IEE IEE2620: System Aspects in Communications

Muhammad Mahtab Alam, Professor

Tunniplaan | Tunniplaani kalendrivaade

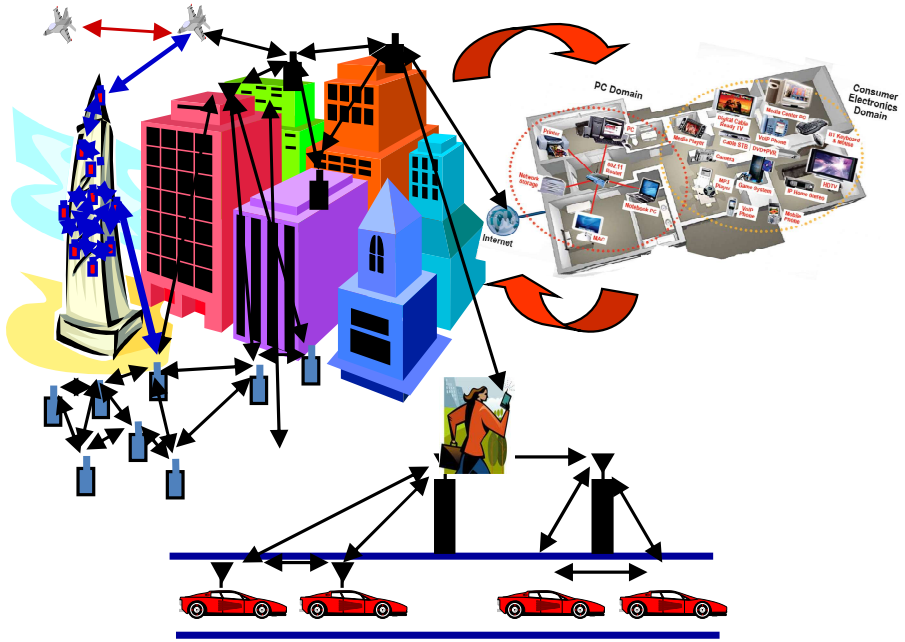
2023/2024 kevad

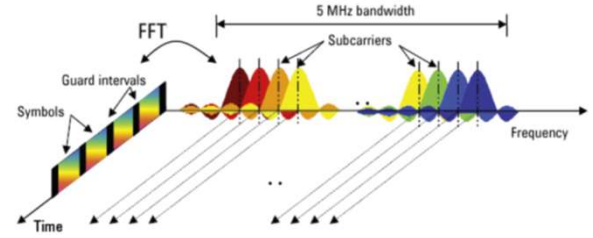
Muhammad Mahtab Alam (1-16. õppenädal)

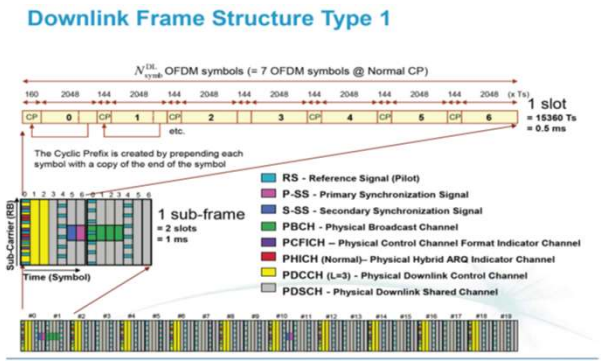
Muu | Paaris | Paaritu | 1 - 16

Kopeeri URL | Ekspordi iCalendar fail | Nädal | Semester

Aeg	Õppeaine	Keel	Kohustuslik / Valik / Vaba	Tüüp	Õppejõud	Ruum	Õppenädalad	Rühmad	Ainekava	Kommentaar
Esmaspäev										
12:00 - 13:30	IEE2620 - Süsteemiaspektid sides	Eesti keel	valik	loeng	Muhammad Mahtab Alam (täisprofessor tenuuris)	Distantsõpe SOC-218	1-16	IAVM21	Vaata	







What do I get from NR ?

Native support for **Low Latency and Ultra Reliability**

Flexible and modular RAN architecture: split fronthaul, split control- and user-planes

Native end-to-end support for **Network Slicing**

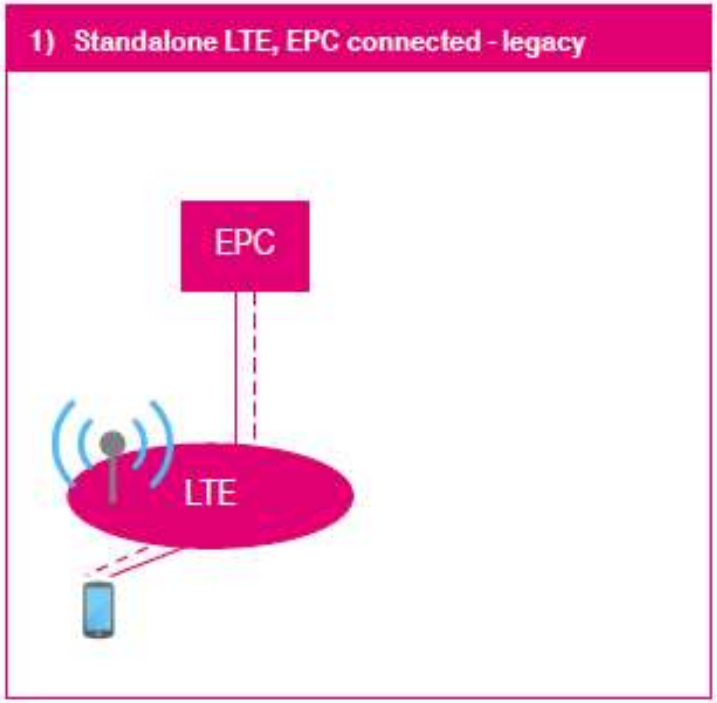
Is 5G just NR ?

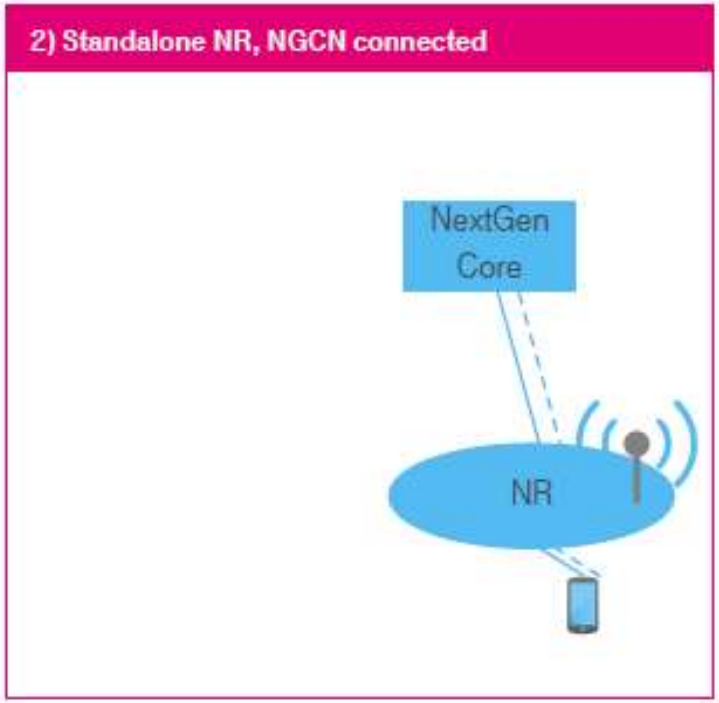
No. To realize the full potential of what NR can offer, the core network needs to evolve from the Enhanced Packet Core (EPS) of 4G to the Next Generation Core Network (NGCN) of 5G.

- So what does the (simplified) 

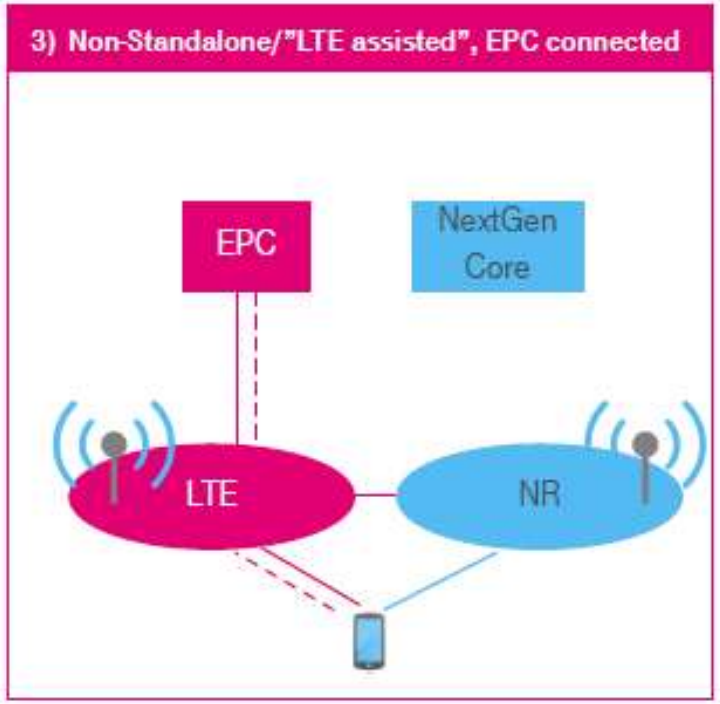
architecture look like?

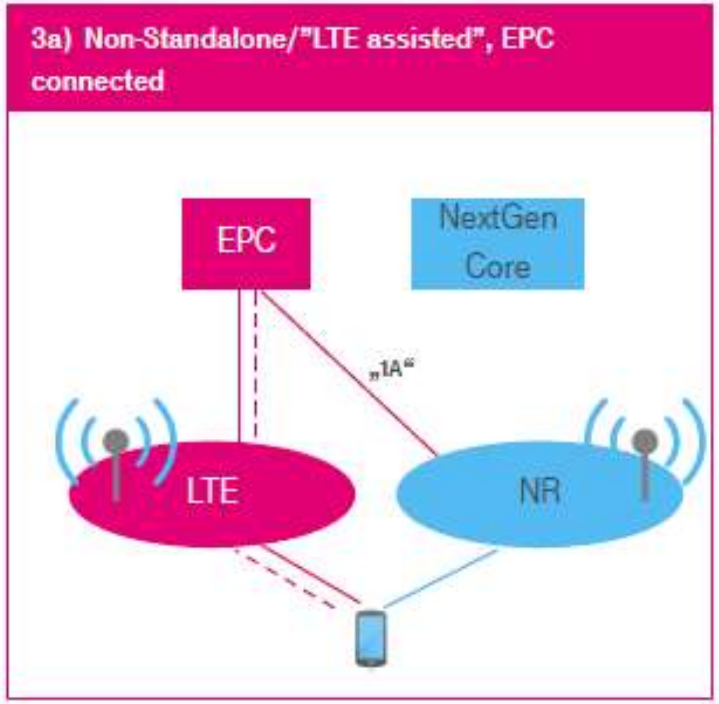
5G system architecture



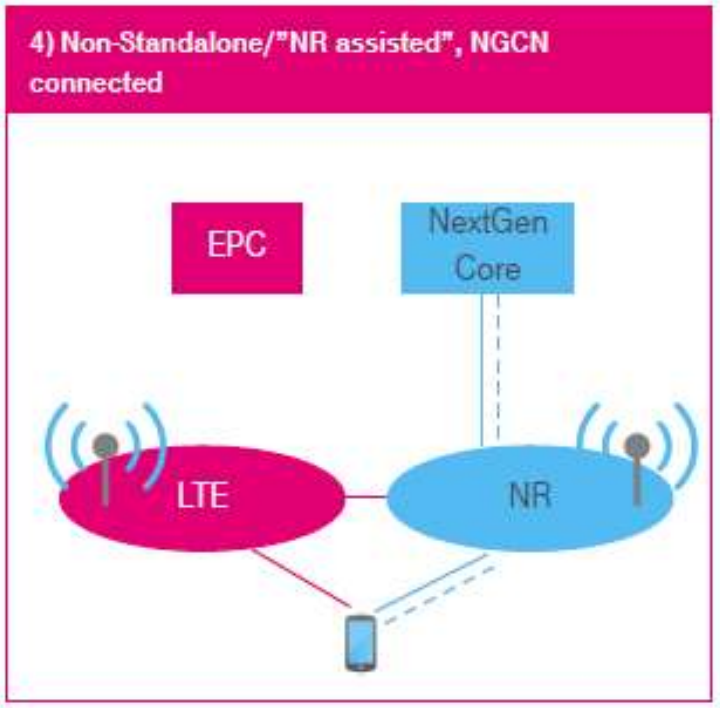


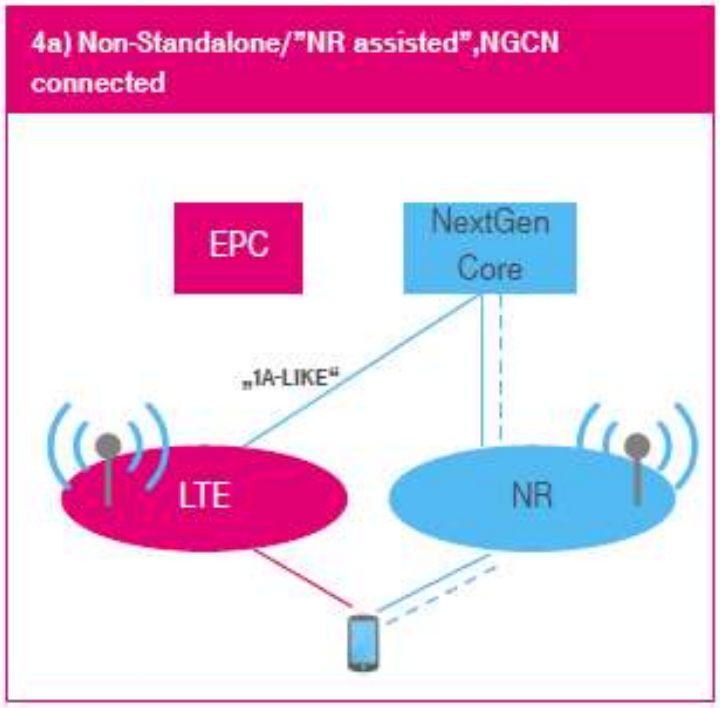
5G system architecture



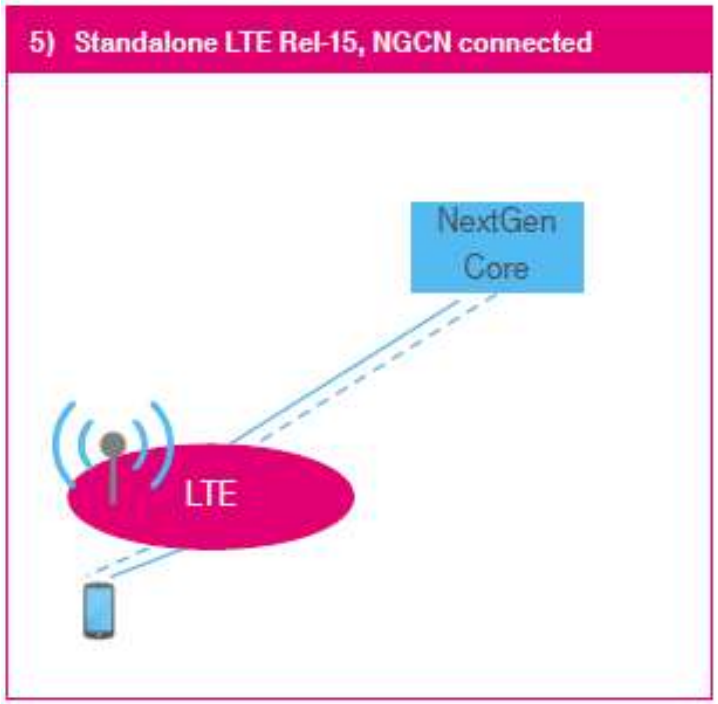


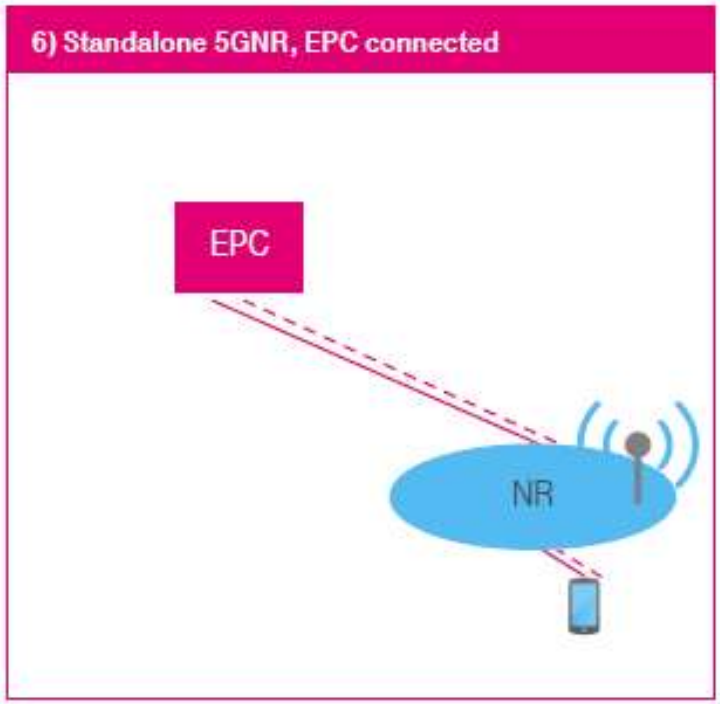
5G system architecture



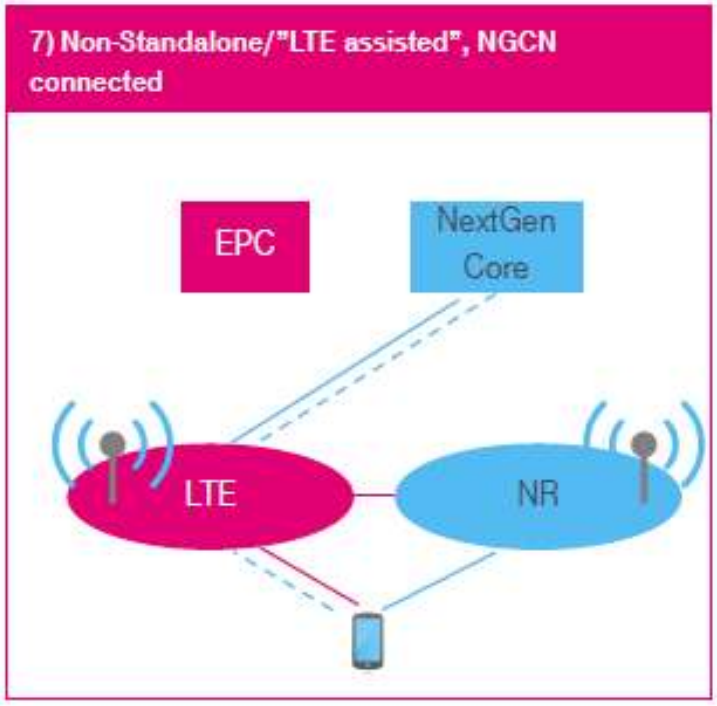


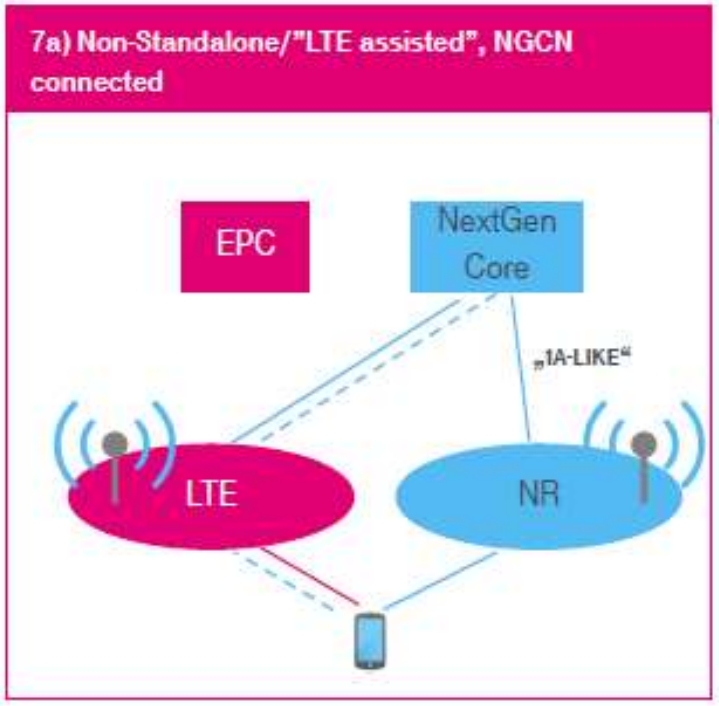
5G system architecture



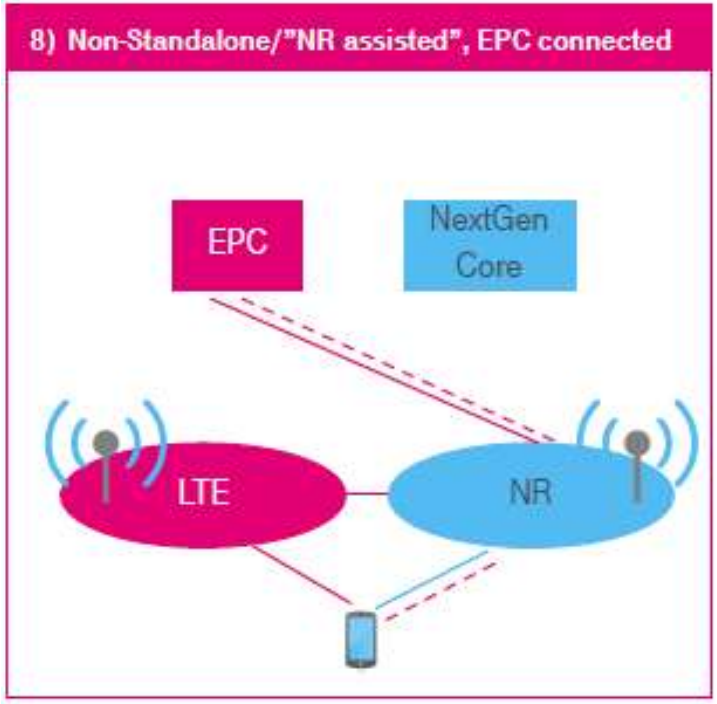


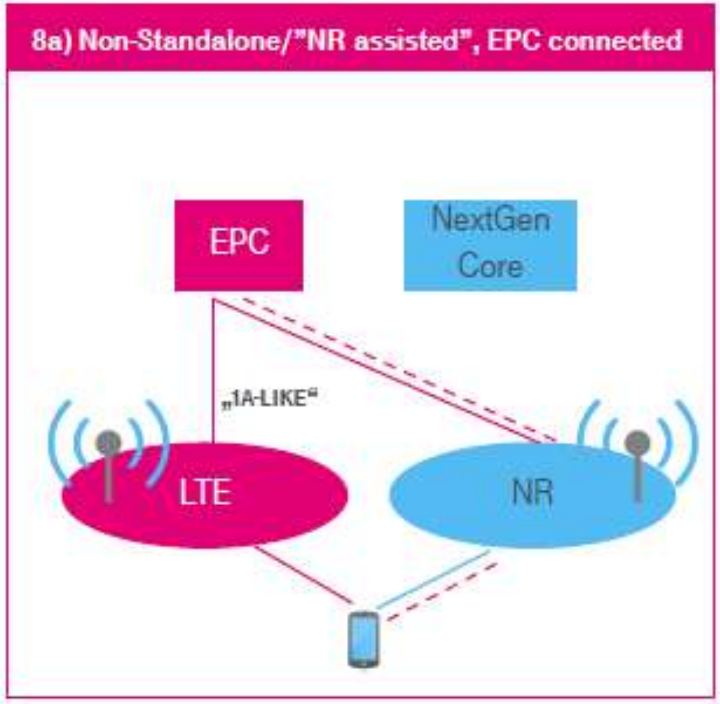
5G system architecture





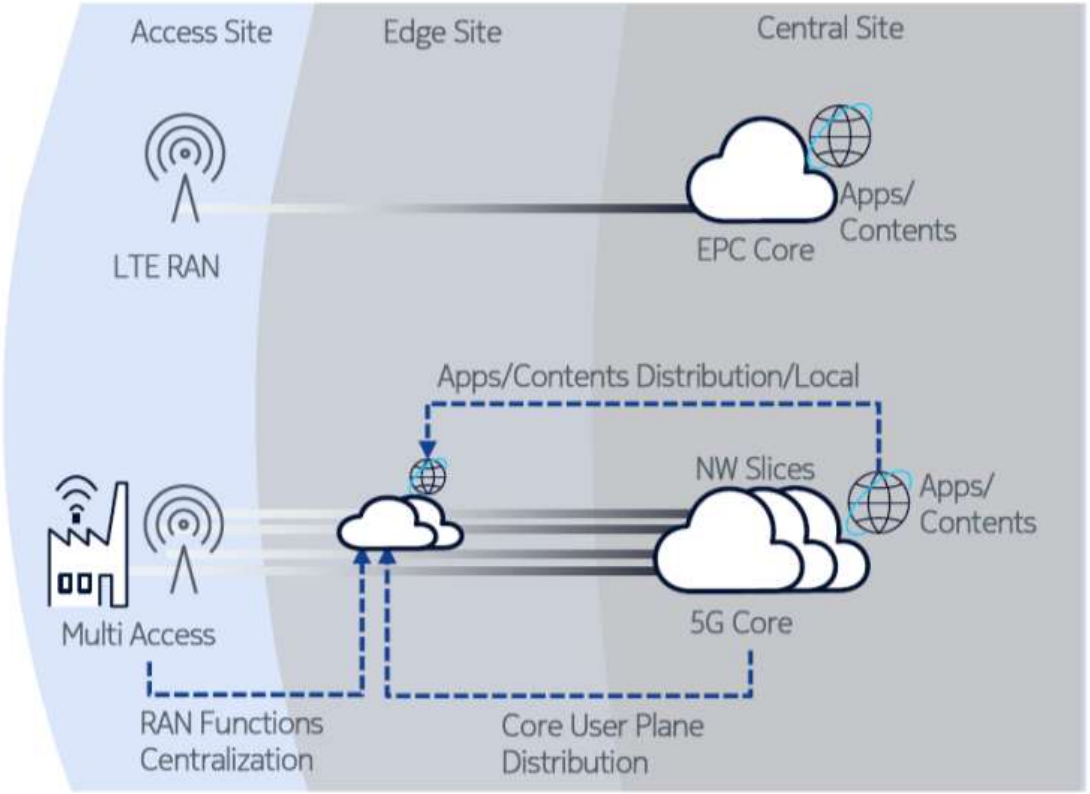
5G system architecture





Evolution from 4G to 5G

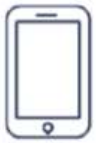
4G Networks



5G Networks

- Centralized Architectures
- VNF/SDN/MANO Adoption
- NW Slices emerge(IoT)

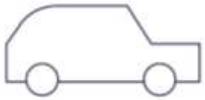
- Functional Decomposition
- RAN/Core/Apps move to Edge
- VNF/SDN/MANO as a foundation
- NW Slicing enabling new use cases
- Multi Access(NR/eLTE, Non 3GPP, Unlicenced, Fixed)



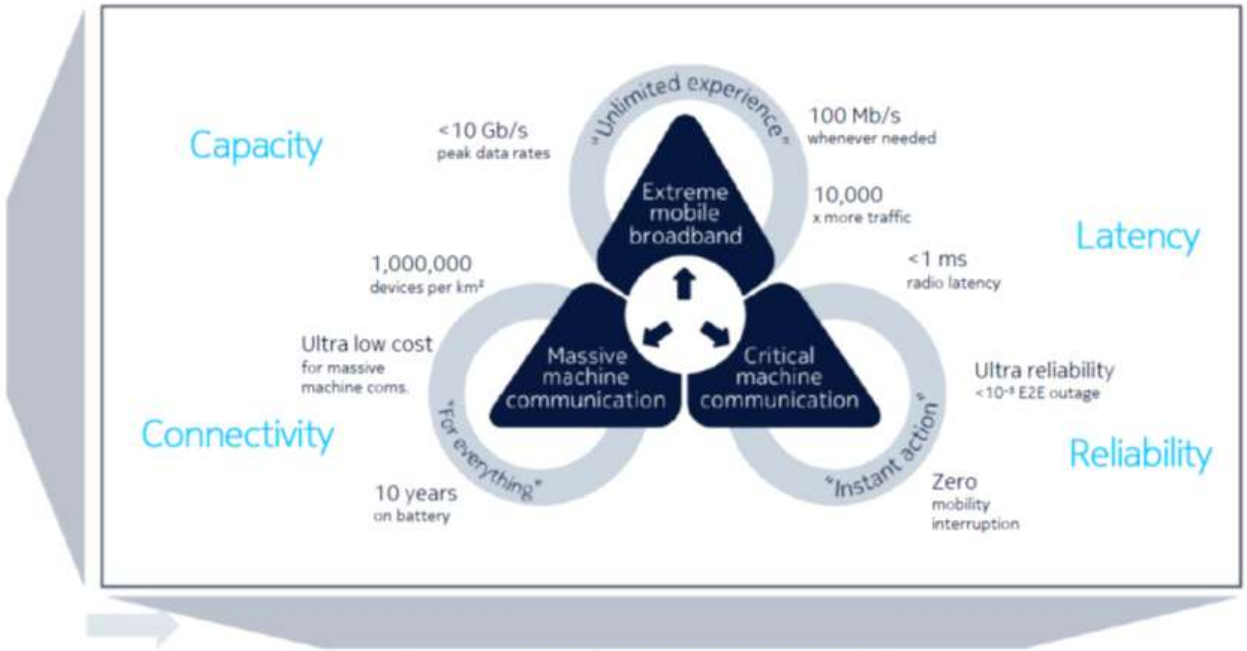
Devices
1.5 GB/day

Smart
factories
1 PB/day
$P = peta = 10^{15}$

Billions of
sensors
connected



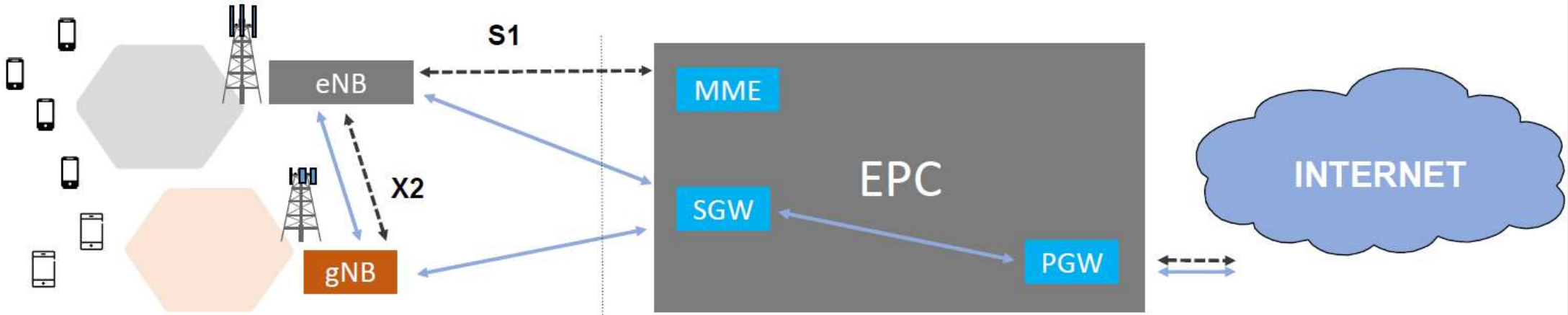
Autonomous
driving
1ms latency



Design and architecture principles:
flexible I scalable I automated I cloud native
software centric I dynamic network slicing

5G Core Network

5G Non Standalone mobile network



Specialized Nodes / Purpose Built

E-UTRAN

Evolved Packet Core (EPC)

Evolved Universal Terrestrial Radio Access Network

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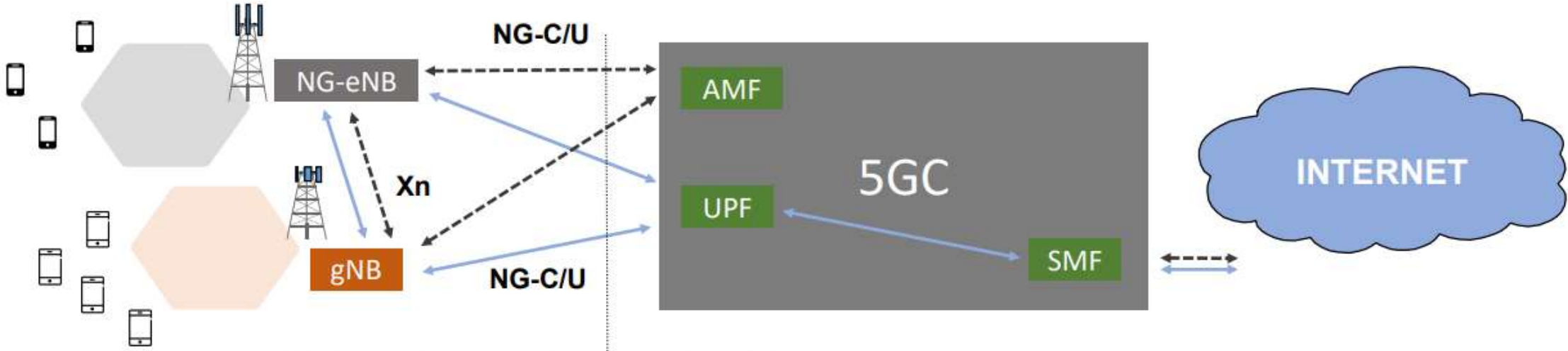
MME - Mobility Management Entity

PGW - Packet Data Network Gateway

SGW - Serving Gateway

5G Standalone mobile network



NFV – Network Function Virtualization

NG-RAN

5G Core

NG – Next Generation

C - Control

U - User

AMF - Access and Mobility Management Function

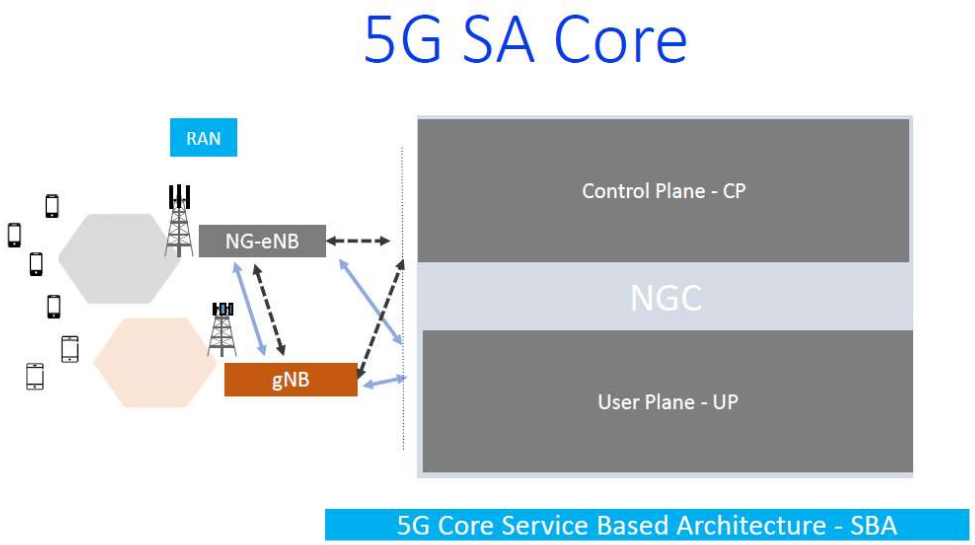
SMF - Session Management Function

UPF - User Plane Function

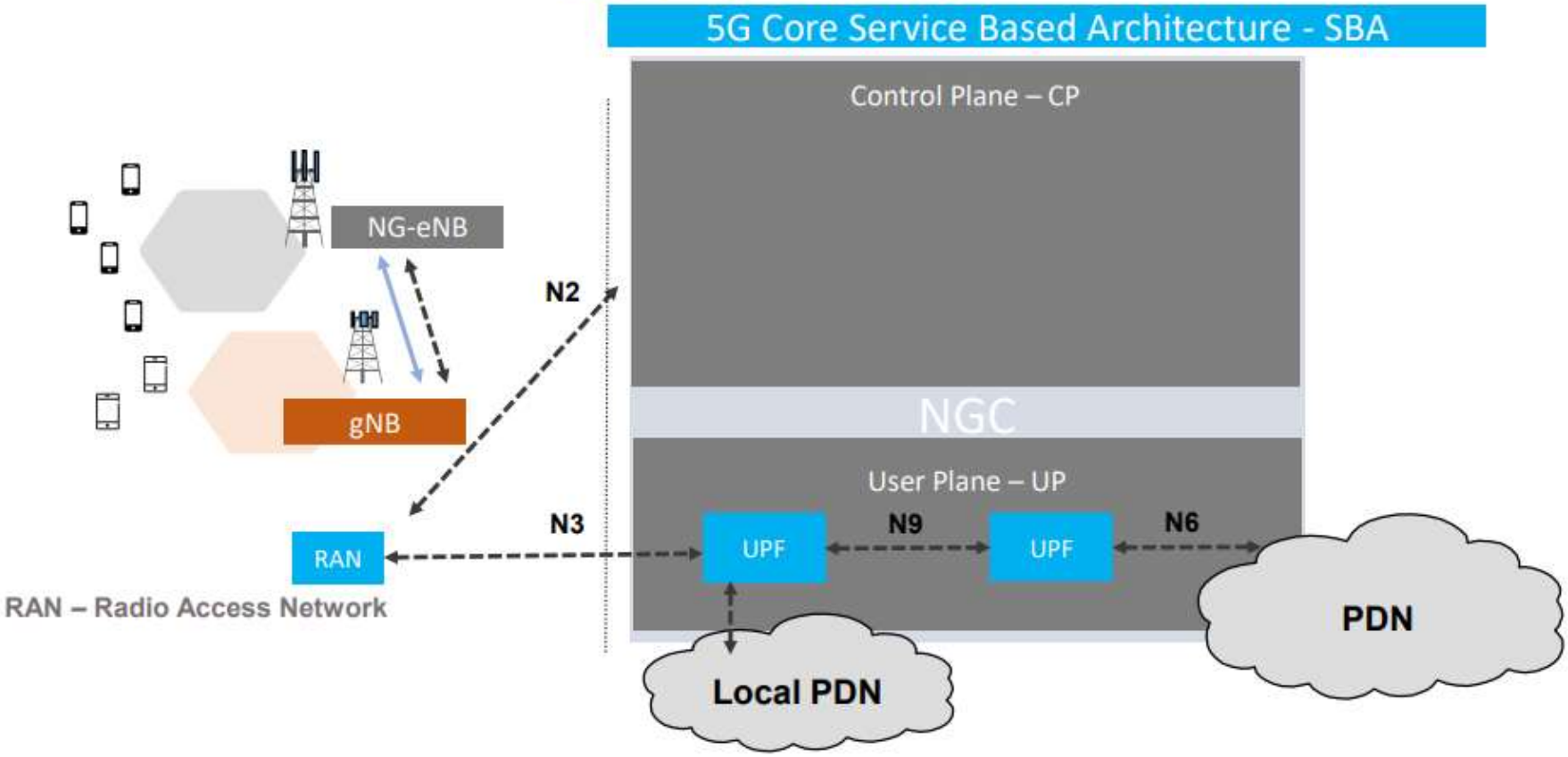
TAL TECH

Service-based Architecture

- The 3GPP defines a Service-Based Architecture (SBA) in which the control plane functionality and common data repositories of a 5G network are delivered through a set of interconnected Network Functions (NFs), with each *NF authorized to access the services of other NFs*.
- If an instance or a physical node fails, monitoring systems can detect this and spin multiple instances.
- SBA's design enables network slicing. Multiple logical networks can run on a single physical network. Network functions in SBA are exposed via well-defined Service based Interfaces.



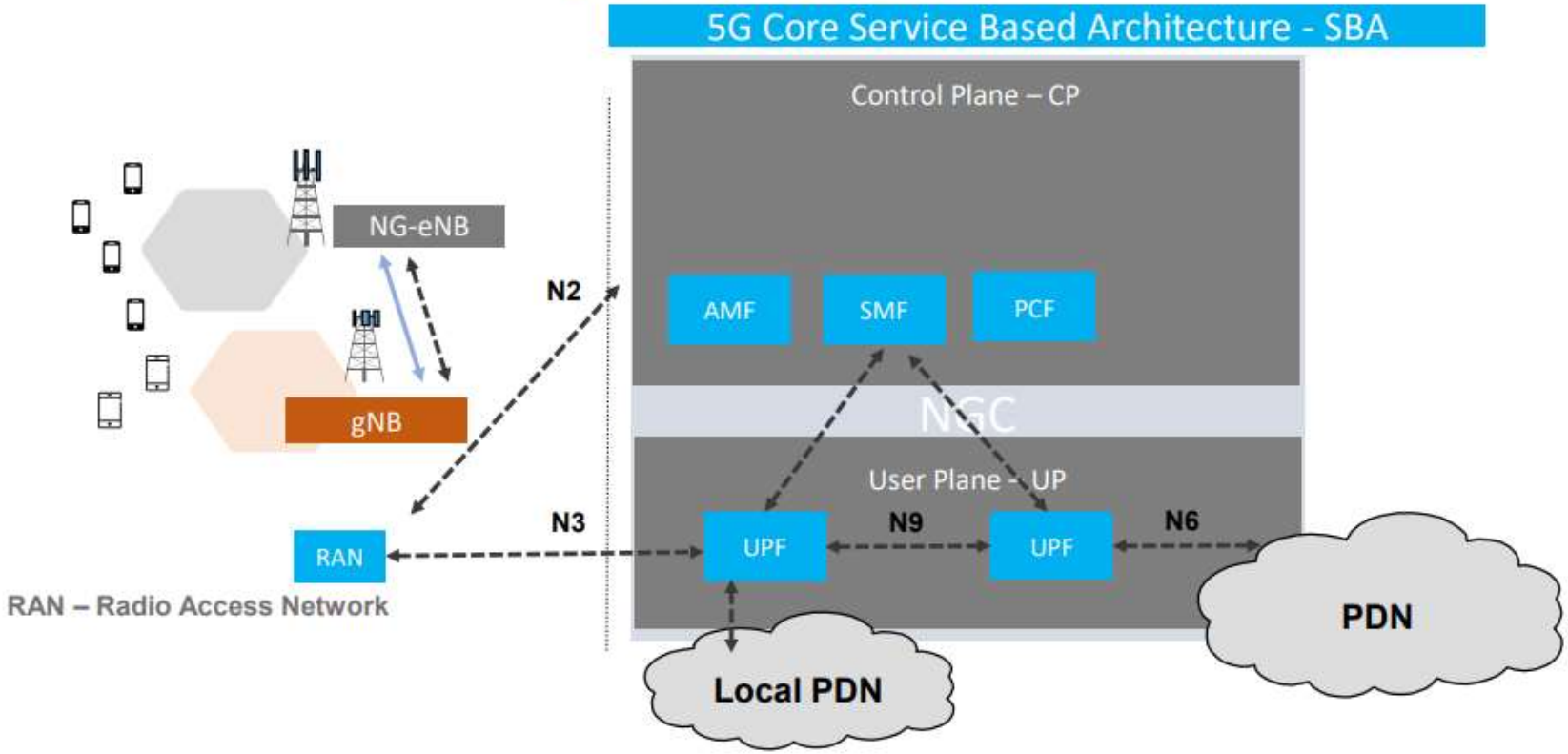
5G SA Core



UPF – User Plane Function

PDN – Packet Data Network

5G SA Core



RAN – Radio Access Network

UPF – User Plane Function

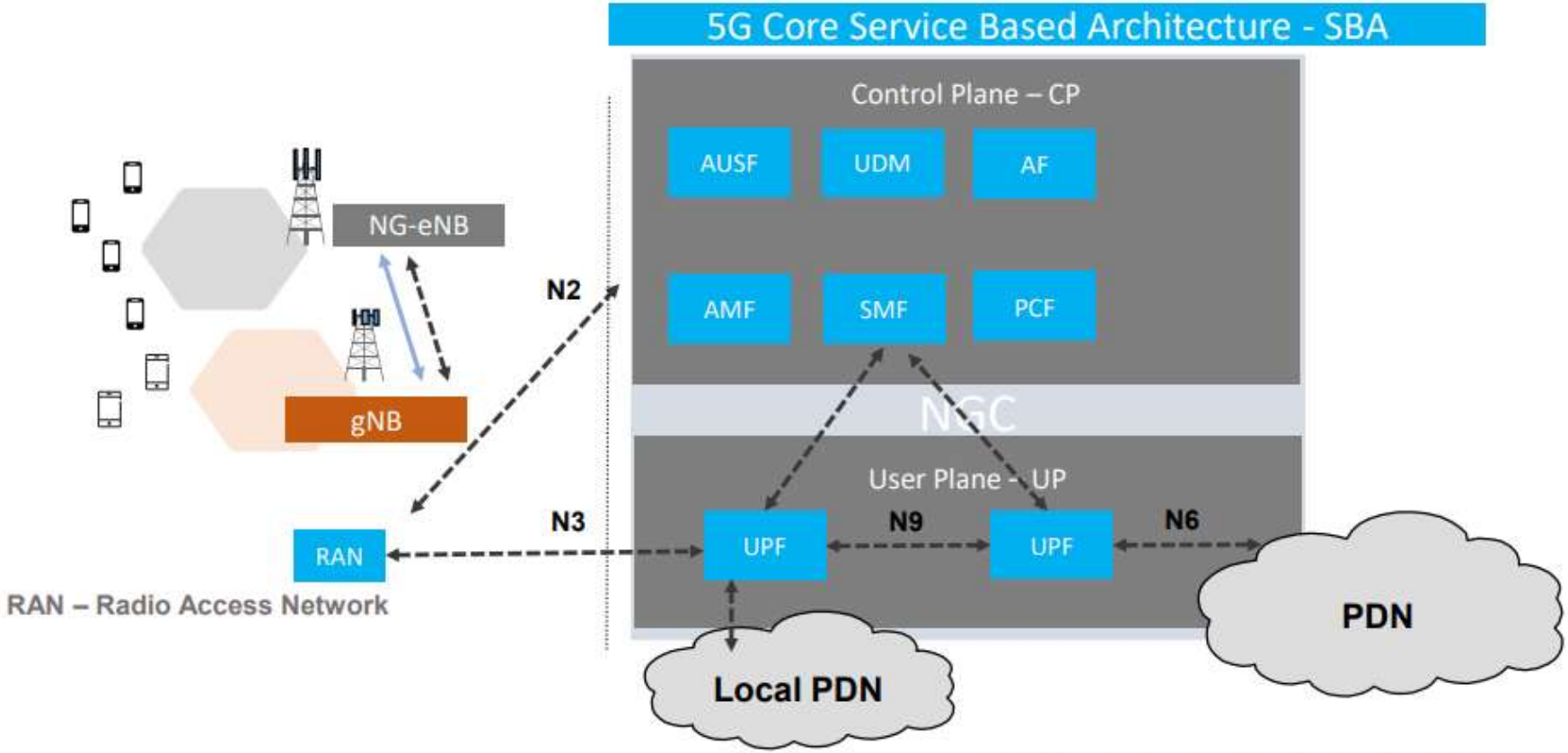
PDN – Packet Data Network

AMF – Access and Mobility Managaement Function

SMF – Session Management Function

PCF – Policy Control Function

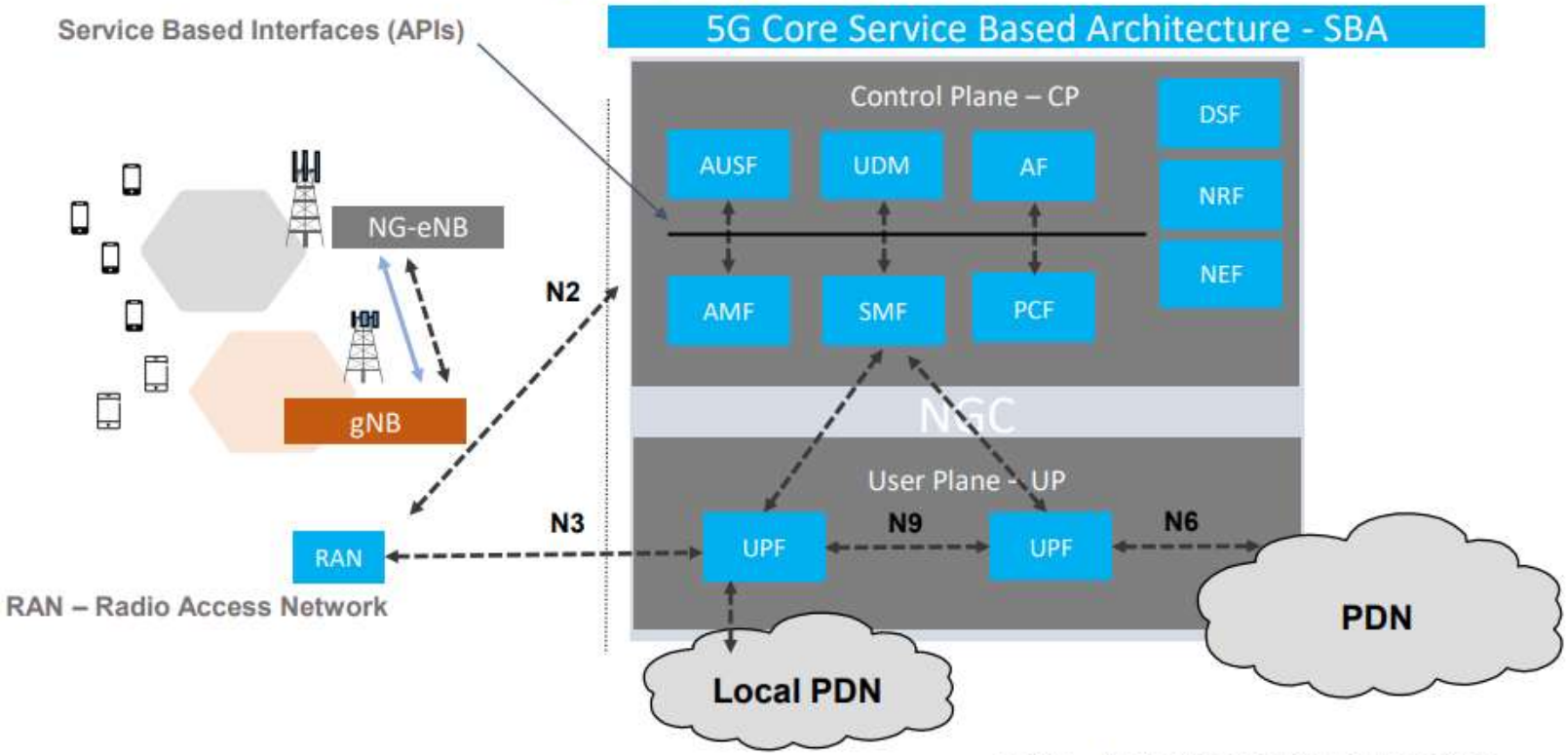
5G SA Core



AUSF – Audentication Server Function
UDM – Unified (User) Data Management
AF – Application Function

UPF – User Plane Function
PDN – Packet Data Network
AMF – Access and Mobility Managaement Function
SMF – Session Management Function
PCF – Policy Control Function

5G SA Core



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PCF – Policy Control Function

AUSF – Audentication Server Function

UDM – Unified (User) Data Management

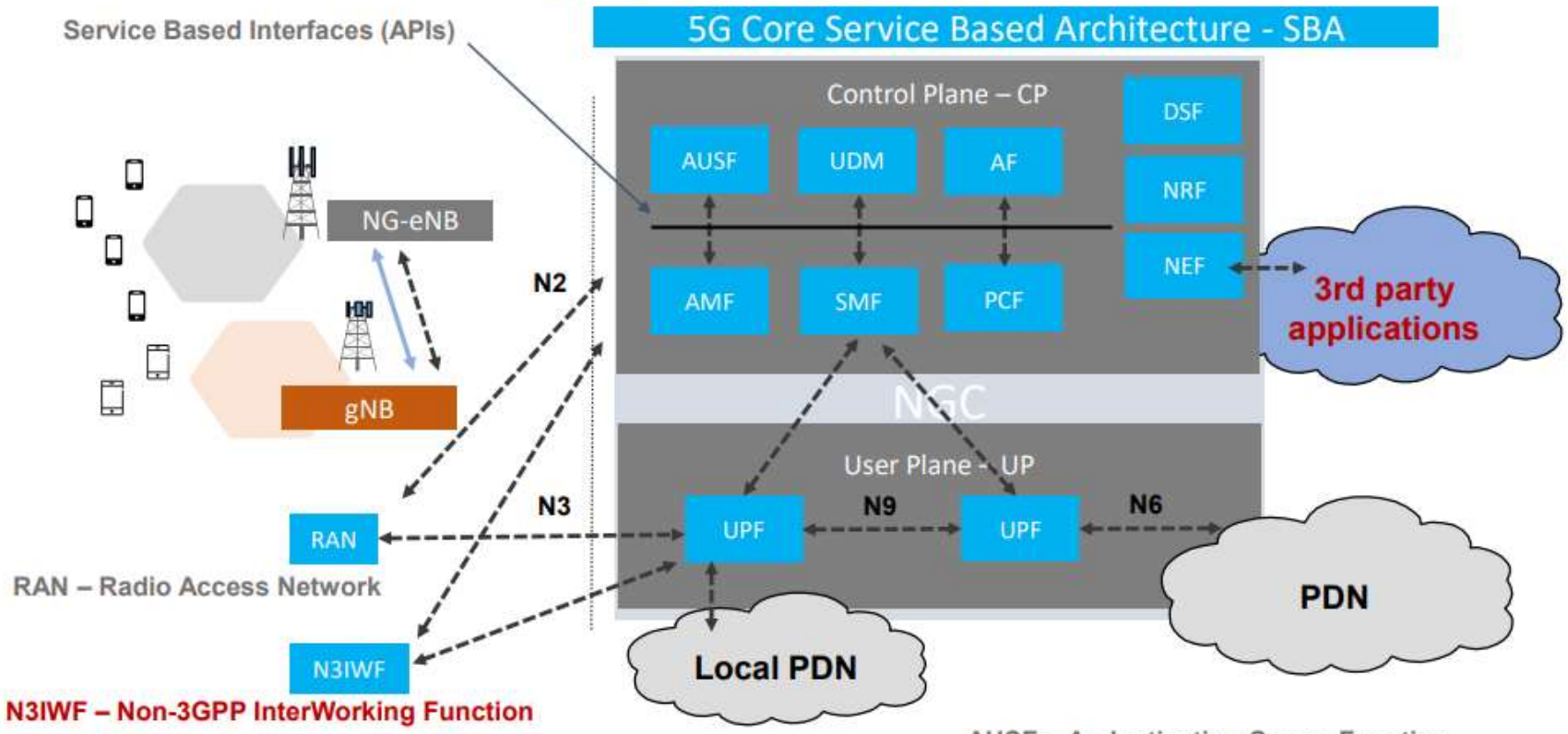
AF – Application Function

DSF – Data Storage Function

NRF – Network Repository Function

NEF – Network Exposure Function

5G SA Core



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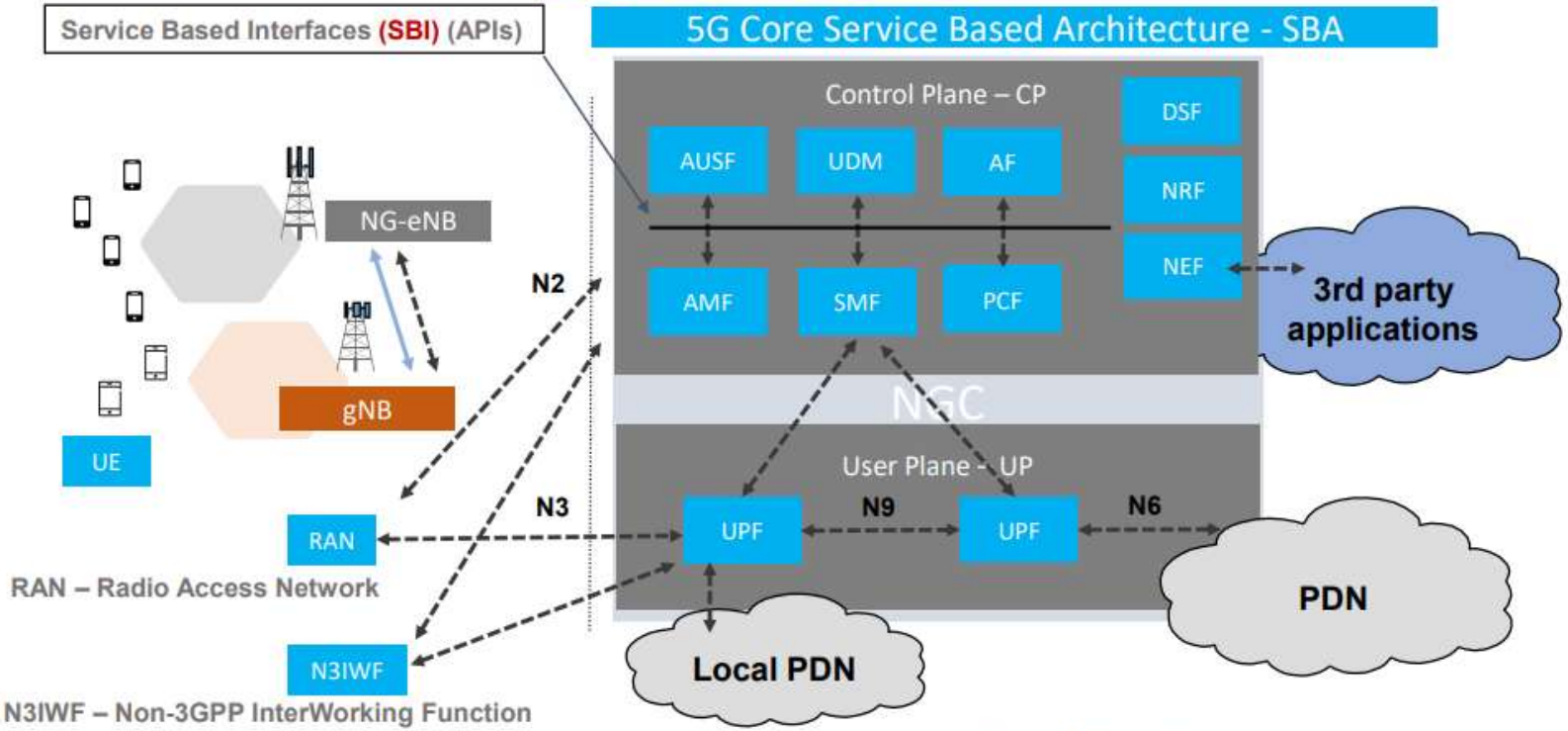
NRF – Network Repository Function

NEF – Network Exposure Function

NF services are self-contained, reusable and independent management schemes

5G SA Core



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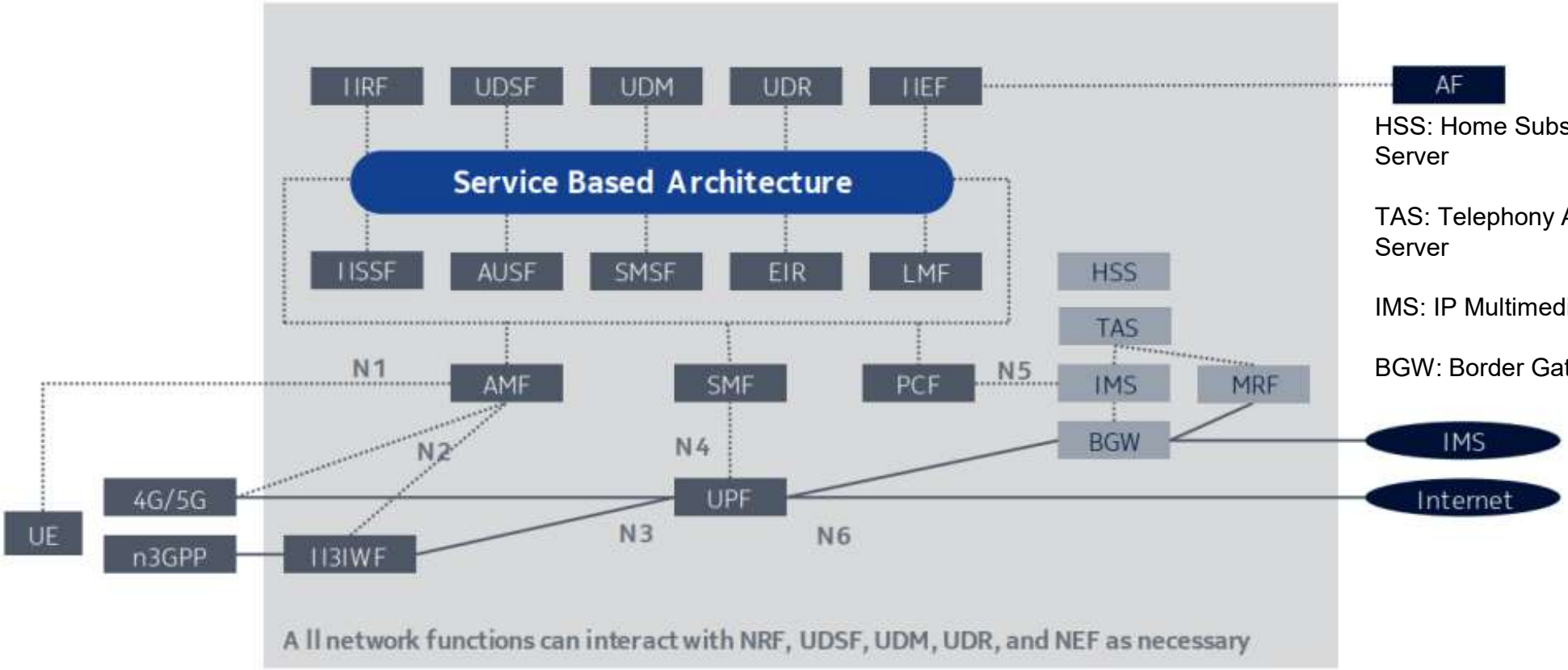
NRF – Network Repository Function

NEF – Network Exposure Function

5G Service based Architecture



HSS: Home Subscriber Server

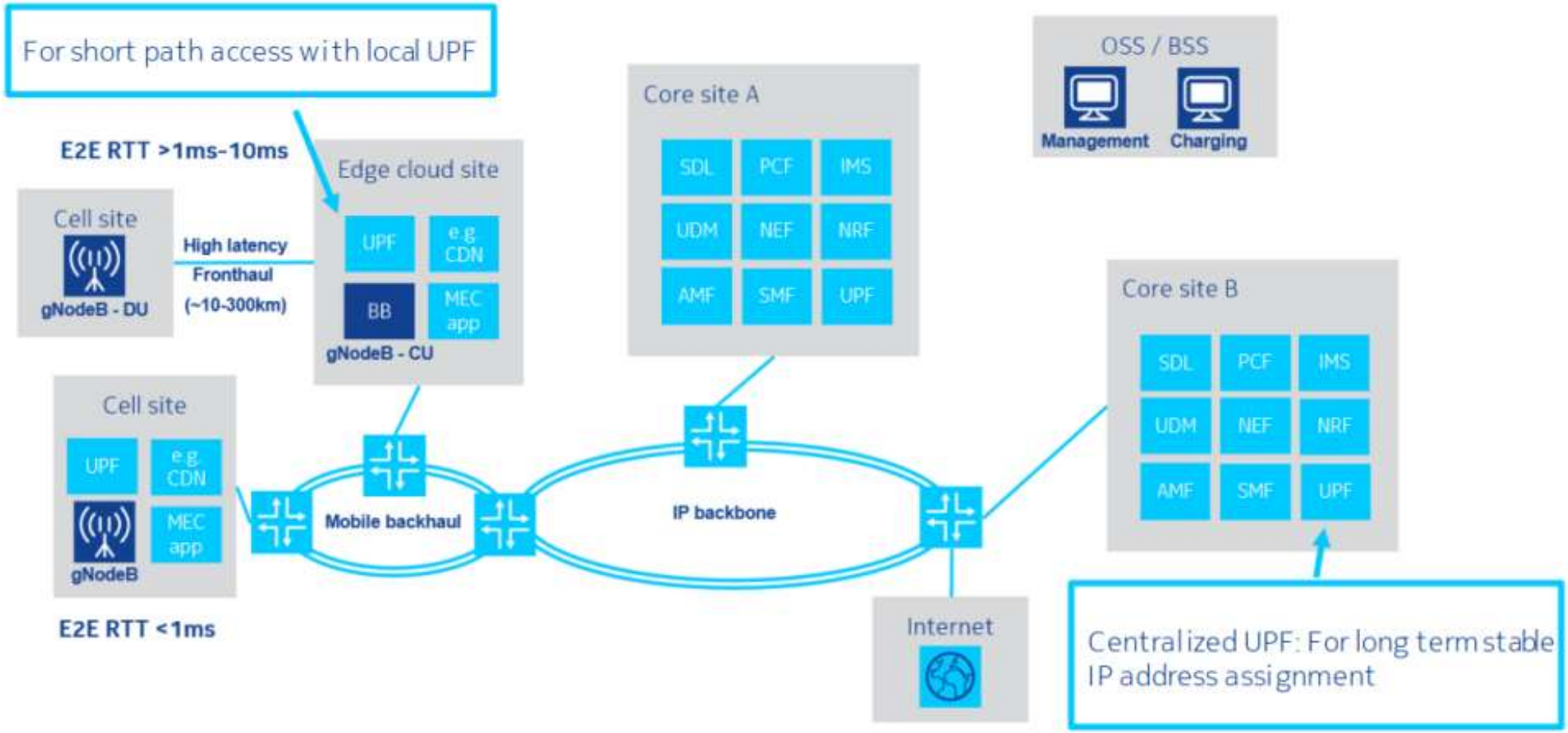
TAS: Telephony Application Server

IMS: IP Multimedia Service

BGW: Border Gateway

This offers Communications Service Providers greater flexibility and more efficiency by decoupling the service consumer from the service producer

5G Distributed User Plane (UP)



CDN – Content Delivery Network (Nokia)

5G SA Core deployment and Tests

TTU Provides Ericsson's 5G Core including:

- Multi-PLMN feature to execute inter-PLMN handover
- Technologies (Slicing, Positioning ..)

AMF:

UE is registered and connected

```
Subscriber Data
-----------------------------------------------------------------------
IMSI                                : 248270000000003
Mobile Subscriber ISDN No.          :
IMEI                                : 863305041249940
Radio Access Technology             : NGRAN
Mobility Management State           : RM-REGISTERED CM-CONNECTED
UE Time Zone
    time offset                     : GMT + 3 hour(s) 0 minute(s)
    daylight saving time            : 1 hour(s) adjustments
Time of Registration in AMF         : 2023-10-03 14:26:51.352+03:00
Time released                       :
RAT restrictions                    : [WLAN]
Forbidden areas                     : []
Core network type restrictions      : Information not available
RFSP Index in Use                   : 1
Service area restriction
    Restriction type                : NOT_ALLOWED_AREAS
    TACs                            : []
    Max num. of TAs                 : Information not available
Subscribed UE Usage Type            : 0
AMF UE NGAP Id                      : 6394620680
RAN UE NGAP Id                      : 16793637
NAS Uplink Count                    : 10
NAS Downlink Count                  : 12
Security Context State              : Security Context with Secure exchange
UE Security Capability
    NPS Encryption Algorithms       : nea0, nea1_128, nea2_128, nea3_128
    NPS Integrity Algorithms        : nia1_128, nia2_128, nia3_128
    EPS Encryption Algorithms       :
    EPS Integrity Algorithms        :
5GMM Capability                     : sl_mode_not_supported
In MICO Mode                        : No
CN Assistance Info RRC INACTIVE to NG-RAN : false
Paging Proceed Flag                 :
Last Visited Tracking Area (TAI)    : 248-27-5000
Tracking Area List                  : 248-27-5000
Latest NG-RAN Node List (MCC-MNC-Size-gNBId) : 248-27-22-1
IMS VoPS                            :
SMS over NAS Allowed                : false
SMSF Instance ID                    : Information not available
SMSF Service Instance ID            :
Subscribed S-NSSAIs
    Default S-NSSAIs                : 1,2
    Non Default S-NSSAIs            :
Registered S-NSSAIs                 : 1,2
Requested S-NSSAIs                  : 1,2
Rejected S-NSSAIs                   :
5G-GUTI
    PLMN Id                         : 248-27
    AMF Region Id                   : 255
    AMF Set Id                      : 2
    AMF Pointer                     : 13
    5G-TMSI                         : 4026583370 (#F000C94A)
```

Registered in the network

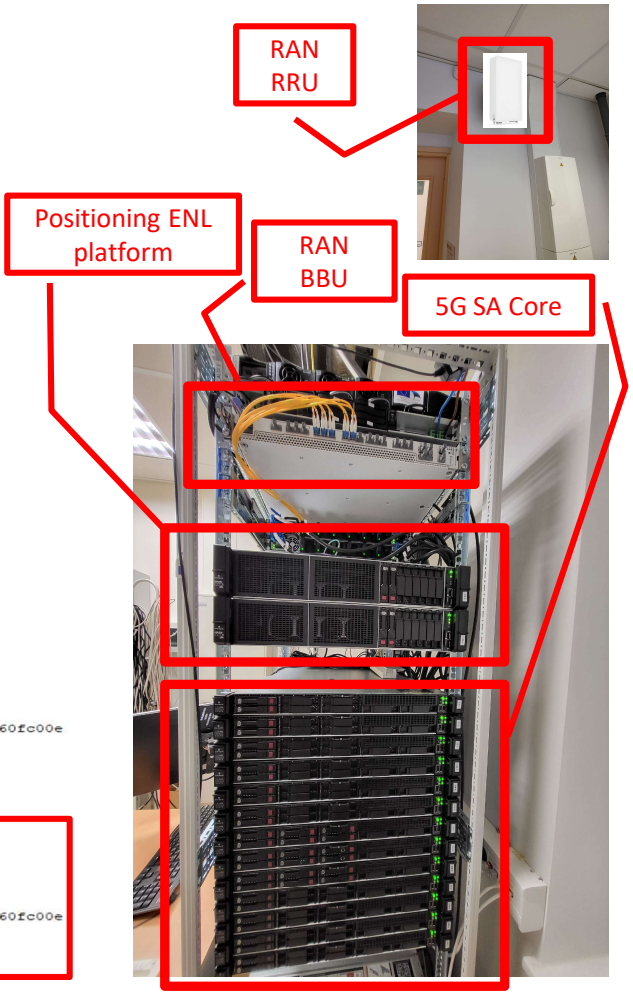
Registered slices

SMF:

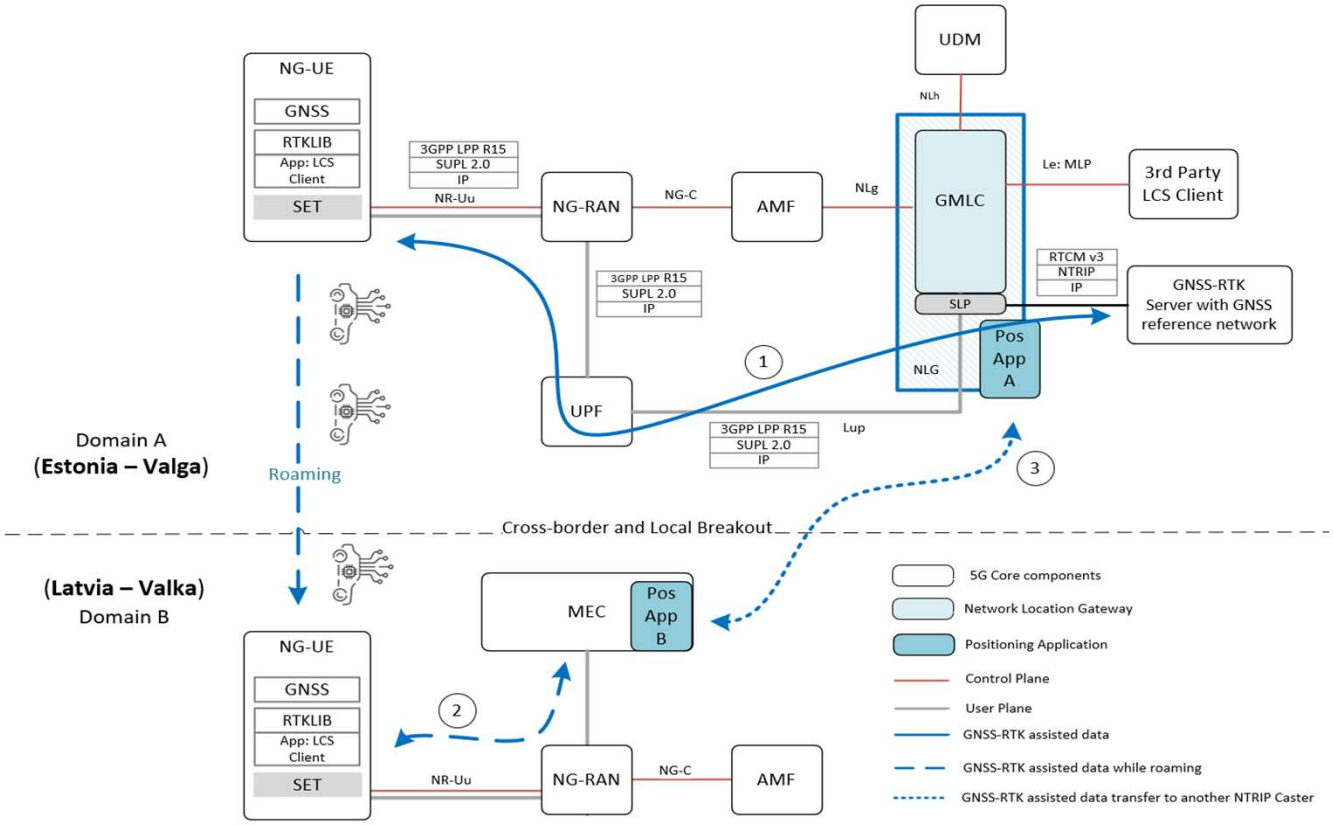
UE has been created in two slices

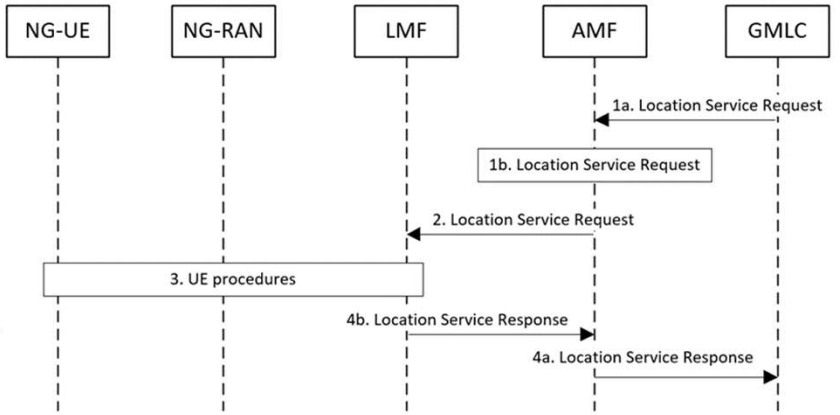
```
Smf Selection Subscription Data
-----------------------------------------------------------------------
S-NSSAI 1
    DNN                             : internet1.taltech.ee
    Default DNN Indicator           : true
S-NSSAI 2
    DNN                             : internet2.taltech.ee
    Default DNN Indicator           : true

Subscribed DNN Configuration
-----------------------------------------------------------------------
Associated PDU Session IDs          : 1
DNN                                 : internet1.taltech.ee

Subscribed DNN Configuration
-----------------------------------------------------------------------
Associated PDU Session IDs          : 2
DNN                                 : internet2.taltech.ee

Active PDU Session
-----------------------------------------------------------------------
Id                                  : 1
S-NSSAI                             : 1
DNN requested                       :
DNN in use                          : internet1.taltech.ee
Active EPS Bearer IDs               :
SMF in use
    Instance ID                     : d67766fc-210f-4ecf-858f-cc42a60fc00e
    IPv4                            : 172.22.200.96
    IPv6                            :
    FQDN                            : Information not available

Active PDU Session
-----------------------------------------------------------------------
Id                                  : 2
S-NSSAI                             : 2
DNN requested                       : internet2.taltech.ee
DNN in use                          : internet2.taltech.ee
Active EPS Bearer IDs               :
SMF in use
    Instance ID                     : d67766fc-210f-4ecf-858f-cc42a60fc00e
    IPv4                            : 172.22.200.96
    IPv6                            :
    FQDN                            : Information not available
```

This is active slice



5G-ROUTES – 5G integrated GNSS-RTK positioning



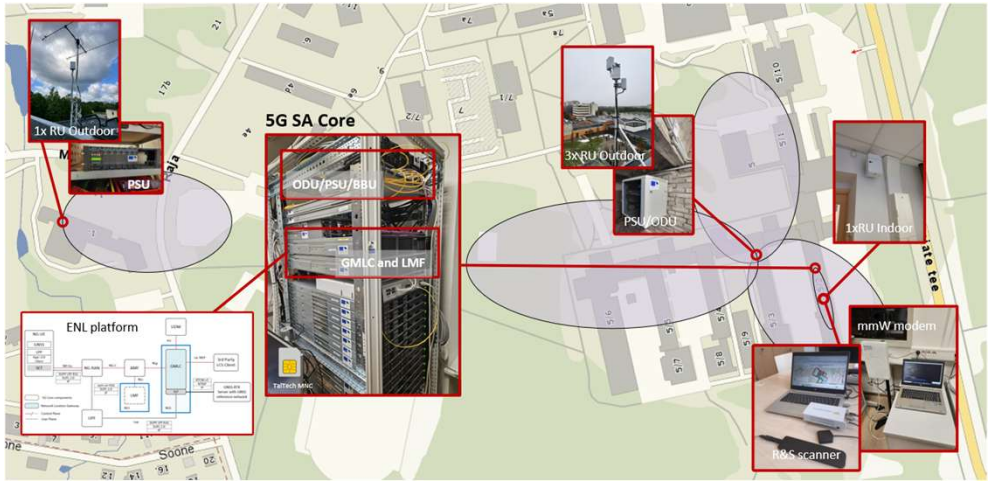


5G AND BEYOND TESTBED (1/2)

To provide 5G advanced network with **unique features supporting verticals** i.e., Smart Cities, Education and Health sectors

Objective is to provide full (end to end) 5G advanced infrastructure **unique feature based which is the novelty of the proposed testbed**:

1) We have a frequency license from the Estonian regulatory authority to operate mmWave network in n258 band (24 GHz)..
2) 5G Stand-Alone (SA) Core deployment is based on Ericsson's Small Size Target Solution (SSTS). 5G Core is operational
3) Our mmWave Radio network is operational. We have installed 4 outdoor radio units and 1 indoor radio unit all connected to a single baseband unit and configured.
4) Precise positioning is based on Ericsson Network Location (ENL) platform, and slicing will be offered from the network side as specific features.
5) Co-located virtualised service orchestration platform for application integration (via N6 interface)



5G Advanced operational infrastructure at TalTech illustrating mmWave radio network (outdoor and indoor radio units and a baseband unit), 5G SA core network including Ericsson network location platform, and terminal including mmWave Quectel modem, radio scanner.

5G AND BEYOND TESTBED (2/2)

i) To **provide demonstration** of the **following unique KPIs** from the proposed network:

   a. very high throughput - up to 1.2 Gbps (DL) and up to 120 (UL) - [mmWave]

   b. very low latency (5-6 ms) – [mmWave]

   c. High-speed mobility handover (intra-network and inter-network)

   d. Fully integrated and end-to-end hybrid precise positioning through Ericsson Network Location platform (2-5 cm)

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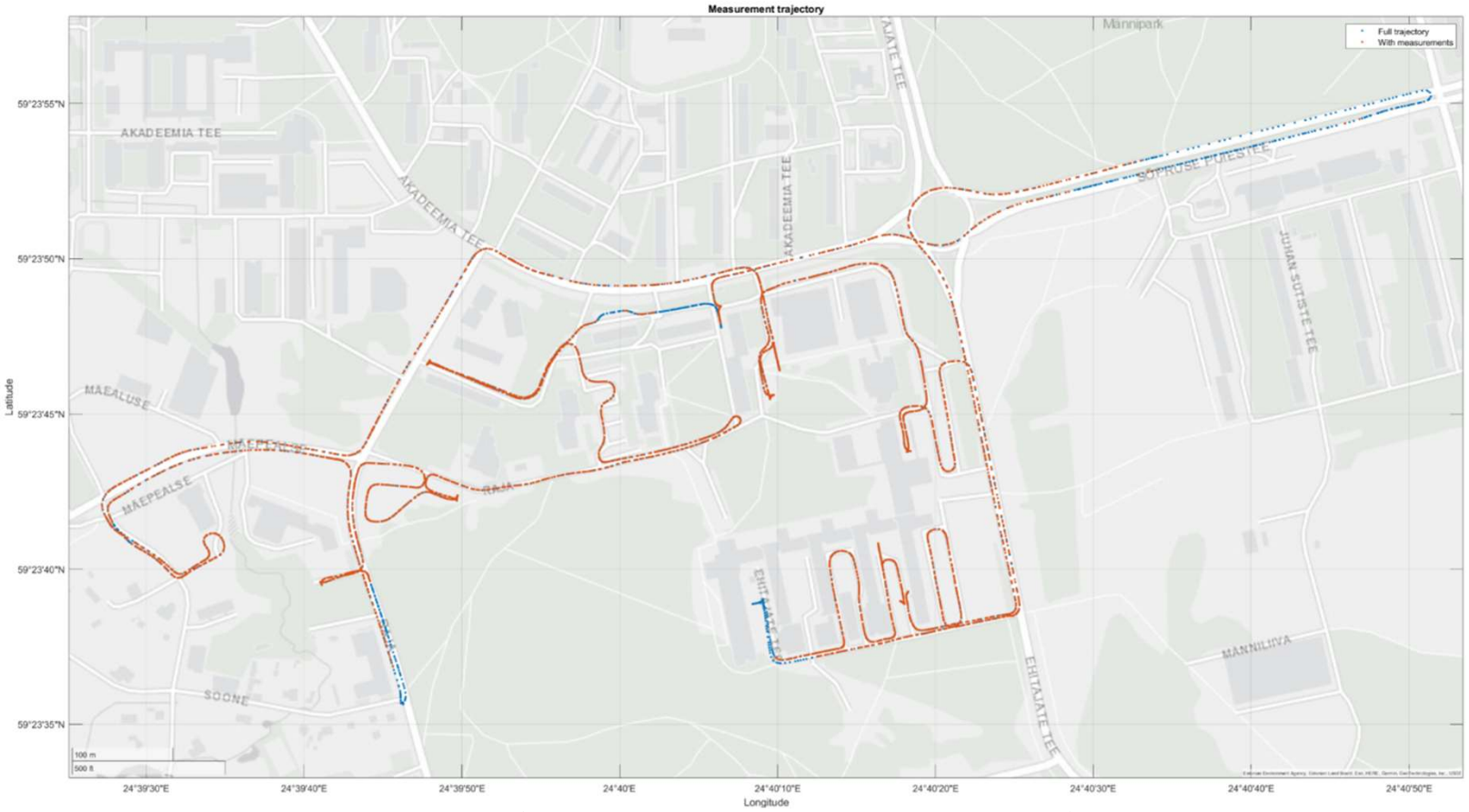
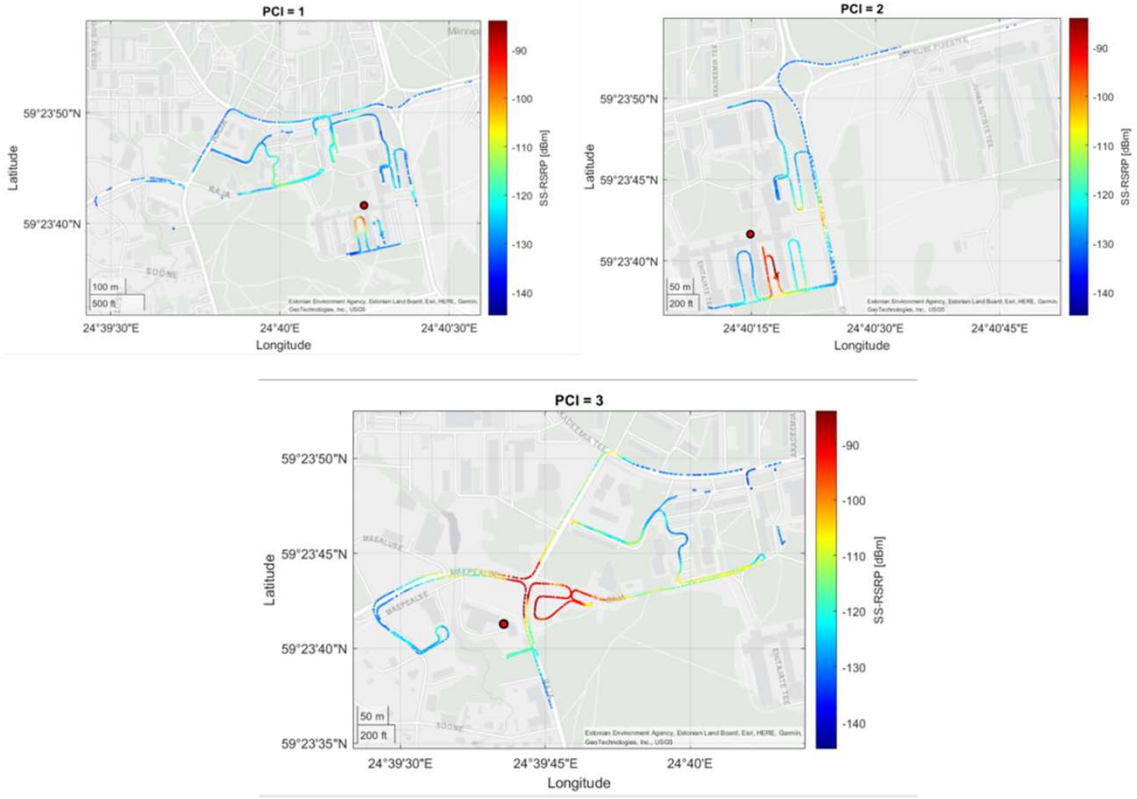
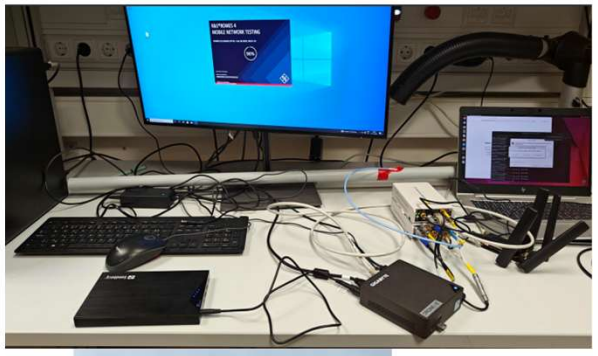
mmWave coverage around TalTech (1/2)



Measurement trajectory (initial measurement campaign performed in October 2024)

mmWave coverage around TalTech (2/2)





Initial measurement results of n256 band with 3 mmWave outdoor RUs. Corresponding RUs of the PCI1 and PCI2 are on the same mast with different pointing direction and PCI3 is on the different building location

Test Flights with UAVs