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5G Network: Analysis and Compare 5G NSA /5G SA

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Abstract

The fifth generation 5G mobile is the newest global solution wireless standard after 4G. Also, it is a solution that opens the door to new services: Transport, industry…, and help achieve a variety of high-level goals for consumers and businesses. This paper starts by reviewing the evolvement of the mobile generations beginning by 1G until 5G and presenting their characteristics. Secondly, analyzing the implementation of the 5G architecture according to two modes: 5G Standalone Mode (SA) and 5G Non-Standalone (NSA) Mode. Then presenting the options of each mode and deployment scenario of each of these modes. Finally, we draw a conclusion by trying to answer the question that majority of operators are asking, searching for the best implementation of the 5G Network.

Keywords: 1G, 5G, NSA, SA.

1. Introduction

In a few years, the whole world will face the saturation of the 4G network, because according to several studies in 2025 more than 75 billion internet of things (IOT) devices will be connected with using wireless technology but 4G will not be able to provide this connectivity. Therefore, this increase will push operators around the world to be ready for an evolution towards the new 5G network. 5G will bring breakthrough innovations in mobile technologies that will help achieve a variety of high-level goals for consumers and businesses. However, 5G have three main advantages: Low latency, higher speeds, capacity for a larger number of connected devices.

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2. Evolution of different technologies:

2.1. 1G: First Generation

In 1980 was the appearance of the first-generation mobiles communication on the basis of an analog mobile communication system. This network was dedicated only to voice calls; the latter is modulated at a frequency of 150MHZ or more. This first generation used various standards analogue such as the AMPS (Advanced Mobile Phone System) analogue network, which is based on FDMA (Frequency Division Multiple Access) technology, the NMT (Nordic Mobile Telephone) the first mobile telephone network, which offered international roaming and the TACS (Total Access Communication System).

2.2. 2G: Second Generation

In the late 1980s was the appearance of the second generation of cellular systems. 2G is the first mobile telephone network to use digital technology for the link as well as for the voice signal, allowing data security (with encryption). Several standards are used by this generation such as the GSM (Global System for Mobile Communication), the intermediate standard CDMA (Code Division Multiple Access) called CDMAOne where IS-95. We also find the D_AMPS the advanced digital telephone system portable. The purpose of 2G is to make voice calls and to send SMS (Short Message Service) and MMS (Multimedia Message Service). In this generation, the GSM standard used two techniques between the wireless terminal and the base station, namely CDMA (Code Division Multiple Access) and TDMA (Time Division Multiple Access).

Evolution of 2G: GPRS (General Packet Radio Service 2.5 technologies) / EDGE (Enhanced Data Rates for GSM Evolution 2.75 technologies) in 2001, GSM developed the GPRS service in order to provide Internet access to users as well as a download speed of up to 114Kbps. The GPRS service evolved into EDGE in providing transfer rates of up to 384Kbps max.

2.3. 3G: Third Generation

In 2000 was the appearance of the third generation of mobile networks. This generation of network was named IMT 2000 (International Mobile Telecommunication 2000) by the ITU (The International Telecommunication Union). 3G uses a standard called UMTS (Universal Mobile Telecommunications) based on W-CDMA technology and which makes it possible to offer a wide range of voice, data and image services as well as Internet access. The networks of this generation offer internet access with a high speed between 144Kbitps and 2Mbs, which makes it possible to provide fast downloading of data and applications as well as sending videos and video conferencing. In 2007, 3G experienced its first evolution towards 3G+ or 3.5G (HSDPA: High Speed Downlink Packet Access). Thanks to this technology, the network makes it possible to reach an average speed of 3.6 Mbit/s. 3G experienced a second evolution towards H+ (HSDPA+) with an average speed of 5 Mbit/s and the last evolution was towards H+ dual carrier (DC-HSDPA+) with an average speed of 10 Mbit/s.

2.4. 4G: Fourth Generation

The appearance of the fourth generation of mobile networks was In the 2010s. 4G is based on the LTE standard (Long Term Evolution) theoretical speed 150Mbips, according to the ARCEP (Regulation Authority for Electronic Communications and Posts) 4G provides a connection 3 times faster than 3G. Two points characterize the 4G network. The first point is the circulation of voice calls, which is done directly via the internet no longer via the telephone network; the second point is multiplexing (passage of different types of information via the same channel).Evolution of 4G to 4G+ (LTE Advanced) with a minimum speed of 200 to 300 Mbps, twice as good as 4G. 4G+ brings several advantages such as faster internet access than with the 4G network, instant viewing of videos in very high definition (4K) and the possibility of answering a phone call while remaining connected (VoIP)

2.5. 5G: Fifth Generation

In late 2010, the new 5G generation of mobile communication was launched. 5G is not a simple evolution of 4G like the previous generations that came to increase the flow. It is considered as a breakthrough technology, which must respond to the explosion of our data consumption. By 2025, a user out of 5 will consume 200 GB every month, so the first interest of 5G is to avoid network saturation in very dense areas such as stations, airport….

The 3 categories of 5G use cases:

- *URLLC (ultra-reliable low latency communications):* This category includes ultra-reliable and low-latency communications that require an ever-faster connection with higher throughput capacities, for example: autonomous driving.
- *mMTC (massive Machine Type Communications):* This category offers the ability to connect a high density of objects to 5G, which requires extensive coverage, as well as low energy consumption and restricted speeds for example: Internet of Things (IoT).
- *eMBB (Enhanced Mobile Broadband):* This category will provide higher bandwidth and better latency for newer applications for example: 4K media and virtual reality.

3. Deployment of 5G architecture

5G system is defined as 3GPP (3rd Generation Partnership Project) system including 5G Access Network, 5G Core Network and UE (User Equipment). At the 72nd general meeting of 3GPP some options for 5G network architecture are proposed.

3.1.1. Standalone Mode (SA)

The 5G SA Standalone is the model of deployment where 5G provided an end-to-end 5G network; in this architecture, we have an independent network such as 5G (NR) New radio and 5G (CN) Core Network.The characteristics of SA deployment that is a pure architecture 5G, this implementation will be based on using 5G for Control Plane and User Plane.

- *SA Option 1:* Option1 represents a pure 4G networking architecture Standalone LTE; it is also called EPC (Evolved Packet Core) connected system.
- *SA option 2:* In the deployment scenario 5G base station is connected to 5G core network, this option will be beneficial where the operators want to implement 5G NR without 4G network. This architecture needs to have new base stations and a core network should be built which is very costly; in this option, we can deploy all types of 5G using cases such as eMBB, mMTC and URLLC. (Releause-15 June 2018)
- *SA option 5:* In this option, the eNodeB (evolved NodeB) will be upgraded to next generation eNodeB in order to connect to the 5G Core. So, LT nodes will continue supporting the legacy devices and, at the same time, connecting to 5G core which allow operators to eliminate 4G EPCs. According to a comparison between the 5G and improved 4G base stations, there are undeniable differences in terms of peak rate, delay and capacity. As a result, enhanced 4G base station may not be able to support the 5G characteristics (peak rate, delay and capacity). Therefore, the prospect for Option 5 architecture is not good either. (Release-15 June 2018)
- *SA Option 6:* This option is not a considered standardization by 3GPP, because in this architecture, the 5G base stations will be connected to the 4G core network. Moreover, this option considers the 5G base station more important than core network, which is unreasonable.

3.1.2. Non-Standalone Mode (NSA)

The 5G NSA Non-Standalone is the model of deployment where the architecture depends on the existed LTE radio access and core network (EPC). For the characteristics of NSA deployment, we can find 5G network supported by 4G core infrastructure and 5G radios coupled with LTE Evolved Packet Core (EPC).

- *NSA Option3:* In this option, the EPC (core 4G) is reused and the interconnection between different elements is done according to three sub-options: 3, 3A and 3X. (Release-15 December 2017 with June 2018 corrections)

Table 1. 5G-NSA Option3

NSA Option3	NSA Option3A	NSA Option3X
• Data split anchor is on the 4G base station .	• Data split anchor is on the 4G base station	• Data split anchor is on the 5G base station.
• The 4G base station is responsible for splitting the data from the core network into two paths: 1. One in sent to UE 2. The second is distributed to the 5G base station	• The 4G core distributes UserData to the 4G/ Data split anchor is on the 4G base station.5G base station	• Combination of option3 and option 3A. • This configuration can be used in scenarios where LTE coverage reach is superior that of NR and thus leverages EPC.

- *NSA Option4:* This option provides the dual connectivity with NR gNB master node and enhanced LTE eNB as a secondary node with 5GC Core Network. In this option, the Core Network is the 5G Core, the 5G base station has also become the anchor point of the control plane, this option is more appropriate for deployments of law band NR.

Option4 series is divided into two options option 4, 4a. (Release-15 December 2018).

Table 2. 5G-NSA Option4

NSA Option4	NSA Option4a
• Data split anchor is on the 5G base station. • No direct connectivity between ng-eNB and 5GC.	• Data split anchor is on the 5G Core Network. • No Xn interface between gn-eNB and gNB. • Gn-eNB is connected to 5GC via NC-U interface

- *NSA Option7:* The 3GPP defines that option7 is the evolution of the option3 to 5G. In this option, we need to upgrade the 4G core network in option 3 series NSA networking to the 5G core network and the eNodeB must be upgraded to the eLTE eNodeB to support interconnection with the 5G core network. The control plane anchor is on 4G and the data split anchor is on enhanced 4G base station.The option 7 series is divided into 7, 7a, 7x, the difference lies in data split where is located. (Release-15 December 2018)

Table 3. 5G-NSA Option7

NSA Option7	NSA Option7a	NSA Option7x
• Data split anchor is on the enhanced 4G base station	• Data split anchor is on the enhanced 5G core network	• Data split anchor is on the 5G base station
• No interface between gNB and 5GC	• No Xn interface and gNB is connected to5GC via NG-U interface	• Combination of option 7&7a

4. Discussion

4.1. Transition from 4G to 5G (Mode Standalone)

Evolving from 4G to 5G goes through several stages depending on the mode used by the operator. Following the studies already made on this point, we find that the deployment of 5G according to the Standalone mode chosen by most service providers is as follows: Direct evolution from option 1 LTE to option 2. Knowing that the other options (option5/option6) are not considered the best choice to be implemented by operators via Standalone mode.

4.2. Transition from 4G to 5G (Mode Non-Standalone)

The transition by using non-standalone mode can be done by several paths; the following ones are the most adopted by operators:

Option1LT E → Option7xNSA → Option2SA
Option1LT E → Option3xNSA → Option2SA
Option1LT E → Option4NSA → Option2SA

5. Conclusion

This paper covered the characteristics, advantages and disadvantages of SA and NSA networking modes of 5G, which leads to the question “What is the best way of migration towards 5G-SA that the operators will use?”
To answer this question, we can use the first way, which is going straight to option 2. This will take more time to finalize, an enormous investment and taking high risks. Furthermore, the operators will face several difficulties in evolving directly from option 1 to option 2 in terms of equipment. Using the second way means evolving gradually from Option 1 → Option 3x → Option 7x → Option 4 → Option 2. In my opinion this way’s investment is greater than the first one but the second way will allow the operators to test the implementation of each option before going to the next, which decreases the risk.
In reality, only one factor that will determine all of this, and that is the explosion of demand for 5G.

6. Prospect

Today the whole world is preparing for this significant evolution while providing new services with ultra-high speed, low latency and high security, which will allow several sectors to switch automatically to the

new network for new services. This is why 5G introduces the principle of Network slicing technology used by 5G, which allows the network to be divided into several virtual slices. So, the service providers will not only have to implement the new network but also guarantee a tailor-made and on-demand network.
Therefore, the best choice of the deployment of the NSA 5G, the non-standalone mode remains option 1 → Option 3x → Option 7x → Option 4 → Option 2, because this path will allow, as has already been seen, to have a progressive evolution with less risk and more reliability for operators.

References

[1] lboulter@gsma.com. (2022, 2 mars). Mobile Momentum: 5G connections to surpass 1 billion in 2022, says GSMA. Newsroom. https://www.gsma.com/newsroom/press-release/mobile-momentum-5g-connections-to-surpass-1-billion-in-2022-says-gsma/.

[2] Generatrion. (s. d.). net-informations. http://net-informations.com/q/diff/generations.html

[3] Zaame, I., Mazri, T., & Elrhayour, A. (2020). 5G: ARCHITECTURE OVERVIEW AND DEPLOYMENTS SCENARIOS. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLIV-4/W3, 435-440. https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XLIV-4-W3-2020/435/2020/

[4] Zhang, Z., Chen, J., & Hou, J. (2021). Analysis of the Evolution Scheme of NSA RAN Sharing to SA RAN Sharing. 2021 International Wireless Communications and Mobile Computing (IWCMC). https://doi.org/10.1109/iwcmc51323.2021.9498959.

[5] el RHAYOUR, A., & MAZRI, T. (2019). 5G Architecture: Deployment scenarios and options. 2019 International Symposium on Advanced Electrical and Communication Technologies (ISAECT). https://doi.org/10.1109/isaect47714.2019.9069723.

[6] TECHNICAL REPORT, 5G;Study on New Radio (NR) access technology;(3GPP TR 38.912 version 15.0.0 Release 15),ETSI TR 138 912 V15.0.0(201809);https://www.etsi.org/deliver/etsi_tr/138900_138999/138912/15.00.00_60/tr_138912v150000p.pdf

[7] R., & R. (2021, 18 juin). Présentation de la mise en réseau 5G NSA et concepts de base. Communauté de Support de Huawei Entreprise. https://forum.huawei.com/enterprise/fr/pr%C3%A9sentation-de-la-mise-en-r%C3%A9seau-5g-nsa-et-concepts-de-base/thread/749045-100363

[8] Thomas, N. (2020, 11 février). 5G Deployment options – Enabling operators to easily drift from 4G to 5G. The 5G Zone. https://the5gzone.com/index.php/5g-deployment-options/

[9] Agiwal, M., Kwon, H., Park, S., & Jin, H. (2021). A Survey on 4G-5G Dual Connectivity: Road to 5G Implementation. IEEE Access, 9, 16193-16210. https://doi.org/10.1109/access.2021.3052462

[10] 5G_SA_Architecture_Technical_White_Paper_Public. (2021, janvier). https://images.samsung.com/is/content/samsung/assets/global/business/networks/insights/white-papers/0107_5g-standalone-architecture/5G_SA_Architecture_Technical_White_Paper_Public.pdf