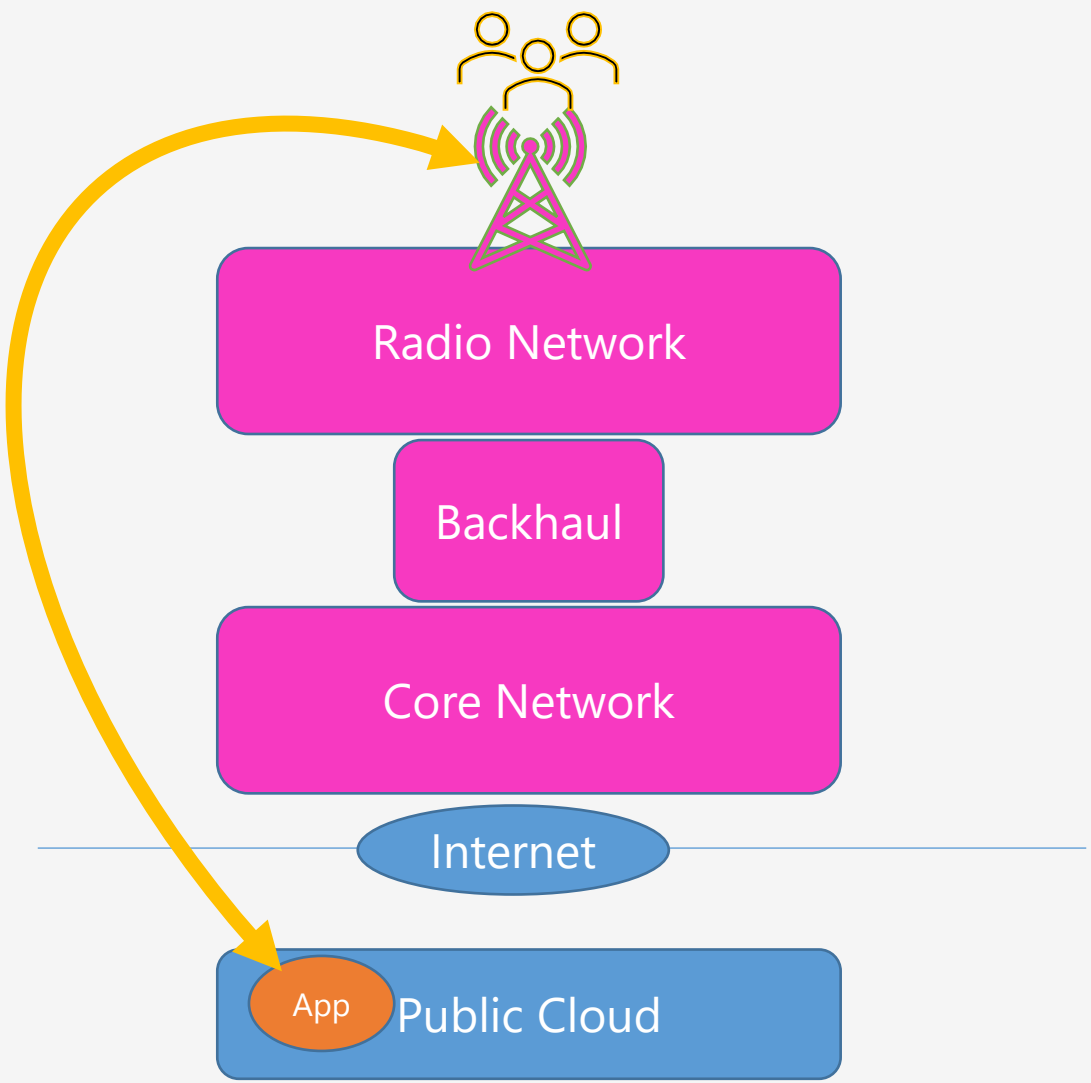
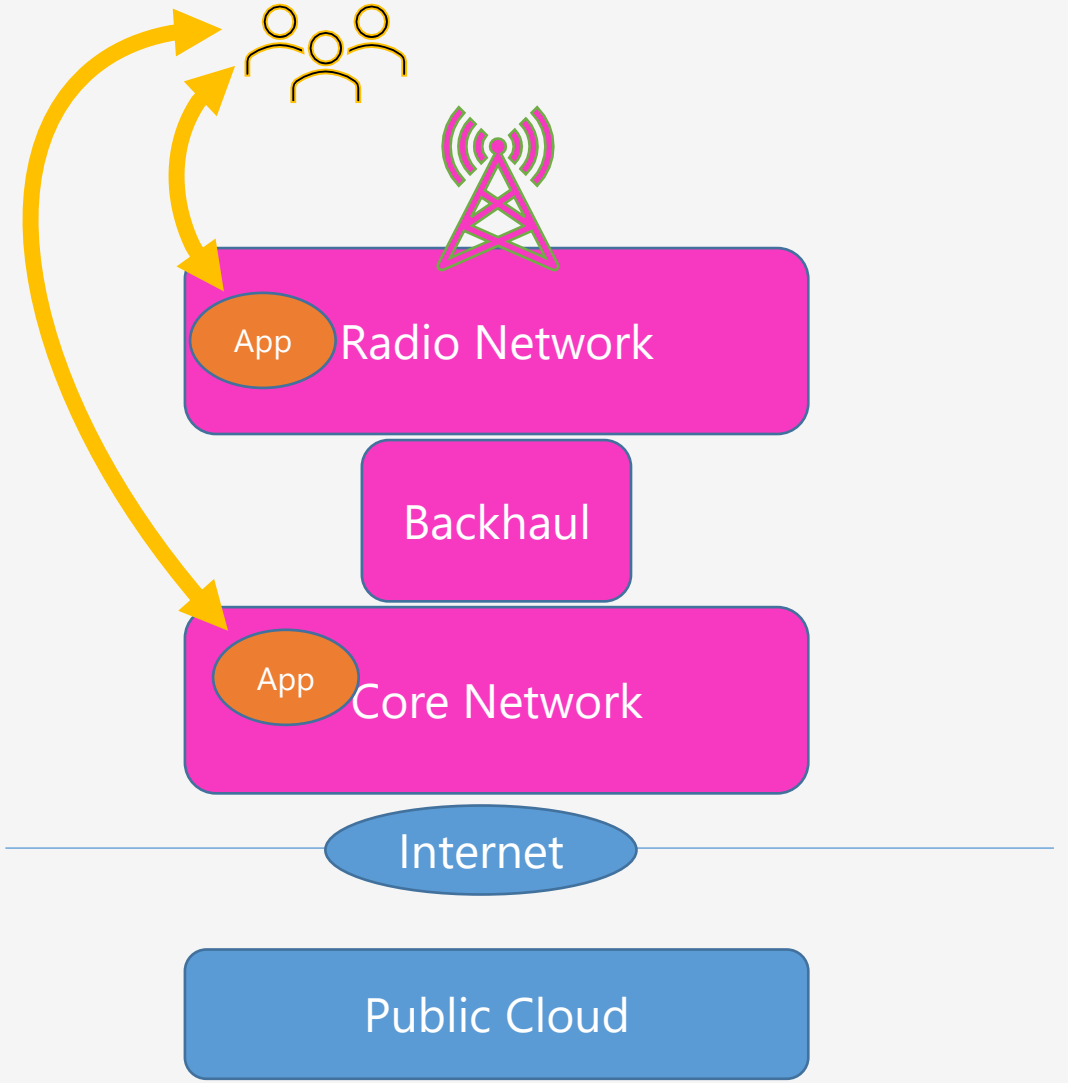
# Mobile Computing Architecture

UW Bothell, WA

Lecture 5: 5G Mobile Network Protocol Stack – Control Plane

# Recall: 5G – Edge Computing Intro [Latency]



# Recall: Network Protocol

A network protocol is an established set of rules that determine how data is transmitted between different devices in the same network. Essentially, it allows connected devices to communicate with each other, regardless of any differences in their internal processes, structure or design. Network protocols are the reason you can easily communicate with people all over the world, and thus play a critical role in modern digital communications.

Network protocols take large-scale processes and break them down into small, specific tasks or functions.

This occurs at every level of the network, and each function must cooperate at each level to complete the larger task at hand. The term protocol suite refers to a set of smaller network protocols working in conjunction with each other.

Network protocols are typically created according to industry standard by various networking or information technology organizations.

The following groups have defined and published different network protocols:
The Institute of Electrical and Electronics Engineers (IEEE)
The Internet Engineering Task Force (IETF)
The International Organization for Standardization (ISO)
The International Telecommunications Union (ITU)
The World Wide Web Consortium (W3C)

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Gateways regulate traffic between two dissimilar networks

For example: Two different protocol stacks on either side

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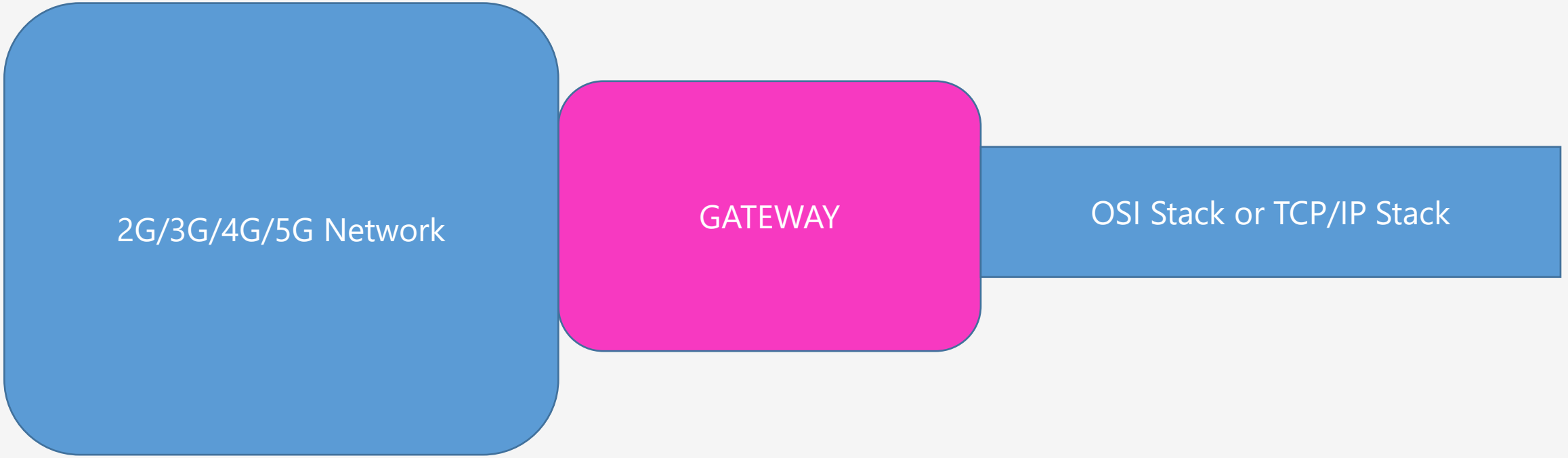
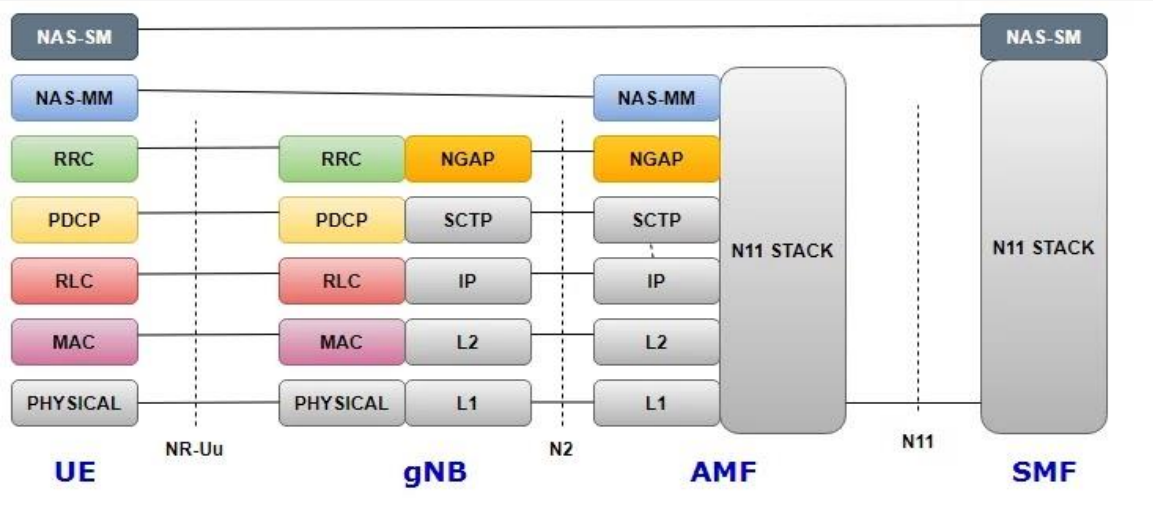
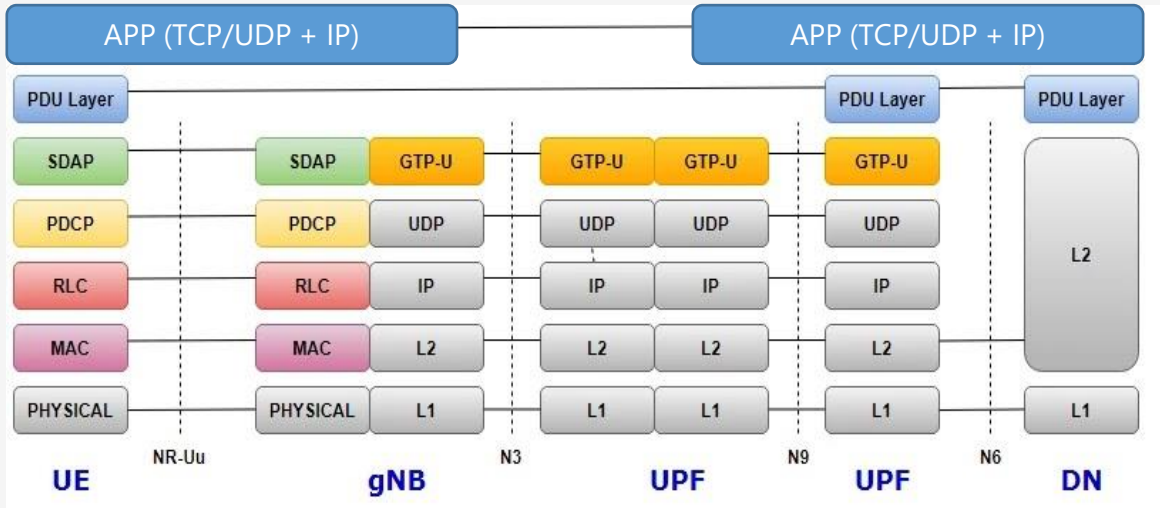


# 5G Protocol Stack

## Control Plane Protocol Stack




## User Plane Protocol Stack



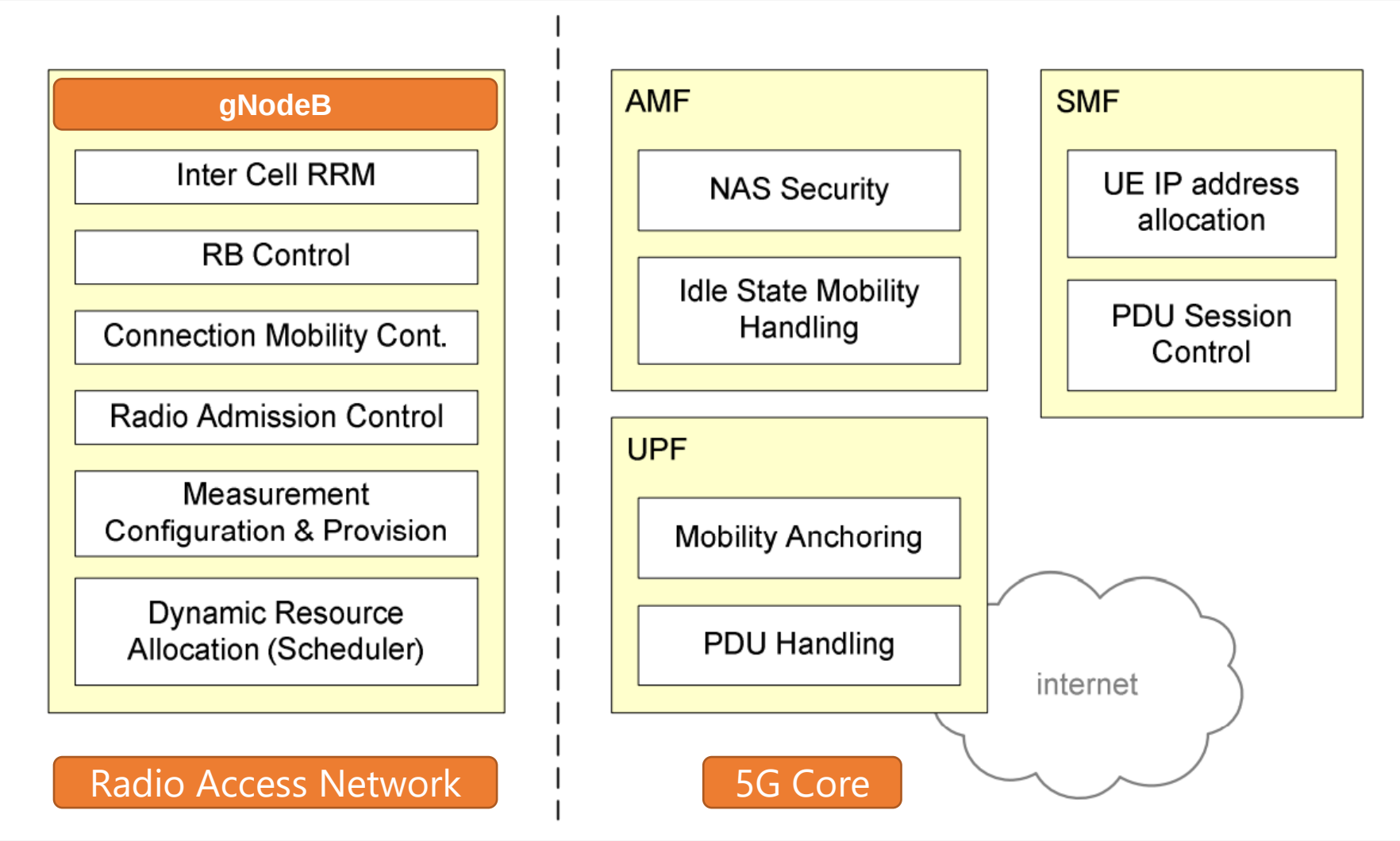




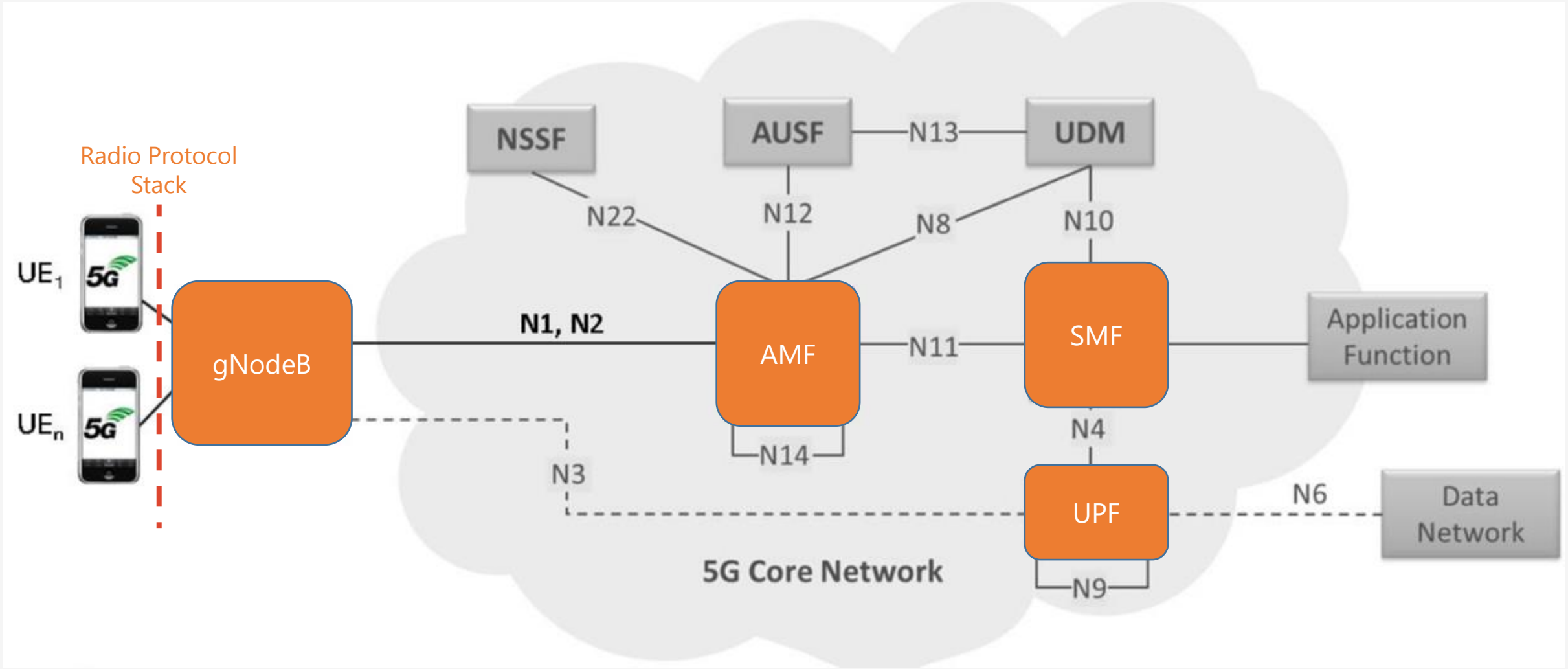

*https://www.6g5g4g.com/2020/02/5g-protocol-stack.html* 

# 3GPP 5G Mobile Network Architecture

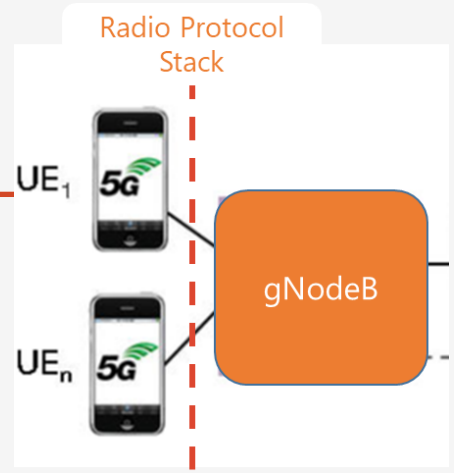
## Functional Split: RAN and 5G Core (5GC)



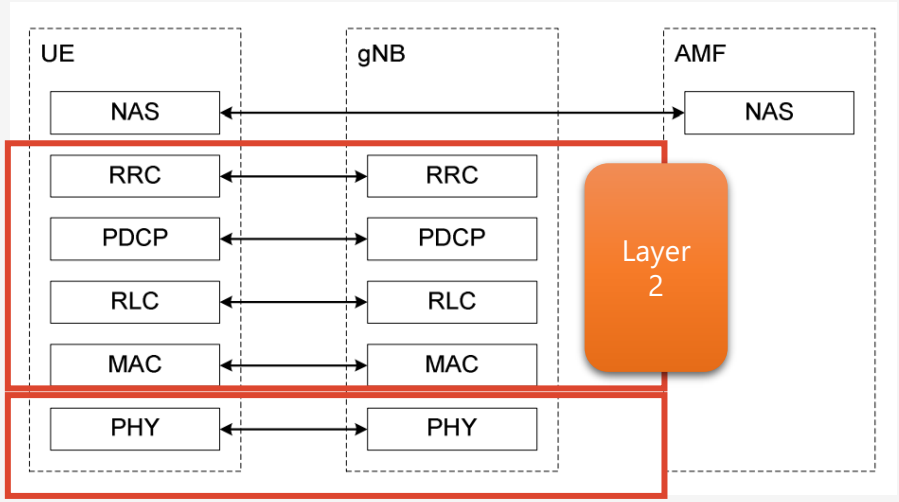
# Interfaces



# Radio Protocol Stack – User and Control Planes

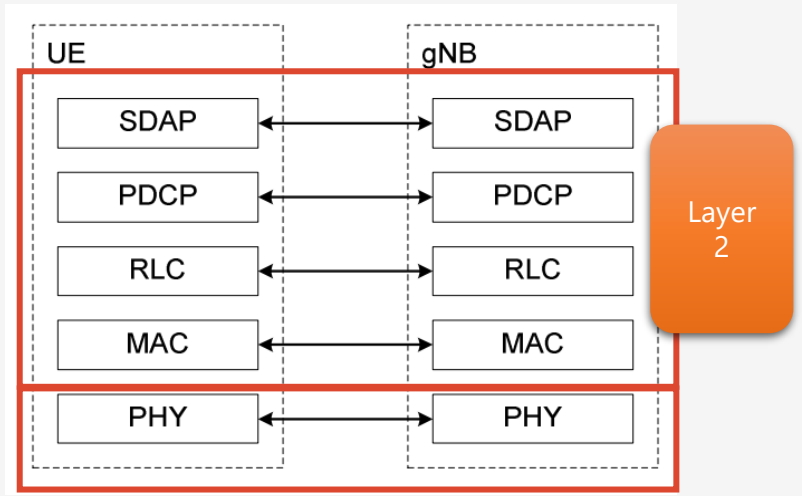



## Control Plane Protocol Stack




- PHY: Physical Layer
- Layer 2: MAC, RLC, PDCP and SDAP
- RRC, PDCP, RLC and MAC sublayers are terminated in gNodeB on the network side
- NAS control protocol is terminated in AMF on the network side (performs the functions listed in 3GPP TS 23.501), for instance: authentication, mobility management, security control

## User Plane Protocol Stack

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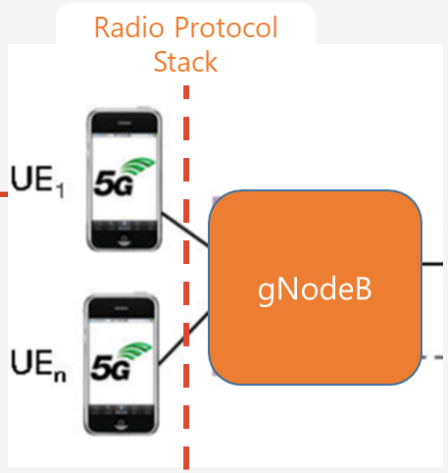
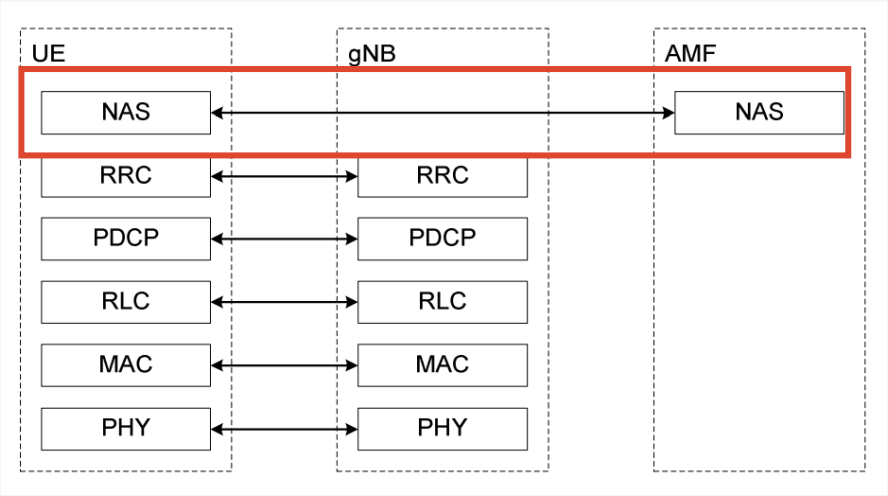



## Control Plane Protocol Stack

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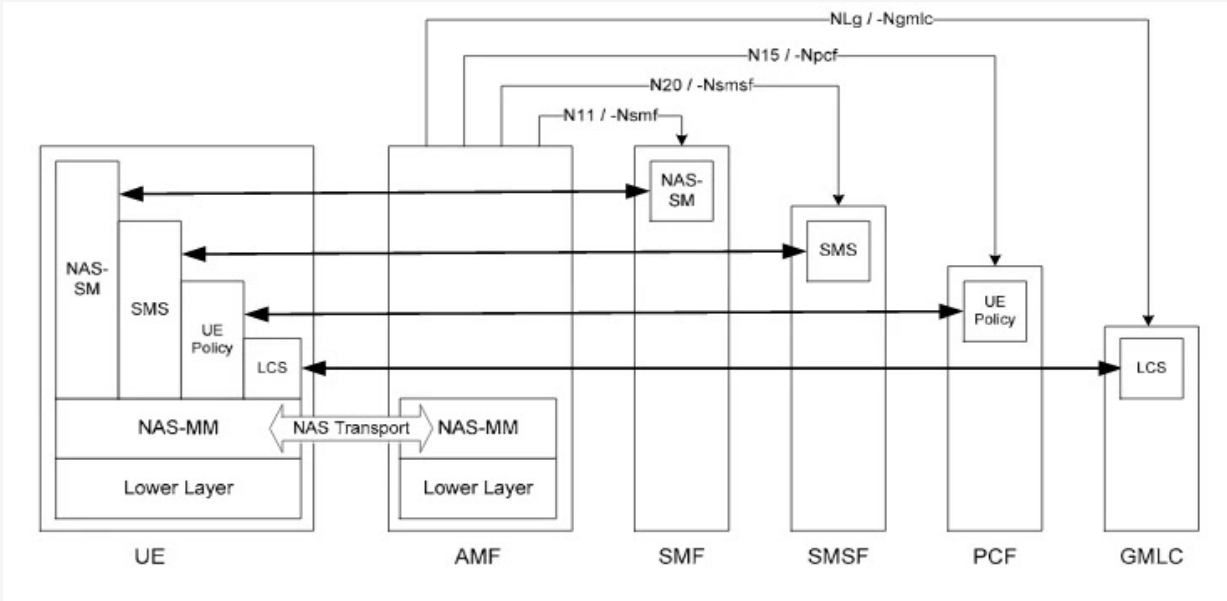
# UE to Core - Control Plane Non-Access-Stratum (**NAS**)

- A single NAS signaling connection is used for each UE
- The single N1 endpoint is placed in the AMF
- Single N1 NAS signaling connections are used for both **registration management and connection management (RM / CM)**
- The NAS protocol on N1 includes the **mobility management (MM)** and **session management (SM)**. For example:
  - Session Management Signaling.
  - SMS.
  - UE Policy, etc.
- Location Services (LCS)
- 5G SMS (SMSF) messaging



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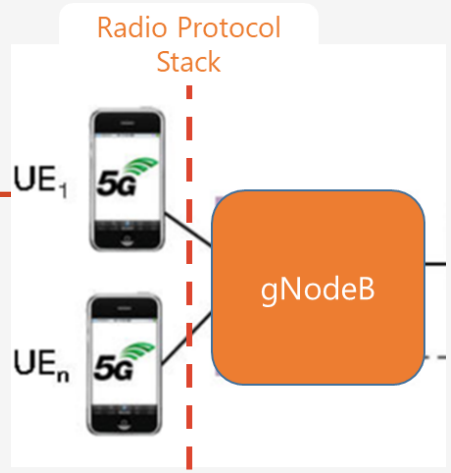


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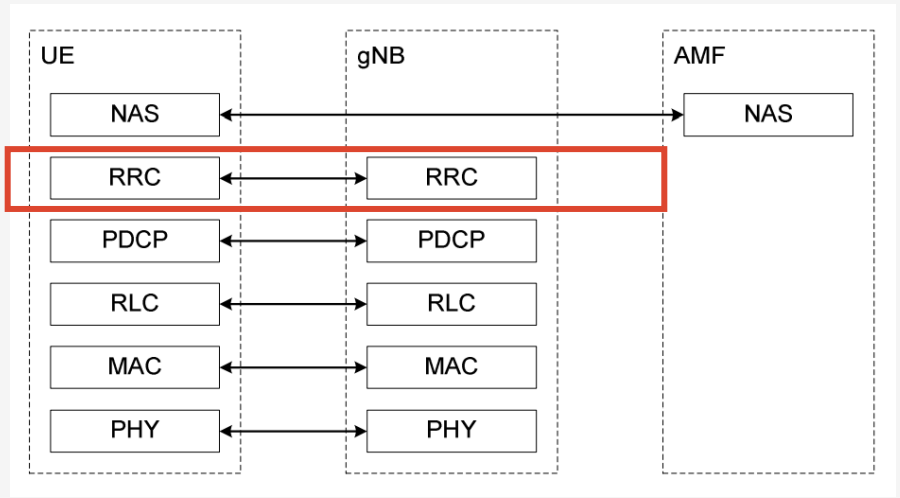


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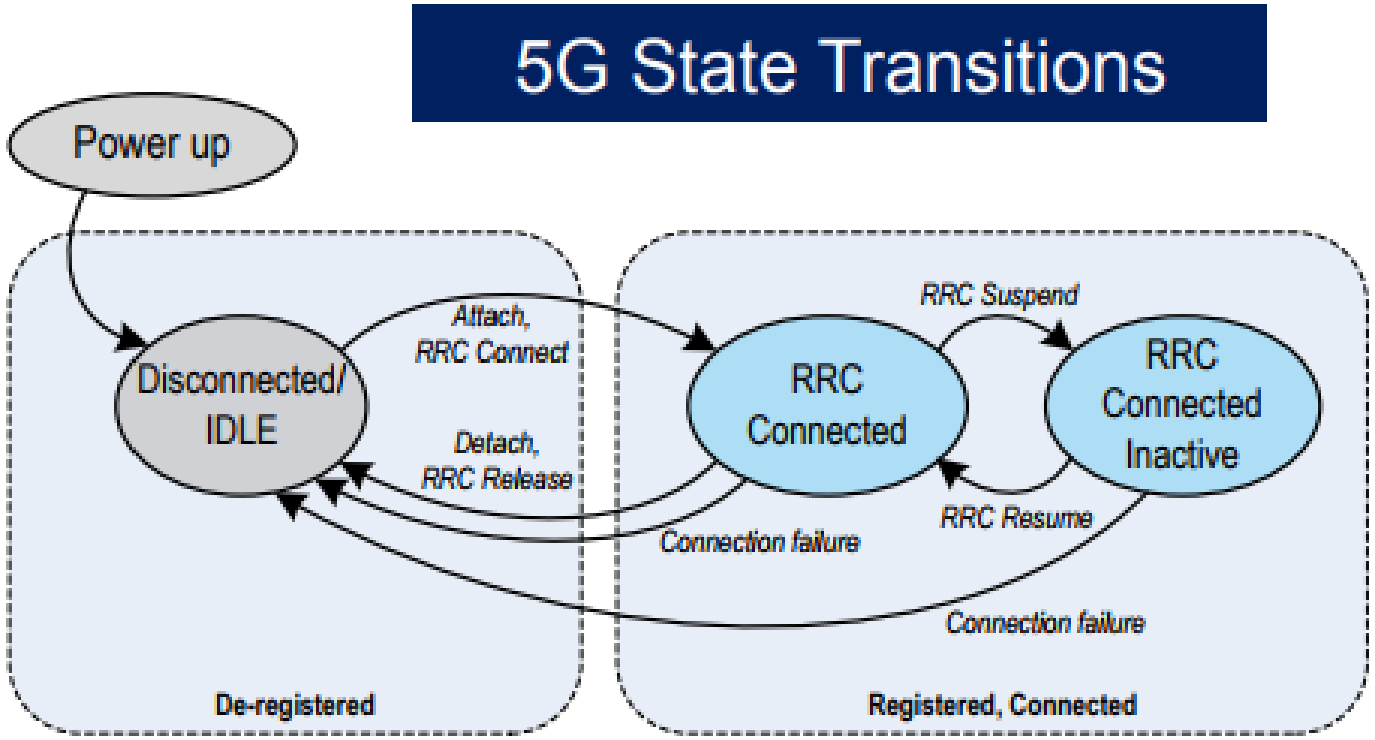
# Control Plane - Radio Resource Control (RRC)

The main services and functions of the RRC sub layer include:

- Broadcast of System Information related to AS and NAS;
- Paging initiated by 5GC or NG-RAN;
- Establishment, maintenance, and release of an RRC connection between the UE and NG-RAN including Addition, modification, and release of carrier aggregation, Addition, modification, and release of Dual Connectivity in NR or between E-UTRA and NR.
- Security functions including key management
- Establishment, configuration, maintenance, and release of Signaling Radio Bearers (SRBs) and Data Radio Bearers (DRBs);
- Mobility functions including Handover and context transfer; UE cell selection and reselection and control of cell selection and reselection; Inter-RAT mobility
- QoS management functions
- UE measurement reporting and control of the reporting
- Detection of and recovery from radio link failure
- NAS message transfer to/from NAS from/to UE

# Control Plane - Radio Resource Control (RRC) – Connection States



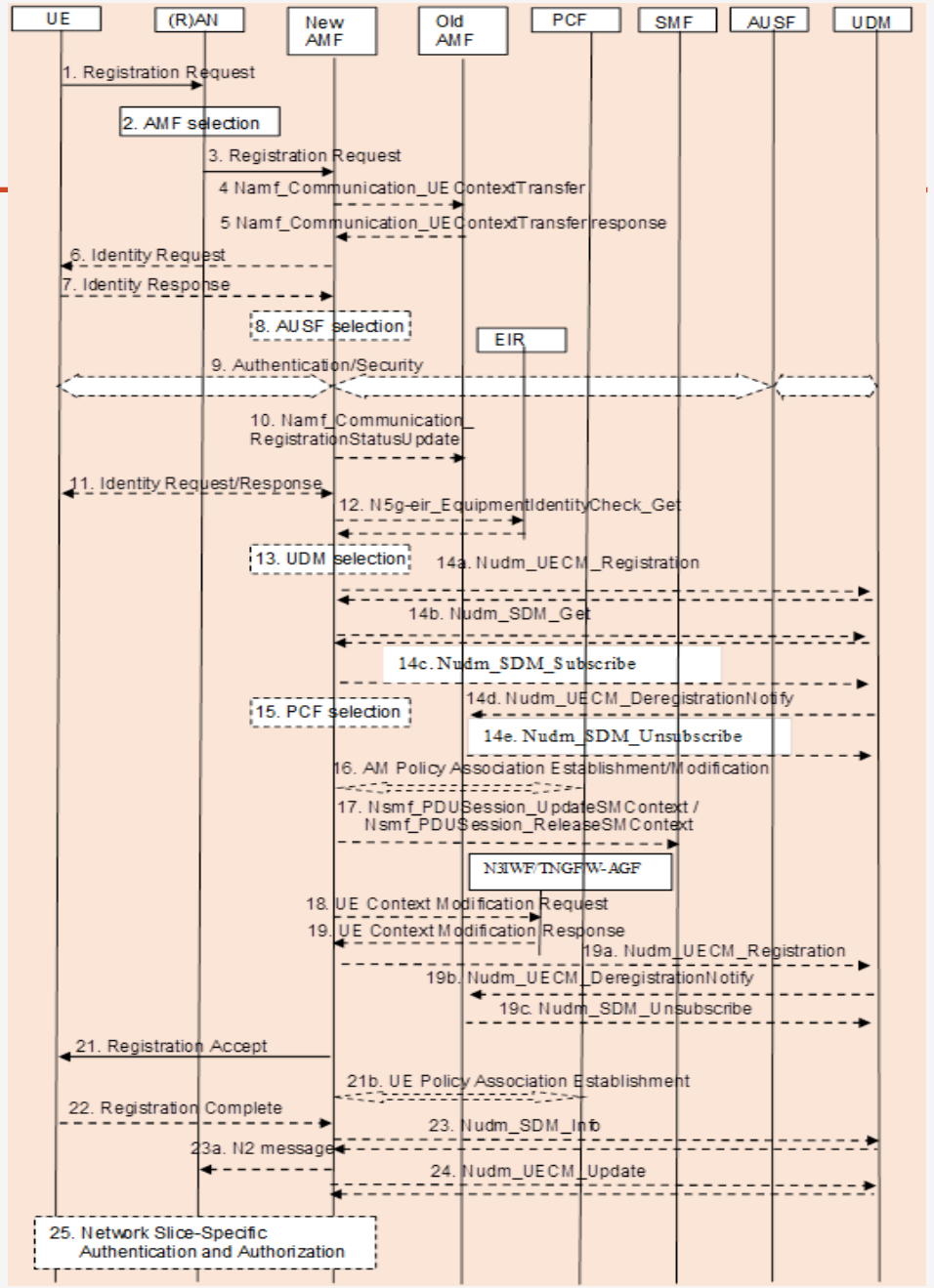

## 5G States

| Off | Attaching | Connected/ Inactive | Connected/ Active |
|---|---|---|---|
| Deregistered | | Registered | |
| - | Connected | | |
| - | Connected | Inactive | Connected |
| - | UE based | UE based, NW assisted | NW based |

# Recall UE Registration

**UE Registration as one example of call flow..**

- UE Sends a Registration Request
- Goes to RAN (gNodeB)
- gNodeB communications with AMF (control function)
- AMF selects AUSF
- Authentication of UE
- AMF Selects a UDM and registers/subscribers the UE
- AMF Selects a PCF and establishes context
- AMF sends the Registration Accept back to UE
- UE send Registration Complete



# RRC Contd….

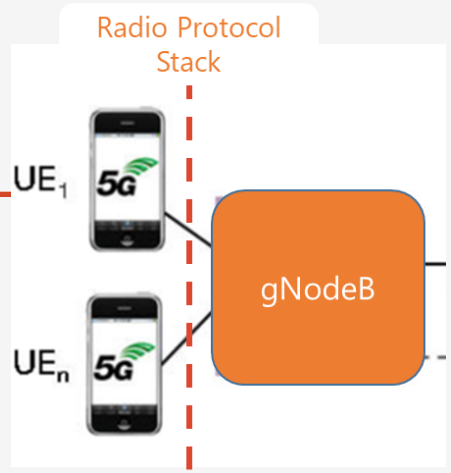
5G has to support Mobile Broadband as well as IoT services at same cost and energy dissipation per day per area

The RRC States solve:

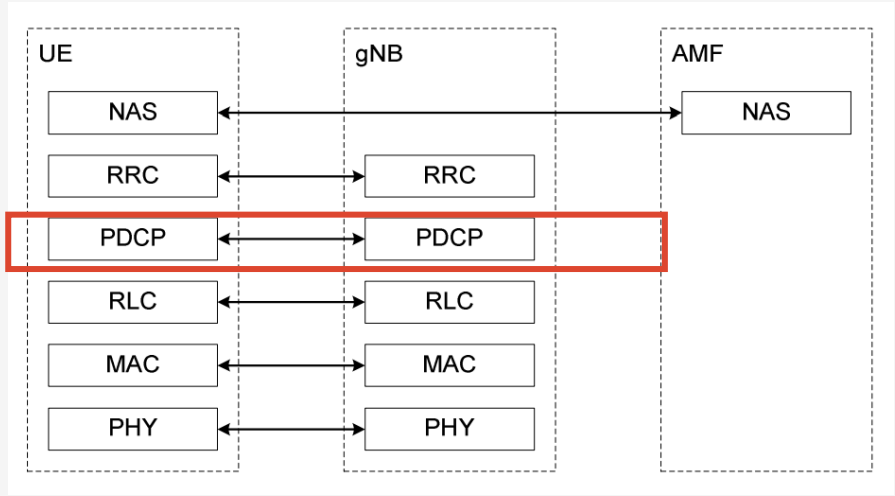
- System access
- Power saving
- Mobility optimization

- To support URLLC services which transmits small packets that require ultra-low latency and/or high reliability
- Massive IoT Devices wakes up seldom power saving mode to transmit and receive a small payload
- Devices need to camp in low activity state, and sporadically transmits UL data and/or status reports with small payload to the network
- Devices need periodic and/or sporadic DL small packet transmission
- When UE is in the connected state, and sporadically transmit UL data and/or status reports with small payload to the network.

# Radio Protocol Stack – Packet Data Convergence Protocol (PDCP)




## Control Plane Protocol Stack

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# Layer 2 Protocols - PDCP

## Packet Data Convergence Protocol (PDCP)

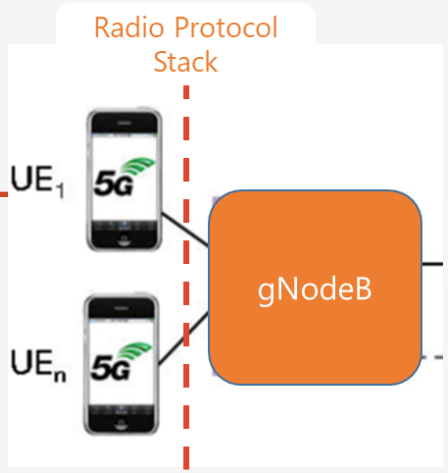
**Packet Data Convergence Protocol** (**PDCP**) is specified by 3GPP in TS 25.323 for UMTS, TS 36.323 for LTE and TS 38.323 for 5G New Radio (NR)

PDCP is located in the Radio Protocol Stack in the UMTS/LTE/5G Air interface on top of the RLC layer.

PDCP provides its services to the RRC and user plane upper layers, e.g. IP at the UE or to the relay at the base station. The following services are provided by PDCP to upper layers:

- Ciphering, deciphering and integrity protection
- Transfer of control plane data
- Duplicate detection

# Radio Protocol Stack –Control Plane

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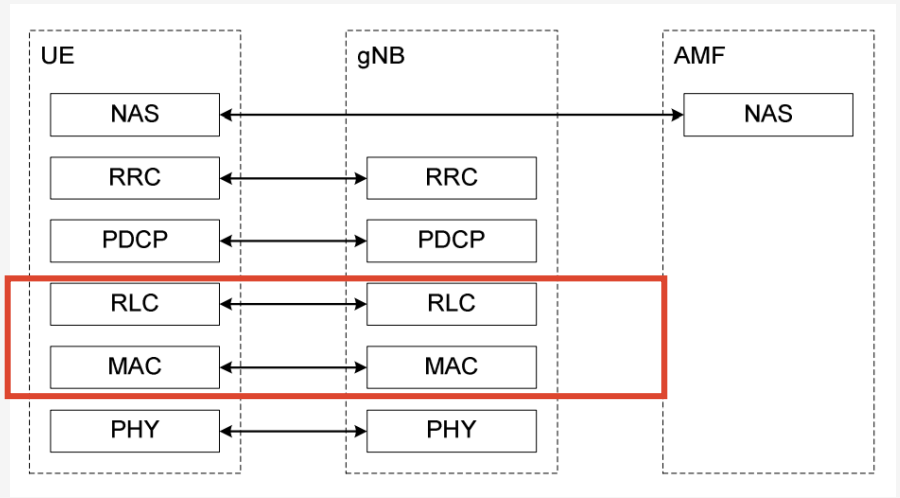


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# Control Plane Protocols – RLC and MAC

**Radio Link Control (RLC)**

The main services and functions of the RLC sublayer depend on the transmission mode and include:

- Transfer of upper layer PDUs
- Sequence numbering
- Error Correction through ARQ
- Segmentation and re-segmentation
- Reassembly of SDU
- RLC SDU discard
- RLC re-establishment

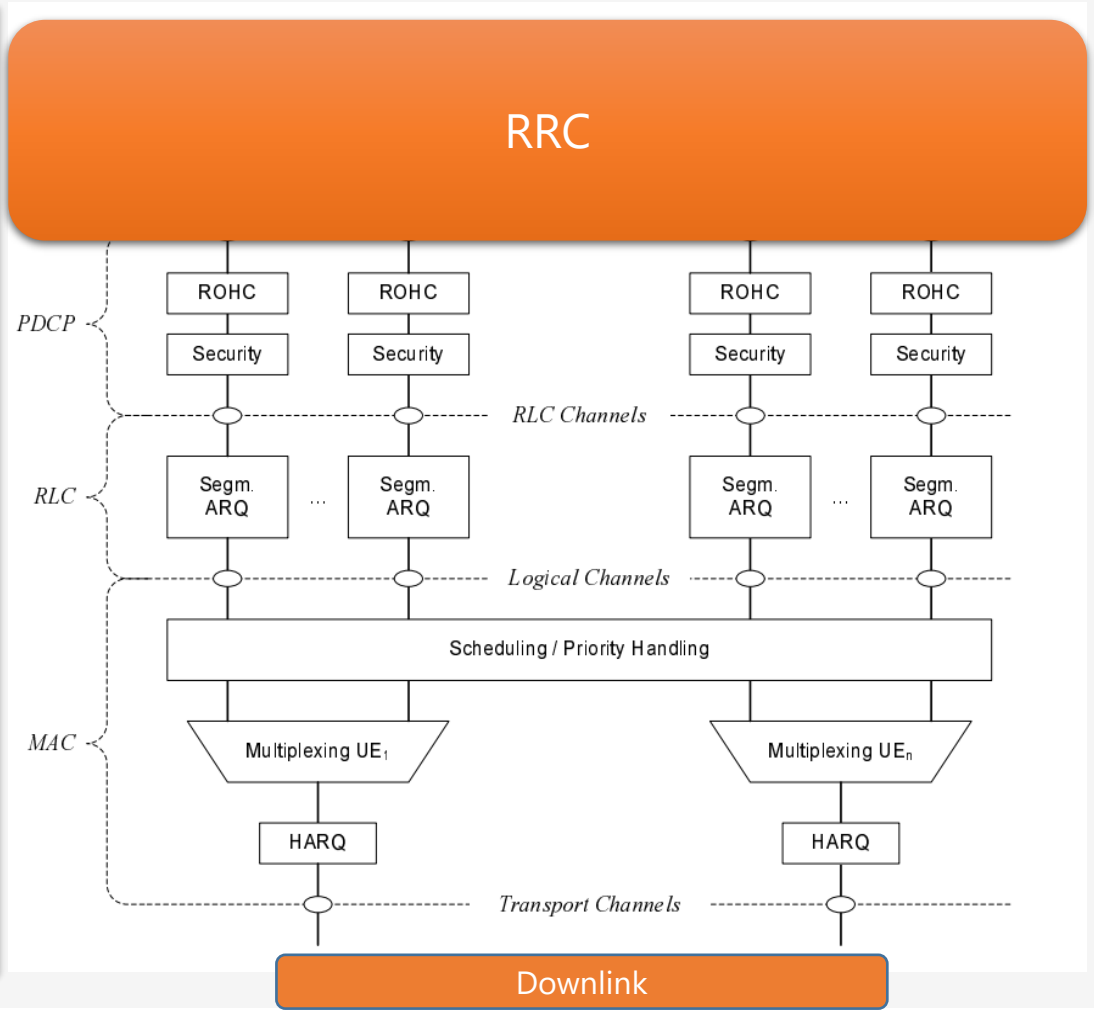
**Media Access Control (MAC)**

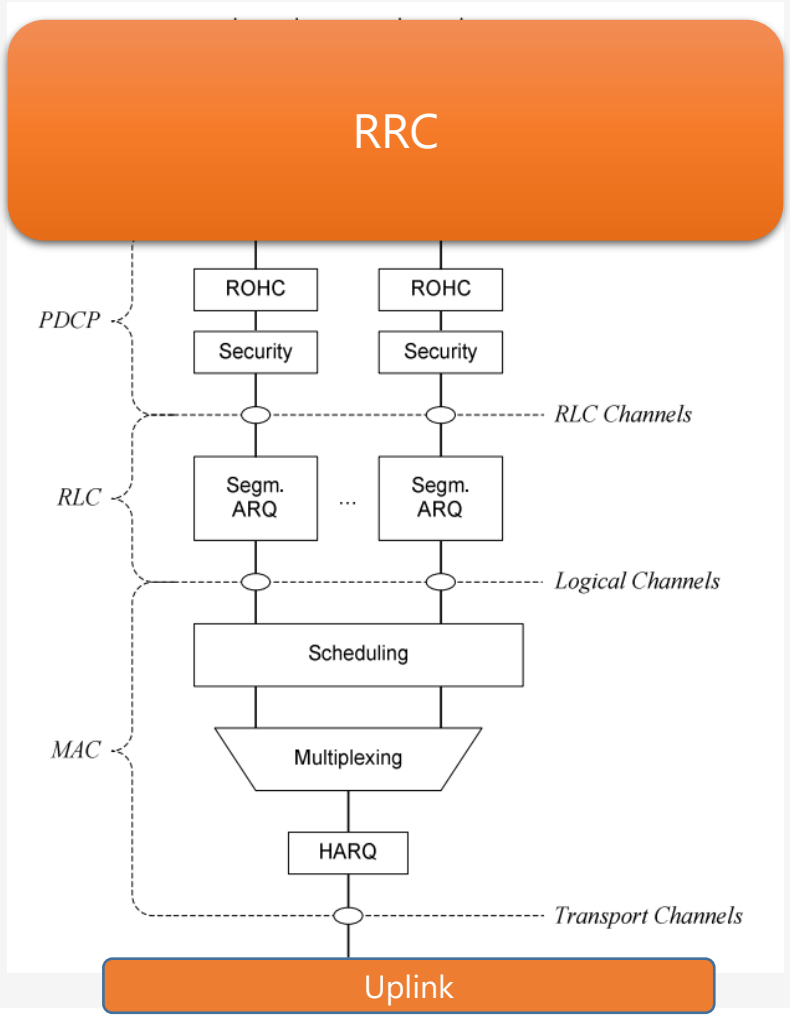
The main services and functions of the MAC sub layer include:

- Mapping between logical channels and transport channels
- Multiplexing/demultiplexing of MAC SDUs belonging to one or different logical channels into/from transport blocks (TB) delivered to/from the physical layer on transport channels
- Scheduling Information Reporting
- Error correction through HARQ
- Priority handling between UEs by means of dynamic scheduling
- Priority handling between logical channels of one UE by means of logical channel prioritization
- Padding

# RAN Protocol Stack - Layer 2

- The physical layer offers to the MAC sublayer transport channels
- The MAC sublayer offers to the RLC sublayer logical channels
- The RLC sublayer offers to the PDCP sublayer RLC channels
- The PDCP sublayer offers to RRC





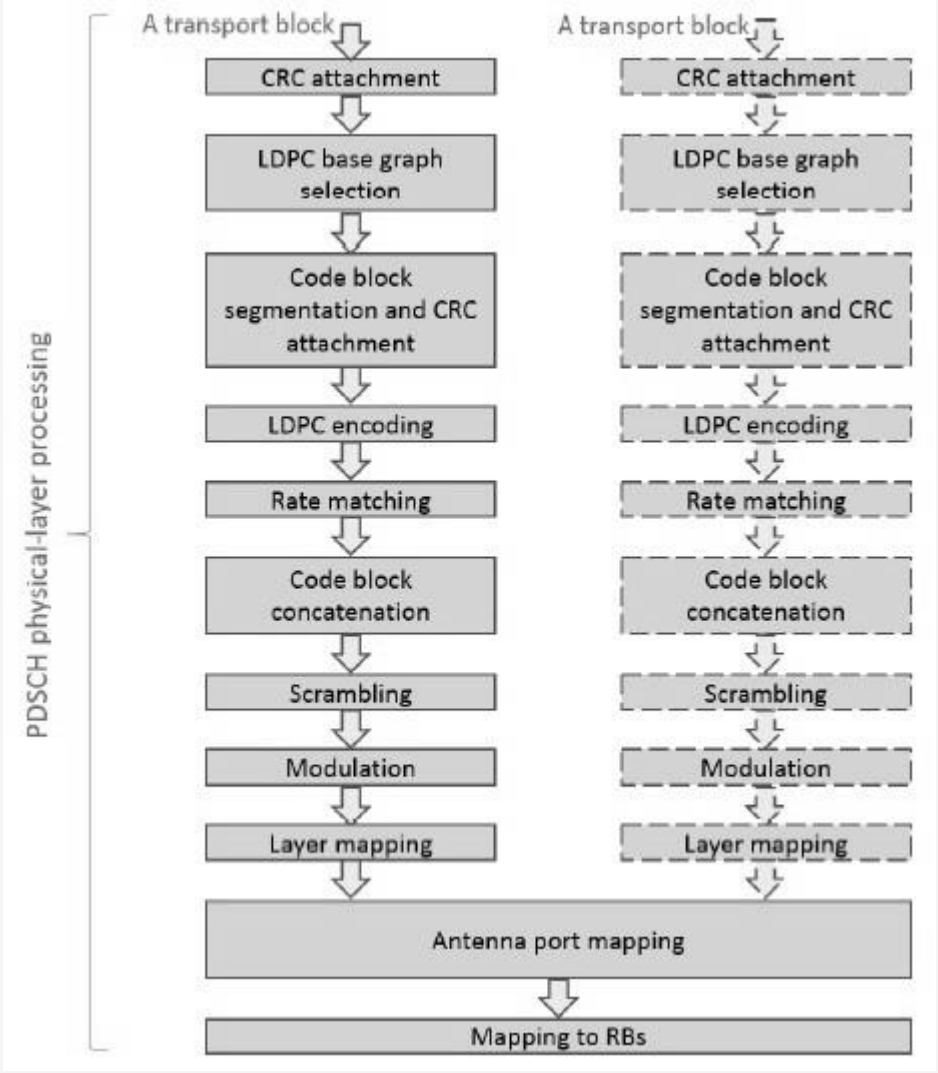



ETSI TS 138 300 V15.3.1

# Physical Layer

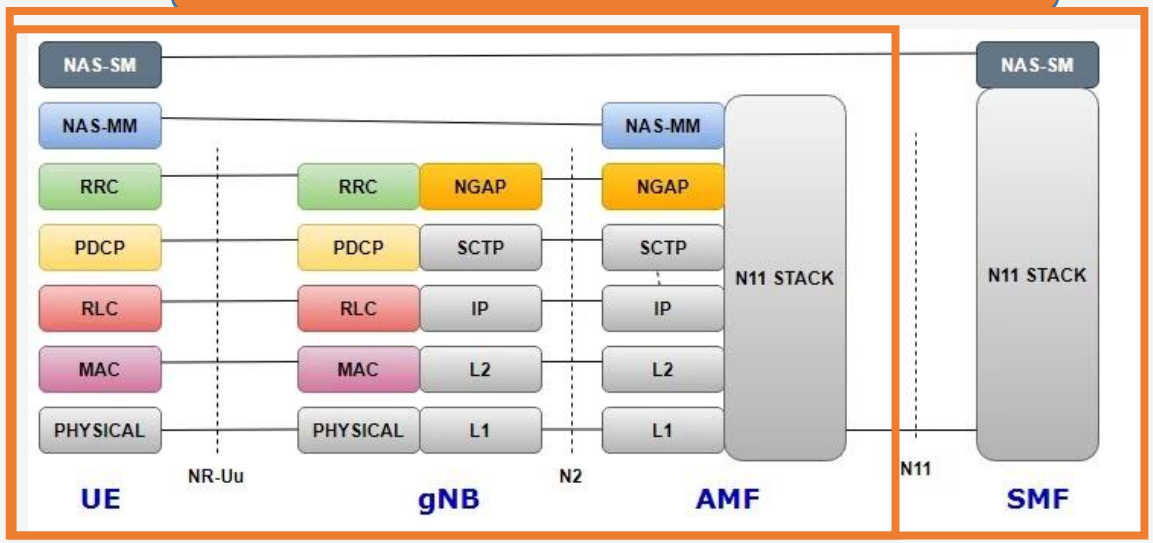
Following are the functions of 5G layer 1 i.e. PHYSICAL (PHY) Layer

- Error detection on the transport channel and indication to higher layers
- FEC encoding/decoding of the transport channel
- Hybrid ARQ soft-combining
- Rate matching of the coded transport channel to physical channels
- Mapping of the coded transport channel onto physical channels
- Power weighting of physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronization
- Radio characteristics measurements and indication to higher layers
- Multiple Input Multiple Output (MIMO) antenna processing
- Transmit Diversity (TX diversity)
- Digital and Analog Beamforming
- RF processing



# 5G RAN- Core Protocol Stack

## Control Plane Protocol Stack

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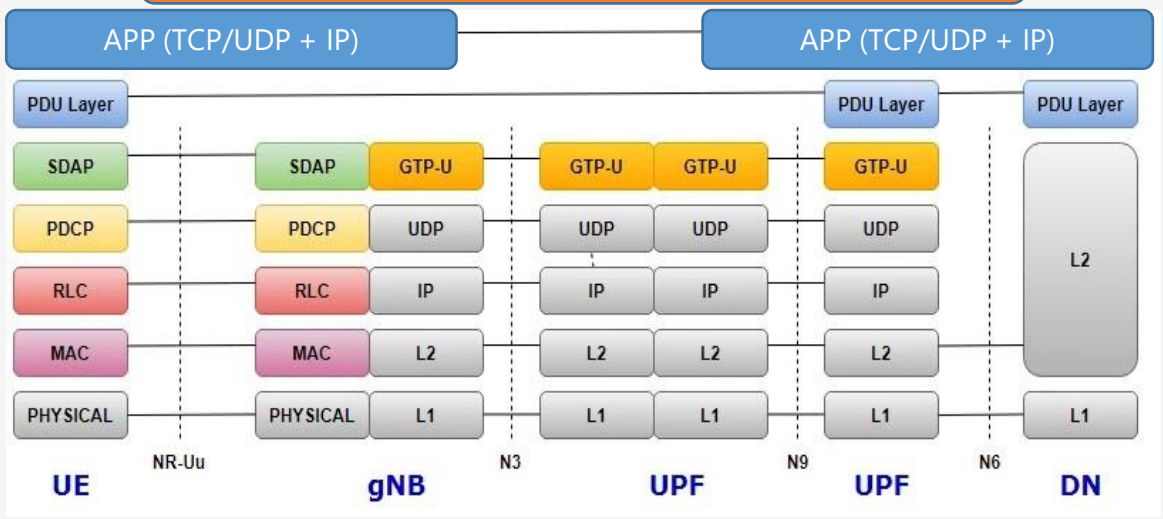


UMTS_FP_MAC_RLC_RRC_NBAP.pcap

# Group Exercise

Wireshark