A survey on 4G and 5G

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1.ABSTRACT:

We are in the period of 4G/LTE Mobiles and Network since from 2010 to now, and as we are entering to new decade we see new advancement in Artificial Intelligence,Machine Learning, Internet of Things,Robotics etc, and with a many new languages are in a series to know more about it.And in the Telecommunication world, 2020 to 2030 is considered as 5G networking, where the users start utilizing the high speed data.The question that comes in our mind is "Are we ready for 5G?".But as we still under the process of understanding and adopting of 4G this article will brings you a little comparison on both, and leads to "Why 5G" to "Why not 5G".

2.INTRODUCTION

2.1. About 4G/LTE

As the telecommunication moved from 3G to 4G we came up with new term that is LTE which means Long Term Evolution started on 2004 by telecommunication body known as the Third Generation Partnership Project(3GPP).LTE evolved from an earlier 3GPP system known as the Universal Telecommunication System(UMTS), which in turn evolved from the Global System for Mobile Communications(GSM).As there are new applications which requires more mobile data, this motivated 3GPP to work on the Long Term Evolution(LTE) on the way towards fourth-generation mobile.

2.2. About 5G/RAN

Not only the increased bandwidth but 5G came up with many features, it came with innovation of the architecture of Access Network.5G's preliminary job is to transition from a single access service i.e broadband connectivity to a richer collection of edge services and devices.5G is expected to provide support for immersive user interface, and in critical applications like public safety, autonomous vehicles, and the Internet of Things.5G also support swarms of autonomous devices working together on their behalf.This requires fundamentally different edge network.The recent technologies such as Software Defined Networking (SDN) and Network Functions Virtualization (NFV) have made easy to upgrade physical infrastructure. These technology can be used as key components in building architecture of 5G network, and these technologies helps in separating networking into different slices where these slices are used in different cases such as Internet of Things, smartphone applications and intelligent vehicles.SDN and NVF helps to:
> Introduce the network slicing concept, which includes areas of the 5G network in   which   slicing   will   be implemented.
> Understanding of different types of network slice requirements.
> Understanding range of techniques.

Radio Access Network (RAN) is a slicing model by characterising diverse radio resources management (RRM) strategies for multi-service 5G scenarios.Now RAN is the part of a telecommunications system that connects individual devices to other parts of a network through radio connections.RAN resides between user equipments with its core network. Components of the RAN include a base station and antennas that cover a given region depending on their capacity, plus required core network items.

3.   LITERATURE SURVEY

If we see the evolution from 1G to 5G, we have seen major differences, 1G was wireless communication technology came in 1980 and used analog technology where speed was measured in terms of Kbps,2G which used cellular network and efficient use of the radio frequency spectrum enabling more users per frequency band. 3G which emerged from 2000 onwards gave major support for wireless technology, it came up with many advanced technologies like UMTS (Universal Mobile Telecommunications System), GSM (Global System for Mobile),Multiplexing,Broadband,Wifi International Mobile Telecommunication, and a speed of 2Mbps.And many network architectures from 1G to 3G which helped us to understand 4G and 5G.Here are some major points which differentiate 4G and 5G in terms of Speed,Architecture,Packet Processing,Algorithms used.

3.1. Speed

 The bit rate plays an important role in networking, how fast we can send the data and how fast we can download the data is more important.The iPhone 12 delivers 4G LTE at up to 2 Gbps. So we can download and stream high quality

photos and video even faster, and can do it in more places, because iPhone 12 has up to 32 LTE bands.[1]. Where as 5G is designed to deliver a peak data rates up to 20 Gbps of data. Not only in mobiles but in other devices of 5G like industrial machines, IoT, medical applications etc , 5G's performance is 20 times faster than 4G. The following table gives the different devices and respective speeds.

SI.no	Device name	Launched year	4G/5G	Technology used	Speed
1	iPhone 12	13/08/2020	4G	LTE	2 Gbps
2	Realme 8 5G	21/04/2021	4G/5G	GSM/HSPA/LTE	90 Hz
3	Oppo A53s 5G	27/04/2021	4G/5G	LTE/NRNSA	2.2GHz
4	Router JMR540	May 2018	4G	LTE	150Mbps download speed,50Mbps upload speed
5	Airtel E5573CS-609	13/02/2017	4G	LTE	40 Mbps
6	Samsung Galaxy Note 10 5G	August/2019	4G/5G	GSM/CDMA/HSPA/ EVDO/LTE	316Mbps
7	Htc 5G Hub	26/02/2019	5G	LTE/5G NR	20Mbps
8	Google home voice controller	November 2016	4G	MIMO,Voice recognition,Soc,NFC	100Gbps

Table 1, different devices and their speed.

3.2. Architecture

To understand any network and its working first thing we need to do is to, understand its architecture.This section gives the brief discussion on hardware and software structures of 4G and 5G networks and the cost analysis.

3.2.1. 4G Architecture

As we know that 4G network is built on the architecture of LTE (Long Term Evolution).The high-level network architecture of LTE is comprised of following three main components:
- The User Equipment (UE)
- The Evolved UMTS Terrestrial Radio Access Network (E-UTRAN)
- The Evolved Packet Core (EPC)

The interfaces between the different parts of the system are denoted by Uu, S1 and SGi as shown below figure 1.
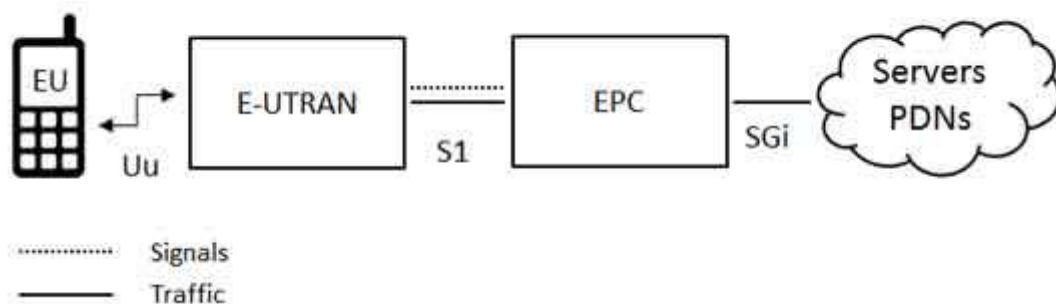

Figure 1. interface between UE,E-UTRAN,EPC

- **The User Equipment (UE)**

It is a User Interface machine which is nothing but a Mobile Equipment (ME). The mobile equipment comprised of the following important modules:

Mobile Termination (MT): This handles all the communication functions.

Terminal Equipment (TE) : This terminates the data streams.

Universal Integrated Circuit Card (UICC) : This is nothing but a SIM,which runs an   application known as the Universal Subscriber Identify Module (USIM).c.

- **The E-UTRAN (Evolved Terrestrial Radio Access Network)**

This is the access network, which uses a flat architecture.The E-UTRAN handles the radio communications between the mobile and the evolved packet core and just has one component, the base stations are called as eNodeB

or eNB.Each eNB is a base station that controls the mobiles in one or more cells.The   communication between base station and mobile is known as serving eNB.

- **The Evolved Packet Core (EPC) (The core network)**
     It includes the components like the Earthquake and Tsunami Warning System(ETWS), the Equipment Identity Register (EIR) and Policy Control and Charging Rules Function (PCRF).

3.2.2. 5G Architecture
     We mentioned earlier that 5G network was developed on the concept called RAN (Radio Access Network), which adopted the concept of network slicing. This RAN slicing technique is based on separation of control and user planes.The proposed architecture is implemented to transmit control data at low frequency and user data at high frequency.Thus the created slices are further divided into control and user plane slices.

5G Mobile Core:
The 5G mobile core, which 3GPP calls the NG-Core, adopts a microservice-like architecture,The viewing the collection of components shown in Figure 2.
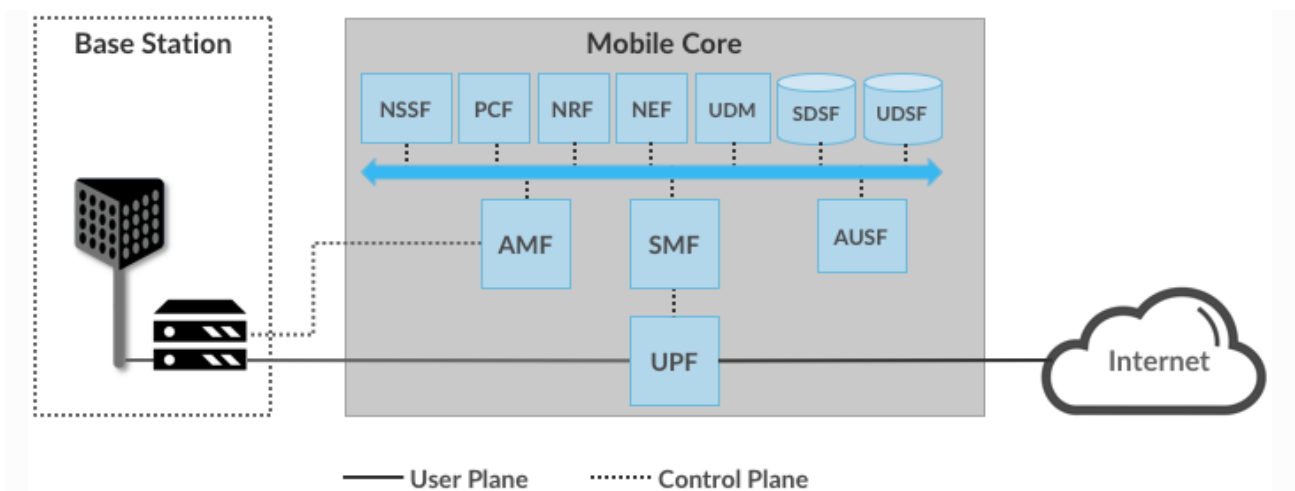

Figure 2. 5G Mobile Core (NG-Core).

It consists of 3 functional blocks
➢   The first group runs in the Control Plane (CP) and has a counterpart in the EPC.
■   AMF (Core and Mobility Management Function)-Responsible for connection and reachability management, mobility management, access authentication and authorization and location services.Manages the mobility related aspects of the EPC's MME.
■   SMF (Session Management Function)-Manages each UE session, including IP address allocation, selection of associated UP function, control aspects of QoS, and control aspects of UP routing.
■   PCF (Policy Control Function)-Manages the policy rules that other CP functions then enforce.Roughly corresponds to the EPC's PCRF.
■   UDM (Unified Data Management)-Manages user identity, including the generation of authentication credentials.Includes part of the functionality in the EPS's HSS
■   AUSF (Authentication Server Function)-Essentially an authentication server. Includes part of the functionality in the EPC's HSS.

➢   The second group also runs in the Control plane (CP) but does not have a direct counterpart in the EPC.
■   SDSF (Structured Data Storage Network Function)-A helper service used to store structured data. Could be implemented by an "SQL Database" in a microservices based system.
■   UDSF(Unstructured Data Storage Network function)-Used to store unstructured data. Could be implemented by a "key/value store" in a micro services based system.
■   NEF (Network Exposure functions)-A means to expose select capabilities to third party services, including translation between internal and external representation for data. Could be implemented in micro services based system.
■   NRF (NF repository Functions)- A means to discover available services. Could be implemented by a "Discovery Service" in a micro service based system.

■   NSSF (Network Slicing Selector Function)-A means to select a Network Slice to serve a given UE.Network slices are essentially a way to partition network resources in order to differentiate service given to different users. It is like key feature of 5G .

➢   The third group includes the one component that runs in the User Plane(UP).
■   UPF (User Plane Function): Forwards traffic between RAN and the Internet, corresponding to the S/PGW combination in EPC. In addition to packet forwarding, it is responsible for policy enforcement, lawful intercept, traffic usage reporting, and QoS policing.

3.3. Packet format
3.3.1. 4G Packet Format:
For transforming of data, LTE uses OFDMA technology, Orthogonal Frequency Division Multiplex is the basic format used and this is modified to provide the multiple access scheme.
LTE data is carried in frames and subframes, which enables the data to be synchronized enabling the radio network to be able to handle the data correctly.There are two types of LTE frame structure:

➢   Type 1: used for the LTE FDD mode systems.

➢   Type 2: used for the LTE TDD systems.

3.3.2. 5G Packet Format

Packet processing in 5G is implemented by the base station.These steps are specified by the 3GPP standard.Figure 3 shows the packet processing, note that the figure depicts the base station as a pipeline (running left to right for packets sent to the UE) but it is equally valid to view it as a protocol stack.Also note that we are agnostic as to how these stages are implemented, but since we are ultimately heading towards a cloud based implementation, we can think of each as corresponding to micro service.
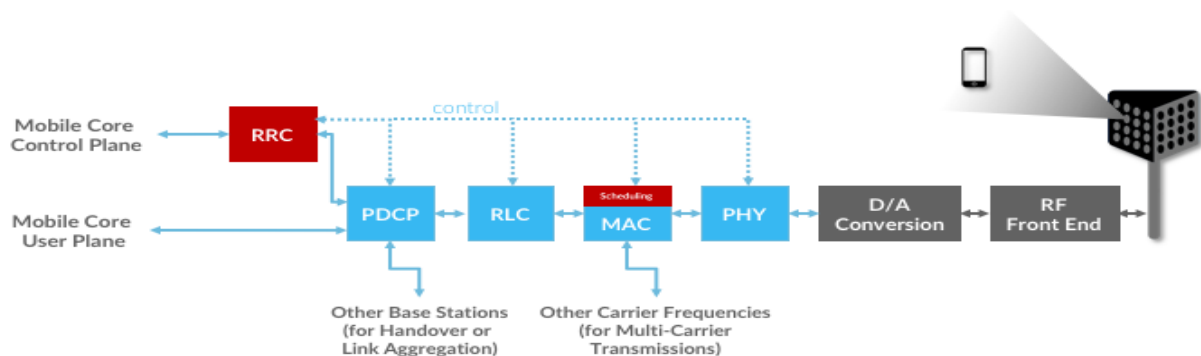

Figure 3. RAN processing pipeline, including both user and control plane components.

The key stages are as follows.
➢   RRC (Radio Resource Control) → Responsible for configuring the coarse-grain and policy-related aspects of the pipeline. The RRC runs in the RAN's control plane; it does not process packets on the user plane.
➢   PDCP (Packet Data Convergence Protocol) → Responsible for compressing and decompressing IP headers, ciphering and integrity protection, and making an "early" forwarding decision (i.e., whether to send the packet down the pipeline to the UE or forward it to another base station).
➢   RLC (Radio Link Control) → Responsible for segmentation and reassembly, including reliably transmitting/receiving segments by implementing a form of ARQ (automatic repeat request).
➢   MAC (Media Access Control) → Responsible for buffering, multiplexing and demultiplexing segments, including all real-time scheduling decisions about what segments are transmitted when. Also able to make a "late" forwarding decision (i.e., to alternative carrier frequencies, including Wi-Fi).
➢   PHY (Physical Layer) → Responsible for coding and modulation (as discussed in an earlier chapter), including FEC.

3.4. Cost Effective
The main objective of this article is to bring out the difference between two network technologies, and how effective we can implement with our current scenarios. This section will give you an rough idea on cost of investment for

these technologies.And we look into certain points where we are lagging behind to adopt 5G.Here we take the two scenarios and discuss our topic based on these.

➢ First 4G 5G router/WiFi that can be implemented in an home or small organization.
➢ Second 4G mobile and 5G mobiles.

3.4.1.Hardware

For a small organization we require a router, there are many routers on the market which offer a wide variety of

features.Table 2 shows few 4G router/wifi, provides to evaluate using the points we have raised above:
5G Router/Wifi/Hotspot

The 2 frequency bands at which WiFi routers transmit signals that are 2.4GHz and 5GHz. If a router can use the 5GHz band, it is called a 5G router.5G routers are mostly dual-band that can operate simultaneously on both bands.5G routers were available in the market for a while.Here are few points that you can consider while purchasing 5G router. Bandwidth,Range and coverage,Congestion and interference,Maximum speed Capacity.
Table 3 shows the few 5G routers that are available in market:

Table 2,4G routers.

Company name	Product Type	Features	Cost
Peplink	Peplink 48 Port SD switch	800W power Balance	$1699
	Pepwave AP One AC mini Wifi	Dual Band 2x2 MIMO 11ac	$149
	Peplink Balance 20Dual Router	WAN router	$299
Cradlepoint	NetCloud IoT Essentials Plan And IBR600c	Router with WiFi(150 Mbps Modem)	46267 rs
	CBA850 CBA850LP6-NA	Cradlepoint Cellular Broadband Adapter, CBA850 with Integrated LTE Adavanced cat 6 modem	55000rs
Cisco	Cisco RV160W VPN Router	4 wireless ports	19000rs
	Cisco Business 240AC Wi-Fi	Access Point 802.11ac 4x4 2 GbE Ports (CBW240AC-B)	15754 rs
Airtel	B310S 927 4G3G2G Sim Based Home Internet ROUTER With WiFi	Router and WIFI	4650rs
	Airtel AMF-311WW Data Card,4g Hotspot	Data Card, 4g hotspot	2199rs
Jio	JIO Reliance	4G USB Portable Router	6000rs
	JioFi JDR740 (Dongle)	150Mbps Wireless 4G Portable Router	3999rs

Table 3, 5G routers.

Company name	Product Type	Features	Cost
Huawei 5G CPE Pro	Router	Powered by Balong 5000,The HUAWEI 5G CPE Pro supports both 4G/5G networks and fix-line networks.It enables a more stable and faster Wi-Fi connection, allowing one to stream a 4K video without lag.	$518.64
MiAIoT Router AX3600	Router	The Mi AIoT Router AX3600 offers two bands of 2.4GHz and 5GHz,each with 802.11ax technology and no mutual interference,dual-band wireless speed of up to 2976Mbps.The 2.4GHz frequency band is associated with longer transmission.	$98.93
TP-Link Archer	C6 Gigabit MU-MIMO Wireless Router	Powered by 802.11ac Wi-Fi technology,the Archer C6 offers both the GHz bands of 2.4 GHz and 5GHz, bands.The 2.4GHz band delivers speeds up to 300Mbps, while the 5GHz band delivers speeds up to 867Mbps.The bands provide a combined speed of 1200Mbps.This router contains 5 high-performance antennas- 4 external antennas and 1 internal antenna for WiFi coverage throughout the home. It has 128Mb of RAM and 5 Ethernet ports.	$32.88

 The following developments have taken place in India on the 5G front:
1. Indian telecommunication firm Bharti Airtel,announced a strategic partnership with IT services from Tata Consultancy Services(TCS) for implementing 5G broadband network solutions in India.Tata Group has developed a 'state-of-the-art' O-RAN(Open Radio Access Network) based Radio and NSA/SA Core and has integrated a totally indigenous telecom stackThis will be available for commercial development starting January 2022.

2. Samsung's connected technology solutions provider Harman it has started 5G testing lab in India to help companies test their devices for operating them on the next generation network.

3. BSNL has signed an MoU with Ciena to conduct field trials with the goal of a commercial launch by 2020.Ciena and BSNL intend to jointly evaluate fronthaul, midhaul and backhaul transport-based use cases and scenarios to address resilience requirements and latency concerns.
4.	Vodafone Idea(Vi) will collaborate with Cisco to improve its existing 4G network and, in the future,5G use cases for offering better quality experience for its customers.The company announced that it would work with Cisco to design and build a cost-efficient network architecture to drive greater speed to market as it taps opportunities in 4G, 5G, Cloud, and IoT.

3.4.1.Disadvantages
Here are few disadvantages of 5G
1.	**Proximity**: 5G will primarily use millimeter wavelengths, which are smaller than 3G and 4G, and they don't travel as far.To combat this limitations, carriers are planning a much larger array of antennas to provide enough coverage.

**2.	Spectrum and bandwidth:**Spectrum will be a key consideration in choosing both carriers and equipment.Much of the 5G deployment will be over existing 3G and 4G spectrum, enabling backward compatibility with older devices.

3.	**Rural and remote locations:**Rural and remote locations probably won't have 5G service until well after most urban build outs have been completed.

4.Battery Drain on Devices: When it comes to cellular devices connected to 5G, it seems the batteries are not able to operate for a significant period of time.

5.Detracting From the Aesthetics: The erection of more cellphone towers, or extension of existing cellphone towers, is not welcomed by most communities because they are seen to diminish the overall look and feel of an area. With 5G, there

is going to be a need for increased infrastructure development, which won't necessarily be seen as a good thing for local residents.

6.Initial costs for Rollout are high: The costs related to the development of 5G infrastructure or adaptations to existing cellular infrastructure will be high,and it's likely the customers will bare the brunt of these big price tags. Cellular operators are looking to minimise these costs by exploring alternative options in the form of network sharing.

4.CONCLUSION

Before you plan to buy a 5G router, it is always better to know if your device will be able to support it or not as buying will no longer be beneficial if compatibility lacks. To work with a 5G router, you will need to have a computer with a Wi-Fi adaptor that is capable of transmit the 5Ghz band.Buying products that support upcoming technological advancement is always a better option.

With the advancement of science and technology, 5G can bring a new revolution to the human lifestyle. We can hope for better connectivity, better interaction, more cooperation, better access to information, faster sharing of information, more privacy of data, and so on. If the implementation of 5G is done correctly, it can benefit many industries considering both its pros and cons. With the development of modern, fast, cost-effective, and reliable routers, 5G looks promising shortly.

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