

Introduction to Cellular Systems





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1st MOBILE RADIO TELEPHONE 1924



Courtesy of Rich Howard

History of Cellular Networks

<ul style="list-style-type: none">1G FDMA (NMT, AMPS, TACS)<ul style="list-style-type: none">- Voice (analog traffic, digital signaling)		80's
<ul style="list-style-type: none">2G TDMA (GSM, D-AMPS, PDC) and CDMA (IS-95)<ul style="list-style-type: none">- Voice, SMS, CS data transfer ~ 9.6 kbit/s (50 kbit/s HSCSD)		90's
<ul style="list-style-type: none">2.5G TDMA (GPRS)<ul style="list-style-type: none">- PS data transfer ~ 50 kbit/s		00's
<ul style="list-style-type: none">2.75G TDMA (GPRS+EDGE)<ul style="list-style-type: none">- PS data ~ 150kbit/s		00's
<ul style="list-style-type: none">3-3.5G WCDMA (UMTS) and CDMA 2000<ul style="list-style-type: none">- PS & CS data transfer ~ 14-42 Mbit/s (HSPA/HSPA+), Voice, SMS		00's
<ul style="list-style-type: none">3.9G OFDMA (LTE/SAE)<ul style="list-style-type: none">- VoIP and Data ~ 100Mbit/s		10's
<ul style="list-style-type: none">4G IMT Advanced		

About 3GPP

- “The 3rd Generation Partnership Project (3GPP) unites [Seven] telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), known as “Organizational Partners” and provides their members with a stable environment to produce the Reports and Specifications that define 3GPP technologies.”
- “The project covers cellular telecommunications technologies, including **radio access, core network and service capabilities**, which provide a complete system description for mobile telecommunications.”
- “The 3GPP specifications also provide hooks for non-radio access to the core network, and for interworking with non-3GPP networks.”

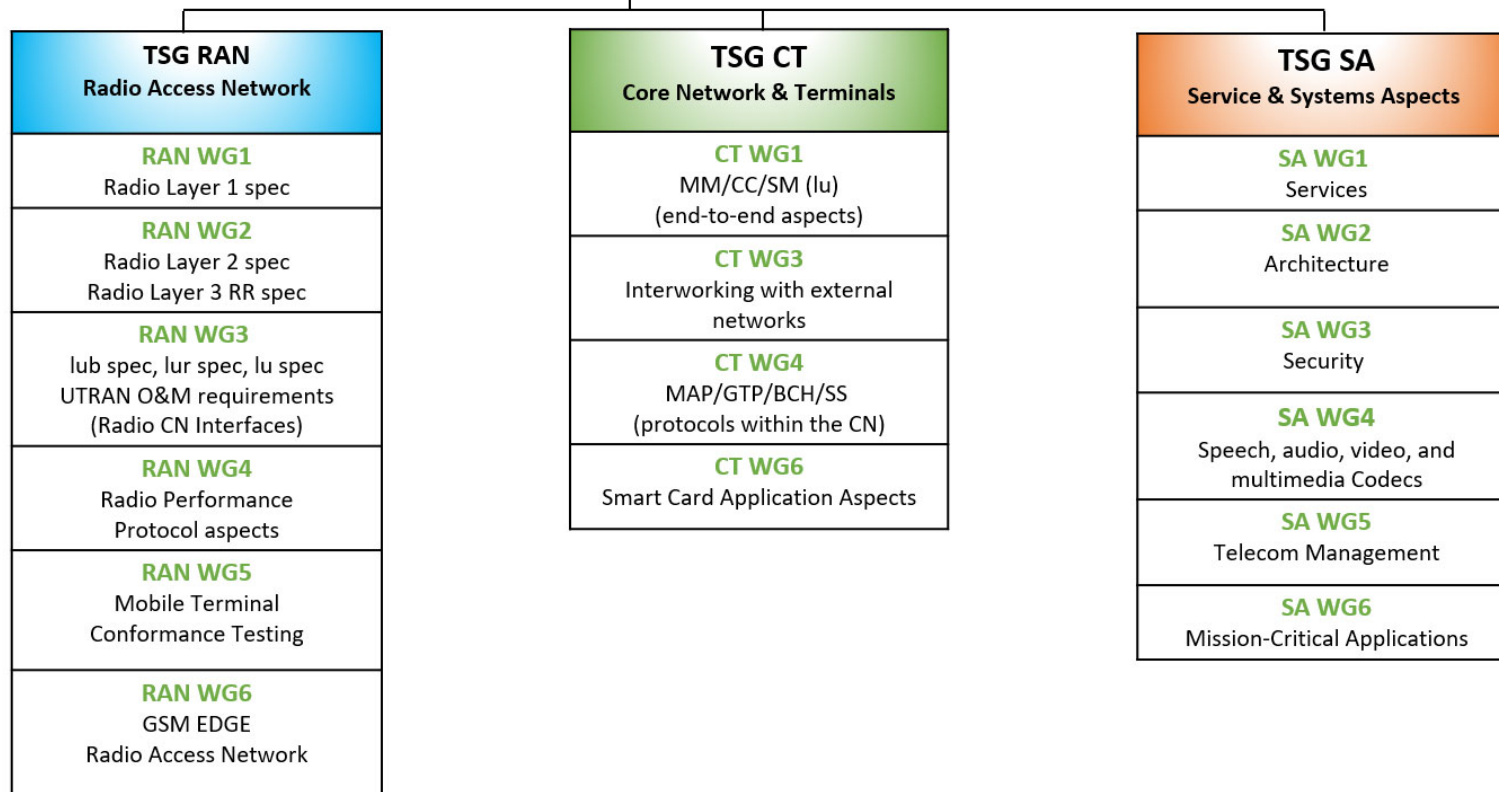
--- <https://www.3gpp.org/about-3gpp/about-3gpp>

Organization of 3GPP

Three Technical Specification Groups (TSG) in 3GPP



Project Coordination Group (PCG)

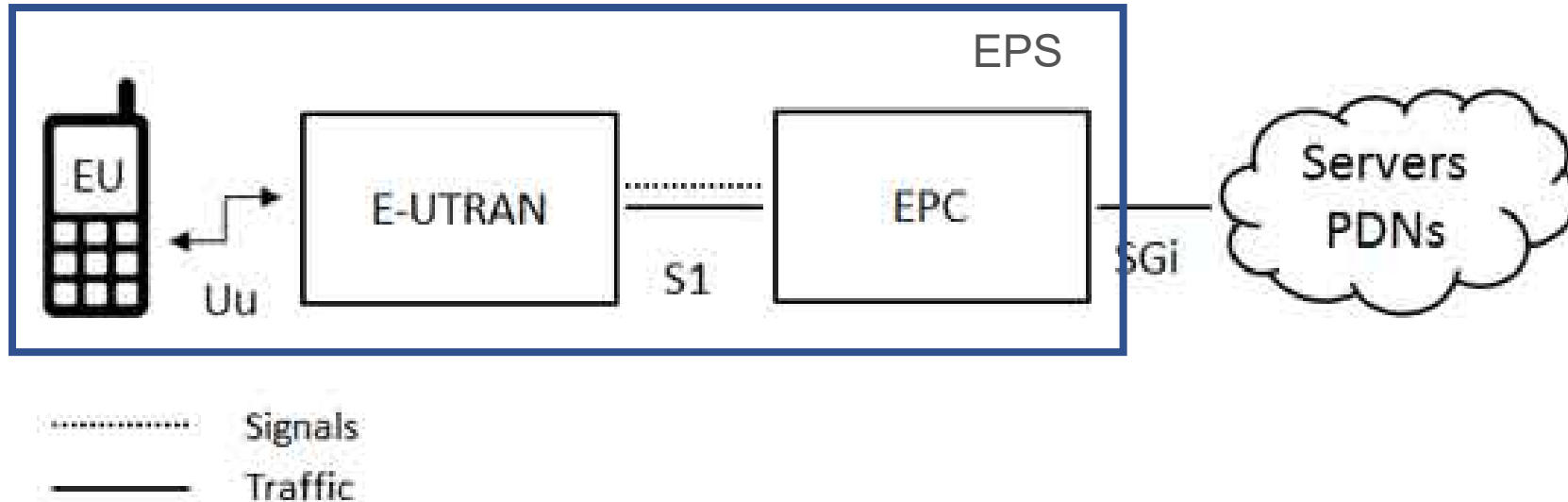


“The TSG Service and System Aspects (TSG-SA) is responsible for the overall architecture and service capabilities of systems based on 3GPP specifications and, as such, has a responsibility for cross TSG co-ordination.”

“The TSG Core Network and Terminals (TSG CT) is responsible for specifying terminal interfaces (logical and physical), terminal capabilities (such as execution environments) and the Core network part of 3GPP systems.”

What are the major differences between cellular and Wi-Fi?

4G: EPS Architecture



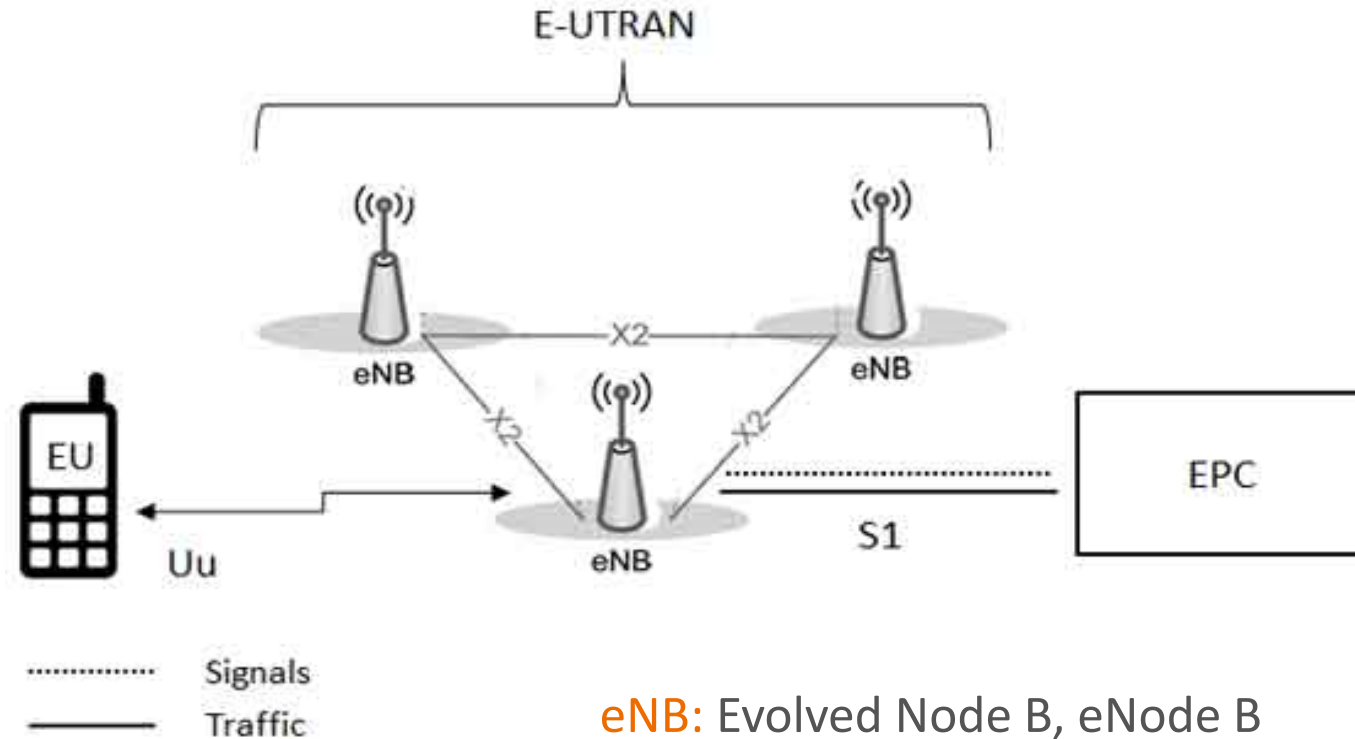
E-UTRAN: Evolved UMTS Terrestrial Radio Access Network (LTE)

EPC: Evolved Packet Core

PDN: Public Data Network

EPS: Evolved Packet System

E-UTRAN



- The eNB sends and receives radio transmissions to all the mobiles.
- The eNB controls the low-level operation of all its mobiles, such as handover commands.

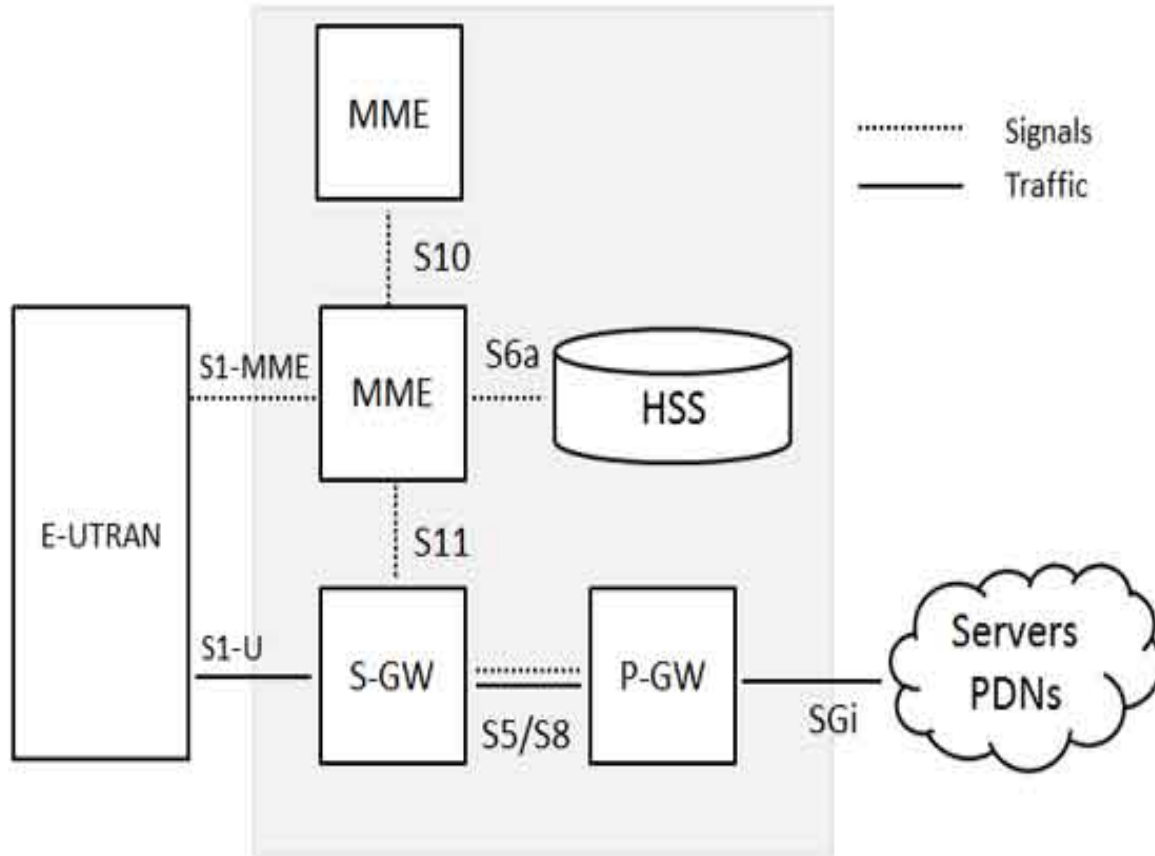
EPC

The Home Subscriber Server (HSS) contains information about all the network operator's subscribers.

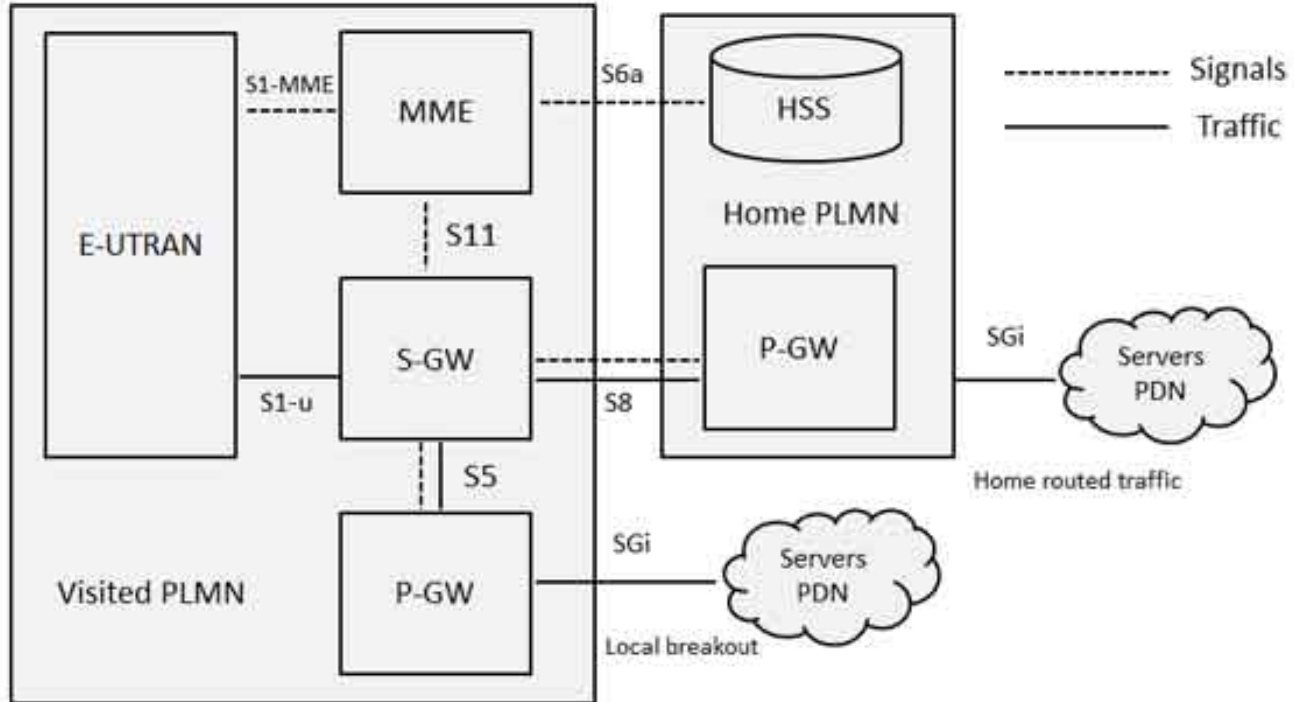
The Packet Data Network (PDN) Gateway (P-GW) communicates with the outside world, i.e. packet data networks PDN, using SGi interface.

The serving gateway (S-GW) acts as a router, and forwards data between the base station and the PDN gateway.

The mobility management entity (MME) controls the high-level operation of the mobile by means of signalling messages and Home Subscriber Server (HSS).



Roaming

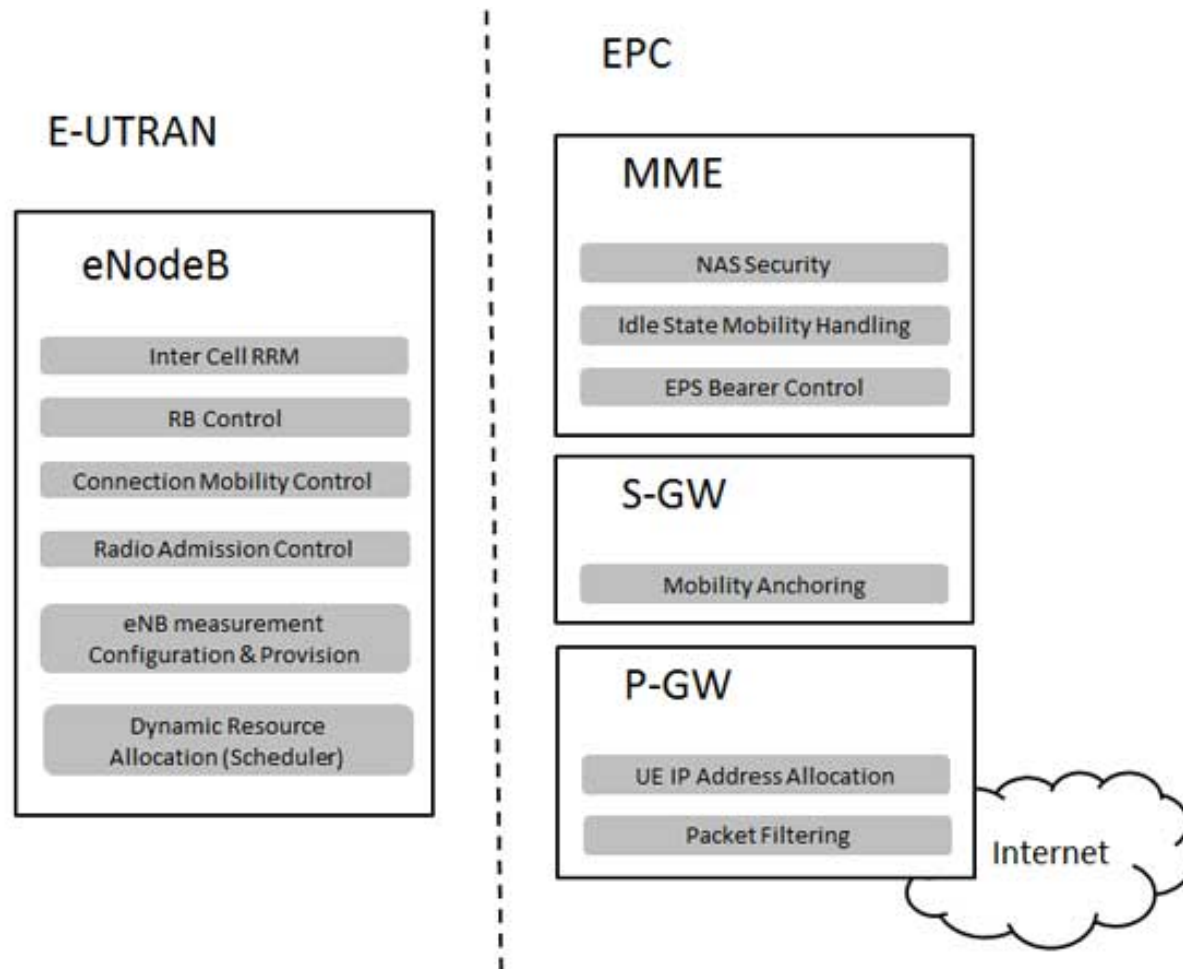


A network run by one operator in one country is known as a **Public Land Mobile Network (PLMN)**

When a subscribed user uses his operator's PLMN then it is said **Home-PLMN**

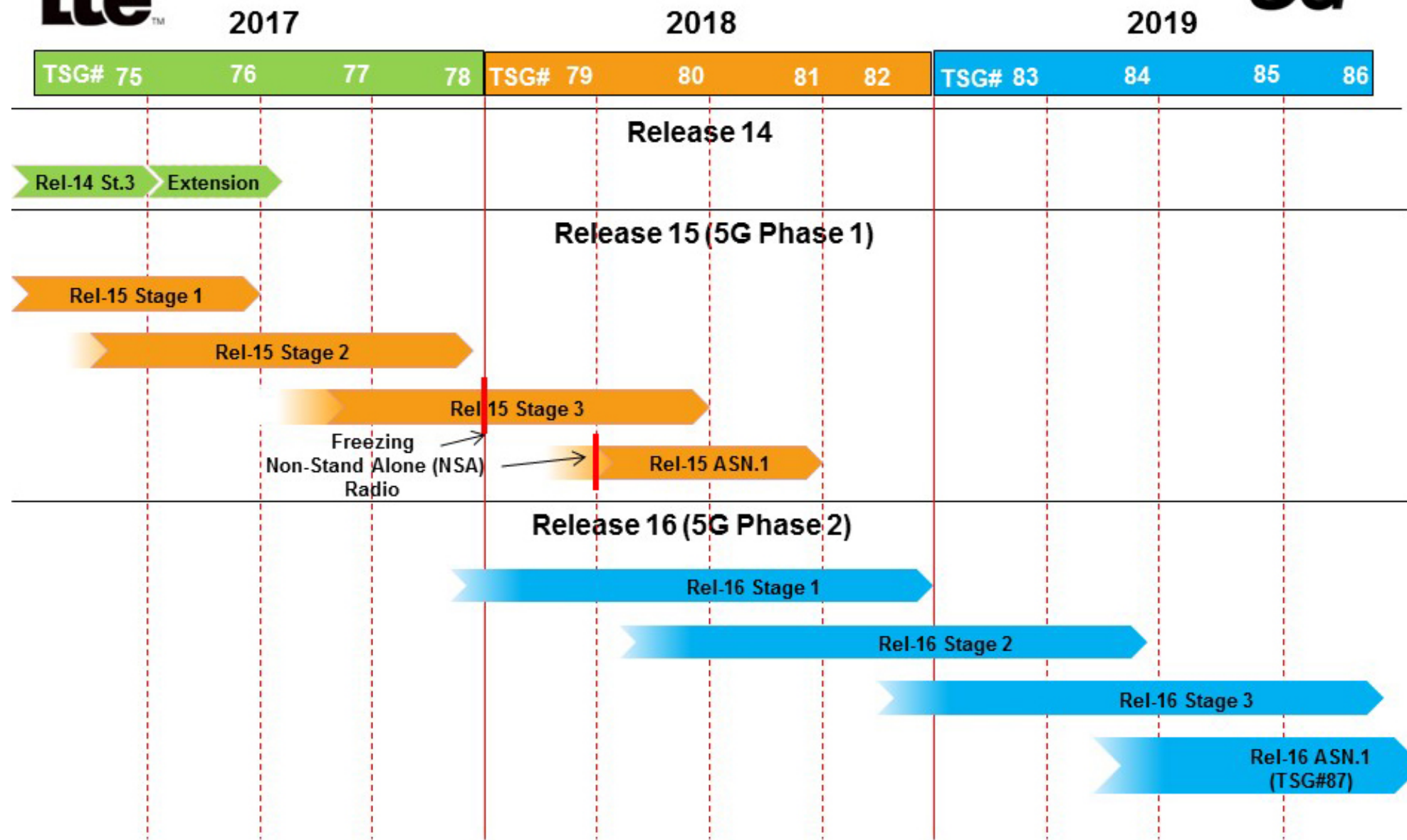
Roaming allows users to move outside their home network and using the resources from other operator's network. This other network is called **Visited-PLMN**.

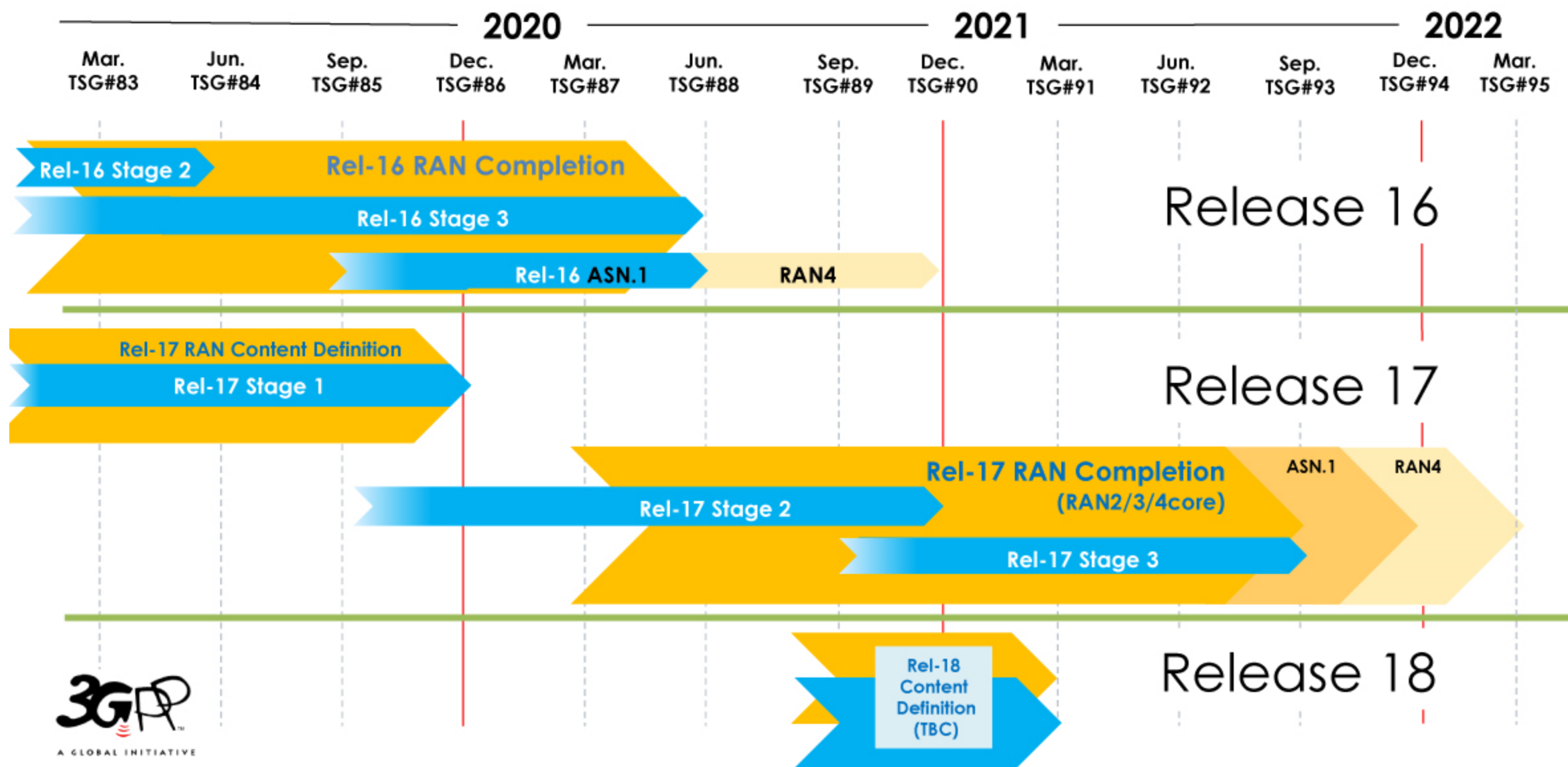
Functional Split



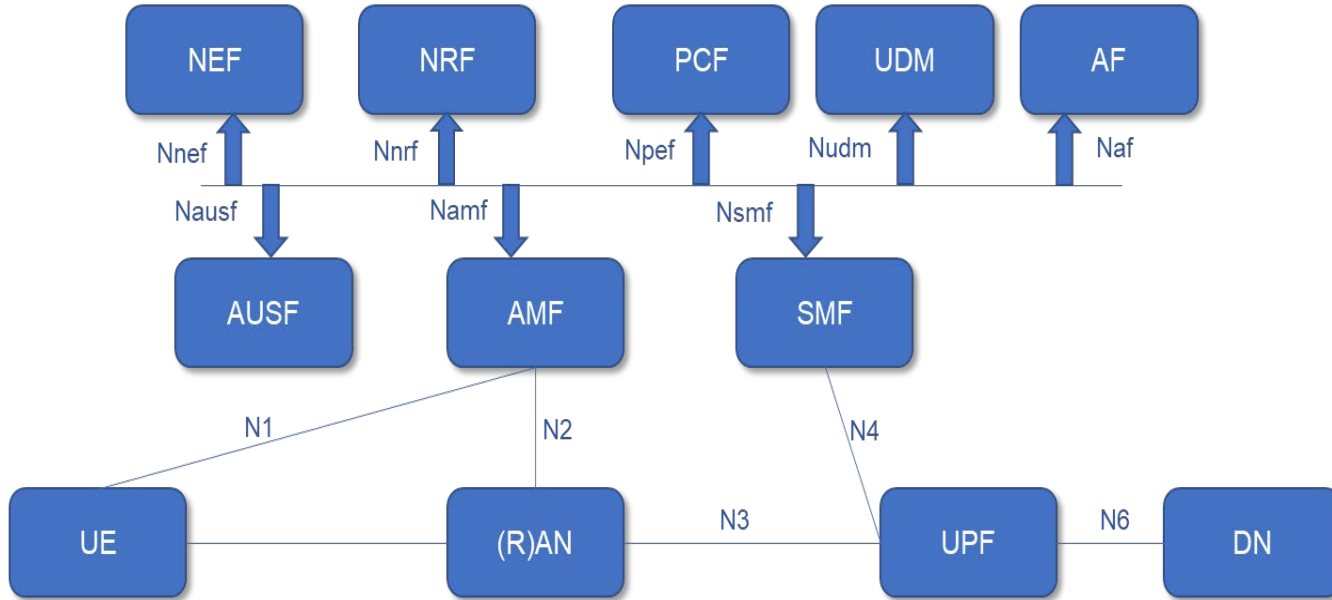
3GPP Releases on 4G

Release Number	Description	Date of Frozen
8	LTE Introduced	2008
9	Enhancement to LTE	2009
10	LTE Advanced	2011
11	Enhancement to LTE Advanced	2012
12	Further enhancement to LTE Advanced	2014
13	Meeting the growing throughput demand	2015
14	Start of 5G	2016





Architecture of 5G Systems



The 5G System (5GS) will have three main components:

- 5G Access Network (5G-AN)
- 5G Core Network (5GC)
- User Equipment (UE)

Authentication Server Function (AUSF)

Core Access and Mobility Management Function (AMF)

Data network (DN)

Network Exposure Function (NEF)

NF Repository Function (NRF)

Policy Control function (PCF)

Session Management Function (SMF)

Unified Data Management (UDM)

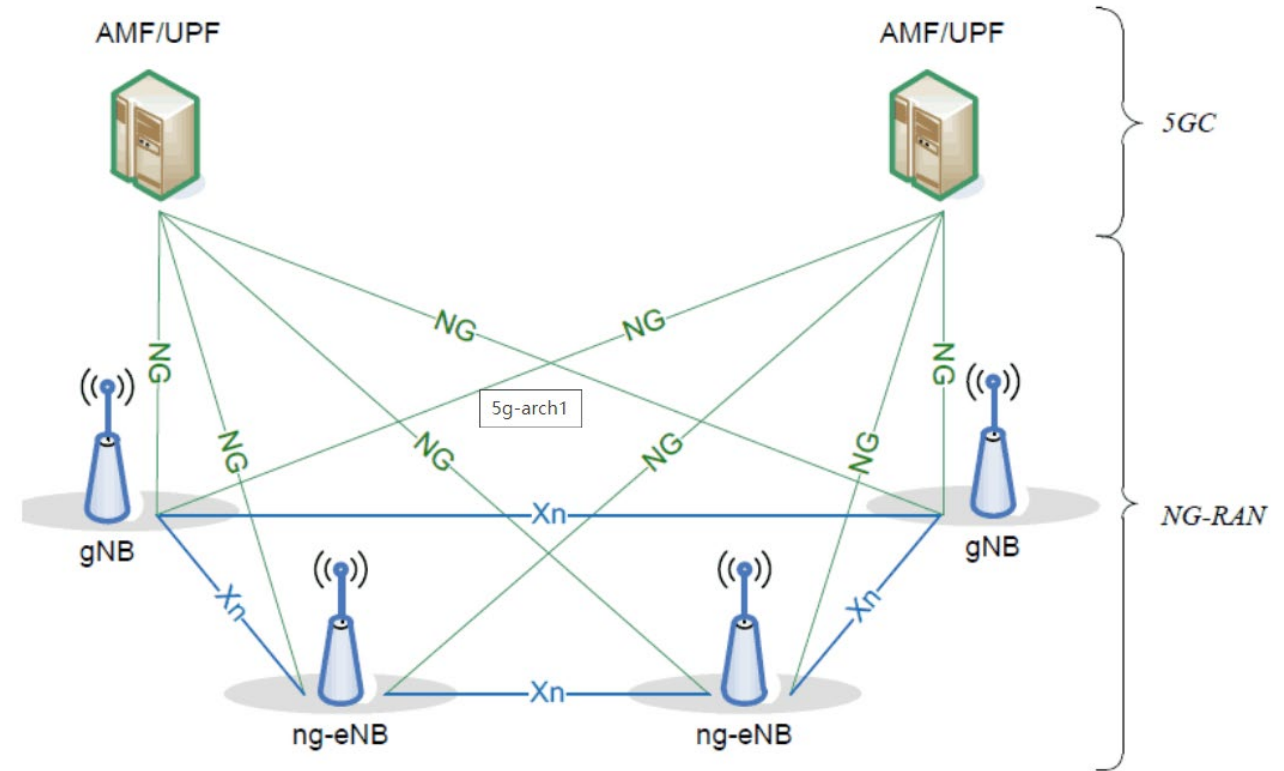
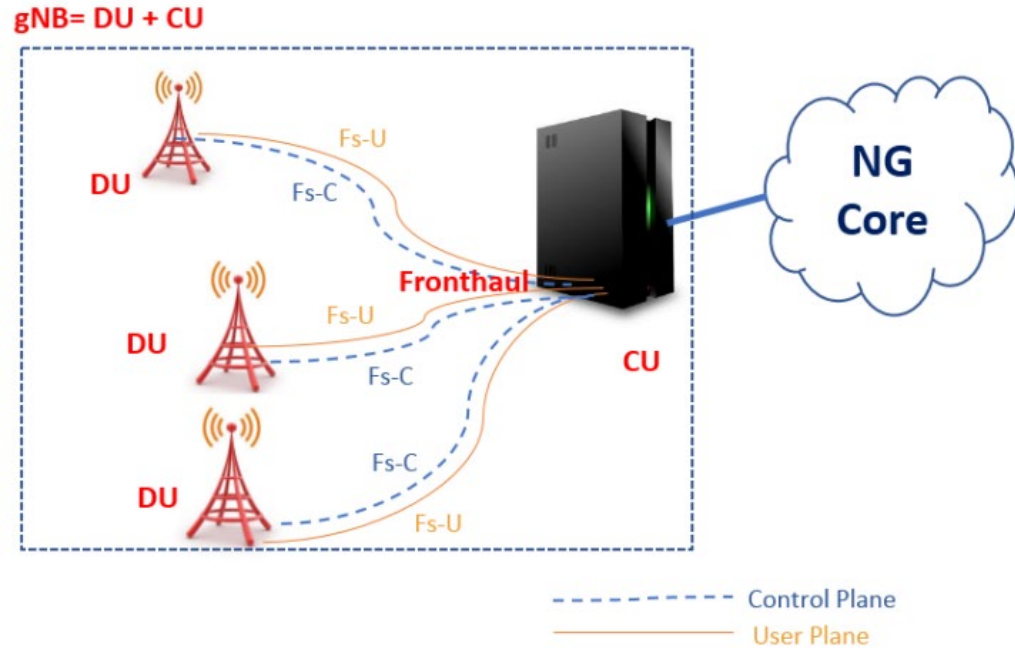
User plane Function (UPF)

Application Function (AF)

User Equipment (UE)

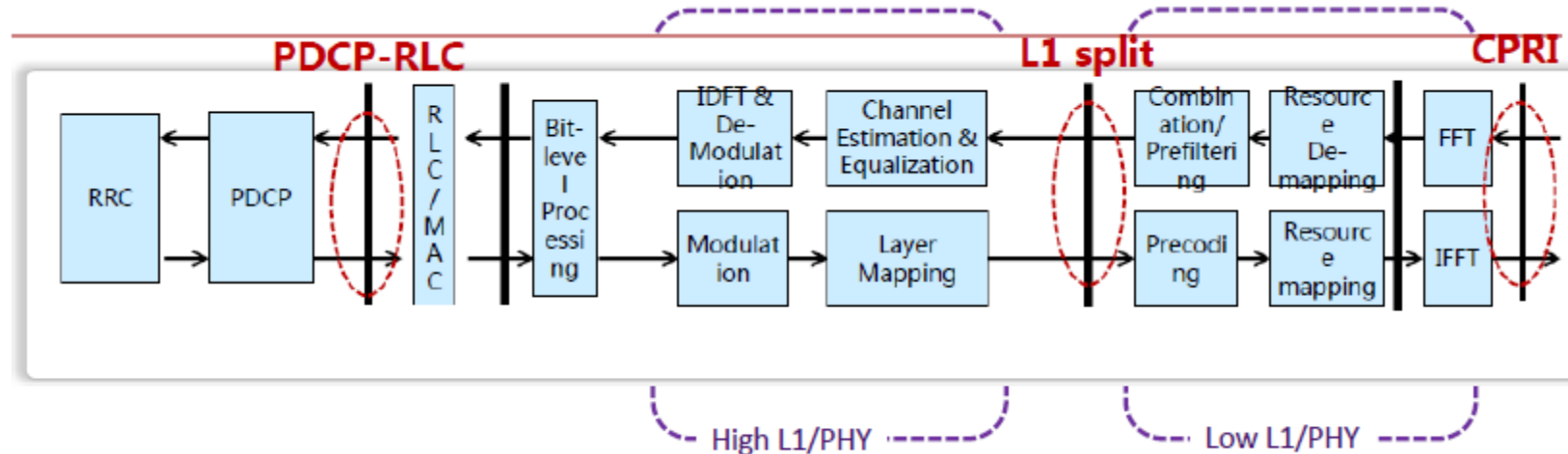
(Radio) Access Network ((R)AN)

5G



Traditional BS is divided into RRH+DU+CU structure

- RRH: Radio transmission and receiving
- DU: baseband close to RRH
- CU: baseband in cloud center



Specification Numbering

- “All 3GPP specifications have a specification number consisting of 4 or 5 digits. (e.g. 09.02 or 29.002).”
- “The first two digits define the series, followed by 2 further digits for the 01 to 13 series or 3 further digits for the 21 to 55 series.”

---<https://www.3gpp.org/specifications/specification-numbering>

- Each specification defines a component of 3GPP systems. With the development of new releases, the specification version will be updated

Spec no.	Title	Rel-12	Rel-13
36.211	Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation	12.9.0	13.5.0
36.321	Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification	12.9.0	13.5.0
36.423	Evolved Universal Terrestrial Radio Access Network (E-UTRAN); X2 Application Protocol (X2AP)	12.9.0	13.6.0

How to find the specification

- Specification Release version matrix:
<http://www.3gpp.org/DynaReport/SpecReleaseMatrix.htm>
- TR: technical report (e.g. TR25.996)
- TS: technical specification
- Locate the specification by number and version

[illegible]

[illegible]

General	Versions	Responsibility	Related	Specification #: 23.501
Release 16 (Spec is UCC for this Release) <div>Latest Remark:</div>				
Meetings	Version	Upload date	Comment	
SA#87-E	16.4.0	2020-03-27	Version updated with TSG SA#8...	
SA#86	16.3.0	2019-12-22	Version updated with TSG SA#8...	
SA#85	16.2.0	2019-09-24	Version updated with TSG SA#8...	
SA#84	16.1.0	2019-06-11	Version updated with TSG SA#8...	
SA#83	16.0.2	2019-04-01	MCC correction swapping claus...	
SA#83	16.0.1	2019-04-01	MCC correction of clause 5.29...	
SA#83	16.0.0	2019-03-28	Rel-16 Version created with T...	
Release 15 (Spec is UCC for this Release) <div>Latest Remark:</div>				
Meetings	Version	Upload date	Comment	
SA#87-E	15.9.0	2020-03-27	Version updated with TSG SA#8...	
SA#86	15.8.0	2019-12-22	Version updated with TSG SA#8...	
SA#85	15.7.0	2019-09-24	Version updated with TSG SA#8...	
SA#84	15.6.0	2019-10-09	Version updated with TSG SA#8...	
SA#83	15.5.0	2019-03-25	Version updated with TSG SA#8...	
SA#82	15.4.0	2018-12-18	Version updated with TSG SA#8...	
SA#81	15.3.0	2018-09-17	Version updated with TSG SA#8...	
SA#80	15.2.0	2018-06-19	Version updated with TSG SA...	

3GPP TS 23.501 V16.4.0 (2020-03)

Technical Specification

**3rd Generation Partnership Project:
Technical Specification Group Services and System Aspects:
System architecture for the 5G System (5GS):
Stage 2
(Release 16)**

