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5G Core Architecture

The evolution of mobile networks has exponentially expanded as more devices entered these wireless networks and the hardware and software got increasingly more demanding and complex. 1G started as an analog standard, deriving from radio-based devices that communicated point to point. As mobile networks evolved, we entered the digital voice world of 2G and 3G expanding on this standard with actual mobile data. 4G was the standard during the 2010s and allowed for high-speed communication regardless of the medium (voice, video, and media). In today's world, 5G is the reality of our mobile networks today. Coming from a need for more bandwidth, features, and scalability, 5G solved these problems that 4G ultimately lacked. 5G is worth the investment because of its cloud-based network, its simplified network architecture over 4G, and its gradual, yet efficient integration from 4G.

The main differentiating factor of 4G from 5G is the adoption of a cloud-based network architecture. In the 4G architecture, there are host of broadband cell towers that capture information from wireless devices and then send it off to cloud data centers to be processed and finally sent back to the user. Latency starts to become a problem when these towers must send these packets to a handful of data centers that are spread across the country. With 5G, instead of having remote data centers, each cell tower location would include a 'mini' data center with capabilities of the 4G based data centers. Thousands of 5G capable towers are being deployed that can have this technology due to Network Function Virtualization (NFV). NFV decouples the software from the hardware, allowing for the software to run in any type of environment, specifically virtual machines. With this idea paired with software defined networking, this allows for each 5G location to be flexible, agile, scalable, and all monitored through an automated DevOps solution. 4G lacks the ability to scale to this level due to the equipment being proprietary which means transit providers are locked to specific vendors and as new mobile technology releases, they must purchase new equipment to keep up with the industry. Expanding from the cloud-based conversation, network slicing utilizes the full capabilities of the low latency networks of 5G.

Network slicing is the idea of separating one physical network into multiple logical networks. What this means for 5G is that certain traffic can remain on one logical network and can be scaled dynamically based on the use case of the mobile network. For example, autonomous systems in a manufacturing environment like autonomous forklifts can utilize the bandwidth of 5G and maintain their workload even when there is an increase of traffic from a nearby area. Network slicing with 5G enables the possibility of autonomous systems to function almost instantaneously when compared to communication via 4G. Keeping all of this in mind, 5G core architecture becomes trivial when comparing it to its predecessor.

Comparing both the 4G and 5G architecture, it is obvious which design allows for long term usability. In figure 1, the 4G architecture starts at the eNB or eNodeB, which is the tower node that the user connects to. The MME or mobility management entity authenticates the user session and monitors the geographic location of the current user. The Home Subscriber Server (HSS) contains the subscription information of the user and manages the specific QoS for that user. The Serving Gateway (SGW) is an anchor point for the data no matter what eNB the user connects to. This data is then sent to the PDN gateway (PGW) that then connects the user from the LTE network to the internet or PDN (Public Data Network). While this network design has worked for hundreds of millions of people for years, it contains proprietary hardware that is expensive to purchase and operate. On top of this, these devices are contained in centralized data centers in some cases hundreds of miles from the eNB. This causes unneeded latency traveling to the site and then being processed from there.

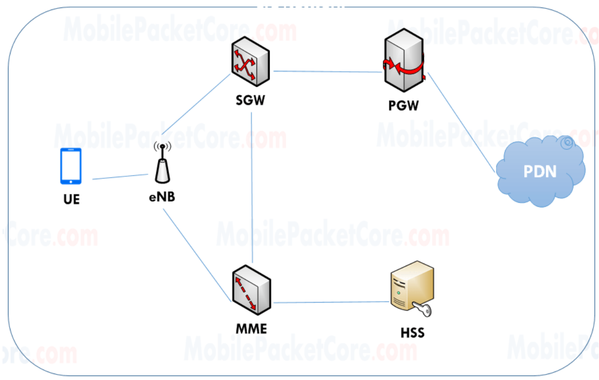

Figure 1 (4G Core Architecture)

Continuing to the 5G architecture as seen in figure 2, we can see that 5G has transitioned to a Service Based Architecture (SBA). SBA is a modular architecture which centers on subscribing to different services that can be introduced into the 5G network design modularly. All the functions in this design are virtualized and are contained in bare metal boxes hosting virtual machines at the same location as the radio. The AUSF (Authentication Server Function) acts like the HSS in the 4G design, first authenticating the user session. The UDM (Unified Data Management) also acts like the HSS, storing authentication information for the user. The PCF (Policy Control Function) applies policy decisions based on the subscription, in turn controlling the network behavior of the device. The AMF (Access and Mobility Management Function) manages most of the connection-based operations for the user and is identified as the first and only point of entry into the 5G design and is like the MME from the 4G design. The SMF (Session Management Function) performs session management, user plane selection and QoS enforcement on the control plane. The SMF acts like the MME in the 4G design. The UPF (User Plane Function) acts as the packet forwarding agent for the user and sends information off to the Data Network and this also acts like the PGW from the 4G design. The 5G network design is highly scalable due to its virtualized environment and all computation is done locally which reduces latency significantly.

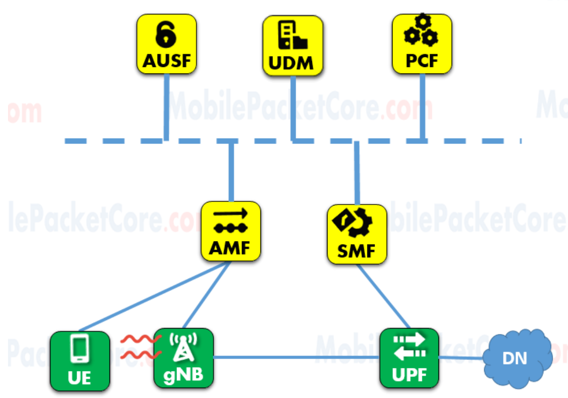

Figure 2 (5G Core Architecture)

While currently it seems that 5G will require all new architecture, its implementation is not as drastic as it seems. Currently, the SBA of 5G does need all new equipment but once installed, is easier to manage and automate than the 4G architecture. For existing 4G architecture, there are non-standalone 5G networks being added to the existing architecture. This includes adding a 5G component carrier that reduces the wavelength to millimeter size and requires installing a multiple antenna array to the existing 4G tower. From there speeds will increase significantly but will remain on the 4G architecture. Implementing 5G does not have to include a ground up, standalone solution, rather it can start gradually from the existing last gen design.

5G is the future for all types of devices that require a high speed, reliable, wireless connection to the internet. Reducing latency and becoming a vendor neutral solution via NFV/SDN is the key to maintaining this architecture in the far future. Even with the large number of sites that 5G will create, it is set up to support a dynamic management solution that completely automates the national architecture. To top this vision, network slicing will support sophisticated devices in any type of scenario with an almost instant latency response. And to start this all off, engineers can upgrade existing architecture to start the wave of 5G. By now, it is safe to say most people have seen an advertisement, article, or TED talk about 5G and its benefits. Now is the time to embrace this technology for what it is and to lead an increasingly connected world.

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