

LTE:

- LTE means that - Long Term Evolution.
- It is a standard for wireless broadband communication for mobile device and data technical.
- It was developed by 3GPP

Architecture:

- UE
- eNodeB
- EPC
 - 1. MME(Mobile management Entity)
 - 2. SGW(Service Gateway)
 - 3. PGW(Packet data network gateway)

Data Rate :

300 mbps download link and 75 mbps uplink

5G Concepts and Overview:

5G is the fifth generation of wireless cellular technology offering faster data speed lower latency(delay).

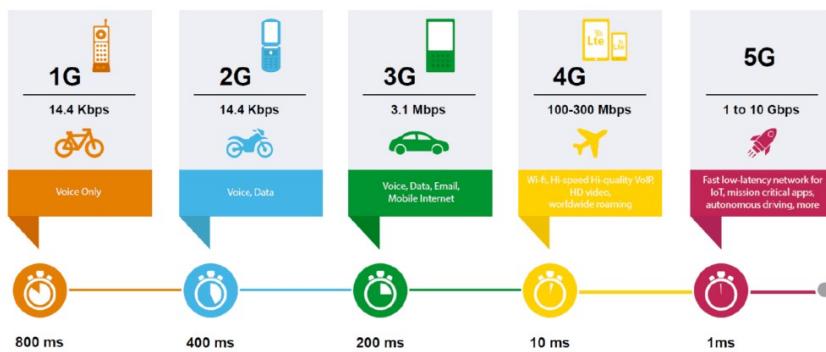
Why Need :

1. Higher Speed : up to 300mbps extend 10Gb/s
2. Ultra Low latency : LTE 300-500ms but 5G 1ms
3. Massive Device Connectivity : LTE support 1000 of device km square but 5g support 1 million device km square.
4. Energy Efficiency
5. Network Slicing :virtual network of same physical machine.

Standardization of 5G :

- ITU-R (international Telecommunication Union)
- Technical specification develop by 3GPP
- 3GPP is the consortium of major Telecom vendor and operator.
- Vendor make the equipment.

EVOLUTION OF 1G TO 5G



3GPP :

3Gpp stands for 3td Generation Partnership Project.

It is a Global group of telecom organization that work together to create technical standards for mobile network – including 2G,3G,4G and 5G

3GPP defines the technical specifications for mobile networks, including radio access, core network, and service capabilities.

5g Architecture :

5G architecture has three main components:

1. UE (User Equipment)
2. NG-RAN(Next Generation-Radio Access Network)
 - Uses 5G NR(New Radio)Technology
 - Based on gNB(Next generation NodeB).
3. 5GC (5G core Network)

What is 5G RAN?

RAN stand for (**Radio Access Network**) In 5G network. The 5G RAN is the part that connects your mobile device to the 5G Core Network.

Key Components:

1. gNB(Next Generation Node B)
2. CU (Central Unit)
3. DU (Distributed Unit)
4. RU (Radio Unit)

Types of RAN in 5G :

1. NG-RAN (Next Generation RAN)
2. C-RAN (Centralized RAN / Cloud RAN)
3. O-RAN (Open RAN)
4. vRAN (Virtualized RAN)
5. DRAN (Distributed RAN)

NG-RAN (Next Generation RAN)

- Standard 5g RAN architecture
 - Uses gNB (Next Gen Node B) split into –
 1. CU (Central Unit)
 2. DU(Distributed Unit)
 - Connect to the 5G core (5GC)
- **AMF : Access and mobility management function** that handle signaling, registration, connection and mobility management
- **UPF : User Plane Function** that manages user data traffic routing.

Types :

NG-RAN two types :

1. **gNB**
 - CU
 - DU
2. **ng-eNB**

CU :

- CU means Central Unit
 - It handles no real function
 - Manages :
 - RRC**
 - Mobility Control**
 - Session Management**
- Connect to the 5G core via the NG interface.

DU :

- DU means that Distributed Unit
 - Handel Real Time Function
 - Manages :
 - MAC :Medium Access Control**
 - RLC : Radio Link Control**
 - PHY : Physical Layer**
- Connect to cu via the F1 interface.

5G Deployment Options

Two main types of 5G deployment:

1. NSA – Non-Standalone 5G
2. SA – Standalone 5G

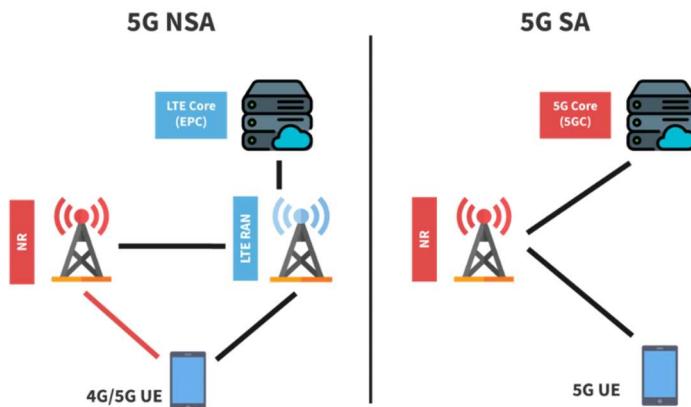
NSA (Non Standalone 5G Architecture):

- Uses 4G and 5G together.
- 4G LTE handles control signals
- 5G is used mainly for faster data.
- Lower Cost
- Quick two easy launch
- Good speed improvement

SA(Standalone 5G Architecture):

- Fully 5G : 5G radio+5G core Network.
- No need for 4G support
- Support advanced features. Like – Network slicing, massive IoT

Feature	NSA (Non-Standalone)	SA (Standalone)
Uses 4G Core	<input checked="" type="checkbox"/> Yes	<input type="checkbox"/> No
Uses 5G Core	<input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes
Speed Improvement	<input checked="" type="checkbox"/> Good	<input checked="" type="checkbox"/> Better
Latency	<input type="checkbox"/> Higher	<input checked="" type="checkbox"/> Lower
Advanced Features	<input type="checkbox"/> Limited	<input checked="" type="checkbox"/> Full Support
Deployment Cost	<input checked="" type="checkbox"/> Lower	<input type="checkbox"/> Higher
Rollout Time	<input checked="" type="checkbox"/> Faster	<input type="checkbox"/> Slower



5G RAN - gNB overview:

It's the 5G base station.

gNodeB (gNB) is the 5G base station that connects User Equipment (UE) to the 5G Core (5GC). It replaces the eNodeB from LTE and supports advanced features like:

- gNB means that (Next Generation Node B)
- it is the 5G base station. Means that it connects user Device (UE) to the 5G core Network.
- It is a part of 5G Radio Access Network(RAN)
- It has 3 parts :
 1. CU (central unit)
 2. DU (distribute unit)
 3. RU (radio unit)

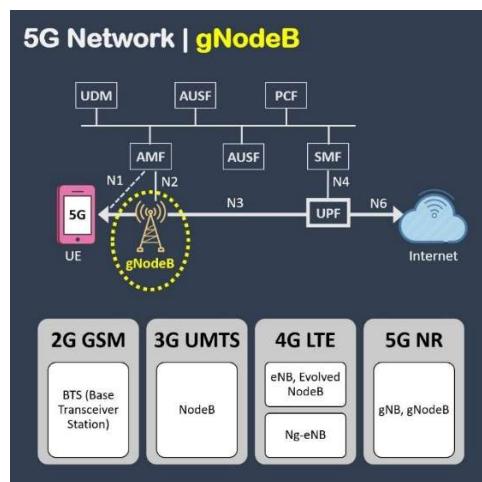
Real-Time Example:

Suppose I am in Kolkata and I used a 5G smartphone and I wanted to watch a 4k video then my smartphone at that time this gNB works like:

1. My phone (UE) sends a request to the nearest 5G tower. This tower is gNB
2. Then (RU) also receives the request and converts the request to digital data.
3. DU also real-time works like error checking and distributes the data.
4. CU also handles the session management and forwards the request to the 5G core Network.

The video data fetched from the internet and passed by to like:

CU → DU → RU



Dual Connectivity (DC) in 5G networks :

Dual Connectivity allows a User Equipment (UE) (like a smartphone) to connect to two different base stations at the same time:

- One is the Master Node (MN).
- The other is the Secondary Node (SN).

This setup improves:

- Data throughput
- Network reliability
- Mobility performance

Types of Dual Connectivity in 5G

1. EN-DC (E-UTRA-NR Dual Connectivity)

- Master Node: LTE eNB
- Secondary Node: 5G gNB
- Used in 5G NSA (Non-Standalone) deployments.

2. NE-DC (NR-E-UTRA Dual Connectivity)

- Master Node: 5G gNB
- Secondary Node: LTE eNB
- Used in 5G SA (Standalone) with LTE fallback.

3. NR-DC (NR-NR Dual Connectivity)

- Master Node: 5G gNB
- Secondary Node: Another 5G gNB
- Used in pure 5G deployments.

L1Bypass Testing (in 5G)

The main motive of this testing without (MAC,RL,PDCP)using the real physical layer L1.

STEP:

1. Disable or bypass L1(Physical Layer)in your test setup.
2. Inject dummy or simulated PHY data to mimic real radio signals.
3. Run tests on L2/L3 Layers(MAC<RLC,PDCP,RRC)
4. Check logs and behavior of upper layer without interface from L1.
5. Yes this method during early development or debugging.

Log Overview (in 5G Testing)

- Collect logs from UE,gNB and core Network.
- Types:
 1. L1 logs : Physical layer (PRB,modulation)
 2. L2,L3 logs : MAC,RLC<PDCP,RRC