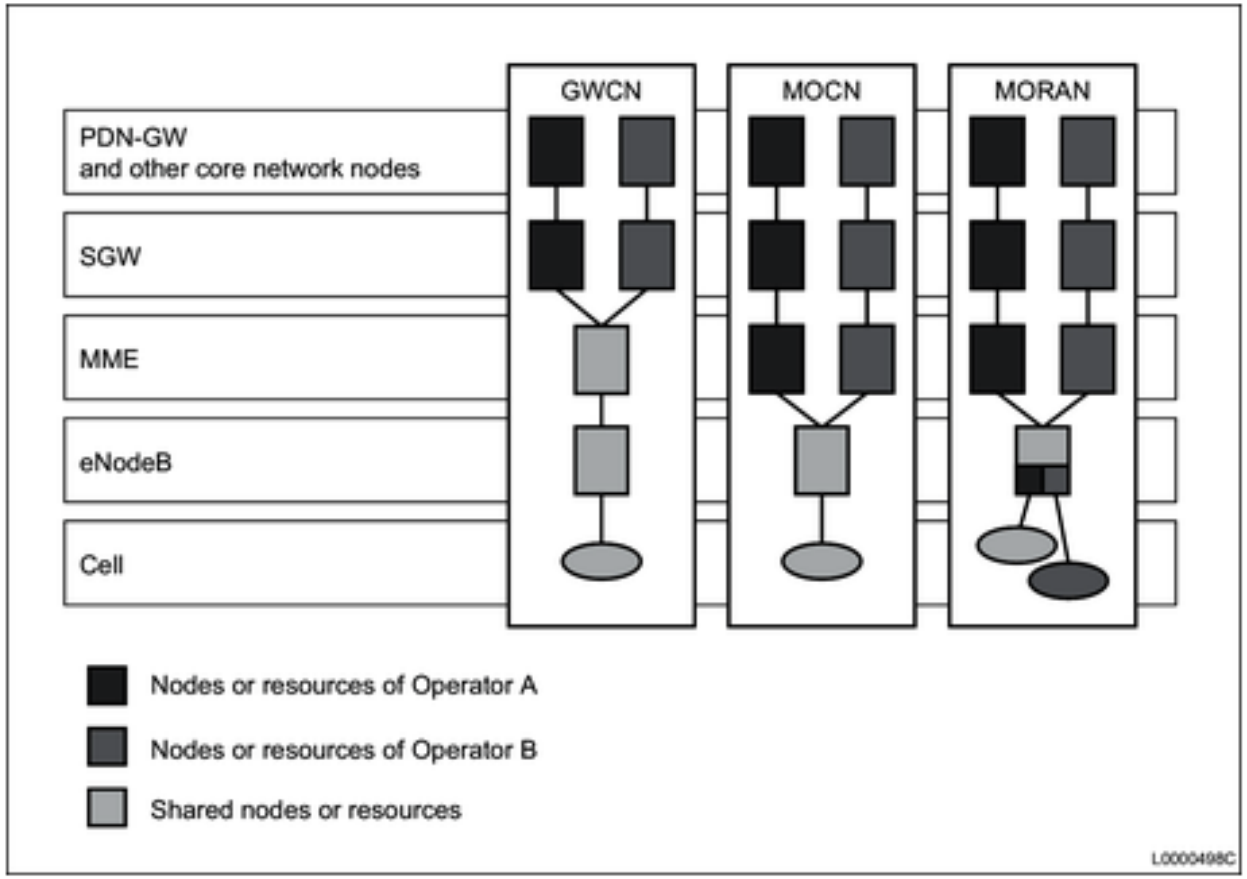
NETWORK SHARING AND SLICING FOR RAILWAY

David Rothbaum –March 2018

NETWORK SLICING VS NETWORK SHARING

- Network Slice is defined within a PLMN but can be roamed to another PLMN.
- Network sharing is performed among different PLMNs sharing common RAN.
- In case of network sharing, each PLMN sharing the NG-RAN defines and supports its PLMN-specific set of slices that are supported by the common NG-RAN.

NETWORK SHARING 4G RAN ARCHITECTURES

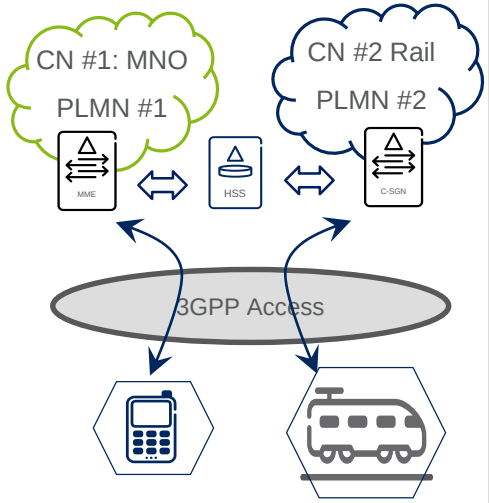


4G RADIO SLICING TECHNIQUES

- Radio Resource Partitioning (using RRC special schedule based on UE SPID)
- QCI prioritizations within a partition
- ARP

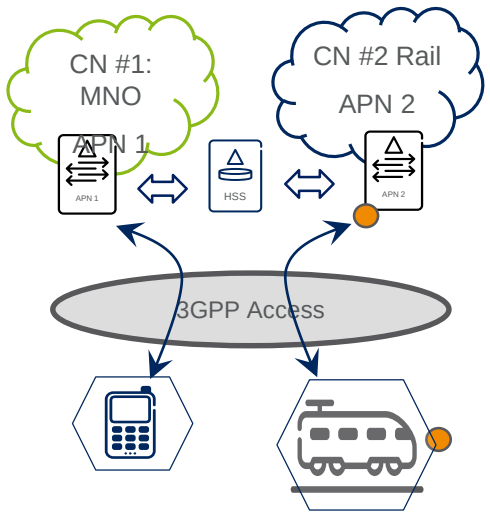
SLICE SELECTION MECHANISMS

PLMN



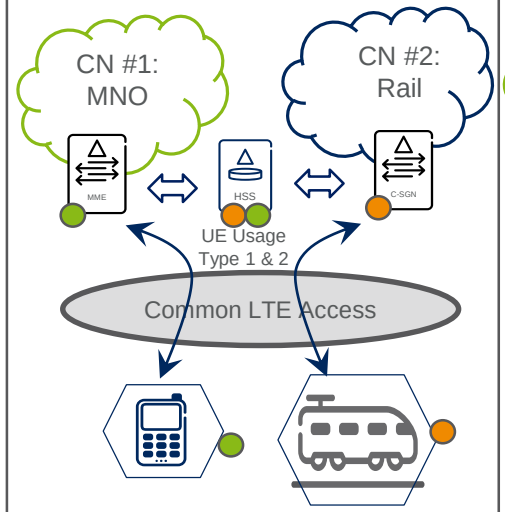
- CN selection by RAN using PLMN ID's
- Requires RAN and Core support
- All device types supported

APN



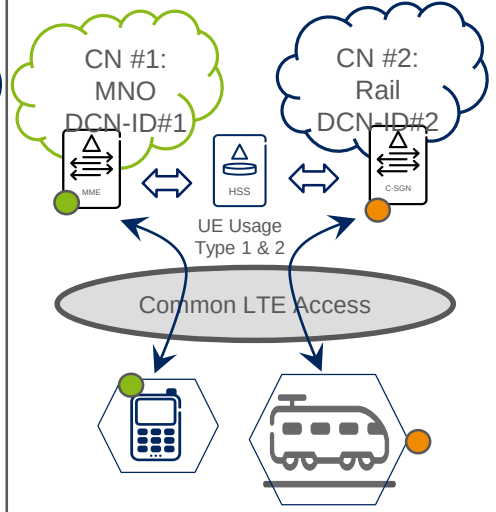
- Separate APNs for isolating UP sessions
- Requires CN support
- All device types supported

DECOR



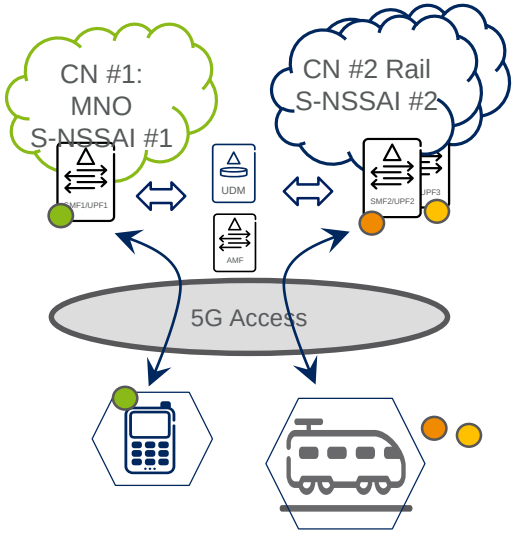
- CN selection using HSS info (UE Usage Type)
- Requires CN and RAN support
- All device types supported

eDECOR



- CN selection by RAN using UE info (DCN-ID)
- Requires UE, CN and RAN support
- Enhancement of DECOR - backward compatible

5G Slicing



- Slice selection based on UE info (S-NSSAI)
- Requires UE, CN and RAN support
- E2E slicing (RAN slice aware)
- Connectivity to multiple slices simultaneously

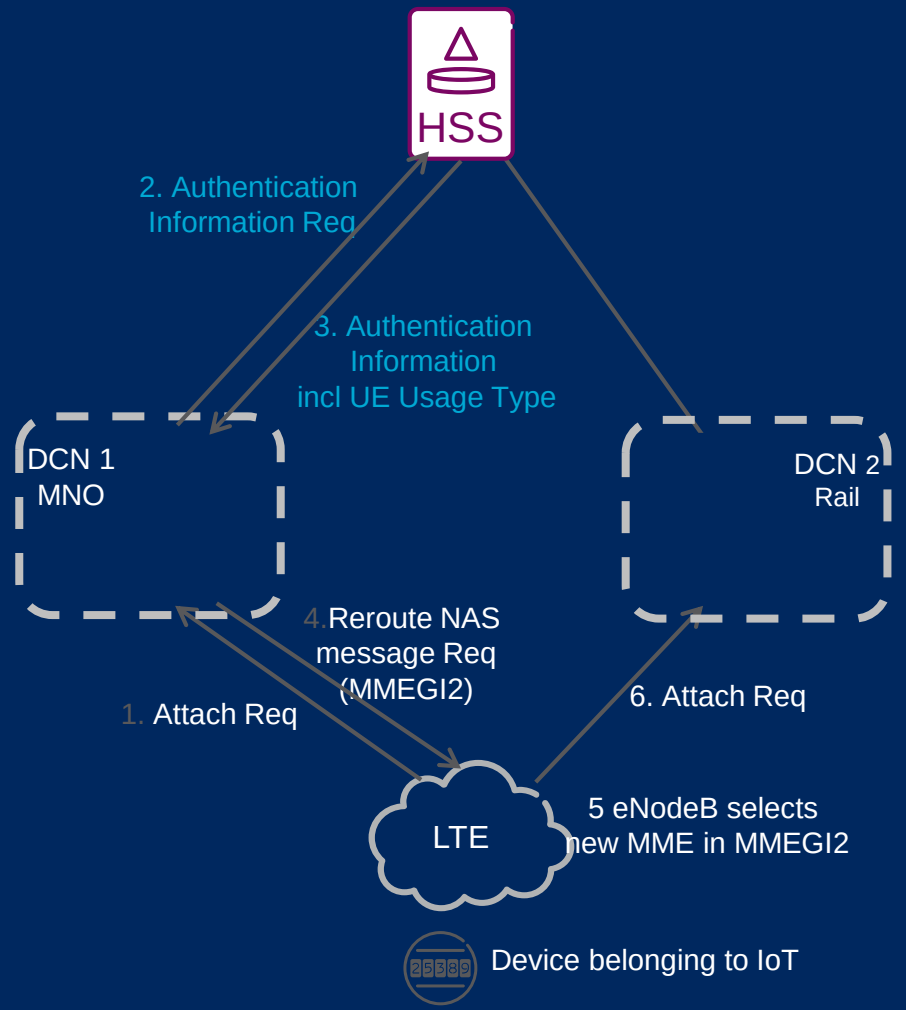
DEDICATED CORE NETWORKS (DECOR) –

› Based on UE Usage Type(UUT) in subscription data, MME redirects the UE to a Dedicated Core Network (DCN) via Attach, TAU and HO procedures

› DCN is reselected when UUT is changed or MME configuration is changed, causing UE cannot be served by the current DCN

Benefit

› Enables **multiple Core Network Segments in one PLMN**, for operator services differentiation. e.g., Rail, MVNO and enterprises.

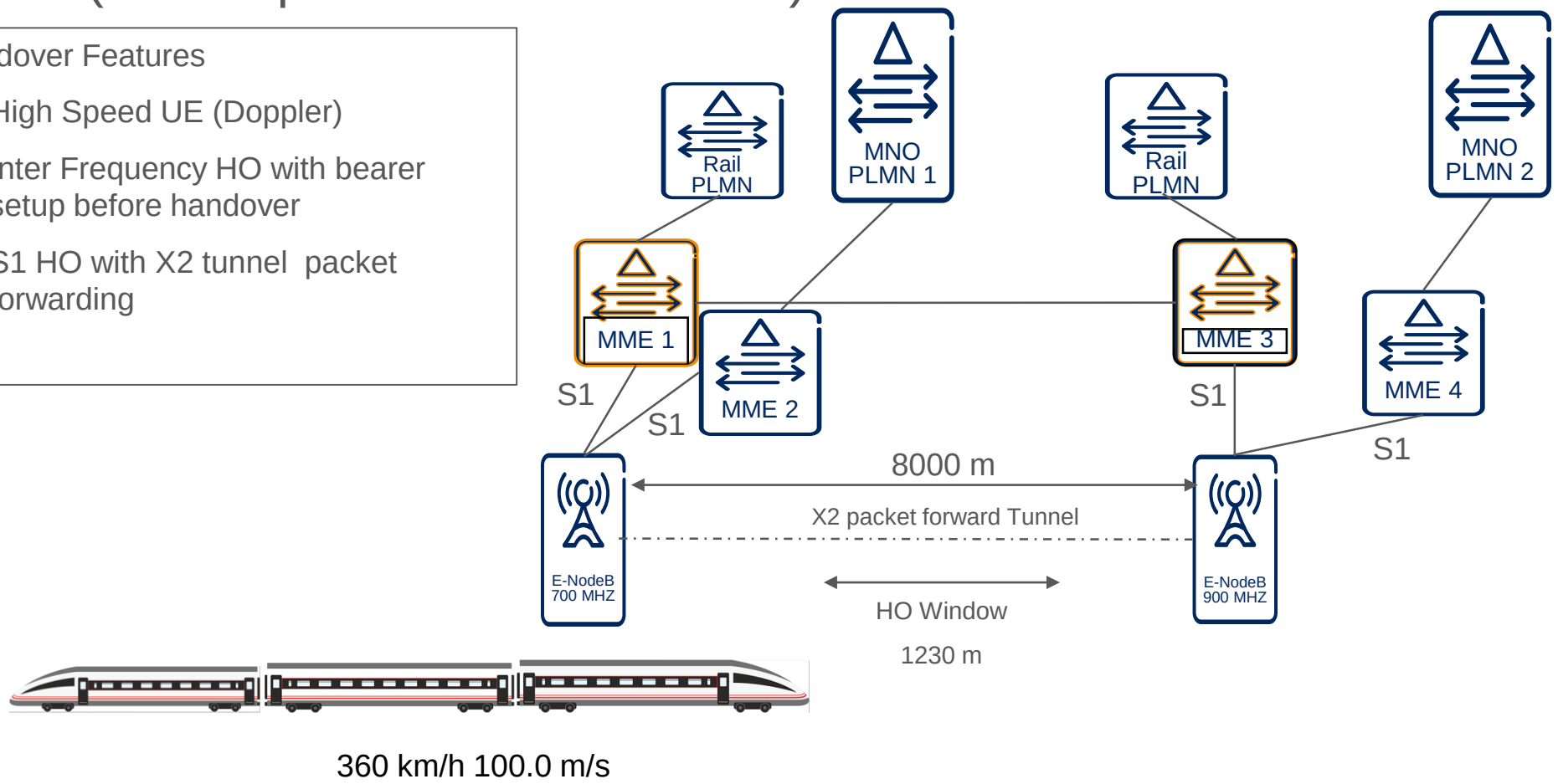


NETWORK SHARING HIGH SPEED HANDOVER

› MOCN (Multi-Operator Core Network)

Handover Features

- High Speed UE (Doppler)
- Inter Frequency HO with bearer setup before handover
- S1 HO with X2 tunnel packet forwarding



HIGH SPEED HANDOFF

- High Speed UE feature compensates for Doppler Shift of up to 1000 Hz
- The LTE standard considers speeds of up to 500km/h. At a carrier frequency of 2GHz, this speed represents a maximum Doppler shift of fdmax~ 950Hz
- See TR 36.878 Study on performance enhancements for high speed scenario in LTE (Release 13)
- Validated in Band 40 at 360 km/h

Ericsson tests LTE in extreme conditions

Nov 1, 2012

#LTE, #mobilebroadband, #4G, #radiobasestations, #radio, #radioaccessnetwork

What happens with an internet connection via LTE/4G on board of a jet plane flying 700km/h? Ericsson's tests reveal that 4G is robust enough to handle extreme situations.

4G is the fastest developing system in the history of mobile communication. Today's LTE networks are capable of providing speeds of over 100Mbps.

Consumers in high-speed trains around the world need reliable 4G connections without any interruptions and Ericsson needs to make sure its network equipment supports this requirement. This was the inspiration for tests that went above and beyond anything Ericsson has done before.

"We tested a high-speed 4G connection using an aircraft flying fast at low altitude.", said Ola Melander, Master Project Manager for R&D at Ericsson.

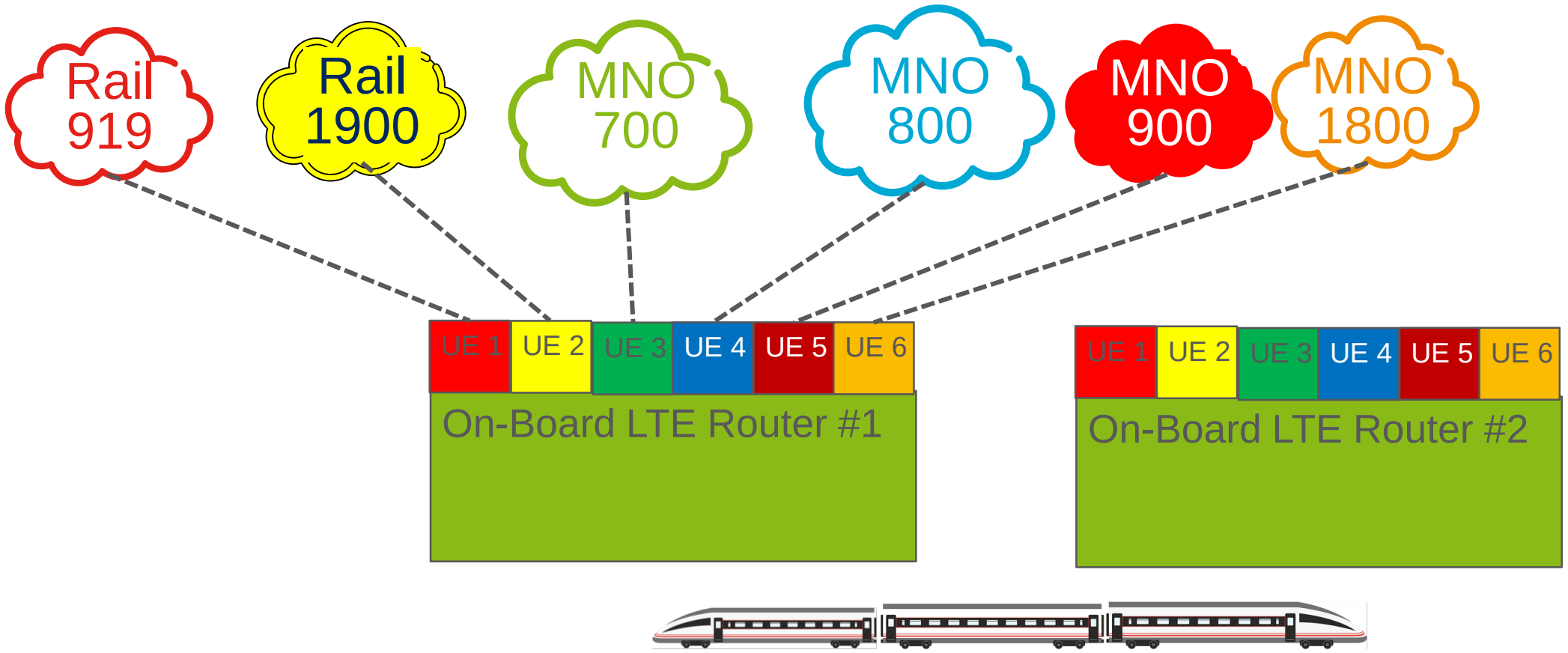
"We continuously evaluate our systems and this was a good opportunity to test a 4G network in Sweden. The commercial network used for the tests was not altered for extreme mobility testing. Our radio and core network products proved to be robust and it was very interesting to see how well these performed."

For the tests, a routine flight with a training jet from Saab Aeronautics carrying two Ericsson engineers with PCs fitted with LTE dongles, took off in Linköping, Sweden. While flying over Västervik at 300 meters above ground, measurements were taken to determine the impact of the Doppler effect, handover performance and video stream stability.

The results showed that the PCs were able to connect to the internet with a maximum downlink speed of 19 megabits per second while flying at 700km/h and with the force of 4G.

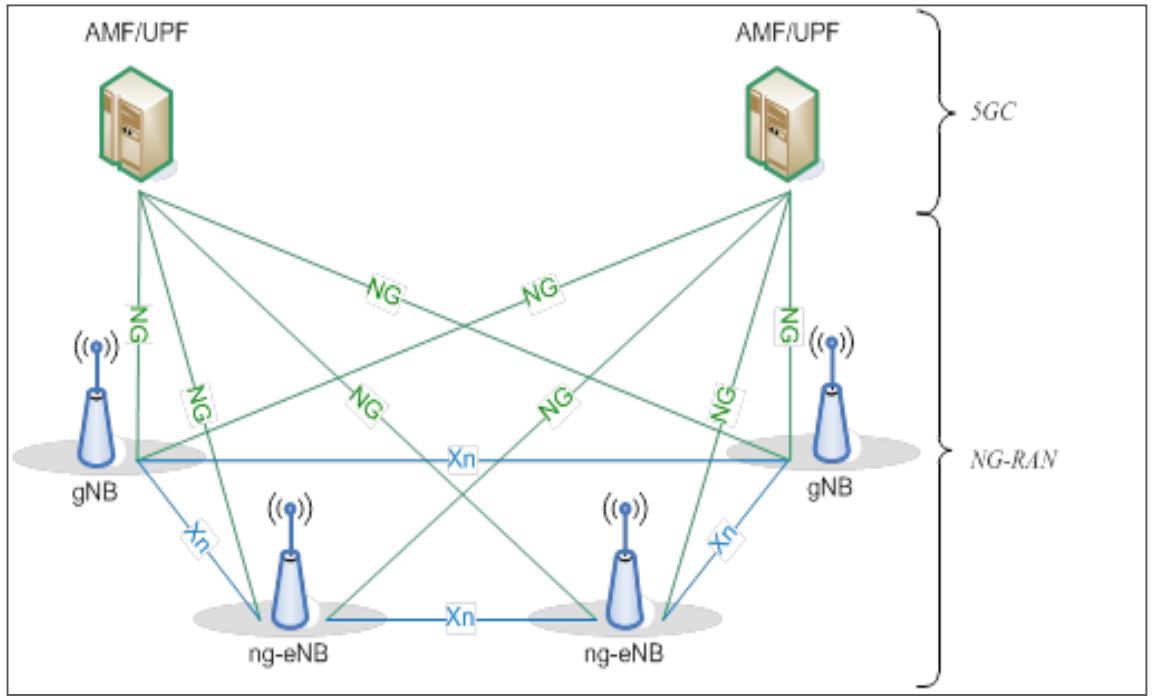
The Doppler effect, which limits how fast the user can move in a straight line to or from the LTE radio base station, was successfully tested and internet connectivity was maintained while flying at more than 600km/h in a straight line toward the LTE radio base station. A seamless handover from one radio base station to the next was possible while flying at a speed of 500km/h, without any visible disturbances to a video stream used to monitor the stability of the internet connection.

MULTI UE ON-BOARD GW



Mission Critical Rail Services use multiple parallel connections

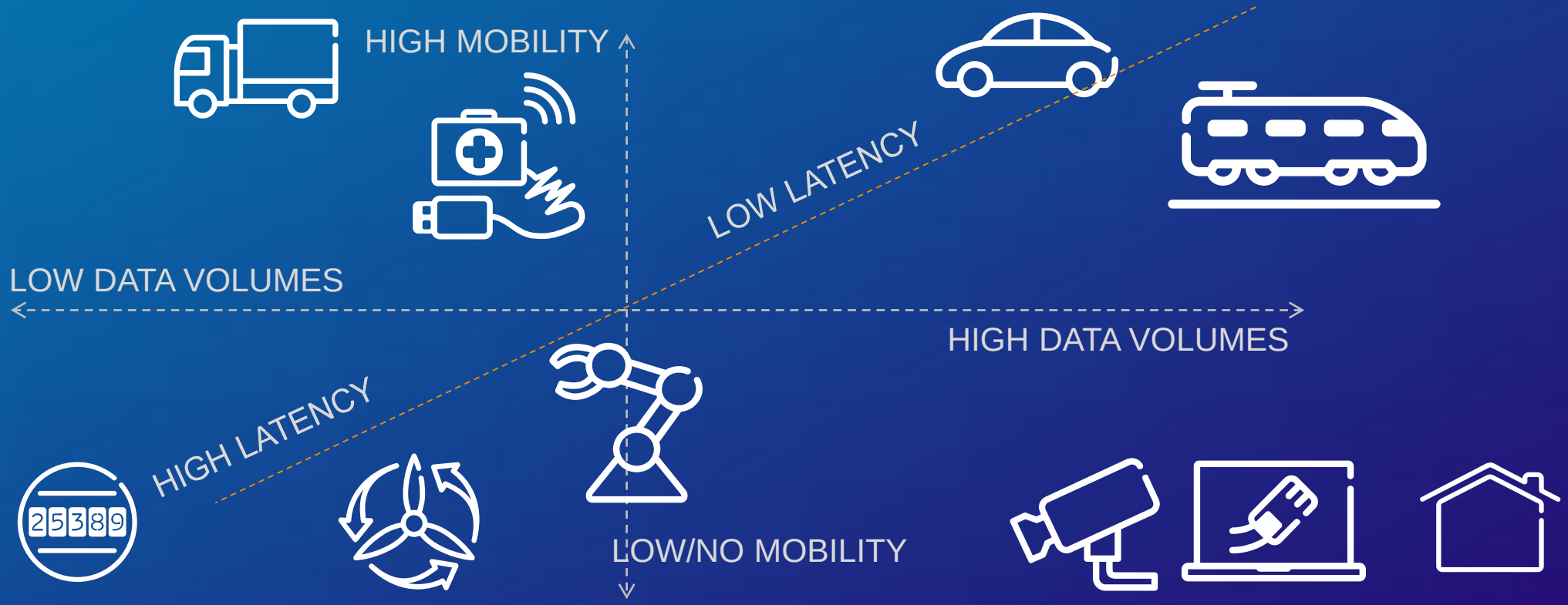
NG-RAN (5G) SUPPORTING E-UTRA



- gNB provides NR user plane and control plane protocol terminations towards the UE
- ng-eNB, provides E-UTRA user plane and control plane protocol terminations towards the UE.

NETWORK SLICING: THE BASIS

Due to large span of use case characteristics

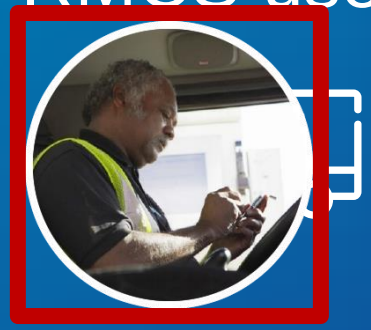


10-100X	10X	5X	10-100X	1000X
Connected Devices	Battery Life	Lower Latency	End-user Data Rates	Mobile Data Volumes

NETWORK SLICING FOR RAIL

Mapping FRMCS use case characteristics

Train Health Monitoring



Mission Critical Push to Talk

HIGH MOBILITY

Train Control

LOW DATA VOLUMES

Passenger Surveillance

HIGH DATA VOLUMES

Virtual Coupling

Wayside Monitoring

HIGH LATENCY

LOW/NO MOBILITY

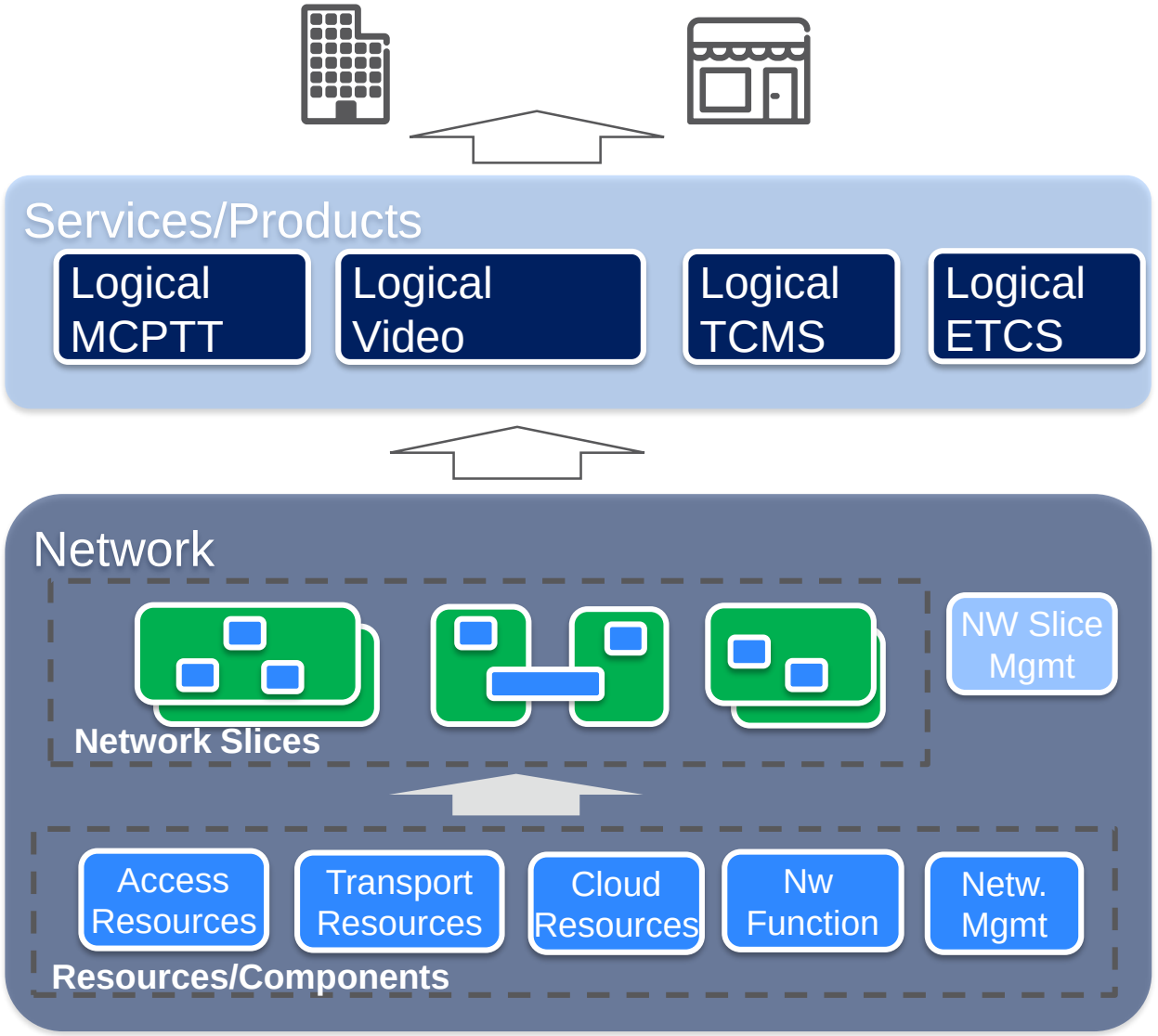
Remote Control Shunting

Platform Monitor

10-100X	10X	5X	10-100X	1000X
Connected Devices	Battery Life	Lower Latency	End-user Data Rates	Mobile Data Volumes

NETWORK SLICE DEFINITION

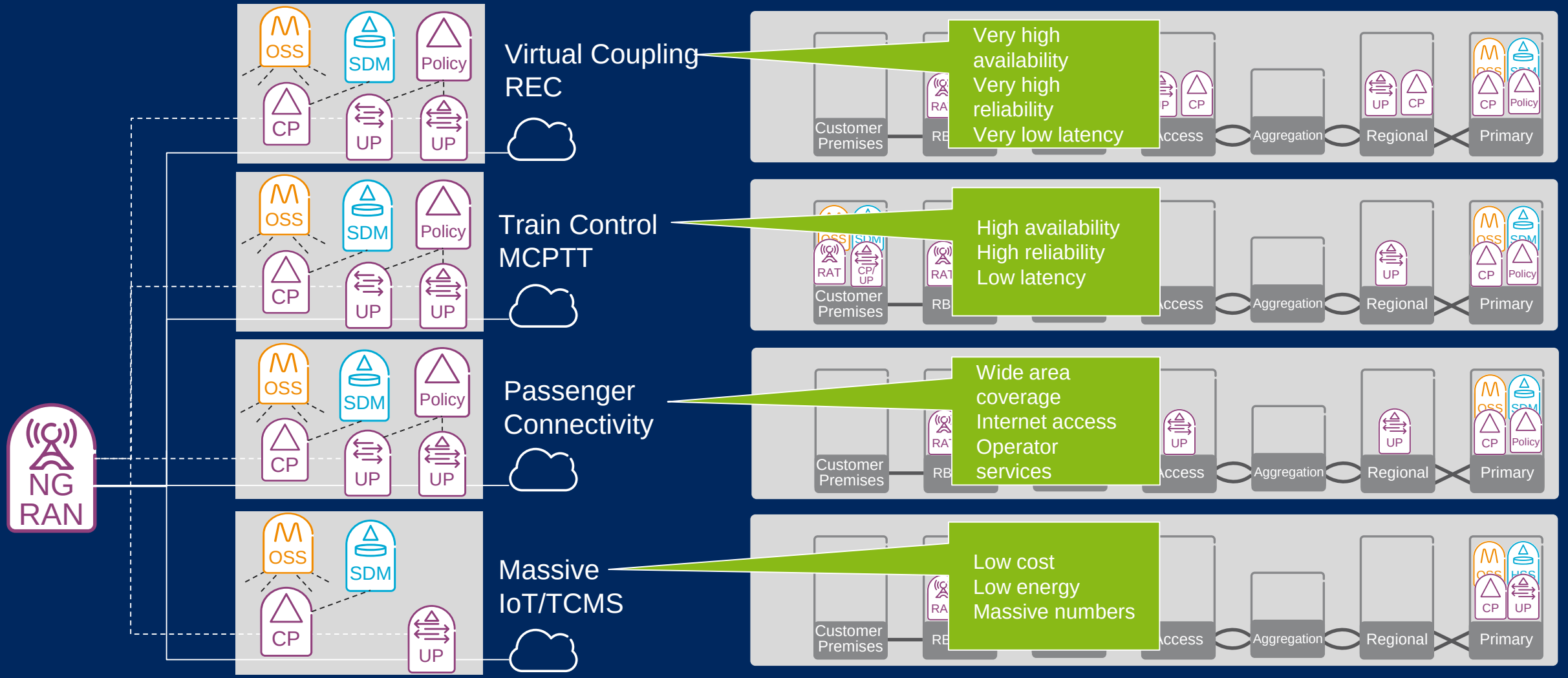
One Network – Multiple Industries and Use Cases



Network slice is a **logical network** serving a defined **business purpose**, consisting of **all** required network resources **configured** together. It is created, changed and removed by management functions.

- "End to end" within a provider
- Enabler for services, not a service
- Mobile and fixed
- Resources may be physical or virtual, dedicated or shared
- Independent/"Isolated" but may share resources
- May integrate services from other providers, facilitating e.g. aggregation and roaming

NETWORK SLICING – RAIL EXAMPLES



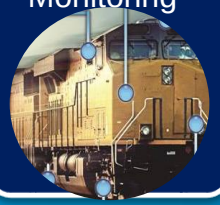
RAILWAY NETWORK SLICES

Train Health Monitoring

Passenger Services

Video

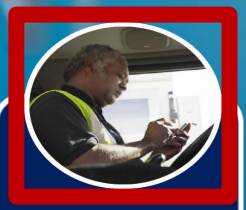
Wayside Monitoring



Train Health Monitoring

Wayside and On-Board IOT sensors

Enhanced MBB



Mission Critical Push to Talk

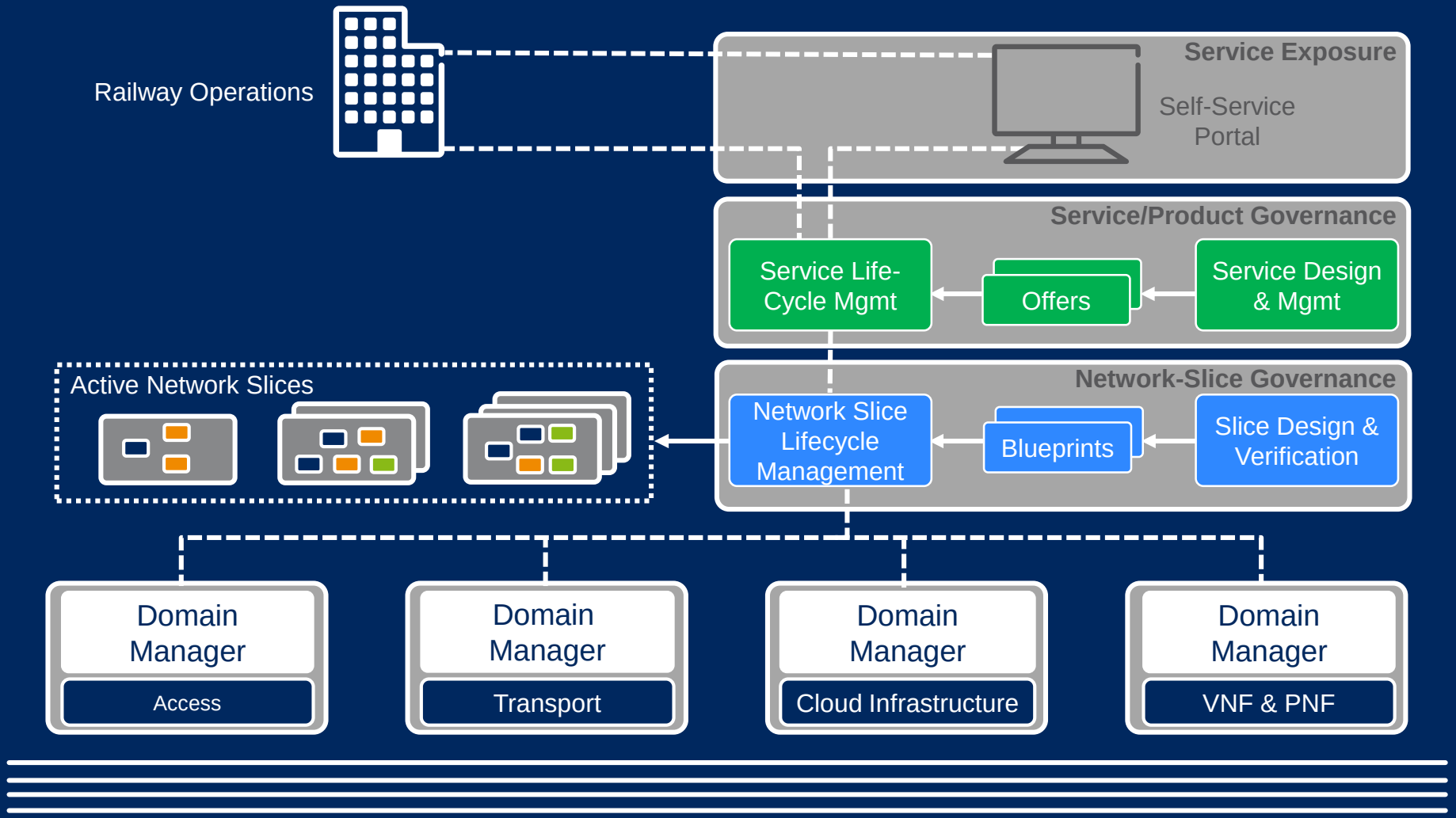
Train Control

Automatic Train Control MCPTT

Passenger Surveillance

Remote Control Shunting

NETWORK SLICE
Life Cycle Management (LCM)



Orchestration based on blue prints

Instantiate NW Slice
Terminate NW Slice
Re Configure NW Slice
Full LCM

DATA DRIVEN ORCHESTRATION

Network Slice Blueprints:

- Mobile Broadband
- Train Control
- MCPTT
- Passenger Surveillance
- Massive Sensors/Actuator
- ……
- ……
- ……
- ……

Network Slice Resources

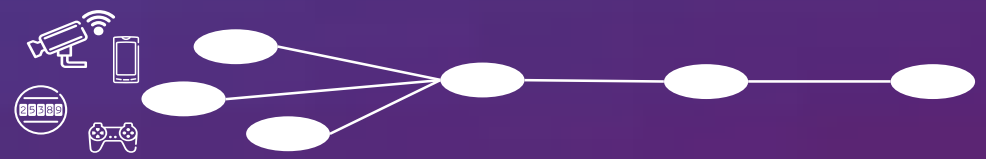
- Access
- Nw Function
- OSS/BSS
- Transport
- Cloud

Whole Sale Customer

- Service n
- Virtual Coupling
- Sensors
- MCPTT + Train Control
- Video
- Passenger Connectivity

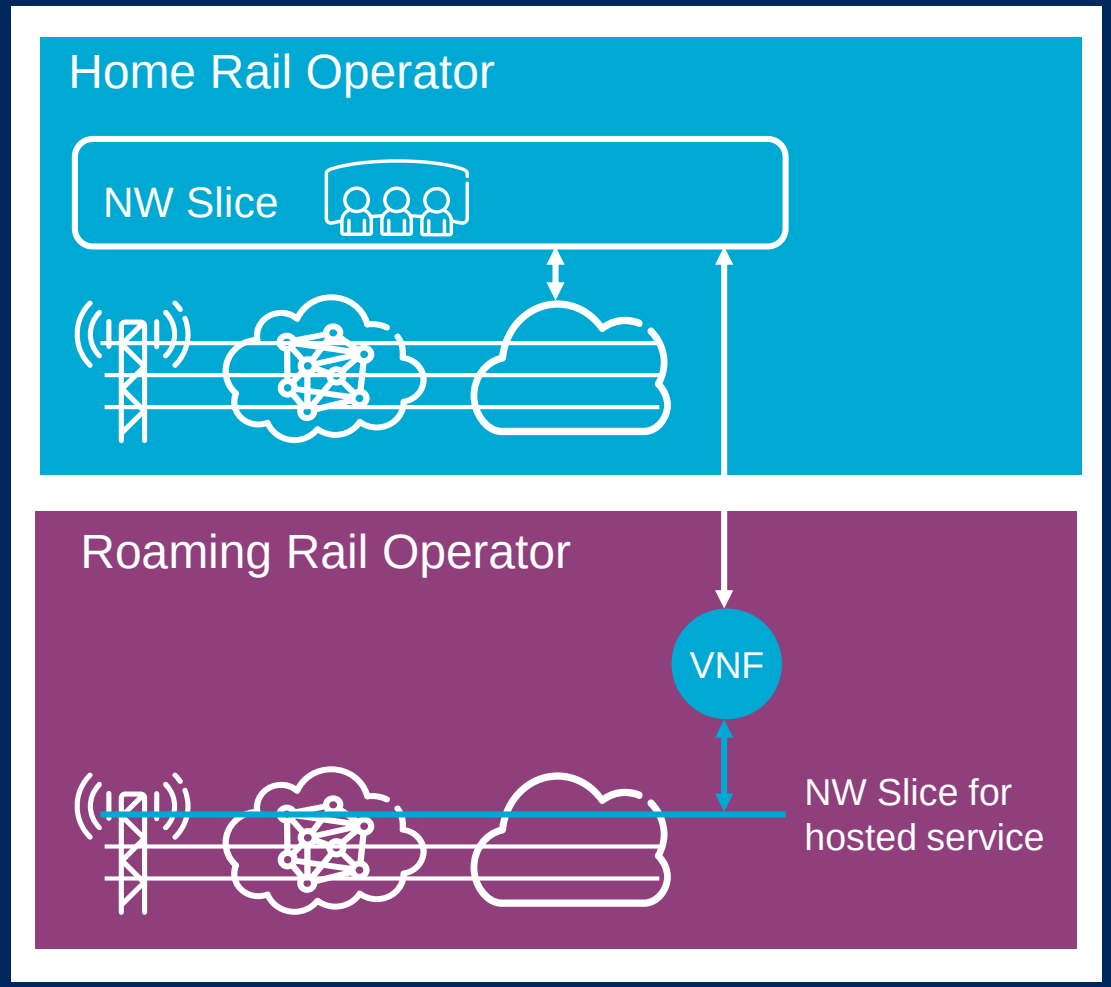
Network Slices

Physical Resources

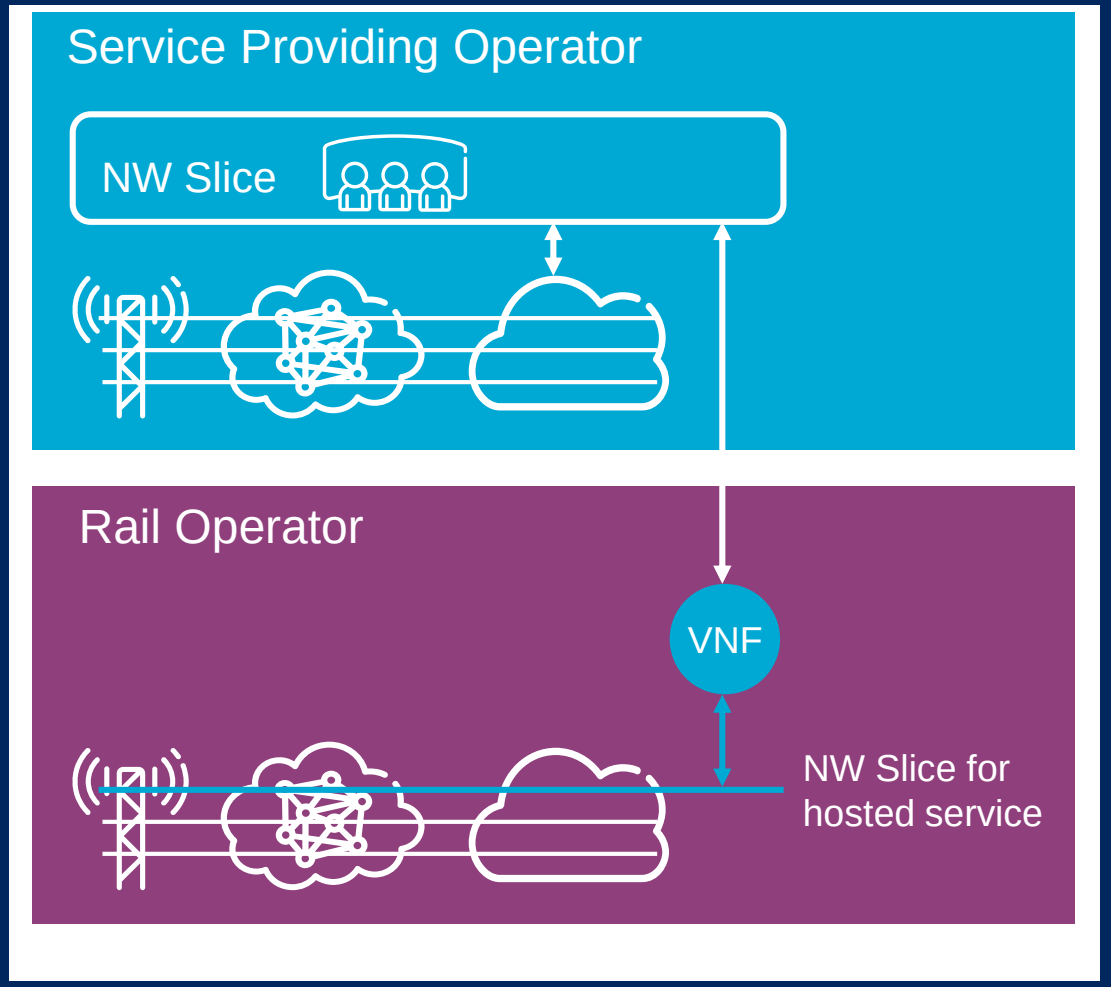


5G FEDERATED NETWORK SLICING

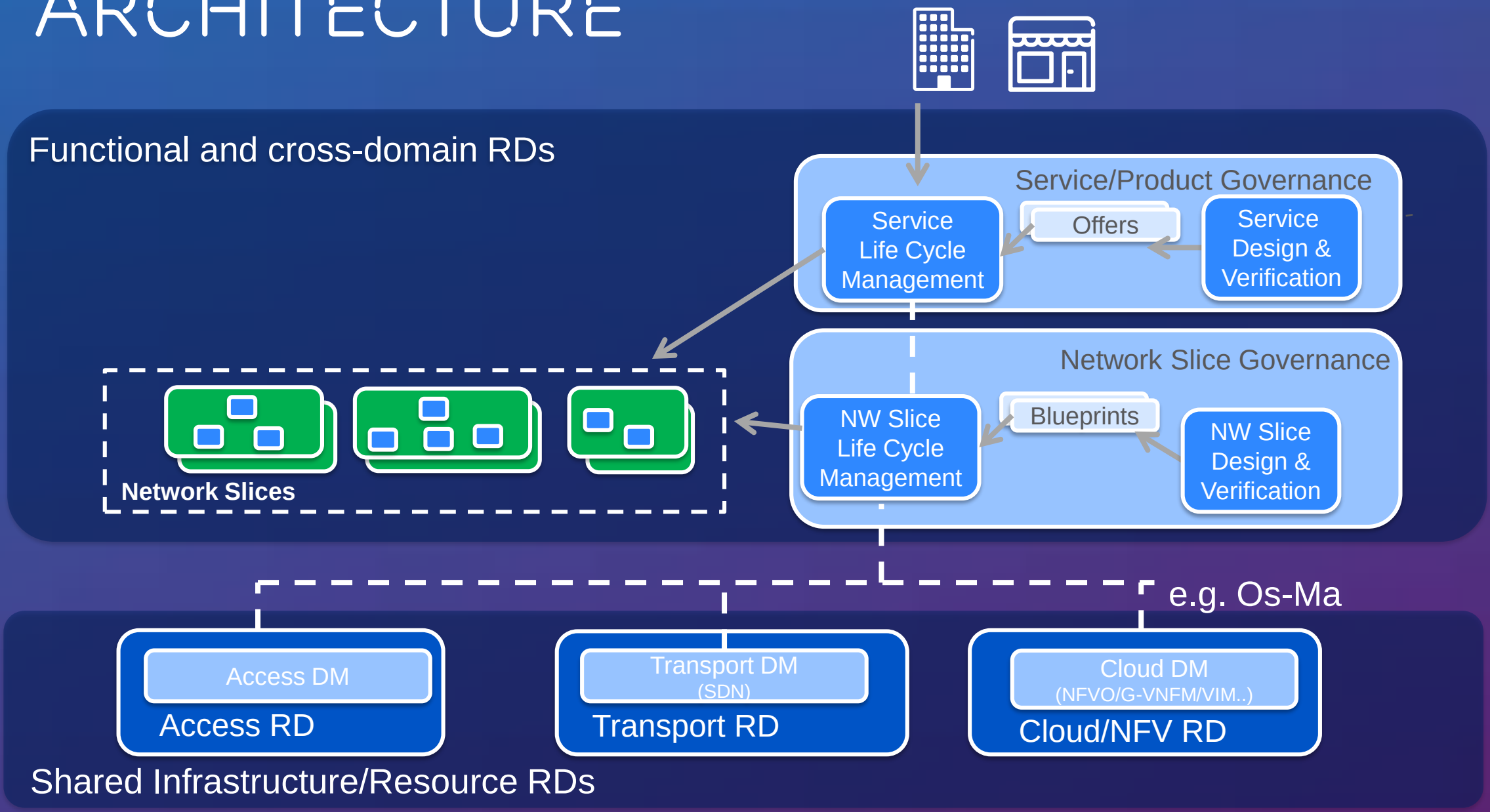
Federation of Home and Roaming Rail Networks



Federation of Railway and Roaming MNO Networks

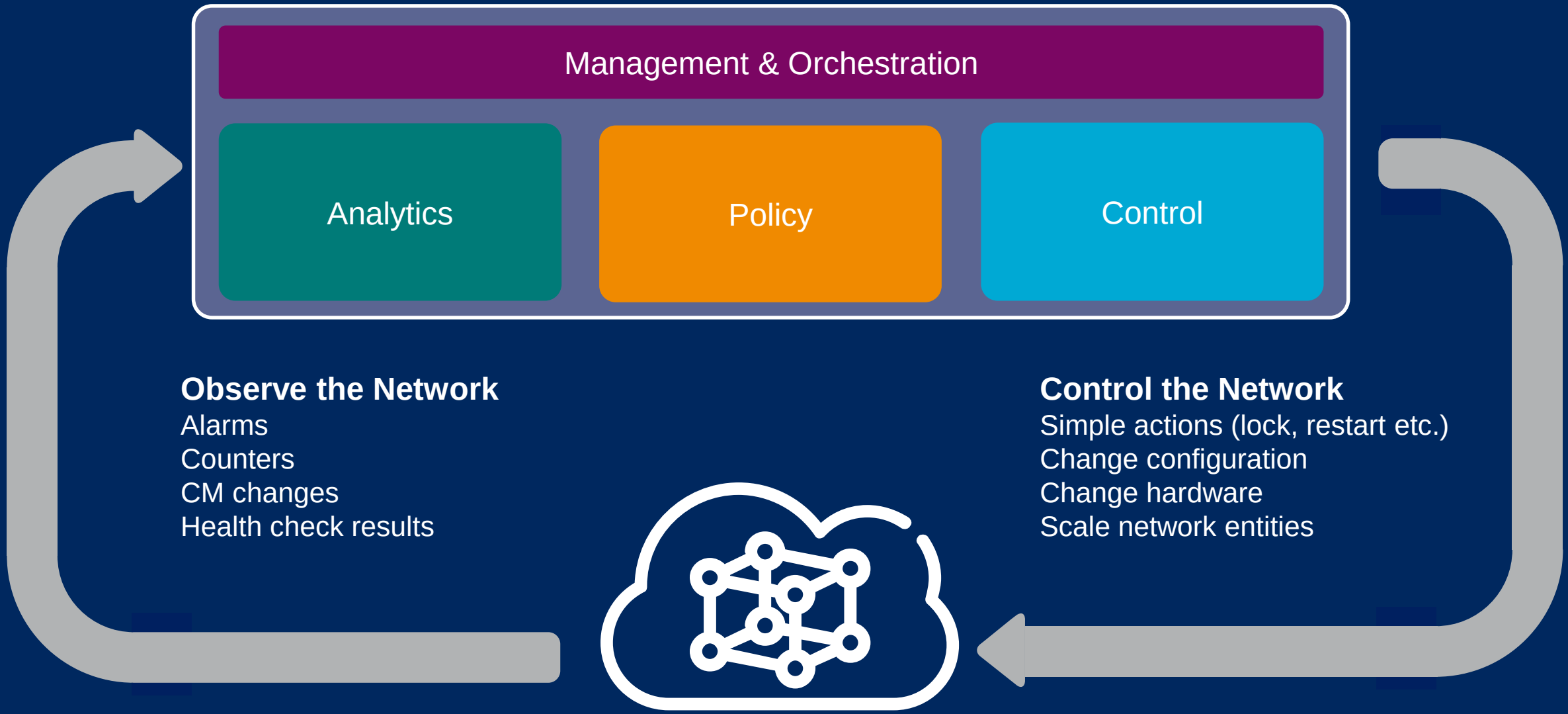


NETWORK SLICING - GOVERNANCE ARCHITECTURE



AUTONOMOUS NETWORKS

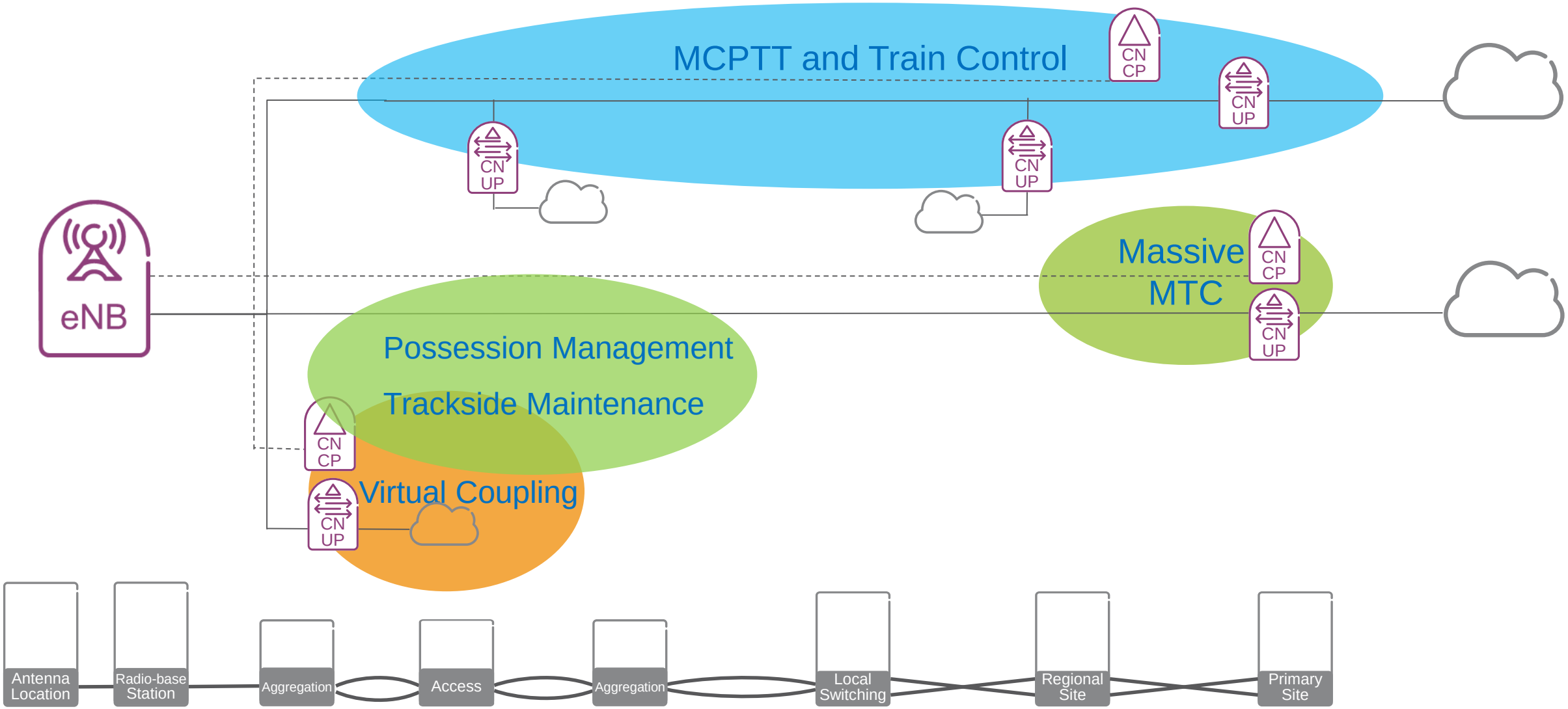
Automation of network management



Observe the Network
Alarms
Counters
CM changes
Health check results

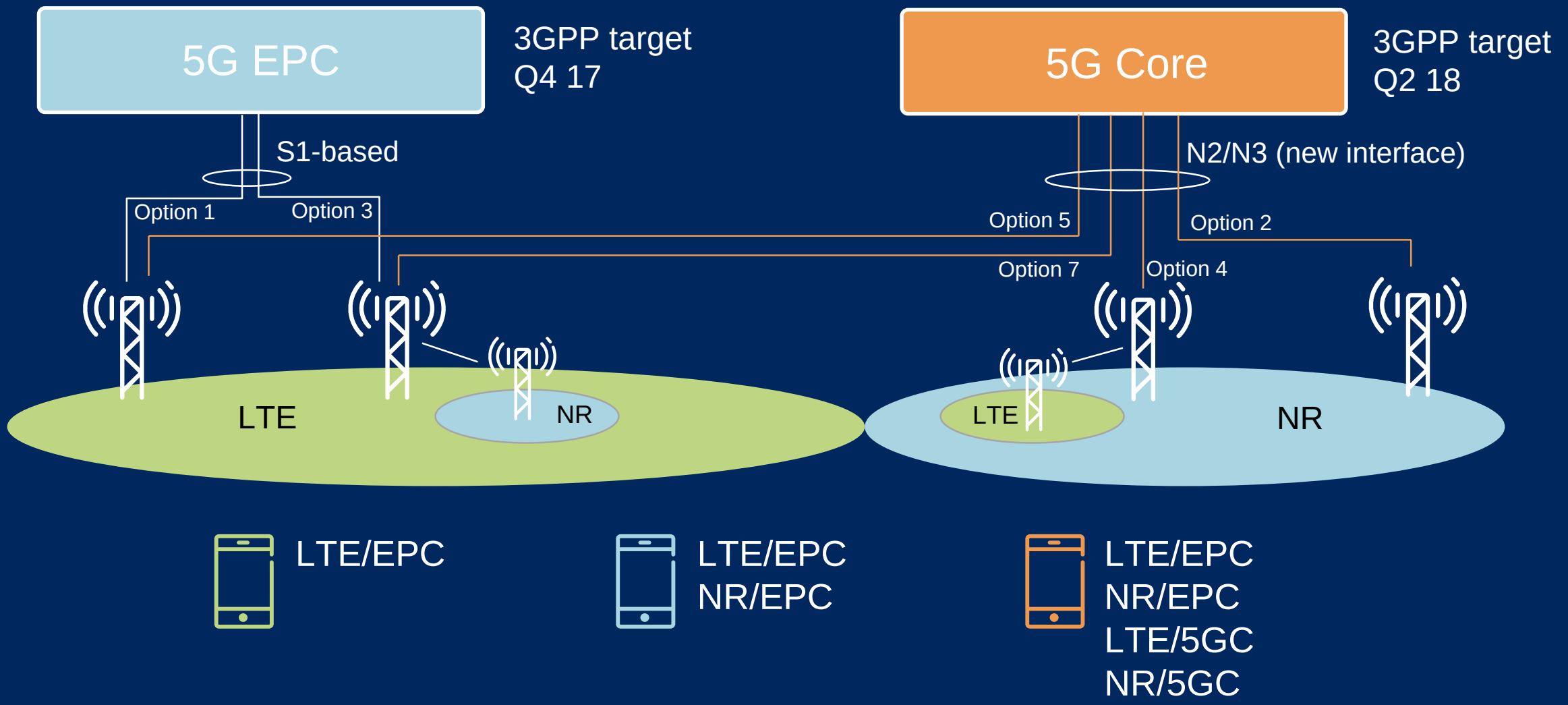
Control the Network
Simple actions (lock, restart etc.)
Change configuration
Change hardware
Scale network entities

DISTRIBUTION OF FUNCTIONALITY

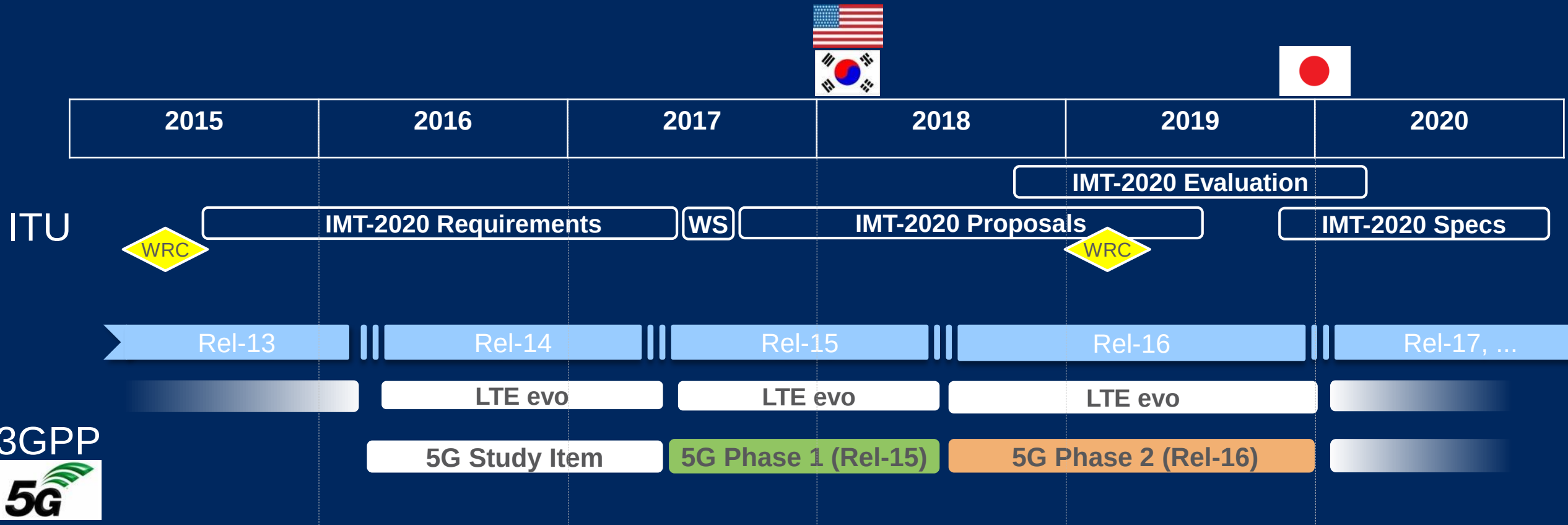


5G RAN-CN CONNECTIVITY OPTIONS

Two architecture tracks in 3GPP rel15



5G STANDARDS PLAN



Non Standalone 5G-NR
LTE as Control Plane anchor - Option 3
Stage 3 Dec. 2017
ASN 1 Freeze March 2018

Standalone 5G-NR
Option 2, 4, 5, 7
Stage 3 June 2018
ASN 1 Freeze Sept 2018

Stage 3 Dec 2019
ASN 1 Freeze March 2020

MOVING TO 5G
- TWO DISTINCT AND DIFFERENT CORE ARCHITECTURES

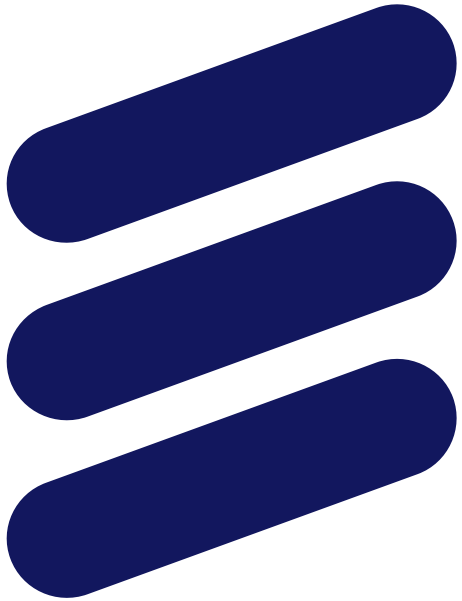
Aspect	5G EPC	5G Core Network (5GC)
Normative 3GPP	From Rel-15	From Rel-15
3GPP Options	Option 3. Option 1 is implicitly supported in the same 5G EPC	Options 2, 4, 5 and 7. Interworking with Option 1 support in 5GC.
Reason for the two different 5G technologies	Accelerated introduction of 5G commercial service	Full, future-looking 5G solution meeting a wide range of expected needs
Architecture	EPC, evolved for 5G access	New, technologically radical
Network functions	EPC, evolved for 5G access	New
Interfaces, protocols, procedures	EPC, evolved for 5G access	New: Service-based CP interworking, http/2 & REST, new QoS, new authentication model etc.
Migration to 5G (principle)	Migrate by adding NR and upgrade existing LTE/EPC	New NR and 5G Core sided by existing LTE/EPC
Main 3GPP specs	23.401, 23.402	23.501, 23.502

3GPP WORK ON NETWORK SLICING

- Release 13 – Dedicated Core Network (DCN) aka DÉCOR
  - DCN selection at ENodeB
- Release 14 – eDECOR –
  - DCN selection at mobile device
- 5G Network Slicing Requirements in TS 22.261
- Network slicing key part of 5G Architecture
  - TS 32.501 System Architecture for the 5G System
  - TS 23.502 Procedures for the 5G System

3GPP WORK ON NETWORK SLICING

- RAN Slicing – TR 38.801 Study on new radio access technology: Radio access architecture and interfaces
- Study on management and orchestration of network slicing for next generation network - TR 28.801
- 5G Management System – TS 28.500



ERICSSON