教育部「5G行動寬頻人才培育跨校教學聯盟計畫」

5G行動網路協定與核網技術聯盟中心

課程:5G垂直應用網路

單元2
5G行動網路技術

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Outline

- System Architecture for the 5G System (5GS)
  - Service-Based Architecture
  - Interworking with EPC
- Radio Access Networks
  - 5G New Radio (NR)
  - 5G Xn Interface
- Core Networks
  - 5G Core Networks (5GC)
  - NG Interface

System Architecture for the 5G System (5GS)

TS 23.501 (16.5.0)

- Defines the Stage 2 system architecture for the 5G System
- Covers both roaming and non-roaming scenarios in all aspects, including
  - interworking between 5GS and EPS
  - mobility within 5GS
  - QoS
  - policy control and charging
  - authentication and
  - in general 5G System wide features
    - e.g. SMS, Location Services, Emergency Service

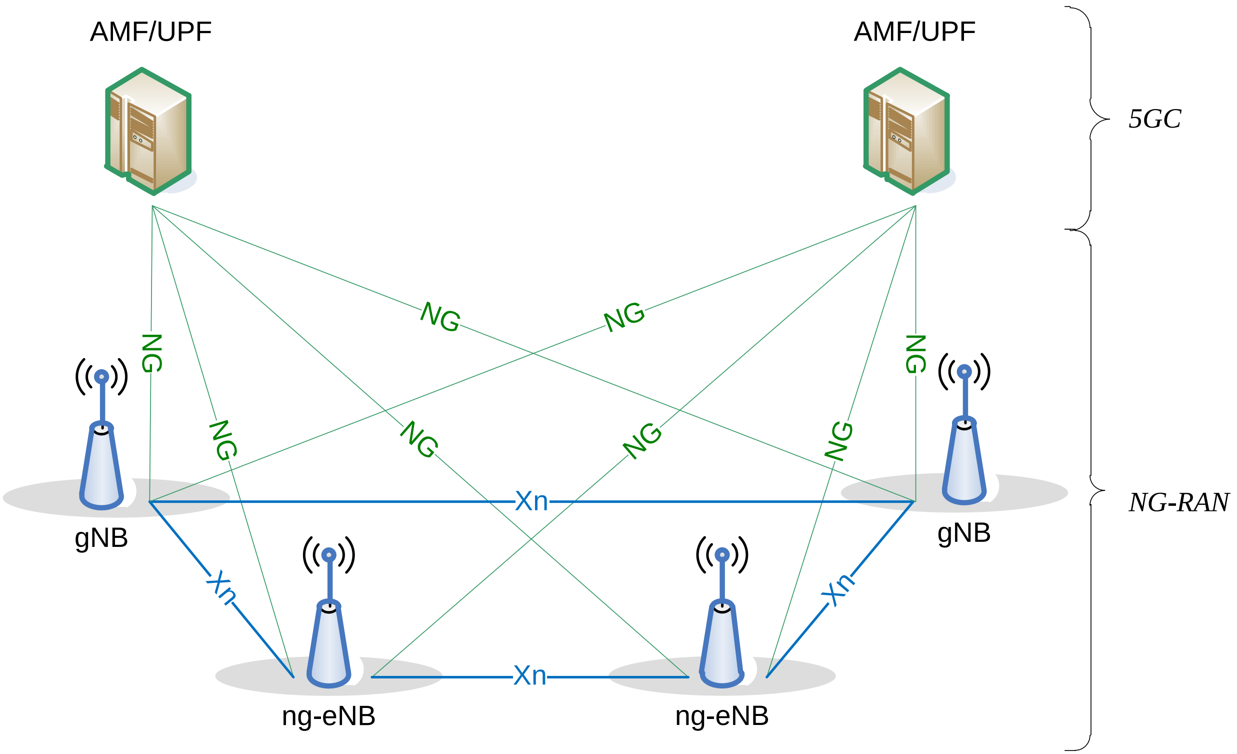
- Companion specifications
  - TS 23.502 contains the stage 2 procedures and flows for 5G System
  - TS 23.503 contains the stage 2 Policy Control and Charging architecture for 5G System

5GS – 5G System

5G System: 3GPP system consisting of 5G Access Network (AN), 5G Core Network (CN) and UE

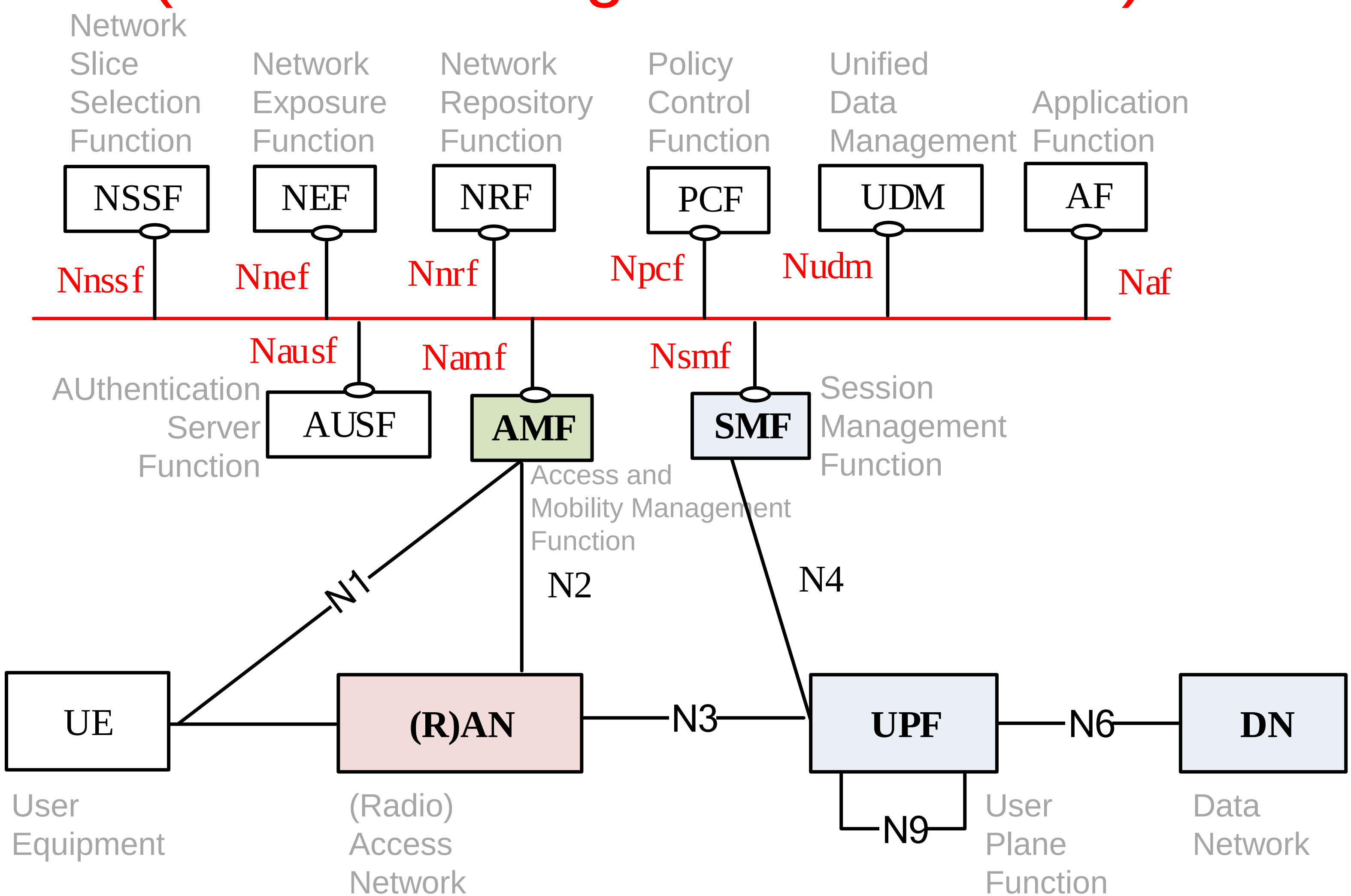
- **5G Access Network**: An access network comprising a NG-RAN and/or non-3GPP AN connecting to a 5G Core Network
  - **NG-RAN**: A radio access network that supports one or more of the following options with the common characteristics that it connects to 5GC:
    1) Standalone New Radio
    2) New Radio is the anchor with E-UTRA extensions
    3) Standalone E-UTRA
    4) E-UTRA is the anchor with New Radio extensions
- **5G Core Network**: The core network specified in the present document. It connects to a 5G Access Network
  - **5G QoS Flow**: The finest granularity for QoS forwarding treatment in the 5G System. All traffic mapped to the same 5G QoS Flow receive the same forwarding treatment
  - **5G QoS Identifier**: A scalar that is used as a reference to a specific QoS forwarding behaviour to be provided to a 5G QoS Flow. This may be implemented in the access network by the 5QI referencing node specific parameters that control the QoS forwarding treatment

5GS (NG-RAN) Overall Architecture



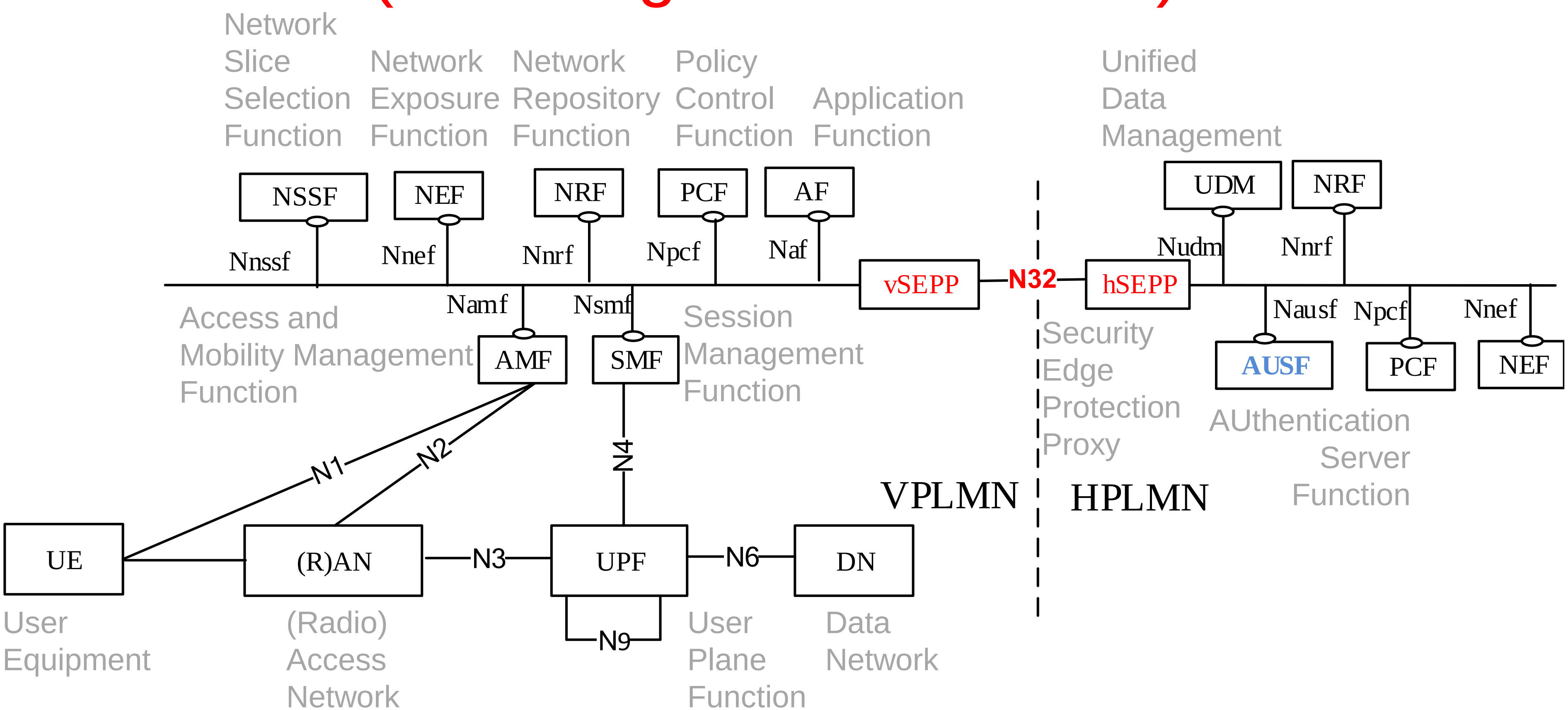
- An NG-RAN node is either
  - A gNB, providing NR user plane and control plane protocol terminations towards the UE
  - An ng-eNB, providing E-UTRA user plane and control plane protocol terminations towards UE
- The gNBs and ng-eNBs are interconnected with each other by the Xn interface
- The gNBs and ng-eNBs are connected by means of the NG interfaces to the 5GC
  - More specifically to the AMF (Access and Mobility Management Function) by means of the NG-C interface and to the UPF (User Plane Function) by means of the NG-U interface (TS 23.501)

5G System Architecture (Non-Roaming Service-Based)



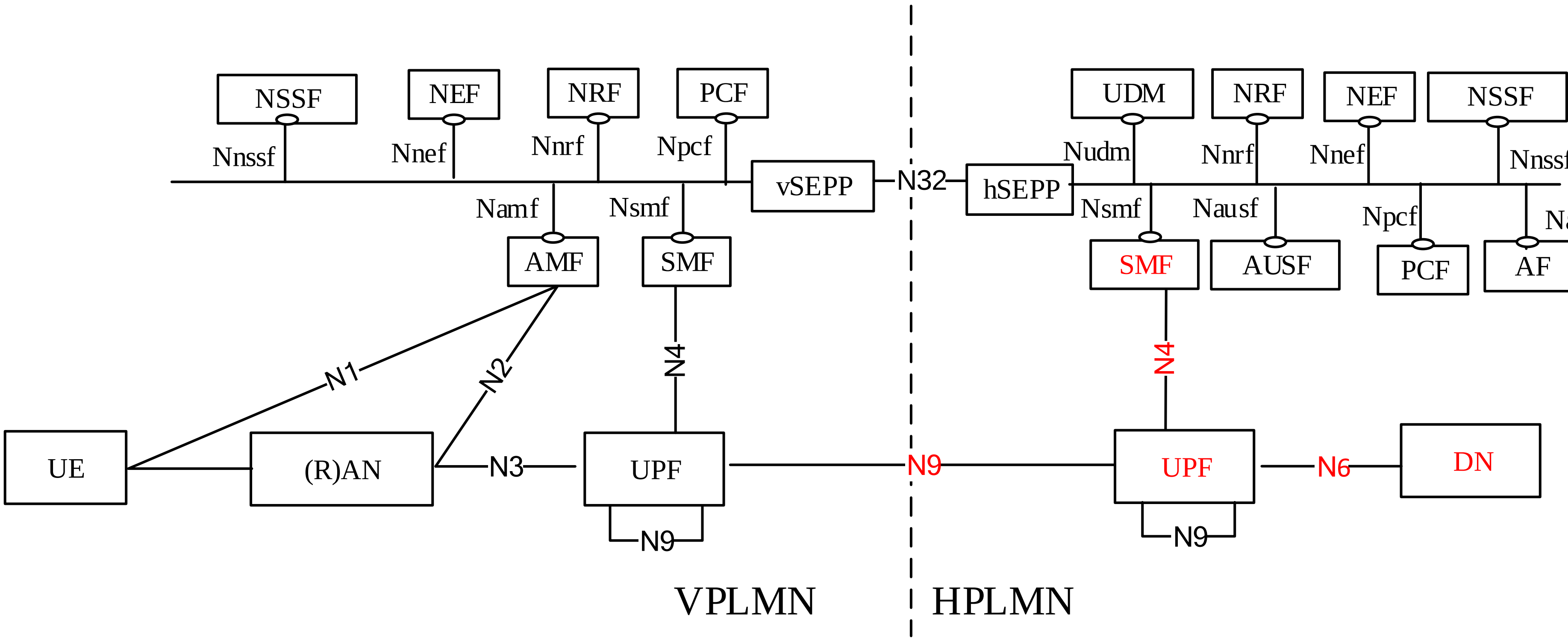
The non-roaming reference architecture with service-based interfaces used within the Control Plane

5G System Architecture (Roaming Service-Based)

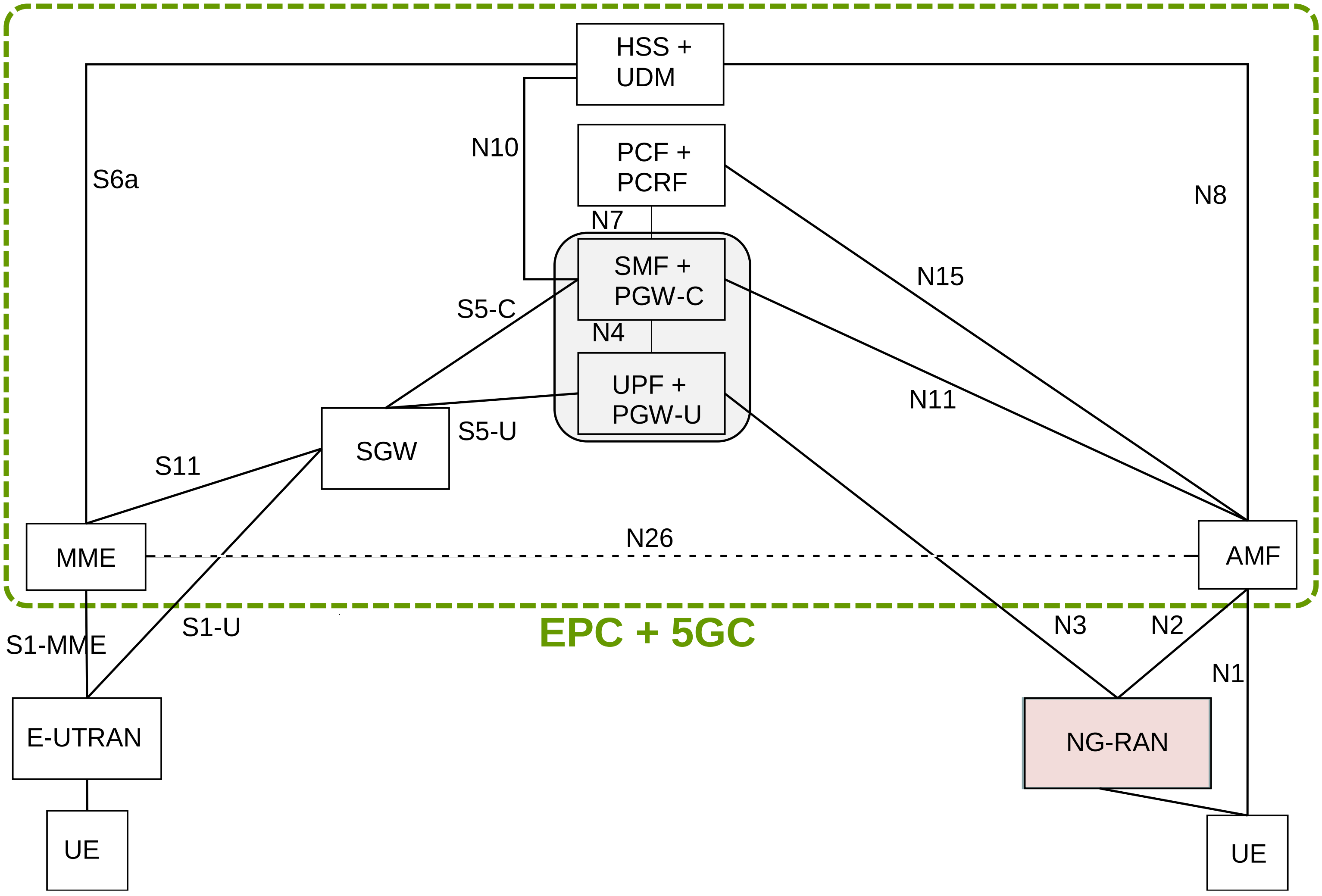


The roaming reference architecture with local breakout using service-based interfaces within the Control Plane

5G System Architecture - Home Routed Scenario (Roaming Service-Based)

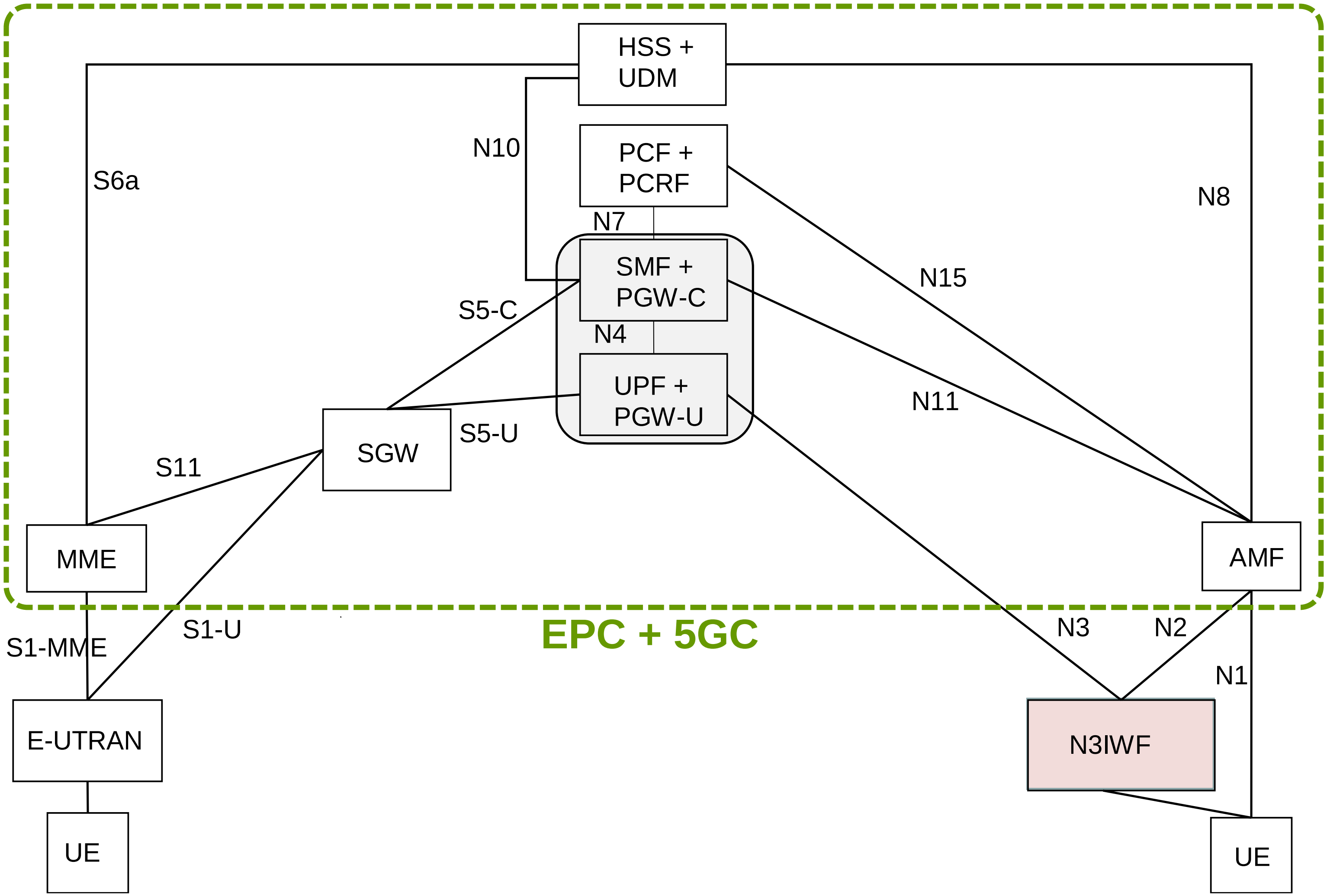


Non-roaming Architecture for Interworking between 5GS and EPC/E-UTRAN



TS 23.501 (Clause 4.3 - Interworking with EPC)

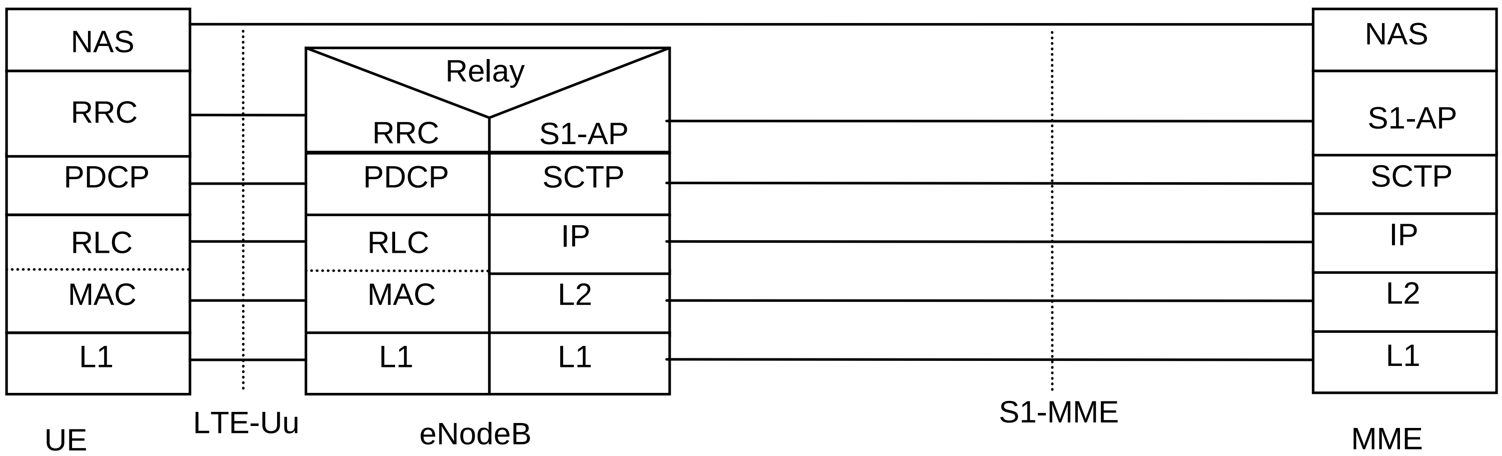
Non-roaming Architecture for Interworking between 5GC via Non-3GPP Access and EPC/E-UTRAN



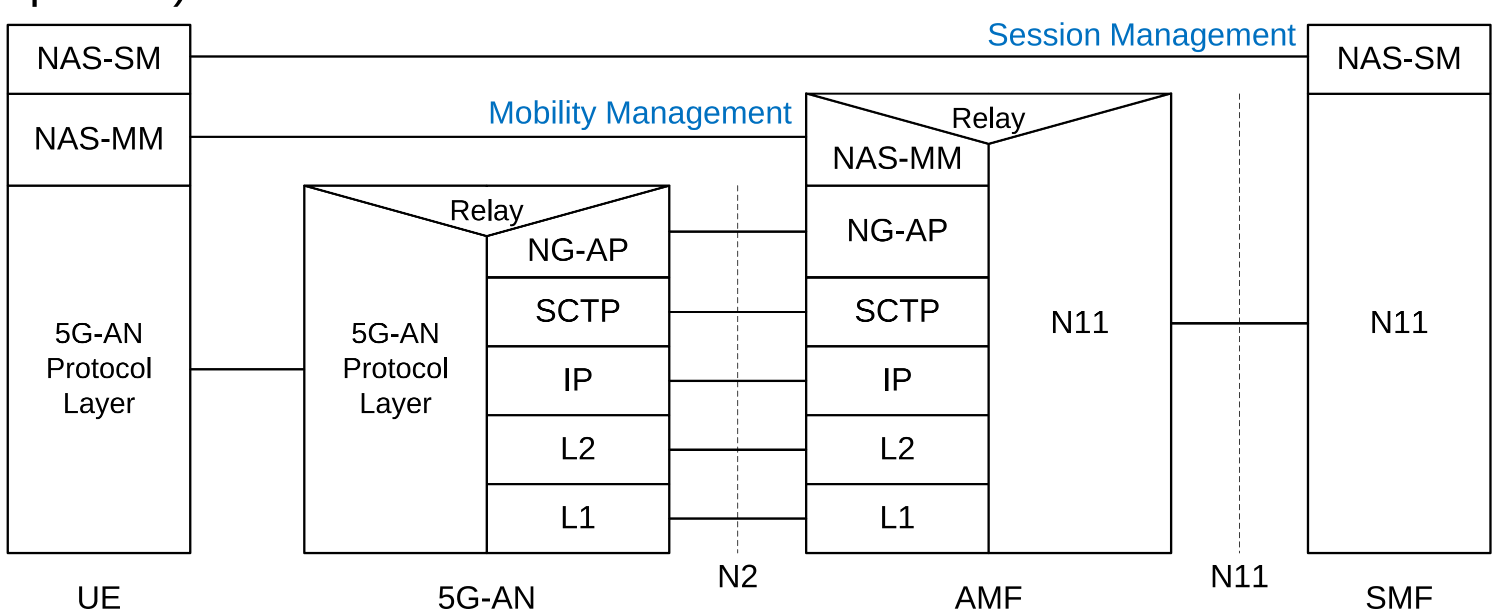
TS 23.501 (Clause 4.3 - Interworking with EPC)

4G/5G Control Plane Protocol Stack

4G (Option 1)

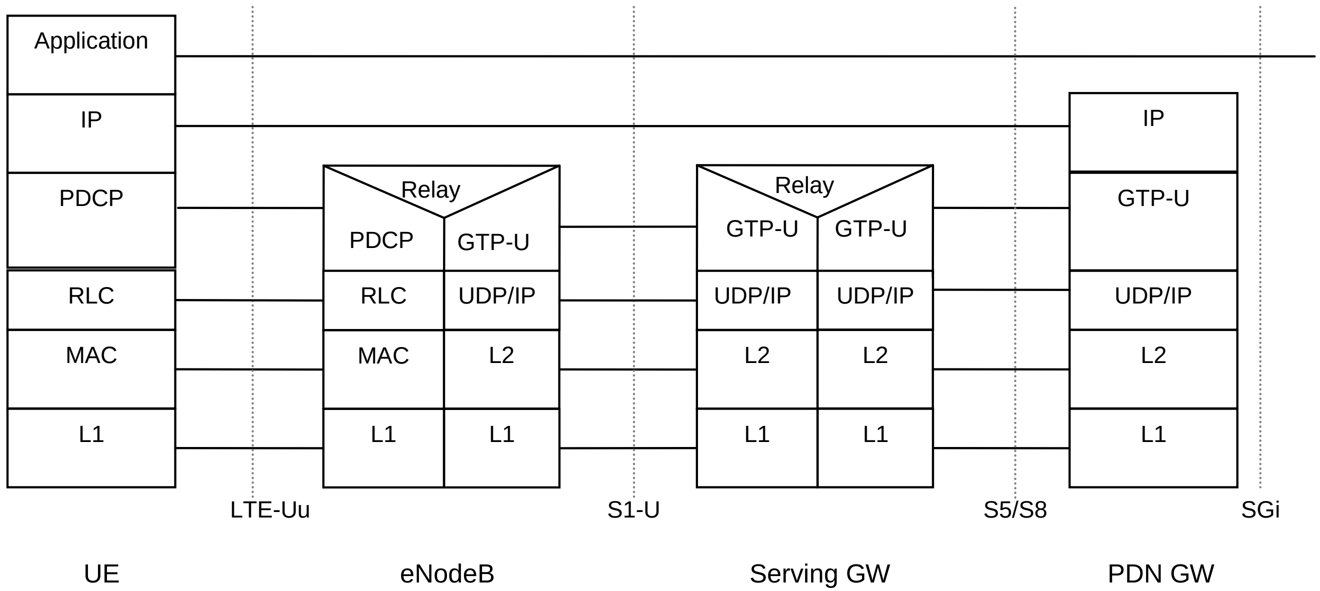


5G (Option 2)

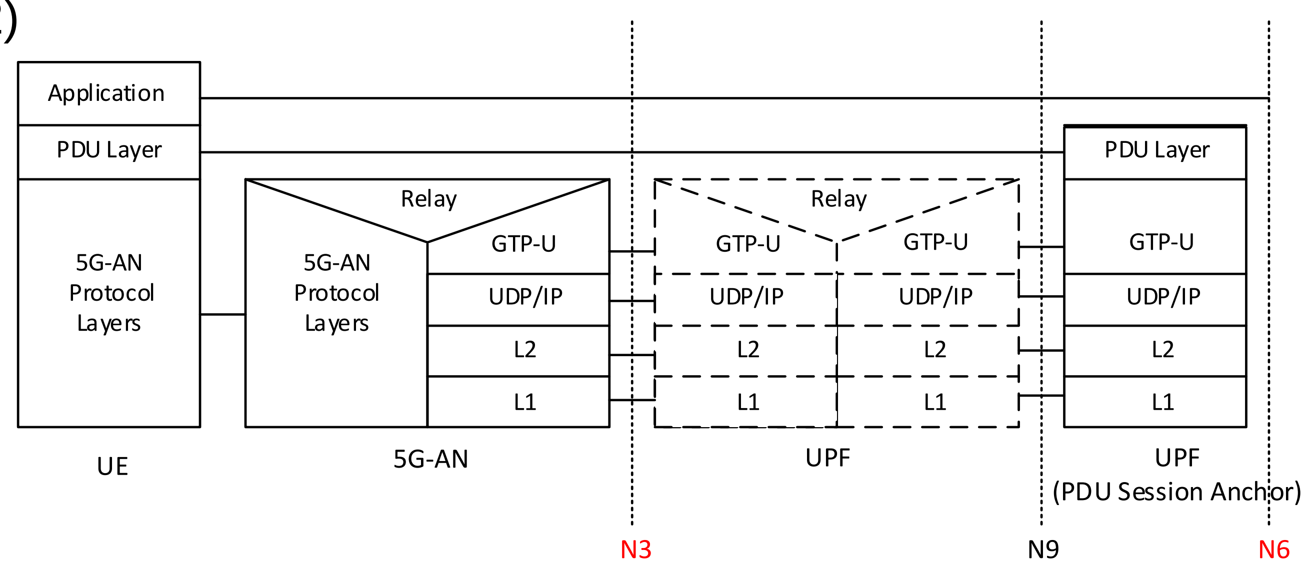


4G/5G User Plane Protocol Stack for 3GPP Access

4G (Option 1)



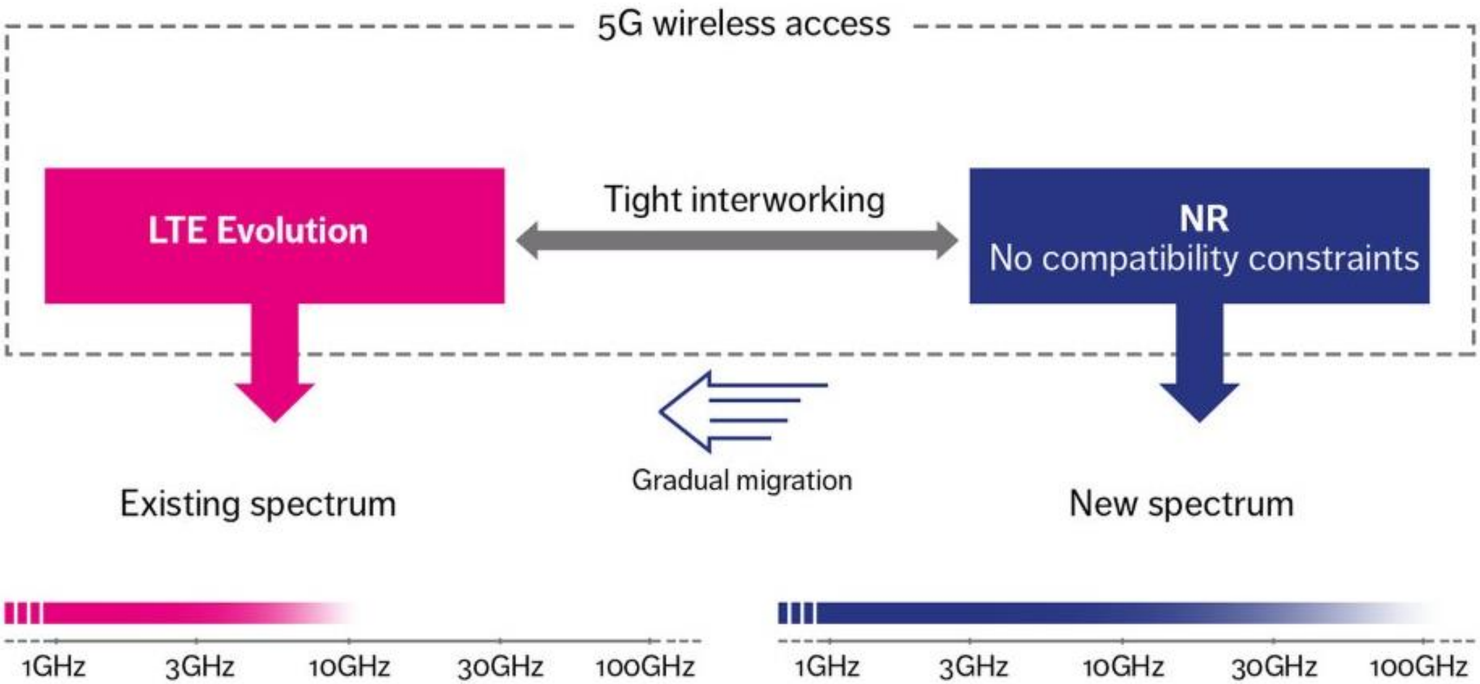
5G (Option 2)



Outline

- System Architecture for the 5G System (5GS)
  - Service-Based Architecture
  - Interworking with EPC
- Radio Access Networks
  - 5G New Radio (NR)
    - Physical Layer Structure
    - Initial Access and Mobility
    - Channel Coding and Modulation
    - Scheduling and Hybrid ARQ
  - 5G Xn Interface
- Core Networks
  - 5G Core Networks (5GC)
  - NG Interface

5G Radio Access Roadmap



- Two tracks
  - Evolution of LTE (Non Standalone)
  - New Radio (NR, LTE-5G)
    - Free from backward compatibility requirements / network slicing
    - Targeting spectrum at high (mm-wave) frequencies
- Two main features
  - FD-MIMO (Full-Dimension)
  - Unlicensed operations

5G NR

- Frequencies
  - FR1: Lower frequencies (below 6 GHz)
  - FR2: Higher Frequencies (above 24 GHz)
- Enabling Technologies

Scalable Numerology	Flexible Frame Structure	Advanced Channel Coding	Enhanced MIMO	Beam Forming
Single framework for f_c = sub 1-GHz – 50+ GHz Low latency* * One way latency ~ 1ms	Forward compatible design Flexible TDD	**LDPC** for high through-put low latency data channels. **Polar** codes for control channels.	Higher spectral efficiency MU-MIMO support	mmWave support Enhanced coverage

- R17 work areas under consideration

NR Light	Multi-SIM	IIoT/URLLC enhancements	NR-U Enhancements
Small data Enhancements	NR Multicast/ Broadcast	MIMO Enhancements	Power saving Enhancements
Sidelink Enhancements	Coverage Enhancements	NTN Enhancements	Data collection Enhancements
Above 52.6 GHz	NB-IoT Enhancements	IAB Enhancements	Positioning Enhancements

https://www.3gpp.org/news-events/partners-news/2061-atis-webinar-%E2%80%93-5g-standards-development

5G/NR MmWave Bands

5G/NR – mmWave

Band	Frequencies [GHz]	BW [MHz]	Duplex mode
n257	26.5–29.5	50–400	TDD
n258	24.25–27.5	50–400	TDD
n260	37.0–40.0	50–400	TDD
TBD	37.0–43.5	50–400	TDD

5G/NR Spectrum Below 6 GHz

5G/NR – Below 6 GHz			
Band	Frequencies [MHz]	BW [MHz]	Duplex mode
n77	3300–4200	10–100	TOD
n78	3300–3800	10–100	TOD
n79	4400–5000	40–100	TOD
n80	1710–1785/N/A	5–30	SUL
n81	880–915/N/A	5–20	SUL
n82	832–862/N/A	5–20	SUL
n83	703–748/N/A	5–20	SUL
n84	1920–1980/N/A	5–20	SUL

5G/NR Re-farmed Spectrum

5G/NR – Refarmed

Band	Identifier	Frequencies [MHz]	BW [MHz]
n1	IMF Core Band	1920–1980/2110–2170	5–20
n2	PCS 1900	1850–1910/1930–1990	5–20
n3	1800	1710–1785/1805–1880	5–30
n5	850	824–849/869–894	5–20
n7	IMF Extension	2500–2570/2620–2690	5–20
n8	900	880–915/925–960	5–20
n13	US 700 Upper C	777–787/746–756	tbd
n20	CEPT800	832–862/791–821	5–20
n25	PCS1900G	1850–1915/1930–1995	tbd
n26	E850 Upper	814–849/859–894	tbd
n28	APT 700	703–748/758–8035–20	5–20
n34	TDD 2000 Upper	2010–2025	tbd
n38	IMF Extension Gap	2570–2620	5–20
n39	China TDD 1900	1880–1920	tbd
n40	TDD 2300	2300–2400	tbd
n41	TDD 2600	2496–2690	10–100
n50	TDDL-band	1432–1517	5–80
n51	TDDL-band, local	1427–1432	5
n66	AWS Extension	1710–1780/2110–2200	5–40
n70	AWS-3/4	1695–1710/1995–2020	5–25
n71	US 600	663–698/617–652	5–20
n74	FDDL-band	1427–1470/1475–1517	5–20
n75	Extended SDL L-band	N/A/1432–1517	5–20
n76	Extended SDL L-band, local	N/A /1427–1432	5

5G NR Radio Interface Technology Components

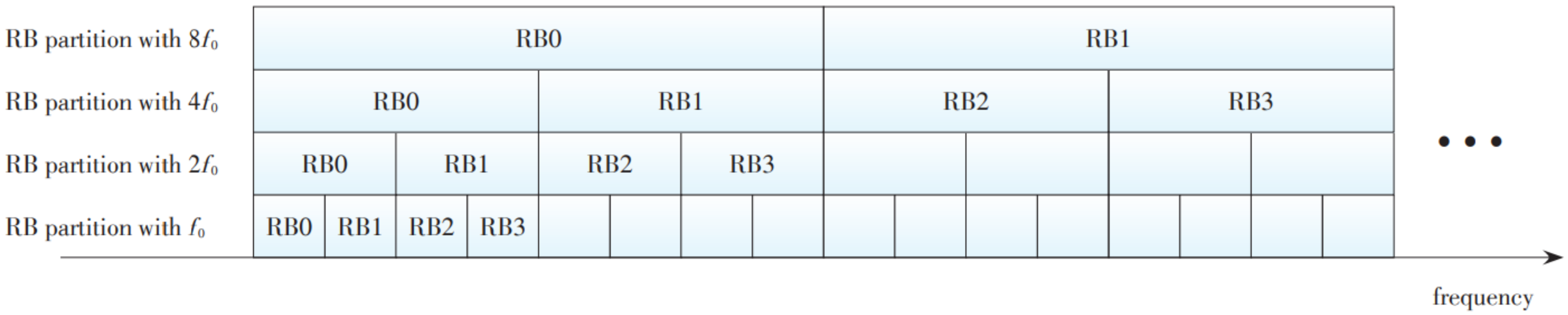
- Physical Layer Structure
- Initial Access and Mobility
- Channel Coding and Modulation
- Scheduling and Hybrid ARQ
- MIMO

Physical Layer Structure

- In NR, similar to LTE
  - A radio frame is fixed to be 10 ms
  - Which consists of 10 subframes each of 1 ms
- NR supports scalable numerology covering a wide range of services and carrier frequencies
  - Different from LTE which has a fixed **Sub-Carrier Spacing (SCS)** for 15 kHz
  - f_0 = 15 kHz * 2^m, where m = {0,1,2,3,4}, i.e., f_0 = {15,30,60,120,240} kHz
  - Sub-6 (6 GHz of lower): 15 kHz, 30 kHz and 60 kHz
  - Above 6 GHz: 60 kHz, 120 kHz and 240 kHz

Subframe Duration

- The subframe duration of 1ms is based on 15 kHz reference numerology with 14 symbols per subframe for the case of **Normal Cyclic Prefix (NCP)**
  - It is also called a slot for 15 kHz SCS
  - For other SCSs, 14-symbol per slot is always assumed for NCP (except for 240 kHz, where 28-symbol per slot is assumed for NCP)
- Illustration of nested RB-structure across numerologies
  - A 30 kHz SCS has a slot duration of 0.5 ms, which can be mapped to two slots (each of 0.25 ms) for a 60 kHz SCS
  - Moreover, frequency-alignment within the channel is also achieved via nested **Resource Blocks** (or **RB**s, each of 12 frequency-consecutive tones) structure across numerologies



NR Supports Up to Two DL/UL Switching Points in a Slot

- *Zero switching point* within a slot
  - Which implies 14 ‘DL’ symbols, 14 ‘flexible’ symbols, or 14 ‘UL’ symbols
  - The flexible symbols can be dynamically and UE-specifically indicated for DL or UL symbols based on actual need
- *One switching point* within a slot
  - Which starts with zero or more DL symbols and ends with zero or more UL symbols, with necessary ‘flexible’ symbols in between
- *Two switching points* within a slot
  - Where the first (or second) 7 symbols start with zero or more DL symbols and ends with at least one UL symbol at symbol #6, with zero or more ‘flexible’ symbols in between

Maximum Channel Bandwidth

- The maximum channel bandwidth supported by NR is 100 MHz for sub-6 and 400 MHz otherwise
  - Note that the maximum supported UL/DL channel bandwidth in the same band can be different
- The minimum channel bandwidth is 5 MHz for sub-6 and 50 MHz otherwise
  - New maximum channel bandwidths, if necessary, can be added in future releases as NR is designed to ensure forward compatibility
  - The channel bandwidth of a cell that can be utilized for communications is as high as 98%

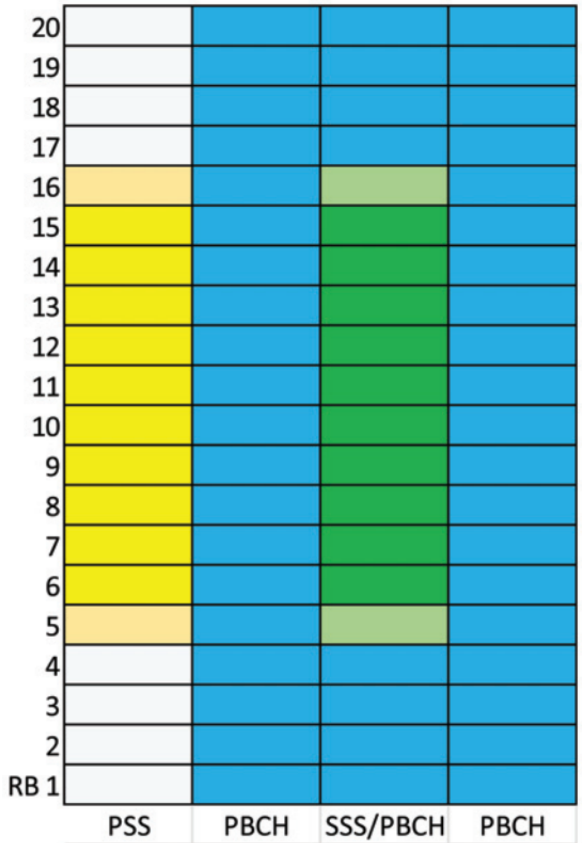
Initial Access and Mobility

- NR supports up to 1008 physical cell identities, twice as many as that of LTE
- It follows a similar two-step cell identification procedure as in LTE, via detection of primary synchronization signal (PSS) and secondary synchronization signal (SSS)
- Time synchronization (in terms of symbol-level and slot-level) and frequency synchronization are also realized via PSS/SSS

Master Information Block (MIB) for Initial Access

- Master information block (MIB) of a cell is detected via a channel called primary broadcast channel (PBCH)
  - System frame number (SFN) synchronization is acquired accordingly
- PBCH demodulation enables reception of subsequent physical downlink control channels (PDCCH) and physical downlink shared channels (PDSCH)
  - Which schedule remaining minimum system information (RMSI), other system information (OSI), and paging messages

SS Block and SS Burst Set



RB – Resource Block
PSS - Primary Synchronization Signal
SSS - Secondary Synchronization Signal
PBCH - Primary Broadcast Channel
SSB - Synchronization Signal Block

- For initial access, an essential building block called **Synchronization Signal Block (SSB)** is defined
  - A 4-symbol SSB consists of a 1-symbol PSS, a 1-symbol SSS, and a 2-symbol (and a bit extra) PBCH
  - Frequency range
    - sub-6 GHz: 15 kHz or 30 kHz for SSB
    - above-6 GHz: 120 kHz or 240 kHz for SSB

- A **SS burst set** is comprised of a set of SS blocks (SSB)
  - Each SS burst set is limited to a 5 ms window regardless of the periodicity, which can be {5, 10, 20, 40, 80, 160} ms as indicated in RMSI, configured for SS burst sets
  - For initial cell selection, the SS burst set periodicity is default at 20 ms for all frequency range

Tones of SS

- Both the number of SS blocks (L) within a SS burst set and the location of SS burst set within the 5 ms window depend on the carrier frequency range. As an example,
  - For carrier frequency range up to 3 GHz, L = 4
  - For carrier frequency range from 3 GHz to 6 GHz, L = 8
  - For carrier frequency range from 6 GHz to 52.6 GHz, L = 64
- The number of possible PSS sequences is 3, each of a frequency-domain BPSK length-127 M-sequence
  - SSS sequence also has a length of 127 and it is a scrambled M-sequence
- Both PSS and SSS are mapped to 127 consecutive tones within 12 RBs, where among the 144 tones, 8 tones and 9 tones are reserved on the two sides respectively (144 = 8 + 127 + 9)
  - A 56-bit payload PBCH (including CRC) is mapped to a total of 240 tones
- PBCH has a transmit-time-interval (TTI) of 80 ms
  - PBCH contents, including information such as SFN, SSB index, raster offset, default DL numerology, RMSI configuration, DM-RS location, etc., are updated every 80 ms
  - PSS, SSS, and PBCH are all one port only and share the same port

Paging

- A UE is explicitly signalled paging occasion configuration
  - e.g., time offset, duration, periodicity, etc

- Paging CORESET reuses the same configuration for RMSI CORESET
- Two paging mechanisms are supported:
  - Paging is done via PDSCH scheduled PDCCH, both channels in the same slot
  - Paging is done via PDCCH only, useful for short paging messages

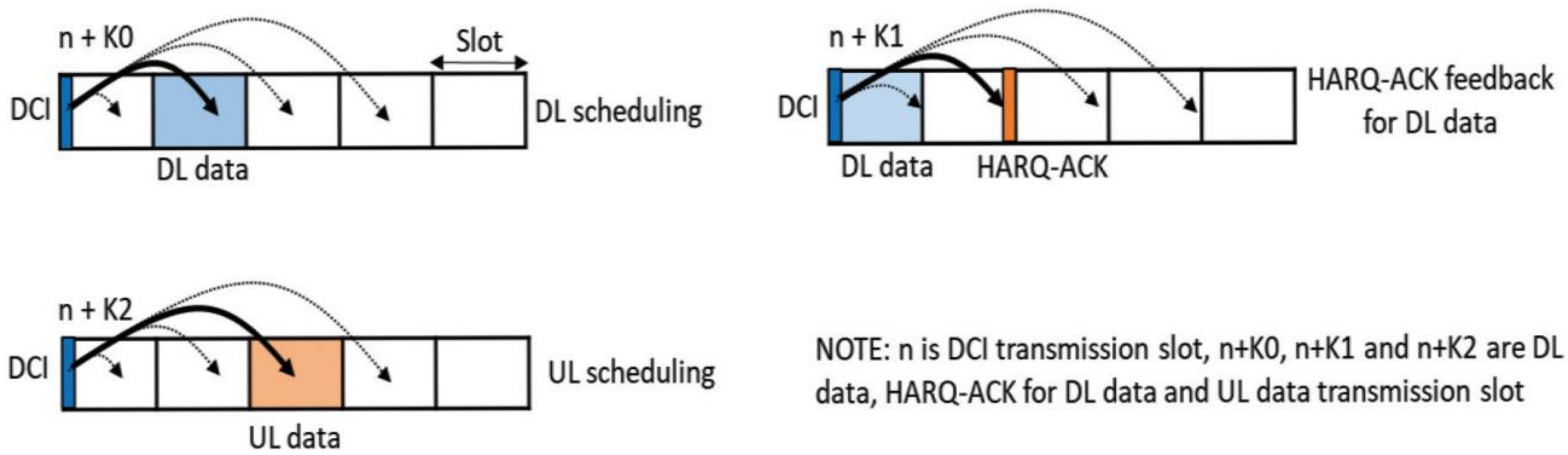
Random Access (RA)

- Enables a UE to access a cell
- It is performed by a 4-step procedure, similar to LTE
  - Message 1 (RA channel preamble): UE → gNB
    - It is based on Zadoff-Chu sequence with two sequence lengths, called long sequences and short sequences
    - Both contention-based RA (CBRA) and contention-free based RA (CFRA) are supported
    - One or multiple SSBs can be mapped to one PRACH transmission occasion
  - Message 2 (Random access response or RAR): gNB → UE
    - It carries information such as TA commands, temporary ID, etc.
  - Message 3 (First PUSCH transmission): UE → gNB
    - It is scheduled by the UL grant in RAR
  - Message 4 (PDCCH/PDSCH): gNB → UE

Differences between NR and LTE

- Highly symmetric properties in the downlink and uplink scheduling and HARQ
  - Hybrid Automatic Repeat Request (FEC + ARQ)
  - In LTE, radio resource allocation schemes are different between downlink and uplink due to different multi access schemes, and downlink HARQ is basically asynchronous and adaptive while uplink HARQ is synchronous and non-adaptive
  - In NR, almost all scheduling and HARQ mechanisms are common between downlink and uplink such as:
    (1) radio resource allocation schemes
    (2) Rank/modulation/coding adaptations
    (3) asynchronous and adaptive Hybrid ARQ
- High flexibility in the time-domain
  - In LTE, time-domain radio resources for scheduled data and/or HARQ-feedback are basically not informed by the scheduling DCI, and it is determined by the frame structure and the UL-DL configuration
  - In NR, the scheduling DCI basically includes time-domain information of the scheduled data (and time-domain information of HARQ-ACK feedback in case of downlink) where the time-domain information here refers to the combination of the scheduled slot, the start symbol position, and the transmission duration

Scheduling and Hybrid ARQ



- NR can easily realize various operations
  - e.g., full/half duplex FDD, dynamic/semi-static TDD, and unlicensed operation etc.
- Satisfy different UE's requirements
  - e.g., lower latency, higher data rates

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- System Architecture for the 5G System (5GS)
  - Service-Based Architecture
  - Interworking with EPC
- Radio Access Networks
  - 5G New Radio (NR)
  - 5G Xn Interface
    - General Aspects and Functions
    - Protocol Stack and Procedures
- Core Networks
  - 5G Core Networks (5GC)
  - NG Interface

5G Xn Interface

The Xn interface is defined between two NG-RAN nodes

- Xn-C: control plane interface
  - The transport network layer is built on SCTP on top of IP
    - The SCTP layer provides the guaranteed delivery of application layer messages
  - XnAP (Xn Application Protocol): the application layer signalling protocol
  - Functions
    - Xn interface management
    - UE mobility management, including context transfer and RAN paging
    - Dual connectivity
- Xn-U: user plane interface
  - GTP-U is used on top of UDP/IP to carry the user plane PDUs
  - Xn-U provides non-guaranteed delivery of user plane PDUs
  - Functions
    - Data forwarding
    - Flow control

Xn Interface General Aspects

- The general principles for the specification of the Xn interface are as follows:
  - The Xn interface is open
  - The Xn interface supports the exchange of signalling information between two NG-RAN nodes, and the forwarding of PDUs to the respective tunnel endpoints
  - From a logical standpoint, the Xn is a point-to-point interface between two NG-RAN nodes
  - A point-to-point logical interface should be feasible even in the absence of a physical direct connection between the two NG-RAN nodes

Xn Interface Specification Objectives

- The Xn interface specifications facilitate the following:
  - Inter-connection of NG-RAN nodes supplied by different manufacturers
  - Support of continuation between NG-RAN nodes of the NG-RAN services offered via the NG interface
  - Separation of Xn interface Radio Network functionality and Transport Network functionality to facilitate introduction of future technology

Xn Interface Capabilities

- The Xn interface supports:
  - Procedures to support intra-NG-RAN mobility
  - Procedures to support dual connectivity between NG-RAN nodes

Functions of Xn-C

- Xn-C interface management and error handling functions
  - Xn Setup function
  - Error Indication function
  - Xn reset function
  - Xn configuration data update function
  - Xn removal function
- UE mobility management functions
  - Handover preparation function
  - Handover cancellation function
  - Retrieve UE Context function
  - RAN Paging function
  - Data Forwarding control function

Functions of Xn-C(cont.)

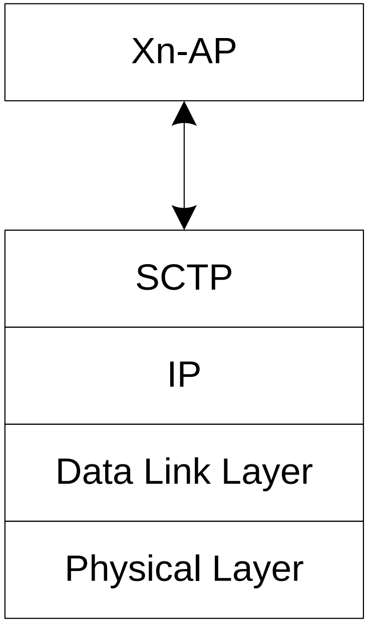
- Dual connectivity function
  - The dual connectivity function enables usage of additional resources in a secondary node in the NG-RAN
- Energy saving function
  - This function enables decreasing energy consumption by indication of cell activation/deactivation over the Xn interface
- Resource coordination function
  - This function enables coordination of cell resource usage between two NG-RAN nodes
- Secondary RAT Data Volume Report function
  - This function enables the NG-RAN node to report Secondary RAT usage data information in case of MR-DC with 5GC, either with a dedicated procedure or by including Secondary RAT usage data information in other messages

Functions of Xn-U

- Data transfer function
  - The data transfer function allows the transfer of data between NG-RAN nodes to support dual connectivity or mobility operation
- Flow control function
  - The flow control function enables a NG-RAN node receiving user plane data from a second NG-RAN node to provide feedback information associated with the data flow
- Assistance information function
  - The assistance information function enables a NG-RAN node receiving user plane data from a second NG-RAN node to provide assistance information to the second node (e.g. related to radio conditions)
- Fast retransmission function
  - The fast retransmission function provides coordination between PDCP-hosting node and corresponding node in case of outage in one of the nodes, to enables the node in good RF conditions to handle data previously forwarded to the node in outage

Xn-C Protocol Stack

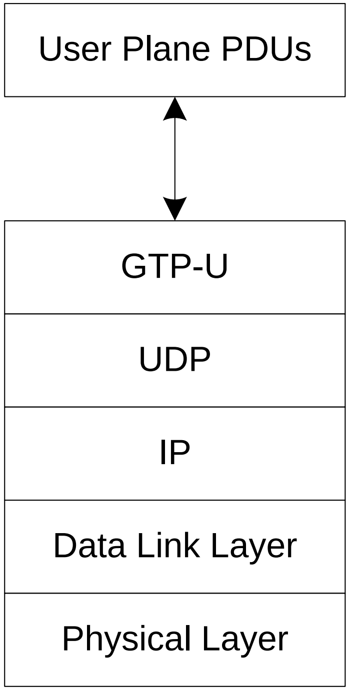
- The Xn control plane interface (Xn-C) is defined between two NG-RAN nodes
- The control plane protocol stack of the Xn interface
- The transport network layer is built on SCTP on top of IP
- The application layer signalling protocol is referred to as XnAP (Xn Application Protocol)



- The Xn-C interface supports the following functions:
  - Xn interface management
  - UE mobility management, including context transfer and RAN paging
  - Dual connectivity

Xn-U Protocol Stack

- The Xn User plane (Xn-U) interface is defined between two NG-RAN nodes
- The user plane protocol stack on the Xn interface
- The transport network layer is built on IP transport and GTP-U is used on top of UDP/IP to carry the user plane PDUs



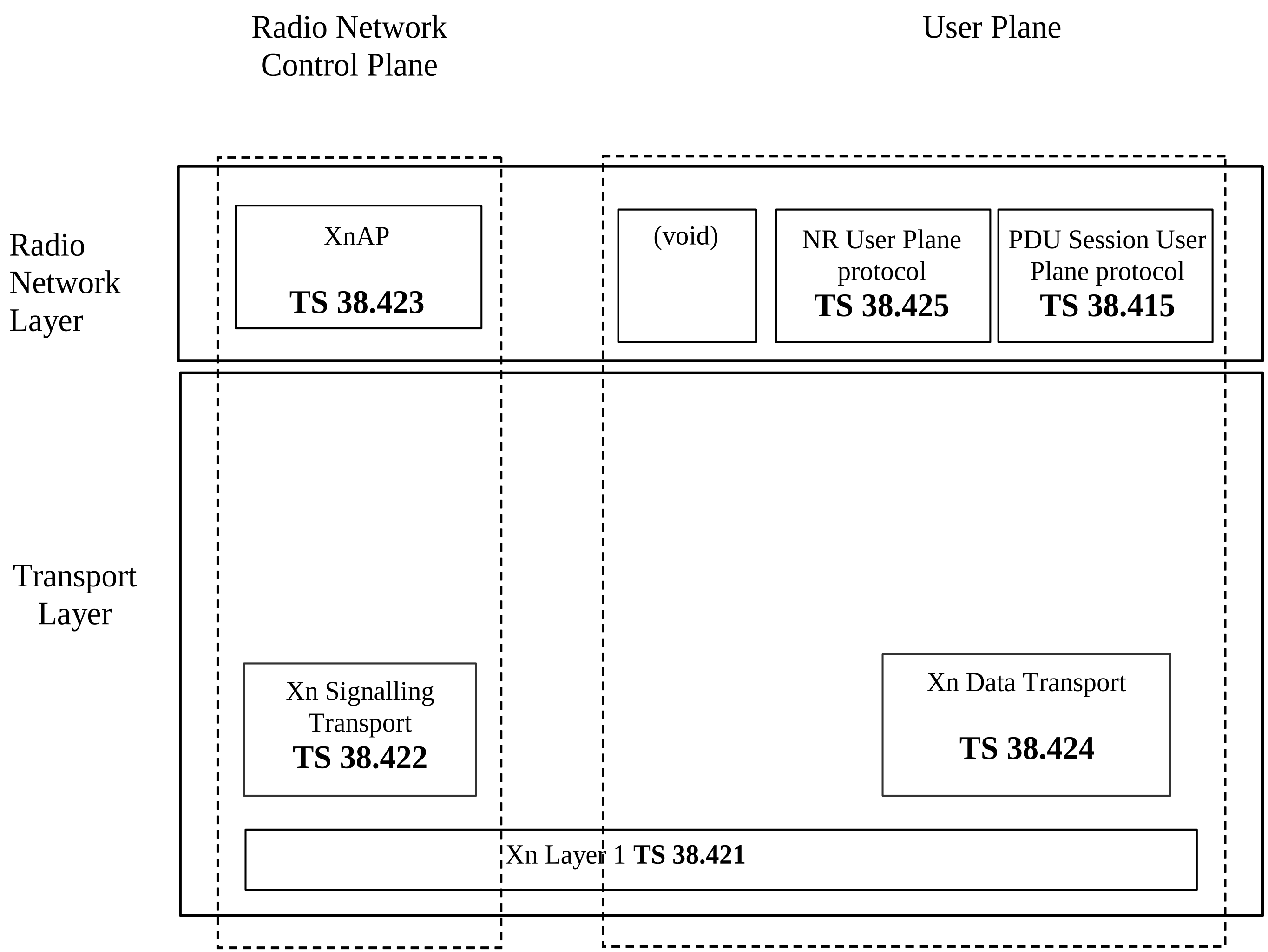
- Xn-U provides non-guaranteed delivery of user plane PDUs and supports the following functions:
  - Data forwarding
  - Flow control

Mapping between Container Fields and Xn User Plane Procedures / Functions

Xn-U Function	Container Type	Xn UP Protocol Procedure
Data transfer	NR RAN Container	Transfer of Downlink User Data
	PDU Session Container	Transfer of DL PDU Session Information Transfer of UL PDU Session Information
	No container	NA
Flow control	NR RAN Container	Downlink Data Delivery Status Transfer of Downlink User Data
Fast retransmission	NR RAN Container	Downlink Data Delivery StatusTransfer of Downlink User Data
Assistance information	NR RAN Container	Transfer of Assistance Information

Note 1: optionally used in Dual Connectivity DL data transfer
Note 2: in case of PDU Session level forwarding only
Note 3: all other cases of data transfer when no other Xn-U functionality is required
Note 4: optionally used in Dual Connectivity

Xn Interface Technical Specifications



Xn Interface Procedures

- Control plane protocol procedures
  - Mobility management procedures
    - Handover Preparation
    - Handover Cancel
    - SN Status Transfer
    - Retrieve UE Context
    - RAN Paging
    - Xn-U Address Indication
    - UE Context Release
  - Dual Connectivity procedures
    - S-NG-RAN-node Addition Preparation
    - S-NG-RAN-node Reconfiguration Completion
    - M-NG-RAN-node initiated S-NG-RAN-node Modification Preparation
    - S-NG-RAN-node initiated S-NG-RAN-node Modification
    - M-NG-RAN-node initiated S-NG-RAN-node Release
    - S-NG-RAN-node initiated S-NG-RAN-node Release
    - S-NG-RAN-node Counter Check
    - RRC Transfer
    - Notification Control Indication
    - Activity Notification
    - Secondary RAT Data Usage Report

Xn Interface Procedures (cont.)

- Control plane protocol procedures
  - Global procedures
    - Xn Setup
    - NG-RAN-node Configuration Update
    - Xn Removal
  - Interface Management procedures
    - Reset
    - Error Indication
  - Energy saving procedures
    - Cell Activation procedure: enables an NG-RAN node to request the activation of a previously deactivated cell hosted in another NG-RAN node.
  - Resource coordination procedures
    - E-UTRA - NR Cell Resource Coordination procedure: enables an ng-eNB and a gNB to interact for resource coordination purposes

Xn Interface Procedures(cont..)

- User plane protocol procedures
  - The user plane protocol procedures are used to exchange user plane information between Xn-U protocol peers:
    - Transfer of Downlink User Data procedure: enables the node hosting the NR PDCP entity to provide user plane information to the corresponding node
    - Downlink Data Delivery Status procedure: enables the corresponding node to provide feedback to the node hosting the NR PDCP entity
    - Transfer of Assistance Information: enables the corresponding node to provide assistance information to the node hosting the NR PDCP entity
    - Transfer of PDU Session Information procedure: enables an NG-RAN node to provide user plane information associated with the forwarding of data towards a peer NG-RAN node, when using PDU session tunnels

Mobility Management Procedures

- The mobility management procedures are used to manage the UE mobility in Connected or RRC_Inactive modes:
  - Handover Preparation
  - Handover Cancel
  - SN Status Transfer
  - Retrieve UE Context
  - RAN Paging
  - Xn-U Address Indication
  - UE Context Release

Dual Connectivity Procedures

- The dual connectivity procedures are used to add, modify and releases resources for the operation of Dual Connectivity:
  - S-NG-RAN-node Addition Preparation
  - S-NG-RAN-node Reconfiguration Completion
  - M-NG-RAN-node initiated S-NG-RAN-node Modification Preparation
  - S-NG-RAN-node initiated S-NG-RAN-node Modification
  - M-NG-RAN-node initiated S-NG-RAN-node Release
  - S-NG-RAN-node initiated S-NG-RAN-node Release
  - S-NG-RAN-node Counter Check
  - RRC Transfer
  - Notification Control Indication
  - Activity Notification
  - Secondary RAT Data Usage Report

Global Procedures

- The global procedures are used to exchange configuration level data between two NG-RAN nodes, or to remove Xn connectivity between two NG-RAN nodes in a controlled manner:
  - Xn Setup
  - NG-RAN-node Configuration Update
  - Xn Removal

Interface Management Procedures

- The interface management procedures are used to align resources between two NG-RAN nodes in the event of failures, and to report detected protocol errors:
  - Reset
  - Error Indication

Resource Coordination Procedures

- E-UTRA - NR Cell Resource Coordination procedure: enables an ng-eNB and a gNB to interact for resource coordination purposes

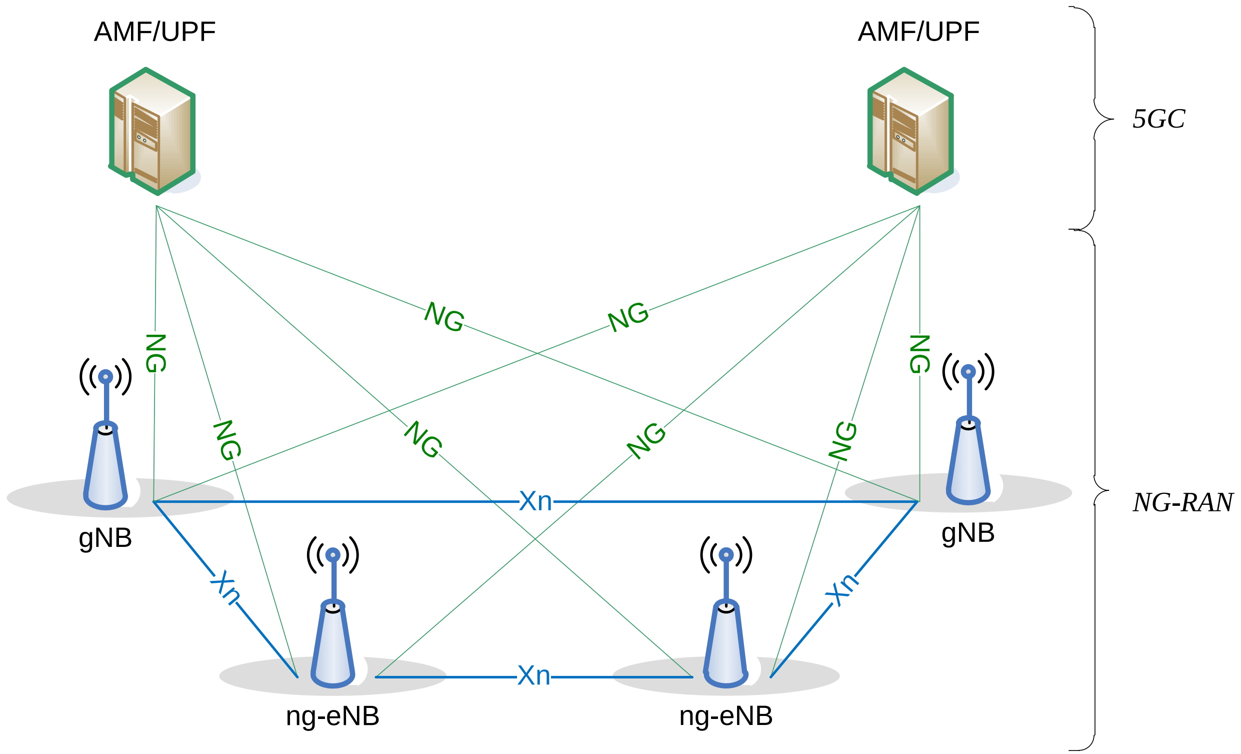
User Plane Protocol Procedures

- The user plane protocol procedures are used to exchange user plane information between Xn-U protocol peers:
  - Transfer of Downlink User Data procedure: enables the node hosting the NR PDCP entity to provide user plane information to the corresponding node
  - Downlink Data Delivery Status procedure: enables the corresponding node to provide feedback to the node hosting the NR PDCP entity
  - Transfer of Assistance Information: enables the corresponding node to provide assistance information to the node hosting the NR PDCP entity
  - Transfer of PDU Session Information procedure: enables an NG-RAN node to provide user plane information associated with the forwarding of data towards a peer NG-RAN node, when using PDU session tunnels

Outline

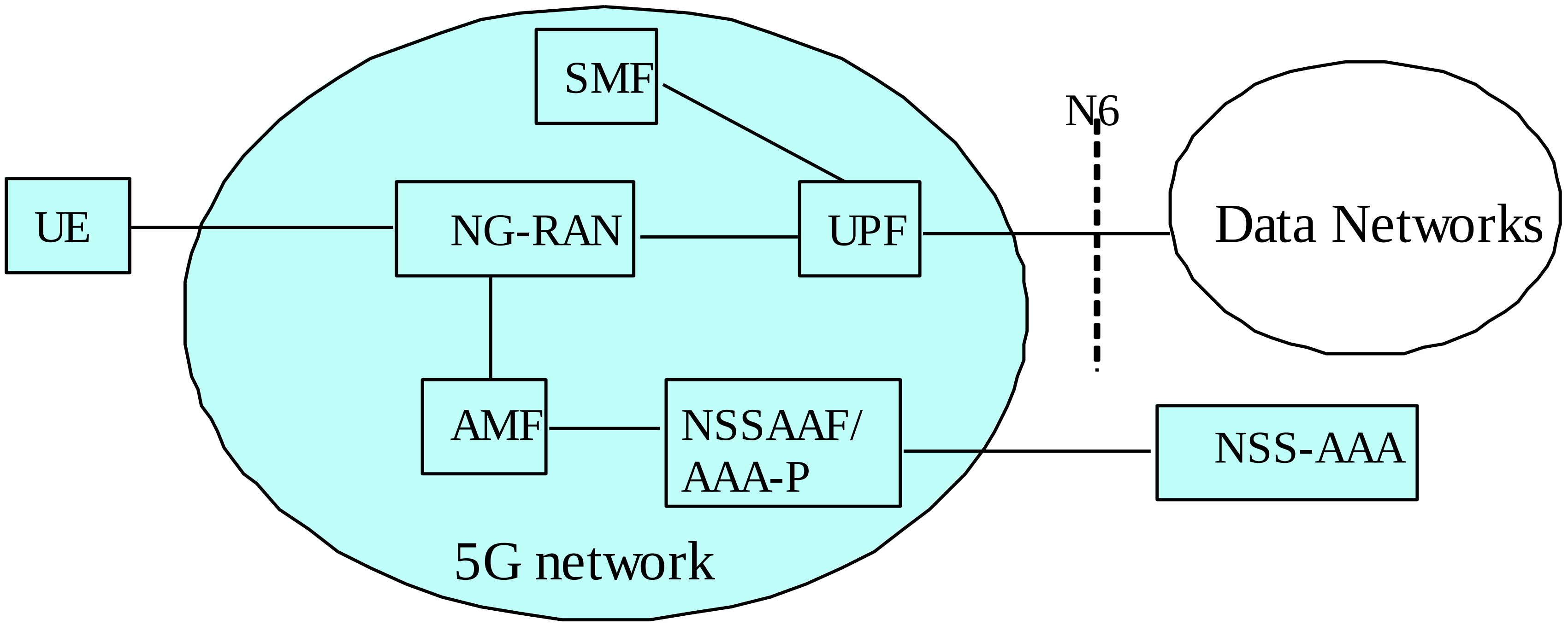
- System Architecture for the 5G System (5GS)
  - Service-Based Architecture
  - Interworking with EPC
- Radio Access Networks
  - 5G New Radio (NR)
  - 5G Xn Interface
- Core Networks
  - 5G Core Networks (5GC)
    - Overview of Core Networks
    - 5GC Architectures
  - NG Interface

5GS (NG-RAN) Overall Architecture



- An NG-RAN node is either
  - A gNB, providing NR user plane and control plane protocol terminations towards the UE
  - An ng-eNB, providing E-UTRA user plane and control plane protocol terminations towards UE
- The gNBs and ng-eNBs are interconnected with each other by the Xn interface
- The gNBs and ng-eNBs are connected by means of the NG interfaces to the 5GC
  - More specifically to the AMF (Access and Mobility Management Function) by means of the NG-C interface and to the UPF (User Plane Function) by means of the NG-U interface (TS 23.501)

Reference Architecture for 5G Network Interworking

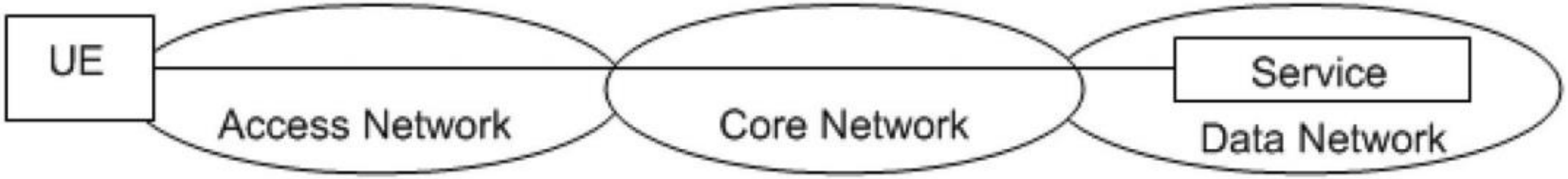


- The access interfaces for the 5G network includes both the 3GPP access and the non-3GPP access
- The NSS-AAA may belong to the H-PLMN in the 5G Network (without AAA-P interworking) or a 3rd party (with AAA-P interworking)

A Simple Model of Service Access Using the 3GPP System

- The purpose of the 3GPP system is to efficiently provide terminals, referred to as User Equipment (UE), with access to services (voice, text, data, etc.) available in data networks

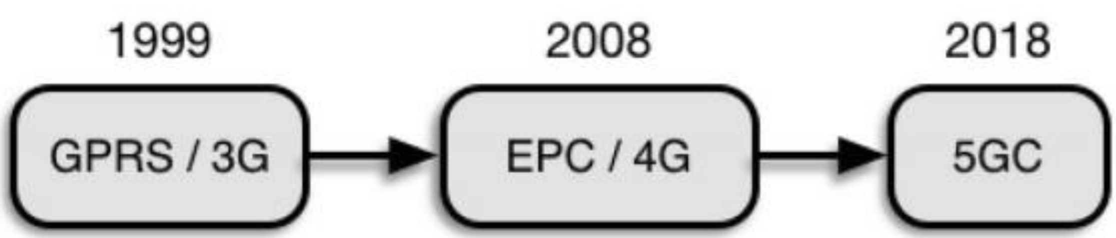
- The following figure shows that UE access to the Data Network involves two other distinct networking domains: the Access Network (e.g. Radio Access Network) and Core Network (GPRS, EPC or 5GC.)



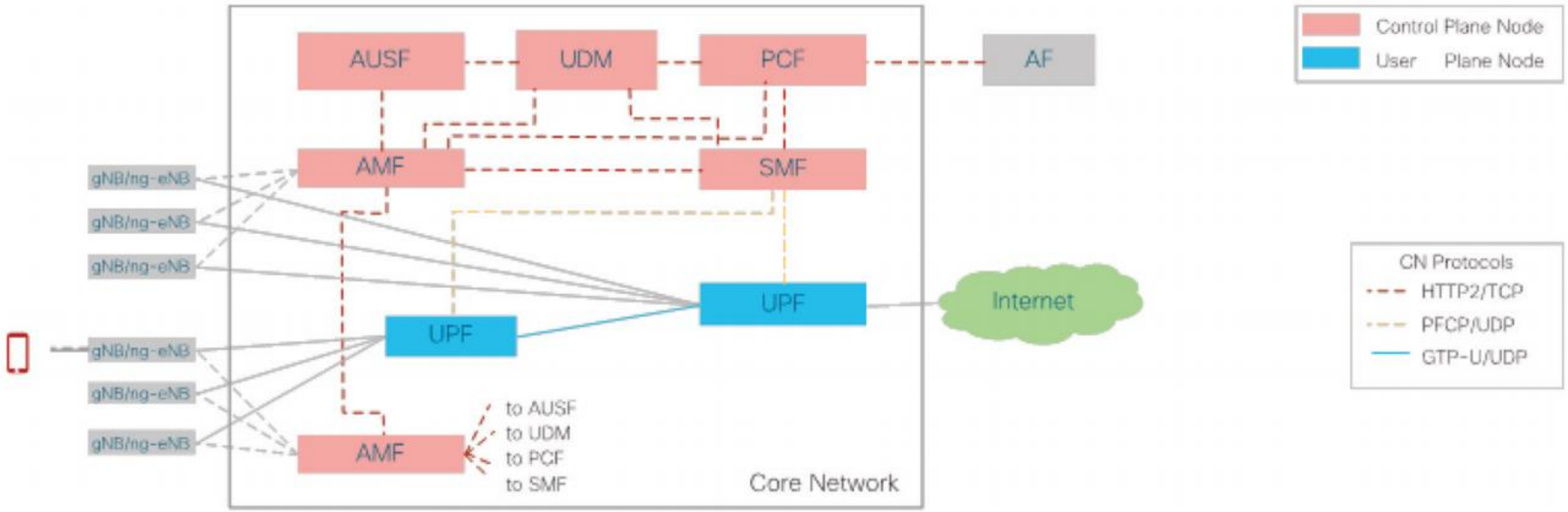
Core Network Evolution through Generations

- network, the UE can register with the network
- Millions of these devices must be supported, even as they periodically cease communication or leave coverage, so that data and other services can be delivered at the first opportunity, both to the UE and from the UE
- Within the Core Network, control plane interactions occur as needed, associated with each UE registered with the network
- It is therefore imperative that the control plane interactions occur efficiently

- The Core Network supports several functions:
  - most essentially access control
  - data packet routing and forwarding
  - mobility management
  - radio resource management
  - UE reachability functions

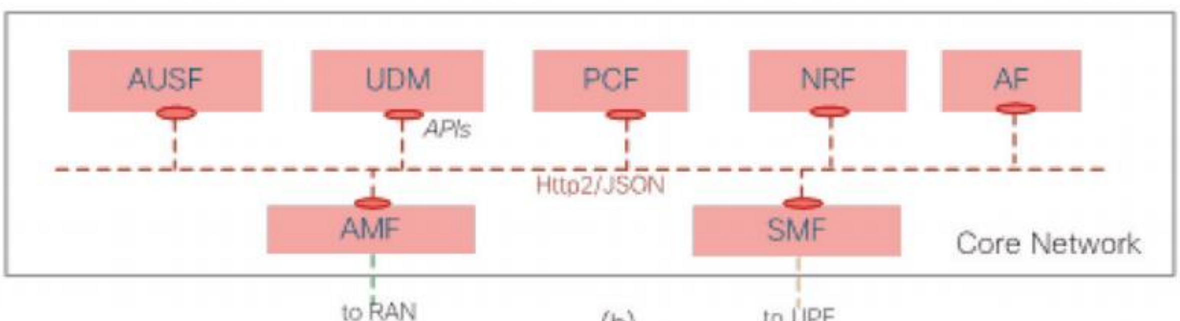


5G Core Network.
(a) Interface Representation



- The 5GC, also separates the control plane and user plane
- The Access and Mobility Management Function (AMF) provides mobility management functions, analogous to mobility management functionsof the MME
- The session management functions of the MME are separated out and combined with the data plane control functions of the SGW and GPW to create the Session Management Function (SMF)
- Thus the AMF, unlike the MME, does not include session management aspects

5G Core Network.
(b) API Level Representation

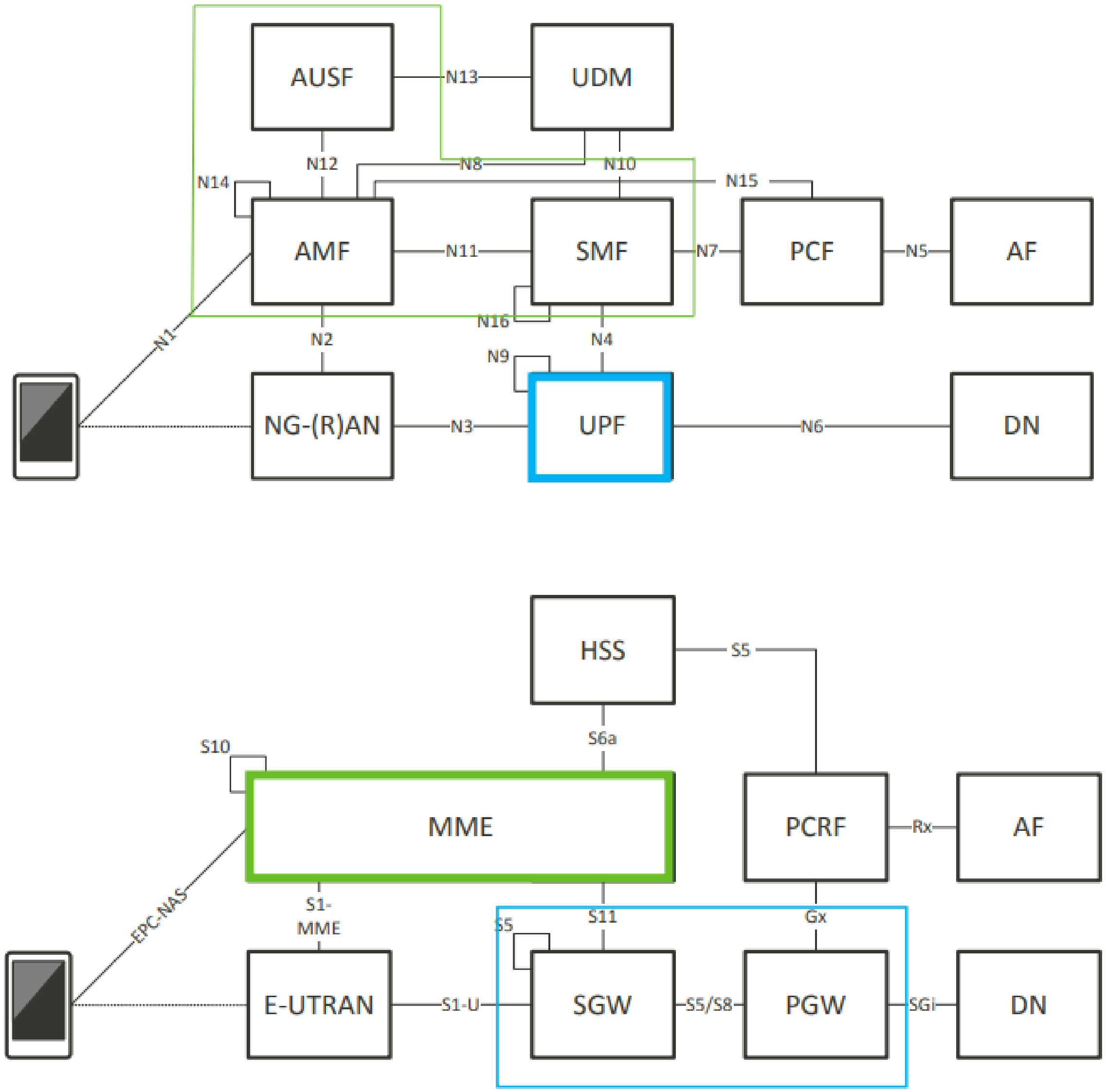


(b)

AF	Application Function
AMF	Access and mobility management Function
AUSF	Authentication Server Function
NRF	Network function Repository Function
PCF	Policy Control Function
PFCP	Packet Forwarding Control Protocol
SMF	Session Management Function
UDM	Unified Data Management
UPF	User Plane Function

- In the 5GC, session management aspects of control messages from the UE are terminated by the SMF, whereas in the EPC, these would be terminated by the MME
- One advantage of this mobility management and session management separation is that AMF can be adapted for non-3GPP access networks also
- The session management aspects are very access specific and hence are specified initially for the Next Generation Radio Access Network (NG-RAN.)

EPC <> 5GC


AUSF
N13
UDM
N12
N8
N10
N14
N15
AMF
N11
SMF
N7
PCF
N5
AF
N1
N16
N2
N4
N9
NG-(R)AN
N3
UPF
N6
DN
HSS
S5
S6a
S10
MME
PCRF
Rx
AF
EPC-NAS
S1-
MME
S11
S5
Gx
E-UTRAN
S1-U
SGW
S5/S8
PGW
SGi
DN

EPC<>5GC Correspondence

EPC <> 5GC Correspondence

EPC		5GC
MME	↔	AMF + SMF + AUSF
SGW	↔	UPF
PGW	↔	UPF
PCRF	↔	PCF
HSS	↔	UDM

EPC		5GC
EPC-NAS	↔	N1
S1-MME	↔	N2
S1-U	↔	N3
S11	↔	N4
Rx	↔	N5
SGi	↔	N6

5G Core Network

- Another important development in successive releases is a consolidation of the number of protocols used between functions in the control plane of the system
- More importantly, in 5GC the protocol for interaction between all control-plane entities is HTTP
  - which is a protocol widely used in the Internet and not telecom-specific like dedicated Diameter applications or GTP-C

Service Based Architecture

- A key advance in the 5GC architecture is the introduction of the service based architecture
- In GPRS and EPC control plane design
  - procedures defined all interactions between network functions as a series of message exchanges, carried out by protocol interactions
- In the 5GC
  - network functions employing the Service Based Architecture offer and consume services of other network functions
  - Allowing any other network function to consume services offered by a network function enables direct interactions between network functions
- In the past, several kinds of interactions piggybacked (or reused) messages exchanged along general purpose paths, since a direct interface does not exist between the consumer and producer network function

Service Based Architecture (cont.)

- The Policy Control Function (PCF)
  - can directly subscribe to location change service offered by the AMF rather than having to have this event proxied via the SMF
- In the EPC,
  - by contrast, analogous information followed a hop by hop path from the MME, to the SGW, to the PGW and finally the Policy and Charging Rules Function (PCRF)

- There are other advantages at the protocol level
  - e.g. uniformity of network protocols leading to simpler implementations, use of modern transport and application protocol frameworks that are more extensible and efficient, etc.

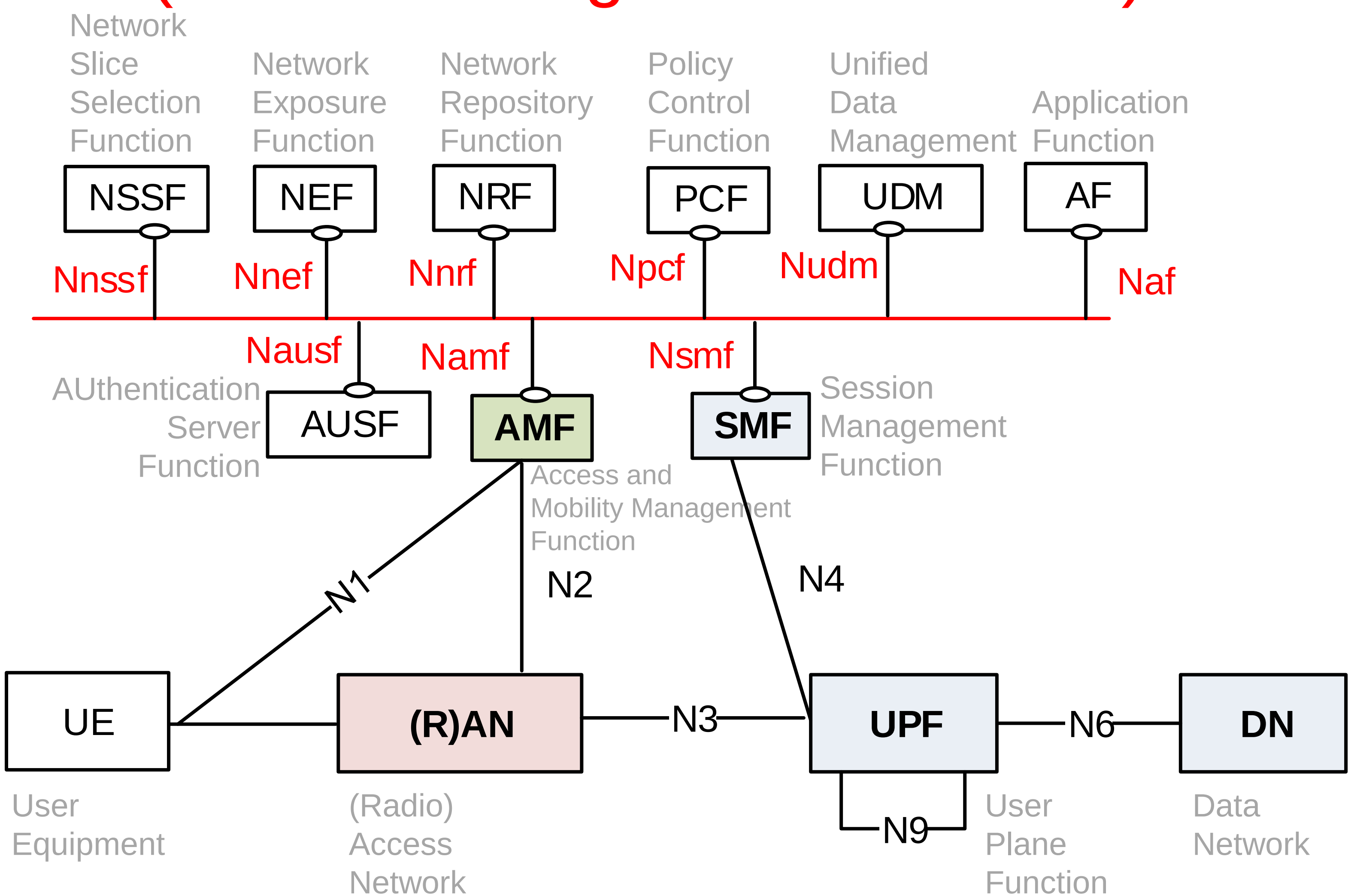
State Management is an 5GC Area

- GPRS and EPC control entities defined state associated with a registered UE, called “context.” This information, both subscription information retrieved from the HSS, and dynamic information corresponding to the registered UE is stored in the SGSN and GGSN in the GPRS architecture and the MME, SGW and PGW in the EPC
- As the UE moves, the SGSN (in GPRS) or MME and SGW (in EPC) may be relocated:
  - new serving nodes may be selected. This procedure requires the ‘context’ to be transferred between the old and new entity, and additional state to be fetched
  - e.g. the subscription data to the new MME

State Management is an 5GC Area (cont.)

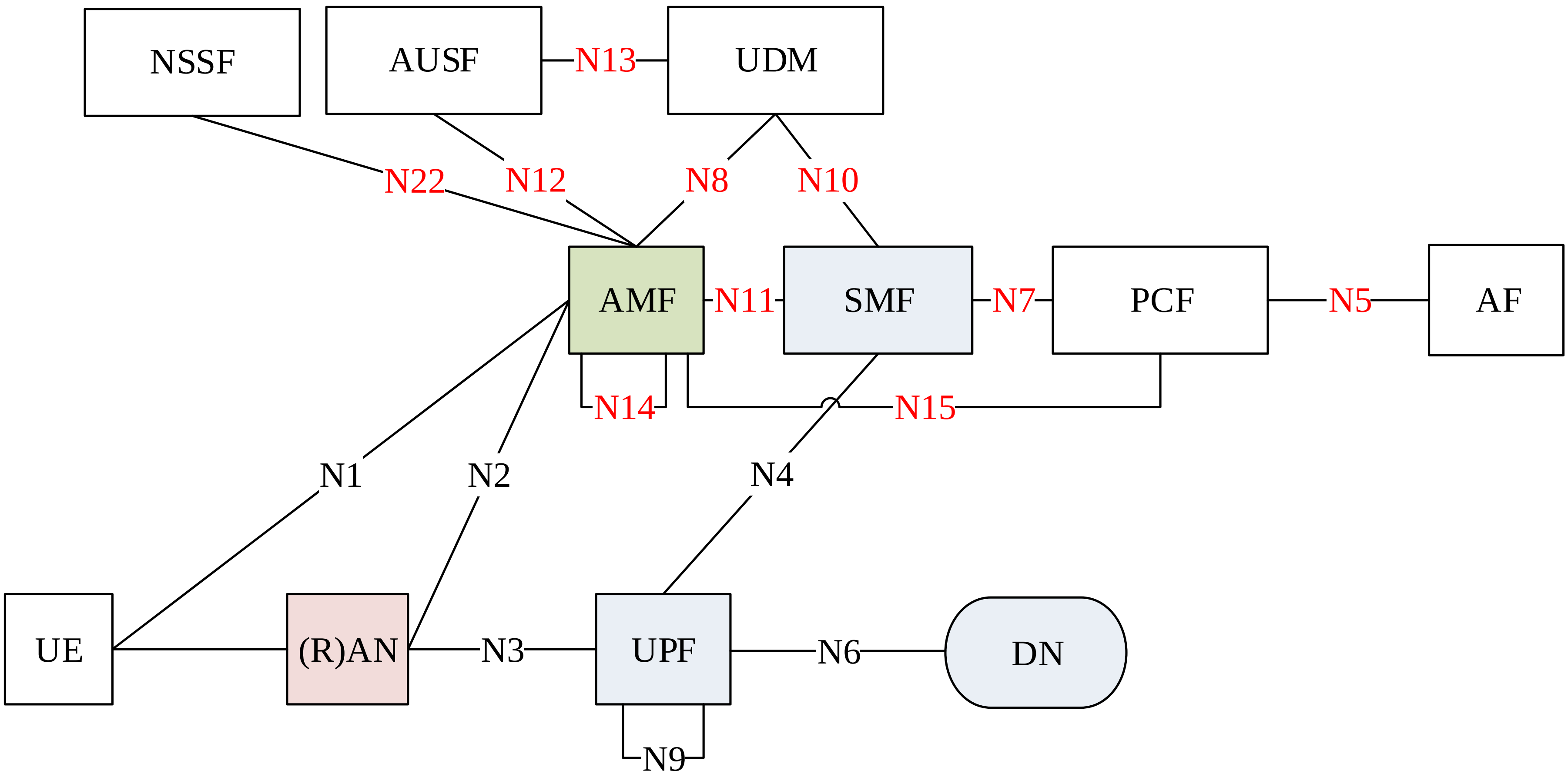
- In the 5GC, state may be stored centrally
- This can ease network function implementations in which state storage per network function and context transfer between network functions are not desirable
- In Rel-15, procedures for AMF relocation specify context transfer procedures, as in 3G and 4G
- In future, use of centralized storage may be defined to eliminate this requirement
- Also in Rel-15, the centralized Unified Data Management (UDM) function is employed for some procedures for retrieval of state
  - for example, in the Registration with AMF-reallocation procedure
  - In this procedure, per slice subscriber data including access and mobility information is stored by the initial AMF and retrieved by the target AMF

5G System Architecture (Non-Roaming Service-Based)



The non-roaming reference architecture with service-based interfaces used within the Control Plane (TS23.501)

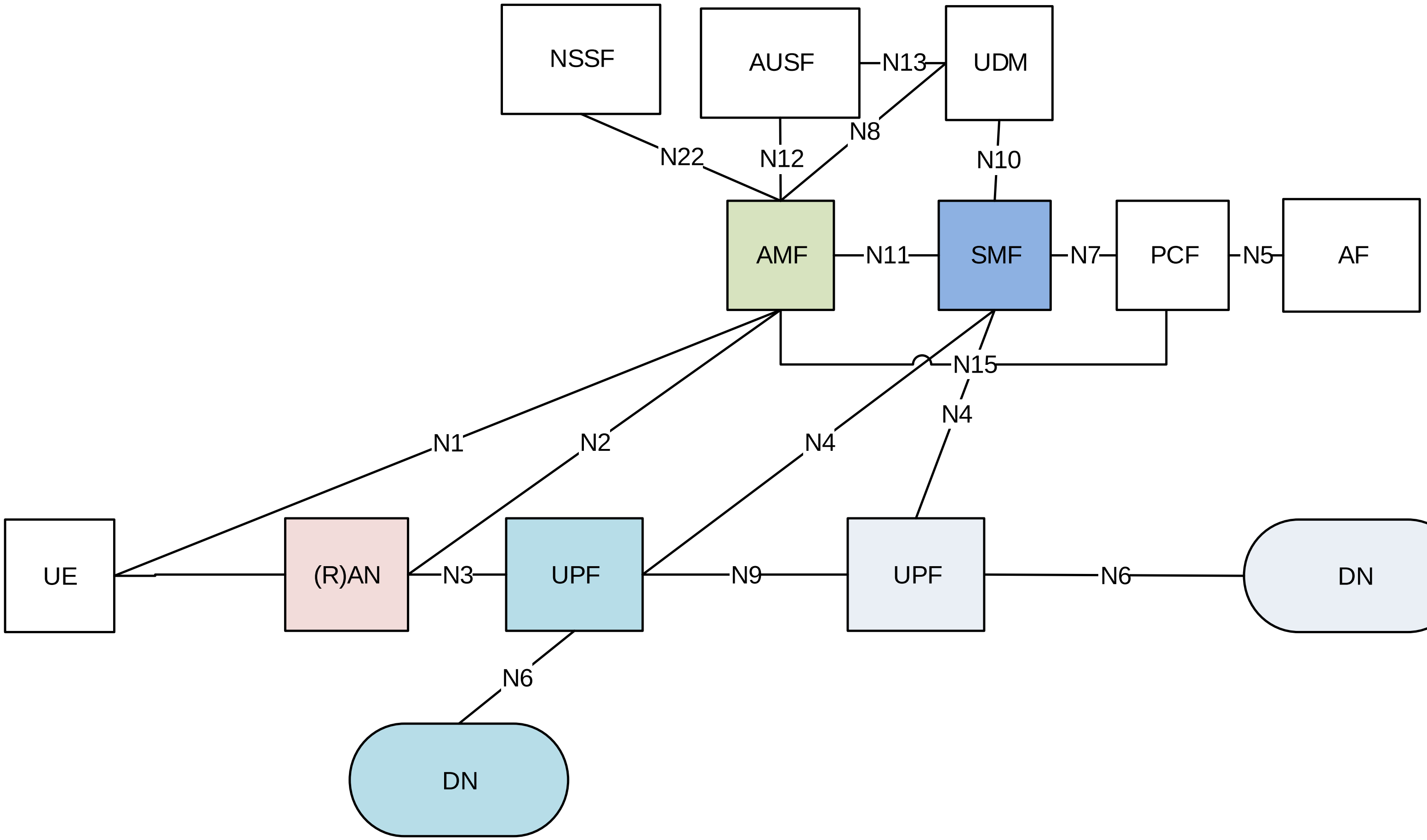
5G System Architecture
(nR-RP, Non-Roaming Reference Point)



The non-roaming reference architecture with the reference point representation showing how various network functions interact with each other

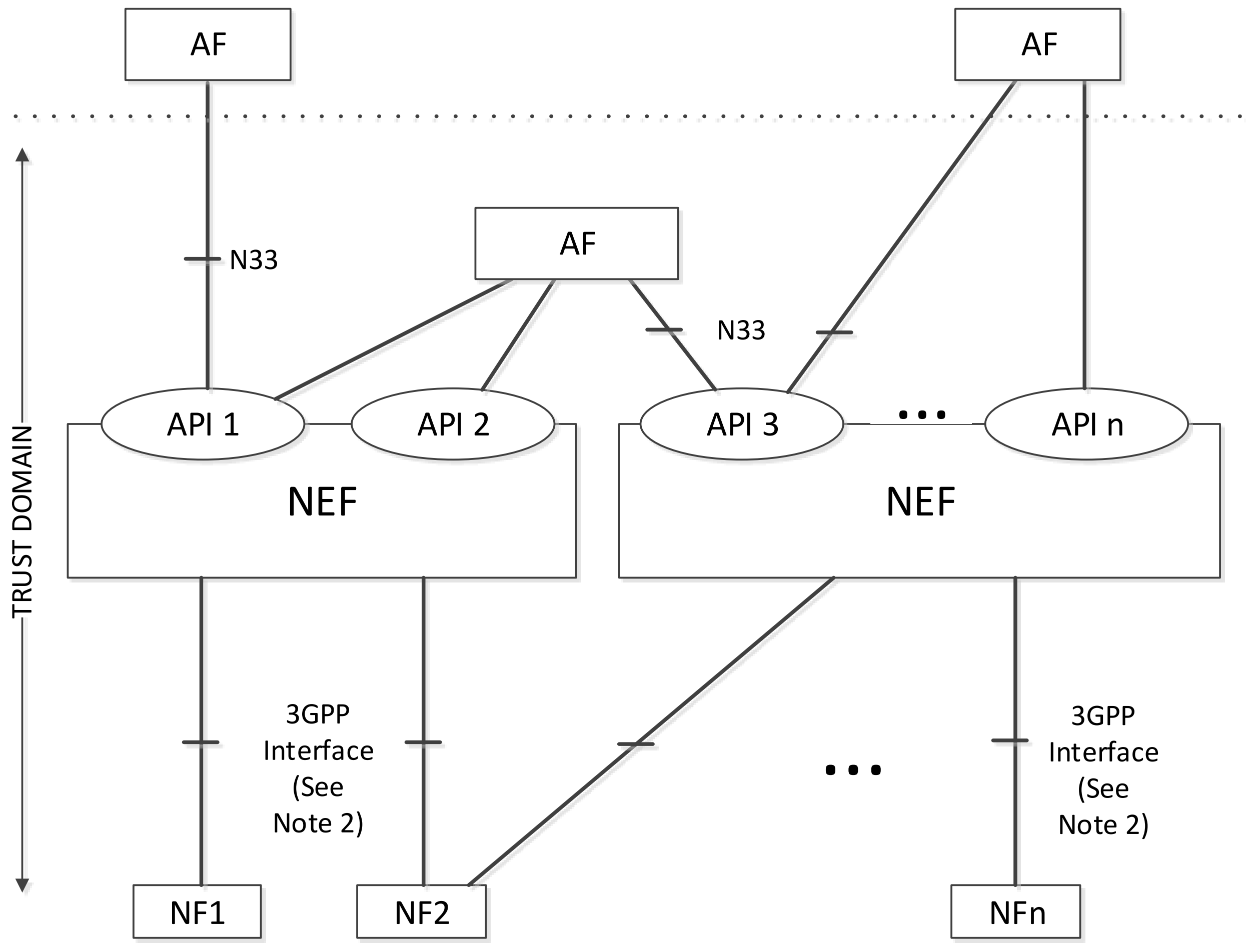
(For clarity, some NFs are not depicted)

5G nR-RP Architecture for Accessing Two DNs with a Single PDU Session



UEs concurrently access two (e.g. local and central) data networks using a single PDU session

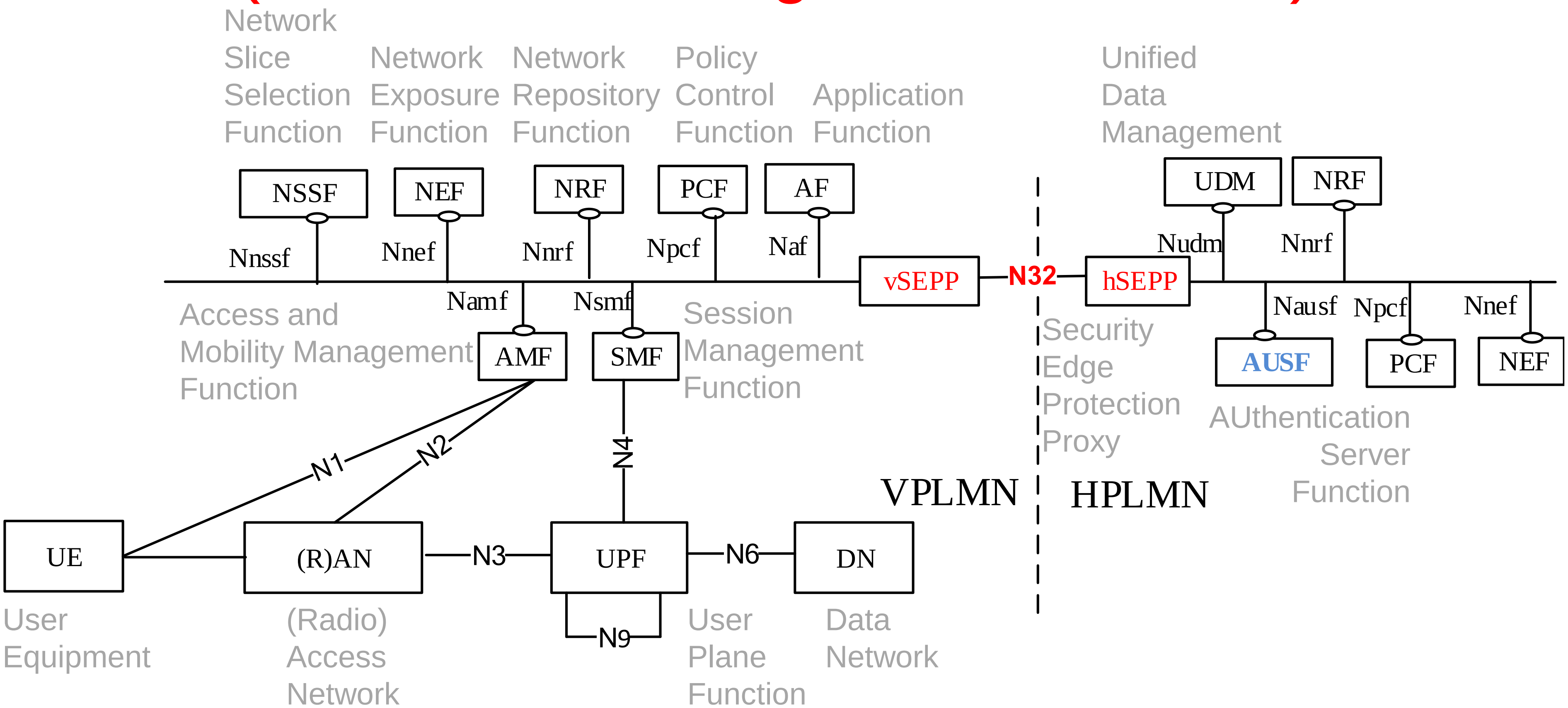
nR-RP Architecture for Network Exposure Function



Southbound Interfaces

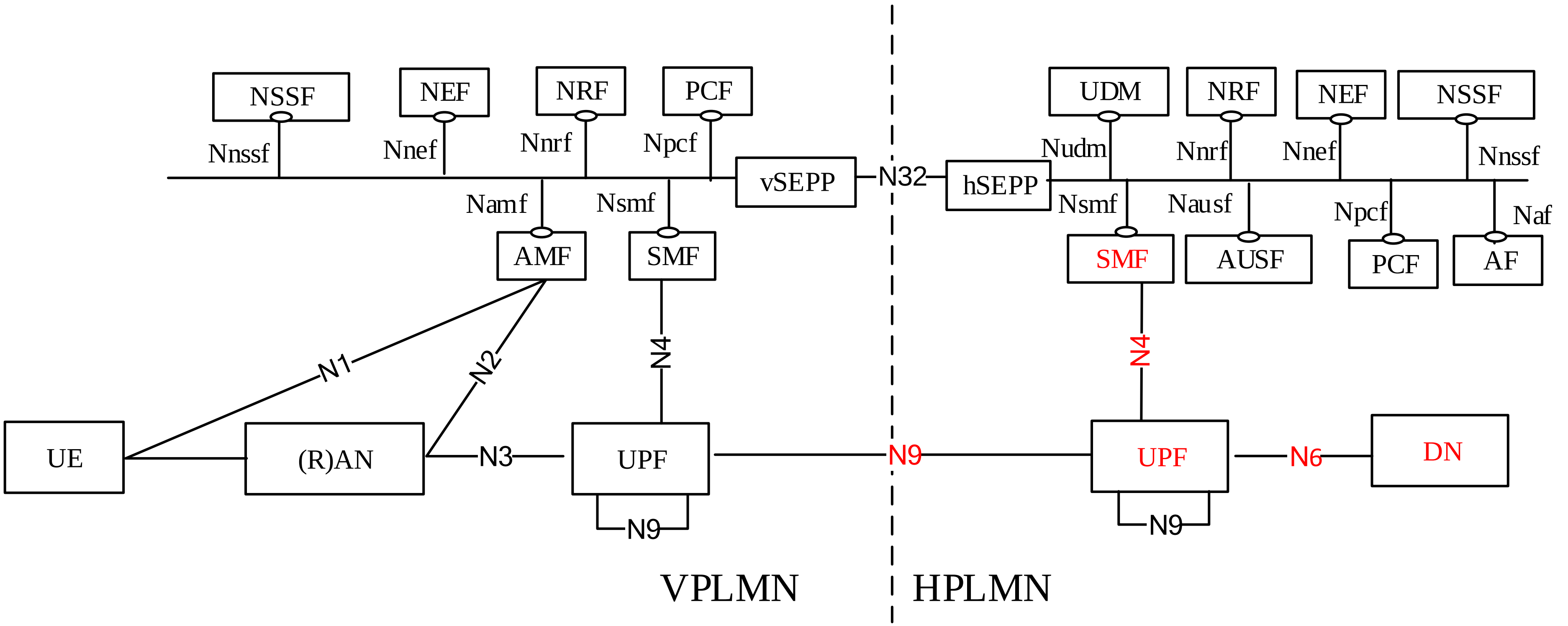
- Trust domain for NEF is same as Trust domain for SCEF as defined in TS 23.682
- Southbound interfaces between NEF and 5GC Network Functions, e.g. N29 interface between NEF and SMF, N30 interface between NEF and PCF

5G System Architecture
(Rm-SB, Roaming Service-Based)

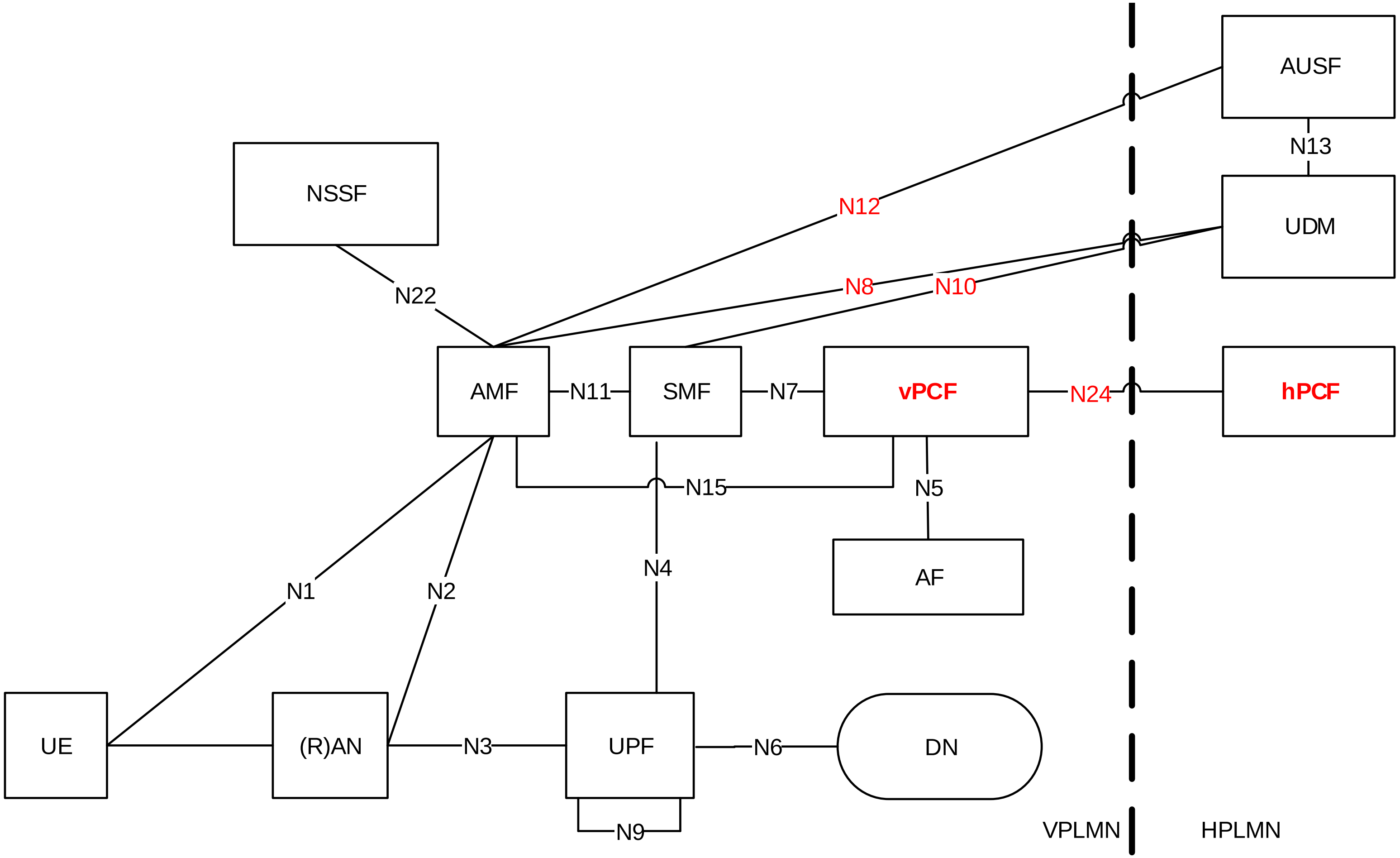


The roaming reference architecture with local breakout using service-based interfaces within the Control Plane

5G System Architecture - Home Routed Scenario (Rm-SB, Roaming Service-Based)

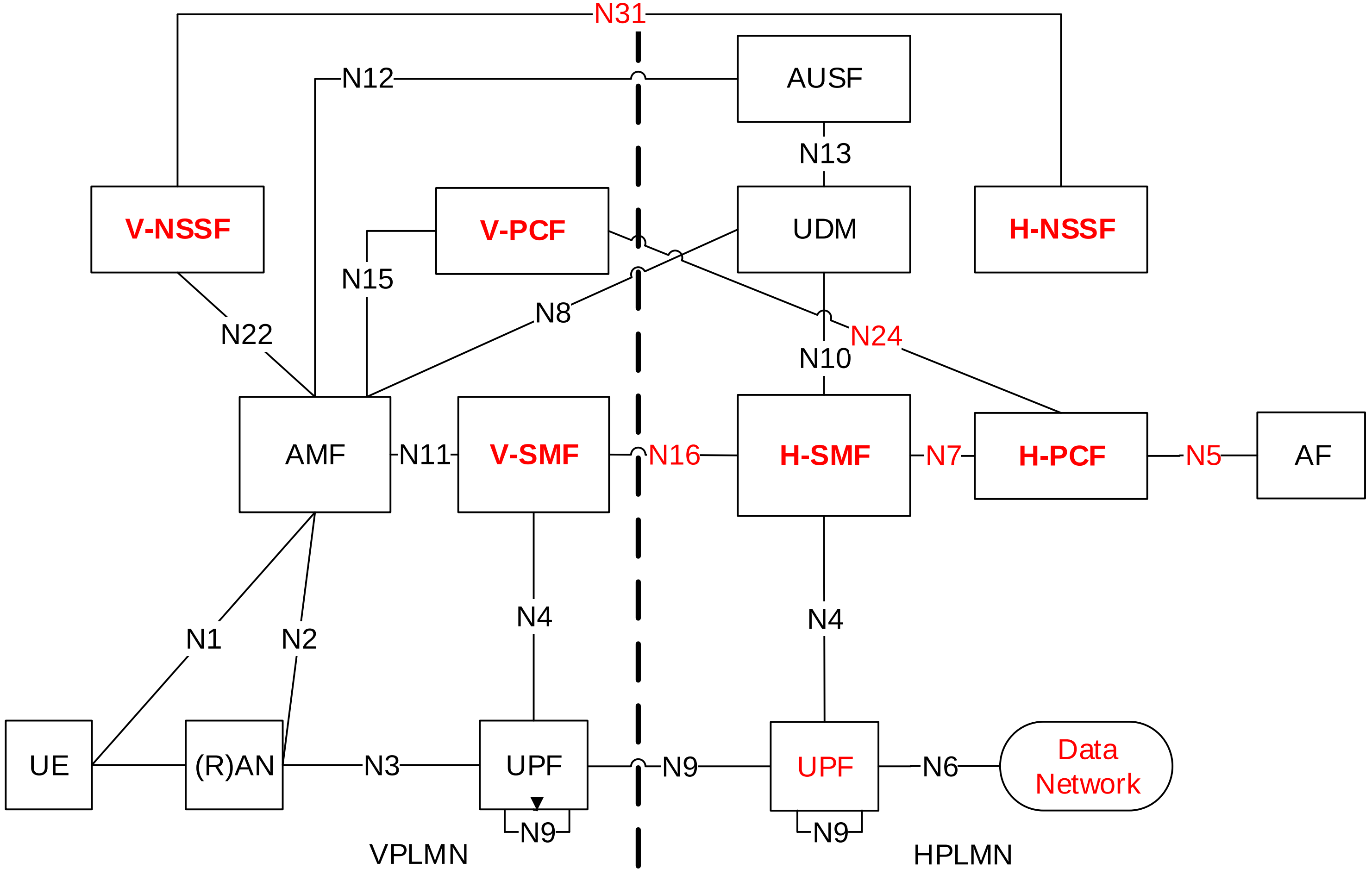


5G System Architecture
(Rm-RP, Roaming Reference Point)



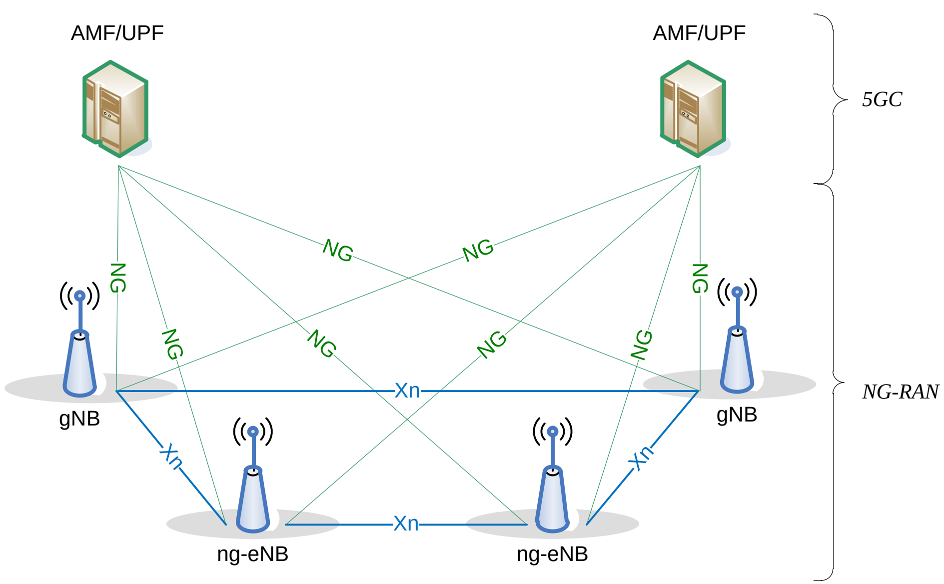
The roaming reference architecture in the case of local breakout scenario using the reference point representation

5G System Architecture - Home Routed Scenario (Rm-RP, Roaming Reference Point)

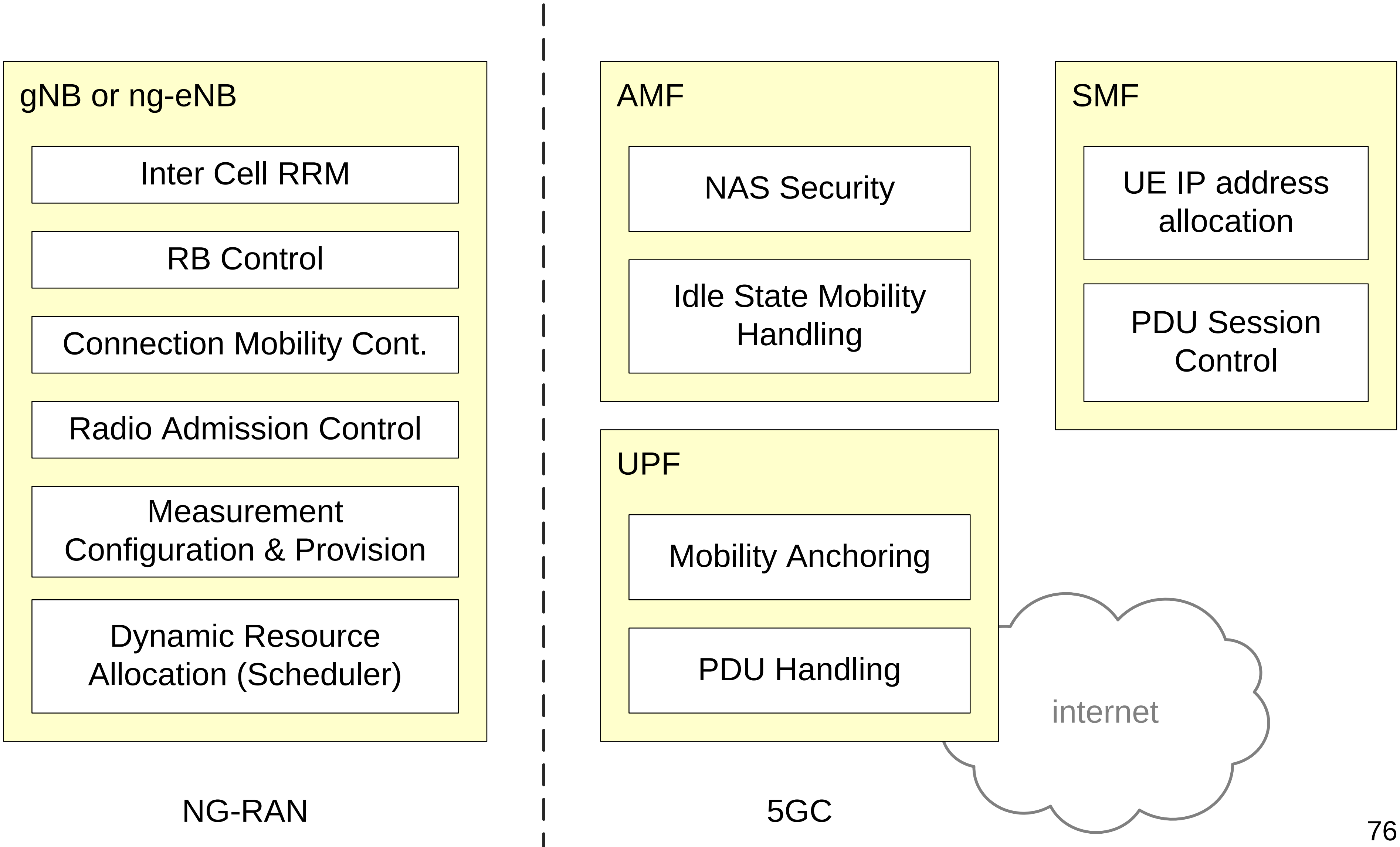


NG-RAN Overall Architecture

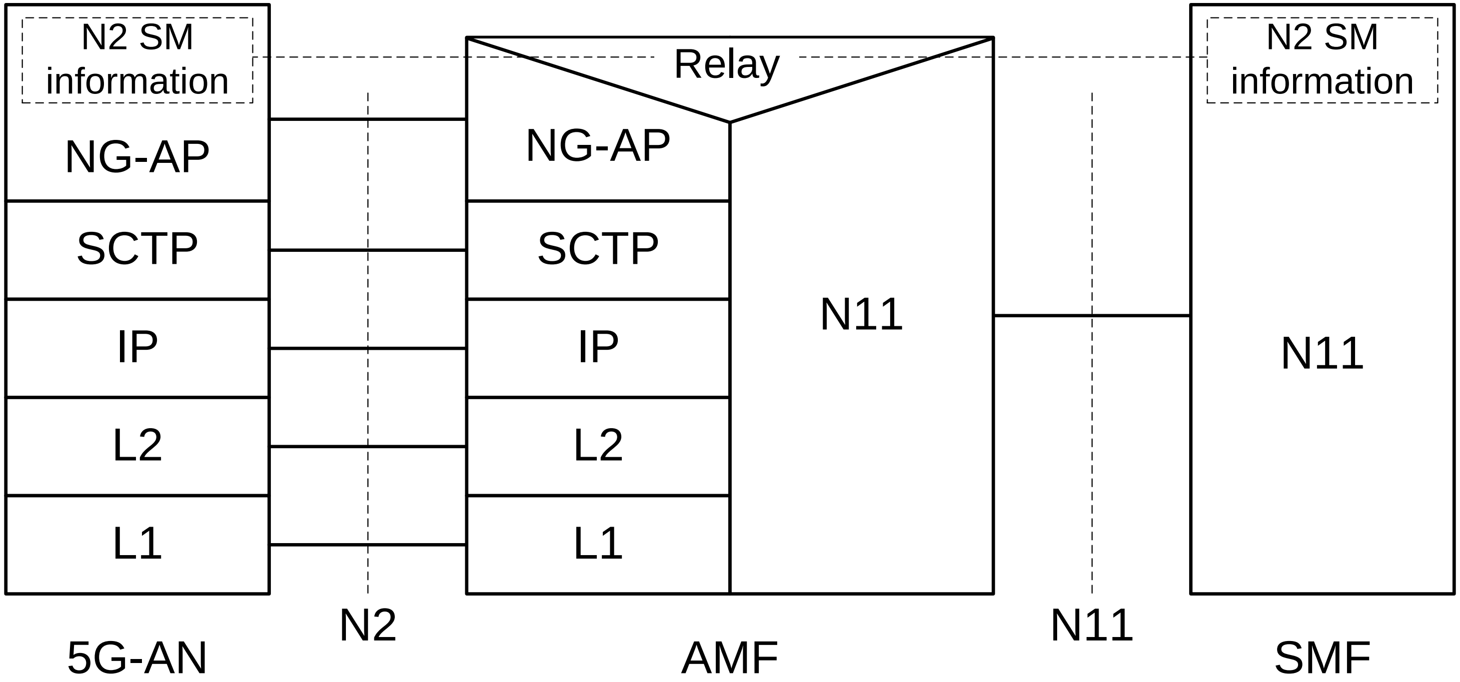
- An NG-RAN node is either
  - A gNB, providing NR user plane and control plane protocol terminations towards the UE
  - An ng-eNB, providing E-UTRA user plane and control plane protocol terminations towards the UE
- The gNBs and ng-eNBs are interconnected with each other by means of the Xn interface
- The gNBs and ng-eNBs are also connected by means of the NG interfaces to the 5GC, more specifically to the AMF (Access and Mobility Management Function) by means of the NG-C interface and to the UPF (User Plane Function) by means of the NG-U interface (see 3GPP TS 23.501)
- The architecture and the F1 interface for a functional split are defined in 3GPP TS 38.401



Functional Split between NG-RAN and 5GC

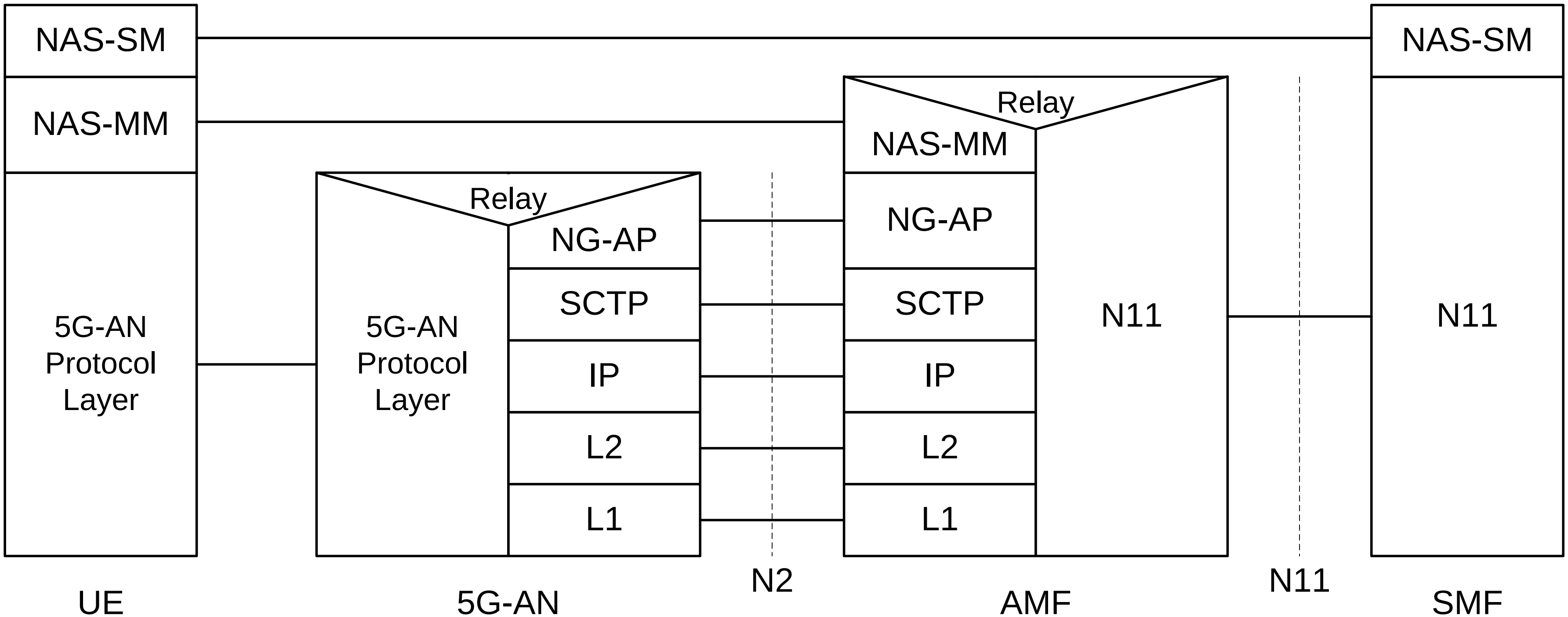


Control Plane between the AN and the SMF



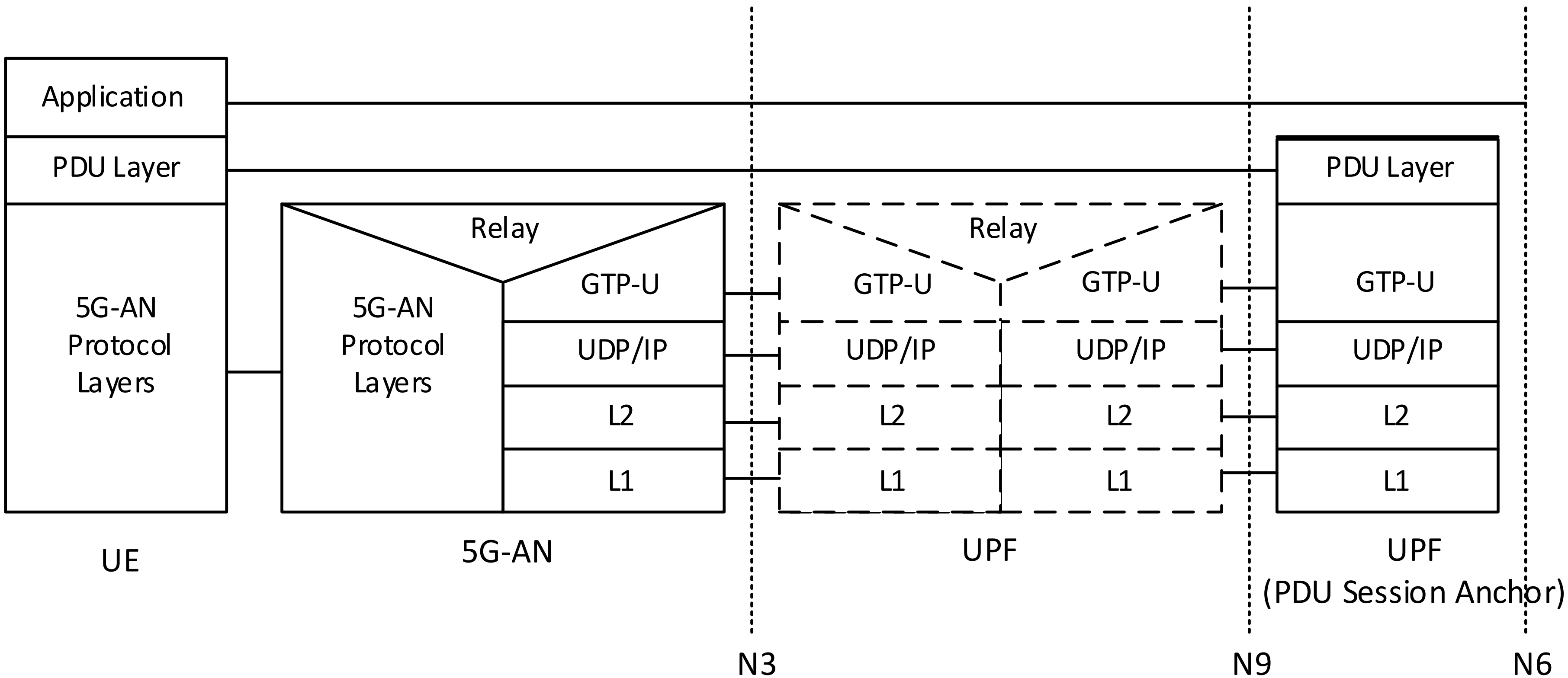
- N2 SM information: the subset of NG-AP information that the AMF transparently relays between the AN and the SMF
  - Included in the NG-AP messages and the N11 related messages
  - From the AN perspective, there is a single termination of N2 i.e. the AMF
  - For the protocol stack between the AMF and the SMF, see TS 23.501 clause 8.2.3

Control Plane Protocol Stack between the UE and the SMF

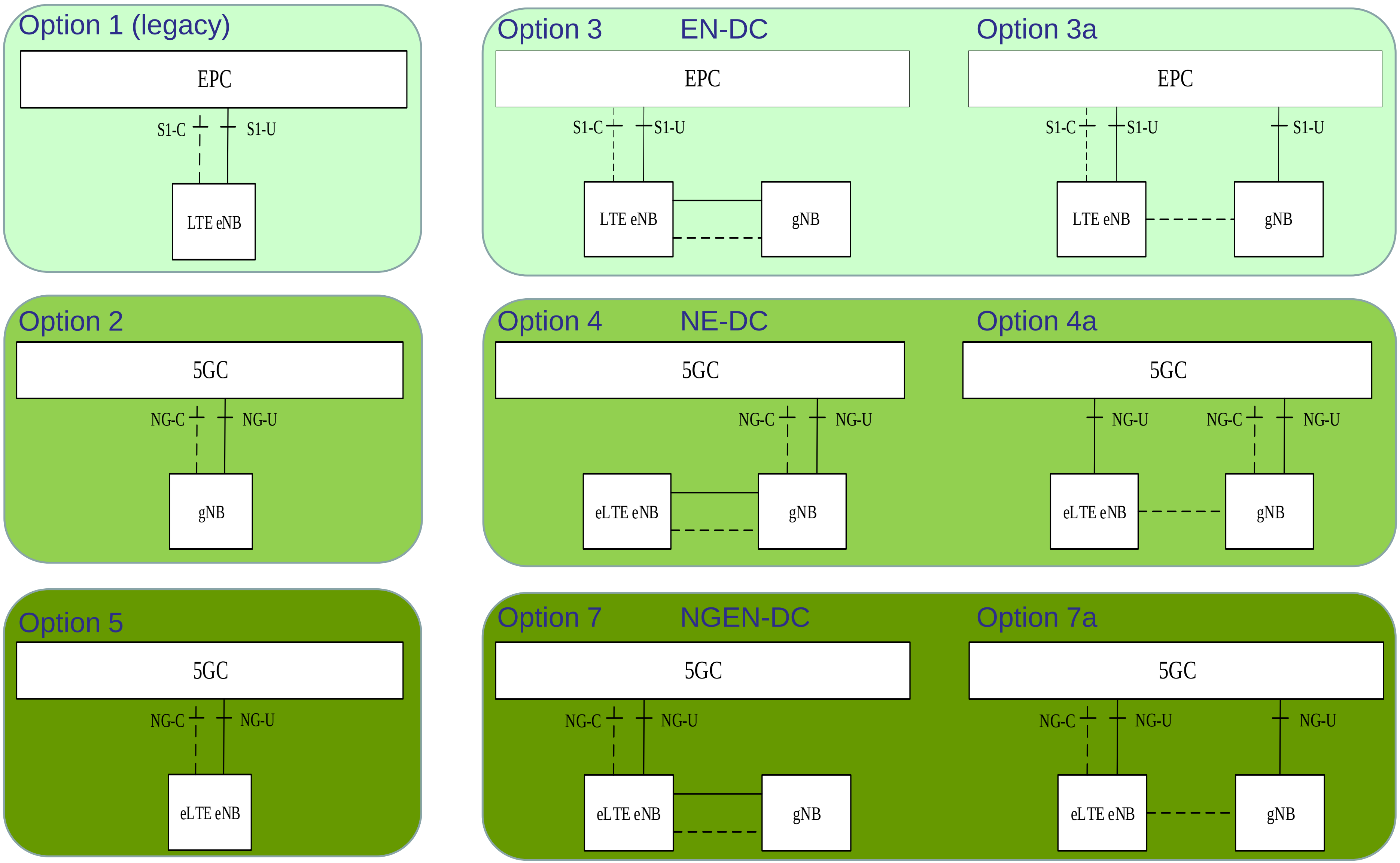


- NAS-SM: The NAS protocol for SM functionality supports user plane PDU Session Establishment, modification and release
  - It is transferred via the AMF, and transparent to the AMF. 5G NAS protocol is defined in TS 24.501
- NAS-SM supports the handling of Session Management between UE and the SMF
- The SM signalling message is handled, i.e. created and processed, in the NAS-SM layer of UE and the SMF
  - The content of the SM signalling message is not interpreted by the AMF

User Plane Protocol Stack for 3GPP Access

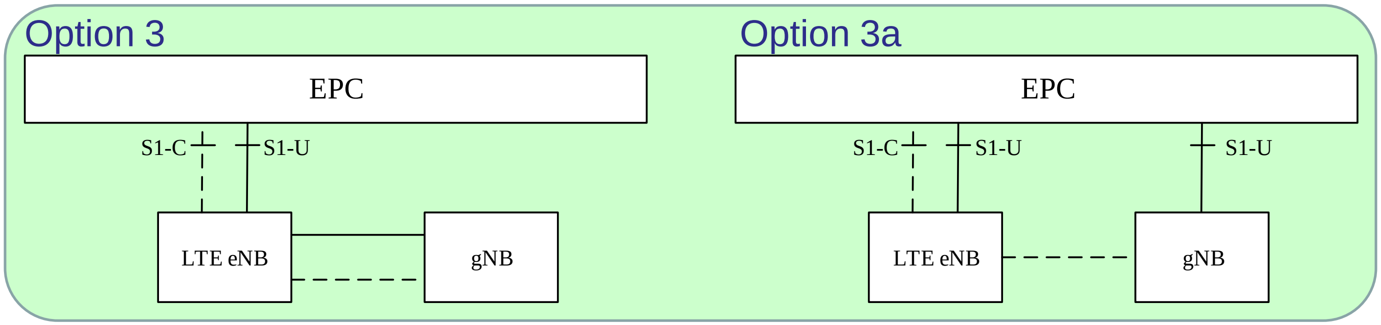


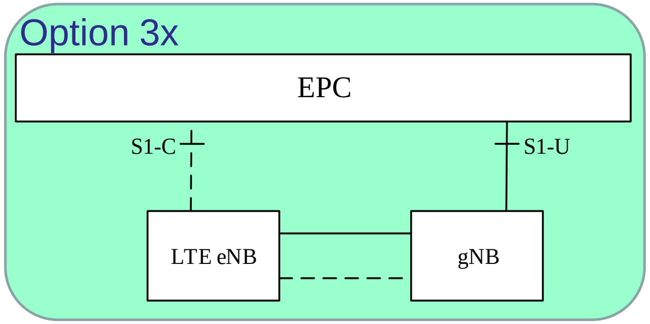
5G Architecture Options (TR38.801)



5G NSA (Release 15)

- Three models of NSA with EN-DC
  - Option 3 – Traffic split at eNB
  - Option 3a – Traffic split at S-GW
  - Option 3x – Traffic split at gNB





Architecture Options and Migration Paths

- NR gNB Connected to the 5GC
  - (Option 2)

    The gNBs are connected to the 5G Core Network (5GC) through the NG interface

    The gNBs interconnect through the Xn interface
- Multi-RAT DC with the EPC
  - (Option 3)

    Commonly known as EN-DC (LTE-NR Dual Connectivity),

    A UE is connected to an eNB that acts as a MN and to an en-gNB that acts as a SN
- Multi-RAT DC with the 5GC, NR as Master
  - (Option 4)

    A UE is connected to a gNB that acts as a MN and to an ngeNB that acts as an SN

    The gNB is connected to 5GC and the ng-eNB is connected to the gNB via the Xn interface

    The ng-eNB may send UP to the 5G Core either directly or via the gNB

Architecture Options and Migration Paths(cont.)

- LTE ng-eNB Connected to the 5GC
  - (Option 5)

    The ng-eNBs are connected to the 5G Core Network (5GC) through the NG interface

    The ng-eNBs interconnect through the Xn interface. Essentially this option allows the existing LTE radio infrastructure (through an upgrade to the eNB) to connect to the new 5G Core
- Multi-RAT DC with the 5GC, E-UTRA as Master
  - (Option 7)

    A UE is connected to an ng-eNB that acts as a MN and to a gNB that acts as an SN

    The ng-eNB is connected to the 5GC, and the gNB is connected to the ng-eNB via the Xn interface

    The gNB may send UP to the 5GC either directly or via the ng-eNB

Common MR-DC Principles

- Multi-Radio Dual Connectivity (MR-DC) is a generalization of the Intra-E-UTRA Dual Connectivity (DC)
- A multiple Rx/Tx capable UE may be configured to utilise resources provided by two different nodes connected via non-ideal backhaul
- One providing NR access and the other one providing either E-UTRA or NR access
  - One node acts as the Main Node(MN) connect to the core network
  - The other node acts as the Second Node(SN)

MR-DC with the 5GC

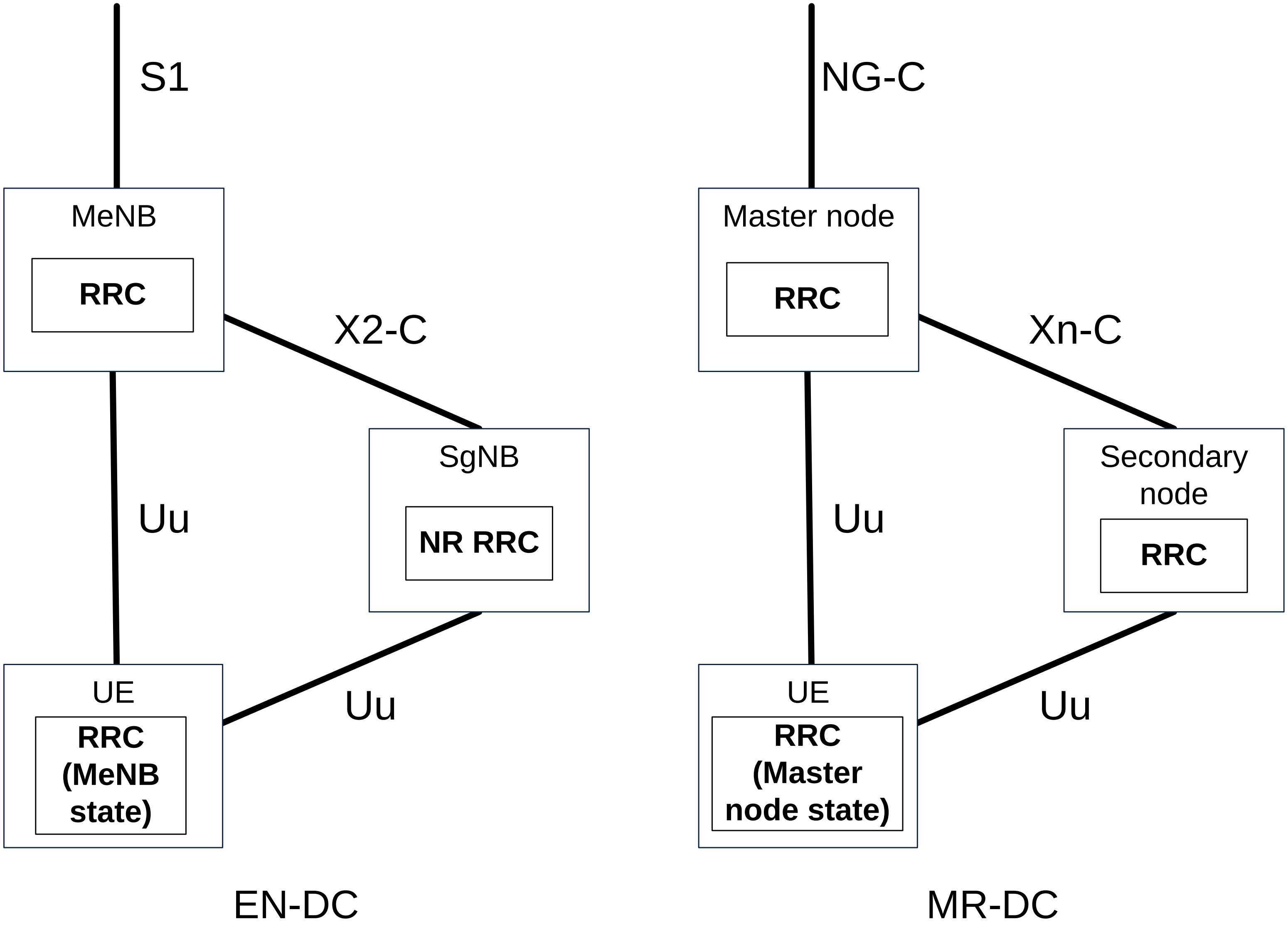
- NG-RAN supports these types of Dual Connectivity

- E-UTRA-NR Dual Connectivity(NGEN-DC)
  - UE is connected to one ng-eNB that acts as a MN and one gNB that acts as a SN

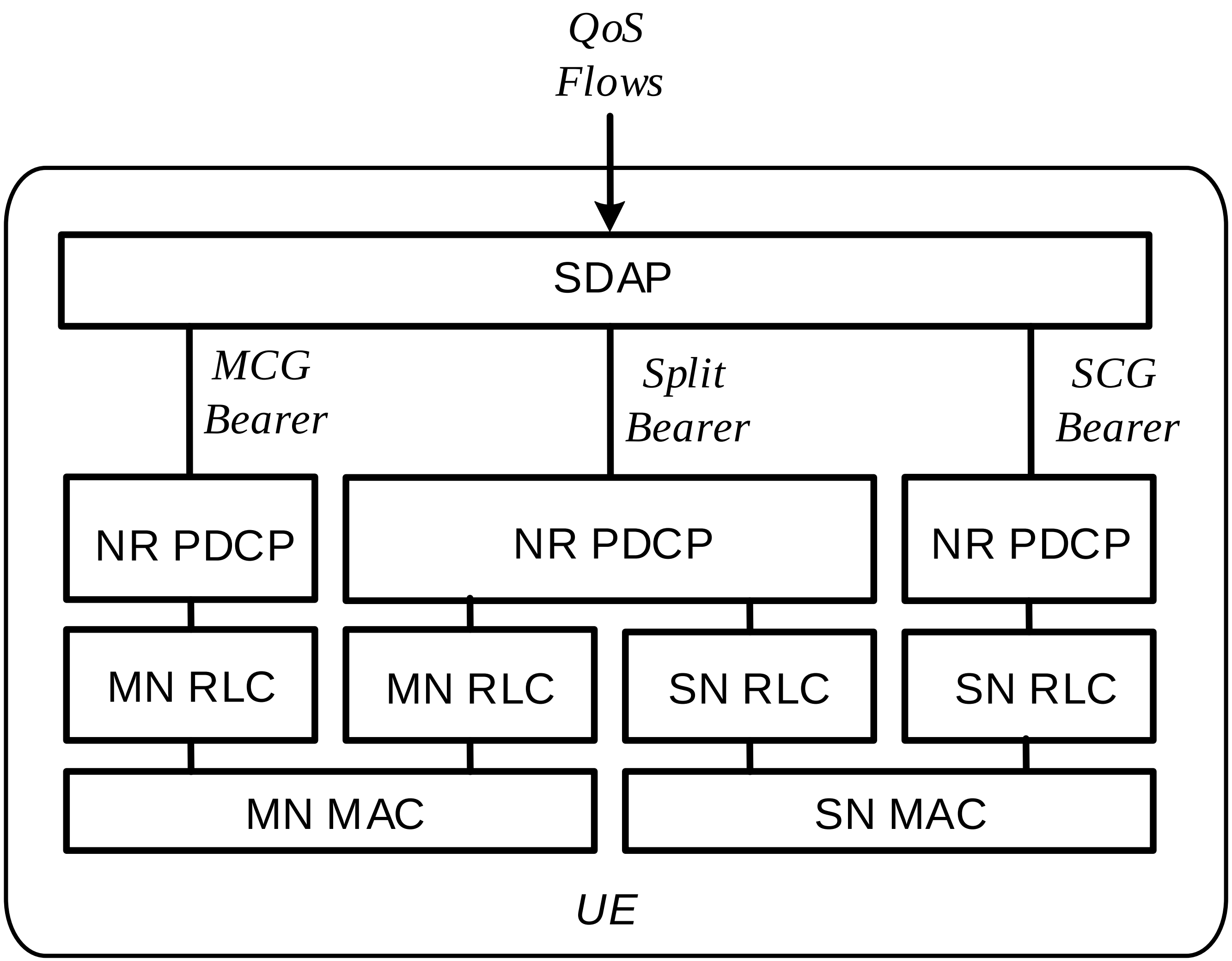
- NR-E-UTRA Dual Connectivity(NE-DC)
  - UE is connected to one gNB that acts as a MN and one ng-eNB that acts as a SN

- NR-NR Dual Connectivity(NR-DC)
  - UE is connected to one gNB that acts as a MN and another gNB that acts as a SN

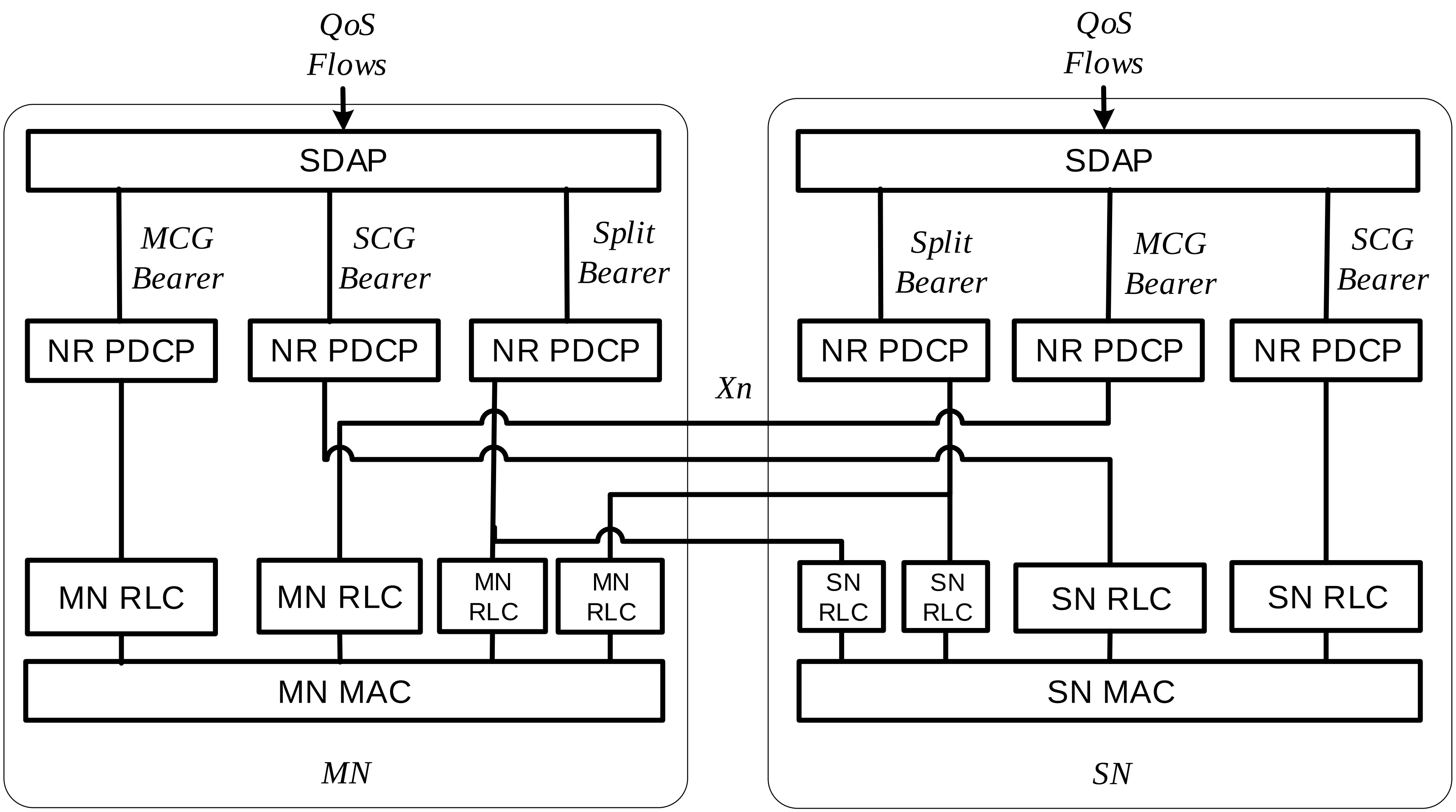
Control Plane Architecture for EN-DC and MR-DC with 5GC



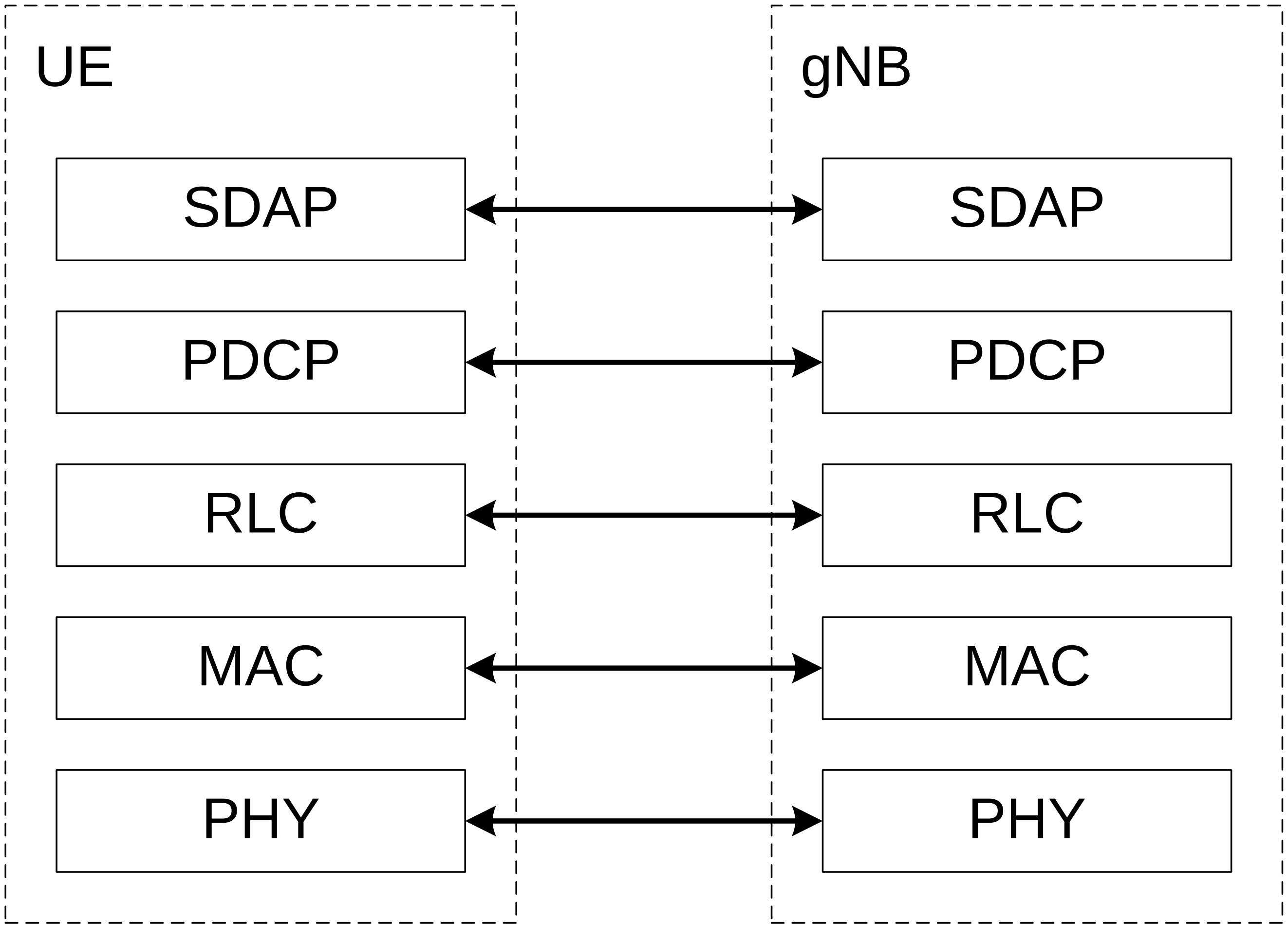
Radio Protocol Architecture in MR-DC with 5GC



Network Side Protocol in MR-DC with 5GC



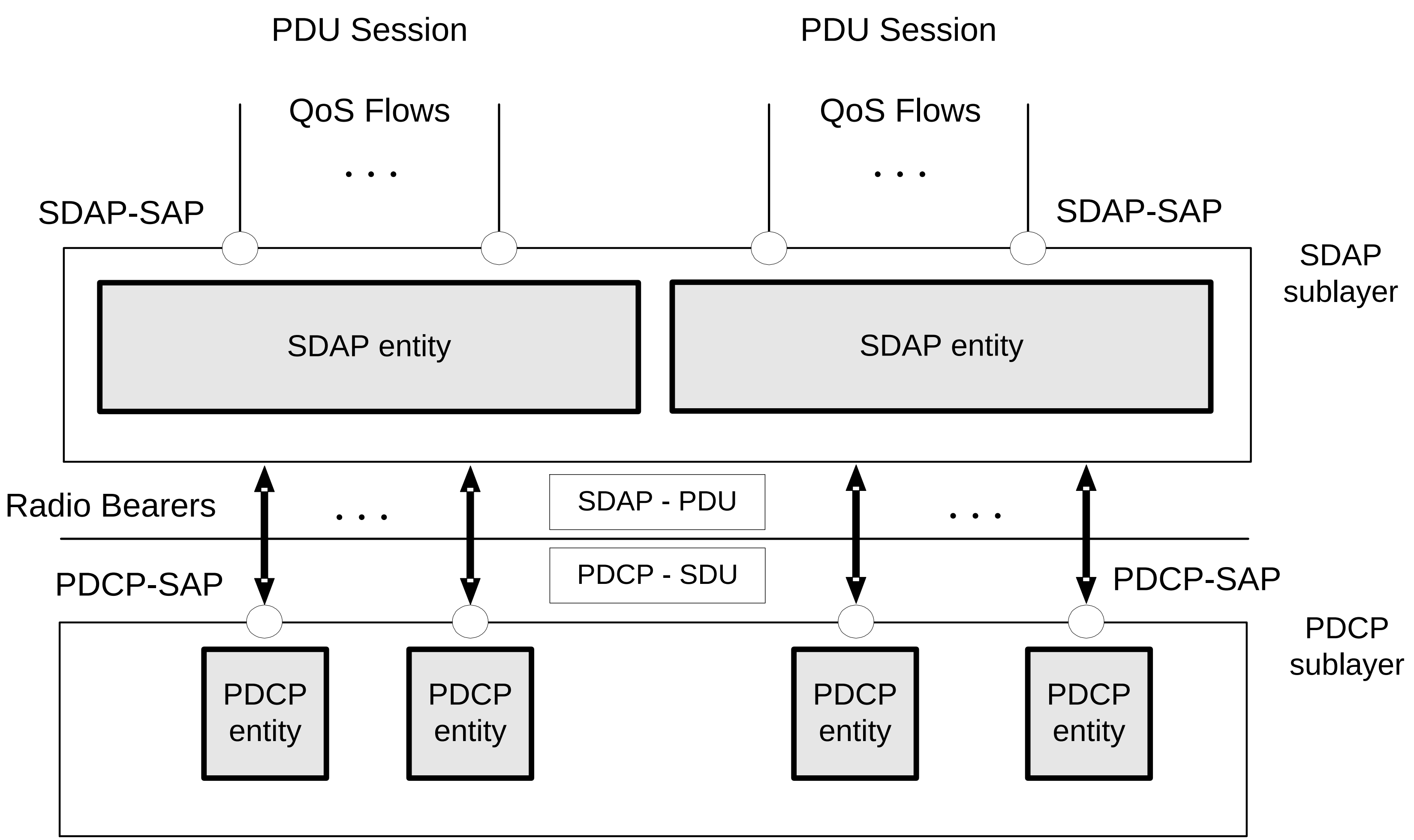
5G – AN Protocol Layers



Abbreviations

- QFI QoS Flow ID
- RDI Reflective QoS flow to DRB mapping Indication
- RQI Reflective QoS Indication
- SDAP Service Data Adaptation Protocol

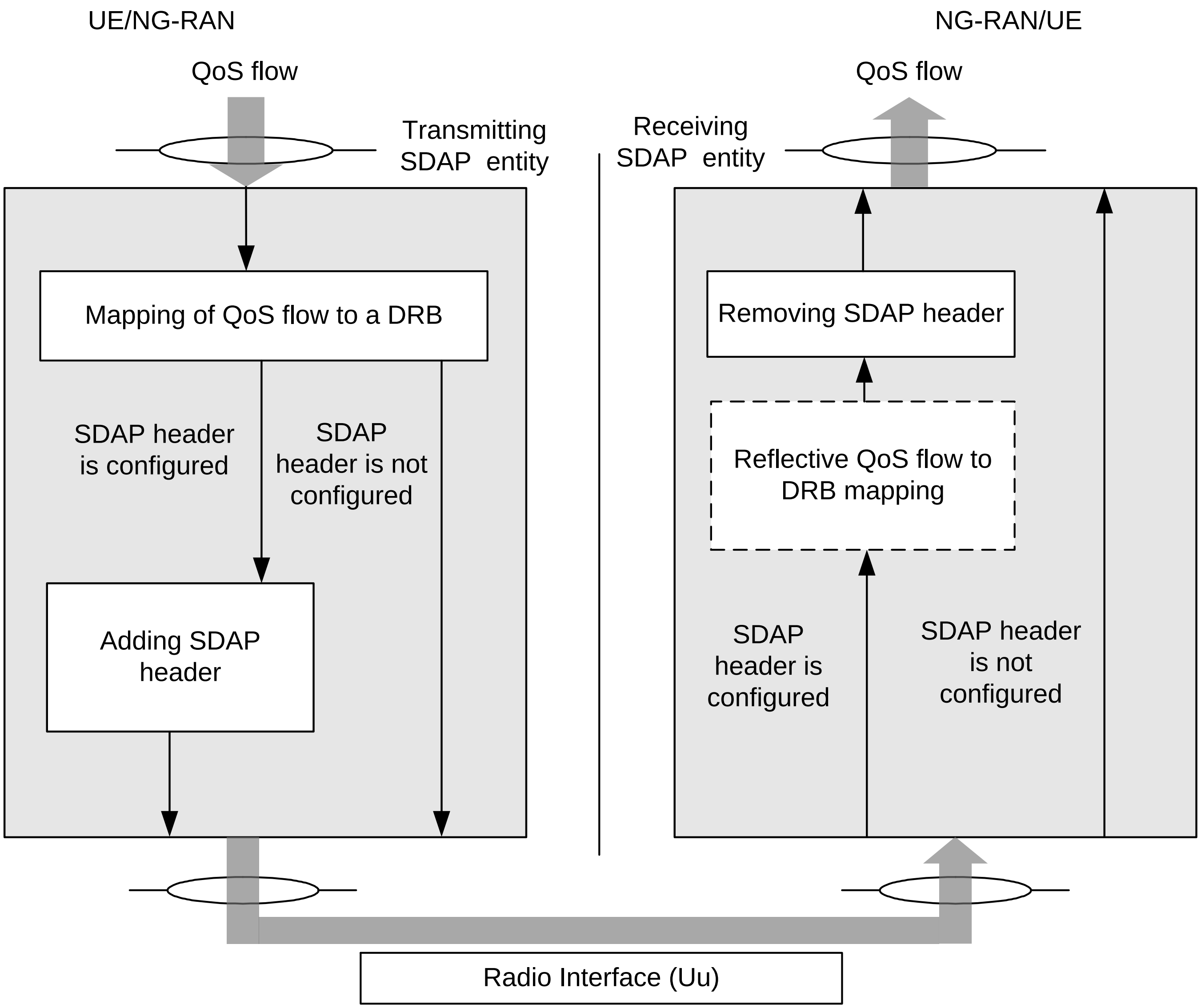
SDAP Sublayer, Structure View



SDAP Entities

- The SDAP entities are located in the SDAP sublayer. Several SDAP entities may be defined for a UE. There is an SDAP entity configured for each individual PDU session
- An SDAP entity receives/delivers SDAP SDUs from/to upper layers and submits/receives SDAP data PDUs to/from its peer SDAP entity via lower layers
  - At the transmitting side, when an SDAP entity receives an SDAP SDU from upper layers, it constructs the corresponding SDAP data PDU and submits it to lower layers
  - At the receiving side, when an SDAP entity receives an SDAP data PDU from lower layers, it retrieves the corresponding SDAP SDU and delivers it to upper layers

SDAP Layer, Functional View



Data Transfer

- Uplink
  - At the reception of an SDAP SDU from upper layer for a QoS flow, the transmitting SDAP entity shall:
    - if there is no stored QoS flow to DRB mapping rule for the QoS flow:
      - map the SDAP SDU to the default DRB
    - else:
      - map the SDAP SDU to the DRB according to the stored QoS flow to DRB mapping rule
    - if the DRB to which the SDAP SDU is mapped is configured by RRC (3GPP TS 38.331) with the presence of SDAP header
      - construct the UL SDAP data PDU
    - else:
      - construct the UL SDAP data PDU
      - submit the constructed UL SDAP data PDU to the lower layers

- NOTE 1:UE behaviour is not defined if there is neither a default DRB nor a stored QoS flow to DRB mapping rule for the QoS flow
- NOTE 2:Default DRB is always configured with UL SDAP header (3GPP TS 38.331)

Data Transfer

- Downlink
  - At the reception of an SDAP data PDU from lower layers for a QoS flow, the receiving SDAP entity shall:
    - if the DRB from which this SDAP data PDU is received is configured by RRC (3GPP TS 38.331) with the presence of SDAP header:
      - perform reflective QoS flow to DRB mapping
      - perform RQI handling
      - retrieve the SDAP SDU from the DL SDAP data PDU
    - else:
      - retrieve the SDAP SDU from the DL SDAP data PDU
      - deliver the retrieved SDAP SDU to the upper layer

Reflective Mapping

- For each received DL SDAP data PDU with RDI set to 1, the SDAP entity shall:
  - process the QFI field in the SDAP header and determine the QoS flow
  - if there is no stored QoS flow to DRB mapping rule for the QoS flow and a default DRB is configured
    - construct an end-marker control PDU, for the QoS flow
    - map the end-marker control PDU to the default DRB
    - submit the end-marker control PDU to the lower layers
  - if the stored QoS flow to DRB mapping rule for the QoS flow is different from the QoS flow to DRB mapping of the DL SDAP data PDU and the DRB according to the stored QoS flow to DRB mapping rule is configured by RRC (3GPP TS 38.331) with the presence of UL SDAP header:
    - construct an end-marker control PDU, for the QoS flow
    - map the end-marker control PDU to the DRB according to the stored QoS flow to DRB mapping rule
    - submit the end-marker control PDU to the lower layers
  - store the QoS flow to DRB mapping of the DL SDAP data PDU as the QoS flow to DRB mapping rule for the UL

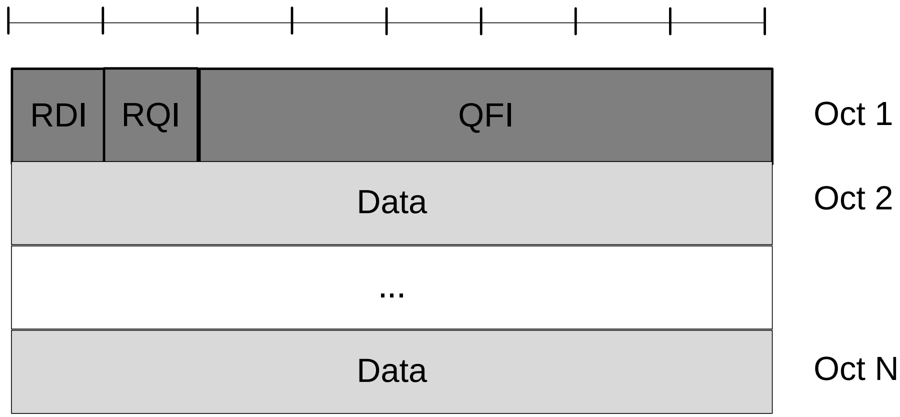
DRB Release and RQI Handling

- DRB release
  - When RRC (3GPP TS 38.331) indicates that a DRB is released, the SDAP entity shall:
    - remove all QoS flow to DRB mappings associated with the released DRB
- RQI handling
  - For each received DL SDAP data PDU with RQI set to 1, the SDAP entity shall:
    - inform the NAS layer of the RQI and QFI

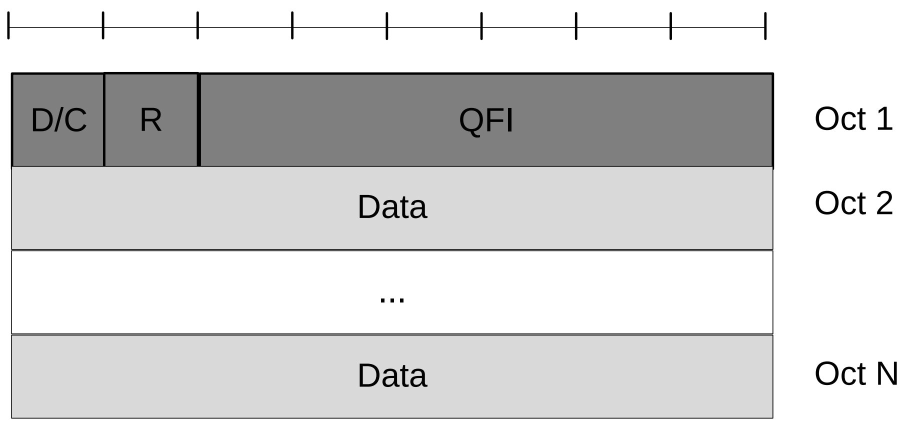
Control PDU

- a) End-Marker Control PDU
- End-Marker control PDU is used by the SDAP entity at UE to indicate that it stops the mapping of the SDAP SDU of the QoS flow indicated by the QFI to the DRB on which the End-Marker PDU is transmitted

DL/UL Data PDU with SDAP Header



DL SDAP Data PDU format with SDAP header



UL SDAP Data PDU format with SDAP header

Outline

- System Architecture for the 5G System (5GS)
  - Service-Based Architecture
  - Interworking with EPC
- Radio Access Networks
  - 5G New Radio (NR)
  - 5G Xn Interface
- Core Networks
  - 5G Core Networks (5GC)
  - NG Interface
    - General Aspects and Functions
    - Protocol Stack and Procedures

NG Interface General Principles

- The general principles for the specification of the NG interface are as follows:
  - The NG interface is open
  - The NG interface supports the exchange of signalling information between the NG-RAN and 5GC
  - From a logical standpoint, the NG is a point-to-point interface between an NG-RAN node and a 5GC node. A point-to-point logical interface is feasible even in the absence of a physical direct connection between the NG-RAN and 5GC
  - The NG interface supports control plane and user plane separation
  - The NG interface separates Radio Network Layer and Transport Network Layer
  - The NG interface is future proof to fulfil different new requirements and support of new services and new functions
  - The NG interface is decoupled with the possible NG-RAN deployment variants
  - The NG Application Protocol supports modular procedures design and uses a syntax allowing optimized encoding /decoding efficiency

NG Interface Specification Objectives

- The NG interface specification facilitates the following:
  - Inter-connection of NG-RAN nodes with AMFs supplied by different manufacturers
  - Separation of NG interface Radio Network functionality and Transport Network functionality to facilitate introduction of future technology

NG Interface Capabilities

- The NG interface supports:
  - Procedures to establish, maintain and release NG-RAN part of PDU sessions
  - Procedures to perform intra-RAT handover and inter-RAT handover
  - The separation of each UE on the protocol level for user specific signalling management
  - The transfer of NAS signalling messages between UE and AMF
  - Mechanisms for resource reservation for packet data streams

Functions of The NG Interface

- Paging function
  - The paging function supports the sending of paging requests to the NG-RAN nodes involved in the paging area
- UE Context Management function
  - The UE Context management function allows the AMF to establish, modify or release a UE Context in the AMF and the NG-RAN node e.g. to support user individual signalling on NG
- Mobility Management function
  - The mobility function for UEs in CM-CONNECTED includes the intra-system handover function to support mobility within NG-RAN and inter-system handover function to support mobility from/to EPS system
- PDU Session Management function
  - The PDU Session function is responsible for establishing, modifying and releasing the involved PDU sessions NG-RAN resources for user data transport once a UE context is available in the NG-RAN node
- NAS Transport function
  - The NAS Signalling Transport function provides means to transport or reroute a NAS message (e.g. for NAS mobility management) for a specific UE over the NG interface

Functions of The NG Interface (cont.)

- NAS Node Selection function
  - The interconnection of NG-RAN nodes to multiple AMFs is supported in the 5GS architecture
  - This functionality is located in the NG-RAN node and enables proper routing via the NG interface
  - On NG, no specific procedure corresponds to the NAS Node Selection Function
- NG Interface Management function
  - The NG-interface management functions provide
    - means to ensure a defined start of NG-interface operation (reset)
    - means to handle different versions of application part implementations and protocol errors (error indication)
- Warning Message Transmission function
  - The warning message transmission function provides means to transfer warning messages via NG interface or cancel ongoing broadcast of warning messages
  - It also provides the capability for the NG-RAN to inform the AMF that ongoing PWS operation has failed for one or more areas, or that one or more areas may be reloaded by the CBC
- Configuration Transfer function
  - The Configuration Transfer function is a generic mechanism that allows the request and transfer of RAN configuration information between two RAN nodes via the core network

Functions of The NG Interface (cont.)

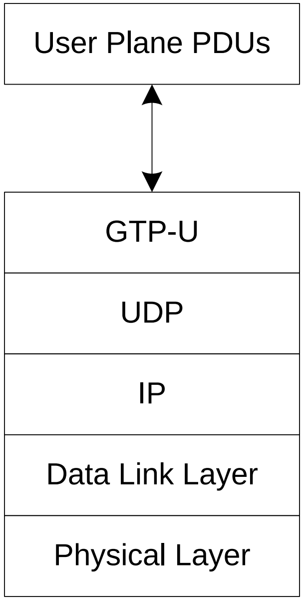
- Trace function
  - The Trace function provides means to control trace sessions in the NG-RAN node
- AMF Management function
  - The AMF management function supports AMF planned removal and AMF auto-recovery
- Multiple TNL Associations Support Function
  - When there are multiple TNL associations between a NG-RAN node and an AMF, the NG-RAN node selects the TNL association for NGAP signalling based on the usage and the weight factor of each TNL association received from the AMF
- AMF Load Balancing function
  - The NG interface supports the indication by the AMF of its relative capacity to the NG-RAN node in order to achieve load-balanced AMFs within the pool area
- Location Reporting function
  - This function enables the AMF to request the NG-RAN node to report the UE's current location, or the UE's last known location with timestamp, or the UE's presence in a configured area of interest
- UE Radio Capability Management function
  - The UE Radio Capability Management function is related to the UE radio capability handling

Functions of The NG Interface (cont.)

- AMF Re-allocation function
  - This function allows to redirect an initial connection request issued by an NG-RAN node from an initial AMF towards a target AMF selected by 5GC
  - In this case the NG-RAN node initiates an Initial UE Message procedure over one NG interface instance and receives the first downlink message to close the UE-associated logical connection over a different NG interface instance
- NRPPa Signaling Transport function
  - The NRPPa Signalling Transport function provides means to transport an NRPPa message transparently over the NG interface
- Overload Control function
  - The overload function provides means to enable AMF controls the load that the NG-RAN node(s) are generating
- Report of Secondary RAT data volumes Function
  - The Report of Secondary RAT data volumes Function enables the NG-RAN node to report Secondary RAT usage data information in case of MR-DC
- RIM Information Transfer function
  - The RIM Information Transfer function is a generic mechanism that allows the transfer of Remote Interference Management (RIM) information between two RAN nodes via the core network

NG-U Protocol Stack

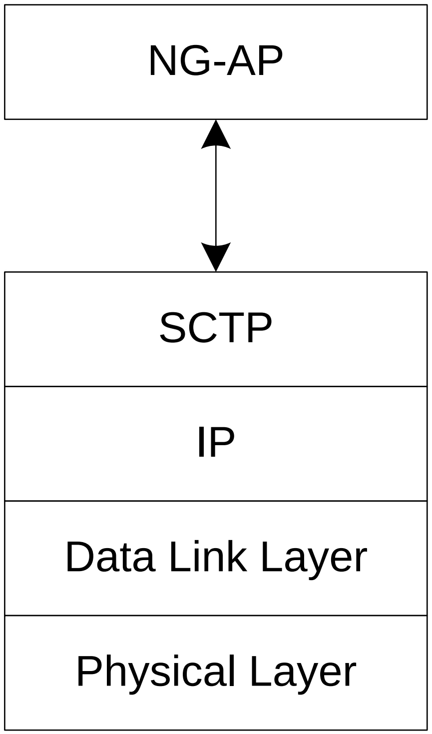
- The NG user plane interface (NG-U) is defined between the NG-RAN node and the UPF
  - The user plane protocol stack of the NG interface
  - The transport network layer is built on IP transport and GTP-U is used on top of UDP/IP to carry the user plane PDUs between the NG-RAN node and the UPF



- NG-U provides non-guaranteed delivery of user plane PDUs between the NG-RAN node and the UPF

NG-C Protocol Stack

- The NG control plane interface (NG-C) is defined between the NG-RAN node and the AMF



- NG-C provides the following functions:
  - NG interface management
  - UE context management
  - UE mobility management
  - Transport of NAS messages
  - Paging
  - PDU Session Management
  - Configuration Transfer
  - Warning Message Transmission

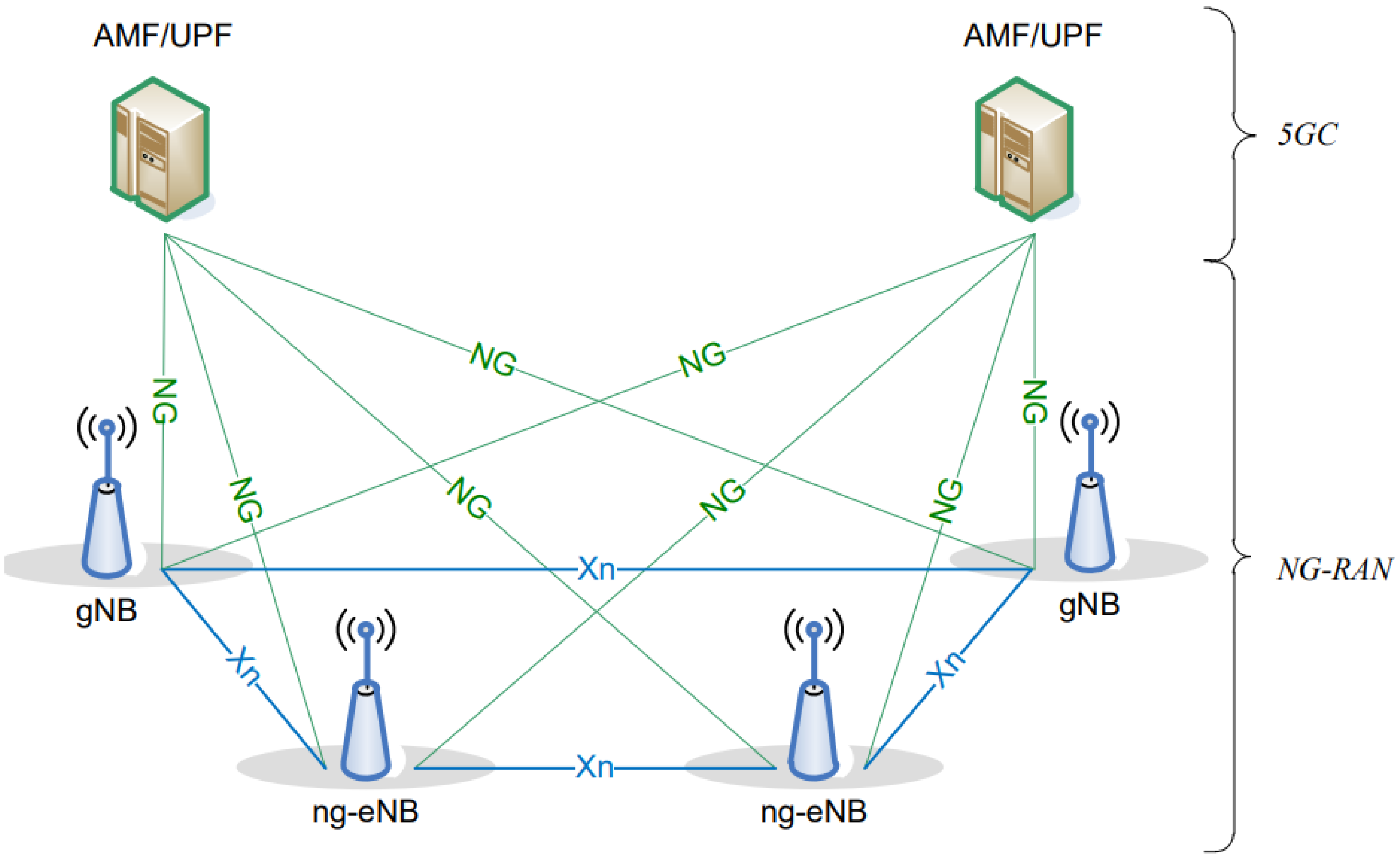
Signalling procedures of the NG interface

- TS 38.410 standard procedures
  - PDU Session Management Procedures
  - UE Context Management Procedures
  - NAS transport procedures
  - UE Mobility Management Procedures
  - Paging procedure
  - AMF Management procedures
  - NG Interface Management procedures
  - Warning message transmission procedures
  - Location Reporting procedures
  - UE Radio Capability Management procedures
  - UE Tracing procedures
  - NR Positioning Protocol A (NRPPa) procedures
  - Overload Control procedures
  - Configuration Transfer procedures
  - Secondary RAT Data Usage Report procedure
  - RIM Information Transfer procedures

Overview of the NG-RAN Architecture

- The NG-RAN represents the newly defined radio access network for 5G
  - NG-RAN provides both NR and LTE radio access
- An NG-RAN node (i.e. base station) is either
  - A gNB (i.e. a 5G base station), providing NR user plane and control plane services
  - An ng-eNB, providing LTE/E-UTRAN services towards the UE

NG-RAN in Relation to the 5G System



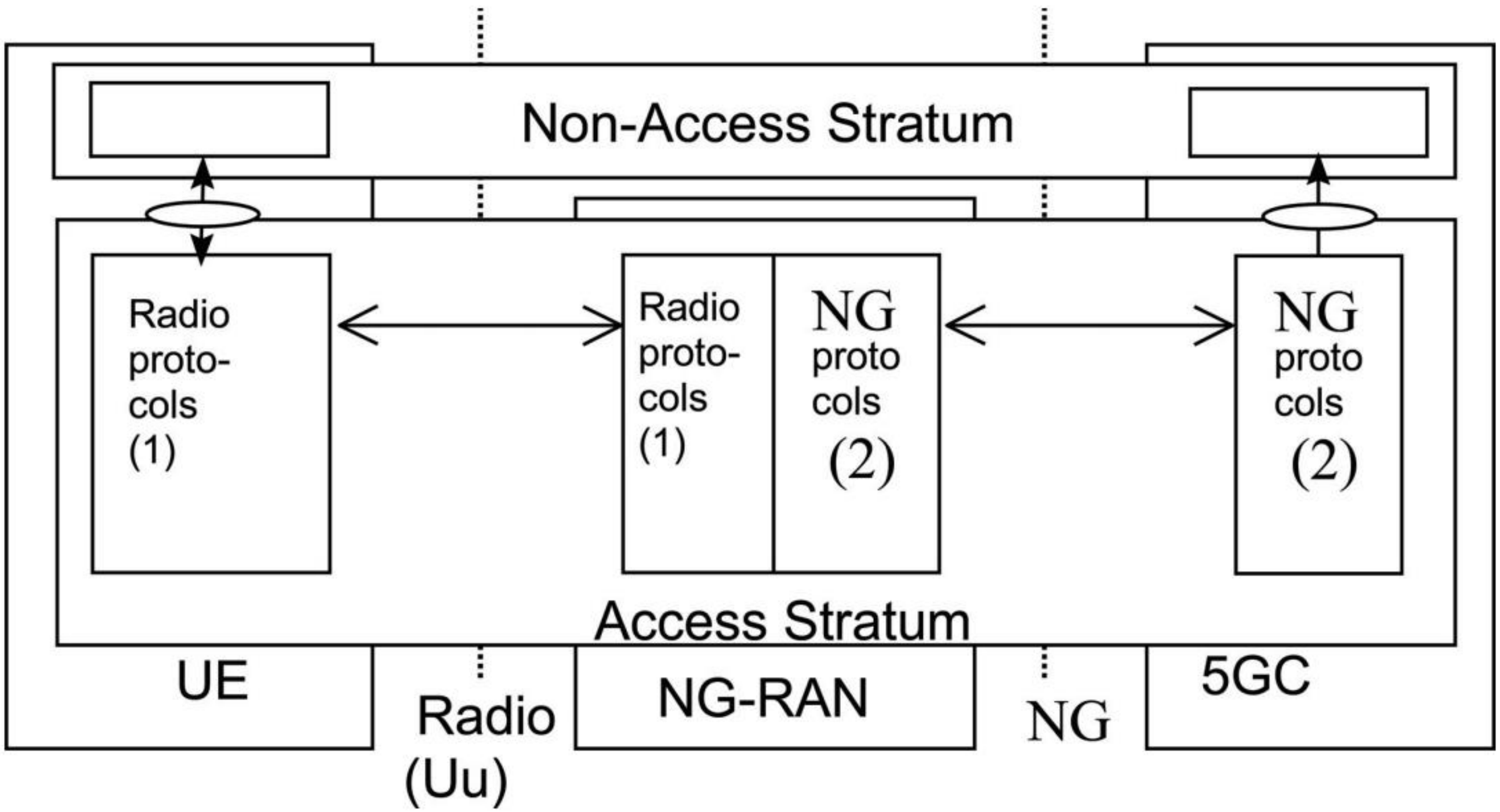
ng-eNB: enhanced node providing E-UTRAN user plane and control plane protocol terminations and connecting to 5GC

Architecture Options and Migration Paths

Two operation modes:

- Stand-Alone (SA) operation: gNB connected to 5GC
- Non-Stand-Alone (NSA): NR and LTE are tightly integrated and connect to the existing 4G Core Network (EPC)
  - Leveraging Dual Connectivity (DC): a Master Node (MN) and a Secondary Node (SN) concurrently provide radio resources towards the terminal for enhanced end-user bit rates
    - Multi-RAT DC

Overall NG-RAN Architecture



Both the user plane and control plane architectures for NG-RAN follow the same high-level architecture scheme

The AMF Hosts The Following Main Functions

- NAS signalling termination
- NAS signalling security
- AS Security control
- Inter CN node signalling for mobility between 3GPP access networks
- Idle mode UE Reachability (including control and execution of paging retransmission)
- Registration Area management
- Support of intra-system and inter-system mobility
- Access Authentication
- Access Authorization including check of roaming rights
- Mobility management control (subscription and policies)
- Support of Network Slicing
- SMF selection
- Selection of CIoT 5GS optimisations

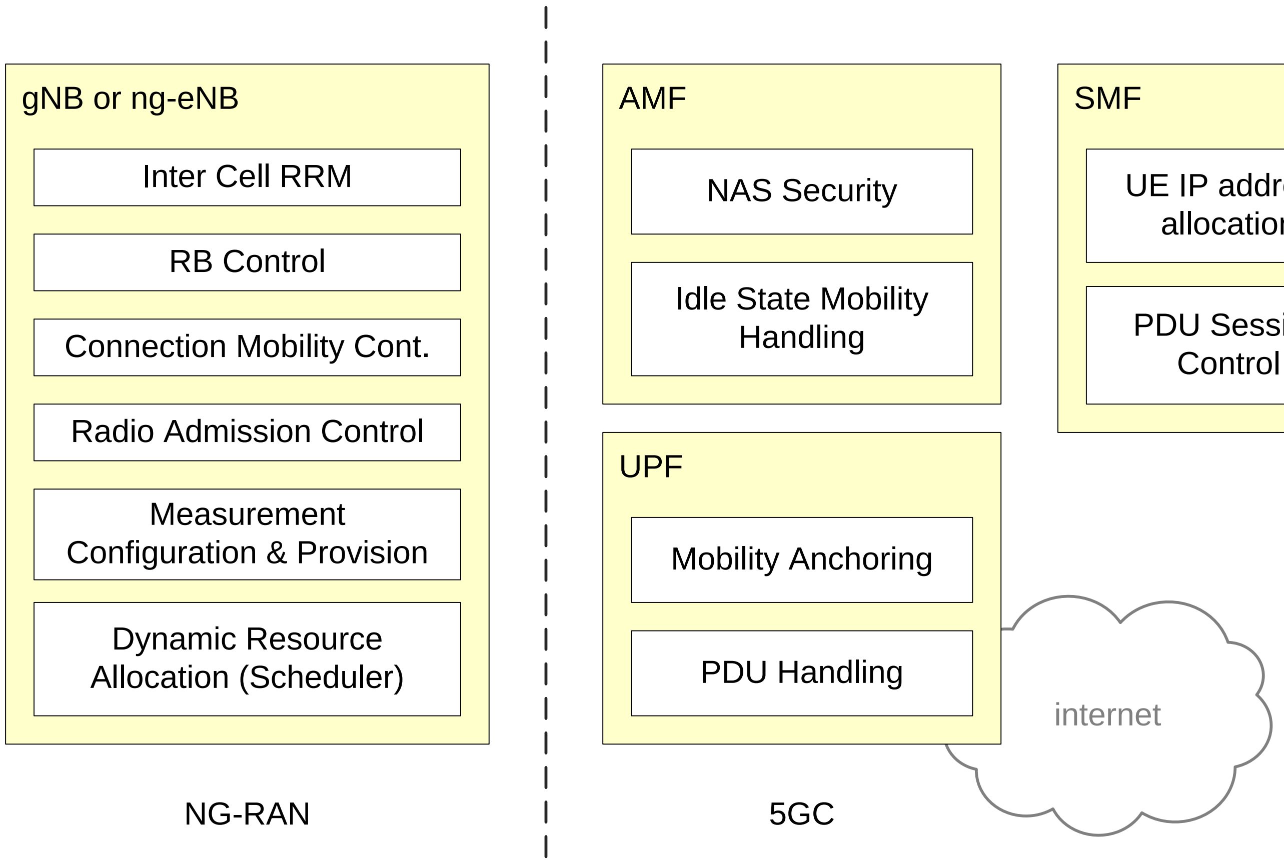
The UPF Hosts The Following Main Functions

- Anchor point for Intra-/Inter-RAT mobility (when applicable)
- External PDU session point of interconnect to Data Network
- Packet routing & forwarding
- Packet inspection and User plane part of Policy rule enforcement
- Traffic usage reporting
- Uplink classifier to support routing traffic flows to a data network
- Branching point to support multi-homed PDU session
- QoS handling for user plane, e.g. packet filtering, gating, UL/DL rate enforcement
- Uplink Traffic verification (SDF to QoS flow mapping)
- Downlink packet buffering and downlink data notification triggering

The SMF Hosts The Following Main Functions

- Session Management
- UE IP address allocation and management
- Selection and control of UP function
- Configures traffic steering at UPF to route traffic to proper destination
- Control part of policy enforcement and QoS
- Downlink Data Notification

Functional Split between NG-RAN and 5GC



Summary

- Overview of common 5GS system architecture
  - As well as interworking with EPC
- 5G NR
  - 5G RAN interface technologies
- 5G Xn Interface
  - Separation of control plane and user plane
- 5GC
  - Service-based architecture
- 5G NG Interface
  - Protocol stack and procedures

References

- TS 23.501 - System architecture for the 5G System (5GS) (16.5.0)
  - TS 23.502 - Procedures for the 5G System (5GS) (16.5.0)
  - TS 23.503 - Policy and charging control framework for the 5GS; Stage 2 (16.5.0)
- TS 38.300 - NR Overall description; Stage-2 (16.2.0)
  - TS 38.321 - NR; Medium Access Control (MAC) protocol specification (16.1.0)
  - TS 38.322 - NR; Radio Link Control (RLC) protocol specification (16.1.0)
  - TS 38.323 - Packet Data Convergence Protocol (PDCP) specification (16.1.0)
  - TS 38.331 - NR; Radio Resource Control (RRC); Protocol specification (16.1.0)
  - TS 38.340 - NR; Backhaul Adaptation Protocol (BAP) specification (16.1.0)
- TS 38.420 - Xn general aspects and principles (16.0.0)
  - TS 38.421 - Xn layer 1 (16.0.0)
  - TS 38.422 - Xn signalling transport (16.0.0)
  - TS 38.423 - Xn Application Protocol (XnAP) (16.2.0)
  - TS 38.424 - Xn data transport (16.0.0)
  - TS 38.425 - NR user plane protocol (16.1.0)
- TS 38.410 - NG general aspects and principles (15.2.0)
  - TS 29.244 - Interface between the Control Plane and the User Plane nodes (16.4.0)