A Survey- Resources Management in 5G Mobile Networks

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Abstract

The network has various issues as a consequence of increased network traffic as a result of employing packet switching instead of circuit switching, which has a constant data rate, a large number of connected devices, and advancement of application services (download, upload, streaming, you tube, etc.). Efficiency resource management entails not only defining the present network design and technology, but also preparing for 5G. There is a link between the mobile business and the internet; how can LTE reach everything, and how many bytes/months of internet because there are so many applications, such as "immersive multimedia experience," that require high data rates and low latency. Many technologies, such as multiple-input multiple-output (MIMO), software-defined networking (SDN), edge computing, network functions virtualization (NFV), millimeter-wave, and others, have been proposed to address some of 5G's issues. This research, based on the magazine "The international journal of intelligent engineering and systems," focuses on resource allocation difficulties in 5G core networks and radio access networks. It is this that has prompted us to look at the most efficient way to manage the resources of fifth-generation mobile networks.

Keywords- Resource Management, 5G RAN Techniques, Cloud Computing, Edge Computing, Network Slicing, 5G.

I. INTRODUCTION

Many countries employ 4G to meet their needs, prompting the question, "Why do we need 5G?" If we wish to connect the entire planet, 3GPP (The 3rd Generation Partnership Project) has developed 5G standards based on three use cases for 5G applications.

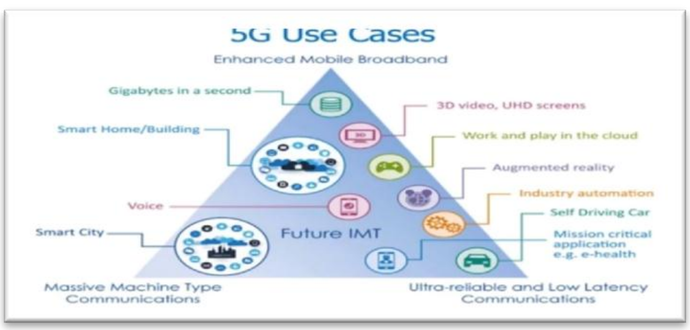

Fig .1 : 5G use cases

including enhanced mobile broadband (eMBB), which supports high data rates of up to 20 MBPS and throughput (5-10 GBPS), massive machine type communications (mMTC), which communicates a large number of devices such as smart cities, and ultra-reliable low-latency communications (URLLC), which supports QOS (quality of service) and availability of 99.999 percent (we know the availability mean from previous generations is the base station is still available 99.999 percent).

I. IDENTIFY, RESEARCH AND COLLECT IDEA

The European Telecommunications Standards Institute (ETSI) define the requirements of 5G .

1. Peak data rate : the throughput must up to 20 Gb/S.
2. User experienced data rate : even when walk or moving up to 100 Mb/S.

3. Spectrum efficiency: enhancement for usage to the spectrum up to 3X more bits/HZ ,by using some techniques such as (advanced antenna technique).
4. Mobility: achieve mobility up to 500KM/H.
5. Latency : reduce latency to 1 ms.
6. Connection density : more effiecient signaling up to 10^6 devices/KM^2.
7. Network energy efficiency : reduce the energy consumption.
8. Area traffic capacity : must the capacity up to 10 Mb/S/m^2 , by support the traffic for example smaa cells.

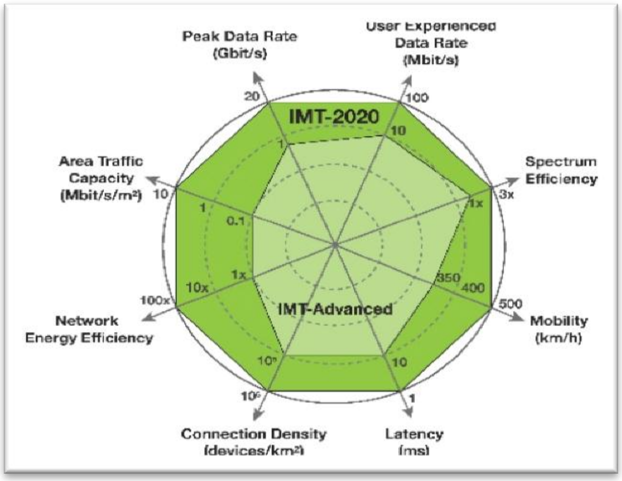

Fig .2 : 5G requirements

The requirements that must be met in 5G are represented by the spider diagram above from 3GPP[3].To reduce overloading on core network equipment, we must identify relationships between needs and use cases, taking into account that not all requirements must be included in the weighting factor. The figure below shows how the 3GPP represents the importance of essential capabilities in various usage scenarios.

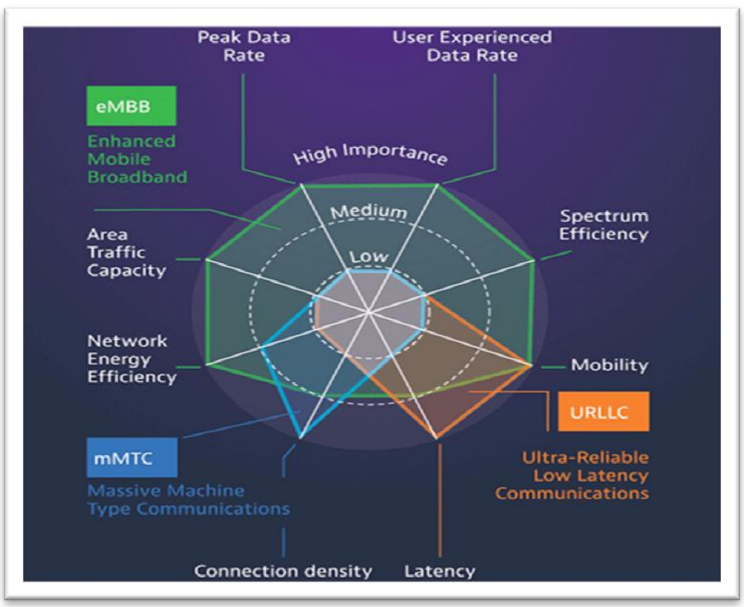

Fig .3 : importance of key capabilities in different usage scenarios

For example of the use case of URLLC is connected cars.

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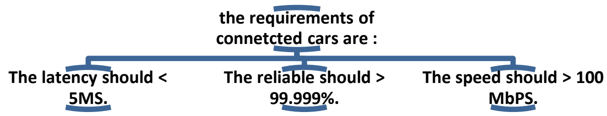
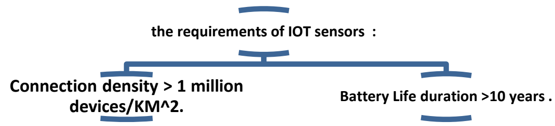


Another example of case mMTC is IOT sensors [4,5]



2. what is 5G new radio (NR) ?

In simple terms, NR stands for new radio access technology (RAT), which refers to new access technology between a mobile device and a base station. Another component is the air interface, which was developed by the 3GPP for the 5G (fifth generation) mobile network and is intended to be the global standard for the air interface of 5G networks.5G New Ran employs modulation, wave propagation, and access techniques to enable the system to meet the demands of high data rate services, those requiring low latency, moderate data rates, and long battery lifetimes, among others. NR will support three 5G use cases, assigning QOS to each one via a slicing method that will be explained later [4.5.6].

The 3GPP defined some requirements for the 5G NEW RADIO VISION, including support for a variety of services (enhanced mobile broadband, massive internet of things, and massive-critical services), as well as dealing with different spectrum bands (low bands, mid bands, and high bands), with the mid band not being used in 4G and the high band reaching up to 24 GH, and finally, support for a variety of deployments (mobile, small cells , indoor that need massive IOT , macro that need spectrum).

New Ran offers advantages over LTE. Among the most important are:

- ✓ HIGHER – FREQUENCY BANDS are a way to get more spectrum to accommodate very wide transmission bandwidths and high data rates.
- ✓ To improve network energy performance and reduce interference, use ULTRA – LEAN DESIGN.
- ✓ LOW LATENCY to boost performance and open up new possibilities.
- ✓ A BEAM-CENTRIC DESIGN that allows for broad beam formation and a large number of antenna elements not just for data transmission (which is possible in LTE to some extent), but also for control-plane procedures like initial access[7].

5G NEW RADIO RELEASE 15 TIME PLANE

In general, like 3G and 4G, 5G includes releases in the 3GPP ranging from 15 to 18. Right now, we're focusing on release 15 to cover the first phase of deployment in all nations that use 5G. With this version, data rates increased while latency reduced.

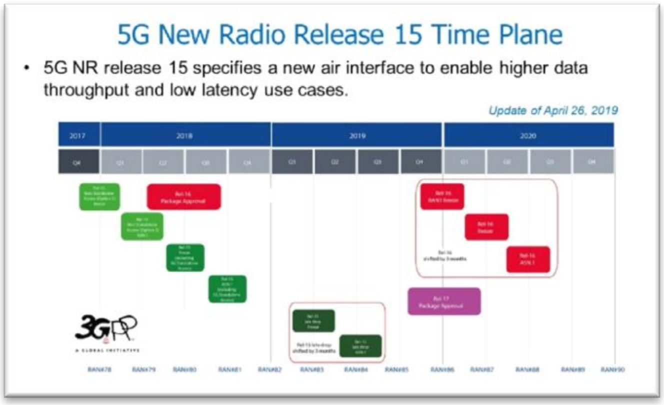
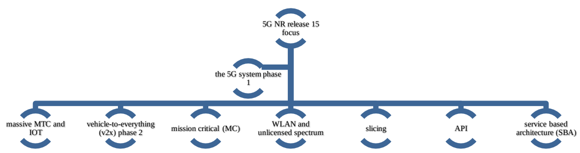
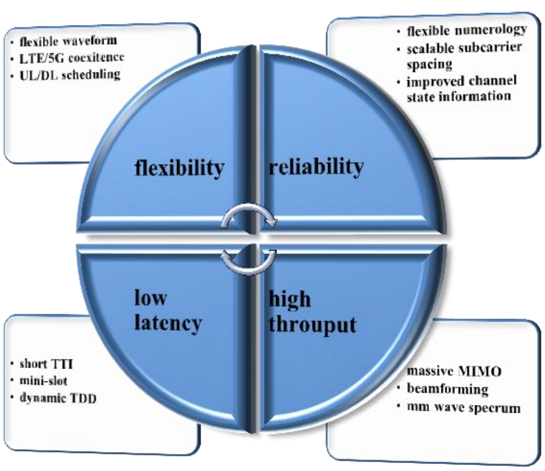


Fig .4 : 5G NEW RADIO RELEASE 15 TIME PLANE

Each release has a work plane manager that specifies which work items the release is responsible for[8,9].



The primary characteristics of 5G NR are that it focuses on the technology that covers the air interface as the first layer of the IOS (physical layer).



3. 5G spectrum

When 5G becomes available to the general public in any country, why do some countries refuse to use it? What is the difference between 5G and 4G, 3G spectrum? 5G can provide some services not found in LTE, not only faster than 4G of about 1G even in case of mobility, but also a new paradigm of low latency in case of data travel from mobile to mobile about 4MS or radia latency (URLLC) about 1MS, and excellent reliability means the signal still connectivity (availability about 99.999 percent), all of these services lead us to ask how to choose frequencies that are appropriate for [10-11].

The answer is to understand the multi-layer spectrum, which achieves the following goal:

- ✓ The COVERAGE LAYER in this target spectrum provides coverage of up to 1KM but not high data rates.
- ✓ In this objective, the COVERAGE & CAPACITY LAYER provides both data rate and speed; the appropriate broadband is 3.5 GHz, also known as sitizien broadband, which provides a balance of coverage and capacity when used.

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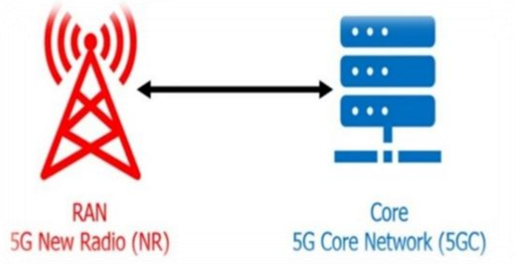
- ✓ CAPACITY LAYER with bandwidth up to 400 MHZ covers small areas such as malls, VIP areas, and hotels.

4. 5G Network Deployment Options



Unlike previous generations, which required both access and core network matching within the same generation to be adaptable, 5G allows for the integration of pieces from many generations and configurations [12,13].

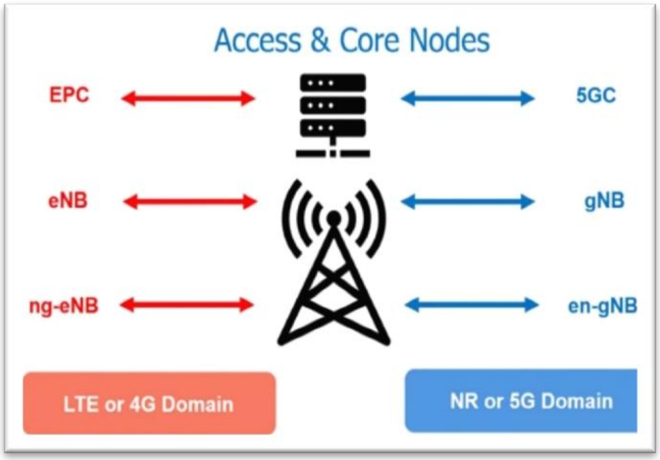
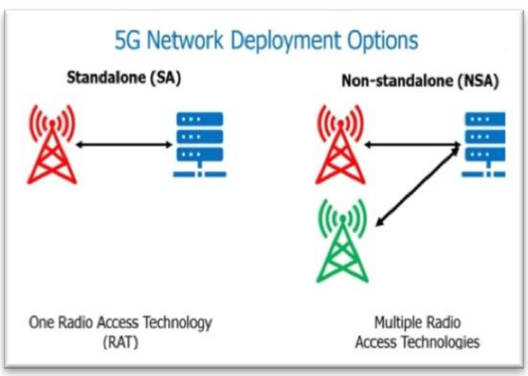


Fig .5 :4G, 5G access & core nodes

There are two deployment options available:

SA (stand - alone) :that contain one radio access technology .

NSA (non- stand - alone) : this option is duel connectivity that contain two or more radio access technology , one of them called master node that control the signal level to the mobile and the other just for data.



Below different type of options (SA, NSA) that combine access and core node from 4G (LTE) & 5G (NR) [14,15].

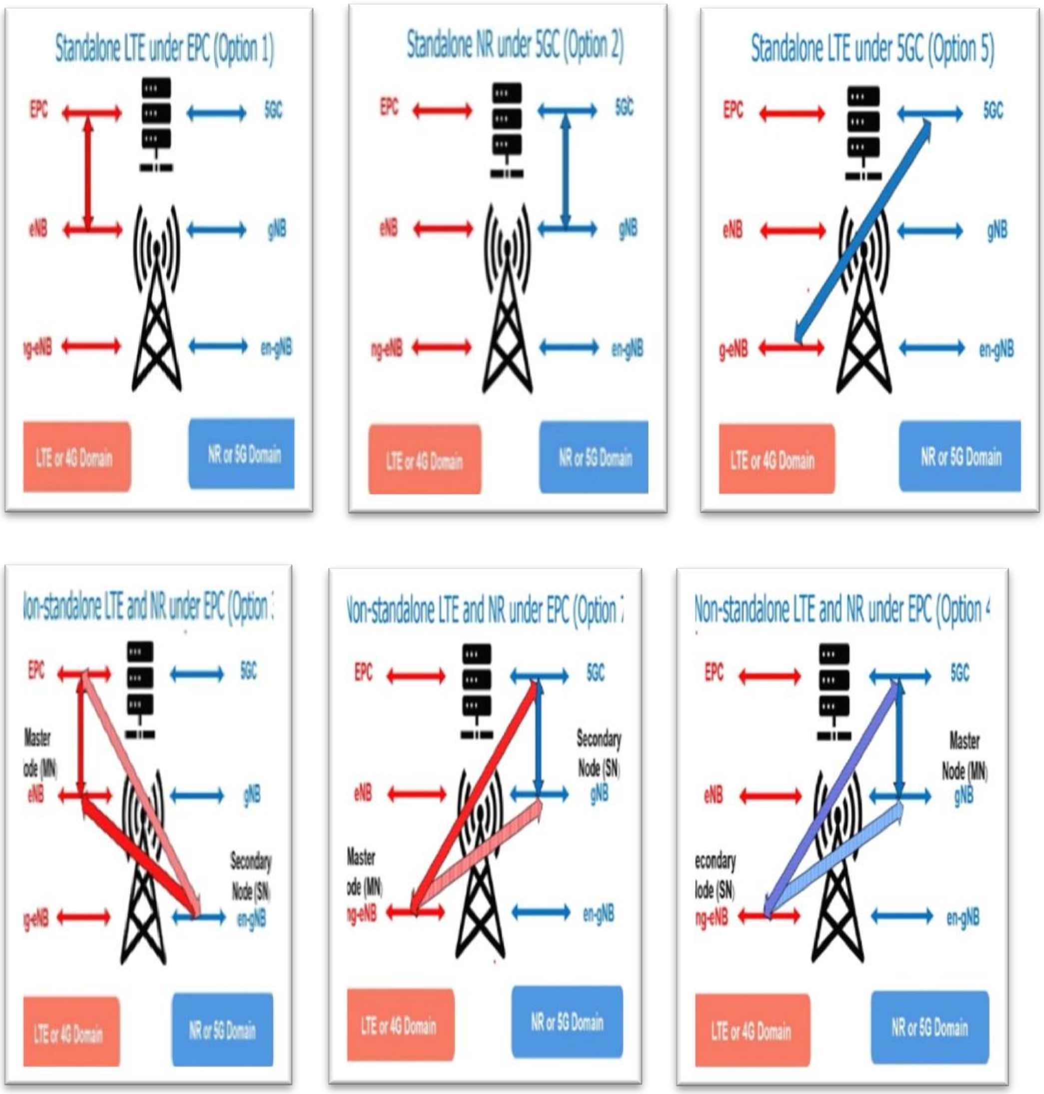
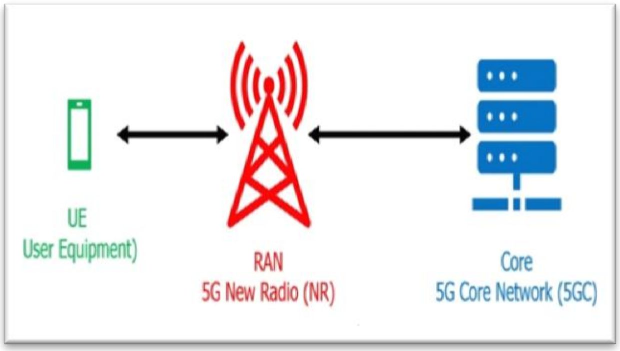


Fig .6 : types of options (SA, NSA) that combine access and core node from 4G (LTE) & 5G (NR).

The most important options from above is NSA LTE & NR under EPC (optin 3) because the start of build most network with this option , use of EPC & eNB instead of 5GC reduce the network cost also increased throughput of the network because of double connectivity [16,17].

5. 5G network architecture .

The 5G system (5GS) includes core network (CN), the 5G access network (AN) and the user equipment (UE)



The core network of 5G is different from core network in 4G,3G, 3GPP defined two forms of 5G network [18] :

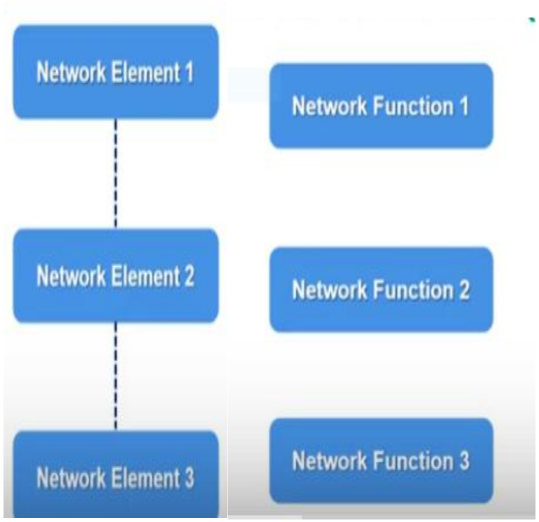


Fig .7 : The core network of 5G is different from core network in 4G,3G.

The signaling between two network elements differs from the signaling between two other elements in the reference point architecture, ensuring complete procedures for that interface. The architecture below explains the nodes and the interfaces between them, which will be explained in detail later. Note AMF (access and mobility function), which performs the same functions as MME in 4G, such as non-access treatment signaling, security, and authentication [19,20].

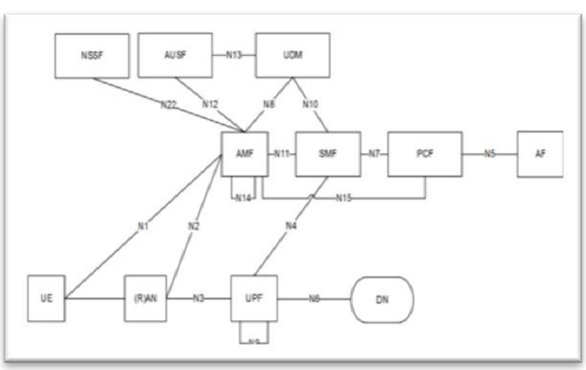


Fig .8: **reference point architecture**

On the other hand, in service-based architecture (SBA), there is what is known as (CUPS) – control and user plane separation, which divides the product into groups of independent services that communicate with one another through a common bus to avoid bottlenecks. As a result, each node has a function that requests a service from any other node, and there is also an SMF (session manage function) that performs the same functions as MME in 4G. The most important interface is N3 [21].

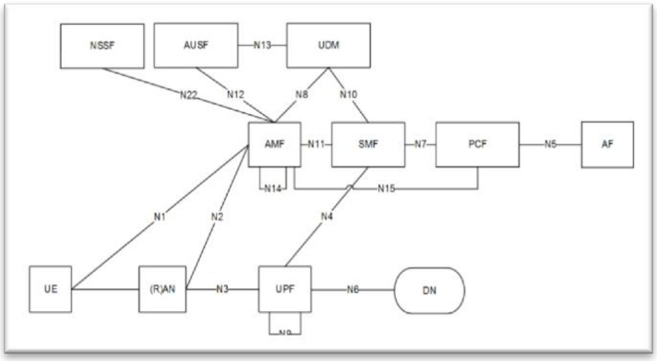
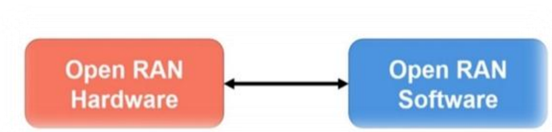


Fig .9: service based architecture

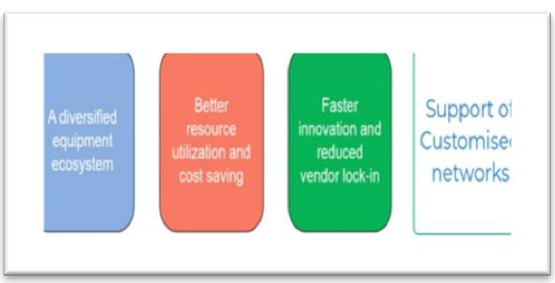
5G networks are more flexible, adaptive, and responsive, improving the level of business MNOs do with each customer. They also support many use cases such as eMBB, m IOT, and URLLC .

6. open RAN

In general, openness means first disaggregating the hardware from the software, then assigning a vendor to each of them, and finally breaking the hardware down into discrete pieces with specific purposes that communicate with one another over open interfaces [22].The open RAN idea entails constructing networks with equipment that separates vendor-specific software and hardware from the vast bulk of radio access network (RAN) equipment.According to the total cost of ownership (TCO) of a network, the RAN accounts for 65 percent of the total, therefore the open RAN is appropriate for maximizing network performance since it runs RAN software on commercial off-the-shelf hardware (COTS) [23,24] .



Open RAN that have many benefits of using it :



- ✓ According to statistics from three manufacturers (Erricson, Huwawi, and Nokia), open RAN helps to integrate new vendors into the core in 80 percent of 5G networks.
- ✓ We can save costs by using open RAN and cloud architecture to better utilize resources.
- ✓ Limit the risk by using the right remedy.
- ✓ Getting the vendor to lower the solution limit.

7. **Multi –Antenna technique**

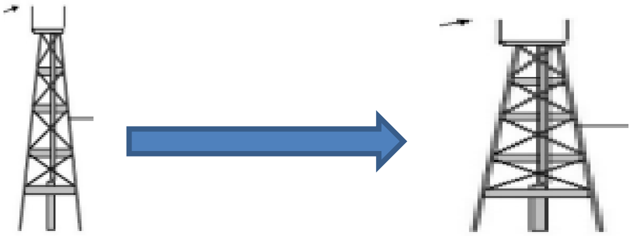
Many techniques are described below, along with their design and how they affect 5G networks:

1- SISO is a multi-antenna technology that uses only one antenna for transmitting and only one antenna for receiving data. It was first used in WIFI and radio broadcasting.

Shanon's LAW is a well-known equation in telecommunications for calculating capacity.

C= B (1 + S /N)

Bandwidth (B)
S: signal
N:noise



Transmit_antanna receiver _ antanna

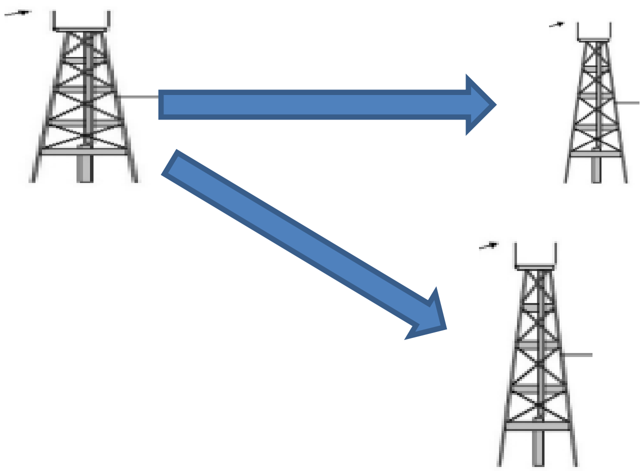
2- SIMO is a multi-antenna technique in which one antenna is used for transmitting and two antennas are used for receiving to improve receive diversity. This technique is superior to SISO in terms of reliability and error rate control, and it is used in some mobile phones.

C = M * B (1 + S / N)

Bandwidth (B)

S : signal

N: noise Mt : no. of receiver antanna



Transmit_antanna receiver _ antanna

3- MISO is a multi-antenna approach that uses two or more antennas for transmitting and one antenna for receiving to improve transmit diversity. This technology is superior to SISO and is used in some digital television.

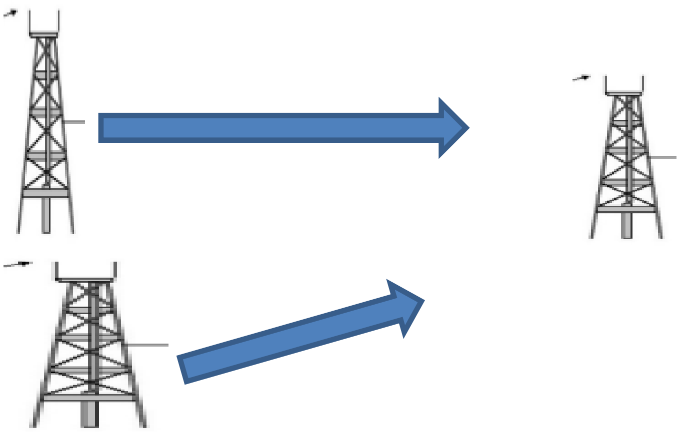
C = Mt * B (1 + S / N)

Bandwidth (B)

S: signal

N: noise

Mt: total number of transmit antanna



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4- MIMO (Massive MIMO) is a multi-antenna technique in which two or more antennas are used for transmitting and two or more antennas are used for receiving to enhance capacity by transmitting and receiving multiple data streams in one second. It is used in LAN, WAN, 4G, and 5G.

Mt * Mc * B (1 + S / N) = C
B: bandwidth Mt: number of transmit antennas
antanna: number of receivers
S: signal
N: noise

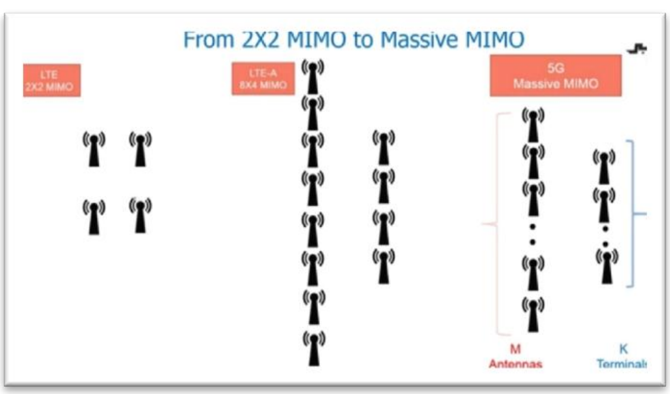
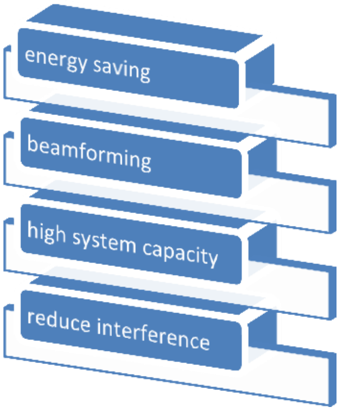


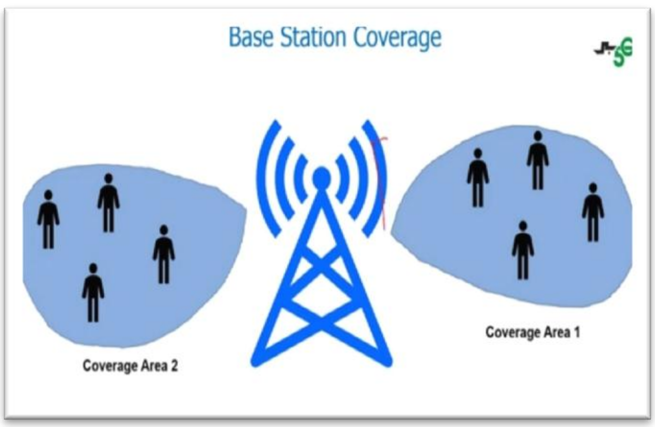
Fig .10: Massive MIMO

Massive MIMO benefits include the following [24,25]:



7.1 beam forming

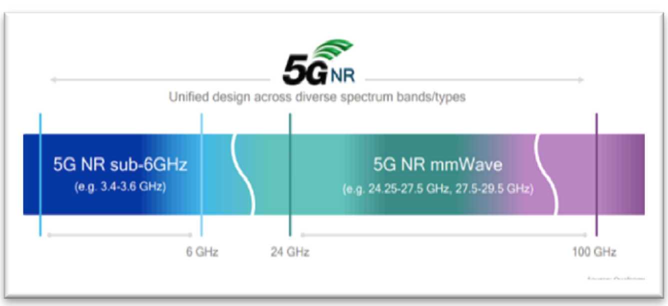
5- Persons in the coverage region of each site enjoy acceptable service; otherwise, people outside the coverage area must travel to another site or alter the direction of the antenna, which is not a feasible solution. This is the case in 1G, 2G, 3G, and 4G [26].



The millimeter wave spectrum is a significant driver of 5G because of its high BW, yet mmWAVE propagation is challenging.

$$\lambda=\frac{c}{f}$$

in 5G using massive MIMO is good with drawback of limited coverage ,to solve this limitation we can use many site but is more cost therefore the solution is to use distributed antenna (coverage to beam).



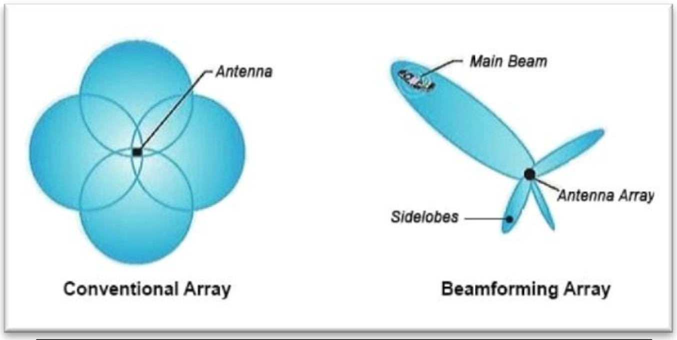


Fig .11: **beam forming**

Instead of broadcasting in multiple directions at once, beam shaping allows for a focussed signal beam exclusively in the direction of a user.

Fig .12: 8T8R antenna

When the number of antennas is increased, the phase shifter and implemented become constructive, and we can also alter the direction of the antenna by stearing it.

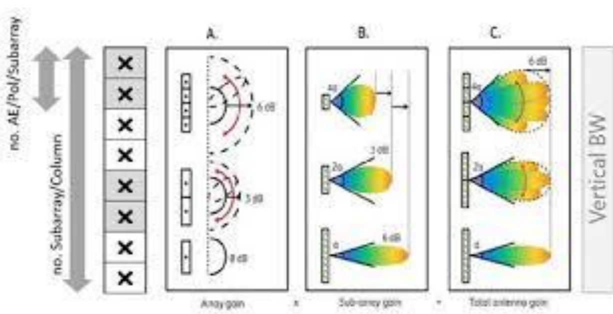


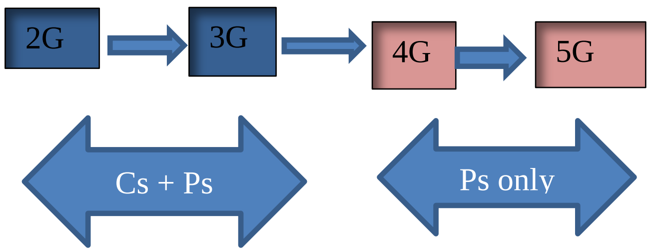
Fig .13: **beamforming stearing**

All broadcast channels (FCCH (frequency correction channel), SCH (synchronization channel), and BCCH (broadcast control channel) support beam formation, with up to 8 beams possible if the B.W is between 3-6 GHz.If we employ vertical beam formation in front of a tall building, we can direct the beam to any place in the structure [27,28,29].

8. voice over 5G NR

What happens in the network as the number of mobile phones grows?

Many operators are cunsetting aging 3G/2G networks as rapidly as possible to make spectrum available for 4G/5G due to new use cases and greater capacity requirements on 4G/5G networks.



The difference in voice in 2G/3G networks is that in 2G, the MSC (mobile switching center) handles CS (circuit switching) and the SGN (serving GPRS node) handles PS (packet switching), whereas in 4G/5G networks, the IMS (IP multimedia subsystem) handles PS and there is no CS to support VOLTE service, however, because there is no IMS in the network, cs fallback occurs, in case of lock fallback to2G,3G [30,31] .

This summarizes the differences in voice services overview by HUAWEI to explain the two portions of the network, one of which is supported by EPC and the other by 5GC and introduces 5G alternatives.

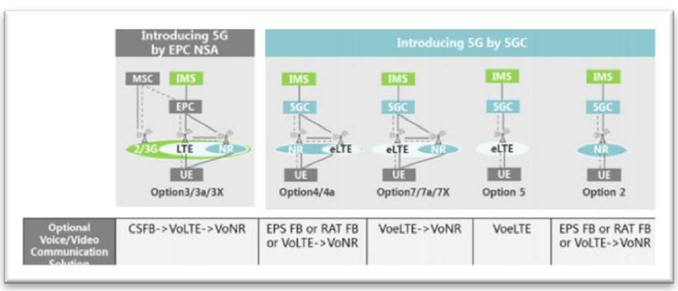
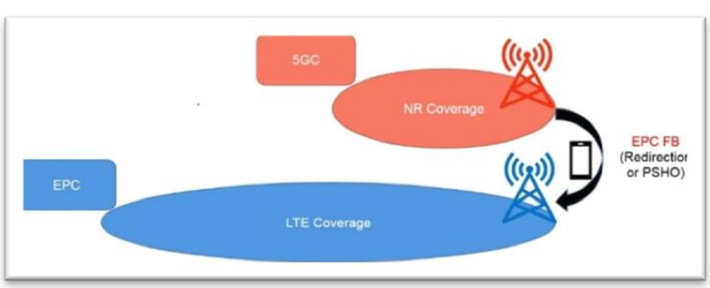


Fig .14: voice services

The voice service is carried on the gNB, as indicated by VONR.

When the gNB starts an IMS voice/video communication channel on the NR network and the mobile moves out of the service area, a handover is triggered [32].



In NSA, there are two deployment choices for 5G voice solutions: early deployment or 5G, NSA, options 3/3a/3x.The only voice solution is VOLTE / CSFB, which has the capability of supporting 2G/3G if in the network [33,34].

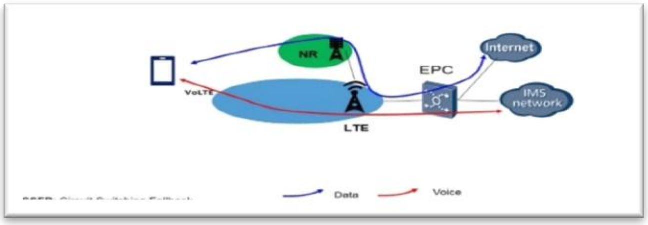


Fig .15: voice services VOLTE

If customers call in NR coverage zones, calls are processed by g node B in accordance with the VONR solution.

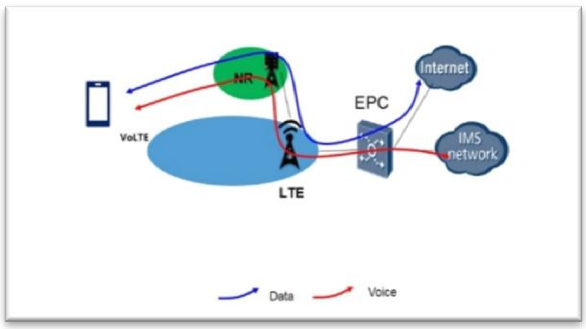


Fig .16: voice services VONR

In 5G SA (standalone), there are two options to support voice services:

- VONR.
- Fallback to EPS.

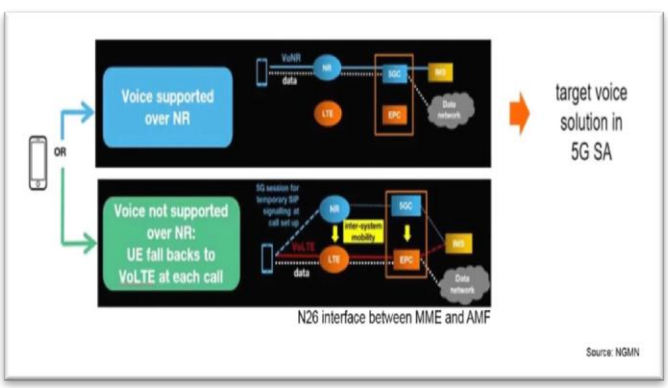


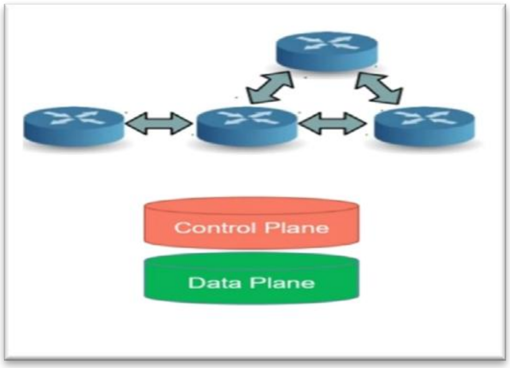
Fig .17: voice services 5G SA

9. SDN (software defined network) .

According to the statistics below from Ericsson Mobility Report, global mobile data traffic is expected to expand by a factor of 4.5 to reach 226EB per month in 2026. Currently, the existing generation cannot cover all data traffic. Furthermore, today's core networks are inflexible and expensive. Typically require truck rolls to upgrade, and are difficult to interconnect, dynamic workloads in which the hardware and software load may change, resulting in underutilization, debugging complex networks is difficult since the network requires ongoing maintenance, and the cost is [35,36].

To evaluate any network's architecture, the essential premise is that a group of switches transport data from source to destination; each switch has two parts:

1. DATA PLANE all operations involving or coming from data packets sent by the end user (fragmentation and reassembly, forwarding, and multicast replication).
2. CONTROL _PLANE all data plane actions that do not involve end-user data packets (defining packet handling policies, building routing tables, security) [37.38]



3. The separation of control and data planes is a solution to all of the above disadvantages: the control becomes centralized (all control planes are grouped as a single point), which reduces cost (only data plane is manufactured for each hardware), time, efficiency, and flexibility in managing the network as a single point; the separation reduced human error and increased security (manage the network as a single point) [39].

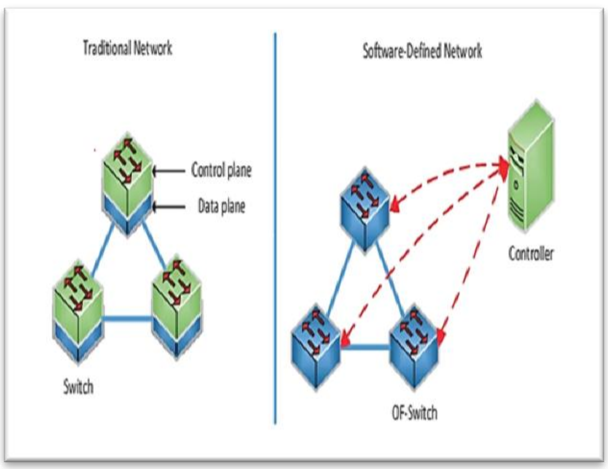


Fig .18: traditional network vs SDN network

"In the software defined networking architecture, the control and data planes are separated, network intelligence and state are conceptually centralized, and the underlying network infrastructure is abstracted from the applications," according to an ONF white paper published on April 13, 2012 [40].

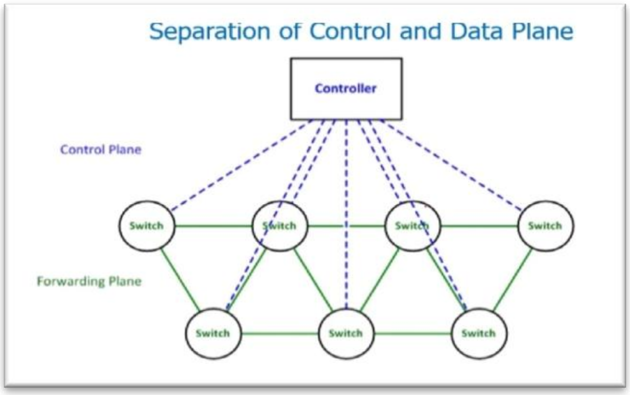


Fig .19: **separation of control and data plane**

The network is programmed by a logically centralized controller based on the global view below, hence SDN is required for the following reasons:

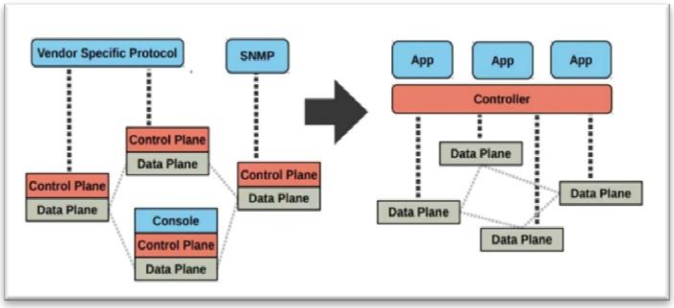


Fig .20: **SDN layers**

- ✓ Virtualization allows you to use network resources without having to worry about where they are physically located, how much they cost, or how they are arranged.
- ✓ Manage thousands of devices with orchestration.
- ✓ Programmable: the ability to change behavior on the fly is essential.
- ✓ Dynamic scaling: the ability to adjust the size quantity should be possible.
- ✓ Automation reduces operating expenses.
- ✓ Monitor resources and connectivity for visibility.
- ✓ Optimize network device use for better performance.

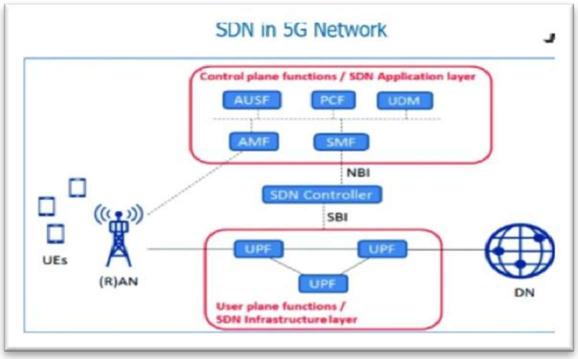


Fig .21: **SDN in 5G network**

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10. NFV (network function virtualization).

In the previous section, we discussed SDN; in this section, we will discuss NFV as a network approach. While both techniques complement each other, there are some issues that have arisen as a result of the NFV thinking[41,42]:

The network becomes more complicated as the number of RANs, H.W., and MMEs grows; new services require new H.W., or upgrades to existing H.W., which is more expensive, especially when working with a single vendor; and there are some issues in data centers, such as power consumption to make all H.W. work.

Softwarization causes a break in the relationship between functions and the underlying hardware (decoupling between H.W. and S.W.). For example, IOS apple can't use a S.W. from Android because IOS isn't open source software (tightly coupled). By producing virtual instances of hardware platforms, operating systems, storage devices, and computer network resources, virtualization refines the software/hardware divide of the softwarization concept.

NFV is the ability to provide network functions on industry standard platforms, rather than buying a dedicated H.W, we can use a generic H.W from another vendor as a standard, giving us more flexibility, for example MME in 4G using of not proprietary there are many benefits of using standards H.W of cost consuming, the flexibility of moving the server to another location so far (google cloud, google agove) [43].

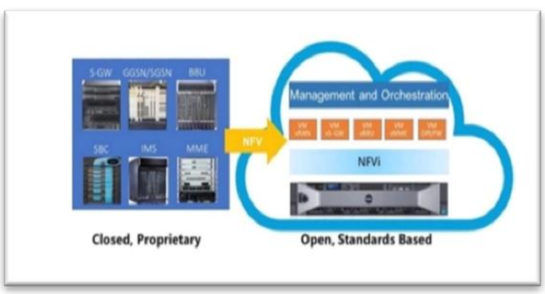


Fig .22: system with virtualization

The architecture below is based on the ETSI NFV reference framework and includes MANO (management and orchestration) for resource management, validation, and authentication, VNF (virtual network functions) for life cycle management, and NFVI (network functions virtualization)(network function virtualization infrastructure).

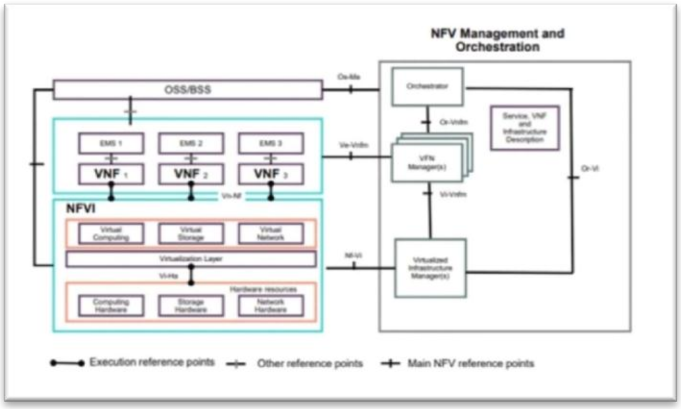


Fig .23: **5G network virtualization**

The virtualization of 5G networks brings with it more flexibility in use, so you don't have to worry about where your network resources are or how much they cost, orchestration to manage thousands of devices and network scaling, automation to deal with machine learning and AI to optimize device usage, and everything in the network becomes plug and play [44,45].

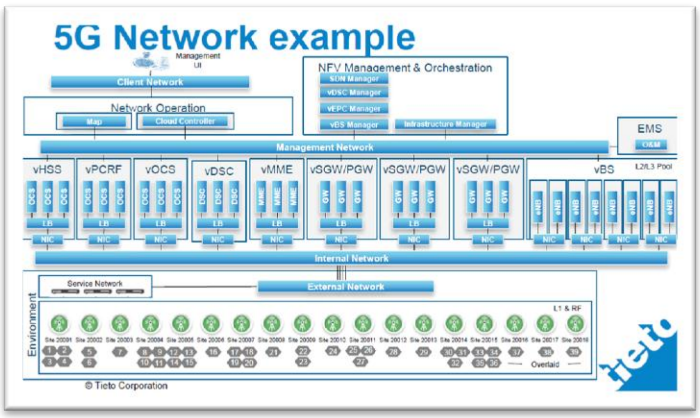


Fig .24: example of 5G network virtualization

11. 5G network slicing.

The 5G network is more than simply a connection service; it is also an assessment and revolution service that can support a variety of applications, as indicated in the diagram below (source from : analysis mason,2020). With a high spectrum band up to 400M in mmWAVE , the target has very low latency, extremely high device density on the same network, high data rate to convert from generation to generation, and low cost of delivery [46] . Slicing of the network should be done in an end-to-end (E2E) manner to improve dedicated services to specific applications over a common physical infrastructure. Slicing is important for 5G because it allows operators to provide portions of their networks for specific customer use cases in verticals like automotive, healthcare, and entertainment. As a result, the network is open to a wide range of partners and is divided into use cases and vertical blocks.
Because vertical industries in general require deterministic service, a specific packet loss rate, and a specific jitter, all of these requirements are difficult to meet in a 4G network because it is one pipe (best effort) and cannot target all use cases, for example VPN and APN are limited, and inflexibility (hard coded), one network does not fit all. So in a 5G network, there are distinct deterministic services, application adaptive network slices one size fits all (open RAN, SDN, NFV, cloud) [47].

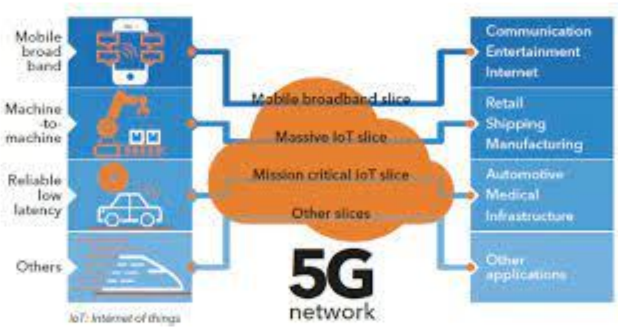


Fig .25: **network slicing deployment**

Network slicing can be used in a variety of ways:

- ✓ Fully shared mode (best effort): shared NFs, unified access, and no impact on the RAN or transport network, as well as no security needs.

- ✓ Partially shared mode: shared host groups and high resource use, cost and security are balanced, and the AMF and SMF are independent.

- ✓ Fully independent mode: a dedicated industry core network, high cost, optimal security, and use in specialist applications (ultra high security), such as the BMW [48].

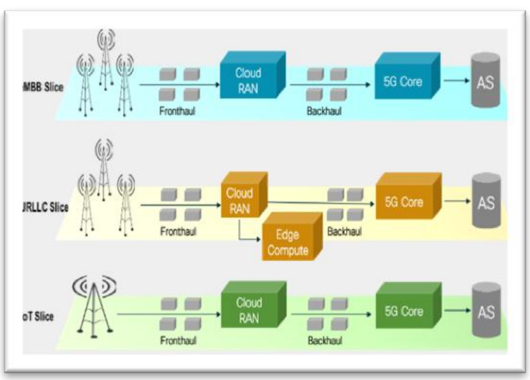
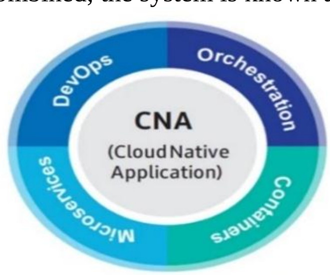


Fig .26: **4G slicing , 5G slicing**

12. 5G cloud native network .

"Cloud native" refers to a method of developing and operating apps that takes use of the cloud computing model.

When these four concepts (source: Samsung) are combined, the system is known as a cloud native system.



Every H.W. includes S.W. that increase function in one system, therefore splitting S.W. into independent little module software may be done to specific software from the rest of the softwares that are regulated by one H.W.

When we package little applications in containers, they are totally isolated from one another, so each one has its own attributes and standards. If one container fails, the others are unaffected (closly coupled).

The orchestration is similar to what is known as MANO, where the H.W. created as infrastructure incorporates computation, CPU, and memory that allocates space to each function.

For example, the software upgrade, devops has a specific business call, and both of them should work together to shorten the cycle time delivery (continuous development).

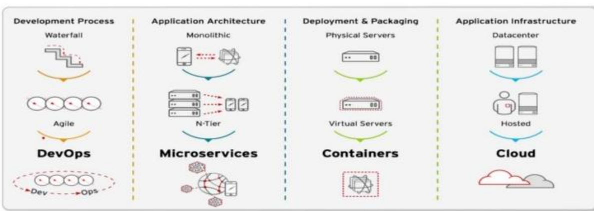


Fig .27: cloud computing model

The cloud native development process begins with the water fall cycle (plan, design, implement), which is followed by the application architecture monolithic division of the service into small services, each of which is packaged in containers, and the data center must contain a server, so convert the H.W. to virtual S.W., and all of them stand for one operating system (source: redhat) [22] . "Cloud native computing leverages an open source software stack to deliver applications as microservices, packaging each portion into its own container, and dynamically orchestrating those containers to optimize resource consumption," according to the prior description. Software developers may create outstanding solutions faster with cloud native technologies" [49] .

The transformation of the core network for 5G begins with network functions on specialized hardware.Then there's NFV (network function virtualization), where each virtual machine has a function and an isolated guest operating system, a COTS server, and VNF is stateful, which means each virtual function saves user equipment in its own storage, making it a heavyweight.

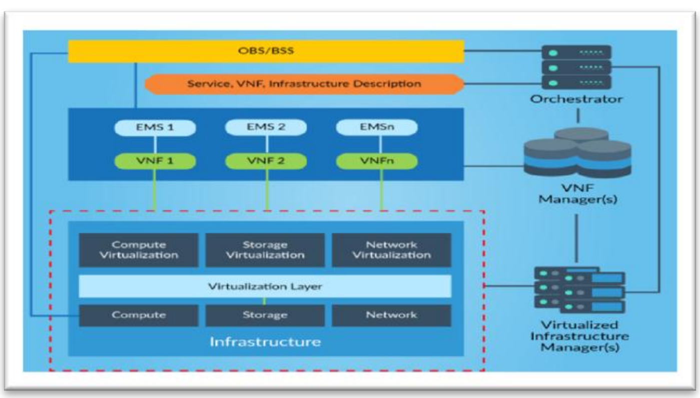


Fig .28: NFV

The CNF (core network function) in the cloud native each microservice in a container and kernel operating system is stateless, which means there is no central storage to reduce a large weight.

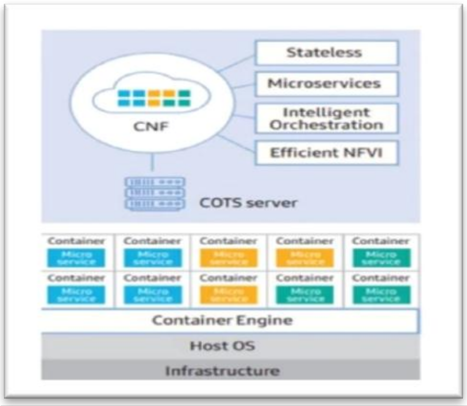


Fig .29: CNF

13. 5G network security

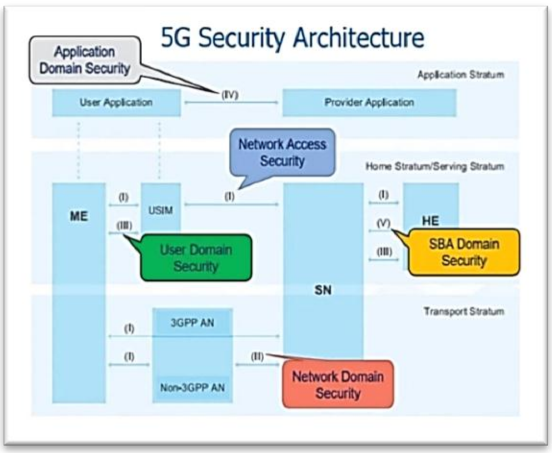


Fig .30: 5G SECURITY ARCHITECTURE

II. CONCLUSION

Existing networks are incapable of supporting an indefinite number of users for ever-changing requirements such as the Internet of Things (IoT), 3D video, smart cities, industry automation, self-driving cars, and the amount of big data. More than merely improving hardware specifications is required. As a result, successful management necessitates frequency resources, computational resources, and deployment costs. A network slicing approach is used to achieve flexible management. MEC structures can be used to achieve complex application situations. This study looks at 5G resource management, covering the core network and RAN, and follows the network architecture, application scenarios, and survey objectives for modeling new technologies in a methodical way. According to the poll, challenges to the management strategies discussed have been suggested. We also offer some future prospects to individuals who are interested, and we want to help more parties learn 5G resource allocation.

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