Analysis of 5G mobile networks A brief review of the state of the art

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Abstract:
Network Functions Virtualisation (NFV) is a networking approach proposed by ETSI (European Telecommunications Standards Institute) - whose founding ideas originate from the IT world and its SDN - that allows the replacement of specific hardware devices, such as routers, firewalls, and load balancers among other equipment, by software-based devices running as virtual machines on industry-standard servers. NFV decouples network functions from dedicated hardware devices and moves them to one or more virtual servers, which can perform multiple functions on a single physical server and the virtualized machines can be located in data centers, network nodes, or in the end-user's home. However, in Telecommunications - which is a capital-intensive industry - the move from hardware-based networks to software-based networks seems to look traumatic. Beyond the well-known problems of implementing new technology (unfamiliarity, interoperability failures, etc.), the path chosen to move from 4G to 5G seems more difficult and costly than what would have happened with the traditional path. In this article, we will mention the traditional path and describe the path chosen for the transition from 4G to 5G mobile networks in a way that will make clear the current state of 5G mobile networks.
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1. Introduction

Globally, telecommunications occupies a prominent place in Industry 4.0 or the fourth industrial revolution [1–3]. In particular, the need for connectivity, speed, low latency and high availability means that telecommunications companies around the world are in a constant race for advancement, which also requires ever-increasing investments with long payback times (a situation that potential investors do not like).

In 2012, during the "SDN and OpenFlow World Congress" in October in Darmstadt, Germany, the whitepaper "Network Functions Virtualization" was presented with the objective of describing the benefits, enablers, and challenges for network functions virtualization and as a justification for fostering international collaboration to accelerate the development and deployment of interoperable, standards-based, high-volume server solutions [4–7].

While in December 2017, the 3rd Generation Partnership Program (3GPP) approved the 5G Non-Stand Alone 5G New Radio (NSA 5G NR, see Figure 1) specifications that will build on existing 4G LTE networks. This first milestone would help accelerate the arrival of a fifth generation (5G) of standardized mobile technologies, it said that year [6–8].

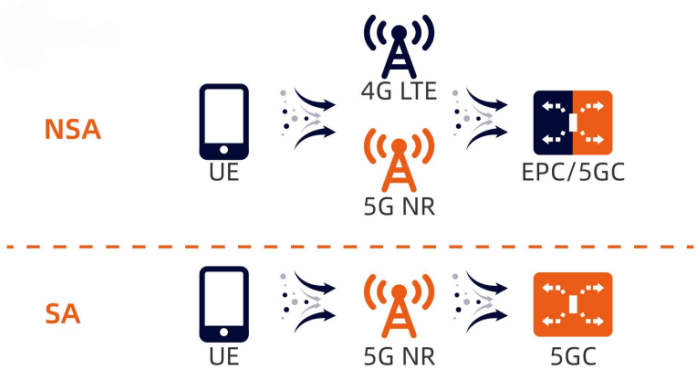

Figure 1. NSA architecture

What difference between SA and NSA deployment in 5G ?

To differentiate between SA and NSA deployment, the following question must first be addressed:

What are 5G NSA and SA architecture?

According to the definition of 3GPP, 5G Standard is divided into two modes: Non-Standalone Networking(NSA) and Standalone Networking (SA).

From the perspective of network architecture, NSA (Non-Standalone) refers to the coexistence of 4G eNodeB and 5G NR on the wireless side with a 4G core network (EPC) or 5G core network (5GC). SA (Standalone) refers to the 5G NR on the wireless side with a 5G core network, which is the ultimate goal of 5G network evolution [7,9,10].

Why NSA architecture is needed

The birth of the 5G standard protocol means that 4G network architecture should gradually develop into 5G network architecture, and SA architecture based on 5G NR + 5GC is the real goal of 5G development. But the reconstruction of the whole network architecture is bound to be time-consuming and expensive, so NSA network architecture came into being [7,9,11].

NSA networking architecture

In NSA networking, 4G eNodeB and 5G NR coexist, there is the concept of the master station and slave station. Taking the OPTION3 series as an example, the signaling of the control surface is completed through the interaction between the 4G eNodeB and EPC. The 4G eNodeB is the master station and the 5G NR is the slave station. There are many paths in the data plane, so there are data diversion points. For example, the data diversion of Option 3x is based on the packet level, and the data diversion point is 5G NR [12–14]. User Plane data can be transferred to 4G eNodeB through 5G NR, and the rest will continue to be carried on 5G NR.

In the NSA networking evolution solution, Option 3 only needs to introduce a 5G wireless system and upgrade EPC to support 5G services, which is conducive to speeding up 5G deployment and achieving flexible network transition. Therefore, it is a networking solution adopted by many operators at the initial stage of 5G deployment. As a transitional network architecture, NSA can make full use of the existing network resources and gradually realize the smooth introduction of 5G and the smooth exit of 4G.

In summary, in 2017, it approved a split in terms of mobile network development, based on modifying the Core or access. In this way, the capital contribution made for 4G networks would not be affected by the move toward the fifth generation. Similarly, in December 2018, standards were approved for 5G Stand Alone, i.e. fifth generation networks that will use Core 5G or virtualized networks.

In short, 4G and 5G networks would coexist for a long time - the time between the development of 5G radio access and the functional debugging of a virtualized 5G core. How long before we enjoy the benefits of 5G? What are those benefits? What is the current state of play? Who is ahead of the curve on 5G and why?

2. Methodology

A qualitative theoretical research methodology was established as a methodology. The reason for this is that no measurements are expected to be made at the moment because it is a review of the scientific literature, it is expected to collect information and leave a basis for future research. Therefore, the scope is limited to exploratory, non-experimental research.

Introducing the fifth generation

5G is the talk of the town. This new mobile technology will increase connection speeds, minimize latency (web response time) and exponentially multiply the number of connected devices. In other words: we will be connected to everything, all day long, and in the shortest possible time [14–16].

Figure 2. Graphical description of 5G networks

As with many other technological improvements, 5G is here (see Figure 2), and it is here to stay, regardless of the technology wars between China and the United States. The implementation of the fifth-generation mobile network will change the way we communicate, multiply the capacity of information highways and enable everyday objects, from fridges to cars, to connect (with us and with each other) in real-time. Its deployment represents a true technological revolution that will make it possible, for example, to carry out remote-assisted surgery, such as the one recently performed in Barcelona, to deploy new fleets of autonomous vehicles, and to coordinate agricultural work through sensors installed at different points in a field of crops.

What exactly is 5G?

5G refers to the fifth generation of mobile networks as we know them. Gone is the old 1G network, the network of those first mobile phones that only allowed you to talk. The 2G technology introduced SMS, and little by little our 'smartphone' became an increasingly widespread communication tool. First came the Internet connection (3G) and then broadband (4G), which brought with it the reproduction of videos in real-time (streaming) or augmented reality, something to which we are now very accustomed, but which a few years ago were completely unfeasible.

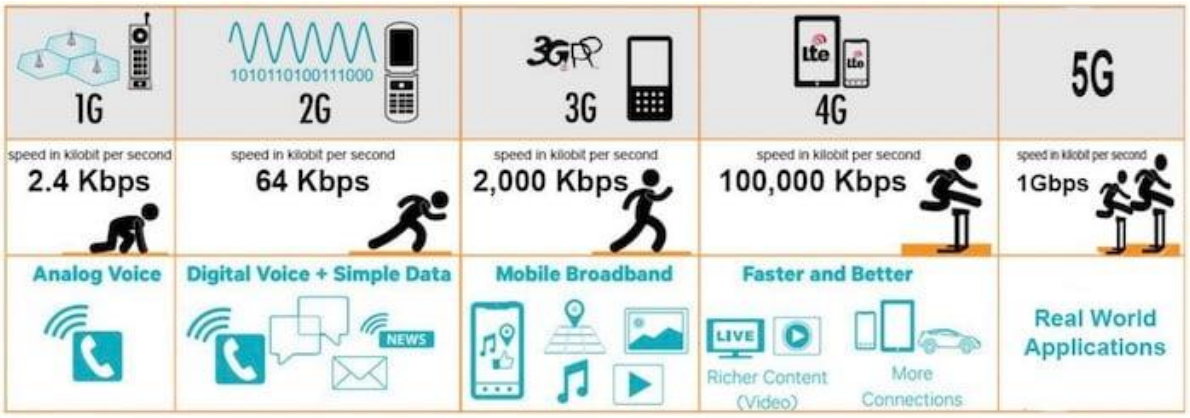

Figure 3. Evolution of mobile networks up to 5G.

The first version of mobile connectivity – 1G – introduced wireless voice (see Figure 3). In 2G, roaming and SMS messaging were introduced and were later enhanced with GPRS for data communication. SMS messaging and GPRS became widely used for basic telemetry. Roaming made mobile technology suitable for deployments in multiple countries. Telenor was one of the first operators to offer M2M communications with things connected over the 2G network as early as the 1990s. 3G became a truly global standard and combined the best of competing technologies in a single standard. 3G evolutions were mainly cantered around high-speed data applications. 4G introduced LTE technology used for devices constantly connected to the internet. 4G answered the consumer' s need for bandwidth and speed and introduced a new way to handle voice, replacing 2G voice. LTE-M and NB-IoT (Mobile IoT) are specially designed for the Internet of Things. LTE-M and NB-IoT support devices that need long battery life and devices that need good network access in areas that are difficult to reach. 5G networks use a combination of existing 4G LTE and new 5G New Radio (5G NR) technology. Today most networks that claim to be 5G networks are in fact using 4G LTE.

How will 5G change the world?

The most significant advance will come in speed. 5G will allow browsing at up to 10 GBps (gigabytes per second), 10 times faster than the main fiber optic offers on the market. At that rate it will be possible, for example, to download a full movie in a matter of seconds (see Figure 4).

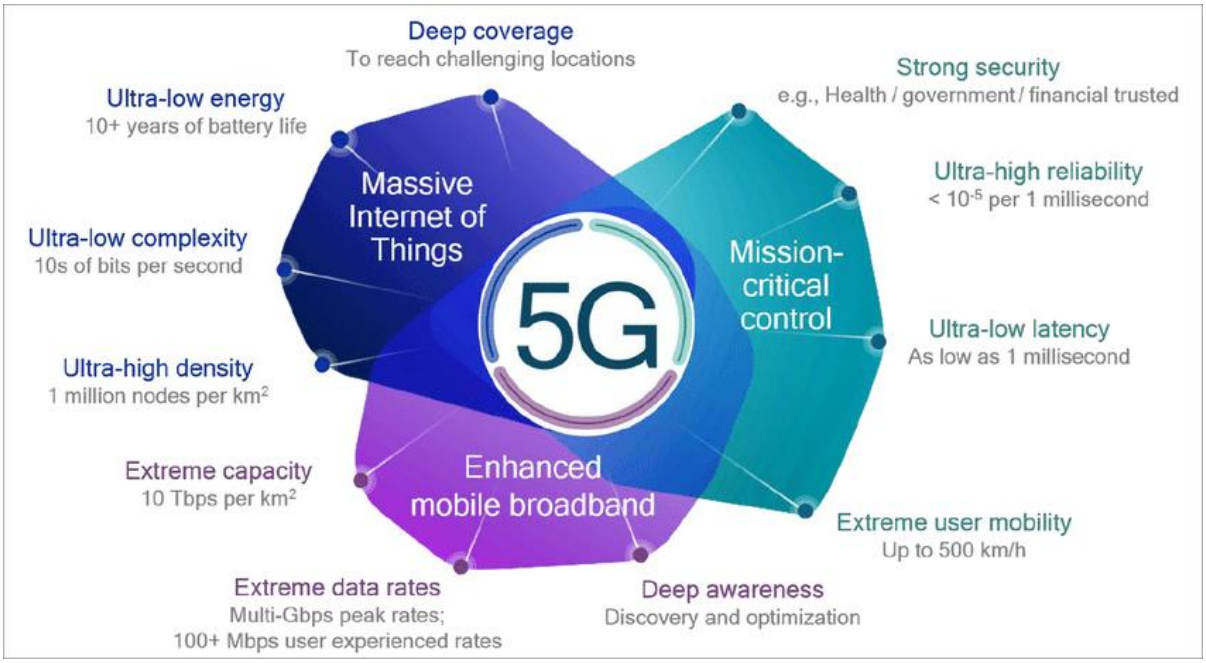

Figure 4. Main features within the target domains of 5G mobile technology [17,18].

In addition, latency (network response time) will also see a significant improvement. According to the operators, it could be reduced to 5 milliseconds, a period almost imperceptible to humans, allowing us to connect in near real-time [12,14–16]. This is particularly important, for example, to minimize the response time of an autonomous vehicle in order to improve the safety of both the occupants and any surrounding pedestrians.

Thanks to this new technology, we can, for example, exponentially increase the number of connected devices. Vehicles, industrial robots, street furniture (speed bumps, roadways, bus stops) or any electronic device we have at home (from the alarm to the washing machine, fridge or robot hoover) will be able to connect and share information in real-time [12,14–16,19,20].

Three ways 5G will change the world.

Healthcare

It is believed 5G networks will "usher in a new era of remote care". Simple home-based devices will monitor and automatically manage the health of people living with chronic conditions, such as diabetes [11]. Wearable devices will alert those in the wider population if any health anomalies are detected, facilitating a conversation with doctors based on the data they gather.

Further down the line, 3D X-rays will become commonplace, while performing precision robotic surgery on people in rural areas from a remote hospital will become possible. 5G-connected ambulances will interact with the local traffic network in an emergency situation to set traffic lights and inform other motorists of their location, thereby ensuring their path is clear.

Retail

5G will change the world of retail in the future by providing shoppers with "a far more personalized experience". 5G-enabled AR and VR-based systems will enable consumers to view how a piece of furniture would look in their living room or an item of clothing on their bodies – all in 3D – and to ask for alternatives using voice commands or gestures [2,3,6,9].

In-store, simply pointing their 'phone at a food shelf will bring up a list of product ingredients so they can establish which ones are ethically sourced and which are nut-free.

In around 15 years' time though, Guillermo Pedraja head of networks, 5G and IOT at IT services provider NTT Data UK, forecasts that, rather than customers driving to the supermarket themselves, self-driving shopping carts will fulfil their orders and negotiate traffic systems to deliver goods to their home.

Entertainment

There will be big shifts in the worlds of entertainment and sport as content moves from a 2D to a 3D format and becomes increasingly interactive. Movies and TV shows will migrate from green screens to smart stages and virtual sets, created on the same platforms as today's computer games. Live sports events, meanwhile, will be filmed using 3D cameras.

This means that, in the future, entertainment will become increasingly interactive, real-time, and viewable from 360 degrees. In other words, viewers will be able to watch films and shows from inside the set and move around inside it, viewing the action from different angles and interacting with the characters, not as an avatar but as a photo-real version of themselves. The speed and amount of data 5G can deal with at any given time offers a huge step up in terms of providing richer, more interactive experiences [11,13],

Development

From a general point of view, it can be described that the use of Information and Communications Technologies (ICTs) has grown exponentially, which has generated an increase in the number of accesses and user demand for improvements in speed and quality of service. These factors, coupled with the adoption of policies by governments in the region to implement their broadband development plans, have led to a scenario that has accelerated the introduction and implementation of 5G technology in South America.

According to [20–22], by 2017, it was estimated that the number of wireless devices would reach a thousand times the world's population and the capacity of networks at that time could not be supported due to spectrum scarcity. The importance of knowing the latest trends in this area lies in the fact that the management and use of spectrum is one of the biggest challenges currently facing 5G technology because it is a finite resource and currently has high occupancy and this will increase as the number of devices connected through 5G increases. devices connected through wireless networks increase.

The economic impact of 5G

Forecasts of the impact of 5G envisage a scenario that a decade ago seemed like pure science fiction: networks that remotely control production factories with little human intervention, autonomous cars and buses, and sensors that control each and every link in the value chain of countless sectors and industries, from logistics to agriculture. The possibilities offered by 5G technologies, together with robotics, AI (Artificial Intelligence) and intelligent machine learning, could reach such a magnitude that part of the industry is convinced that in the medium term it could lead to a transformation of the current production model. Something which, as is evident, has profound economic, social and political implications [1,11,13,23–25].

The 5G mobile network will have an economic impact on all industrial sectors. However, it should be borne in mind that any forecast will depend on the implementation schedule, national regulations and the possibility of consolidation of new business models. In order to reduce the deviations that these variables could have in a short space of time, IHS Markit [26], (see Figure 5) has carried out a forecasting exercise with the horizon set at 2035.

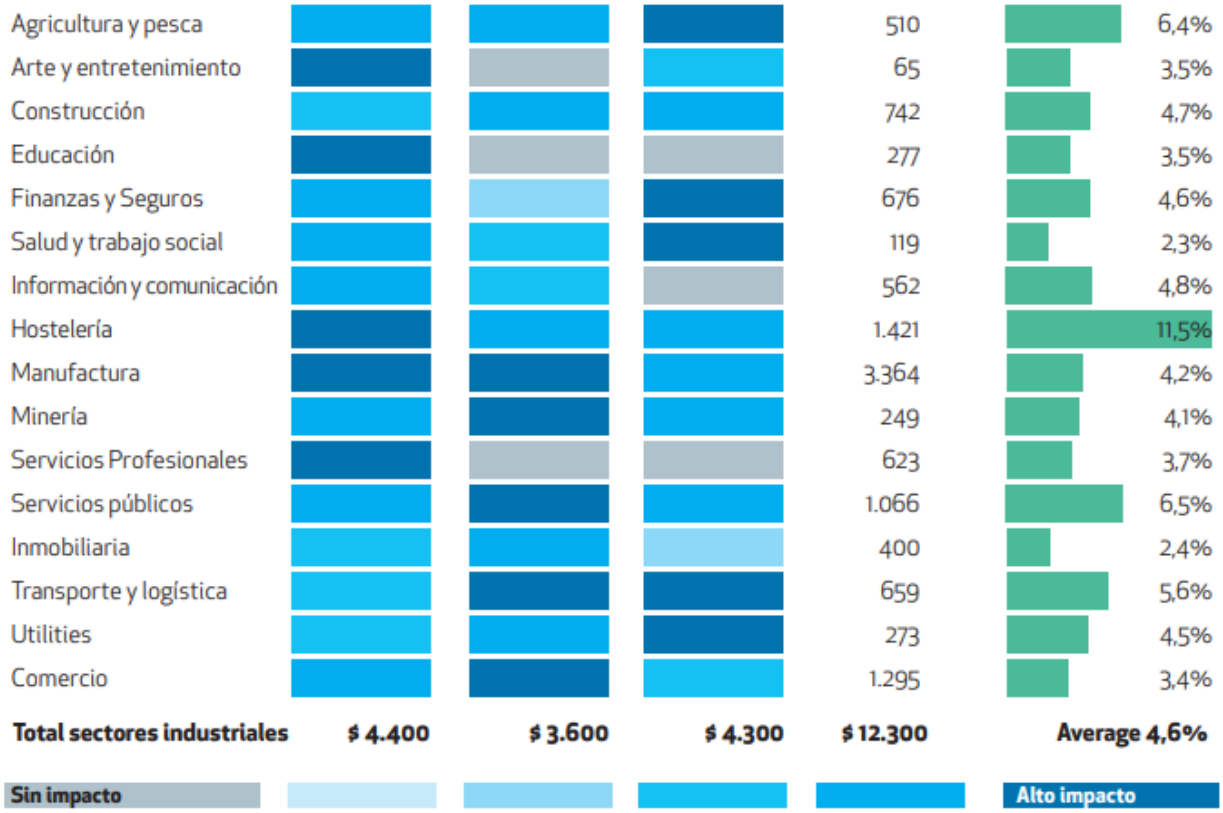

Figure 5. Economic contribution of the 5G network in the different sectors that generate the economy [26].

Based on knowledge of the impact of previous generations of wireless technologies and forecasts of the enormous opportunities that are opening up, the consultancy firm has estimated20 that the potential global multi-sector global activity that will enable 5 multi-sector activity to be enabled by 5G in 2035 could reach $12.3 trillion (million million) by 2035. USD 12.3 trillion. This is equivalent to the total consumption in the US during in the US in 2016.

Manufacturing will, according to this study, attract the largest share of 5G economic activity in 2035 - almost $3.4 trillion. The high amount is explained by the fact that the implementation of any of the uses of 5G will stimulate, among other things, spending on equipment and devices, all of which are also included in the manufacturing sector. manufacturing sector.

3. Conclusions

After 40 years of mobile technology and four successive generations of wireless technology, we are witnessing the arrival of the fifth generation of mobile telephony, 5G, which is expected to be deployed in 2020. The wireless industry - which has gone through four previous generations -

is now preparing for a new generation that will revolutionise not only the world of mobile communications but also the economy and industry in general. and industry in general.
The ambitious development plan proposed by the standardisation bodies includes the fact that by 2020 all the technical specifications will be available to achieve the implementation of a fully functional 5G network, even incorporating radio frequency specifications to achieve greater coverage and data download capacity.

Countries such as China, Korea and the United States are making progress in imposing the future standards for this technology, by investing in developments or through contracts between the state and its companies.

On the basis of the ideas outlined above, the situation of 5G networks in our country can be explained using two thematic axes: on the one hand, the economic one, due to the agro-industrial trend of recent years - we will mention in this regard that agro-industry is moving towards IoT using LoRa or Sigfox type solutions, as opposed to NB-IoT.

In short, 5G technology will reduce the time delay between devices and the servers with which they communicate to practically zero, so it will be faster, more intelligent and will consume less energy, which will allow it to be applied to a large number of new devices, whether they are wireless, household appliances, tools or vehicles, And despite not being implemented worldwide, it is essential that the tests of these 5G networks continue to advance, since no one could make use of it until the mobile devices and industries in which its implementation is provided are compatible with this technology and reach the shelves of mobile phone shops before 2020.

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