

14.2 5G NR

- new frequency ranges and bands

Frequency ranges	Frequency domain limits
FR1 (Frequency Range 1)	410 MHz-7125 MHz
FR2 (Frequency Range 2)	24250 MHz-52600 MHz

- operating bands and duplexing mode for FR1 [3GPP 38.101](#)
- FR1 includes bands classically allocated to previous mobile communication standards and is intended for wide-area coverage
- 5G operation in the FR1 frequency range can be done using the 2100 MHz 4G band using specific mechanisms

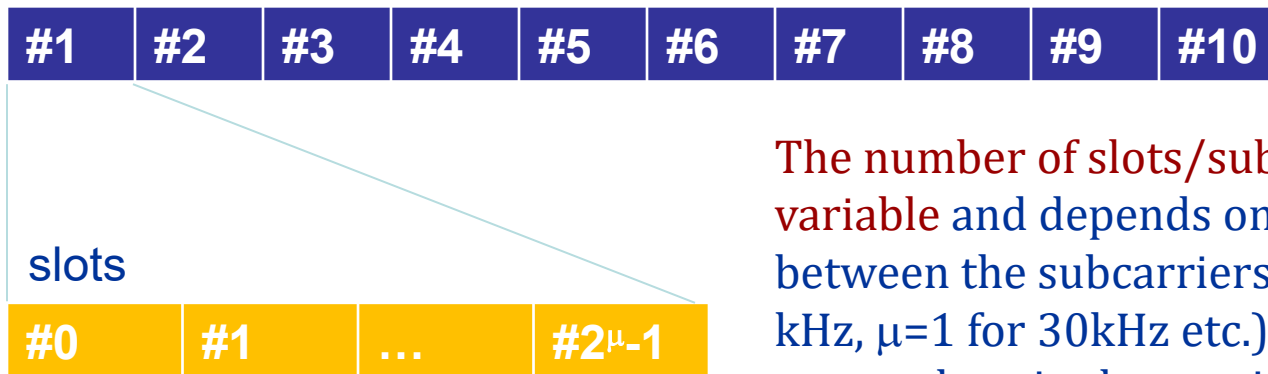
Compared to FR1, the higher frequency bands in FR2 are characterized by a reduced coverage range and increased sensitivity to obstacles, and are used mainly to deliver high-throughput (eMBB) services over short distances

5G NR band	Frequency interval (MHz)	Duplexing technique
n257	26500 – 29500	TDD
n258	24250 – 27500	TDD
n260	37000 – 40000	TDD
n261	27500 – 28350	TDD

- for each frequency band bandwidth is scalable, the aggregation of the carriers being also possible

FR1	FR2
Bandwidth 5,10,15,20,25,30,40,60,70, 80, 90, 100 MHz	Bandwidth 50, 100, 200, 400 MHz
Carrier spacing 15 KHz, 30 kHz, 60 kHz	Carrier spacing 60 kHz, 120 kHz, 240 and 480 kHz
Carrier aggregation: max 16	Carrier aggregation: max16
Radio frame time duration: 10ms	Radio frame time duration: 10ms
Subframe time duration:1ms	Subframe time duration:1ms

- the radio frames have the same duration as in LTE (10ms); subframes also have the same duration(1ms)
- the slots allow the transmission of 14 OFDM symbols, but their duration depends on the spacing between the subcarriers to allow for scalable allocation of resources and better resilience to Doppler effects (at higher frequencies). Smaller carrier sub spacing is suitable for eMBB while larger carrier sub spacing is appropriate for the mMTC and URLLC scenarios

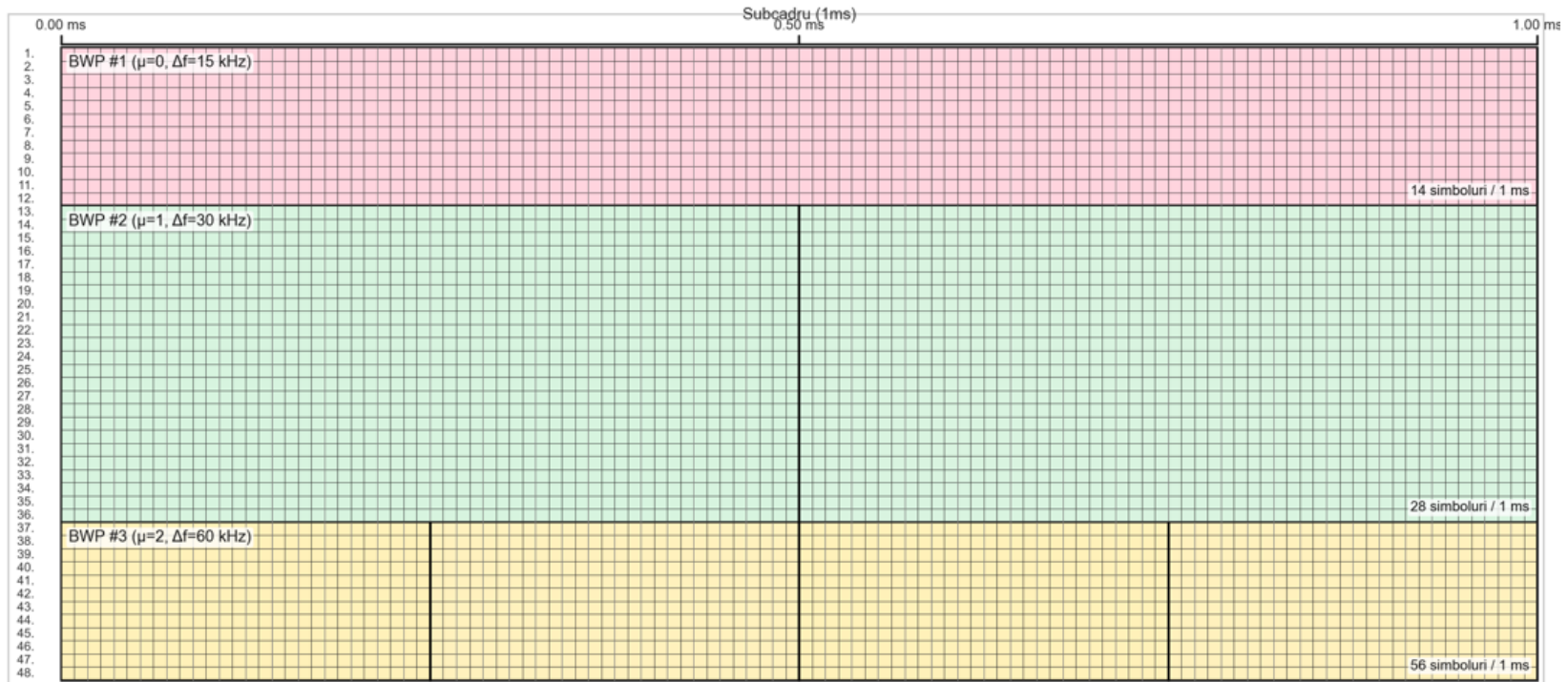


The number of slots/subframe is variable and depends on the distance between the subcarriers ($\mu = 0$ for 15 kHz, $\mu = 1$ for 30kHz etc.) – numerology in the specifications



#0	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15
#0		#1		#2		#3		#4		#5		#6		#7	
#0				#1				#2				#3			
#0								#1							
#0															

240kHz	$\mu=4$	0.0625ms
120kHz	$\mu=3$	0.125 ms
60kHz	$\mu=2$	0.25ms
30kHz	$\mu=1$	0.5ms
15kHz	$\mu=0$	1ms

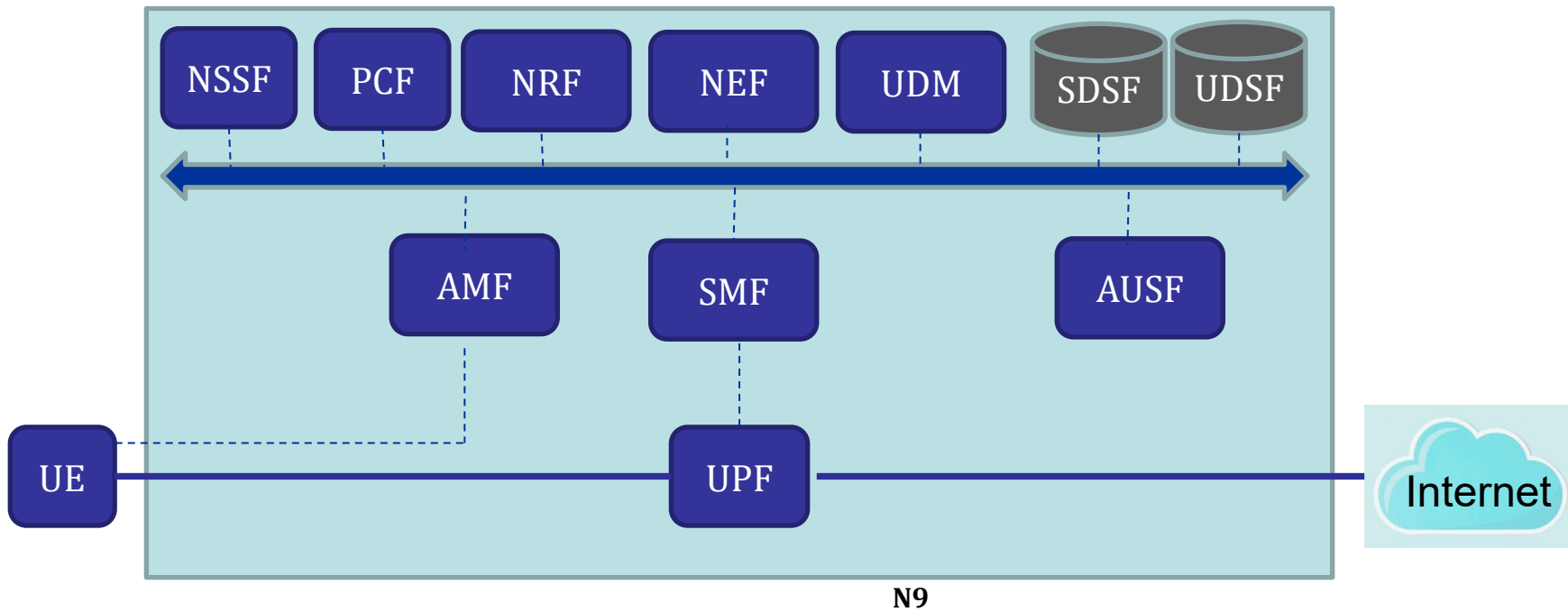


mMTC

eMBB

URLCC

14.3 The 5GC core network



- most of the 5GC functions are implemented in software and are named *Network Functions*



Acronyms

Authentication Server Function (AUSF) – authentication functions (HSS in EPC)

Core Access and Mobility Management Function (AMF) – MME functions in EPC

Session Management Function (SMF) – data session management (IP addresses, QoS) – MME and P-GW functions in EPC

Policy Control Function (PCF) – PCRF functions in EPC

Unified Data Management (UDM) – authentication and user identifiers, HSS functions in EPC

User Equipment (UE)

Structured/Unstructured Data Storage Function (SDSF/UDSF) - databases

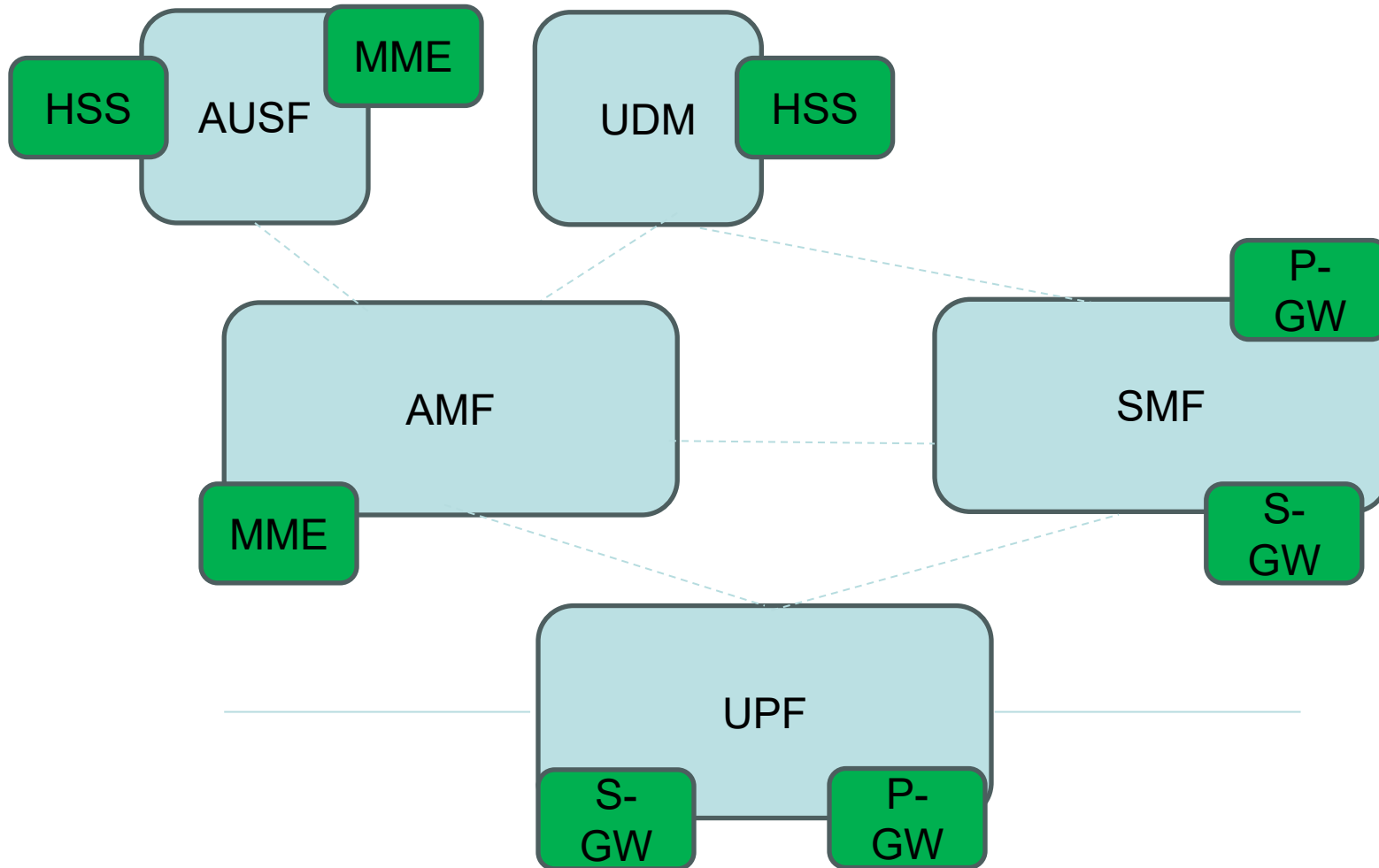
Network Exposure Function (NEF) – interfacing for secure development of applications

NRF (NF Repository Function) – includes all the function implemented

Network Slicing Selector Function (NSSF) – multiplexing of several logical networks on the same physical infrastructure

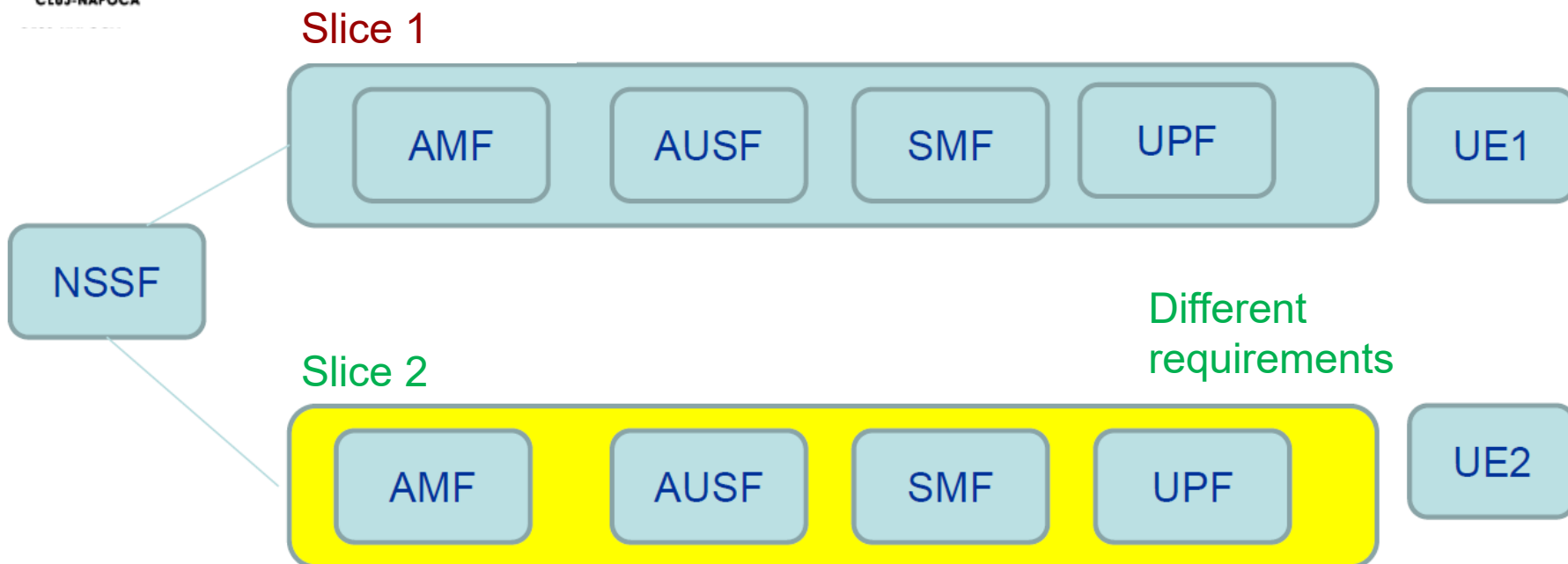
UPF (User plane Functions) : data transfer between RAN and Internet – EPC equivalent S-GW and P-GW

Mapping EPC functionality to 5GC functions



- unlike the equipment-oriented (monolithic) architecture of LTE or UMTS, the modular specification allows implementations on different hardware components manufactured by different suppliers
- network function-level interfacing with authorization mechanisms before access to the services offered by each function
- each network function communicates with a different function using request/reponse or subscribe/notify mechanisms using JSON or web APIs mechanisms based on REST (Representational State Transfer) technologies

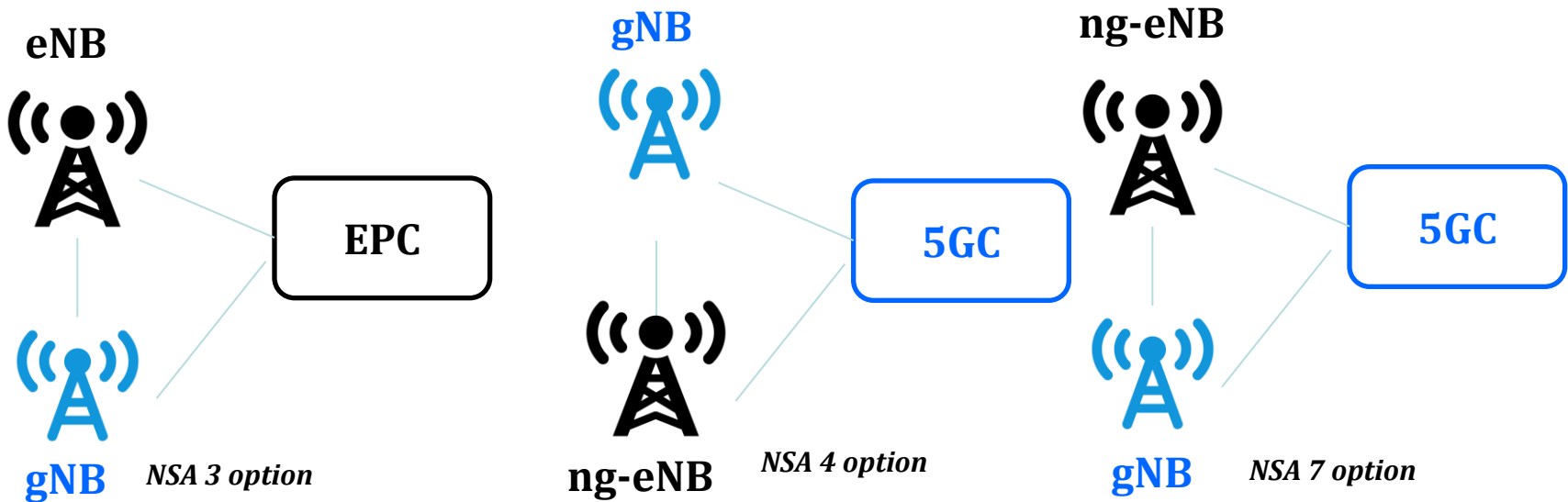
NSSF – key component of 5GC – allows the selection of different functions to be provided by logical slices of a physical network aimed at implementing different constraints imposed by the 5G use cases (eMBB, e.g. for one user and URLLC for another)

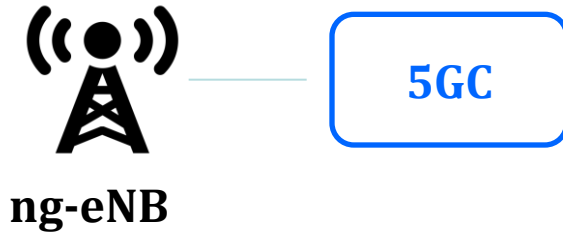


- connections between 5G and 5GC base stations are provided using secure private networks and tunnels (SCTP Stream Control Transmission Protocol for the control plane and GTP – for the user plane)
- as in LTE, registration or establishment of bearer services is done using dedicated signaling procedures ([example](#))

14.4 5G migration options

- multiple migration possibilities structured in 2 groups: **SA (standalone)**, **NSA (non-standalone)**
- SA options use a single access technology
- NSA options are based on dual LTE and 5G NR connectivity





SA 5 option



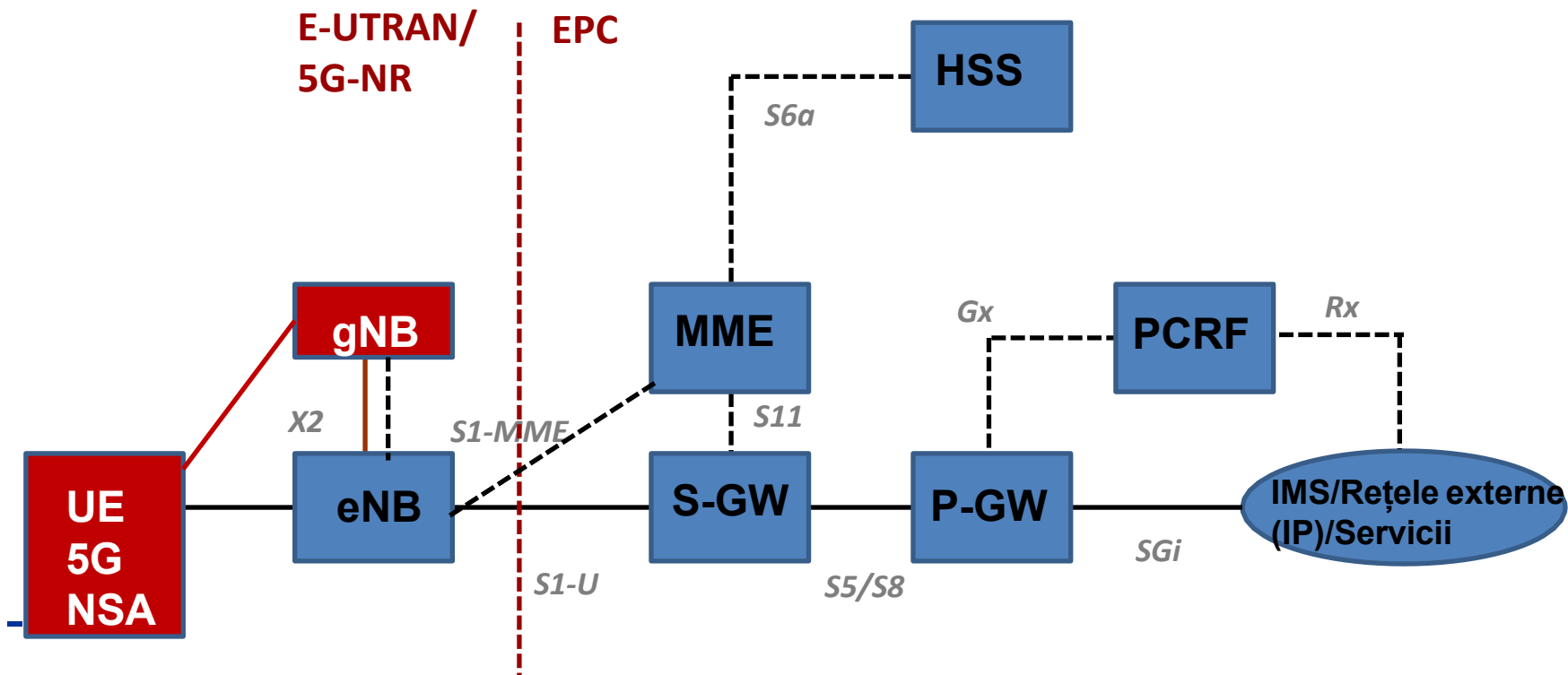
SA 2 option

- the first operational 5G networks are using the SA 5 and the NSA 3 option
- in NSA option 3 configuration dual connectivity is used, control plane data is exchanged using LTE whilst user data is sent using LTE and 5G base stations
- further reading: [link](#)

14.5 NSA-3 5G architectures

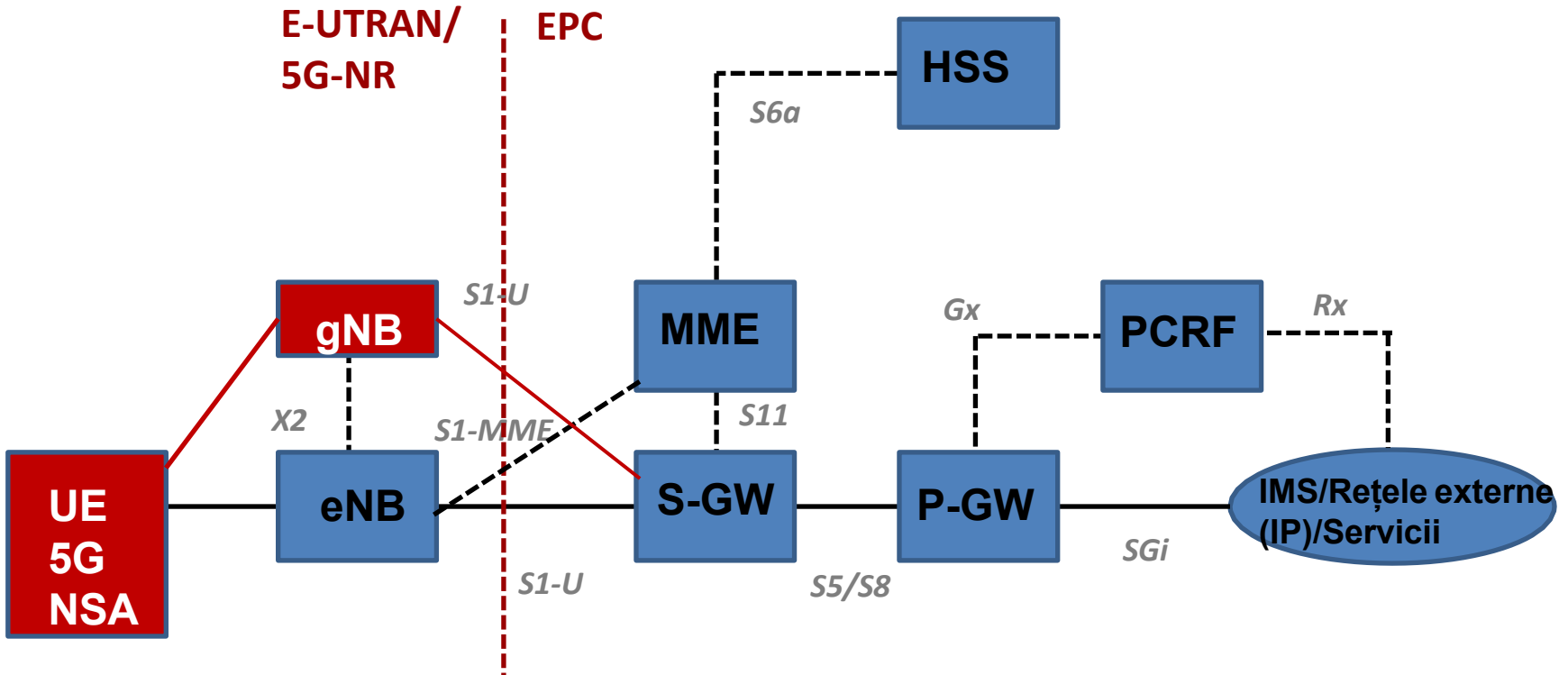
- correspond to configurations where the radio access network is composed of eNBs (eNode B) as primary nodes and gNBs (gNode B) as secondary nodes ([link](#))
- the radio access network is connected to EPC (Evolved Packet Core) allowing the reuse of existing 4G infrastructure on the core network side also providing support for access to services for existing 4G devices and 5G terminals
- NSA Option 3 does not introduce the 5G core network (5GC), so it is not optimized for new 5G use cases excluding eMBB.
- the NSA-3 variants can be implemented in 3 variants and bears generically in the specifications the name **EN-DC (E-UTRA NR Dual Connectivity)** and is referred to in context **MR-DC (Multi Radio Dual Connectivity)**
- does not allow latency reduction or the use of slicing functions

Option 3



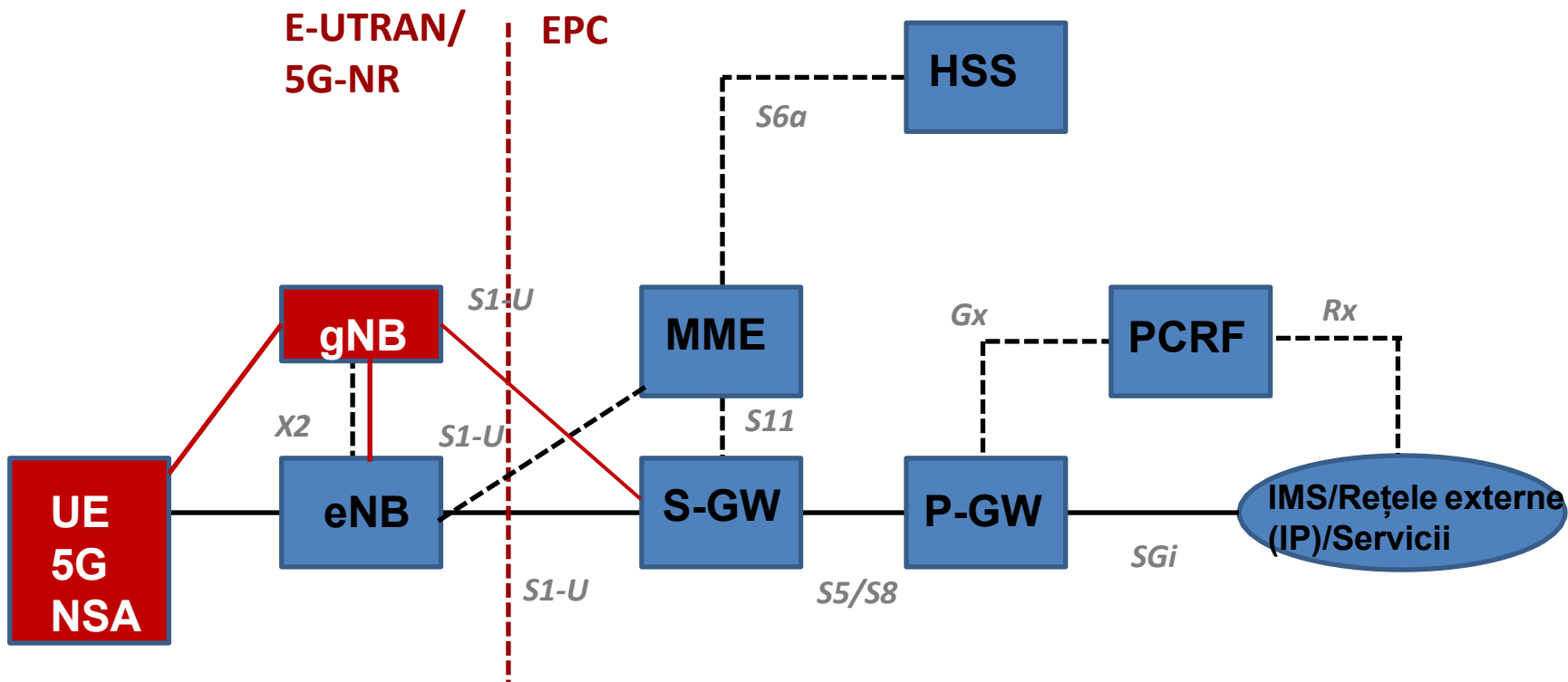
- 5G base stations do not have a dedicated interface for data transfer via EPC. The control plane is provided by eNB, traffic division is also done at eNB level

Option 3a



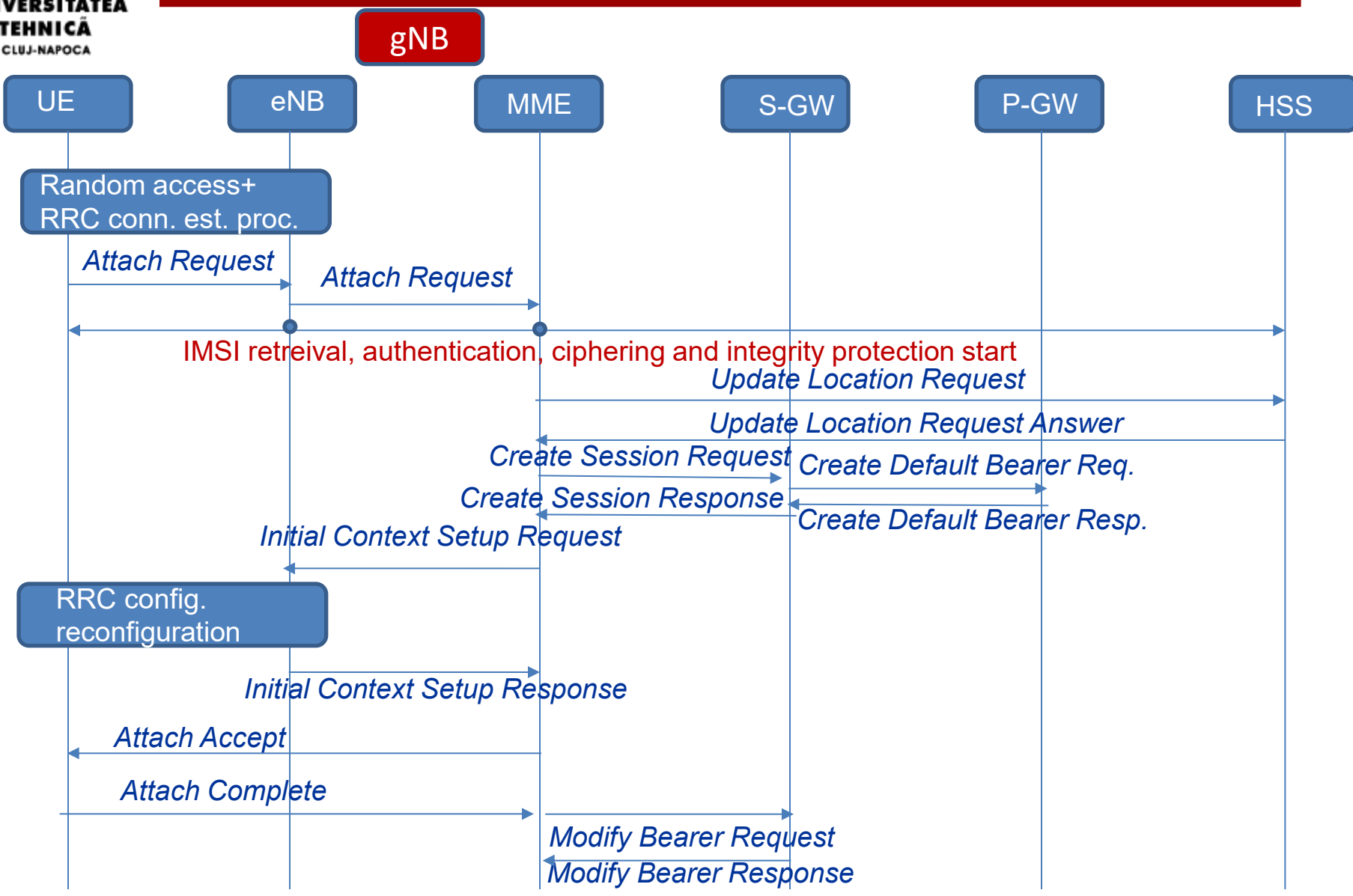
- the X2 interface is used only in the control plane, 4G/5G traffic can coexist; needs major EPC modifications

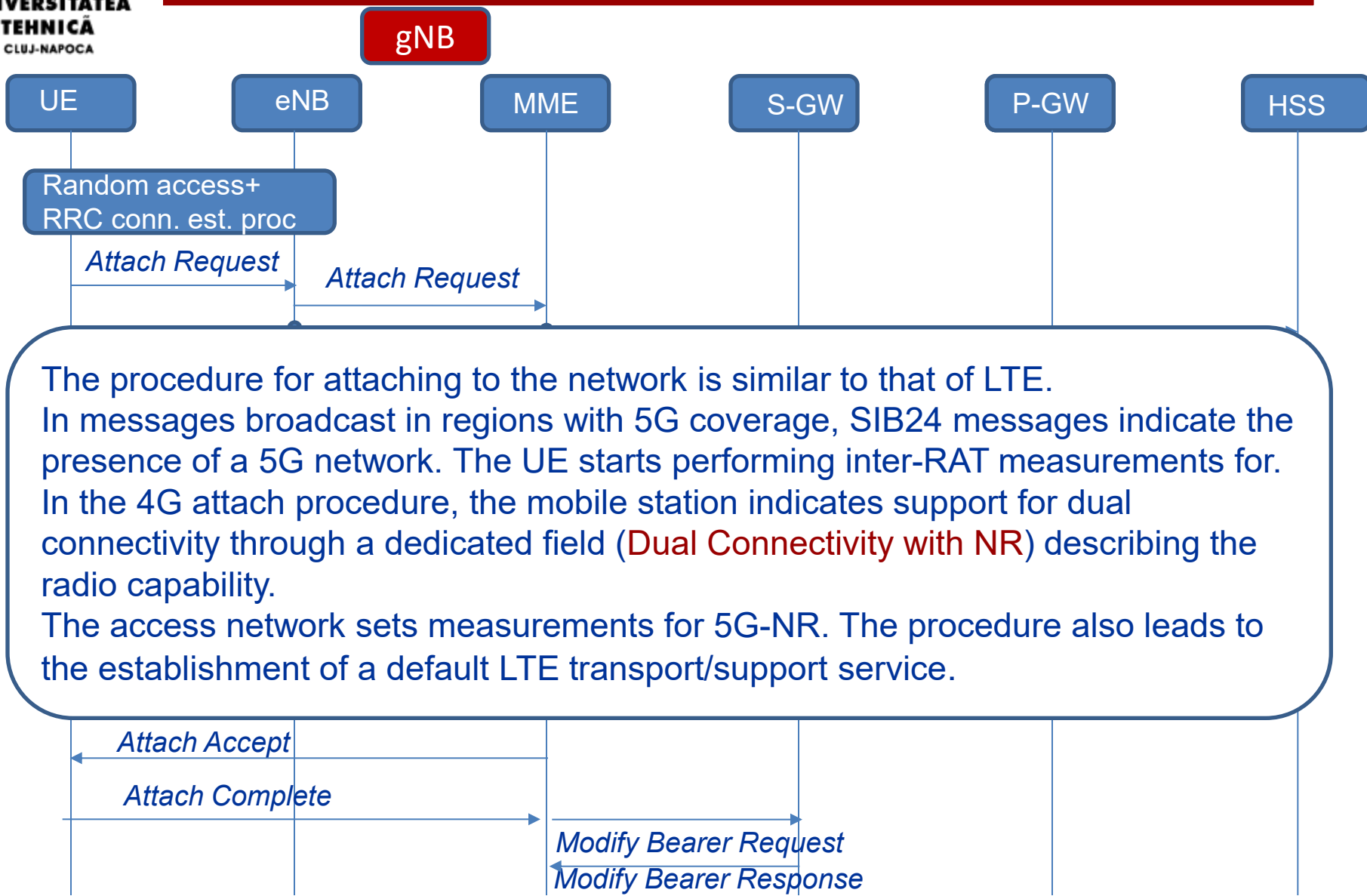
Option 3x

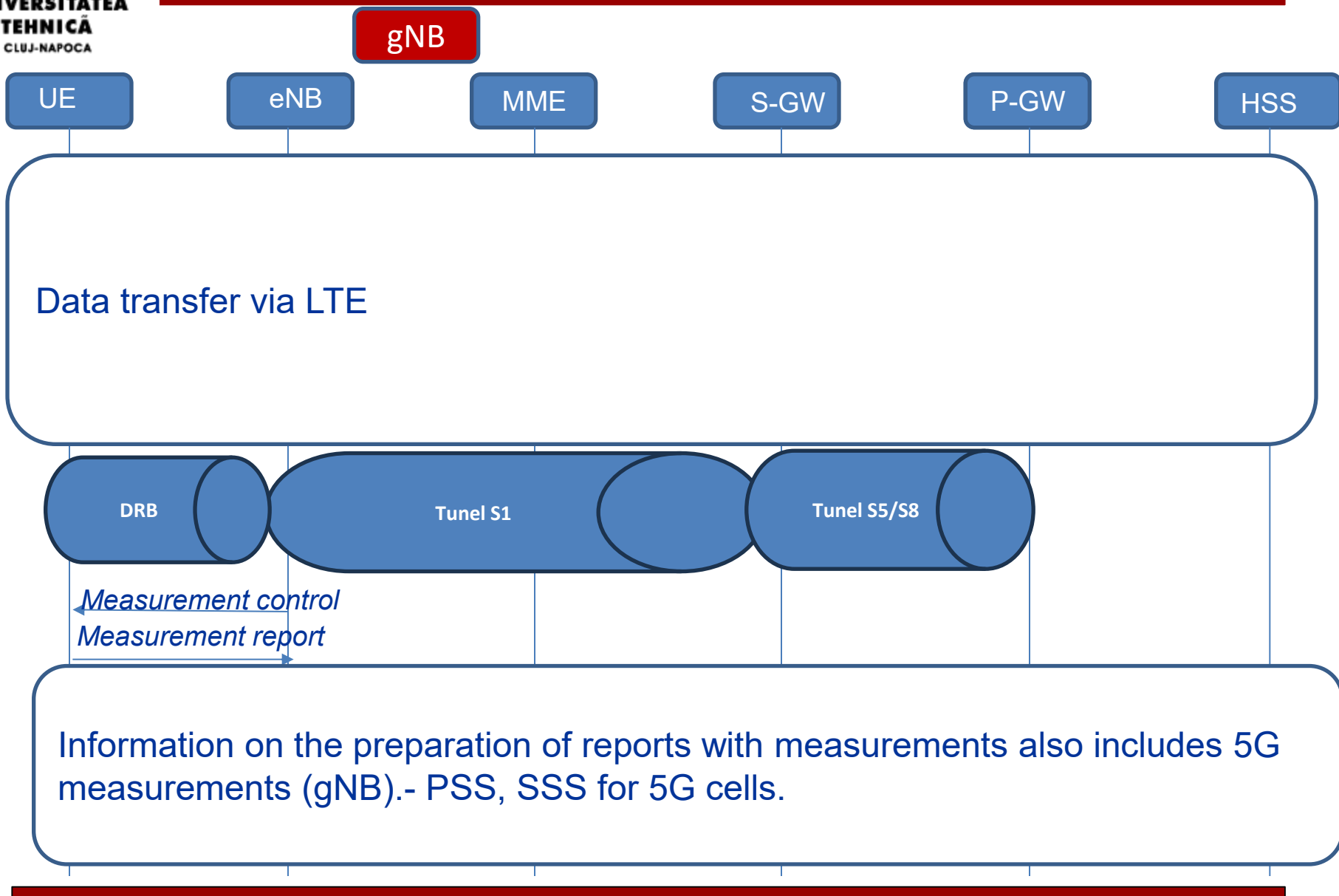


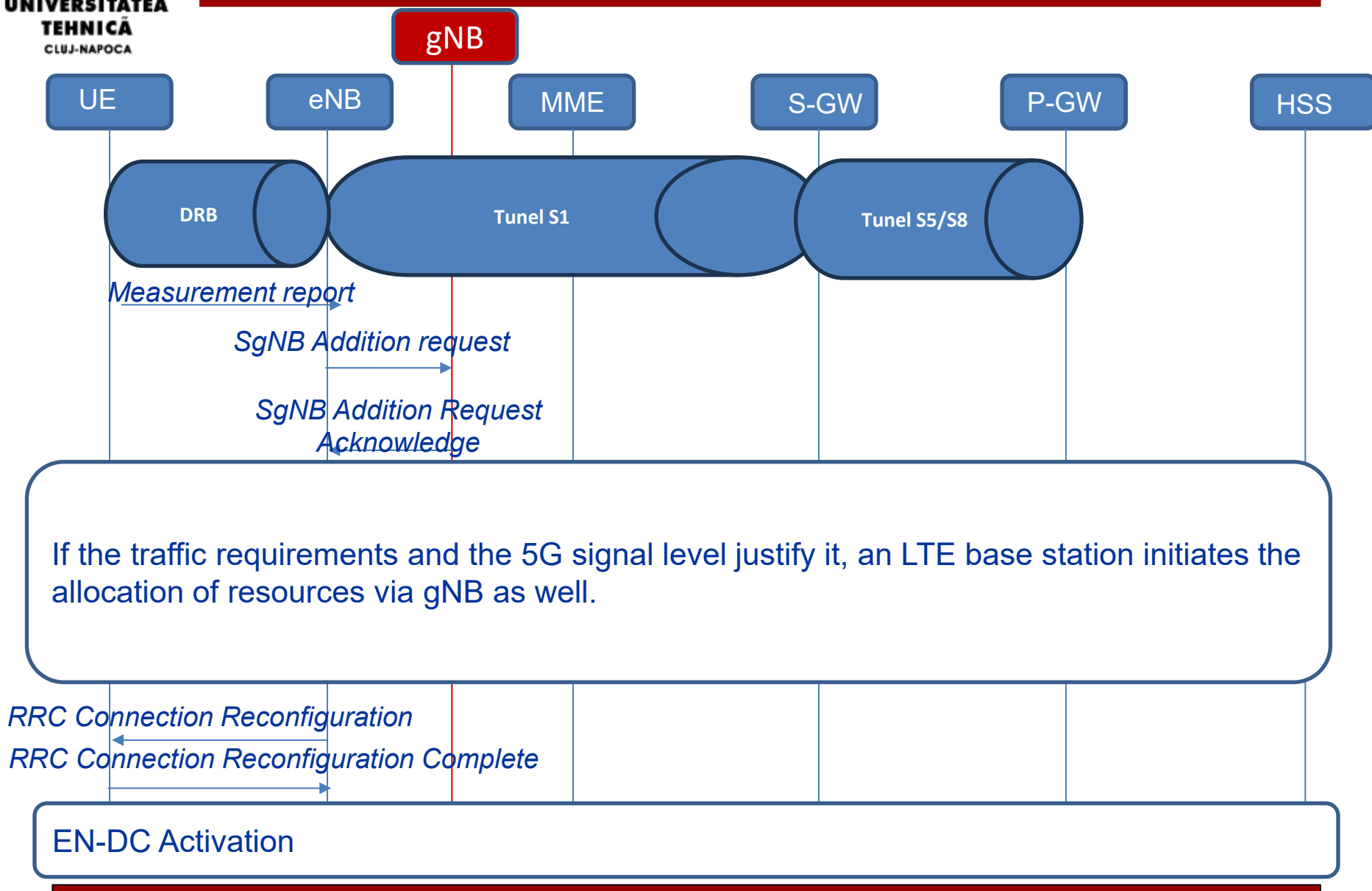
- the X2 interface is used in both the control plane and the user plane with the vast majority of the data volume transferred via gNB. The gNB equipment decides how to split traffic according to information for both technologies

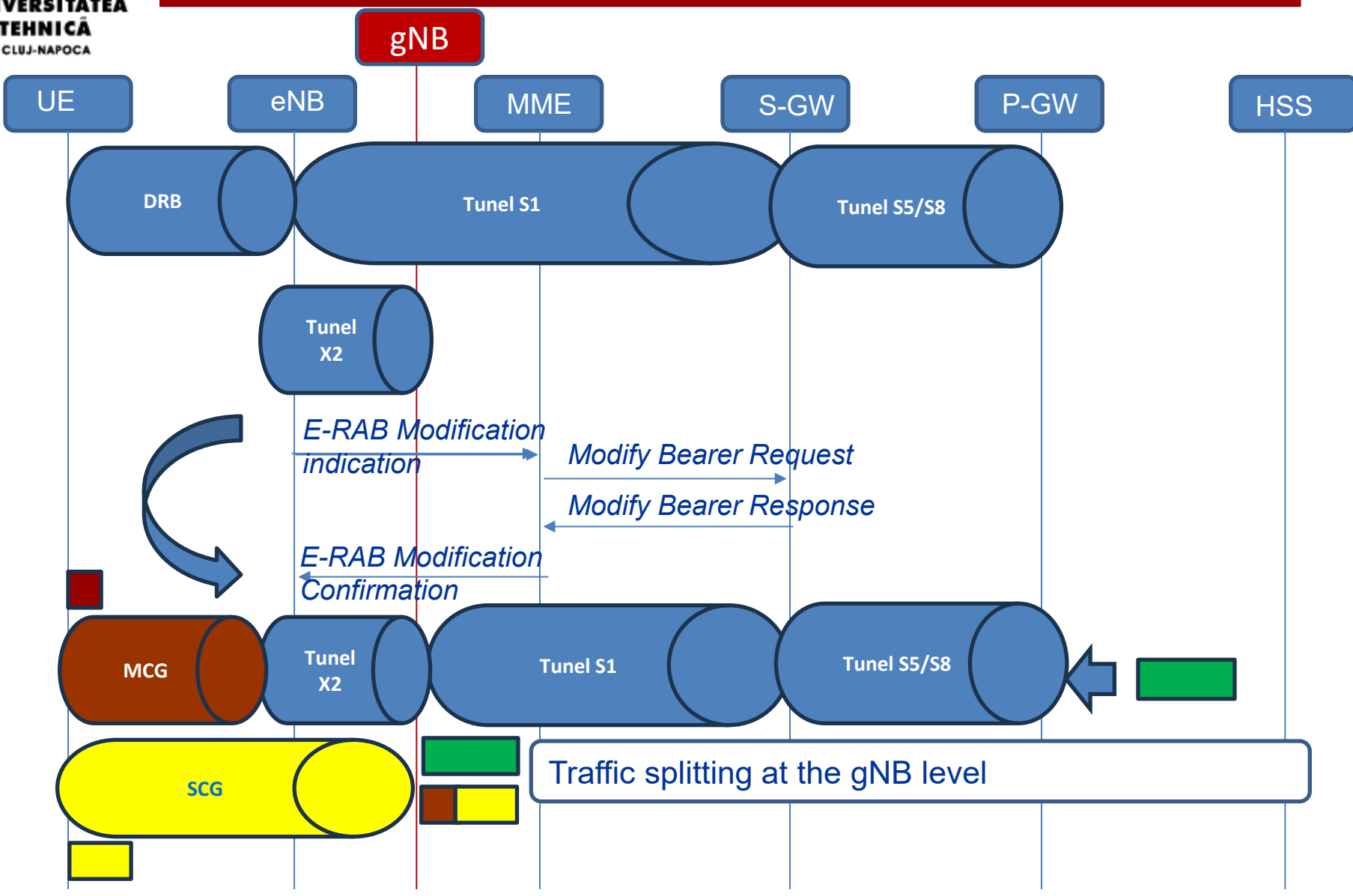
- bearer services for the data transfer offered are referred to in the specifications under the name of **MCG (Master Cell Group) bearer**, **SCG (Secondary Cell Group) bearer LTE** and **Split bearer (3x option) (MGC+SCG)**
- regardless of the variant chosen for the access network, the NSA3 option requires minimal software changes and at the EPC level
- NSA3 deployment has no impact on the mode in which roaming mobility is ensured
- the mechanisms for attaching to the network and establishing data sessions via the NSA3 option are based on those in LTE, with changes for support via 5G NR
- details, stack of protocols ([link](#))
- the attach procedure is that used in LTE











Mobile communications