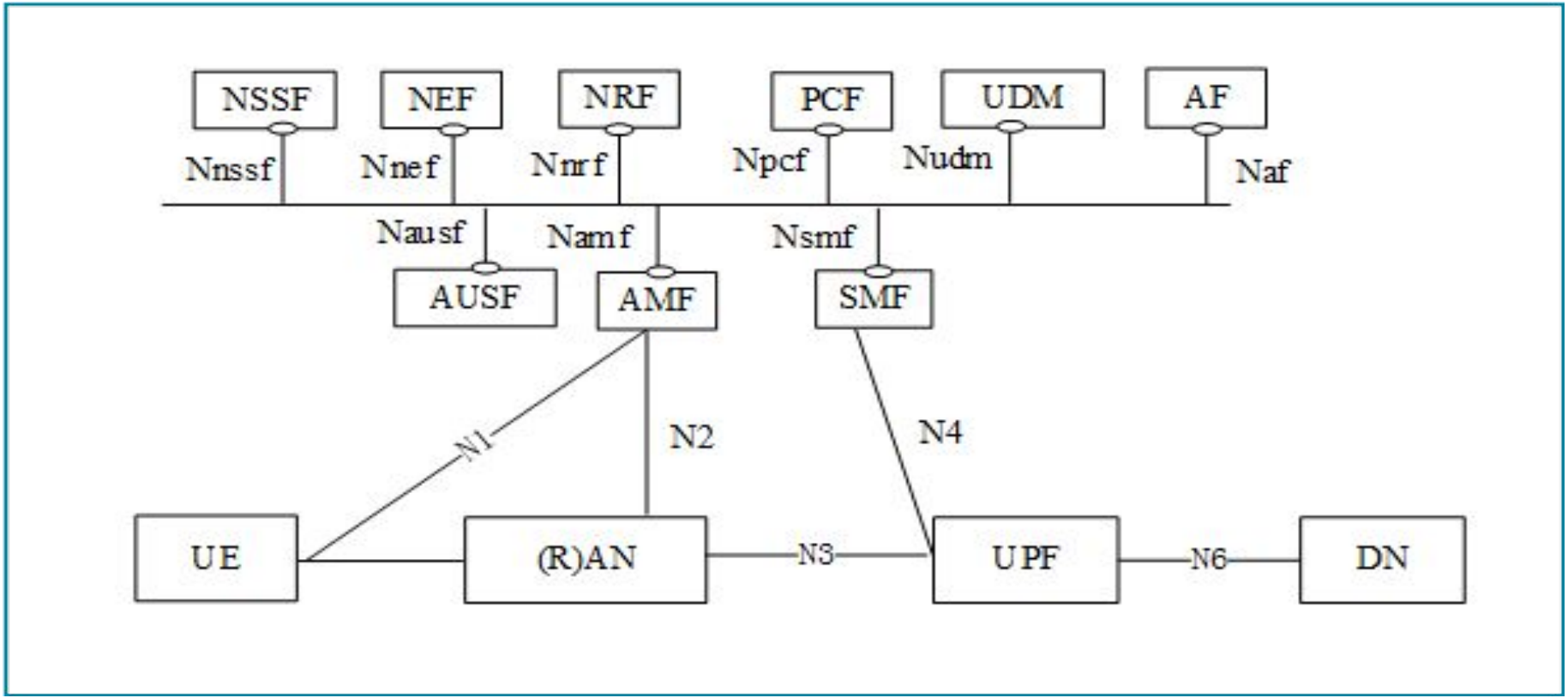
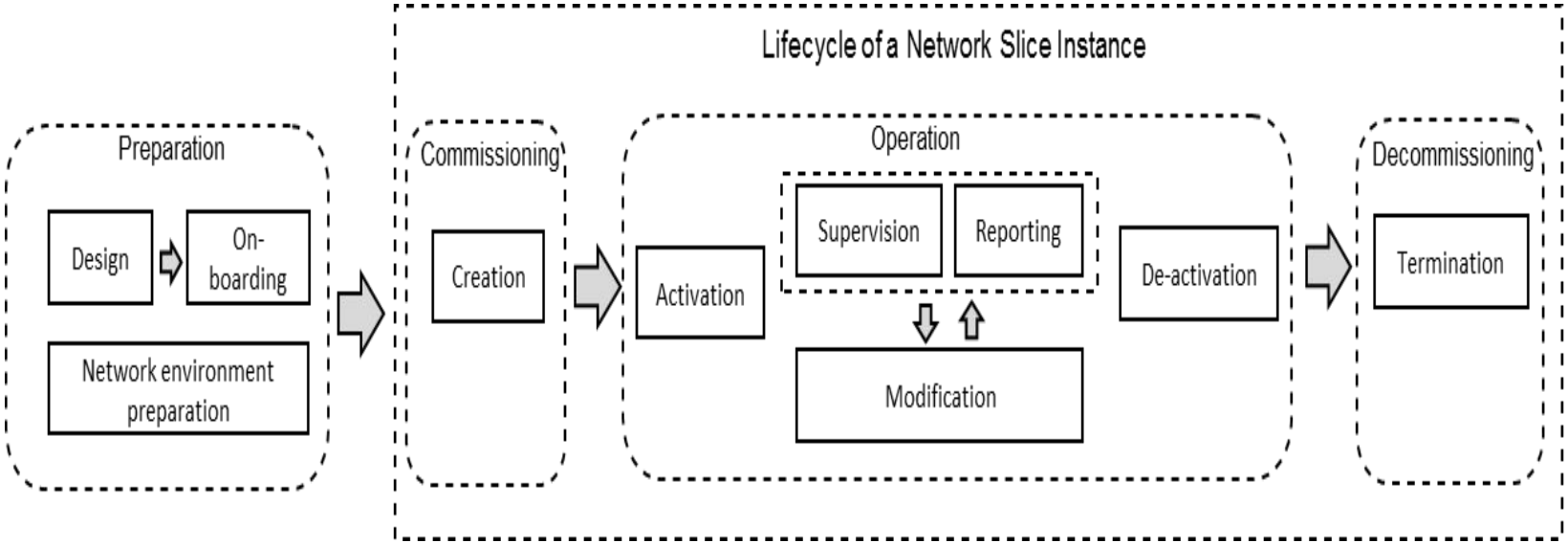
5G Network Slice Network Architecture



TR 28530 Release 15 Network Slice Phases



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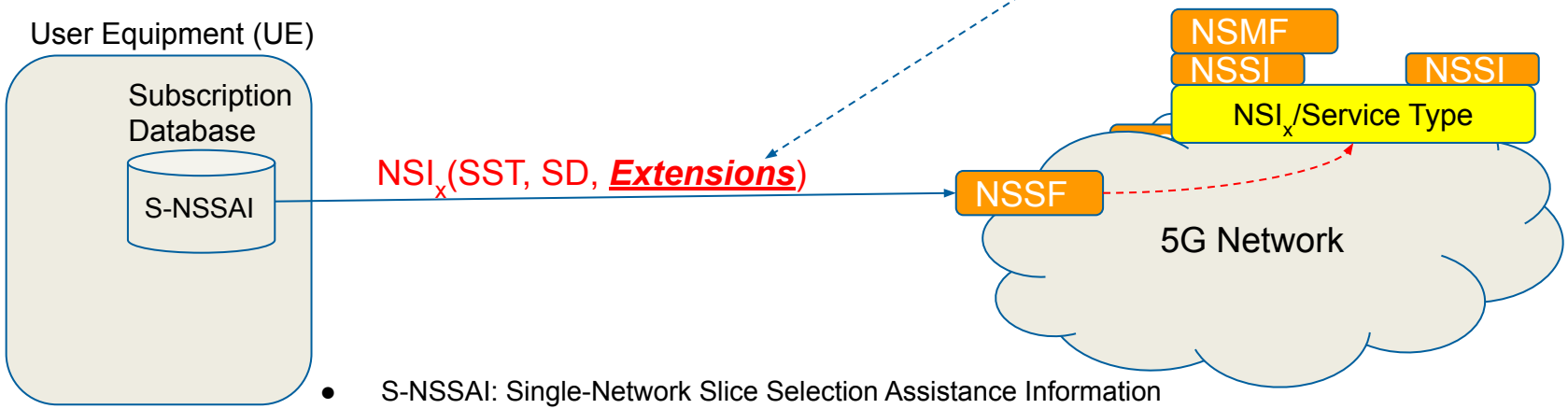

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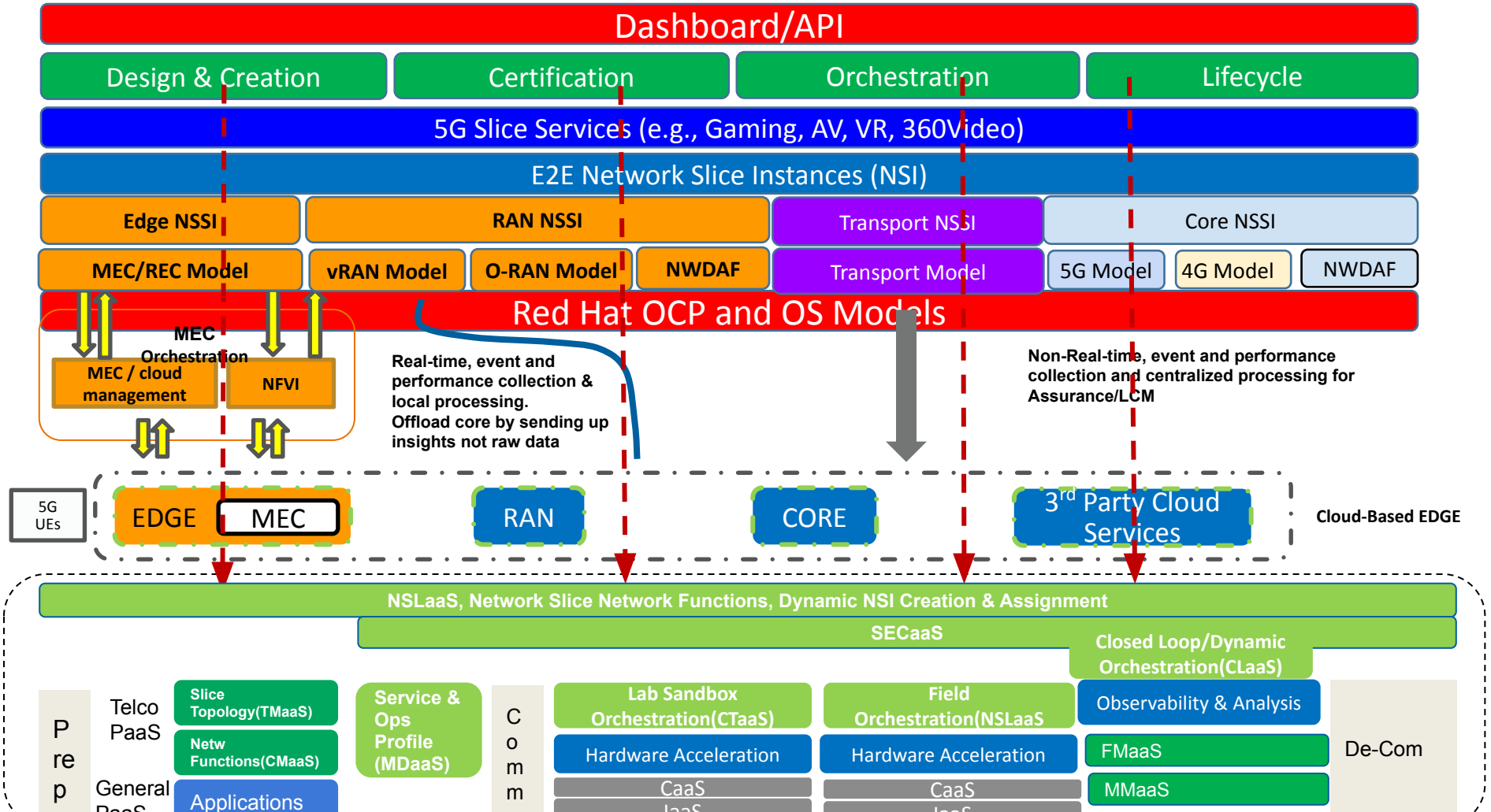
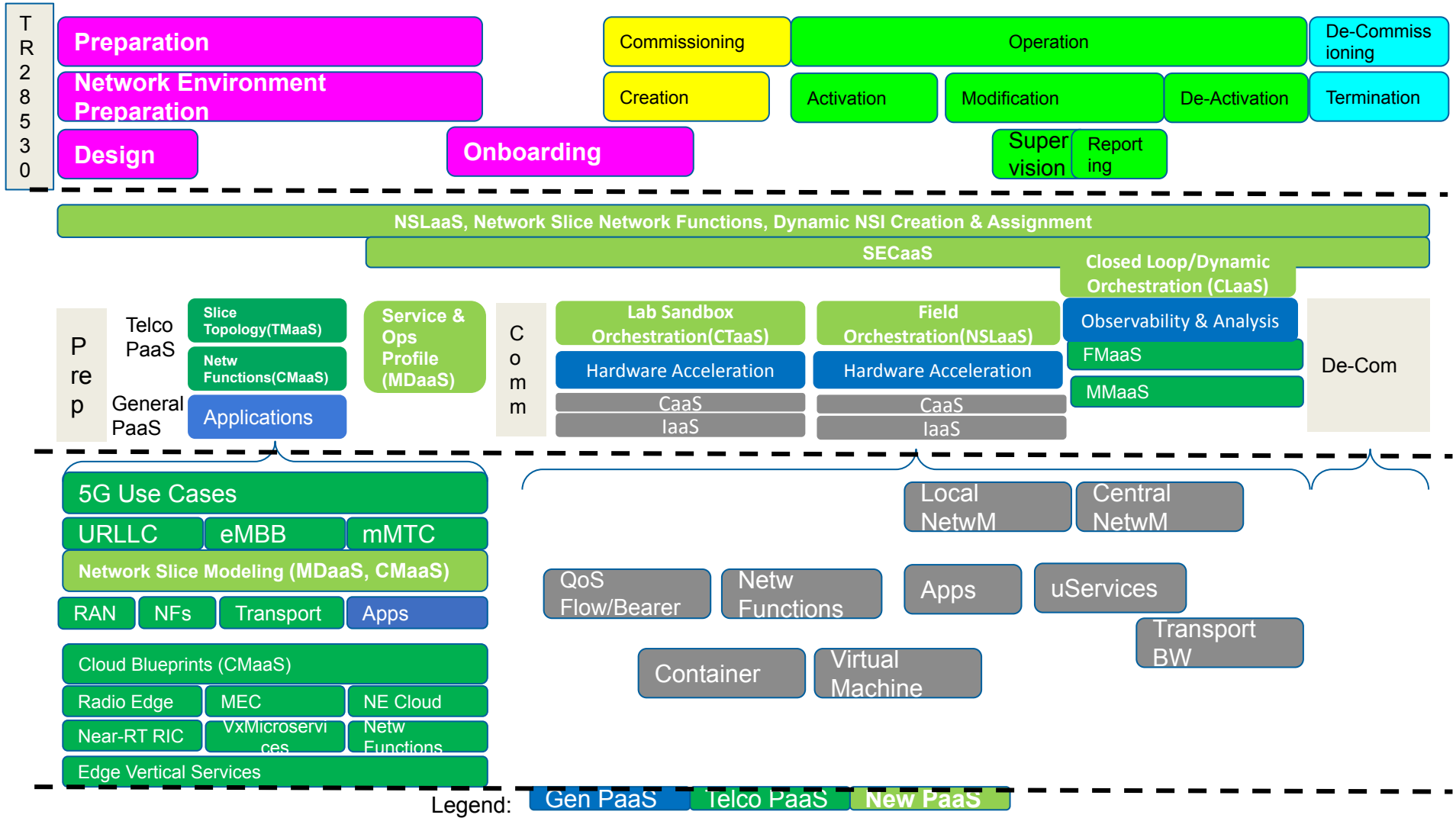
Proposed New Telco PaaS Services

- NSLaaS (Network Slicing as a Service)
  - Dynamic Orchestration and customer assignment of a Slice
  - Dynamic E2E DataPath QoS/CoS Orchestration (e.g., “Choose GBR/SR-IOV”)
  - Network Slice Architecture Network Functions used to create and manage slices
    - 5G Core Architecture Network Functions applied to slicing
- CTaaS (Certification as a Service)
  - Automated sandbox certification of a network slice
  - Why? Telcos require faster TTM; legacy certifications are 6-12 months, NS has limited lifespan
- MDaaS (Modeling as a Service)
  - Models service and operations profile of a network slice
  - Input to CTaaS
- SECaaS (Security as a Service)
  - E2E monitoring of a slice for security risks, potential and active
  - Why? Significant industry concern regarding NS security
- CLaaS (Closed Loop as a Service)
  - Inputs include FMaaS and MMaaS
  - Performs Dynamic Orchestration based on triggers

NSI/NSSI Modeling using ONAP with E2E BSS/OSS Integration

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Preparation
Network Environment Preparation
Design
Onboarding
Commissioning
Operation
De-Commissioning
Creation
Activation
Modification
De-Activation
Termination
Supervision
Reporting
NSLaaS, Network Slice Network Functions, Dynamic NSI Creation & Assignment
SECaaS
Closed Loop/Dynamic Orchestration (CLaaS)
Prep
Telco PaaS
General PaaS
Slice Topology(TMaaS)
Netw Functions(CMaaS)
Applications
Service & Ops Profile (MDaaS)
Comm
Lab Sandbox Orchestration(CTaaS)
Field Orchestration(NSLaaS)
Hardware Acceleration
Hardware Acceleration
CaaS
IaaS
CaaS
IaaS
Observability & Analysis
FMaaS
MMaaS
De-Com
5G Use Cases
URLLC
eMBB
mMTC
Network Slice Modeling (MDaaS, CMaaS)
RAN
NFs
Transport
Apps
Cloud Blueprints (CMaaS)
Radio Edge
MEC
NE Cloud
Near-RT RIC
VxMicroservices
Netw Functions
Edge Vertical Services
Local NetwM
Central NetwM
QoS Flow/Bearer
Netw Functions
Apps
uServices
Transport BW
Container
Virtual Machine
Legend:
Gen PaaS
Telco PaaS
New PaaS

Network Slicing with Red Hat Technologies

Red Hat

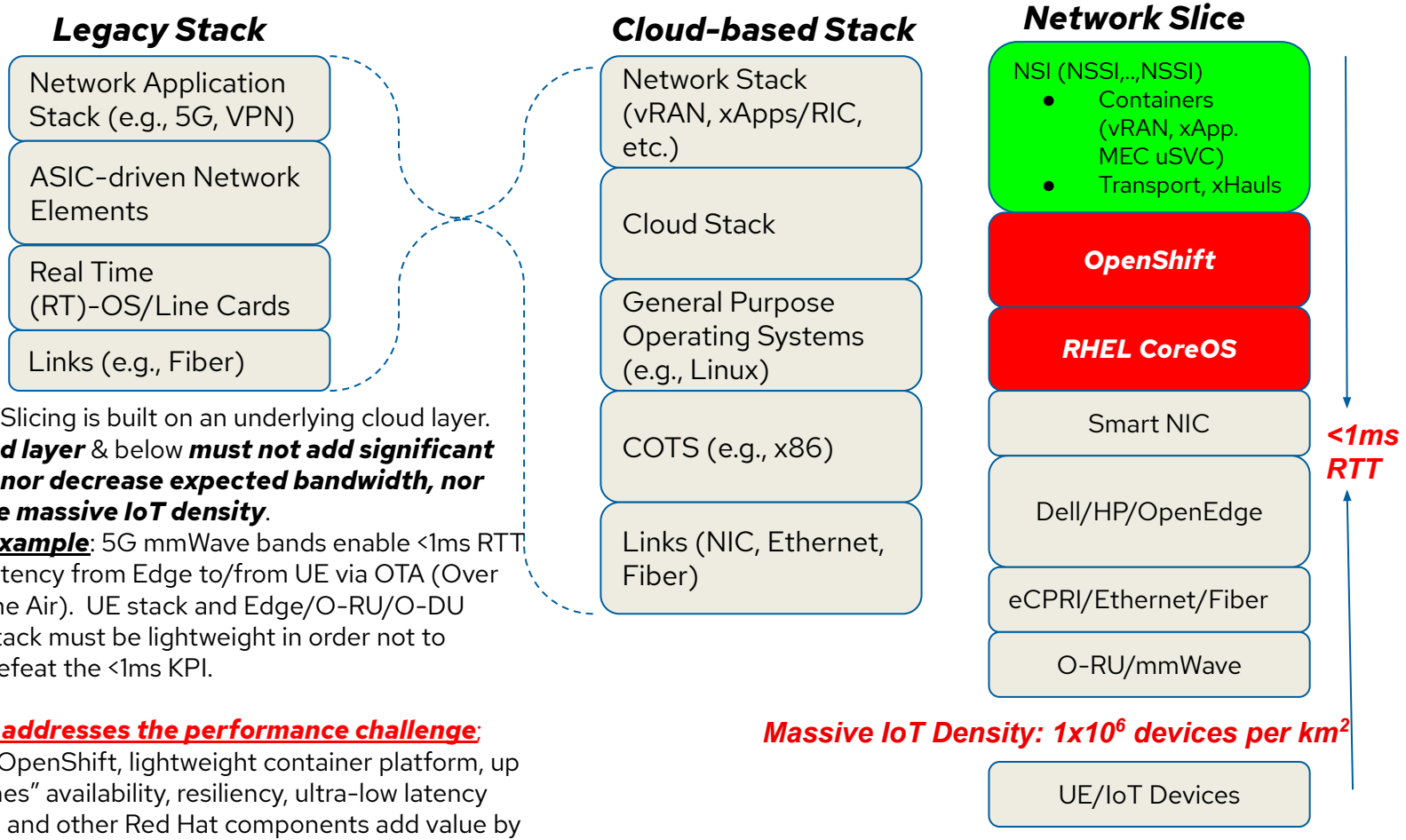
Red Hat Technology and Network Slicing

- OCP clusters can provide up to “6-Nines” (99.9999%) availability for an NSI
- OCP/RHEL Real Time (RT) for Ultra Reliable Low Latency Communications (URLLC) NSI
- OCP/RHEL as the cloud layer for elements within a Network Slice (RIC, MEC, O-RU, O-DU, and O-CU)
- OCP/RHEL as the cloud layer for an E2E Orchestrator for NSI
  - OCP & RHEL Real Time for Closed-Loop
  - Cloud layer for O-RAN Services Management & Orchestration (SMO)
- Orchestration systems, such as ONAP, can run in an OCP cluster, and hence the entire process of NSI design, Commissioning, Lifecycle, and Decommissioning would be dependent on the reliable operation of OCP and RHEL.
- Red Hat Ansible Automation Platform is a candidate for monitoring automation deployments
  - A tie-in generally to Orchestration of Network Slices insofar as it involves automated deployment of underlying infrastructures for NSI elements
  - Possibility of modification to provide some orchestration services at the application layer
- “Management of Heterogeneous Cloud infrastructures, use of Red Hat “Insights” to “increase security, operational efficiency”, and reduce OpEx at the infrastructure layer (cloud, containers, etc)
- Red Hat Advanced Kubernetes Cluster Management to reduce OpEx and achieve availability SLAs at the infrastructure layer, which is especially critical in a Telco/MNO deployment for Enterprise services
- Investigation ongoing into the possible use of Red Hat middleware as part of the Network Slicing software architecture itself, such as use within an orchestrator or an agent within the Near-RT RIC that selects and manages particular xApps as part of a given NSI.

Red Hat Network Slicing Partners

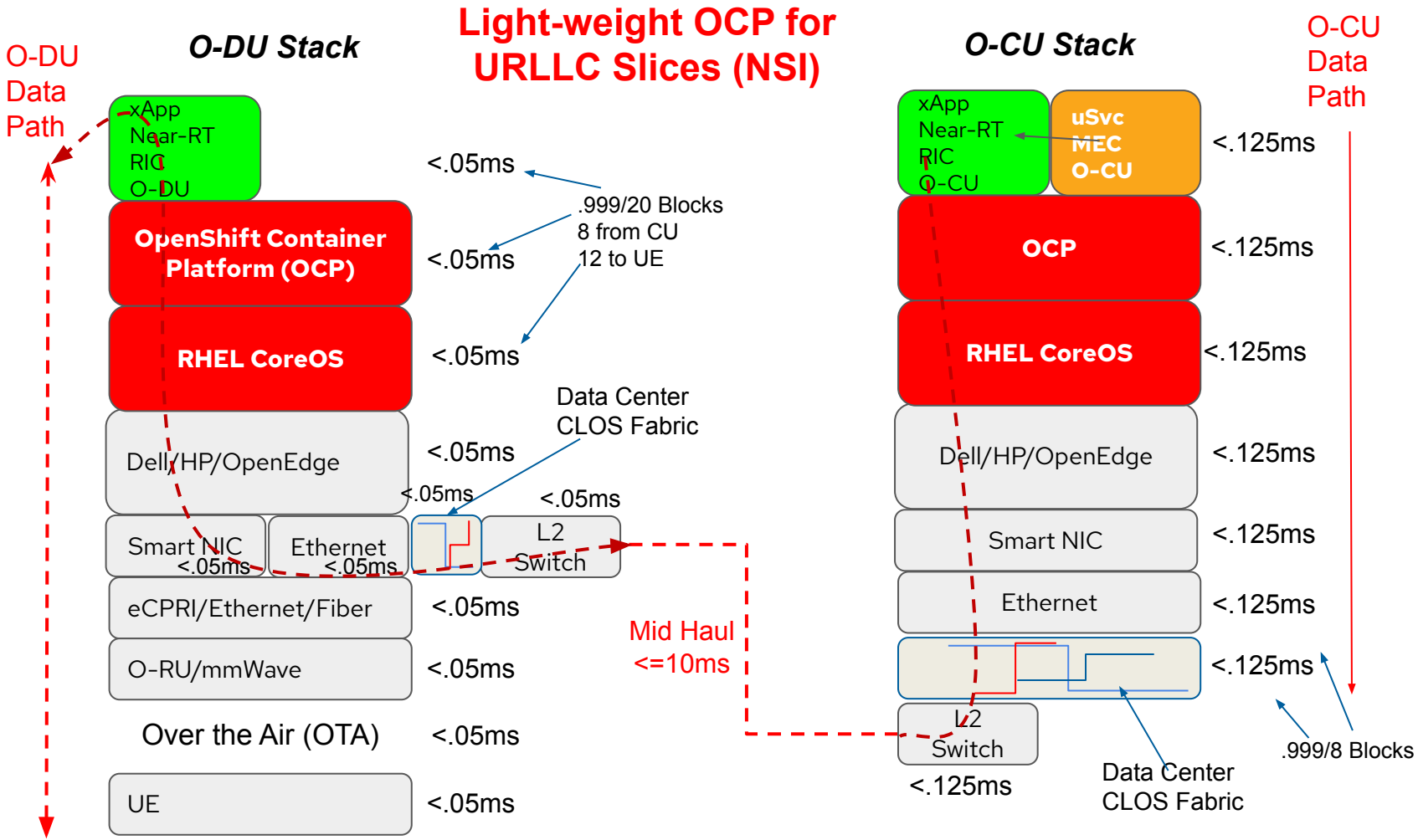
- Currently working with IBM on an E2E Network Slicing concepts, possibilities

Performance Challenge: "*5G Slice on Cloud*"



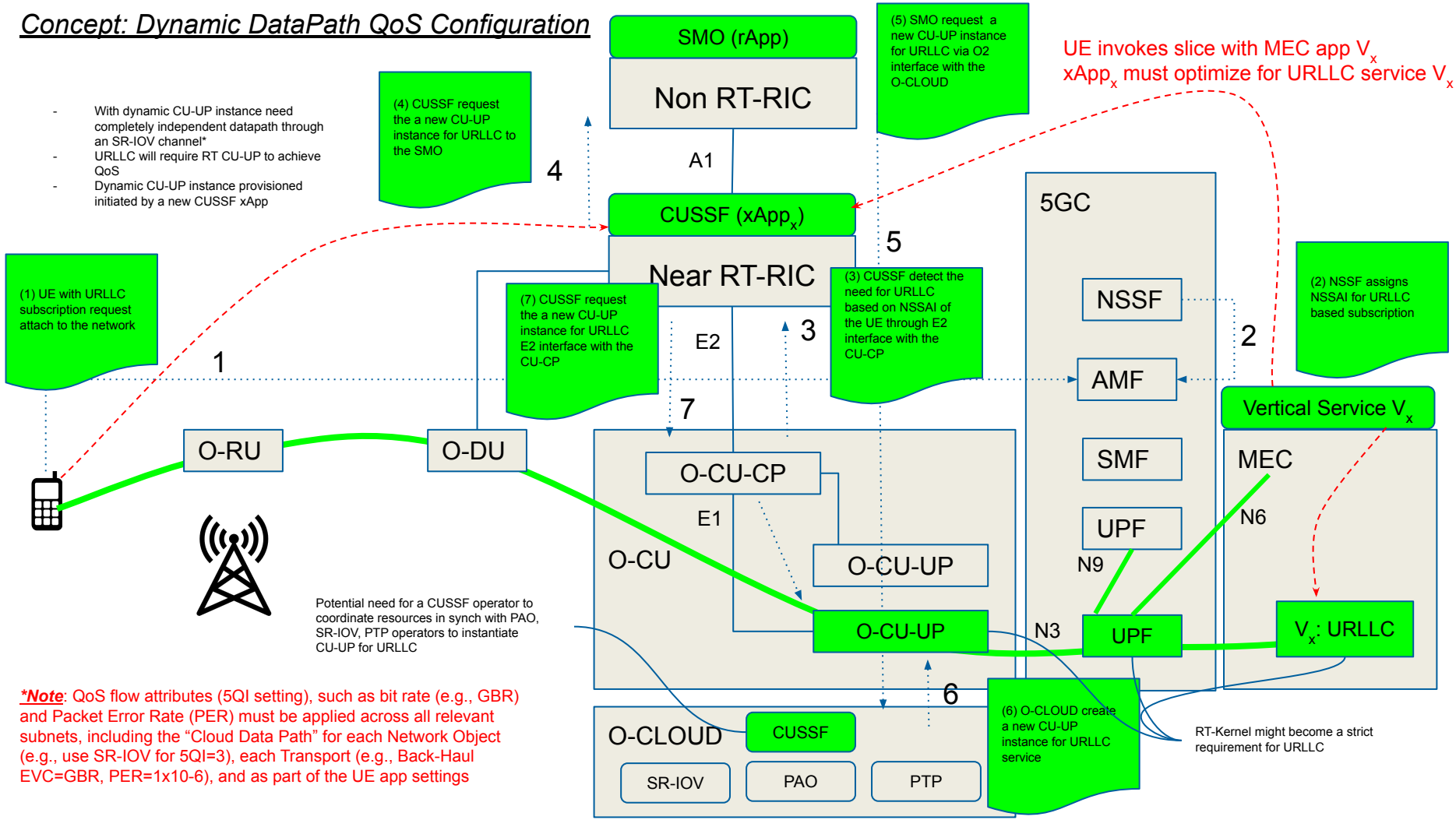
- Network Slicing is built on an underlying cloud layer.
- The ***cloud layer*** & below ***must not add significant latency, nor decrease expected bandwidth, nor decrease massive IoT density***.
  - ***Example***: 5G mmWave bands enable <1ms RTT latency from Edge to/from UE via OTA (Over the Air). UE stack and Edge/O-RU/O-DU stack must be lightweight in order not to defeat the <1ms KPI.

- ***Red Hat addresses the performance challenge***; Red Hat OpenShift, lightweight container platform, up to "6-Nines" availability, resiliency, ultra-low latency data bus, and other Red Hat components add value by enabling & preserving anticipated 5G KPIs.


Light-weight OCP for URLLC Slices (NSI)
O-DU Data Path
O-DU Stack
xApp
Near-RT RIC
O-DU
OpenShift Container Platform (OCP)
RHEL CoreOS
Dell/HP/OpenEdge
Smart NIC
Ethernet
eCPRI/Ethernet/Fiber
O-RU/mmWave
Over the Air (OTA)
UE
<.05ms
.999/20 Blocks
8 from CU
12 to UE
Data Center
CLOS Fabric
L2
Switch
Mid Haul
<=10ms
O-CU Stack
xApp
Near-RT RIC
O-CU
uSvc
MEC
O-CU
OCP
RHEL CoreOS
Dell/HP/OpenEdge
Smart NIC
Ethernet
L2
Switch
<.125ms
O-CU Data Path
.999/8 Blocks
Data Center
CLOS Fabric

Concept: Dynamic DataPath QoS Configuration

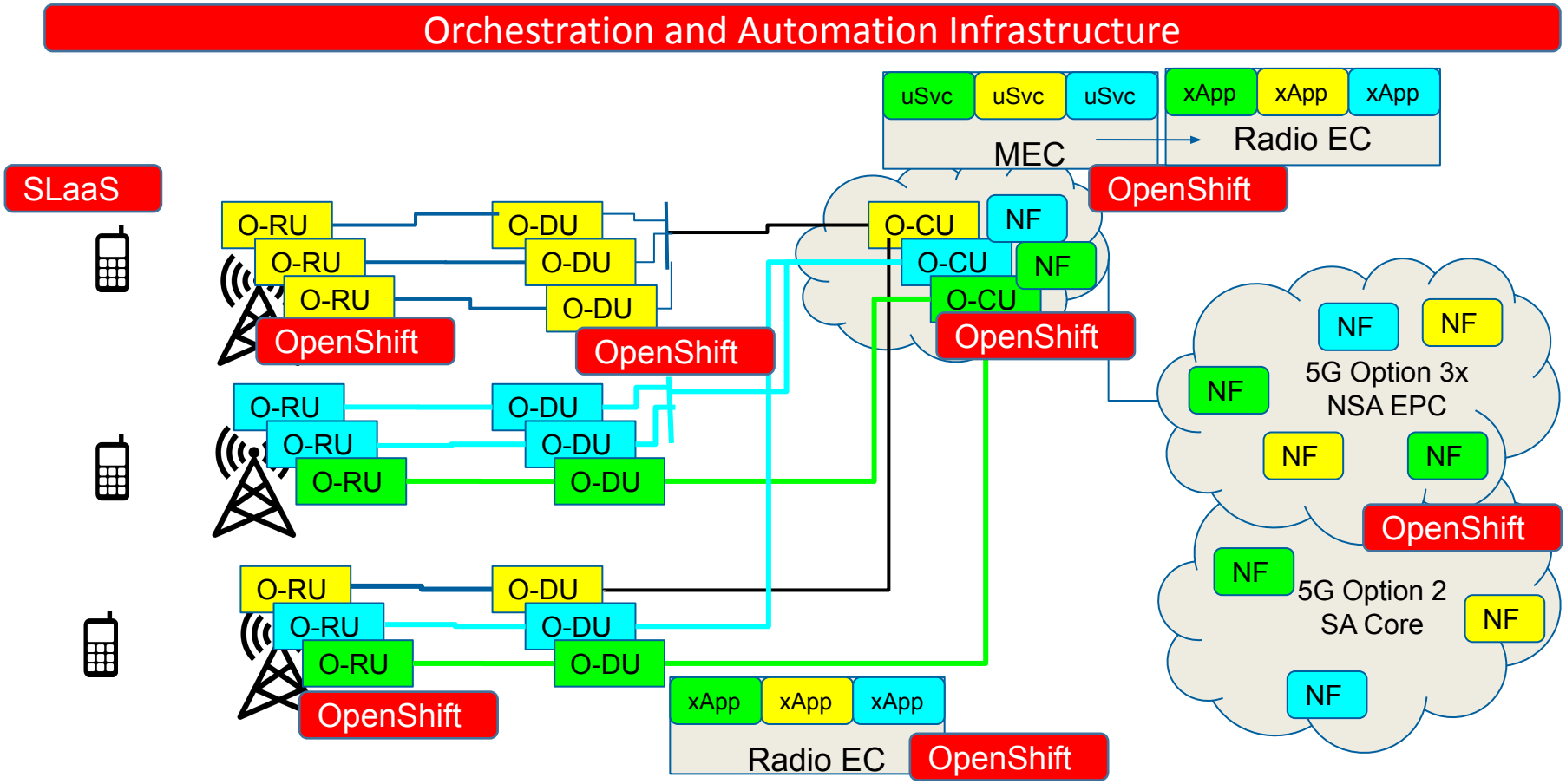
- With dynamic CU-UP instance need completely independent datapath through an SR-IOV channel*
- URLLC will require RT CU-UP to achieve QoS
- Dynamic CU-UP instance provisioned initiated by a new CUSSF xApp

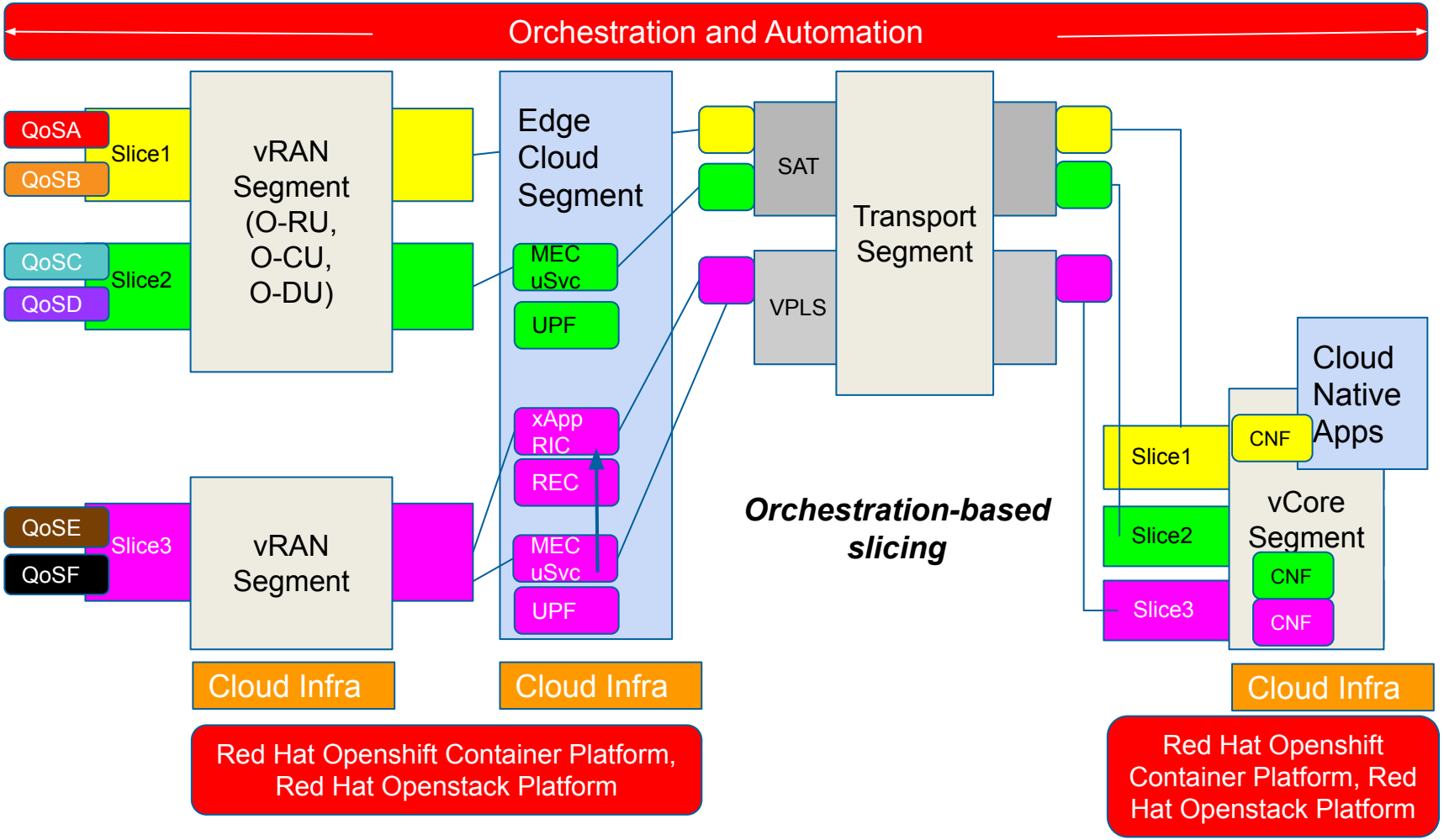


Note: QoS flow attributes (5QI setting), such as bit rate (e.g., GBR) and Packet Error Rate (PER) must be applied across all relevant subnets, including the "Cloud Data Path" for each Network Object (e.g., use SR-IOV for 5QI=3), each Transport (e.g., Back-Haul EVC=GBR, PER=1x10-6), and as part of the UE app settings

Monetization via Network Resource Multiplexing

Urban/Suburban/Local Data Center | Regional Data Center | National Data Center

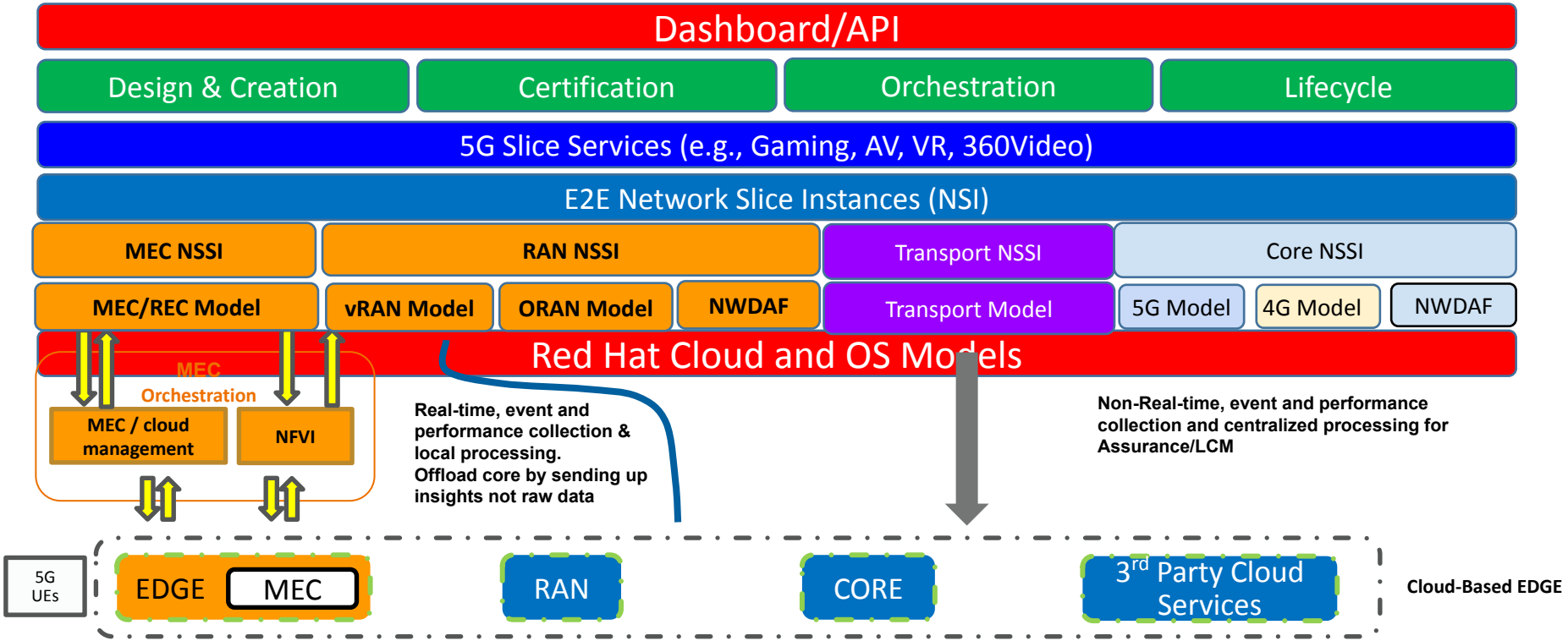




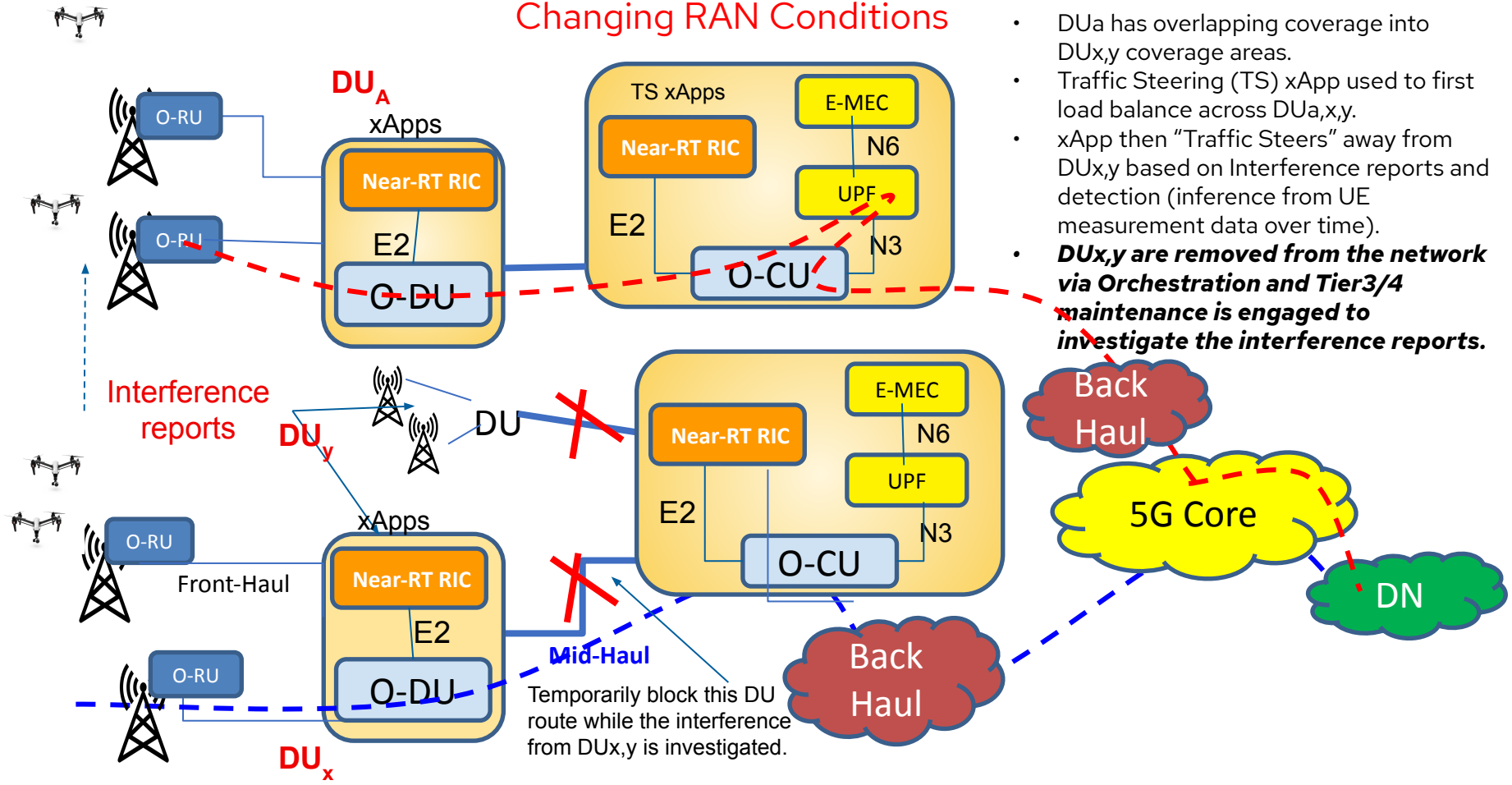
CNF: Core Network Function UPF: User Plane Function VPLS: Virtual Private LAN Service

Proposed ONAP-Based NSI/NSSI Modeling

NSI/NSSI Modeling using ONAP with E2E BSS/OSS Integration



Dynamic (Elastic) Topology Re-Orchestration Based on Changing RAN Conditions



- DUa has overlapping coverage into DUx,y coverage areas.
- Traffic Steering (TS) xApp used to first load balance across DUa,x,y.
- xApp then "Traffic Steers" away from DUx,y based on Interference reports and detection (inference from UE measurement data over time).
- ***DUx,y are removed from the network via Orchestration and Tier3/4 maintenance is engaged to investigate the interference reports.***

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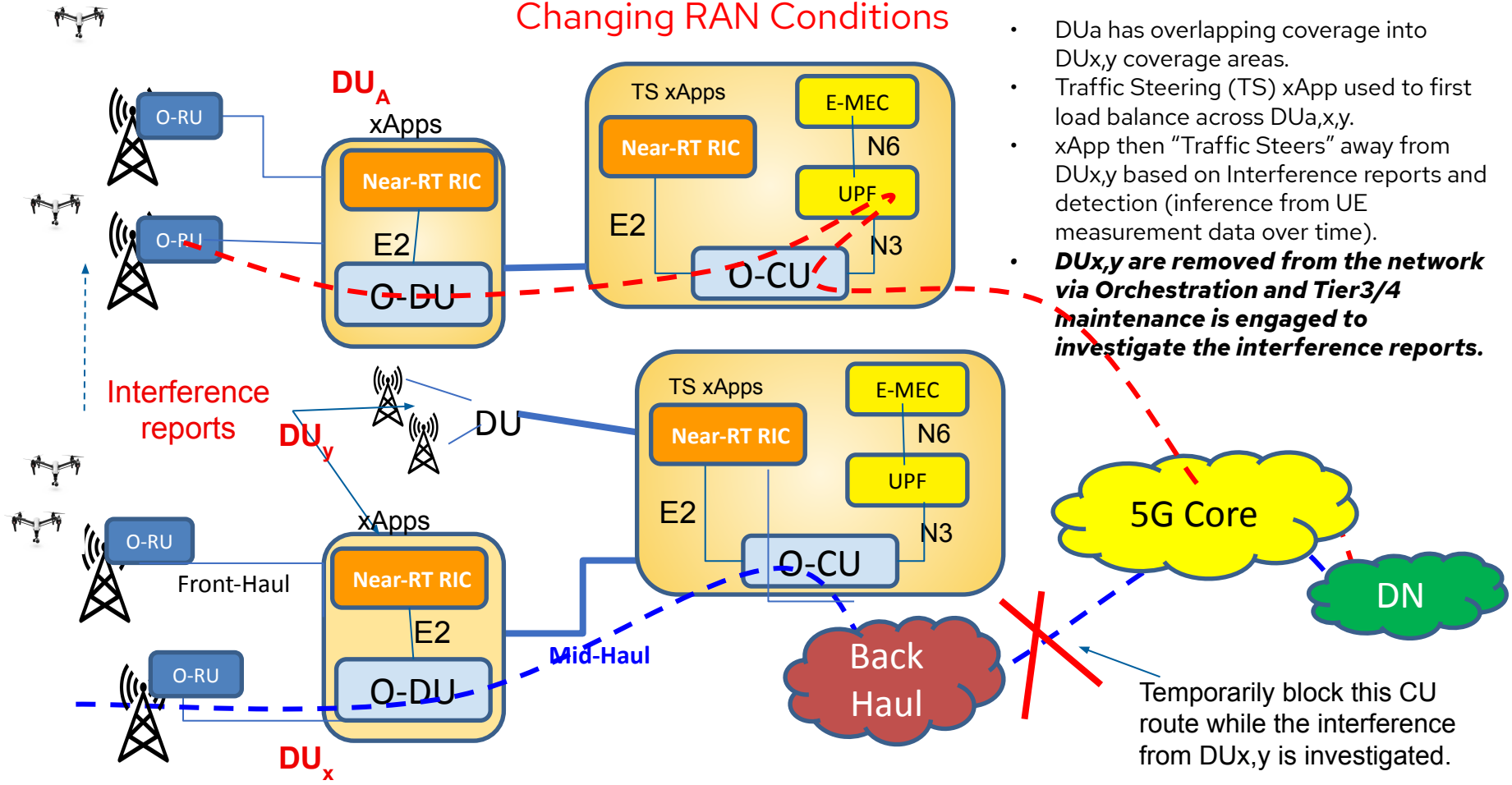

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Network Slice Management
MNO, MVNO, Enterprise

Red Hat

Mobile Network Operators and Network Slice Operators

- ***Mobile Network Operators (MNO)***
  - "Typically" operates and manages all network assets (sw + hw)*
  - Typically has allocation rights for all network assets*
  - "All network assets" in reality means the "network infrastructure as a whole", prior to any NSI (VPN) definitions
  - The allocation of NSI resources are at the discretion of the MNO

- A **"Mobile Virtual Network Operator (MVNO)"** or **Enterprise** would typically manage an NSI
  - An enterprise that "purchases" or "leases" a "slice contract" from an MNO is an MVNO
  - An MVNO "typically" operates and manages the virtual entities comprising the NSI*
  - The design of a particular NSI depends on the business model between an MNO and MVNO (or Enterprise)
    - An MVNO would negotiate with the MNO for the set of services and the Classes of Service (CoS) needed for their NSI(s)
    - Generally, higher CoS for an NSI dictates the allocation of more resources by the MNO
    - Depending on the business model/agreement, the MVNO may take on operation and management of some physical assets (e.g., Far Edge uCPE/Whitebox)

*Depending on the carrier, some assets may be owned and/or managed by other entities based on a prior business arrangement, such as RAN Sharing.

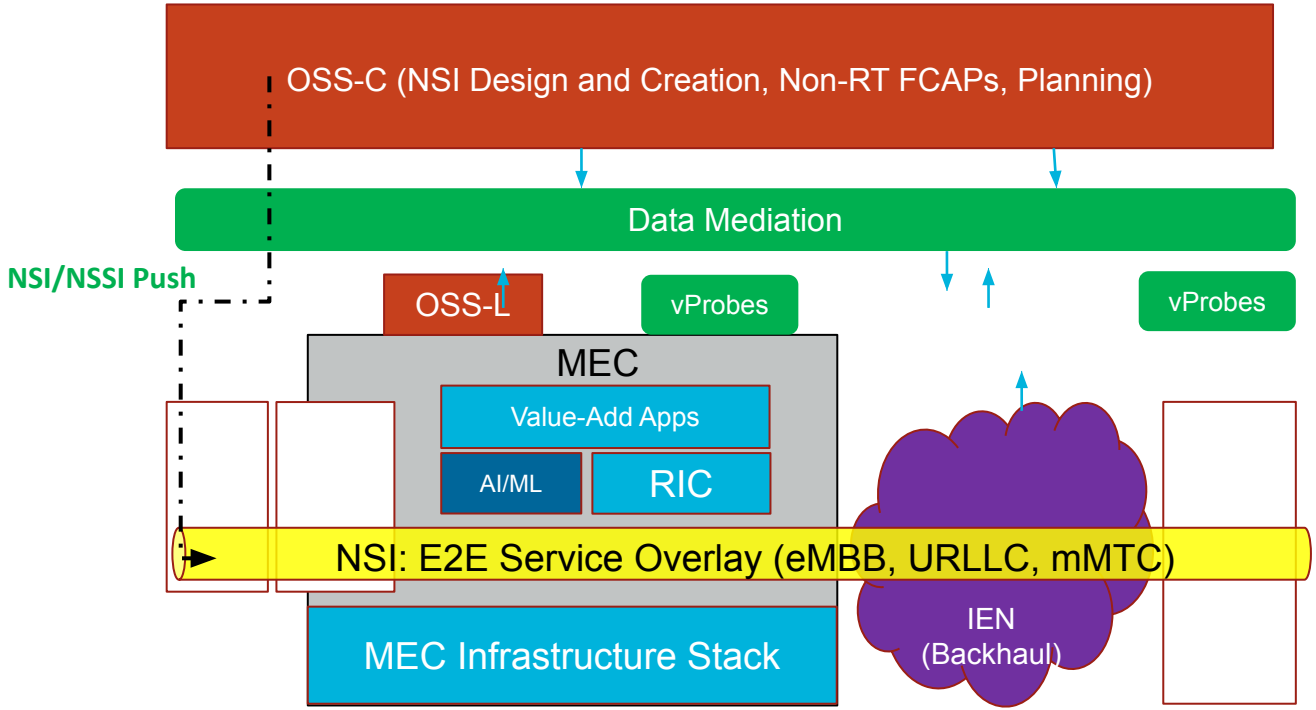
Federated Management Model

- **"Federated" OSS & BSS functions**
  - OSS-Central (OSS-C) focused on Non-RT FCAPS (>200ms)*
    - Legacy functions, such as Billing, Cap Mgmnt
    - NSI design, NSSI modeling, NSI orchestration
  - OSS-Local (OSS-L, distributed)
    - Focuses on data mediation
      - offload/aggregation, insight generation toward OSS-C
    - Low-latency closed-loop control
    - Other latency sensitive operations
      - Operations requiring RT (<=20ms) or Near-RT (<=100-200ms) latency (Edge or Far-Edge)*
        - E.g., Video Rendering
- **Management Demarcation**
  - MNO and MVNOs (Enterprises) will do parts of OSS-C and OSS-L
  - Examples:
    - MVNOs may have their own Billing systems for an NSI's services
    - MNO will bill MVNOs based on the business model for NSI allocations
    - MVNOs may provide video rendering services for their "Gaming" NSI

*All latency numbers are Round Trip Time (RTT) including SOL and node processing times.

OSS Future Mode of Operation (FMO) with Network Slicing

- Distributed OSS Model
  - OSS-Central, OSS-Local
  - Proposed NSI stack
- OSS-C Role
  - E2E Network Slice Instance (NSI) Design, Creation and Lifecycle
  - NSI Non-RT FCAPS, Planning
  - Network Non-RT FCAPS
- OSS–L Role
  - OSS-C data offload
  - FCAPS of low-latency NSSI components within the Edge



OSS NSI Life Cycle Model using OSS-C & OSS-L

- Network Slice Instance (NSI) Design & Creation
- Ordering
- Deployment (Orchestration)
- Customer Provisioning
- Service Assurance
- Performance
- Capacity Management Planning
- Business Planning

NSI FCAPS

NSI Customer Experience Analytics

NSI RAN Analytics

NSI KPI Analytics

OSS-C(entral)
Non-Real Time (**>100ms**)
Life Cycle
RTT

- Low latency MEC App Instantiation & FCAPS
- Performance data/processing offload from OSS-C
- RAN Optimization ORAN RAN Intelligent Ctrl (RIC) (e.g., Beam Forming, ANR, DC)
- Low latency Closed Loop for NSSI resources (e.g., Fast Switch)
- Local vProbe & Automated Troubleshooting
- Local app data rendering (e.g., gaming video)
- Transport QoS setting and validation
- Processing of vRAN UE Measurements and Events
- Edge Learning and Response via AI, ML
- Service chaining at the edge (e.g., UPF□MEC App□RIC App--vRAN)
- Data aggregation and mediation to OSS-C

NSI UE Measurements

NSI RAN Events

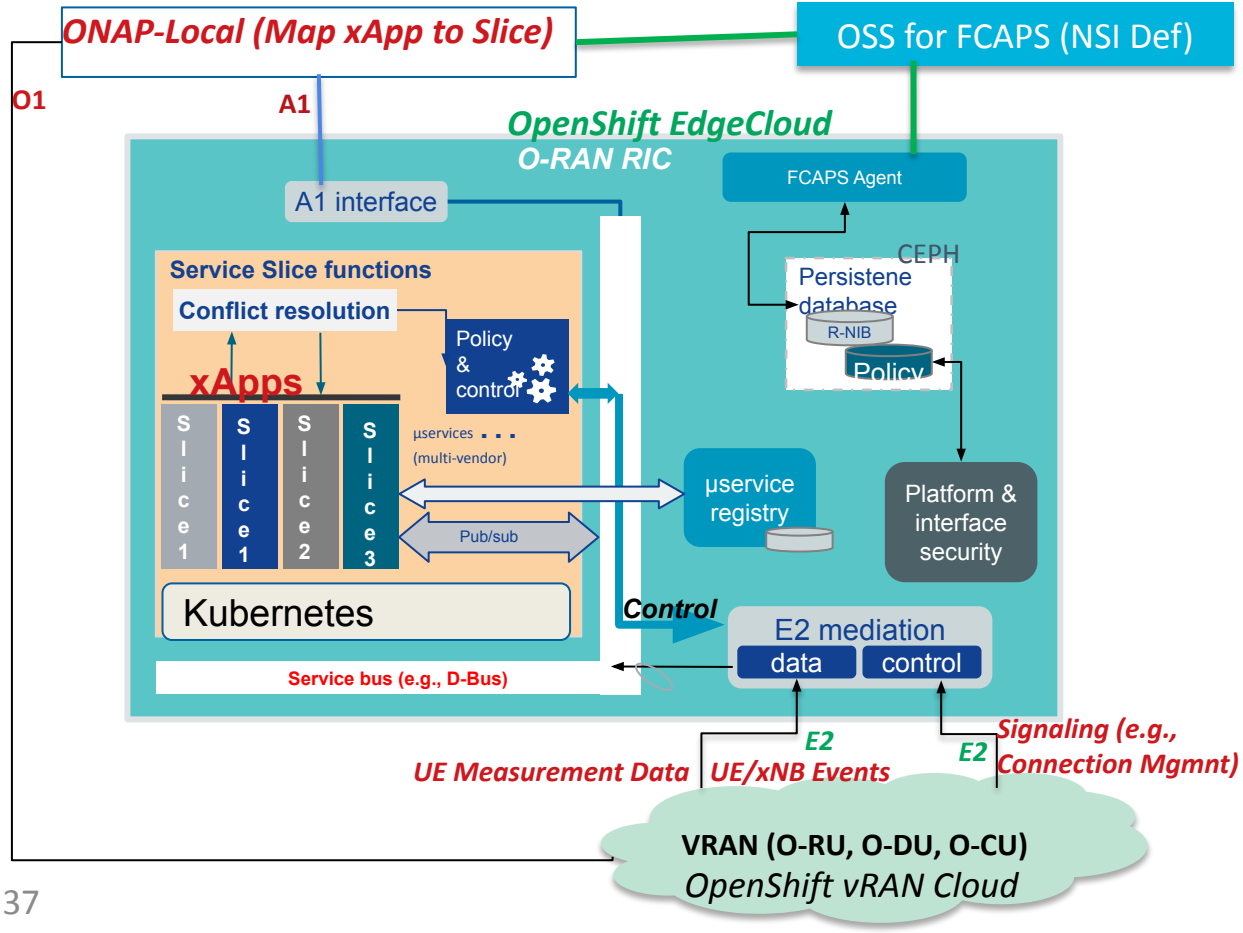
NSI RAN Optimization

RIC Events

Data Offload

OSS-L(ocal)
Real Time (**<=20ms**)
Near Real Time (**<=100ms**)
RTT

Example OSS/BSS Architecture with O-RAN RIC NSI Integration



OSS-C/BSS-C

- Focus on infrastructure and NSI def, NSI orchestration and FCAPS
- ***RIC xApps, MEC micro-services mapped to SliceN by ONAP-L***
- Orchestration is Non-RT but services orchestrated may be RT or Near-RT in nature (e.g., AV, Robotic Surgery)
- Slice configs "Pushed" to MEC

RIC Slicing via xApps

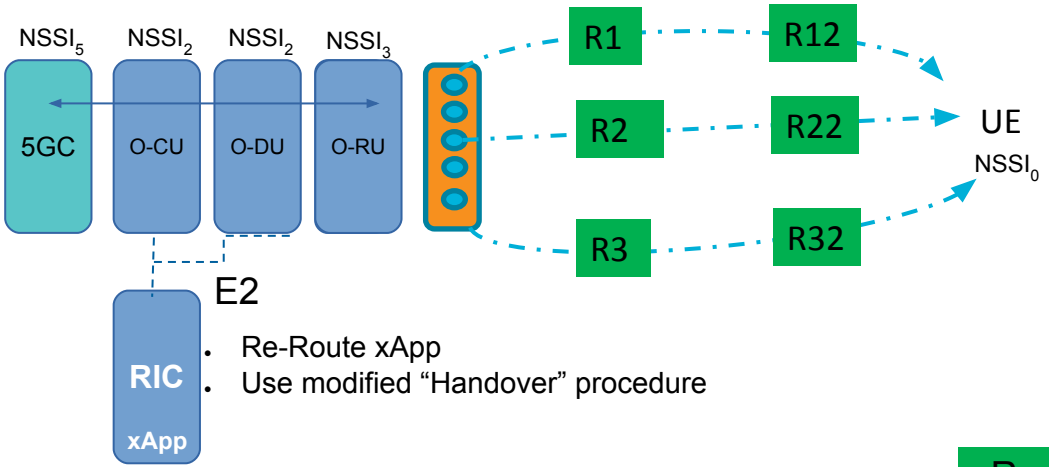
- Carrier-grade EdgeCloud (e.g., OpenShift)
- ***RIC xApps, MEC Mservices mapped to SliceN by ONAP-L (e.g., 2 xApps in 1 Slice)***
- Each "Slice" disaggregates vRAN CP/UP components to provide differentiated RAN optimization per SliceN
- Focus on RT & Near-RT Low-latency use cases
  - E.g., ANR which may require RT or NRT latency (<=10ms)
  - E.g., Dual Connectivity, Beam Forming

ONAP-Local

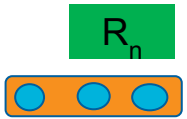
- Low latency Closed-Loop-Orchestration, Management
- Manage O-RAN and vRAN via standard ORAN/xRAN interfaces (A1, O1, E1, E2)
- Shares management responsibility with OSS/BSS
- Data Mediation, Insight Generation
- Policy, xApp to Slice mapping

Example NSI: Improving Performance of Network Beam Steering using mmWave and Massive MIMO

- NSI & NSSI constructs used to model slice instances and slice subnets
- Multiple Input Multiple Output Antenna at Macro-cell
- Use Network of Smart-repeaters and/or Small-cells to route around obstacles or “bad links”
- Beam Forming and Steering per UE
  - Network Beam Steering where obstacles, blockage, refraction, dispersion are problematic



- $NSSI_1$ = RIC Re-Route xApp
- $NSSI_2$ = O-CU and/or O-DU port bandwidth (e.g., Port 1.x, where x = logical sub-port)
- $NSSI_3$ = O-RU port bandwidth
- $NSSI_4$ = UE NSI Application
- $NSSI_5$ = Core Network Function(s) needed
- $NSSI_{6\text{-}8}$ = Front, Mid, Back Haul
- $NSSI_0$ = R1-R32 = Intelligent Repeaters/Micro-Cells/Smallcells path to UE App



Small Cell/Smart Repeater

MIMO Radio & Antenna

Cyber Security in 5G NSI

- **Vertical Security via Slicing: Distinct Virtual Networks**
  - Physical infrastructure is multiplexed into virtual Network Slice Instances (NSI)
    - MNOs/MVNOs want to monetize the network via Virtual Network Slices
  - Network Slices minimize or eliminate common data structures between NSI
  - Hardware and Firmware commonality between NSI is easier to firewall
  - Each NSI maintains a unique set of SLAs, QoS, CoS, and FCAPS
- **Horizontal Security:**
  - **5G UP & CP Encryption**
    - Protection against eavesdropping and modification
    - Signaling traffic and bearer data is encrypted
      - Encryption based on SNOW 3G, AES-CTR, and ZUC
      - Key generation based on HMAC-SHA-2569
  - **New Integrity Protection**
    - Based on SNOW 3G, AES-CMAC, and ZUC
    - Applies to small, bursty data as would be expected from IoT devices

Cyber Security in 5G (cont'd)

- **Horizontal Security (cont'd)**
  - **Identity Management**
    - ✔ Secure methods for authenticating subscribers (apply to each NSI)
    - ✔ 5G Authentication & Key Agreement (5G AKA) and Extensible Authentication Protocol (EAP)
    - ✔ MNO/MVNO determines authentication credentials, methods, and ID formats for subscribers (incl devices)
    - ✔ Previous releases required SIM cards
    - ✔ 5G accepts certificates, pre-shared keys token cards, and other objects
    - ✔ EAP allows for different authentication protocols and credential types without affecting intermediate nodes
  - **5G inherits Equipment Identity Register (EIR)**
    - ✔ **Prevents stolen devices from using network services**
  - **Subscriber Presence Validation**
    - ✔ MNO/MVNO validates subscriber presence during authentication (including Roaming)
    - ✔ Identifies and mitigates fraud for the Carrier/Operator and the subscriber

Backup

Definitions & Assumptions

- ***Critical Functions*** **are implemented on "Carrier Grade" Cloud infrastructure (*CGCI*)**
  - "Cloud Infrastructure" such as OpenShift, Kubernetes K8s
  - Multi-Access Edge Cloud (***MEC***)
  - RAN Intelligent Controller (***RIC***)
  - Virtual RAN (***vRAN***)
  - (v/c)NFs on Virtual Machines (VMs) or Containers

- **A *RIC* (specified by the ORAN-Alliance) is integrated with the MEC and vRAN**
  - The RIC contains micro-services (xApps, rApps) and AI/ML components for RAN Optimization and Management
  - RAN Optimization occurs per service slice or in the aggregate

- ***"Service Slices"*** **are defined by the Mobile Network Operator (MNO, MVNO) or Customer (Enterprise)**
  - The MEC contains Apps (micro-services) driven by MNO or Enterprise value-added use cases
  - Use Cases fall within URLLC, mMTC, eMBB categories

- **"*Orchestration*" functions include:**
  - VNF/CNF instantiation and stitching
  - App instantiation
  - Service chaining, configuration and stitching for NFs and other devices
  - RRU/BBU or O-RAN decomposed O-RU, O-DU, O-CU static and dynamic configuration
  - Transport instantiation and config (Front-Haul, Mid-H, Back-H, IP Core Xport)

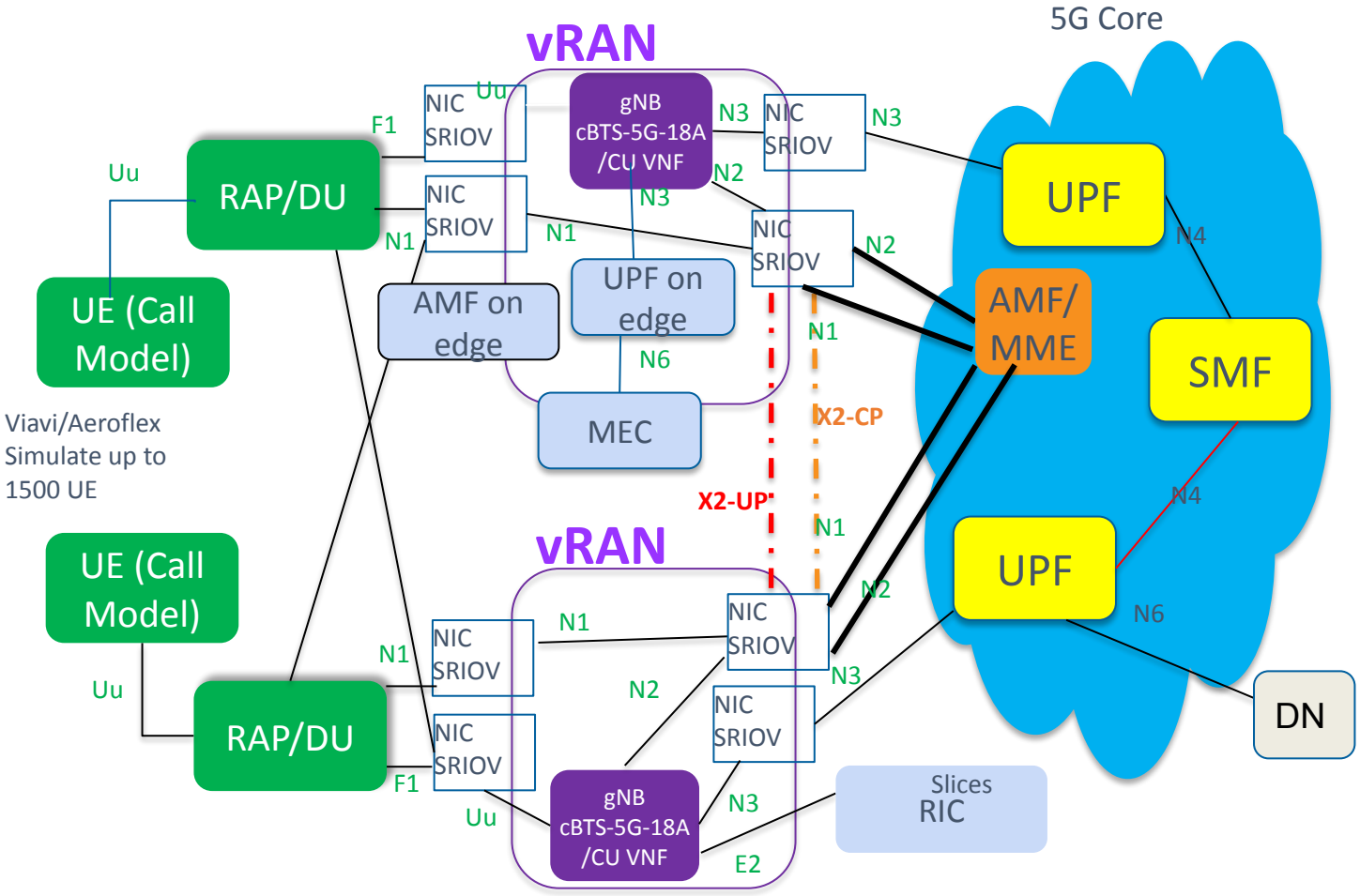
5G Service Slicing - Definitions

- ***NSI*** **(Network Slice Instance): Virtual service overlay on a common physical network.**
  - Each NSI provides a specific service capability that is isolated as a logical entity from other Slices. For example, VoLTE can be considered a service slice over a physical LTE network.
  - Physical and logical resources can be dedicated to particular slices.
  - Network Functions (NFS) from the 5G 3GPP reference architecture are arranged E2E in a slice.
- ***NSSI*** **(Network Slice Subnet Instance): A subnet, such as RAN, and associated configurations as part of the E2E NSI definition.**
- ***Micro-Services*****: A software architecture technique to instantiate service slicing.**
- ***MEC*****: Mobile Edge Cloud or Multi-Access Edge Cloud.**
- ***REC*****: Radio Edge Cloud**
- ***ORAN*****: Open-RAN Alliance**
- ***RIC*****: RAN Intelligent Controller, part of the ORAN specification**
- ***5Gc*****: The 5G Packet Core**

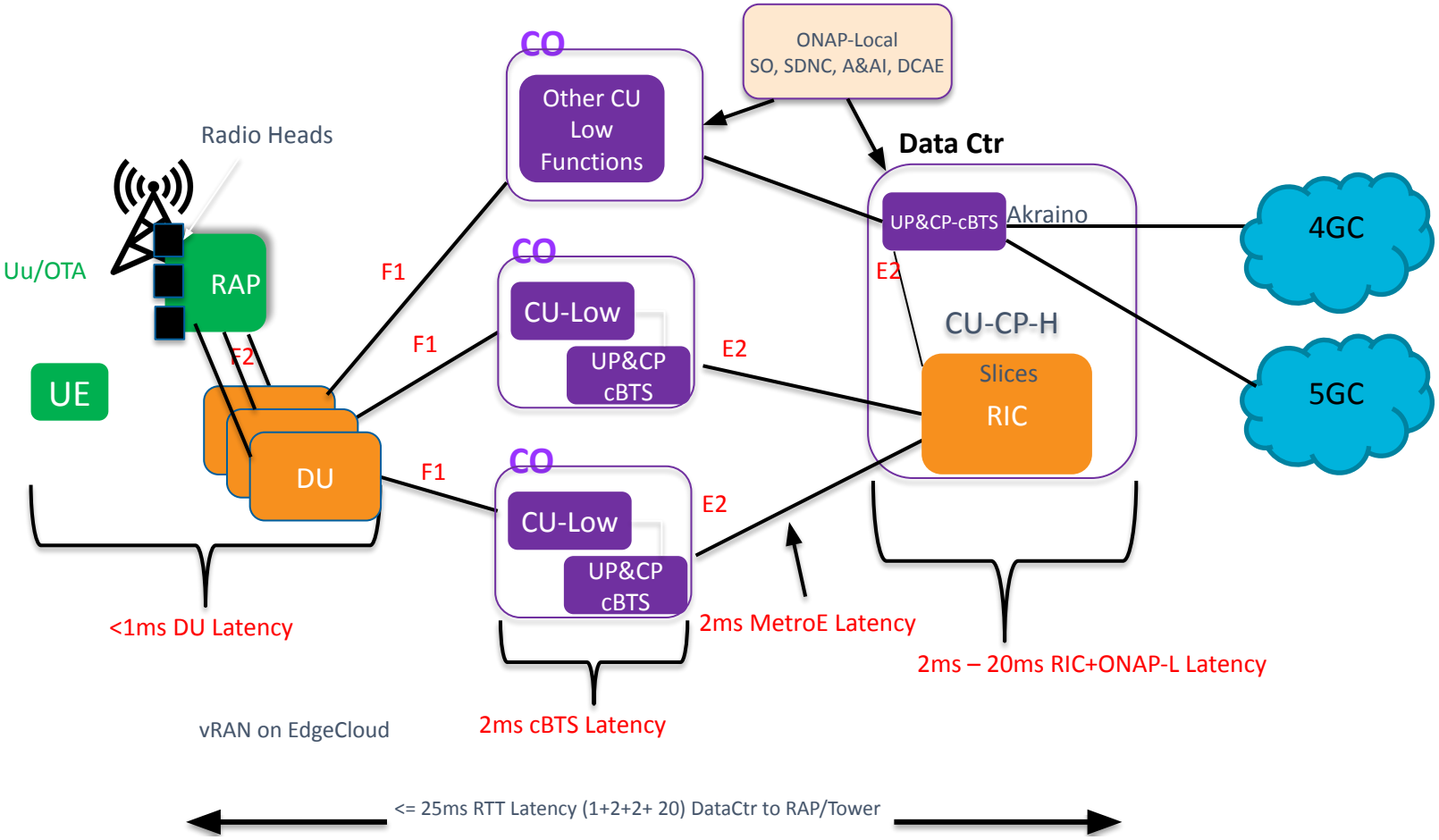
CUPS

- **Control and User Plane Separation (CUPS) architecture and spec completed in TR 23.714 and TS 23.214/23.244.**
- **CUPS enables scaling of UPF by architectural separation of control and user plane functions using Sx.**
  - UPF can be distributed and deployed independently from the centralized control plane.
  - This includes on the MEC/REC and the Far Edge (Cloud).

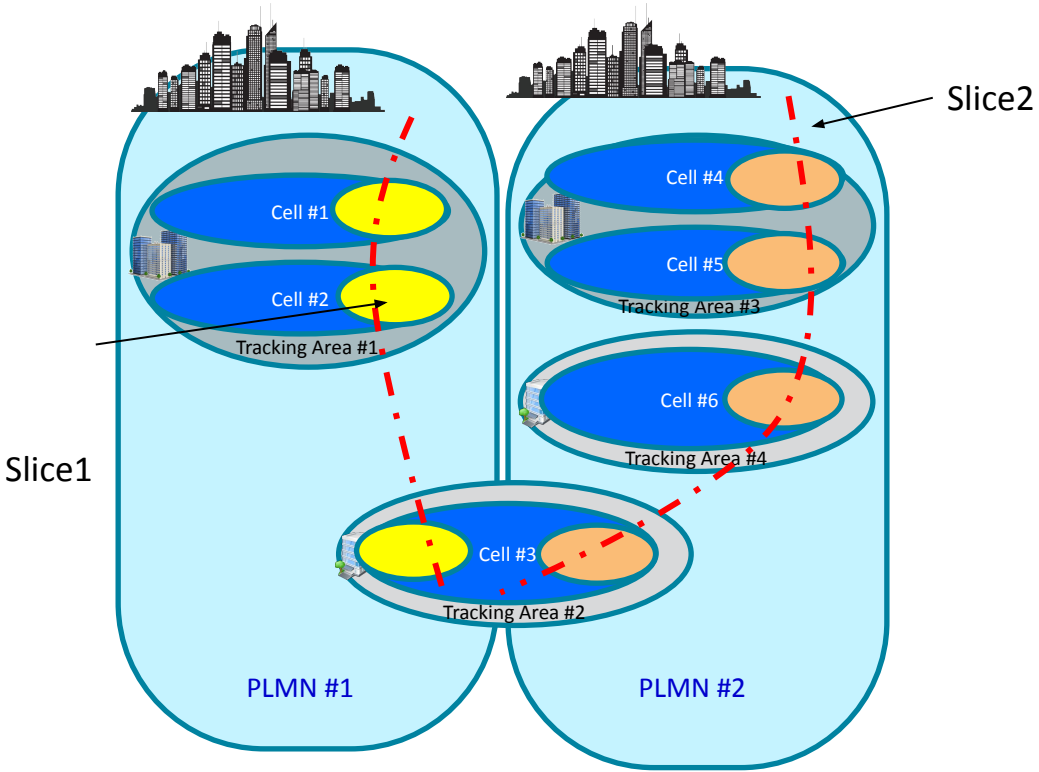
Edge Distribution of NFs Based on Service Slices



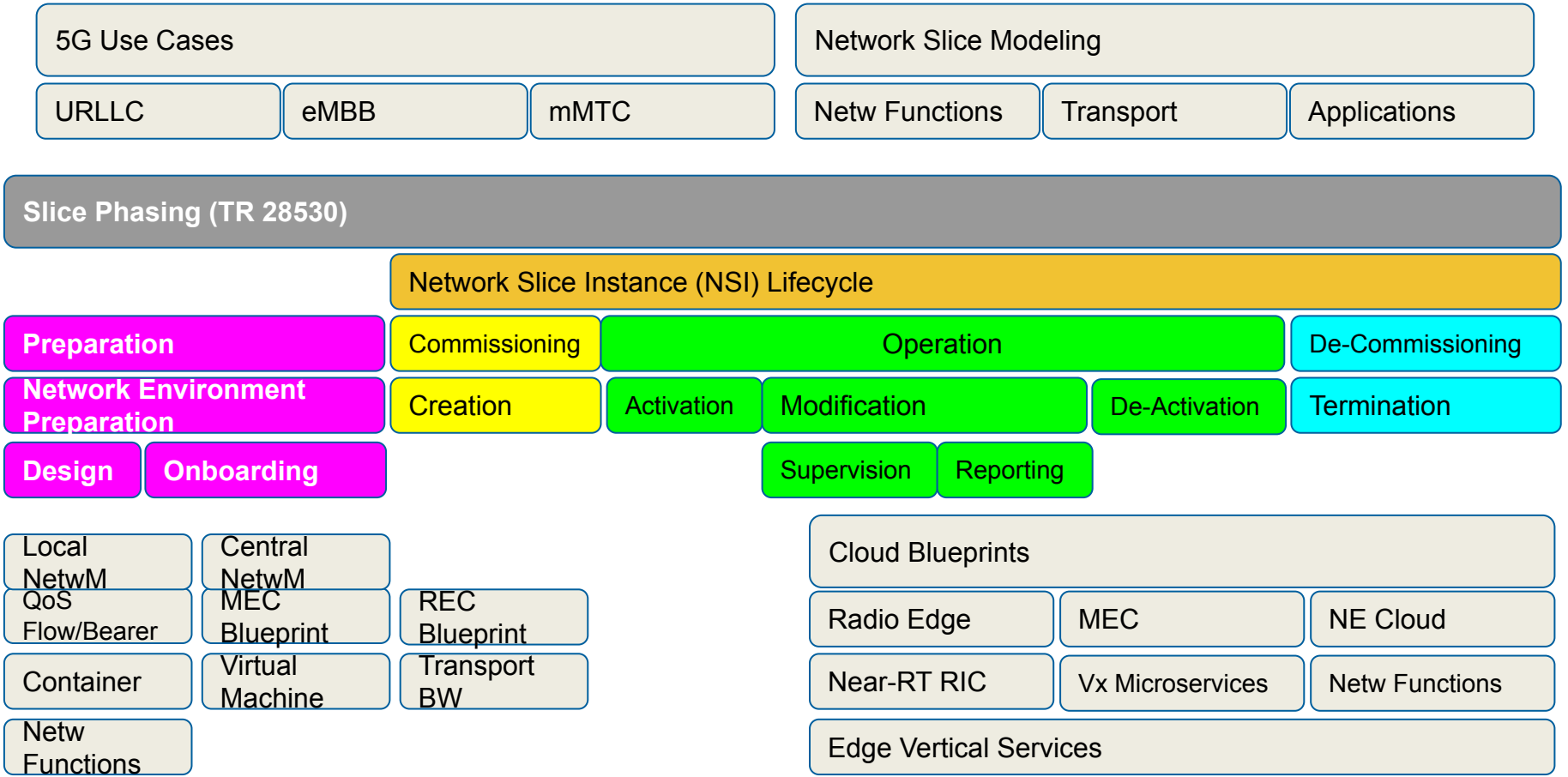
e/gNb Dis-aggregation with Latency Optimization

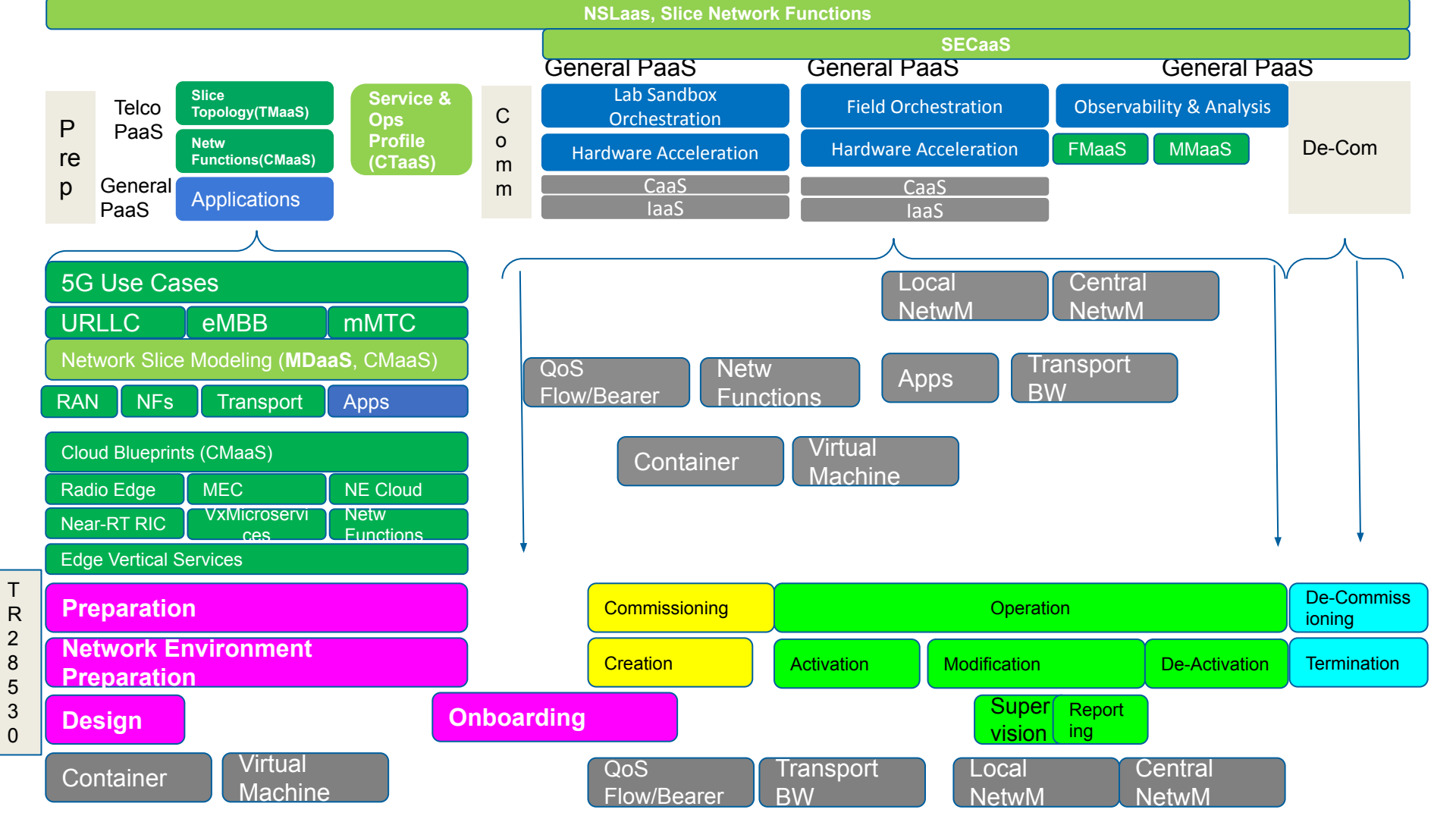


From AT&T RAN-Slicing POC using ONAP



Hi Level Platform Requirements




NSLaas, Slice Network Functions
SECaaS
General PaaS
General PaaS
General PaaS
Prep
Telco PaaS
General PaaS
Slice Topology(TMaaS)
Netw Functions(CMaaS)
Applications
Service & Ops Profile (CTaaS)
Comm
Lab Sandbox Orchestration
Hardware Acceleration
CaaS
IaaS
Field Orchestration
Hardware Acceleration
CaaS
IaaS
Observability & Analysis
FMaaS
MMaaS
De-Com
5G Use Cases
URLLC
eMBB
mMTC
Network Slice Modeling (MDaaS, CMaaS)
RAN
NFs
Transport
Apps
Cloud Blueprints (CMaaS)
Radio Edge
MEC
NE Cloud
Near-RT RIC
VxMicroservices
Netw Functions
Edge Vertical Services
Local NetwM
Central NetwM
QoS Flow/Bearer
Netw Functions
Apps
Transport BW
Container
Virtual Machine
TR28530
Preparation
Network Environment Preparation
Design
Container
Virtual Machine
Onboarding
QoS Flow/Bearer
Transport BW
Local NetwM
Central NetwM
Commissioning
Operation
De-Commissioning
Creation
Activation
Modification
De-Activation
Termination
Supervision
Reporting

Thank you

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