5G E2E Network Architecture

TP00005-V-1701 V0 - S01M01 Ed1

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

Learning objectives

Upon completion of this module, you should be able to:

- Review 3GPP 5G system specifications
- Describe 5G e2e Network Architecture
- Recall 5G Network Architecture Options
- Identify 5GC Network Functions
- Identify NG-RAN Network Architecture
- Explain 5G System Interface Protocols
- Explain Integrated Access and Backhaul

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

Table of contents

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

NOKIA

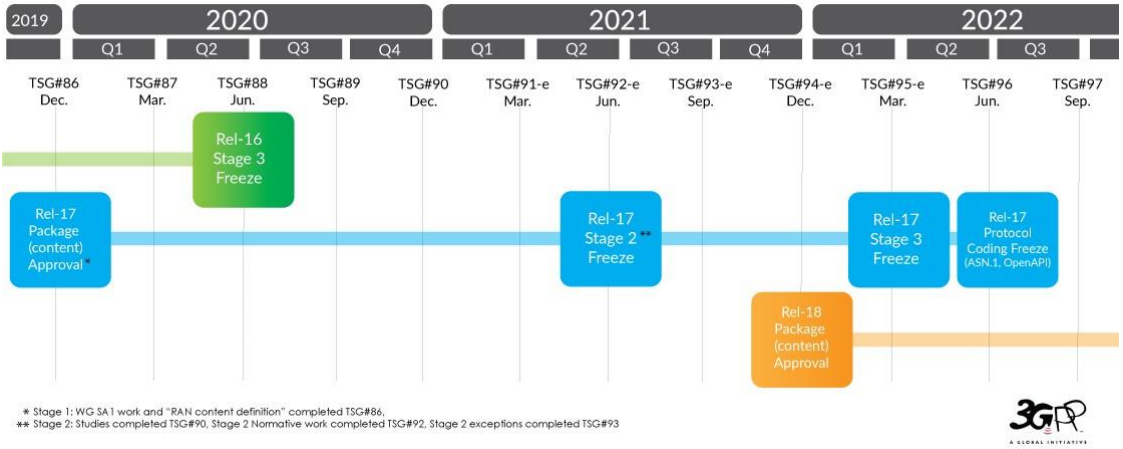
3GPP 5GS Specifications

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

3GPP 5GS Specifications

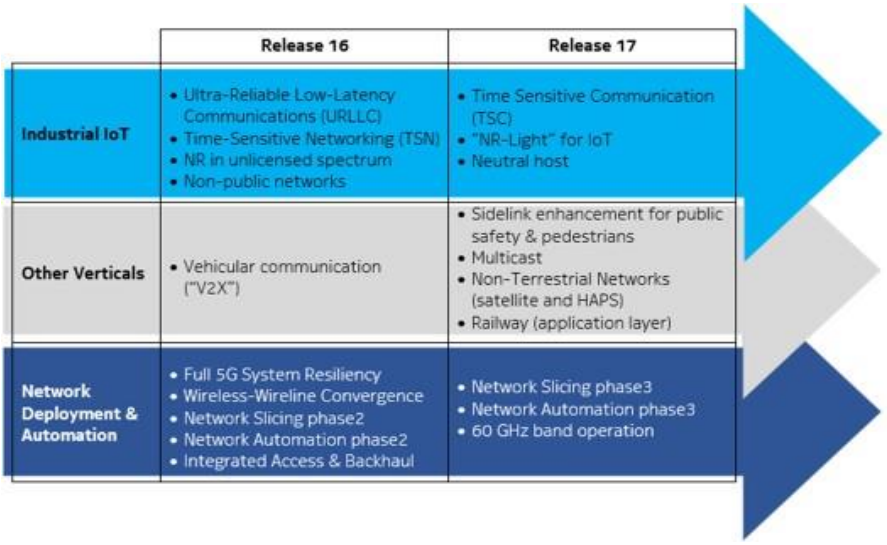
Review the timelines for 5G standards and roll out



© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

3GPP 5GS Specifications
3GPP 5G Release 16 and 17 evolution



	Release 16	Release 17
Industrial IoT	• Ultra-Reliable Low-Latency Communications (URLLC) • Time-Sensitive Networking (TSN) • NR in unlicensed spectrum • Non-public networks	• Time Sensitive Communication (TSC) • "NR-Light" for IoT • Neutral host
Other Verticals	• Vehicular communication ("V2X")	• Sidelink enhancement for public safety & pedestrians • Multicast • Non-Terrestrial Networks (satellite and HAPS) • Railway (application layer)
Network Deployment & Automation	• Full 5G System Resiliency • Wireless-Wireline Convergence • Network Slicing phase2 • Network Automation phase2 • Integrated Access & Backhaul	• Network Slicing phase3 • Network Automation phase3 • 60 GHz band operation

© Nokia 2023 Nokia Confidential

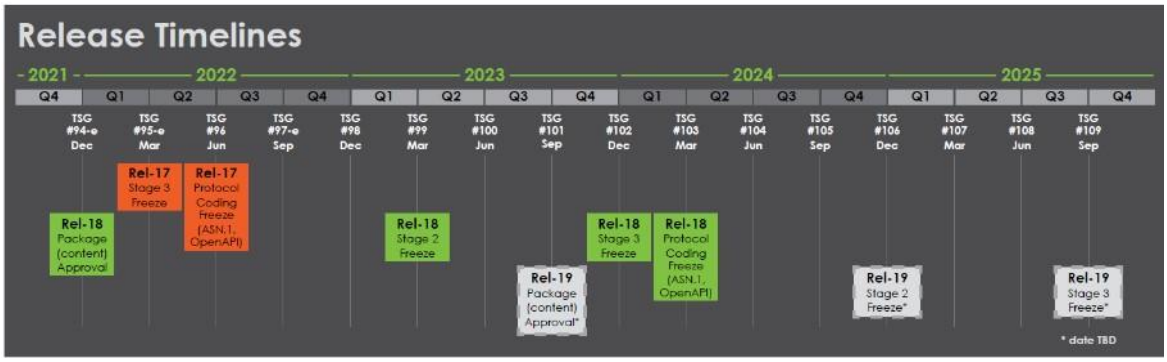
© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G-Advanced is set to evolve the 5G system to its fullest capabilities. It will comprise a large set of innovations offering a plethora of benefits for network and system operators, end-users and verticals. 5G-Advanced will include features that will be specified in 3GPP Release 18 and beyond, including, among others, improved coverage and capacity, enhanced end-user experience and expanded capabilities beyond connectivity.

Nokia wants to lead the market in 5G-Advanced era.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

Ongoing Release timelines (Oct. 2023)



© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G-Advanced, starting with Release18, is expected to offer improved Experience for people and machines, Extensions for new use cases, and Expansions to offer new services beyond pure communication. This is powered by innovations that provide operational Excellence.

[1] The domain of enhanced Experience aims to lift 5G end-user experience to the next level, including better support for eXtended Reality (XR); enhancement techniques include further development of MIMO, and improvements in mobility and flexible duplexing are envisioned.

[2] The Extensions domain aims to extend the reach of 5G connectivity and to make it available to new market segments; including innovations for improved coverage, enhanced low-cost massive IoT, and further support for non-terrestrial networks (NTN) and drones.

[3] The Expansions domain targets the expansion of 5G services beyond traditional communication, by introducing enhanced positioning with sub-10cm accuracy consistently both indoors and outdoors, as well as time synchronization as a service, offering valuable benefits for use cases as diverse as smart power grid control, industrial automation and real-time financial transactions.

[4] 5G-Advanced will be powered by operational Excellence that aims to enhance and optimize the 5G platform and its operation by the gradual introduction of Artificial Intelligence (AI) and Machine Learning (ML) enablers, network slicing enhancements, wireline and wireless convergence, network coordination and energy efficiency enhancements. Energy efficiency improvements for both the network infrastructure and the devices will be in focus. These operational enhancements will ensure efficient network operation at affordable operational expense (OPEX) so that 5G-Advanced can efficiently serve a larger number of services with diverse QoS requirements.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G E2E Network Architecture

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G Core Network Architecture

General concepts for 5G Core Network

Some of the general concepts and key principles to a 5G Network are presented below:

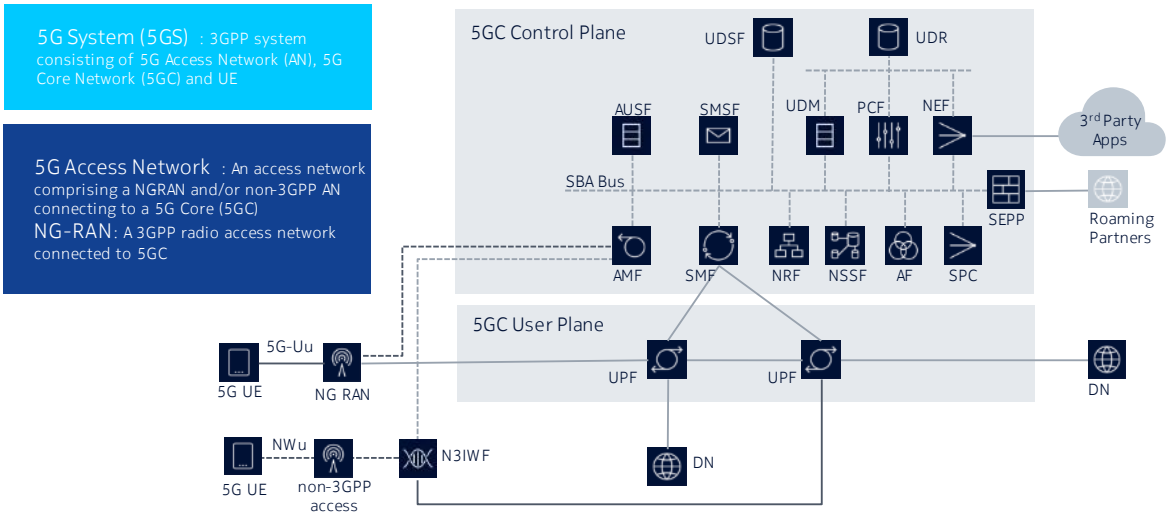
- Separate the User Plane (UP) functions from the Control Plane (CP) functions, allowing independent scalability, evolution and flexible deployments.
- Modularize the function design.
- Enable each Network Function and its Network Function Services to interact with other NF and its Network Function Services directly or indirectly via a Service Communication Proxy (SCP) if required.
- Support a unified authentication framework.
- Support "stateless" NFs, where the "compute" resource is decoupled from the "storage" resource.
- Support capability exposure.
- Support concurrent access to local and centralized services.
- Support low latency services and access to local data networks, UP functions can be deployed close to the Access Network.
- Support roaming with both Home routed traffic as well as Local breakout traffic in the visited PLMN.

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G System Architecture

5G end-to-end System Architecture



© Nokia 2023

Nokia Confidential

Before describing the 5G System architecture let's first look at some definitions:

- 5G System is a 3GPP system consisting of 5G Access Network (AN), 5G Core Network 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 (Next Generation Radio Access Network) : A radio access network that supports one or more of the following options with the common characteristics that it connects to 5GC:
    - Standalone New Radio.
    - New Radio is the anchor with E-UTRA extensions.
    - Standalone E-UTRA.
    - E-UTRA is the anchor with New Radio extensions..

Note the interworking with LTE, but not with 2G/3G/CS voice.

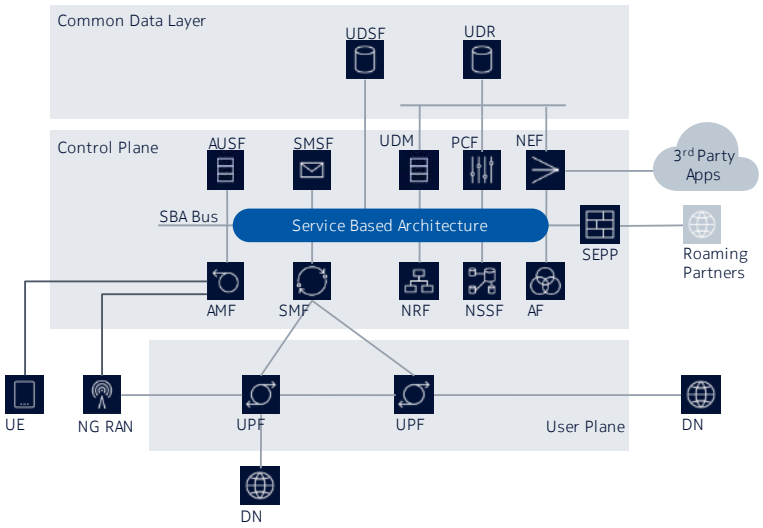
The 5G System architecture is defined as service-based and the interaction between network functions is represented in two ways:

- A service-based representation, where network functions within the Control Plane enables other authorized network functions to access their services. This representation also includes point-to-point reference points where necessary. Network functions within the 5GC Control Plane shall only use service-based interfaces for their interactions.
- A reference point representation described by point-to-point reference point (e.g. N2) between any two network functions. This representation shows the interaction existing between the NF services in the network functions.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G System Architecture
Service Based Architecture (SBA)

- Functional Decomposition
- Open API (SBI using HTTP 2.0)
- Common Data Storage
- Network Capabilities Exposure
- Unified Access (incl. non 3GPP)
- Network Slicing
- Edge Computing Enablers
- Flow Based QoS



© Nokia 2023

Nokia Confidential

The 5G Core Network (5GC) consists of the functional elements shown in this diagram. Some of these core functions perform similar roles as the existing EPC while others, such as the Network Functions Repository Function (NRF), are new.

The 5GC introduces a new Services Based Architecture (SBA) where the 5GC control plane (CP) design is based on services exposed by network functions (NFs) using new service-based interfaces (SBIs). Once a 5GC function registers its services with the new 5G Core Network Functions Repository Function (NRF), it then simply expose services that any authorized consumer can consume, rather than having to define a new point-to-point interface and the procedures between the two network functions as an EPC requires. This offers operators greater flexibility and more efficiency by decoupling the service consumer from the service producer.
This architecture model is chosen to enable deployments to take advantage of the latest virtualization and software technologies.

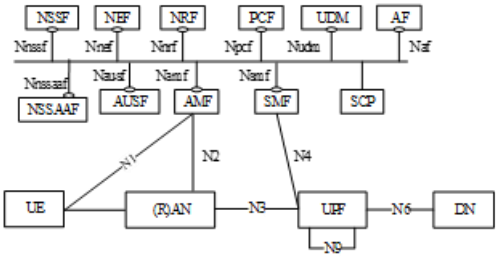
5G Core Network Functions will be described in the upcoming slides.
Authentication Server Function (AUSF).
- Access and Mobility Management Function (AMF).
- Data Network (DN), e.g. operator services, Internet access or 3rd party services.
- Unstructured Data Storage Function (UDSF).
- Network Exposure Function (NEF).
- Network Repository Function (NRF).
- Network Slice Specific Authentication and Authorization Function (NSSAAF).
- Network Slice Selection Function (NSSF).
- Policy Control Function (PCF).
- Session Management Function (SMF).
- Unified Data Management (UDM).
- Unified Data Repository (UDR).
- User Plane Function (UPF).
- UE radio Capability Management Function (UCMF).
- Application Function (AF).
- User Equipment (UE).
- (Radio) Access Network ((R)AN).
- 5G-Equipment Identity Register (5G-EIR).
- Network Data Analytics Function (NWDAF).
- CHarging Function (CHF).
- Service Communication Proxy (SCP).
- Security Edge Protection Proxy (SEPP).
- Non-3GPP InterWorking Function (N3IWF).
- Trusted Non-3GPP Gateway Function (TNGF).
- Wireline Access Gateway Function (W-AGF).
- Trusted WLAN Interworking Function (TWIF).

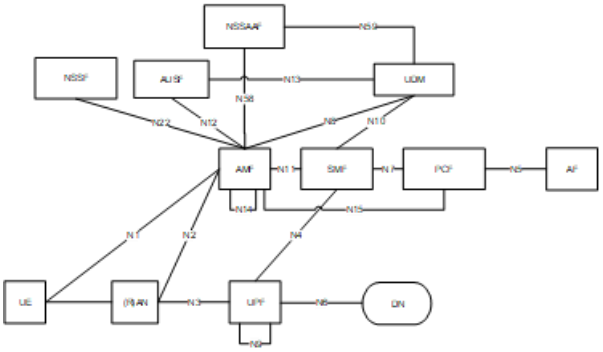
© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G System Architecture
Non-roaming reference architecture

The 5G architecture is defined as service -based and the interaction between network functions is represented in two ways.

- A service-based representation
- A reference point representation





More Non-roaming reference architectures, such as multiple PDU Session, are provided in 3GPP TS 23.501

© Nokia 2023 Nokia Confidential

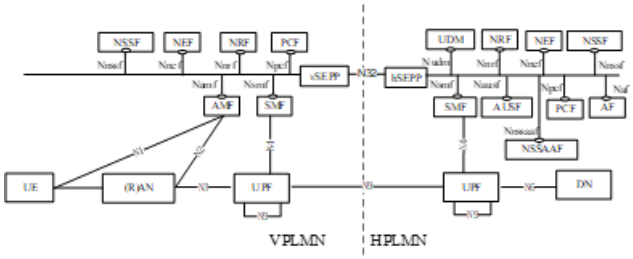
The 5G architecture is defined as service-based and the interaction between network functions is represented in two ways.
- A service-based representation, where network functions (e.g. AMF) within the Control Plane enables other authorized network functions to access their services. This representation also includes point-to-point reference points where necessary.
- A reference point representation, shows the interaction exist between the NF services in the network functions described by point-to-point reference point (e.g. N11) between any two network functions (e.g. AMF and SMF).

Reference point representation:
N1: Reference point between the UE and the AMF.
N2: Reference point between the (R)AN and the AMF.
N3: Reference point between the (R)AN and the UPF.
N4: Reference point between the SMF and the UPF.
N6: Reference point between the UPF and a Data Network.
N9: Reference point between two UPFs.
N5: Reference point between the PCF and an AF.
N7: Reference point between the SMF and the PCF.
N8: Reference point between the UDM and the AMF.
N10: Reference point between the UDM and the SMF.
N11: Reference point between the AMF and the SMF.
N12: Reference point between AMF and AUSF.
N13: Reference point between the UDM and Authentication Server function the AUSF.
N14: Reference point between two AMFs.
N15: Reference point between the PCF and the AMF in the case of non-roaming scenario, PCF in the visited network and AMF in the case of roaming scenario.
N16: Reference point between two SMFs, (in roaming case between SMF in the visited network and the SMF in the home network).
N16a: Reference point between SMF and I-SMF.
N17: Reference point between AMF and 5G-EIR.
N18: Reference point between any NF and UDSF.
N19: Reference point between two PSA UPFs for 5G LAN-type service.
N22: Reference point between AMF and NSSF.
N23: Reference point between PCF and NWDAF.
N24: Reference point between the PCF in the visited network and the PCF in the home network.
N27: Reference point between NRF in the visited network and the NRF in the home network.
N28: Reference point between PCF and CHF.
N29: Reference point between NEF and SMF.
N30: Reference point between PCF and NEF.
N31: Reference point between the NSSF in the visited network and the NSSF in the home network.
N32: Reference point between SEPP in the visited network and the SEPP in the home network.
N33: Reference point between NEF and AF.
N34: Reference point between NSSF and NWDAF.
N35: Reference point between UDM and UDR.
N36: Reference point between PCF and UDR.
N37: Reference point between NEF and UDR.
N38: Reference point between I-SMFs.
N40: Reference point between SMF and the CHF.
N50: Reference point between AMF and the CBCF.
N51: Reference point between AMF and NEF.
N52: Reference point between NEF and UDM.
N55: Reference point between AMF and the UCMF.
N56: Reference point between NEF and the UCMF.
N57: Reference point between AF and the UCMF.
N41: Reference point between AMF and the CHF in HPLMN.
N42: Reference point between AMF and the CHF in VPLMN.
N58: Reference point between AMF and the NSSAAF.
N59: Reference point between UDM and the NSSAAF.

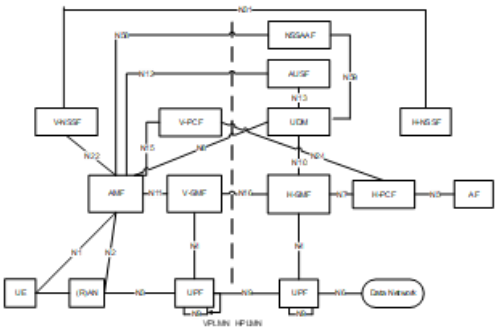
© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G System Architecture
Roaming reference architecture

Roaming 5G System architecture- home routed scenario



in service-based interface representation



in reference point representation

More Roaming reference architectures, such as local breakout scenario, are provided in 3GPP TS 23.501

© Nokia 2023 Nokia Confidential

Reference point representation:
N1: Reference point between the UE and the AMF.
N2: Reference point between the (R)AN and the AMF.
N3: Reference point between the (R)AN and the UPF.
N4: Reference point between the SMF and the UPF.
N6: Reference point between the UPF and a Data Network.
N9: Reference point between two UPFs.
N5: Reference point between the PCF and an AF.
N7: Reference point between the SMF and the PCF.
N8: Reference point between the UDM and the AMF.
N10: Reference point between the UDM and the SMF.
N11: Reference point between the AMF and the SMF.
N12: Reference point between AMF and AUSF.
N13: Reference point between the UDM and Authentication Server function the AUSF.
N14: Reference point between two AMFs.
N15: Reference point between the PCF and the AMF in the case of non-roaming scenario, PCF in the visited network and AMF in the case of roaming scenario.
N16: Reference point between two SMFs, (in roaming case between SMF in the visited network and the SMF in the home network).
N16a: Reference point between SMF and I-SMF.
N17: Reference point between AMF and 5G-EIR.
N18: Reference point between any NF and UDSF.
N19: Reference point between two PSA UPFs for 5G LAN-type service.
N22: Reference point between AMF and NSSF.
N23: Reference point between PCF and NWDAF.
N24: Reference point between the PCF in the visited network and the PCF in the home network.
N27: Reference point between NRF in the visited network and the NRF in the home network.
N28: Reference point between PCF and CHF.
N29: Reference point between NEF and SMF.
N30: Reference point between PCF and NEF.
N31: Reference point between the NSSF in the visited network and the NSSF in the home network.
N32: Reference point between SEPP in the visited network and the SEPP in the home network.
N33: Reference point between NEF and AF.
N34: Reference point between NSSF and NWDAF.
N35: Reference point between UDM and UDR.
N36: Reference point between PCF and UDR.
N37: Reference point between NEF and UDR.
N38: Reference point between I-SMFs.
N40: Reference point between SMF and the CHF.
N50: Reference point between AMF and the CBCF.
N51: Reference point between AMF and NEF.
N52: Reference point between NEF and UDM.
N55: Reference point between AMF and the UCMF.
N56: Reference point between NEF and the UCMF.
N57: Reference point between AF and the UCMF.
N41: Reference point between AMF and the CHF in HPLMN.
N42: Reference point between AMF and the CHF in VPLMN.
N58: Reference point between AMF and the NSSAAF.
N59: Reference point between UDM and the NSSAAF.

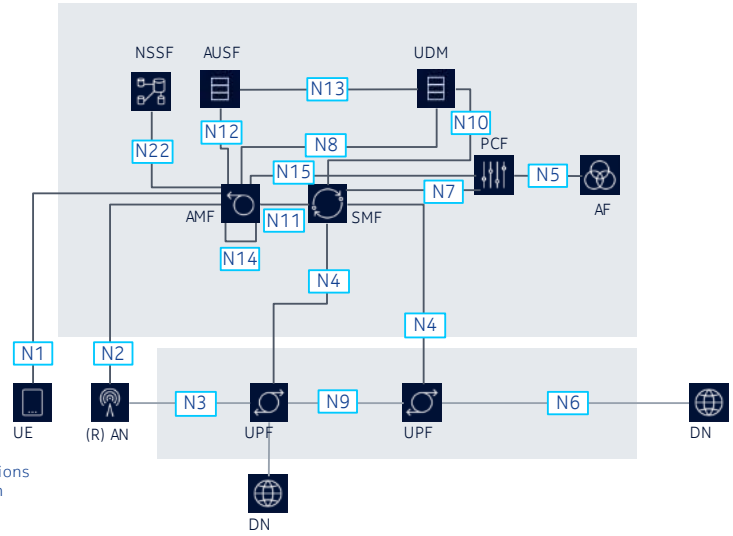
© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G System Architecture
Reference Point Representation

Reference point- based architecture is a point-to-point architecture with functions interconnected with specific interfaces

N1:	• between the UE and the AMF.
N2:	• between the (R)AN and the AMF.
N3:	• between the (R)AN and the UPF.
N4:	• between the SMF and the UPF.
N6:	• between the UPF and a Data Network.
N9:	• between two UPFs

Other reference points (N5, N7…) that show the interactions that exist between the NF services in the NFs are given in TS23.501



© Nokia 2023

Nokia Confidential

In addition to the reference points above, Many other reference points (Listed in TS23.501) show the interactions that exist between the NF services in the NFs. These reference points are realized by corresponding NF service-based interfaces and by specifying the identified consumer and producer NF service as well as their interaction in order to realize a particular system procedure.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G System Architecture
Service – based interfaces

5G Core Network is a Service– Oriented Architecture where services are provided to the other components by application components using pre-defined protocols over a network.

- Namf: Service-based interface exhibited by AMF.
- Nsmf: Service-based interface exhibited by SMF.
- Nnef: Service-based interface exhibited by NEF.
- Npcf: Service-based interface exhibited by PCF.
- Nudm: Service-based interface exhibited by UDM.
- Naf: Service-based interface exhibited by AF.
- Nnrf: Service-based interface exhibited by NRF.
- Nnssaaf: Service-based interface exhibited by NSSAAF.
- Nnssf: Service-based interface exhibited by NSSF.
- Nausf: Service-based interface exhibited by AUSF.
- Nudr: Service-based interface exhibited by UDR.
- Nudsf: Service-based interface exhibited by UDSF.
- N5g-eir: Service-based interface exhibited by 5G-EIR.
- Nnwdaf: Service-based interface exhibited by NWDAF.
- Nchf: Service-based interface exhibited by CHF.
- Nucmf: Service-based interface exhibited by UCMF.

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G System Architecture
Quiz 1

1. Which of the following is a correct statement?
   a. Service based principles apply between the control plane network functions of the Access Network.
   b. Service based principles apply between the User plane network functions of the Core Network.
   c. Service based principles apply between the User and control plane network functions of the Core Network.
   d. Service based principles apply between the control plane network functions of the Core Network.

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

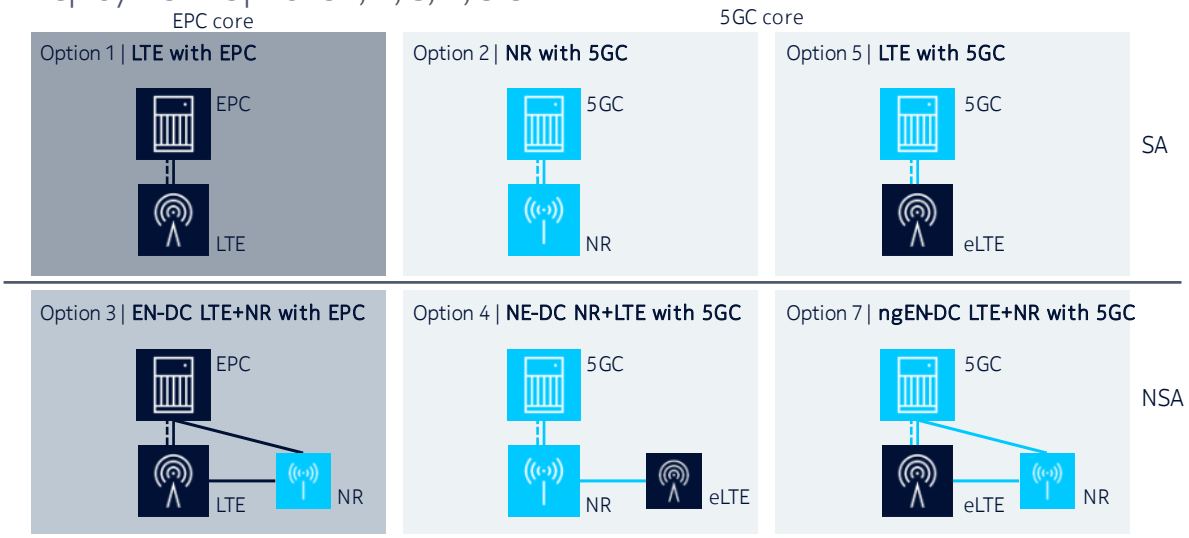
5G Network Architecture Options

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G Network Architecture Options

Deployment Options 1, 2, 3, 4, 5 & 7



SA: StandAlone; NSA: Non-StandAlone

© Nokia 2023

Nokia Confidential

Option 1, formally termed E-UTRA using LTE access

Option 2, formally termed NR

Option 3, formally termed "E-UTRA – NR Dual Connectivity" or EN-DC. 3X is a specific variant where Split radio bearers as terminated on the Secondary Node

Option 4, formally termed "NR – E-UTRA Dual Connectivity" or NE-DC

Option 5, formally termed "next generation RAN E-UTRA. Often referred to as eLTE

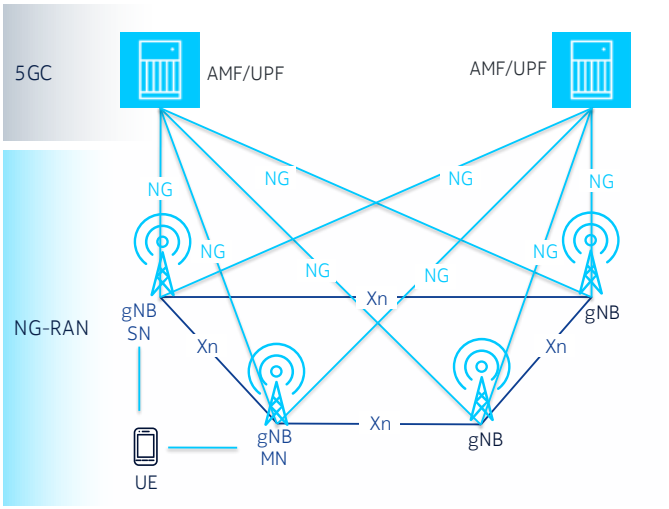
Option 7, formally termed "next generation E-UTRA – NR Dual Connectivity" or ngEN-DC. . 7X is a specific variant where Split radio bearers as terminated on the Secondary Node

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

NR-NR Dual Connectivity (NR-DC)

NG-RAN supports 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.
- In addition, NR -DC can also be used when a UE is connected to a single gNB, acting both as a MN and as a SN, and configuring both MCG and SCG.



© Nokia 2023

Nokia Confidential

As per the late drop of 3GPP Release 15, NG-RAN supports NR-NR Dual Connectivity (NR-DC), in which a UE is connected to one gNB that acts as a MN and another gNB that acts as a SN. The master gNB is connected to the 5GC via the NG interface and to the secondary gNB via the Xn interface. The secondary gNB might also be connected to the 5GC via the NG-U interface. In addition, NR-DC can also be used when a UE is connected to two gNB-DUs, one serving the MCG and the other serving the SCG, connected to the same gNB-CU, acting both as a MN and as a SN.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

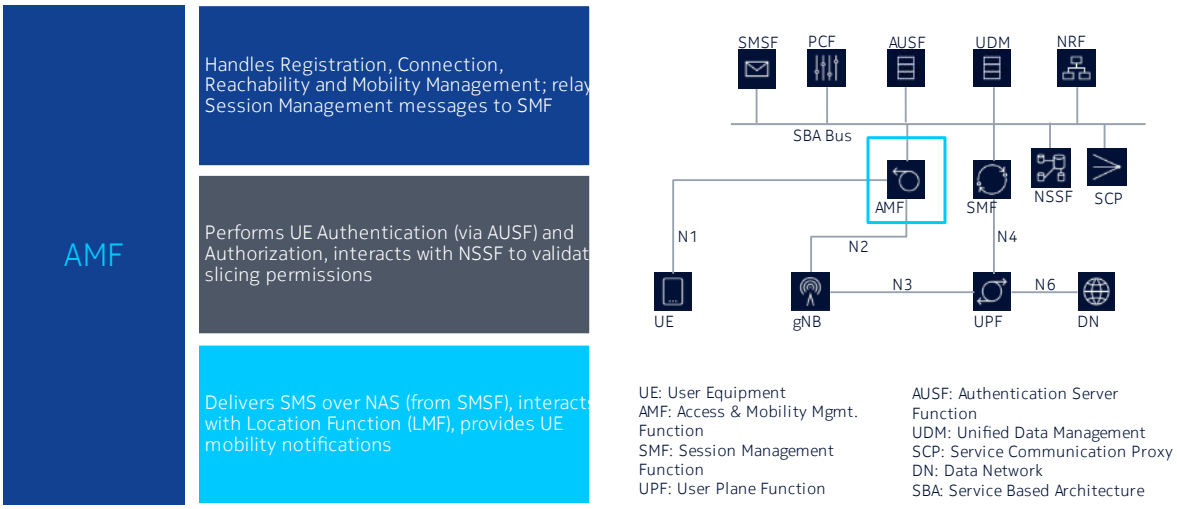
NOKIA

5GC Network Functions

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5GC Network Functions
Access and Mobility Management Function



© Nokia 2023

Nokia Confidential

Access and Mobility management Function (AMF) is the single control plane component that terminates the interface from the access networks and from the UE, manages access control and mobility, and plays a key role in network slice functionality by serving all slices a UE is accessing.

The AMF hosts the following main functions:

- NAS signaling termination;
- NAS signaling security;
- AS Security control;
- Inter CN node signaling 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.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

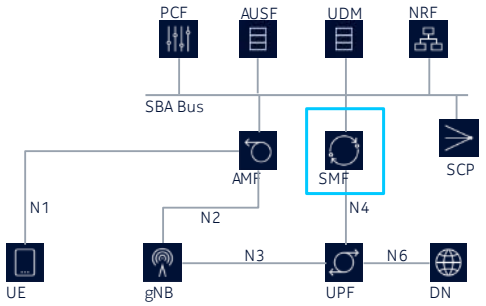
5GC Network Functions
Session Management Function

SMF

Handles establishment, modification and release of PDU sessions. Interacts with the access network via the AMF

Performs UPF selection (via NRF) and control (via N4). Handles IP address management, including DHCP, and ARP/ND for Ethernet PDUs (via proxy on UPF)

Interfaces with the Charging and Policy functions. Determines the SSC mode of a PDU session



UE: User Equipment
AMF: Access & Mobility Mgmt. Function
SMF: Session Management Function
UPF: User Plane Function

AUSF: Authentication Server Function
UDM: Unified Data Management
DN: Data Network
SBA: Service Based Architecture

© Nokia 2023

Nokia Confidential

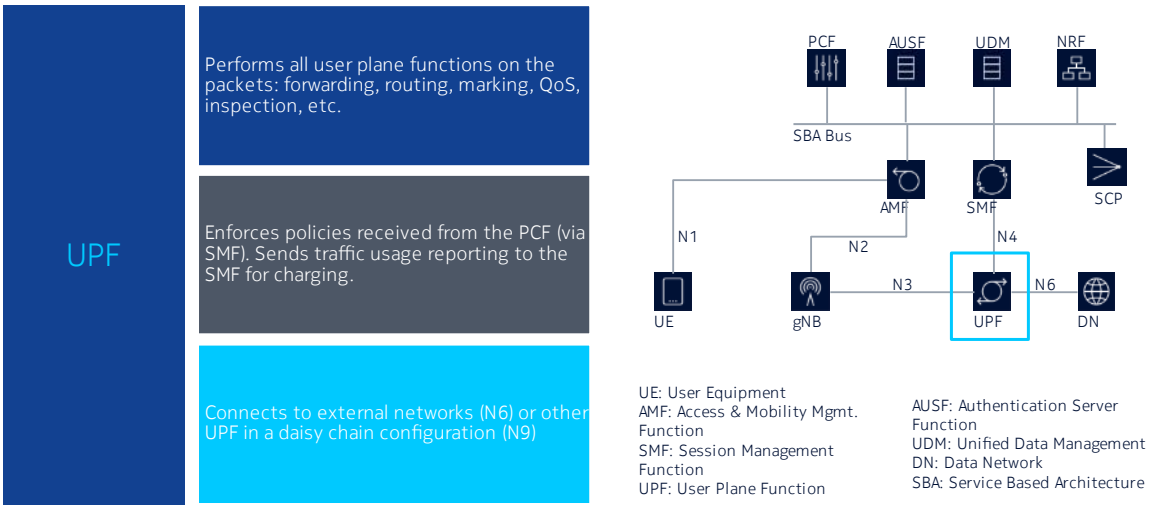
Session Management Function (SMF) is the only function that establishes and manages sessions for all access types according to the network policy. It absorbs in one function session management functionality spread across the control plane functions of the Evolved Packet Core (EPC).

The Session Management function (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.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5GC Network Functions
User Plane Function



© Nokia 2023 Nokia Confidential

User Plane Function (UPF) is equivalent to the user plane of the EPC serving/packet data network gateway (S/P-gateway), but enhanced to support flow-based QoS and a new session and service continuity mode that allows a ”make before break” approach quintessential for URLLC. Multiple UPF instances are possible within distributed and centralized deployments, allowing completely disjointed paths from the access network for the sessions of the same user endpoint.

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.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

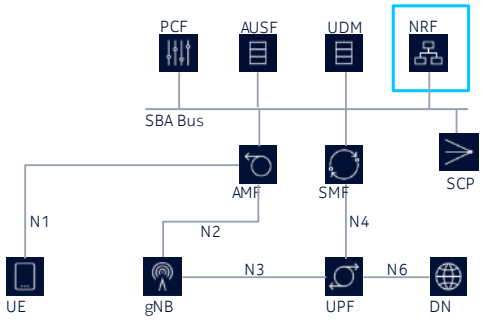
5GC Network Functions
Network Repository Function

NRF

Maintains the NF profile of available NF instances and their supported services, and provides NF discovery and selection

Selection criteria can include location (latency), load, Data Network Name (application), access network type, slice, etc

Provides much more granular policies and dynamic capabilities when compared to DNS selection



UE: User Equipment
AMF: Access & Mobility Mgmt. Function
SMF: Session Management Function
UPF: User Plane Function

AUSF: Authentication Server Function
UDM: Unified Data Management
DN: Data Network
SBA: Service Based Architecture

© Nokia 2023

Nokia Confidential

Network Repository Function (NRF): This is a new functionality with no equivalent in 4G networks. NRF provides registration and discovery functionality to enable other network functions/services to discover and communicate with each other.

Main functions of NRF:

- Supports service discovery function
- Receive NF Discovery Request from NF instance, and provides the information of the discovered NF instances (be discovered) to the NF instance
- Maintains the NF profile of available NF instances and their supported services (e.g. ID, Type, PLMN, Slice, FQDN, capabilities, authorization information, service names)
- All network functions interact with NRF
- Multiple NRFs can be deployed in network slicing per PLMN, per group of slices, or slice specific
- In roaming cases VPLMN and HPLMN may be used.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

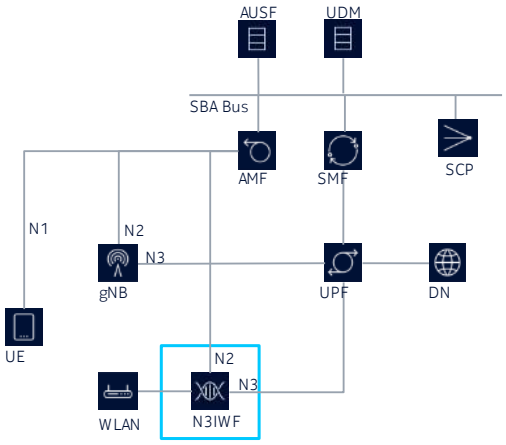
5GC Network Functions
Non-3GPP Interworking Function

N3IWF

Common set of interfaces for UEs and Access Nodes to access the 5G Core. Common framework for Registration, Connection and Session Management

Current release targets untrusted access via IPSec only (similar to ePDG/VoWiFi in LTE). Release 16 will add trusted access via collaboration with BBF

IP, Ethernet and Unstructured PDU types provide the flexibility needed for multiple access technologies



© Nokia 2023

Nokia Confidential

Non-3GPP Interworking Function (N3IWF) is a core network function for the integration of the stand-alone untrusted non-3GPP access to the access agnostic, universal core. The N3IWF supports IPsec tunnel establishment with the UE. It terminates the IKEv2/IPsec protocols with the UE over NWu and relays over N2 the information needed to authenticate the UE and authorize its access to the 5G Core Network. It also terminates N2 and N3 interfaces to 5G Core Network for control - plane and user-plane respectively.

N3IWF functions are:

- UE IPSEC/IKEv2 tunnel termination
- Termination of N2 and N3 interfaces to 5G Core Network for Control-Plane and user-plane respectively
- Relaying uplink and downlink control-plane NAS (N1) signaling between the UE and AMF
- Handling of N2 signaling from SMF (relayed by AMF) related to PDU sessions and QoS
- Establishment of IPsec Security Association (IPsec SA) to support PDU Session traffic
- Relaying uplink and downlink user-plane packets between the UE and UPF. (De-capsulation/Encapsulation of packets for IPSec and N3 tunneling)
- Enforcing QoS corresponding to N3 packet marking, taking into account QoS requirements associated to such marking received over N2
- N3 user-plane packet marking in the uplink.
- Local mobility anchor within untrusted non-3GPP access networks using MOBIKE
- Supporting AMF selection.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

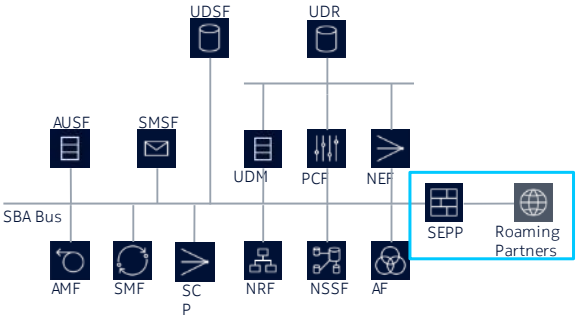
5GC Network Functions
Security Edge Protection Proxy

SEPP

The Security Edge Protection Proxy interconnects the control plane in roaming agreements

Provides message filtering and topology hiding between domains

Implemented by an HTTP proxy to control which APIs and values are accessible from other PLMNs



AMF: Access & Mobility Mgmt. Function
SMF: Session Management Function
NRF: NF Repository Function
NSSF: Network Slice Selection Function
AF: Application Function
AUSF: Authentication Server Function

UDM: Unified Data Management
SMSF: SMS Function
PCF: Policy Control Function
NEF: Network Exposure Function
UDR: Unified Data Repository
UDSF: Unstructured Data Storage Function

© Nokia 2023

Nokia Confidential

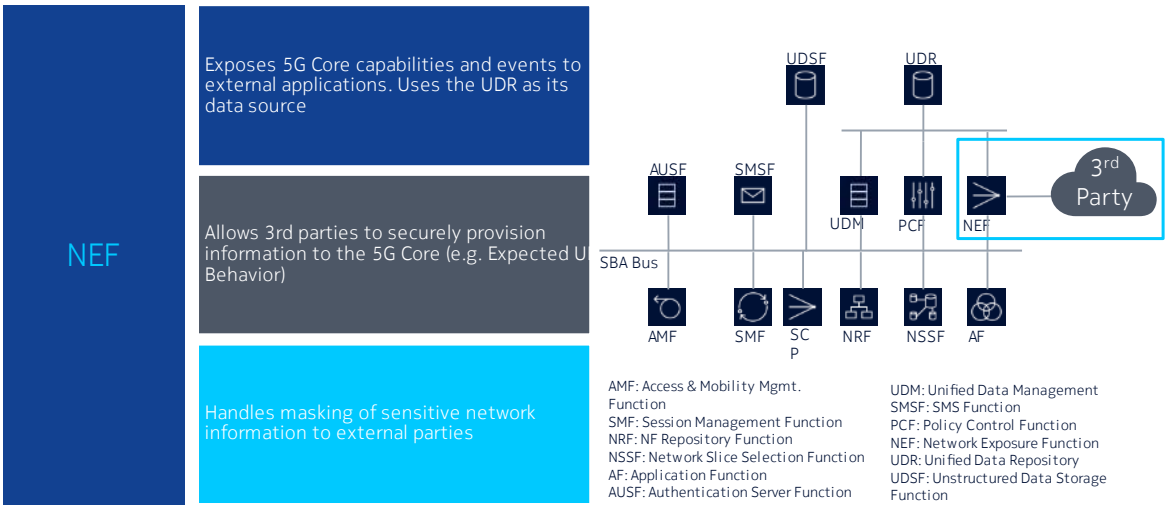
Security Edge Protection Proxy (SEPP) is a non-transparent proxy that protect the interactions between PLMNs. The SEPP applies the functionality listed on the slide to every Control Plane message in inter-PLMN signaling, acting as a service relay between the actual Service Producer and the actual Service Consumer. For both Service Producer and Consumer, the result of the service relaying is equivalent to a direct service interaction.

SEPP functions:

- Protect the interactions between PLMNs
- Used in roaming networks
- Non-transparent proxy
- Message filtering and policing on inter-PLMN control plane interfaces
- Topology hiding.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5GC Network Functions
Network Exposure Function



© Nokia 2023 Nokia Confidential

Network Exposure Function (NEF) is an extension of the Service Capability Exposure Function (SCEF) in 4G networks.

NEF allows the operator to expose 5G Core Network functionalities available to 3rd parties such as service providers and vertical industries outside the operator's domain.

The interface provided by the NEF to 3rd parties can be regarded as one of the essential membranes through which 5G communicates more closely towards vertical industries than mobile networks of earlier generations did. With the advent of 5G, new network capabilities need to be exposed to the 3rd party (e.g., to allow the 3rd party to customize a dedicated network slice for diverse use cases; to allow the 3rd party to manage a trusted 3rd party application in a Service Hosting Environment to improve user experience, and efficiently utilize backhaul and application resources).

External exposure

- The NEF provides a means to securely expose the services and capabilities provided by 3GPP network functions
- E.g., 3rd party, internal exposure/re-exposure, Application Functions, Edge Computing.
- The NEF provides a means for the Application Functions to securely provide information to 3GPP network
- E.g. Expected UE Behavior.
- The NEF translates between information exchanged with the AF and information exchanged with the internal network function..

Furthermore, NEF provides a means for the Application Functions to securely provide information to 3GPP network, e.g. Mobility Pattern, communication pattern

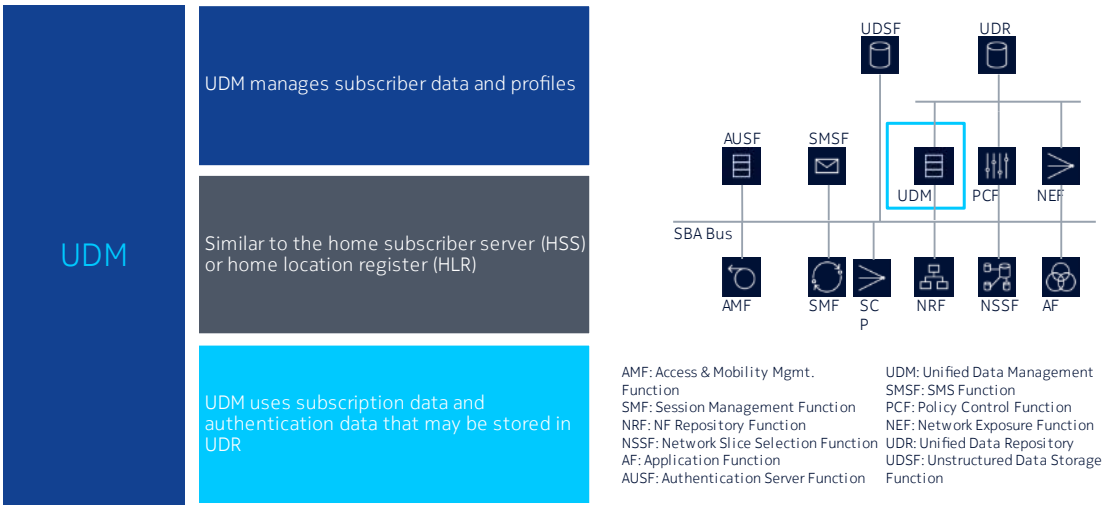
Authenticate, authorize and throttle the Application Functions. It translates information between AF and internal network function. It receives information from other network functions (based on exposed capabilities of other network functions) and may implement a Front End to store the received information as structured data using a standardized interface to a Unified Data Repository (UDR). The stored information can be accessed and "re-exposed" by the NEF to other network functions and Application Functions, and used for other purposes such as analytics.

Internal exposure

- The NEF receives information from other network functions (based on exposed capabilities of other network functions).
- It may implement a Front End (NEF FE) to store the received information as structured data using a standardized interface to a Unified Data Repository (UDR).
- The stored information can be accessed and "re-exposed" by the NEF to other network functions and Application Functions, and used for other purposes such as analytics.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5GC Network Functions
Unified Data Management



© Nokia 2023 Nokia Confidential

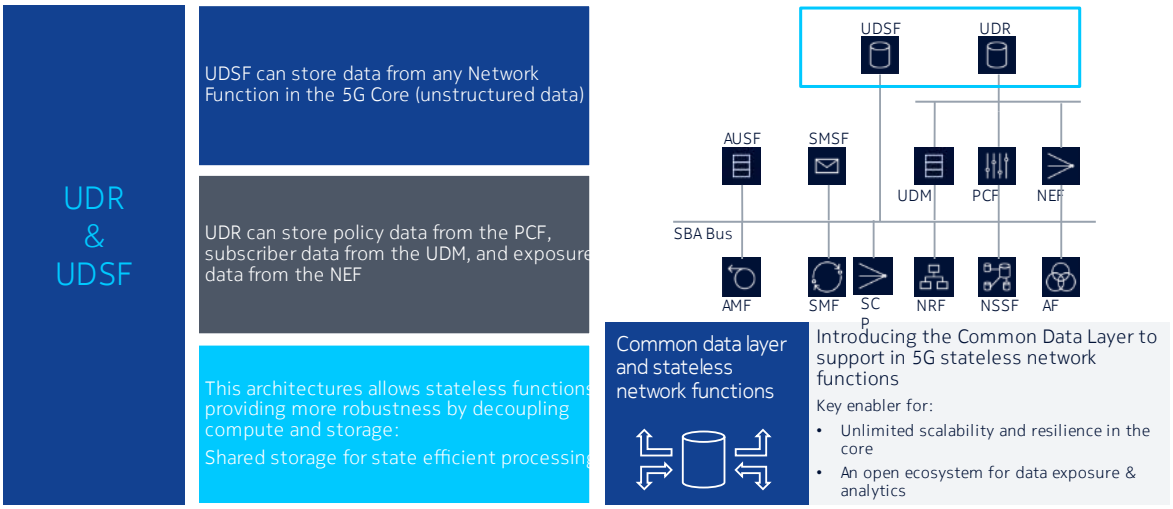
Unified Data Management (UDM) stores subscriber data and profiles, similar to the home subscriber server (HSS) or home location register (HLR).

UDM main functions:

- 3GPP AKA Authentication Credential Processing
- User Identification Handling
- Access Authorization
- Registration/Mobility management
- Subscription management
- SMS management
- UDM uses subscription data and authentication data that may be stored in UDR.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5GC Network Functions
Common Data Layer



© Nokia 2023 Nokia Confidential

The 5G System architecture allows the UDM, PCF and NEF to store data in the UDR, including subscription data and policy data by UDM and PCF, structured data for exposure and application data by the NEF (including Packet Flow Descriptions for application detection, Application Function request information for multiple UEs).

There can be multiple UDRs deployed in the network, each of which can accommodate different data sets or subsets, (e.g. subscription data, subscription policy data, data for exposure, application data) and/or serve different sets of NFs. Deployments where a UDR serves a single NF and stores its data, and, thus, can be integrated with this NF, can be possible.

Each NF Service Consumer accessing the UDR, shall be able to add, modify, update or delete only the data it is authorized to change. This authorization shall be performed by the UDR on a per data set and NF service consumer basis and potentially on a per UE, subscription granularity.

Unstructured Data Storage Function (UDSF) is a new functionality allowing control plane elements to store their session data and become session stateless.

The 5G System architecture allows any NF to store and retrieve its unstructured data into/from a UDSF (e.g. UE contexts). The UDSF belongs to the same PLMN where the network function is located. Control Pane Network Functions may share a UDSF for storing their respective unstructured data or may each have their own UDSF (e.g. a UDSF may be located close to the respective NF).

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5GC Network Functions
Policy Control Function

© Nokia 2023 Nokia Confidential

Policy Control Function (PCF) provides a common policy framework by exposing policies as a service that are consumed by any authorized client. Besides QoS and charging, it supports network slicing, roaming and mobility policies.

PCF functions:

- Supports unified policy framework to govern network behavior
- Provides policy rules to Control Plane function(s) to enforce them
- Implements a Front End (PCF FE) to access subscription information relevant for policy decisions in a Unified Data Repository (UDR).

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

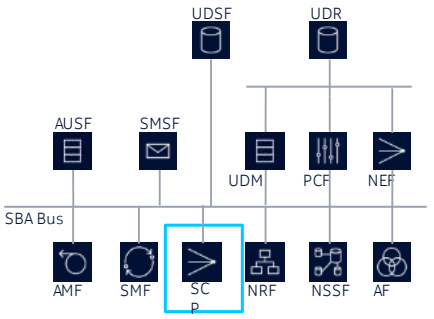
5GC Network Functions
Service Communication Proxy

SCP

Service Communication Proxy is an optional Network Function. It will help in a highly distributed multi-access edge Service-based compute environment.

Performs delegated discovery in the form of an internal service registrar and controller, it implements an individual Service Agent for each Network Function.

Allows for indirect communications between each 5G core component in the SBA



AMF: Access & Mobility Mgmt. Function
SMF: Session Management Function
NRF: NF Repository Function
NSSF: Network Slice Selection Function
AF: Application Function
AUSF: Authentication Server Function
UDM: Unified Data Management
SMSF: SMS Function
PCF: Policy Control Function
NEF: Network Exposure Function
UDR: Unified Data Repository
UDSF: Unstructured Data Storage Function

© Nokia 2023

Nokia Confidential

The Service Communication Proxy (SCP) includes one or more of the following functionalities. Some or all of the SCP functionalities may be supported in a single instance of an SCP:

- Indirect Communication
- Delegated Discovery
- Message forwarding and routing to destination NF/NF service.
- Message forwarding and routing to a next hop SCP.
- Communication security (e.g. authorization of the NF Service Consumer to access the NF Service Producer API), load balancing, monitoring, overload control, etc.
- Optionally interact with UDR, to resolve the UDM Group ID/UDR Group ID/AUSF Group ID/PCF Group ID/CHF Group ID/HSS Group ID based on UE identity, e.g. SUPI or IMPI/IMPU.

The SCP may be deployed in a distributed manner.

SCPs can be deployed at PLMN level, shared-slice level and slice-specific level. It is left to operator deployment to ensure that SCPs can communicate with relevant NRFs.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5GC Network Functions
Other Network Functions

Authentication Server Function (AUSF):

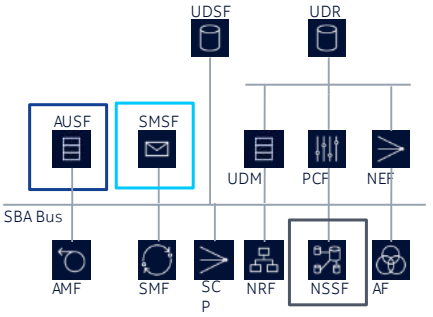
Facilitates a common authentication framework for all access types: 3GPP access and untrusted non-3GPP access.

Network Slice Selection Function (NSSF):

- It determines the allowed slices a UE can use
- It determines the AMF to be used to serve the UE, or, based on configuration, a list of candidate AMF(s), possibly by querying the NRF.
- And it selects the set of network slice instances serving the UE

SMS Function (SMSF):

It s used for SMS over NAS support. It performs SMS management subscription data checking and conducting SMS delivery according



AMF: Access & Mobility Mgmt. Function
SMF: Session Management Function
NRF: NF Repository Function
NSSF: Network Slice Selection Function
AF: Application Function
AUSF: Authentication Server Function
UDM: Unified Data Management
SMSF: SMS Function
PCF: Policy Control Function
NEF: Network Exposure Function
UDR: Unified Data Repository
UDSF: Unstructured Data Storage Function

© Nokia 2023 Nokia Confidential

Authentication Server Function (AUSF) facilitates a common authentication framework for all access types: 3GPP access and untrusted non-3GPP access.

Network Slice Selection Function (NSSF) is a new functionality tasked to assign network slice instances to the UEs. It is outsourcing some policies decisions from AMF and also allows to centralize some decisions that would otherwise be distributed. Namely:

- It determines the allowed slices a UE can use
- It determines the AMF to be used to serve the UE, or, based on configuration, a list of candidate AMF(s), possibly by querying the NRF.
- And it selects the set of network slice instances serving the UE.

The SMS Function (SMSF) is used for SMS over NAS support. It performs SMS management subscription data checking and conducting SMS delivery accordingly.

- SMS over NAS gateway
- SMS subscription checking.
- SM-RP/SM-CP with the UE
- Relay the SM from UE toward SMS-GMSC/IWMSC/SMS-Router.
- Relay the SM from SMS-GMSC/IWMSC/SMS-Router toward the UE.
- SMS related CDR.
- Lawful Interception.
- Interaction with AMF and UDM for notification procedure that the UE is available for SMS transfer (i.e., set UE not reachable flag, and notifies UDM when UE is available for SMS).

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5GC Network Functions
Quiz 2

1. What is the 5GC control plane NF that serves as the single -entry point for a UE for all its communication?
   a. UPF
   b. SMF
   c. AMF
   d. NRF
2. What best describes UDSF?
   a. It is a new functionality allowing control plane NFs to store their session data and become session stateless
   b. It is the only function that establishes and manages sessions for all access types according to the network policy
   c. It provides registration and discovery functionality to enable other network functions/services to discover and communicate with each other
   d. It is used to securely exposes the services and capabilities provided by 3GPP network functions for e.g. 3rd party

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5GC Network Functions
Quiz 3

Which of statement (a, b,c,d) best describe the Network Functions below?

Match each NF with corresponding item?

UPF	a. It provides registration and discovery functionality to enable other network functions/services to discover and communicate with each other
NRF	b. It performs access authentication and authorization, Security anchor function, registration, connection, reachability, and mobility management
SMF	c. It is equivalent to the user plane of the EPC serving/packet data network gateway (S/P -gateway)
AMF	d. It is the only function that establishes and manages sessions for all access types according to the network policy

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5GC Network Functions
Quiz 4

Which of statement (a, b,c,d) best describe the Network Functions below?

Match each NF with corresponding item?

UDM	a. Securely exposes the services and capabilities provided by 3GPP network functions for e.g. 3rd party
NEF	b. It is a common backend for the UDM, NEF and PCF. It allows the storage and retrieval of subscription data by the UDM FE and policy data by the PCF
UDR	c. It manages subscriber data and profiles
UDSF	d. It is a new functionality allowing control plane elements to store their session data and become session stateless

© Nokia 2023

Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

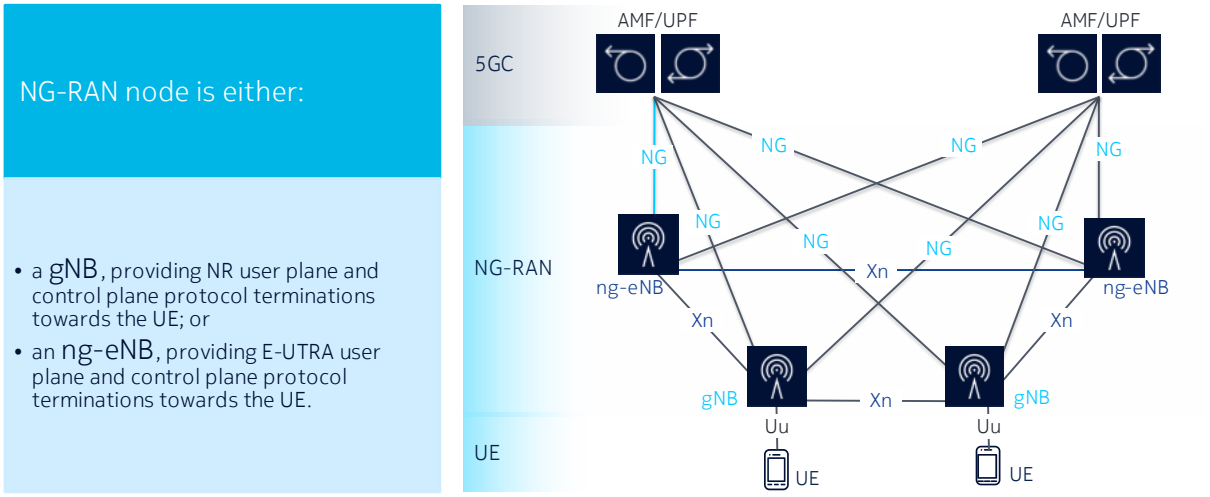
NG-RAN Architecture

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

NG-RAN Architecture

NG-RAN Architecture and Interfaces



© Nokia 2023

Nokia Confidential

This diagram shows the NG-RAN architecture. The NG-RAN consists of a set of NG-RAN nodes connected to the 5G Core Network (5GC) through the NG interface. NG-RAN node is either:

- a gNB, providing NR user plane and control plane protocol terminations towards the UE; or
- an ng-eNB, providing E-UTRA user plane and control plane protocol terminations towards the UE. ng-eNB (also referred to as eLTE eNB) is the evolution of eNB that supports connectivity to LTE Core Network (EPC) and 5GC.

NG and Xn are logical interfaces. 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. The NG interface supports a many-to-many relation between AMF or UPF and the NG-RAN nodes in NG-RAN. It is worth noting that in NG-Flex configuration, each NG-RAN is connected to all AMFs within an AMF Region.

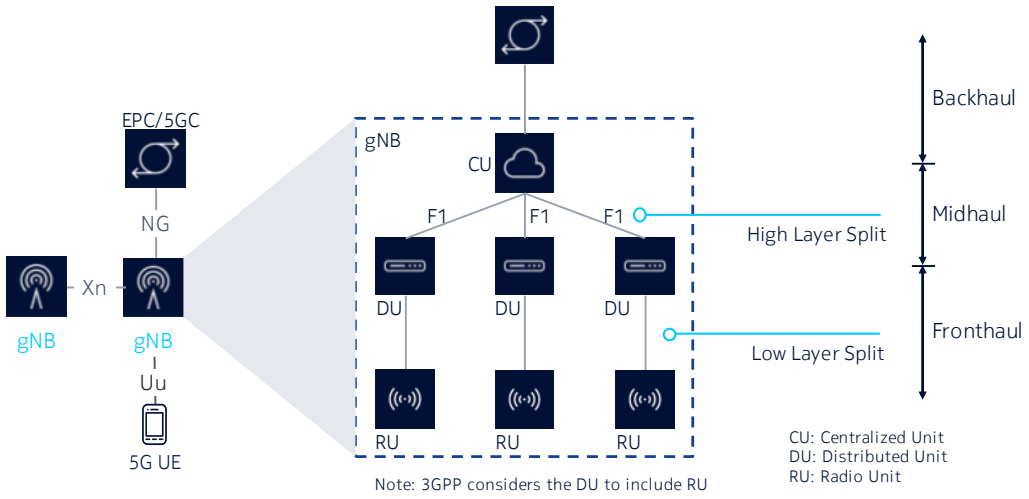
gNB and ng-eNB host different functions for Radio Resource Management, that is to say: Radio Bearer Control, Radio Admission Control, Connection Mobility Control, Dynamic allocation of resources to UEs;, or scheduling of UEs in both uplink and downlink.

Last but note least, do not forget the user equipment (UE) which is any device used directly by an end-user to communicate. It can be a hand-held telephone, a laptop computer equipped with a mobile broadband adapter, or any other connected device. The UE connects to the NG-RAN via the air interface which referred to as Uu.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

NG-RAN Architecture

NG-RAN Architecture and Interfaces



© Nokia 2023

Nokia Confidential

This diagram shows the NG-RAN architecture. The NG-RAN consists of a set of NG-RAN nodes connected to the 5G Core Network (5GC) through the NG interface. NG-RAN node is either:

- a gNB, providing NR user plane and control plane protocol terminations towards the UE; or
- an ng-eNB, providing E-UTRA user plane and control plane protocol terminations towards the UE. ng-eNB (also referred to as eLTE eNB) is the evolution of eNB that supports connectivity to LTE Core Network (EPC) and 5GC.

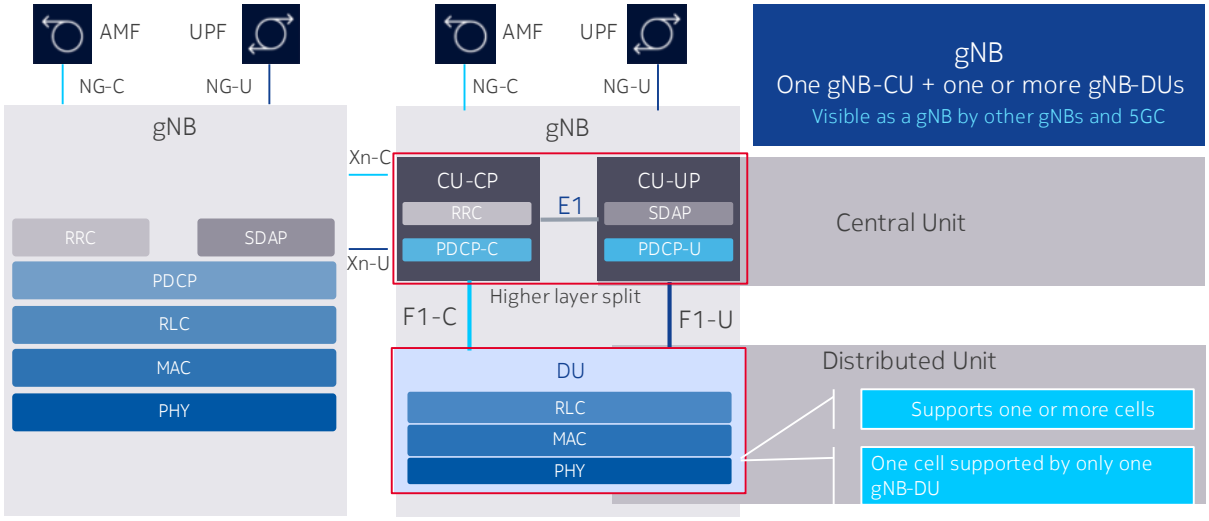
NG and Xn are logical interfaces. The gNBs and ng-eNBs are interconnected with each other by means of the Xn interface. The gNBs and ng-eNBs are also connected by means of the NG interfaces to the 5GC, more specifically to the AMF (Access and Mobility Management Function) by means of the NG-C interface and to the UPF (User Plane Function) by means of the NG-U interface. The NG interface supports a many-to-many relation between AMF or UPF and the NG-RAN nodes in NG-RAN. It is worth noting that in NG-Flex configuration, each NG-RAN is connected to all AMFs within an AMF Region.

gNB and ng-eNB host different functions for Radio Resource Management, that is to say: Radio Bearer Control, Radio Admission Control, Connection Mobility Control, Dynamic allocation of resources to UEs;, or scheduling of UEs in both uplink and downlink.

Last but note least, do not forget the user equipment (UE) which is any device used directly by an end-user to communicate. It can be a hand-held telephone, a laptop computer equipped with a mobile broadband adapter, or any other connected device. The UE connects to the NG-RAN via the air interface which referred to as Uu.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

NG-RAN Architecture
F1 Interface



© Nokia 2023

Nokia Confidential

3GPP has introduced a new standardized interface between a Centralized Unit (gNB-CU) and a Distributed Unit (gNB-DU). This High Layer Fronthaul interface is called F1 by 3GPP. It has been chosen to have this interface being between PDCP (handled in gNB-CU) and RLC (handled in gNB-DU) layers.

gNB Central Unit (gNB-CU) is hosting RRC, SDAP and PDCP protocols of the gNB and it controls the operation of one or more gNB-DUs. The gNB-CU terminates the F1 interface connected with the gNB-DU.

gNB Distributed Unit (gNB-DU) is hosting RLC, MAC and Physical layers of the gNB, and its operation is partly controlled by gNB-CU.

One gNB-DU supports one or multiple cells. One cell is supported by only one gNB-DU. The gNB-DU terminates the F1 interface connected with the gNB-CU.

Furthermore, a gNB may consist of a gNB-CU and one or more gNB-DU(s). The gNB-CU and connected gNB-DUs are only visible to other gNBs and the 5GC as a gNB.

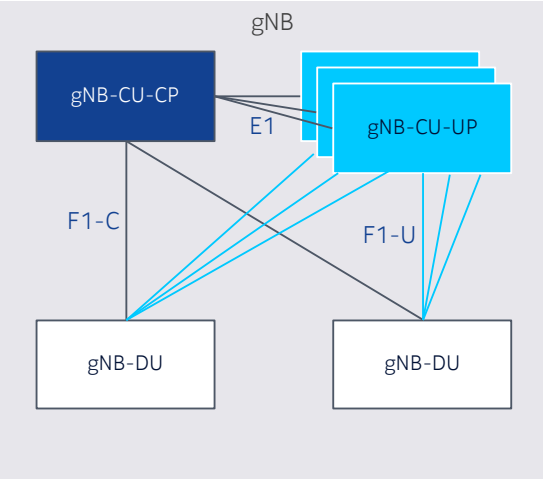
Also, It is noteworthy that as this interface is standardized, it will also allow multi-vendor deployments, where gNB-CU and gNB-DU are from different providers.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

NG-RAN Architecture
E1 Interface

E1 interface

- E1 is a control plane interface and not used for user data transmission
- A gNB may consist of a gNB -CU-CP, multiple gNB -CU-UPs and multiple gNB -DUs
  - gNB-CU-UP is connected to the gNB-CU-CP through the E1 interface
  - One gNB-DU is connected to only one gNB-CU-CP
  - One gNB-CU-UP is connected to only one gNB-CU-CP
  - One gNB-DU can be connected to multiple gNB-CU-UPs under the control of the same gNB-CU-CP
  - One gNB-CU-UP can be connected to multiple DUs under the control of the same gNB-CU-CP



© Nokia 2023 Nokia Confidential

The E1 interface supports the exchange of signaling information between a gNB-CU-CP and a gNB-CU-UP. It is an open interface: inter-connection of a gNB-CU-CP and a gNB-CU-UP can be supplied by different manufacturers.

E1 is a control plane interface and not used for user data transmission

A gNB may consist of a gNB-CU-CP, multiple gNB-CU-UPs and multiple gNB-DUs

gNB-CU-CP is connected to the gNB-DU through the F1-C interface

gNB-CU-UP is connected to the gNB-DU through the F1-U interface

gNB-CU-UP is connected to the gNB-CU-CP through the E1 interface

One gNB-DU is connected to only one gNB-CU-CP

One gNB-CU-UP is connected to only one gNB-CU-CP

One gNB-DU can be connected to multiple gNB-CU-UPs under the control of the same gNB-CU-CP

One gNB-CU-UP can be connected to multiple DUs under the control of the same gNB-CU-CP

NOTE: For resiliency, a gNB-DU and/or a gNB-CU-UP may be connected to multiple gNB-CU-CPs by appropriate implementation.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

NG-RAN Architecture
Nokia proprietary Xp interface (Xp -If)

5G Xp terminated on virtual IP interface

5G Xp terminated on transport IP interface

5G X2-C and Xp shared, terminated on virtual IP interface

5G X2-C and Xp shared, terminated on transport IP interface

Any other combination also supported

Xp Interface

- Introduction of DSS (Dynamic Spectrum Sharing) related features for LTE< ->NR. WCDMA / GSM not in scope (there are already features in place)
- High performant inter BTS communication (refer to Carrier Aggregation)
- Decoupling of internal BTS communication from external communication
- Used for signaling purposes (no User Traffic)
- Manages compatibility
- Based on X2 specification
- Split into basic XP procedures and application specific procedures
- Extendable in order to support potential additional features in future

© Nokia 2023 Nokia Confidential

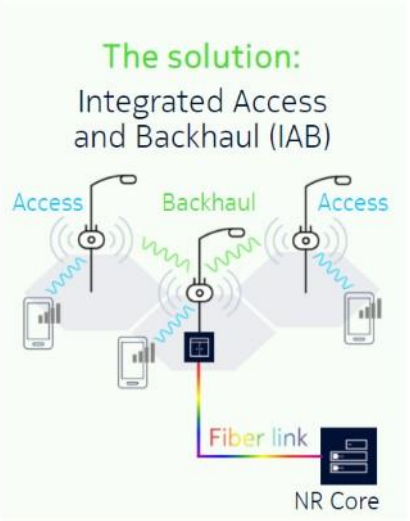
© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

Integrated Access and Backhaul

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

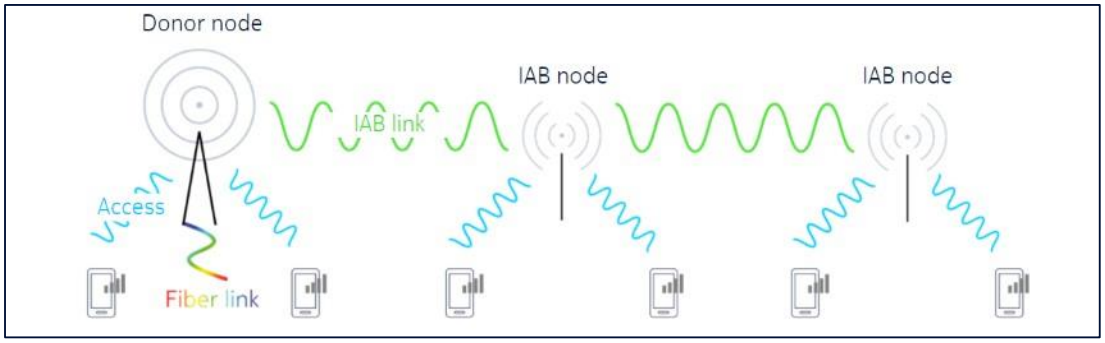
Integrated Access and Backhaul
Deployment issues in mobile systems



© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

Integrated Access and Backhaul
Architecture

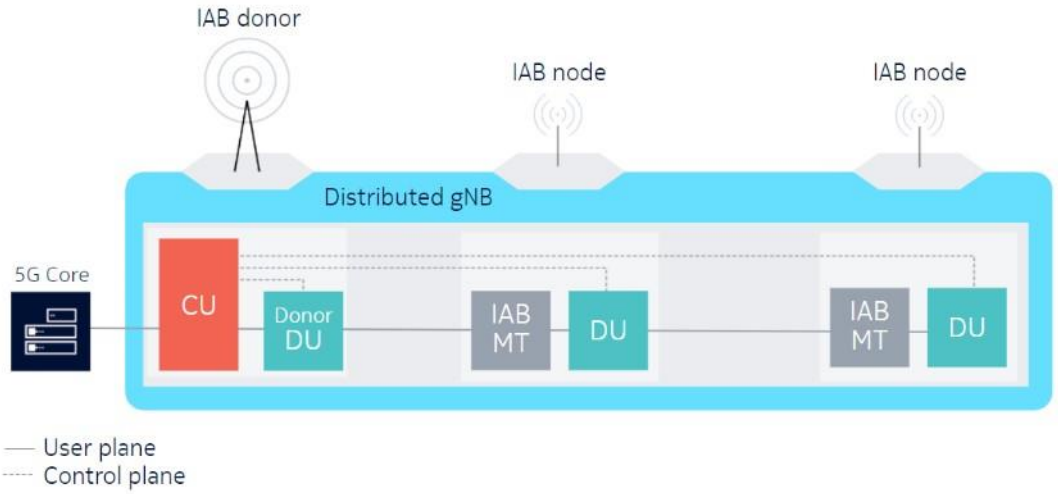


Local UE access
IAB link

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

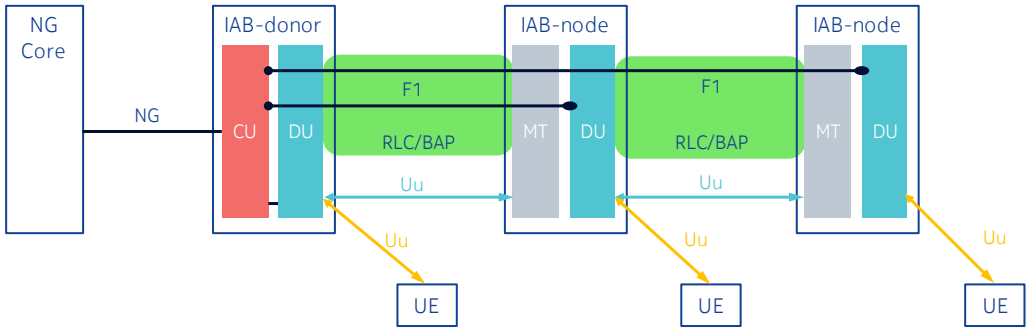
Integrated Access and Backhaul
gNB distrubuted architecture



IAB MT – IAB Mobilte Termination

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

IAB Architecture



- F1 extended over wireless backhaul (BH) links
- Relaying of RLC channels (L2 relay), new Backhaul Adaptation Protocol (BAP) introduced
- NG (core network interface) termination at the IAB-donor
- IAB-MT part connects to the upstream parent IAB-DU, either IAB-donor or another IAB-node
- Supports multi-hop relaying
- Both SA and NSA modes supported

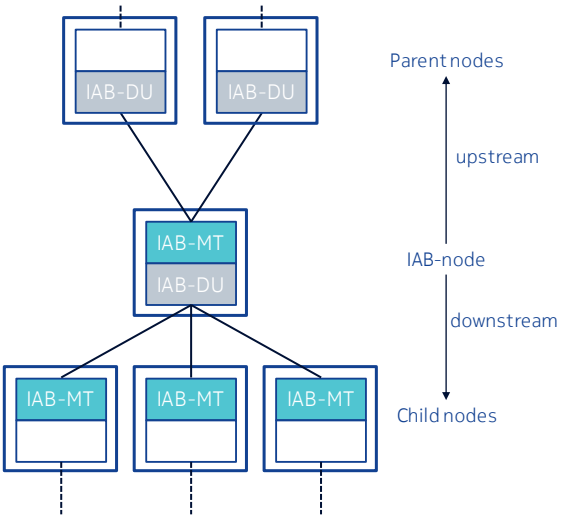
© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

IAB Architecture

Parent/child relationship for IAB-node and other definitions

- Upstream: Direction toward parent node in IAB-topology
- Downstream : Direction toward child node or UE in IAB-topology
- Parent node : IAB-MT's next hop neighbour node; the parent node can be IAB-node or IAB-donor-DU
- Child node : IAB-DU's next hop neighbour node; the child node is also an IAB-node
- IAB-node: RAN node that supports NR access links to UEs and NR backhaul links to parent nodes and child nodes. The IAB-node does not support backhauling via LTE
- IAB-donor gNB: gNB that provides network access to UEs via a network of backhaul and access links. It consists of IAB-donor-CU and IAB-donor-DU parts.



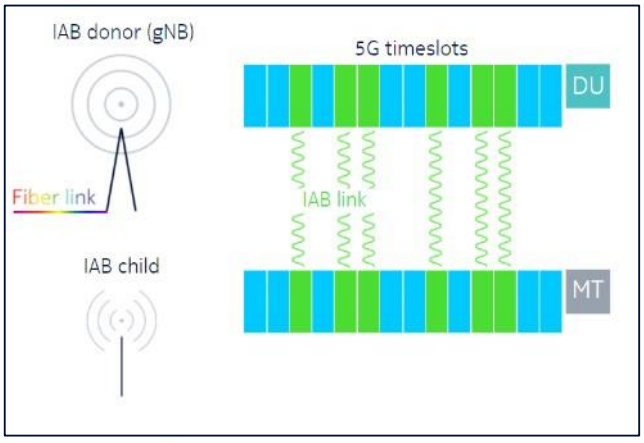
© Nokia 2023

Nokia Confidential

IAB-node contains MT-part and DU-part, CU in the IAB-donor

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

Integrated Access and Backhaul
How it works



Scheduling principle:
- Downlink IAB node (DU) transmissions are scheduled by the IAB -node itself
- Uplink IAB node (MT) transmissions are scheduled by Parent node/IAB donor

IAB supports TDM (Time Division Multiplexing) between access and BH links subject to a half - duplex constraint
TDM: four separate time domain resources needed (BH DL/UL, Access DL/UL)

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

Integrated Access and Backhaul
Possible deployments

© Nokia 2023 Nokia Confidential

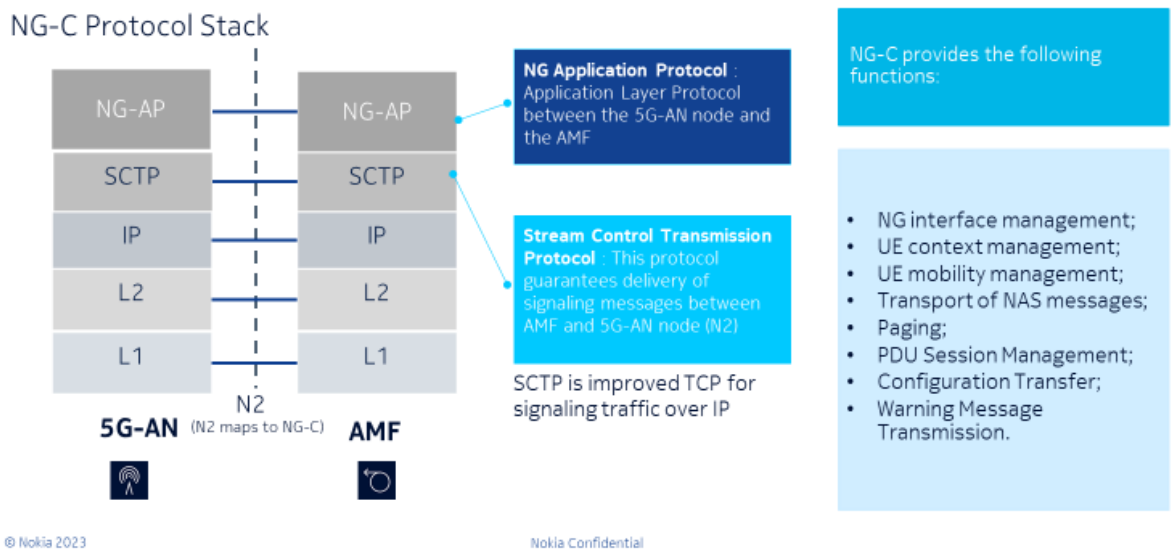
© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

NOKIA

5G System Interface Protocols

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1



The NG interface supports a one-to-many relation between NG-RAN nodes and 5GC nodes.

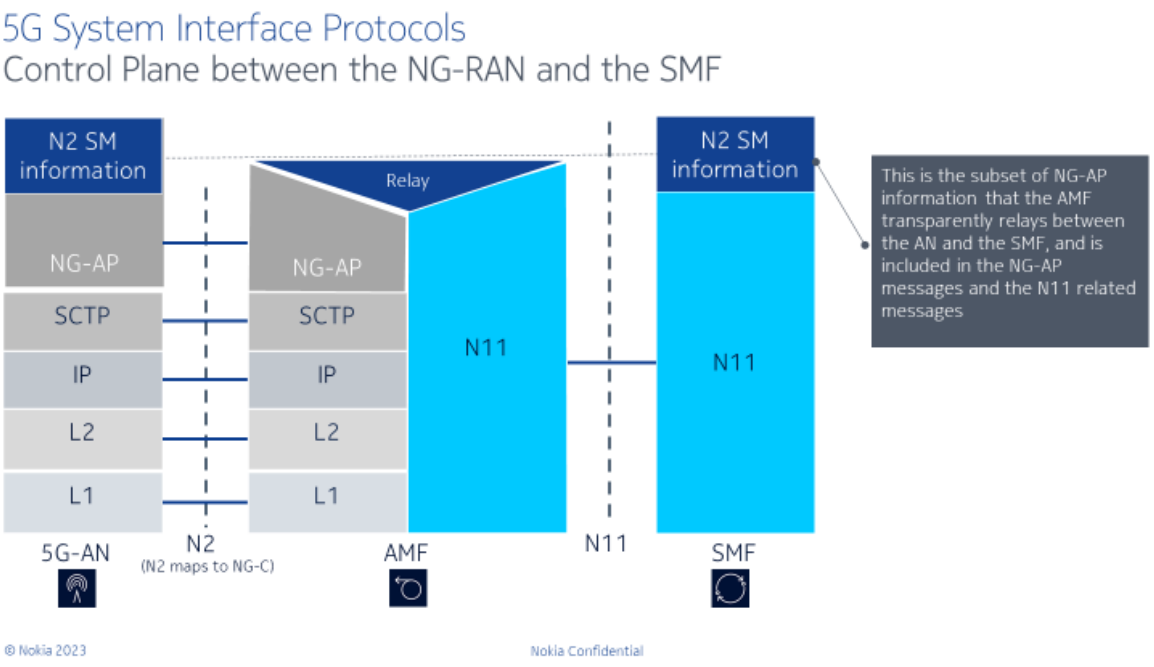
The NG control plane interface (NG-C) is defined between the NG-RAN node and the Access and Mobility management Function (AMF). The control plane protocol stack of the NG-C interface is shown in the Figure here on the slide. The transport network layer is built on IP transport. For the reliable transport of signaling messages, SCTP is added on top of IP. The application layer signaling protocol is referred to as NGAP (NG Application Protocol). The SCTP layer provides guaranteed delivery of application layer messages. In the transport, IP layer point-to-point transmission is used to deliver the signaling PDUs. SCTP/IP is the agreed transport protocol for NG-C.

- L2: Data link layer: The support of any suitable Data Link Layer protocol, e.g. PPP, Ethernet, etc.,
- IP layer:
  The 5GC and NG-RAN shall support IPv6 (IETF RFC 2460) and/or IPv4 (IETF RFC 791).
  The IP layer of NG-C only supports point-to-point transmission for delivering NG AP message.
  The 5GC and NG-RAN shall support the Diffserv Code Point marking as described in IETF RFC 2474
- SCTP: SCTP refers to the Stream Control Transmission Protocol developed by the Sigtran working group of the IETF for the purpose of transporting various signaling protocols over IP network.

NGAP interface is also used between a non-3GPP Access Node (N3IWF) connect to AMF via NGAP

- 3GPP TS36.413:
  New NG-RAN node ID is defined for non-3GPP N3IWF node, i.e. Global N3IWF ID
  New content for User Location Information is defined for non-3GPP access.
- 3GPP TS29.413:
  Defines the applicable NGAP procedures and NGAP messages
  Also defines the handing of non-applicable IEs, i.e. receiver node shall ignore the non-application Ies
  The handling for non-applicable messages is the same as normal NGAP.

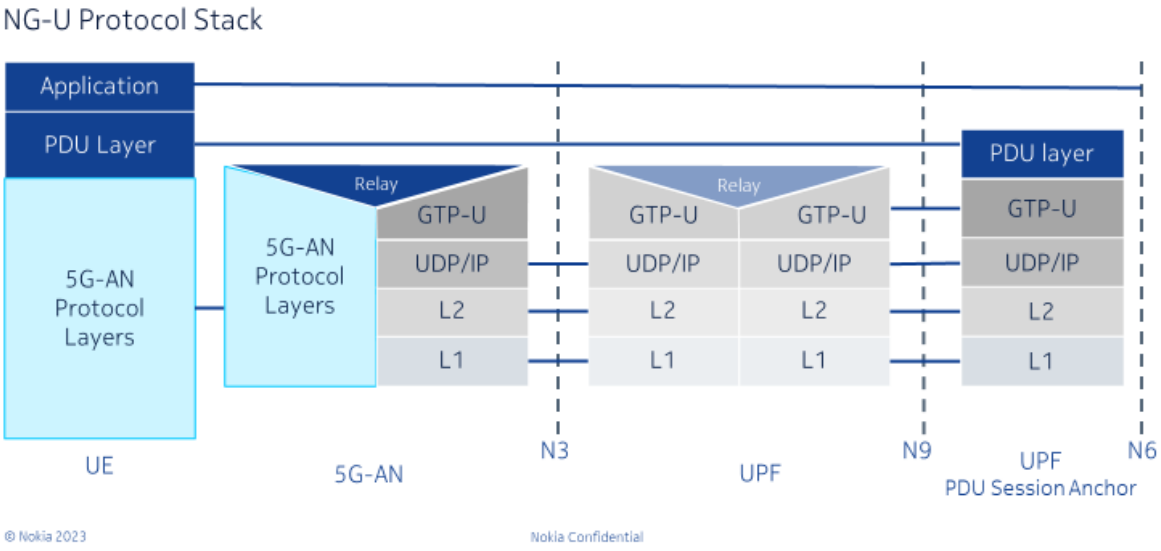
© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1



N2 SM information is the subset of NG-AP information that the AMF transparently relays between the AN and the SMF, and is included in the NG-AP messages and the N11 related messages.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G System Interface Protocols
NG User Plane Protocol Stack



The NG user plane interface (NG-U) is defined between the NG-RAN node and the UPF. 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 User Plane Function (UPF).

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

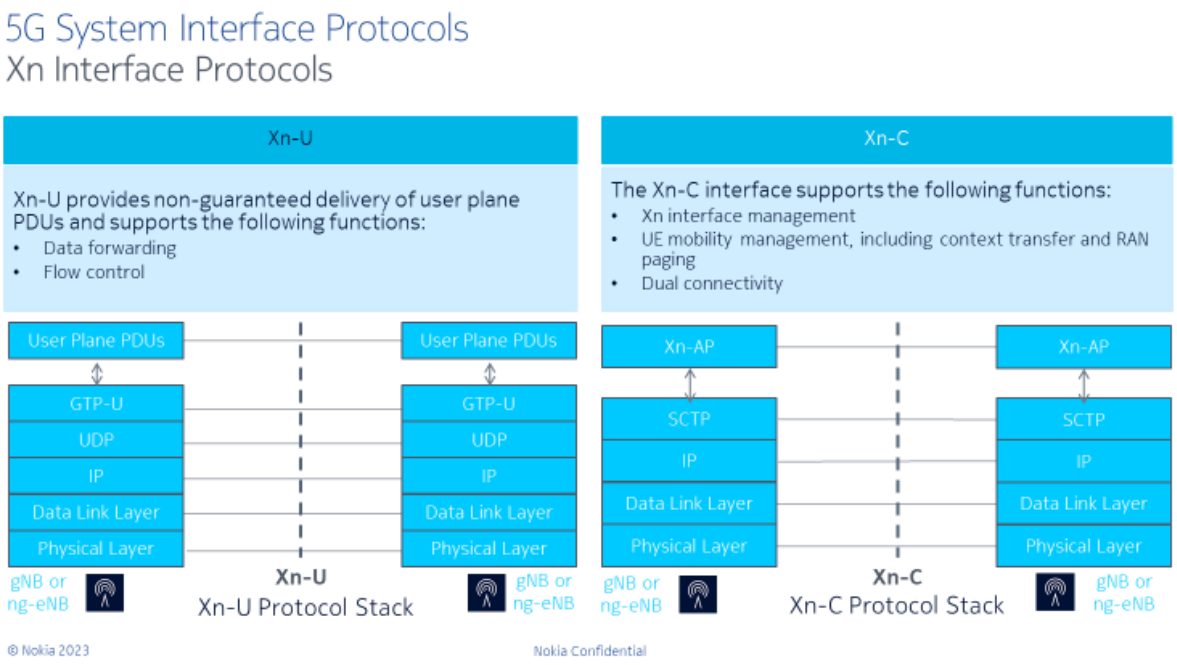
The PDU layer corresponds to the PDU carried between the UE and the Data Network (DN) over the PDU Session. When the PDU Session Type is IPv4 or IPv6 or IPv4v6, it corresponds to IPv4 packets or IPv6 packets or both of them; When the PDU Session Type is Ethernet, it corresponds to Ethernet frames; etc.

The GPRS Tunneling Protocol for the user plane (GTP U) supports multiplexing traffic of different PDU Sessions (possibly corresponding to different PDU Session Types) by tunneling user data over N3 (that is to say, between the 5G-AN node and the UPF) in the backbone network. GTP shall encapsulate all end user PDUs. It provides encapsulation on a per PDU Session level.

The 5G Encapsulation layer supports multiplexing traffic of different PDU Sessions (possibly corresponding to different PDU Session Types) over N9 (i.e. between different UPF of the 5GC). It provides encapsulation on a per PDU Session level.

UDP/IP: These are the backbone network protocols

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

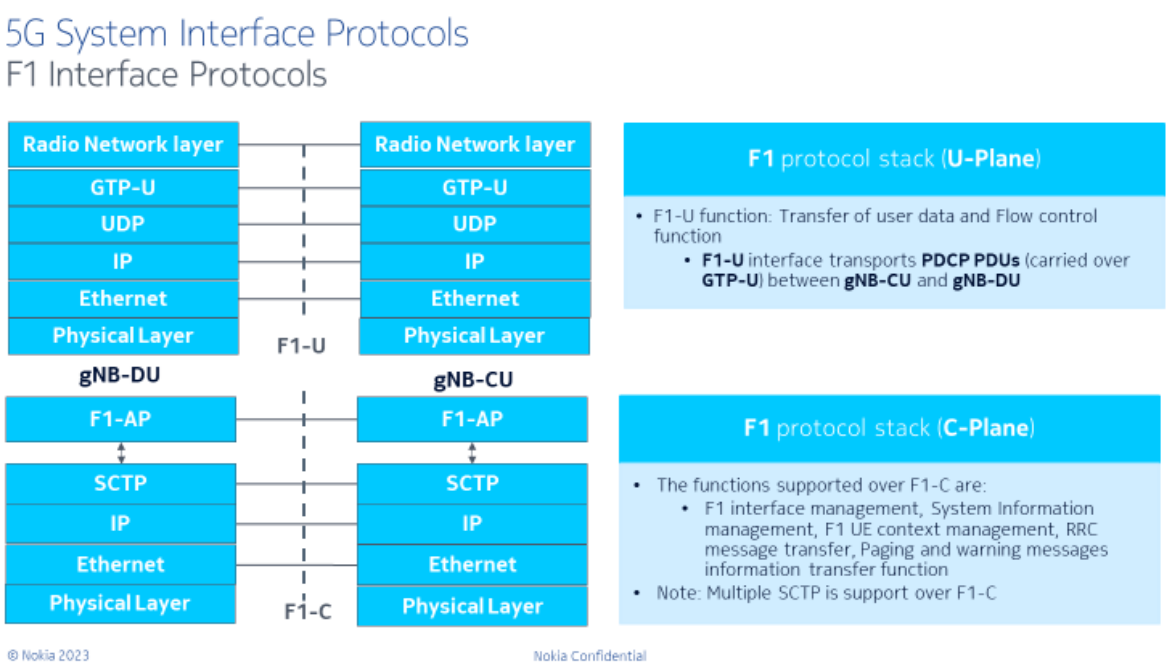


The interface allowing to interconnect two gNBs or one gNB and one ng-eNB with each other is referred to as the Xn interface. The interface Xn is also applicable for the connection between two ng-eNBs. It is an open interface which supports the exchange of signaling information between two NG-RAN nodes, and the forwarding of PDUs to the respective tunnel endpoints.

The Xn User plane (Xn-U) interface is defined between two NG-RAN nodes. 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.

The Xn control plane interface (Xn-C) is defined between two NG-RAN nodes. The transport network layer is built on SCTP on top of IP. The application layer signaling protocol is referred to as XnAP (Xn Application Protocol). The SCTP layer provides the guaranteed delivery of application layer messages. In the transport IP layer point-to-point transmission is used to deliver the signaling PDUs.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1



F1 is an open interface that supports the exchange of signaling information between the endpoints (gNB-CU and gNB-DU), It also supports data transmission to the respective endpoints.

The F1 interface supports:

- procedures to establish, maintain and release radio bearers for the NG-RAN part of PDU sessions and for E-UTRAN Radio Access Bearers;
- the separation of each UE on the protocol level for user specific signaling management;
- the transfer of RRC signaling messages between the UE and the gNB-CU.

The protocol stack for F1-C is shown on the slide. The Transport Network Layer is based on IP transport, comprising the SCTP on top of IP. The application layer signaling protocol is F1AP (F1 Application Protocol).

The functions supported over F1-C are: F1 interface management, System Information management, F1 UE context management, RRC message transfer, Paging and warning messages information transfer function.

F1 Application Protocol (F1AP) procedures over the F1-C interface between a gNB-CU and a gNB-DU are described in 3GPP TS 38.473.

The following non-UE specific F1AP procedures for the F1-C interface are supported:

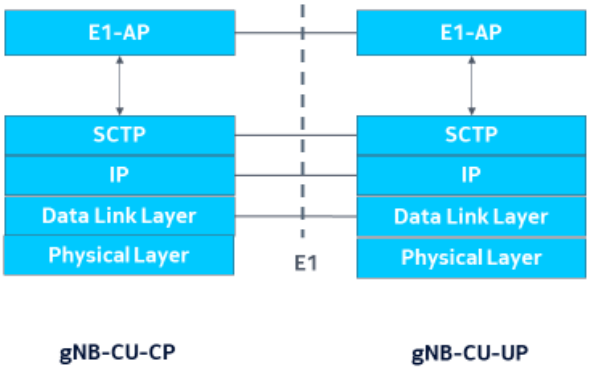
- F1 Setup (initiated by gNB-DU): It is the basic procedure for triggering by gNB-DU all other FS1AP procedures.
- F1 Reset (initiated by gNB-DU and gNB-CU): It allows F1 UE contexts cleanup for recovery procedure in case of error/failure (gNB-CU or/and gNB-DU)
- F1 Error Indication (initiated by gNB-DU and gNB-CU: It allows reporting of a failure. information to the message sender.

On the control plane: SCTP association is established between gNB-CU and each gNB-DU. SCTP association establishment is initiated by gNB-CU.

F1 User Plane Protocol (F1-U): The Transport Network Layer is based on IP transport, comprising the UDP and GTP-U on top of IP.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G System Interface Protocols
E1 Interface Protocols



Interface protocol structure for E1

- The functions supported over E1 are:
  - E1 interface management function (error indication, E1 reset, E1 setup, gNB-CU-UP Configuration Update and gNB-CU-CP Configuration, gNB-CU-UP Status Indication)
  - E1 bearer context management function (establishment/modification of the E1 bearer context)
  - TEIDs allocation: gNB-CU-UP is responsible for the allocation of the F1-U UL GTP TEID for each data radio bearer

The E1 interface is a control interface and is not used for user data forwarding

© Nokia 2023 Nokia Confidential

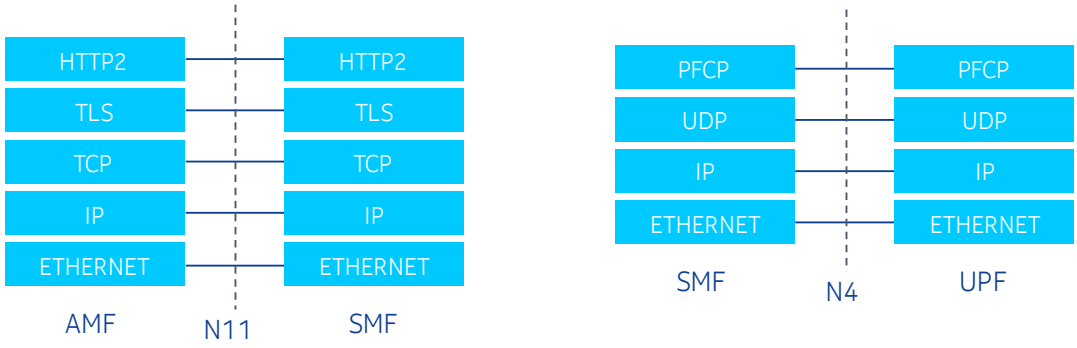
The Transport Layer Network is based on IP transport, comprising the SCTP on top of IP. The application layer signaling protocol is referred to as E1AP (E1 Application Protocol).

The functions supported over E1 are:

- E1 interface management function (error indication, E1 reset, E1 setup, gNB-CU-UP Configuration Update and gNB-CU-CP Configuration, gNB-CU-UP Status Indication)
- E1 bearer context management function (establishment/modification of the E1 bearer context)
- TEIDs (Tunnel Endpoint Identifier) allocation: The gNB-CU-UP is responsible for the allocation of the F1-U UL GTP TEID for each data radio bearer. The gNB-CU-UP is responsible for the allocation of the S1-U DL GTP TEID for each E-RAB and the NG-U DL GTP TEID for each PDU Session. The gNB-CU-UP is responsible for the allocation of the X2-U DL/UL GTP TEID or the Xn-U DL/UL GTP TEID for each data radio bearer.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

5G System Interface Protocols
5G Core protocols – Control plane



© Nokia 2023 Nokia Confidential

The Control Plane Session Management Function controls the packet processing and forwarding in the UPF, by creating, modifying or deleting PFCP Sessions.

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

NG-RAN Protocols
Quiz 5

1. What are the interfaces supported by gNB?

a. NG to interface with 5GC
b. S1 to interface with EPC
c. NG to interface with EPC
d. S1 to interface with 5GC

® Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

Wrap-up

In this module we have covered the following items

- Review 3GPP 5G system specifications
- Describe 5G e2e Network Architecture
- Recall 5G Network Architecture Options
- Identify 5GC Network Functions
- Identify NG-RAN Network Architecture
- Explain 5G System Interface Protocols
- Explain Integrated Access and Backhaul

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1

© Nokia 2023 Nokia Confidential

© NOKIA 2023 ALL RIGHTS RESERVED.
TP00005-V-1701 V0 - S01M01 Ed1