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5G: Where is the Money?

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INTRODUCTION

The era of 5th generation wireless[1] is on its way. 5G is a very new and highly unaware technology.

The biggest names in telecommunications, as well as their home countries, are investing heavily in 5G to ensure they have the biggest voice in setting the technological standard. The winners will reap billions of dollars in patent fees as well as a dominant position in the market for their own 5G technologies. The 5G deployment is accelerating rapidly, but the implications are much wider than just a network update. One of the most frequent questions asked by telcos[2] is

"How do we plan for 5G monetization?".

The challenges reference how to put in place the business models in place, the value prepositions, the processes, and the systems to monetize 5G. Some companies in different sectors are discovering the business opportunities that these new technologies offer. It seems that business cases are running head to head with technology. It is the first time, in the history of telecommunication industry, that a standard is being defined based on specific use cases. Every mobile[3] generation has paved the way for new business models and services (Balaji Ethirajulu, 2019). 5G also will bring innovation in business models and new services. Lightly, it could be perceived as another mobile technological step offering bigger bandwidth and speed. However, 5G goes further than that. It is a technological revolution that has a very important role in the business environments' Digital Transformation.

5G will contribute to telco operators by offering a high number of new services. No industry can touch the world like telecommunications but, it is not clear how telcos will manage these new businesses. With 5G, it has been noticed that the start of fundamental changes will impact, not just the final consumer, but also many industries that are not related to the telecommunication sector. The potential that is used to grow these new businesses areas is amazing, as never seen before in any other industry.

The Digital Transformation of our society brings a lot of opportunities to businesses, but it also brings challenges also.

Currently, telco companies face out their structures, to adapt to the way that they have been doing business, from the past 30 years.

The classic models are not valid anymore in the new digital society.

A Theoretical Model will be discussed in detail in this dissertation. The model will be constructed with basements in literature, experts' feedback and real-life case studies. Considering the novelty of 5G, we are going to analyze the use cases as illustrations to complete the model.

Keywords: 5G, telecommunications, business models, Cloud, Virtualization, NFV, SDN, Artificial Intelligence, Big Data Analytics, Machine Learning, Virtual Reality, ecosystems, 5G definition, Internet of Things.

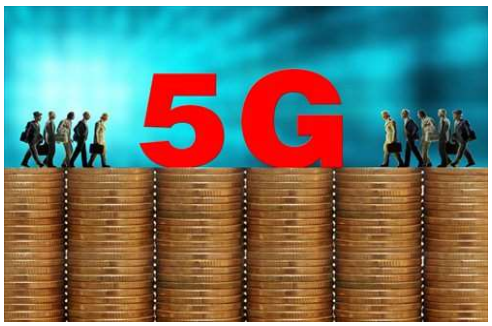
ABSTRACT –

[1] *Wireless refers to mobile technology. Also, cellular term is used in this paper as synonym.*

[2] T*elecommunication companies/sector.*

[3] *Mobile is used as synonymous of wireless and cellular technology.*

One of the most relevant issues in the new Digital Transformation is how telcos could create new 5G ecosystems. The use of new 5G technologies enters the telecommunication market in a very disruptive way. Telcos could be prepared for another technological change since the telco industry lived many transformations in the past. With 5G and their disruptive technologies, the result will be, making telcos enter in a non-telco area. Because of that, they will need to interact with different verticals and new partners.



There are many technical kinds of literature covering these new 5G technologies, but few of them, cover how telcos should manage and do business with them. Some studies affirm that

> The telco companies who do not understand that they must interact with others as part of the new ecosystem will eventually die.

However, not all are bad news for telcos, the future is not written. There are new opportunities and considering the logical technological restrictions and the possible and realistic possibilities, there is an open space that will be defined by the decisions that will be taken by the industry.

This paper aims to clarify these concepts behind the new business models which are its usages, and its roles in the information system domain. To do that, the paper identifies the terminologies used to describe new business models and reuses the previous literature to elaborate on the research. General usages, roles, and potential of the concept are also outlined.

The intention of this dissertation is to be used by non-technical people. Basic concepts are explained in a very simple way to allow readers to have an overview of the technical issues needed to understand the conclusions. How to present technical information, in a non-technical way, represents an extra challenge for the author.

Finally, concrete and pragmatic proposals will be offered to telco managers and CEOs[4], to start working in the direction towards monetization of 5G, helping them with company decisions.

[4] *Chief Executive Officer of a big company, in this context of a telco.*

2. BACKGROUND

This background review begins with some basic concepts, which is based on the theoretical approach to the subject of this thesis. The basics and general concepts of business models, ecosystems and Digital Transformation are provided.

The two worlds of Communication Technologies (CT) and Information Technologies (IT) have come closer, and sometimes the boundaries are so overlapping/blurred, hence the origin of new term IT+CT=ICT. In fact, some telcos have become either media or IT companies. Our focus in this chapter will be managing them as a mix, knowing that IT companies have already played very well and, in some cases, making inroads in business areas of telcos. Lastly, in this chapter, the author covers the first approach to a definition of 5G, which is important to understand the rest of the dissertation.

2.1 BUSINESS MODELS

Research on business models has thousands of articles published in academic journals, along almost twenty years, nevertheless the notion of business models is not unique (Zott et al, 2011). The business model has been defined as a system of interdependent activities performed by a focal firm and its partners, and the mechanisms that link these activities to each other (Amit & Zott, 2015). A business model describes the rationale of how an organization creates, delivers, and captures value (Osterwalder, Pigneur, & Clark, 2010).

We will use a similar approach in which business model articulates the logic, the data, and other evidence (system, rationale), putting emphasis that must be supported by a value proposition for the customer (Teece, 2010). Nevertheless, in the telecommunication industry, today the business models related to 5G are unclear. The reasons are the high-velocity markets, and the use of the new disruptive technologies (Eisenhardt & Martin, 2000; Lippman & Rumelt, 1992).

There are numerous reasons for why business model innovation is important for doing business in the 21st century. It represents a great potential to unlock sources of future value. It can be harder for competitors to copy an entire novel business model, rather than a single product or process. Because of this, companies need a good understanding of the concept, to better analyze their competitive landscape. The competitive advantage of business model innovation resides mainly, in its ability to either create a new market or allow a company, to create and exploit opportunities in existing markets (Amit & Zott, 2012).

Business models allow a common vision of:

- Who are the target customers and its understanding?
- What are the common attributes of the value propositions in the products and services of the company, and how they solve the problems of the target client? (Basically, it is the way in which the value is created for the client).
- What is the income model associated with the value proposition (to who pays and why; product/service; flat rate, etc). The income model segments of the market. Reducing it or expanding it.

In fact, the business models allow having a shared and integrated vision of how to obtain its benefits. Therefore, it is a value system on how to do business. Their understanding allows the whole company to be customer oriented and at the same time, be consistent with the way they create value. It allows hundreds and thousands of people to work in a coherent, integrated, and sustained way over time. It is very powerful and difficult to copy and modify because it integrates multiple dimensions which, in addition, are applied in a decentralized manner.

However, business model innovation can be sometimes confused with use cases. Before going further into the rest of the literature and analyzing the business cases, the next chapter compares and contrasts between use cases and business models.

2.1.1 Business Models and Use Cases Comparison

There are considerable differences between business models and use cases. A business model is a system with the rationale which integrates a value proposition, an income model and a cost structure viable to deliver it, to the target customer while, a use case is only a set of functionalities. Often, use cases are easier to see and understand, especially for technical people like engineers, since use cases do not require extra business knowledge. On the other hand, business models require education in business as methodology and group effort, to generate knowledge about the creation activity (Kirikova, 2001).

To illustrate these differences, we can take the business case of Apple and Microsoft in the earlies 80. Steve Jobs created Apple Inc. in 1976, focused on the new microcomputer technology. Apple created the first PC in the world, using a proprietary HW[5] and SW[6]. In 1981, IBM introduced their own PC, open to any HW and using the DOS [7]from the new Microsoft Corporation. Because IBM used an open modular architecture, they enabled other manufacturers to use the same hardware components. As well as license DOS from Microsoft, new software developers could count on a wide IBM PC-compatible market for their software (Steven Levy, 1998). Steve Jobs (Apple), created a use case, but the business model was not part of his worries. Bill Gates (Microsoft), instead, elaborated a complete business model oriented to create value, not only to their customers but also to their partners. This allowed him and his company to capture 99% of the market in only a few years. Apple promoted the premise that "*It just works*" (Daryl Ullman, 2018).

Another example is how Microsoft created a new business model is the Office Suite. In November 1990, Microsoft launched the first version of Office Suite, integrating packages including word processing, spreadsheet, database and used wizards to accomplish many tasks, like preparing a letter or a resume (Da Costa Andre, 2015). Microsoft Office quickly gained on the competition (Aaron Axline, 2014).

With these examples, it is clear how important is business modeling to transform a use case into a sustainable source of profit.

2.2 BUSINESS ECOSYSTEMS

An ecosystem can be defined as "a biological system composed of all the organisms found in a particular physical environment, interacting with it and each other" (Masaharu Tsujimoto, Yuya Kajikawa, Junichi Tomita, Yoichi Matsumoto, 2018). Also, in extended use "a complex system resembling this" (Oxford English Dictionary, 2017). The extended definition concept can be applicable to the field of management of technology and innovation. That is the focus of analysis in this research. Business environments are often compared to our ecological environment. The intention of this comparison is to point out the complexity of a dynamic business landscape, where many different individual organizations depend on each other to survive.

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[5] *HW stands for hardware. It refers to a computer and any associated physical equipment directly involved in the performance of data-processing, communications functions and in general any type of machine and physical equipment directly involved in performing a technological function.*

[6] *SW stands for software. It refers to the programs that can be used within a computer system*

[7] *DOS was the Operation System used by first PC compatible models, licensed by Microsoft by MS-DOS.*

In the field of management of technology and innovation, the word "ecosystem" is used in various formulations, such as industrial ecosystem, business ecosystem, digital ecosystem, IT ecosystem, and innovation ecosystem. The objective of the ecosystem, in the field of management of technology and innovation, is to provide a product/service system, a historically self-organized or managerially signed multilayer (McKinsey Quarterly, 2017).

It is known that the ecosystem is a complex system and it is self-organized. Even though, some actors seem to succeed or try to manage the ecosystem level network strategically. In digitally driven future ecosystems, the orchestrators—the operators who own the data and therefore can be the first touchpoint, and define what a customer gets, when and how—will have disproportionate power over the whole value chain (McKinsey Quarterly, 2017).

We are also interested in studying the definition of business ecosystems as value creators. There is a wide range of definitions, which tries to capture the meaning of a business ecosystem. A more generic one is, "It is an economic community supported by a foundation of interacting organizations and individuals" – the organisms of the business world (Peltoniemi and Vuori, 2004). It is also described as "A dynamic structure which consists of an interconnected population of organizations". Adding to that, it is "A business ecosystem that should be self-sustaining", that they "Develop through self-organization, emergence, and coevolution, which helps it to acquire adaptability", and that "There is both competition and cooperation present simultaneously".

Zott & Amit 7 (2010), explain business ecosystems as activity systems –which emphasizes the interdependence among entities within the ecosystem, and its role in creating value. Also, they define it as "A set of interdependent organizational activities centered on a focal firm, including those conducted by the focal firm, its partners, vendors or customers, etc. The firm's activity system may transcend the focal firm, and span its boundaries, but it will remain firm-centric to enable the focal firm, not only to create value with its partners but also to appropriate a share of the value created itself". This definition raises the importance of the ecosystem for a firm to do business, which means, that a firm increasingly needs to go beyond its boundaries and adopt a more holistic perspective to create capture value (Wei, Yang, Sun, & Gu, 2014). The last definition is the most useful in the context of this paper.

Observing the authors in this matter, it is notorious some common characteristics in the previous definitions. They seem to agree on the fact that, companies shall continuously manage and develop its business model in order stay competitive and constantly innovating and evaluating all the ecosystems generated from those business models if they want to create the value of the ecosystems. Many of the biggest winners are companies which are in the middle connecting the dots. One more time, many authors come back to the same argument,

> Is about reinventing the business model and reinventing how the customer value proposition is being created (McKinsey Quarterly, 2017).

In the past, business ecosystems were built by default, and it was not needed to integrate and coordinate them. Today, the rhythm of change makes it necessary to design the ecosystem in a consciously and integrated mode, and at the same time, the business model of each member evolves. The cost structure, even if it is going through scalability or not, determines the way they grow. Broadly speaking, there are two keystones in the strategy. The first is to create value within the ecosystem. Without value, there is no way. The second key is to share that value with other participants in the ecosystem, as a condition to leverage the ecosystem is to create value (Harvard Business Review, 2009).

From now on in this paper, each time that "ecosystem" is mentioned, it refers to the telco business ecosystem, because it is our matter of study.

2.3 DIGITAL TRANSFORMATION

Digital Transformation (DT) is the integration of digital technology into all areas of business, fundamentally changing how to create and deliver value to customers (The Enterprisers Project). Because of that, it is inevitable that the transformation of the business model to harness all the potential of Digital Transformation.

Focusing on the DT concept applicable to the telecommunication industry, it is necessary to remark the following literature review, that is critical for this paper:

> Modernizing the business and opening new channels is positive. Being a digital adapter following marketing trends, latest technologies, and pulling by technology is part of the Digital Transformation, but it is not enough to be ahead to the competence. Just integrating the technologies in the current models does not exploit all the possibilities of the technologies. It is necessary to modify the models but to transform them. It is needed to study and understand the capabilities[8] that the technology can offer (Ionology, 2016).

To capitalize on the change that DT brings is necessary to understand the concept of third platform technology. For our purposes, in this paper, "platforms" are "frameworks that permit collaborators – users, peers, providers– to undertake a range of activities, often creating *de facto* standards, forming entire ecosystems for value creation and capture". To illustrate that, Google and Facebook are digital platforms providing search and social media, but also platforms on which other platforms are built (Martin Kenney, 2015).

The approach of the third platform has emerged due to the growth of information technology, which consists of three phases, each characterized by the impact and reach of its respective platform. The first platform refers to terminals and mainframes, while the second focuses on the client-server model with the use of PCs and the Internet. Finally, the third platform is characterized by its rapid growth and enormous billions of users. Each platform is defined, not so much by the technologies, but by the scale and scope of users that the technology enables. The main forces of the third platform are the Cloud, Big Data Analytics, mobility, and social business, all of which are significant drivers of Digital Transformation (Gens, 2013).

Several use cases have been already prepared, and telcos will have a key role to provide their connectivity. Combinations of the third platform technologies that will be transformed —and already are transforming— industries such as retail, financial services, telecommunications, healthcare, and government. Today telecommunications providers are looking forward to the Digital Transformation fighting not to become a commodity (Gens, 2013). Platforms are likely, to effectively define the digital era, with the algorithm, Internet and Cloud as the building blocks (Martin Kenney, 2015).

Finally, the relationship between DT and transformation of the business model goes through the construction of an ecosystem created around a core product, which becomes a service, inviting partners, having a well-defined third platform that allows profits, and of course, totally opened to new actors.

[8] *Capabilities stands for the qualities, abilities, features, etc., that a telecommunication system can reach. Most common it refers to the potential that a network can offer.*

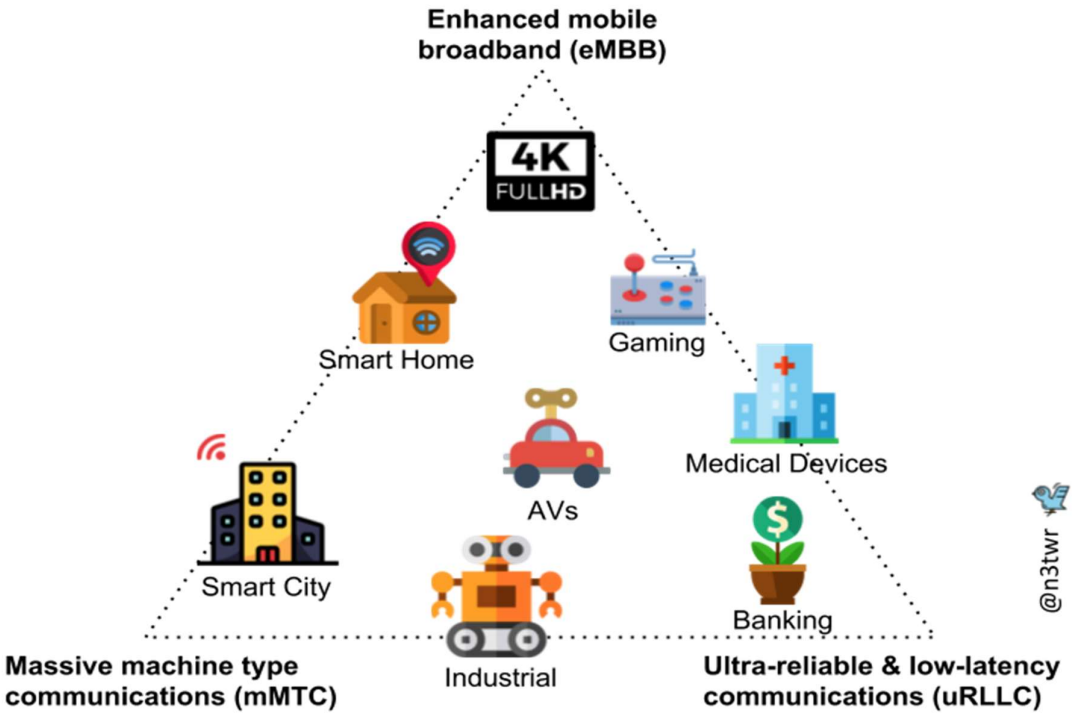
2.4 5G DEFINITION

After 40 years of the life of mobile technology, and only seven years after the appearance of the first 4G[9] mobile phone. The 5th generation of telephony 5G mobile knocks on the door and announces its commercial massive deployments by around 2020. The wireless industry is already preparing for a new generation called to revolutionize, not only the world of mobile communications but the entire economy and industry (Julio Cerezo y Pepe Cerezo, 2018).

Today, the acronym of 5G has many meanings depending on which sector it comes from, and who you talk to. For this paper, only the relevant ones, focused on business perspective are considered as follows:

5G refers to the telecommunication standard. In this context, strictly 5G is the term used to describe the next-generation of mobile/wireless networks beyond the 4G LTE mobile networks of today (SDX Central, 2018). 5G can also refers to services. According to their required KPIs[10], the new 5G services have been classified into three categories, which are:

- Enhanced Mobile Broadband (eMBB)
- Ultra-Reliable Low-Latency Communications (URLLC)
- Massive Machine-Type Communications (mMTC)



At the same time, for each of these categories, a group of use cases has been identified for a group of industries, that are called verticals. For example, if we consider that 5G is expected to play a major role in growing industry digitalization. Some of the use cases of the key industries identified are manufacturing, automotive, energy and utilities, public safety, healthcare, media, entertainment, public transport, financial services, retail, and agriculture. The manufacturing and energy/utilities and

[9] *Refers to current wireless/mobile telco standard 4G LTE*

[10] *KPI: Key Performance Indicator is a measurable value that demonstrates how effectively a company is achieving key business objectives. Organizations use KPIs at multiple levels to track performance measures.*

other sectors remain the biggest operator revenue opportunity for use cases created or enhanced by 5G such as critical control of robotics and drone monitoring (Ericsson, 2018). 5G technologies enablers support all those use cases in the digitalization of the industry, and the rest of the market. The 5G networks will heavily rely on new technology enablers like Virtualization/Cloud, Internet of Things (IoT), Network Slicing (NS), Big Data Analytics, Augmented Reality[11]and Virtual Reality[12] (AR/VR), Machine Learning (ML), etc. Together, they will bring flexibility and network programmability in future architecture (Marco Gramaglia, 2018).

5G is also used to generalize some characteristics and values, with social and economic impacts at a non-technical level like:

- 5G is far more than just a new radio interface [13]with faster throughput[14]. It has the potential to change the way people live and transform the way businesses work in nearly every vertical industry (Nokia, 2017). 5G uses newer bands to make the best use of the available spectrum. This will enable 5G to offer unprecedented user speed and experience for mobile broadband applications. New apps based on technologies such as Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI), will be created, especially since some of these applications require latency that only 5G can offer.

[11] *Unlike virtual reality, which seeks to immerse the user in a completely virtual environment, augmented reality enhances the real world using digitally produced perceptual overlays.*

[12] *Virtual reality is a broad term for a multi-sensory computer-generated experience that allows users to both experience and interact with a simulated environment.*

[13] *The radio interface refers to Radio Access Network (RAN). It is the part of the cellular network through which the mobile devices can establish connection to the network. Basically, it resides between a mobile device/user equipment and the core network, like antennas and radio receivers.*

[14] *Throughput is a measure of how many units of information a system can process in a given amount of time.*

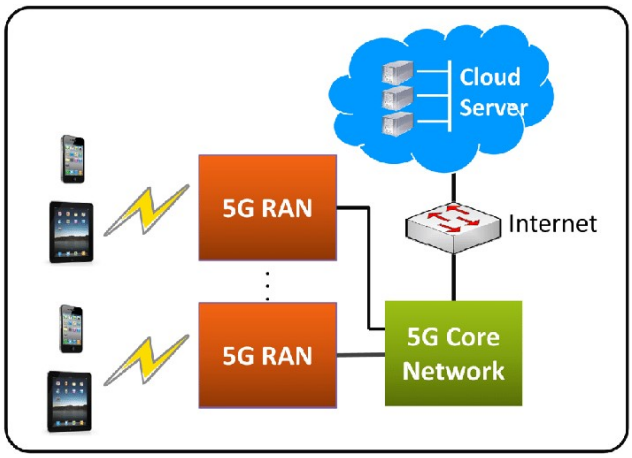
- 5G is expected to enable the next level of human connectivity and human-to-human or human-to-environment interaction, with a large impact on society and industry (Marco Gramaglia, 2018). Some examples of it are Virtual Reality (VR) and Augmented Reality (AR).
- New use cases are being defined and considered as part of the 5G definition itself (Jose A Rubio, 2018), some of them will be explained later in this paper.

Before services or products will be available commercially for final customers, telcos will have to put all the technical resources needed in place for the network. This process is called "integration". In addition to the complex performance, the 5G environment presents new challenges in terms of timing and agility for these integration activities. The time it takes to get new features into the network, and the time it takes to put services in the hands of users, need to be minimized. Tools to enable fast features introduction are a prerequisite. Above all, overcoming the challenges requires a dynamic 5G network (Ericsson, 2018).

Another key of 5G as technology is that it is being architected and deployed depending upon how the network is used.

It is simple, the network will change dynamically following the needs in real time. For example, video traffic is expected to grow substantially making it necessary to provide higher speeds for applications such as streaming video, video conferencing, and Virtual Reality (SDX Central, 2018).

The 5G network architecture is composed of Radio Access Network[15] (RAN) and the Core Network[16] (CN), they would include both physical (PNF) and virtual network functions (VNF) supported by a distributed or a central Cloud (Ertan Öztürk, 2017). There is much more to introduce about 5G, than simply deploying new radio interface technology. For a successful 5G launch, the operator needs to secure a network platform, that includes end-to-end (E2E[17]) capabilities aligned across devices, CN and management systems Then, 5G is a technology transformation for operators striving for more flexibility and speed in network deployment —and with an expectation of being able to address new business opportunities (Anders Hillbur, 2018).



A not less important definition of 5G is in terms of economics. In Europe, the 5G deployment will represent approximately € 56 billion in 2020 (EU 28). In the US, the deployment of 5G in Smart Cities could create up to 3 million jobs. Operators are expected to invest around USD 275 billion in infrastructure by 2024 (Accenture, 2017), and globally 5G value chain will invest USD 200 billion annually, 5G will create 22 million jobs (IHS, 2017). Developed countries have already begun implementing 5G networks like Japan, South Korea, China, and the United States. Operators from

[15] *Radio Access Network (RAN), is the part of the network through which the mobile devices can establish connection to the network. Basically, it resides between a mobile device/user equipment and the core network, like antennas and radio receivers.*

[16] *Core Network (CN), refers to the high capacity communication facilities that connect primary nodes. A core/backbone network provides paths for the exchange of information between different sub-networks.*

[17] *The end-to-end principle is a network design method in which application-specific features are kept at communication end points. The intention in this paper refers to a service that is offered using a connectivity from starting point to the final one.*

these countries will be the first to transform their infrastructure, business models, and internal culture to meet the new demands of 5G networks (Volodymyr Krolivets, 2017).

Concluding our first definition for 5G, the engagement from all parties is essential to make 5G a success story and make any industry digitalization a reality (GSA with contributions from Ericsson, Huawei, and Nokia, 2017). The essence of 5G is about digital services to individual consumers, and the business model refreshing for industrial players. In the 5G era, because the Digital Transformation, fueled by the power of mobility, Cloud and broadband, is taking place in almost every industry. The society will be further tightly connected with the digital world, digital changes will take place even faster with enlarged scope in manufacturing, health, education, airline, transport and more (Fu Jianjun, 2019). New use cases are emerging for consumers, enterprises, and industries. This opens for new business opportunities for both operators and verticals.

3. LITERATURE REVIEW

This chapter begins with an overview of telecommunication business model's evolution, as a specialization of the generic business models. Later, the most relevant technologies systems in 5G will be deployed from the business view. The section ends with the identification of the research gap that informs the Research Question of this paper.

3.1 DIGITAL TRANSFORMATION IN THE TELECOMMUNICATION INDUSTRY

People are becoming more and more dependent on communications networks, for both business and personal use. Internet usage by mobile and tablet devices has exceeded desktop users worldwide. The global smartphone installed base was less than half a billion in 2009. Nowadays, the smartphone is a more capable and sophisticated platform than any previous-generation PC. It is equal to a pocket supercomputer. Also, is worth mentioning, the explosive growth of mobile traffic (Volodymyr Krolivets, 2017).

All those facts have a huge impact on the telecommunication industry. Yet, they are just some of the factors influencing the industry. In chapter 2.1, the baselines for a generic definition of a business model was done. This chapter will cover the role of the communication industry, how it is evolving in time, the challenges of driving innovation, and the ingredients for a successful future, finding out on how the business models' need to develop the capability to follow the technologies trends to be innovative (Henry Chesbrough, 2010).

The relationship between technologies and business are turning the balance towards the innovation in the business models than in the technology. Some authors go further affirming that a mediocre technology pursued within a great business model, may be more valuable than a great technology exploited via a mediocre business model.

> The economic value of technology remains latent until it is commercialized in some way via a business model. The same technology commercialized in two different ways will yield two different returns (Henry Chesbrough, 2010).

3.1.1 Telecommunications Business Models Evolution

The telco industry has passed through several huge transformative stages. The transition from analog to digital with the emergence of a global standard (GSM) occurred in the 1990s. Then it came 3G, that brought data and web services to our lives. Finally, as the latest step, 4G came to our devices, which led us the mobile broadband, which can transmit much more information than ever with thousands of applications.

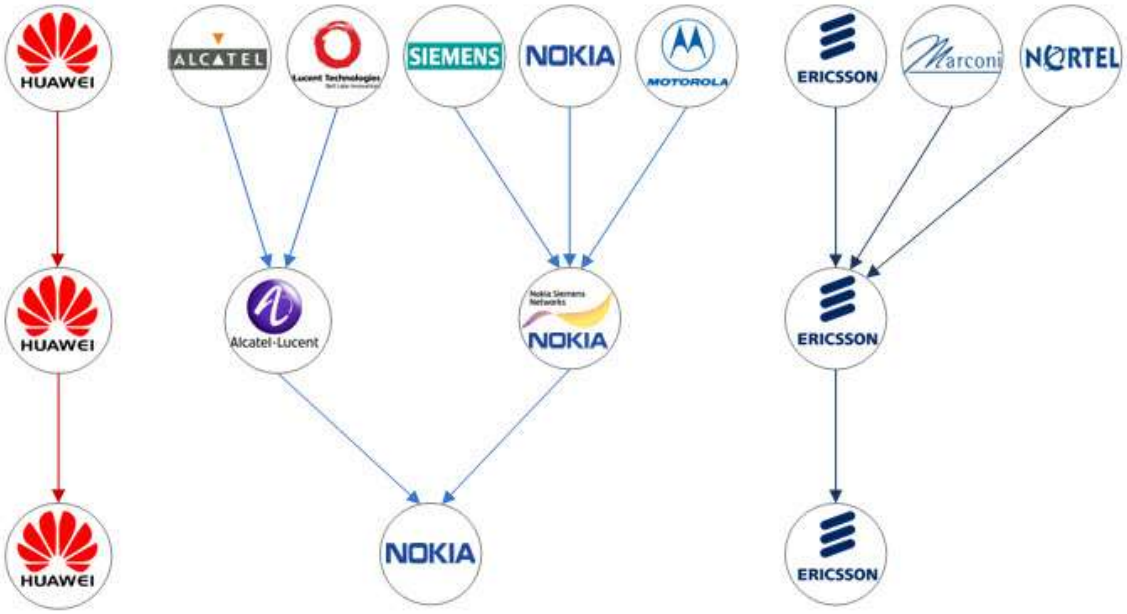
The traditional business models used for decades by telcos were focused around connectivity and subscriptions. In fact, most of today business models are based on post-paid methods where the unit for prizing is the bandwidth and the number of subscribers. Many factors become increasingly difficult to offer extra values to the market. However, the DT revolution is creating value elsewhere in the ecosystem (Jamie Davies, 2018). 5G is a "game changer", creating new business models and roles for both operators and vendors. The models that have been in operation for the last 10 years, they will not work for the next decade (Volodymyr Krolivets, 2017).

CLASSIC TELECOMMUNICATION ECOSYSTEMS

Consider some classic telco operators like ATT, Movistar, Vodafone, Sprint, Telecom or any other in the world. They offer telecommunication services to final subscribers (people using mobile phones or

ADSL or fiber). In the other side, we have the classic telco vendors like Ericsson, Nokia or Huawei. They sell products and services to telco operators/providers to equip their networks with HW and SW needed. For regular people (out of the telecommunication sector) is relevant to do not confuse the cell/mobile phones manufactures with telco vendors. Just in some cases, the same company can act in both areas, but from the business, perspective is a totally different case. Telco vendors do the main business with telco operators –from enterprise to enterprise level. In the case of the phone, manufacturers are doing business with final users selling terminals (cellphones[18]) –this last case is out of the scope of this paper.

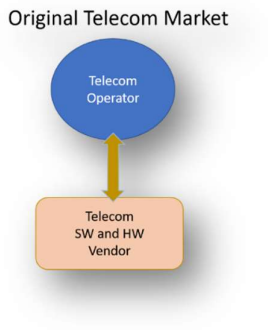
To illustrate with real examples, Ericsson is a telco vendor, but it is not cellphone manufacture (it was in the past). Huawei acts today as telco vendor and also as a mobile manufacturer. The following picture shows the main acquisitions inside the telecom vendors market throughout the last years.



ORIGINAL TELECOM ECOSYSTEM

Let study, how telcos operators and telcos vendors made business in the past in a closed ecosystem. The business model was composed by a telco operator that buys big or even entire parts of their network infrastructure and services to telco vendors.

[18] *Cell stands for cellular about a mobile phone.*



Telco[19] Operators

Traditional telcos and data communications providers, mobile network operators.

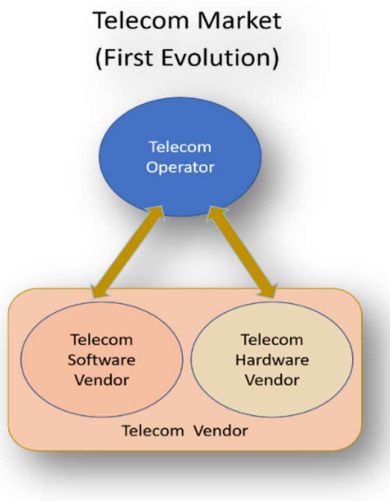
Telco SW and HW Vendors

They provide HW to be used by telco operators worldwide. They design, develop, test and support their own SW to be used in their proprietary HW.

For example, Operator A buys a part of their network to vendor B and another part to vendor C. It was a closed ecosystem with 2 or 3 main actors, all of them are big companies fromthe telecommunication industry. Telco vendors only had to worry about integrating[20] its own products within the operator network. Integration challenge is lower for these solutions based on single-vendor because it's only one set of programs/protocols to integrate into an existing system (Henry Cheang,2014).

MULTI-VENDOR TELECOM ECOSYSTEM

Virtualization technology allows the HW and SW decoupling (chapter 3.2.1). The ecosystem has Telco vendors which sell HW and SW independently and integrate them in the telco operator networks. At the same time, operators could "mix" SW and HW from different vendors. Due to this technology, some new actors (non-telcos), entered to the telecom market, offering specific pieces of HW or the SW independently. The main interest for operators was to decrease the costs of HW since they can re-use the same HW for different SW. The following figure illustrates the actors and their business.



Telco Operators

Traditional telcos and data communications providers, mobile network operators.

Telco Equipment (HW) Vendors

They provide HW to be used by telco operators worldwide.

Telco Software (SW) Vendors

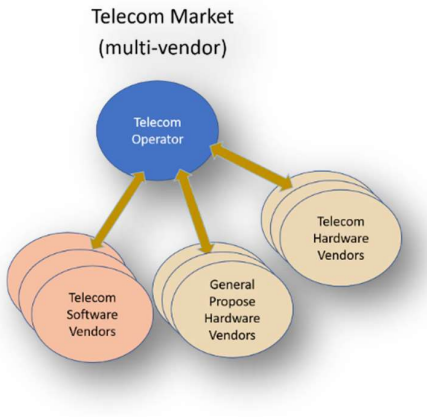
They design, develop, test and support the SW to be used by telco operators worldwide under generic HW, in most cases, this HW was provided by others.

[19] *Telco and telecom are used as synonyms.*

[20] *In the telco industry, "integration" is the term to indicate that parts of a new system (HW or/and SW) start working together for the already existing parts. This represents an outsize challenge for the telcos where many small parts from different vendors must work together.*

Traditional IT architectures have typically been based on computing resources dedicated to specific applications, as well as over-provisioning [21] to accommodate peak demands and potential future growth. Virtualized systems have replaced these silos with a layer of shared resources. It has reduced IT costs, by improving infrastructure efficiency, and by enabling greater flexibility as organizations, and the scale of their environment. However, Virtualization also creates new challenges for the data center, virtual and cloud environments are dynamic and become infinitely more complex as they scale. This paradigm shift demands a new understanding, which requires a new approach to solve the increasingly complex problems they create (Turbonomic, 2019).

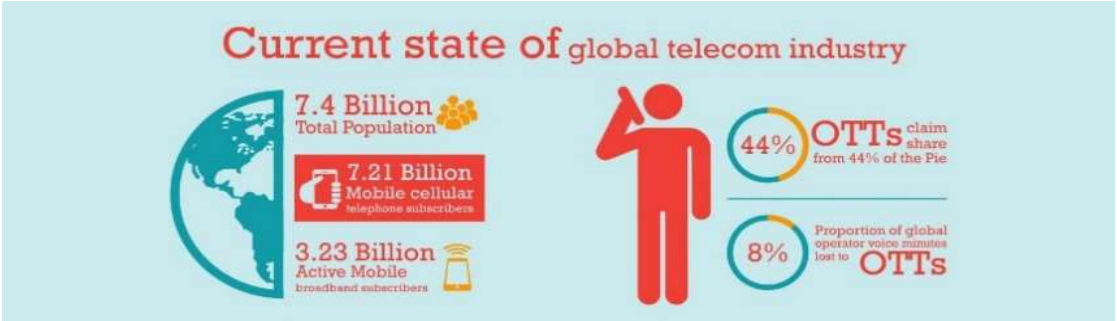
When Virtualization and Cloud reached the telco industry, a multi-vendor scenario started to develop in most of the operators. So, the new enforcement for operators is how to build a working solution from, separate individual modules and from different sellers. Multi-vendor solutions typically require more effort to put into place, because operator and vendors must coordinate the integration of disparate (and potentially incompatible) systems (Henry Cheang,2014). This is the most typical telco ecosystem today, where a telco operator deploys solutions buying infrastructure (HW/SW) to different vendors from different industries (telco and non-telco). This scenario is called a multi-vendor. Today, hand in hand with digitalization, the design of complex telecommunication networks and infrastructures in general, are being created by ecosystems like is shown in this figure. Business models are created at the same time designing the ecosystem.



3.1.2 OTTs and Telcos, Friends or Enemies

3.1.2.1 OTTs Background

This brief analysis of the current telecommunication ecosystem status will not be complete if we do not consider the OTTs. OTT stands for Over-the-Top, the term used for the companies that offer the delivery of film, TV, Cloud services and in general any kind of content via the Internet. Examples of OTTs are Google, Netflix, Amazon, etc. Since OTT apps and services are delivered over the Internet, users still need a broadband connection (fixed or mobile), which they usually get from telcos companies. Nowadays, in 4G, the market is moving faster than ever, and OTTs are leading it. The numbers talk by themselves: there is a business of billions of dollars and the evolution in the model is coming from the OTTs. Netflix had 93.8 million subscribers globally in 2015 (Digiday, 2015) and is quickly approaching 150 million subscribers in 2019 (CNN, 2019).



[21] *Install more resources that which are need from the starting time in prevision of future peak cases. Most typically case is to install hard disk with extra storage capacity. The application of this term in this paper is wider that just to overprovisioning disks.*

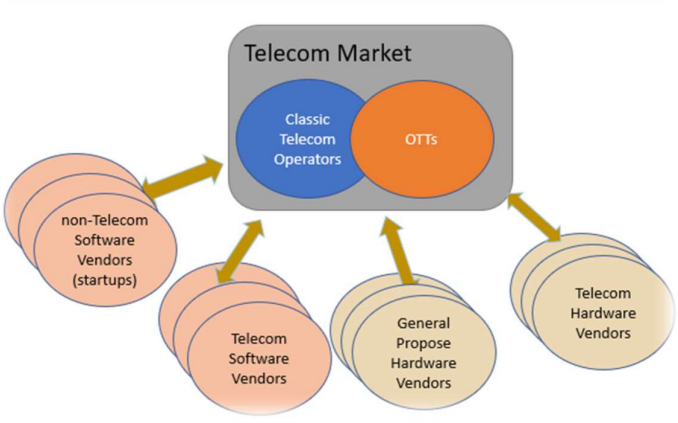
OTT players offer a wide array of digital content, broadcasting, and streaming services for consumers over the web. These players have also increased their dominance in former core telcos services like text messages (like WhatsApp, with 300 million daily active users worldwide) and voice calls. With this, OTT players have taken a huge chunk of telco's market share, decreasing its revenue and diluting its value proposition. Telcos are left with no choice, but to adapt. For telcos what worked in the past… it will not work in the future. In the past, services and networks were designed for a specific use and for one device. For example, a VPN (virtual private number), service that allows "short numbers" inside the companies, is implemented in ad-hoc HW/SW and it was specially designed for mobile phones. Today, the scenery is to have new services that require:

> The multiplicity of services + multiplicity of devices + multiplicity of networks and multiplicity of ecosystems (Dean Bubley, 2012).

Nobody better than OTTs has understood how to use the new disruptive technology to make business, and who is demanding it. Today, the use of the Internet is characterized by high levels of smartphone ownership and access to high-speed broadband. 32% of the world's population that falls under the age of 25 is fueling the digital disruption within the telecommunication industry. While this digital disruption pushes telcos to change the value proposition of its current offerings, the industry continues to battle pain points like commoditization of services, bandwidth issues. These issues have determined the capacity of telco companies to fully embrace digital disruption. This also means that telcos have not been able to monetize most of the digitized data running over their networks, probably because of the high initial cost.

3.1.2.2 OTT as New Players in The Telecom Ecosystems

This scenario has made the telcos sector vulnerable to the competition, posted by future-ready digital entities like OTT players. This is basically since the costs to start an OTT, new services, and the infrastructure required, is almost nothing comparing to the enormous cost that telcos must spend to maintain and update their cellular networks (core and radio).



To capture the market and avoid being only pipelines, major telcos players are already preparing the rolling-out[22] of the 5G networks but, they are also providing services like OTTs. Today, before 5G will be commercially deployed, OTTs and classic telco operators, both, are part of a new telecom ecosystem. We are in the middle of a transformative and evolutionary change in the telco industry. The movement is towards a partner-based ecosystem, with contributions from many external partners (Andrea Parascandolo, 2019).

5G encompasses the whole end-to-end network architecture. The telco vendors within its role in the telecom ecosystem can help telco operators with their ongoing transformation strategies, outlining

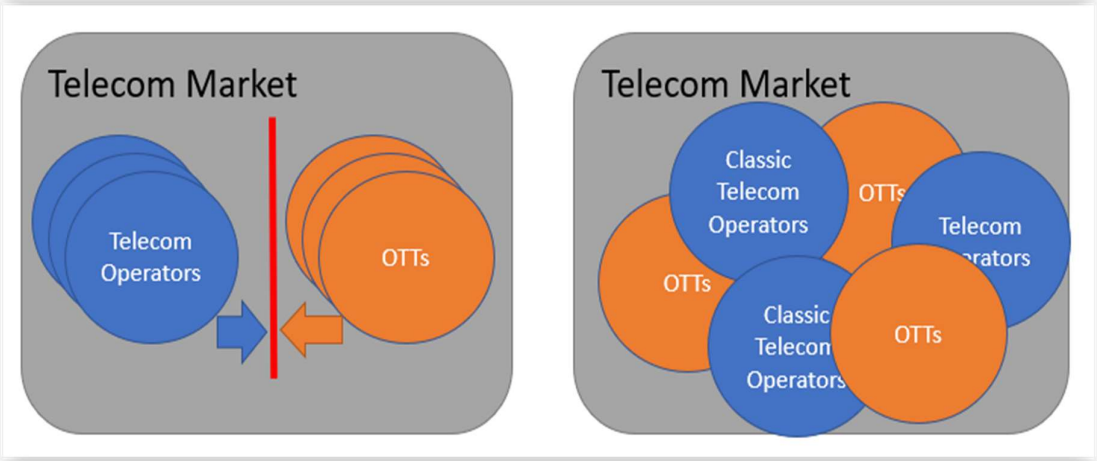
[22] *It is a term used when a new network deployment is done.*

the key technologies and innovations. The disaggregation trend is continuing and is opening new opportunities to for many vendors, along with allowing new players into the ecosystem, but the big prize for 5G is the Digital Economy - the emergence of new digital businesses and increased Digital Transformation by vertical industries (Phil Davis, 2019)

3.1.2.3 Friend or Enemies

Reality shows that, while telcos are striving to maintain and expand an increasingly complex, multi-domain network infrastructure (chapter 3.1.1), they must simultaneously provide optimal customer experience, if they intend to keep their subscribers happy and prevent costly churn (Andrea Parascandolo, 2019).

Today the literature is not conclusive. Some authors put telcos against OTTs, within a competitive edge, but others join them, to create an extra value ecosystem within a rich new telecom market. In the following figure, both models are graphically shown.



Both models will continue to evolve with 5G towards open ecosystems, with the arrival of new actors coming from other industries (non-telco). All of this is possible due to the evolution and the maturity of some technologies. New players like OTTs and startups are needed in these open ecosystems. Next chapter is about, how these technologies are modifying the business models.

3.1.2.4 Telcos and OTTs First Alliances

We do not know today, how the new business models will be in 5G. After the literature review, we can affirm that, if telco companies (operators and vendors), will not be open to afford these dramatic changes, they will be cut off from the market sooner or later. Telcos must create value propositions within new ecosystems, in which operators be integrated with the OTT services and verticals like hospitals, industries with many robotic parts, smart cities, farms, etc.

OTT vs. Telcos

Part of this, it is already taking place today with 4G considering the first "big alliances" that are beginning to consolidate. Some examples that have been defined recently:

- Movistar offers Netflix in its digital platform Movistar+ (movistar.es). Of course, the impact of the 5G introduction in the society will be at another level, compared with this simple example. In this case, the ecosystem is composed of a big telco operator and one of the most important OTTs in the world.

- March 25th, Verizon and the NFL announced (Verizon Wireless Newsroom, 2019), an innovative partnership to jointly develop new products and services that utilize 5G to enhance NFL games and the overall fan experience. This innovation partnership positions Verizon as "The Official 5G Innovation Partner of the NFL," and will initially include three pillars:
  1. In-Stadium Experience – Verizon and the NFL will develop new in-stadium mobile features designed to enhance the in-stadium fan experience by harnessing the power of 5G.
  2. 5G Mobile Gaming Challenge – Verizon and the NFL will call on game developers to create one or more NFL themed mobile games powered by 5G. The game(s) will be designed to showcase the power of 5G in gaming by taking advantage of low latency to enable higher quality experiences.
  3. Emerging Video Streaming Technology – Verizon will explore the use of 5G to stream volumetric video, an emerging media format, for the development of new fan experiences and applications.

In this case, the ecosystem is composed of a big telco operator and one important vertical in the US.

- Another recent example of collaboration is the case of Telefonica that selected Google and Vodafone that selected IBM as cloud partners for enterprise services. Obviously, this puts pressure on other EU operators. More than any other market area, the EU is a combination of an integrated economy and a political federation with a lot of former national competitors in the telco space. A unified vision of cloud features, not a vision that separates operators from the rest of the market could be positive. Operator (telcos) interest in partnering with cloud providers (OTTs) might help with that. It seems that we have perhaps two years as the window where this will all play out. My model suggests that if operators don't achieve at least 60% of the opportunity-driven optimum carrier cloud deployment by 2022, they are unlikely to make the shift to the carrier cloud at all. At the current pace, we'd be lucky to get 30% of the optimum, so something radical has to happen (CIMI Corp, 2019)

3.2 5G TECHNOLOGY SYSTEMS

This section analyzes a group of technologies identified as keys, in the Digital Transformation that is combined as a system, they will be enablers to make thousands of new use cases possible in 5G. This paper will be focused on social and business aspects, to allow the author to reuse them later in the Research Question. Technical level analysis of these technologies is out of the scope of this paper.

5G is the 5th generation of mobile[23] connectivity (chapter 2.4). Four years ago, LTE or what we know as 4G, connectivity arrived to shake the smartphone world, and boost data transmission speed, so we are familiar with this concept. However, it seems that what we experienced at that time, will pale in

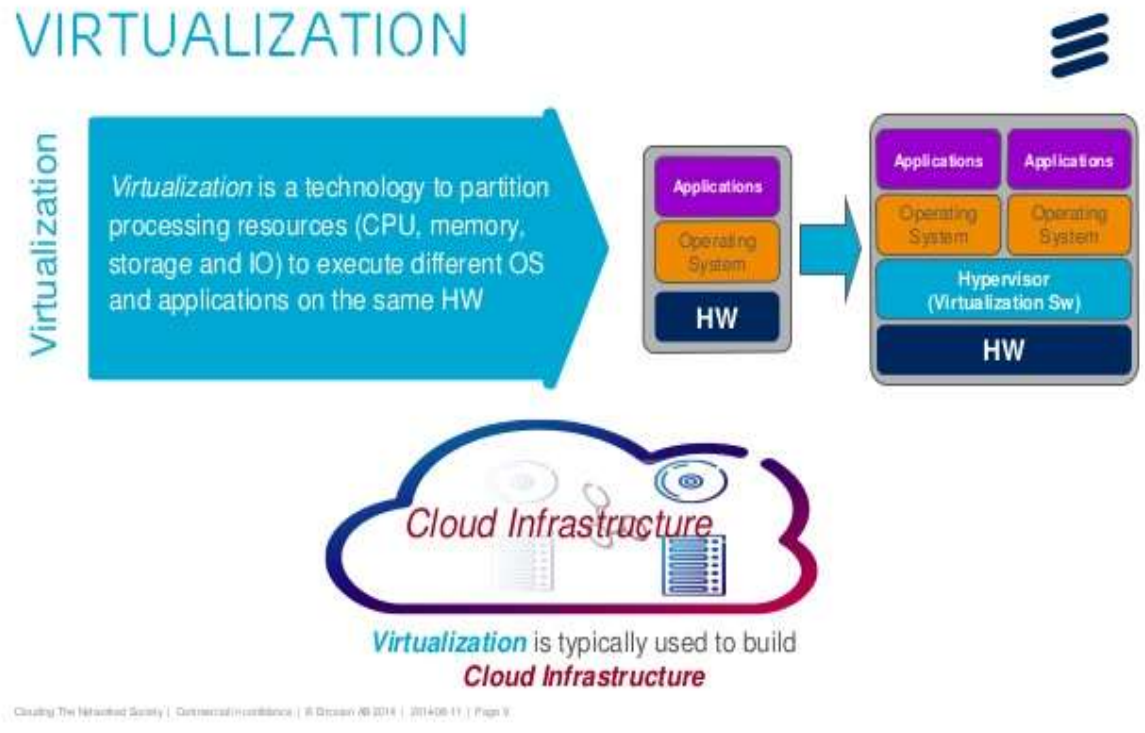
[23] *Mobile is normally used by many authors as synonym of cellular or wireless. For this non-technical research, it is used any of them indistinctly.*

comparison to the vast array of possibilities carried under its belt by this new generation of wireless connectivity, which is being built over the foundations of the previous one (Gizmodo, 2019).

From 1G to 4G, mobile communication has been constantly changing the behavior the experience and lifestyle. 5G technology will provide a common base to a more cost-efficient, open, interoperable and large eco-system, enabling solution platform for the various vertical industries. Coming to the 5G era, mobile communication will further change our society. To enable such vision, it is essential to have a deep understanding of the various requirements of the vertical industries, and serve them without sacrificing efficiency, while keeping costs low (GSA with contributions from Ericsson, Huawei, and Nokia, 2017). In fact, 5G is addressing to more stringent and business-critical requirements of the vertical industries. 5G will provide an industry vertical optimized platform (chapter 2.3), catering in an economical way the various requirements, and business needs of each vertical. For service providers, to offer these capabilities to vertical industries in an attractive, scalable and economical way. They will use Cloud platforms, analytics, system automation, and Network Slicing technologies, as well as new business models. This will be explained later in this chapter. Only some of the 5G technologies are mentioned here as follows.

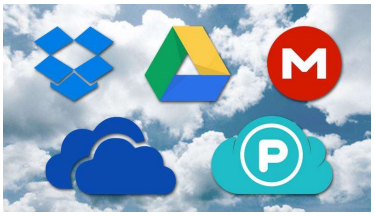
3.2.1 **Telco Clouds**

The hardware (HW) in the IT industry (chapter 2), is categorized as either compute, storage, or networking. Virtualization technic is focused on bringing these HW resources (functions), to a virtual entity abstracted as a piece of software (SW). Basically, it can be understood like the digitalization of the HW. The functions, that were executed in the past in a physical bare metal deployment, are now virtual functions (VF). In a data center (DC)[24], we find several virtual functions that run over generic HW (HW from different vendors). The big advantage is that several VFs can run together under the same HW, reducing the cost of acquisition and maintainability of the HW.



[24] *Data Center is a facility used to house computer systems and associated components, such as telecommunications and storage systems. Today, Cloud solutions are in big DCs*

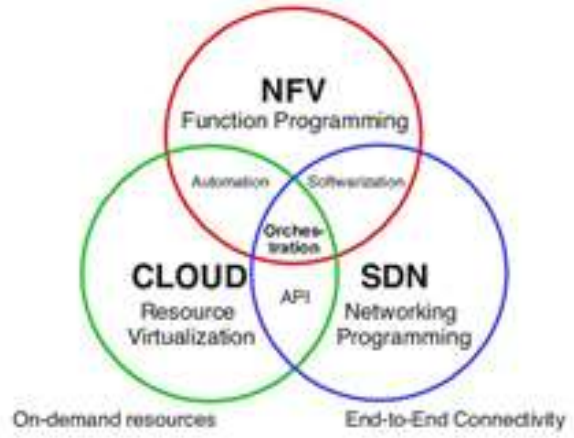
A Cloud is a modern concept that groups several mechanisms to manage all those resources (HW and SW) together. Some Cloud characteristics like automatization[25] and scalability[26], redundancy[27], resiliency[28] and many others, offer a perfect baseline to the developing technologies that we will study later in this chapter (Jackson and Goessling, 2018).



Some IT Cloud examples are Google, Azure, and AWS (Amazon Web Services) that are in one same infrastructure, marketplace and ecosystem. They provide infrastructure and tools with which others can build their application like Netflix, Airbnb, and Uber that are forcing deep change on quite different businesses are residing in the same Cloud (Martin Kenney, 2015).

In fact, Cloud technology opens new lines of business models based on those new capabilities that Cloud offers (Gens, 2013). With the advancement of Cloud computing, new services can now be rapidly provisioned, managed, and operated with minimal effort (Desmet, Maerkedahl and Shi, 2018). This is the case where new services must be introduced in existing infrastructure since they can be installed without adding new HW. The integration cost in terms of time and money is less, compared with a non-Cloud environment. This allows an easy and automatized network management and orchestration.

Within the Digital Transformation (DT), the telecom ecosystem definition explained in 3.1, plus the IT Cloud, we have the baseline to focus on Telco Clouds which is one of the pillars for 5G. Based on the Virtualization technics and IT Clouds, the telcos adopted and expanded them towards their own needs. New architectures, like Network Functions Virtualization (NFV), allow network operators to manage and expand their network capabilities on demand using virtual, software-based applications, where physical boxes once stood in the network architecture. This makes it easier to load-balance, scale up and down (scaling), and move functions across distributed hardware resources. With continual updates, telco operators can keep things running on the latest software without interrupting their customers. The implementation of the specific functions of NFV is called Virtual Network Functions (VNF). Now, most of the telco service providers are driving a transformation to Network Functions Virtualization (NFV), which moves network functionality to software and leverages commercially available, commodity server hardware from the IT sector and teams with a Virtualization technology (Dell, 2016).



Another relevant architecture to be mentioned is the Software Defined Networking (SDN). It provides a powerful complement to NFV's ability to maximize the utilization of hardware resources. SDN allows a service provider to expand the bandwidth capacity, the geographic reach of the network, flexible and easy, across a multi-vendor network of devices, from a centralized management center (Dell 2016).

[25] *Automatization in this concept refers to have automatic process that are triggered and executed without a manual intervention*

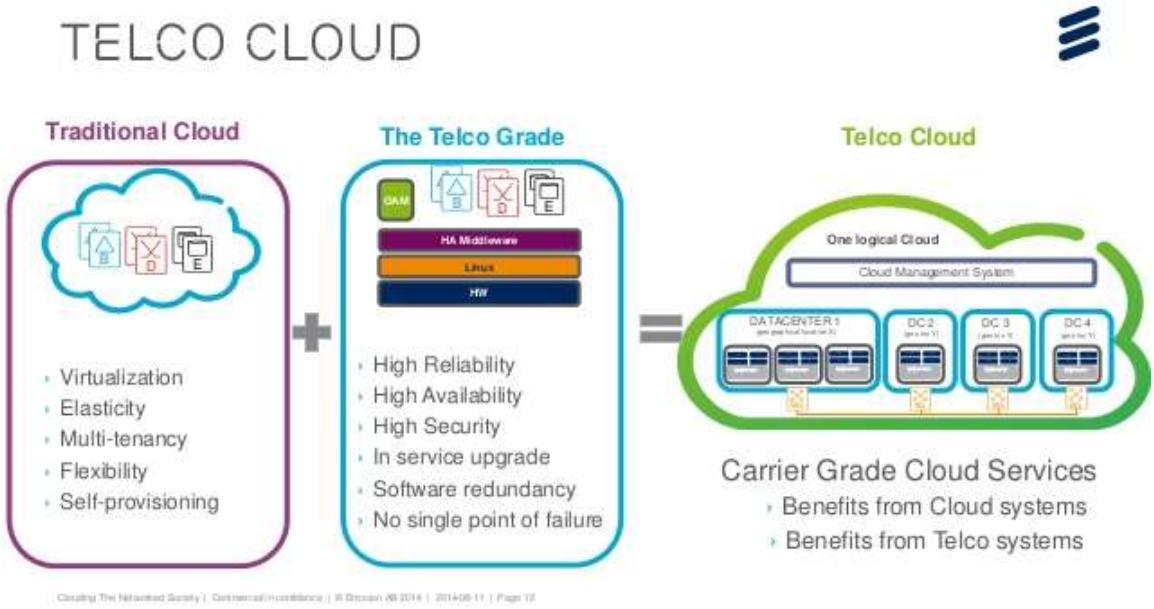
[26] *Scalability or scaling: the possibility to grown and decrease their own resources in real time*

[27] *Redundancy: the possibility to switch to other equal systems in case of failures*

[28] *Resiliency: the ability of a network to recover traffic affected by failures*

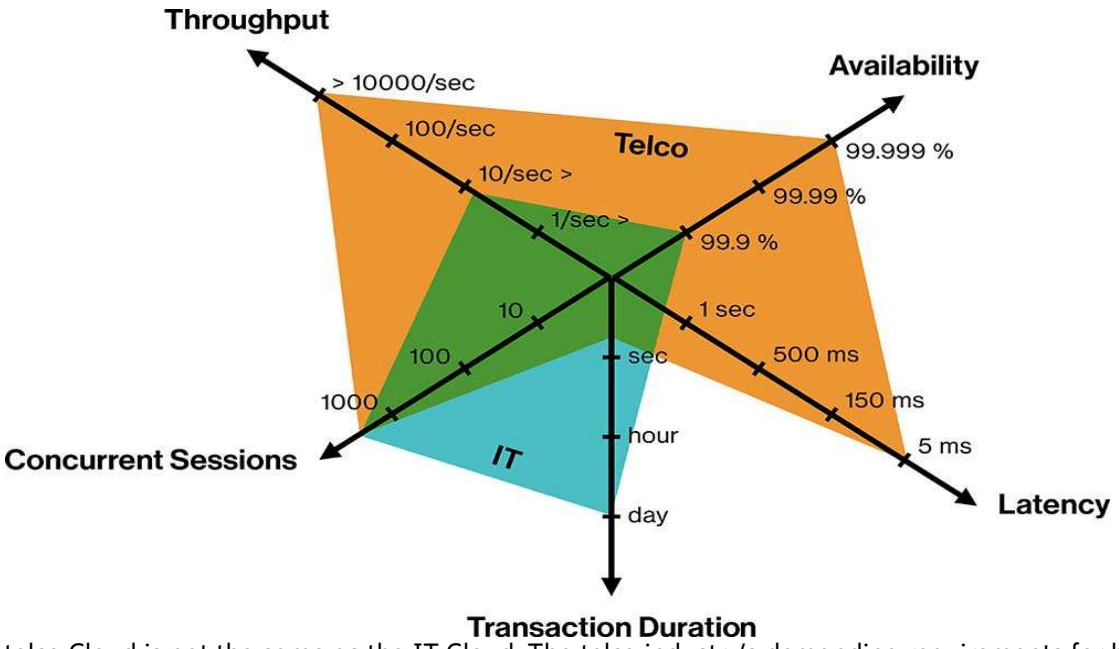
NFV (Network Function Virtualization) and SDN (Software Defined Networking) are the main Cloud-centric technological advances, appearing in the market today. After a slower start than initially anticipated, the NFV/SDN market will expose moderate growth through ongoing investments by major telcos.

NFV/SDN and service orchestration are the approaches that are going to make telco networks and operations more agile, programmable, and Cloud-connected. They also want to be more innovative, to achieve faster time-to-market for services and products and start to regain the business lost to OTT players. But NFV and SDN present a challenge: how to manage an increasingly divergent set of capabilities, policies, features, and functions (Volodymyr Krolivets, 2017).



NFV can help businesses move beyond traditional proprietary hardware, and achieve greater efficiency and agility while reducing operational costs. To harness the capabilities that NFV has to offer, service providers not only have to simplify operations but also increase the speed at which digital services can be deployed and managed. To support this is critical the automatization and orchestration of the complex processes across multiple domains and functions (RedHat, 2019)

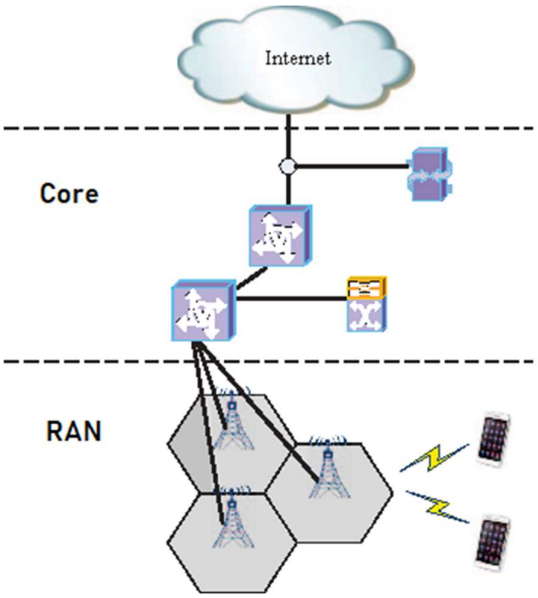
In this context, with the success of Virtualization and Cloud computing in the enterprise ITs, telco network operators and service providers are looking to the Cloud a way to reap the same benefits: the economics of scale, cost-effectiveness, scalability (Dell, 2016), and orchestration. If we combine NFV, SDN and Cloud technics, we build a typical telco Cloud as are shown in the figure the illustrates a simple difference between IT Cloud and telco Cloud requirements (Volodymyr Krolivets, 2017).



A telco Cloud is not the same as the IT Cloud. The telco industry's demanding requirements for high levels of availability, latency, and throughput, must be met. These are still mandatory in the telco industry (Jackson and Goessling, 2018).

Adding NFV and SDN techniques, we reach the scale, performance, flexibility and other requirements for 5G. From these foundations, 5G will build a system of technologies that will be constructed over like, Internet of Things (IoT), Network Slicing (NS), Machine Learning (ML), etc. Even if some of them have already existed before telco Cloud, they are expanding to new horizons (Jackson and Goessling, 2018).

Another important aspect is that telco Clouds are not an only key enabler for 5G Core Networks (5G-CN), but also, it plays a key role in 5G Radio Access Network (5G-RAN).

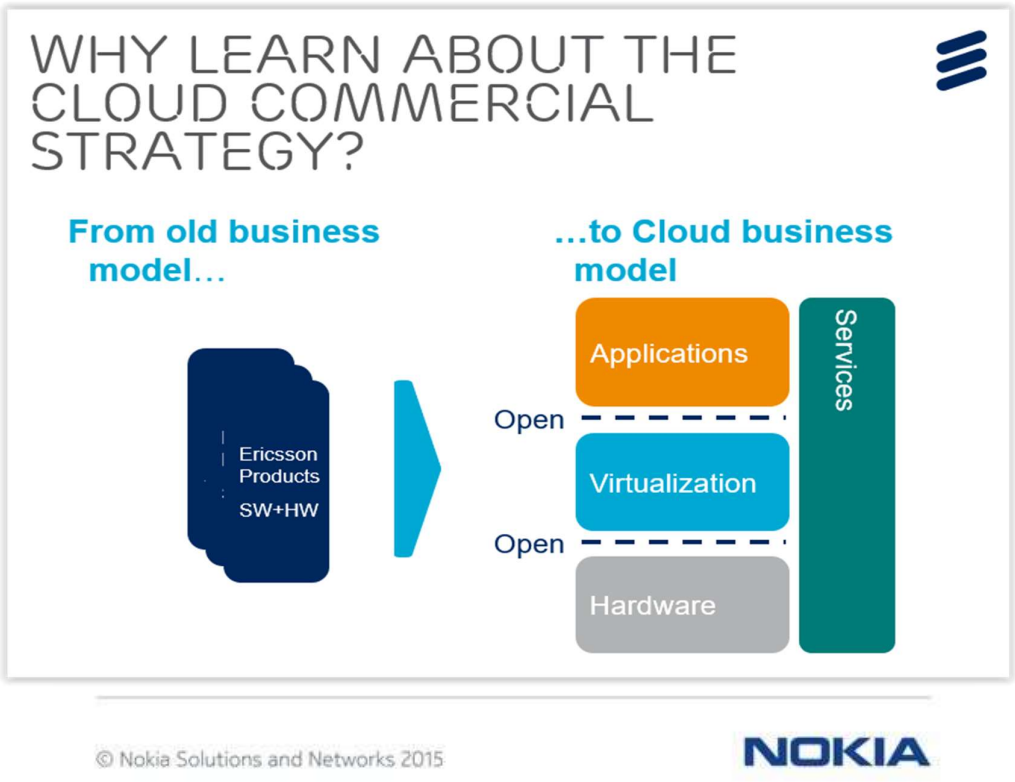


The evolution toward 5G mobile networks will be characterized by an increasing number of wireless devices, increasing device and service complexity, and the requirement to access mobile services ubiquitously. So, in this context Cloud technology is perfect to provide this 5G-RAN realization (Rost, Maeder, Carlos J. Bernardos, Antonio De Domenico, Marco Di Girolamo, Lalam, Dario Sabella and Wübben, 2014). For example, any 5G use case based on Network Slicing (chapter 3.2.2) will require that both, CN and RAN will manage the dedicated slice from end to end (E2E).

Focusing on the Cloud's commercial perspective, the study of how the business model has changed from a model based on monolithic products (HW+SW together), to selling a flexible model based on telco Clouds, results relevant. The HW, the virtual applications, and the services are sold independently. In 5G, subscribers will benefit by gaining a better experience, because of rapid network

adaptation to demand and the introduction of new services, which previously might not have provided enough return to justify the investment (Thulasi Kumar, 2018).

Source: Commercial Product Strategy, Ericsson 2016



The telecommunication industry has been entirely disrupted by the Cloud. Being a Cloud player means today to have a future or be out of the game (Rufus Grig,2018). Cloud services from telcos provide a key opportunity to move up the value chain, from the inevitable utility business of networks and connectivity. Offering a rich Cloud platform that enables local IT providers, telcos will have the possibility to scale their businesses (Arthur D. Little, 2013). This represents a first big change in the pricing and selling model in the telco industry and it was 100% originated by this technological evolution.

It seems to be a consensus in the literature, in terms that Cloud brings higher growth and dynamic services business creation than ever. Cloud truly offers a disruptive way to take full advantage of it, and it is a great example of how telcos can be innovative and offer new services. Due is undertaking advanced levels of preparations to deploy 5G services this year (Dr. Ayman El Nashar, Mobile World Congress 2019, Barcelona, Spain).

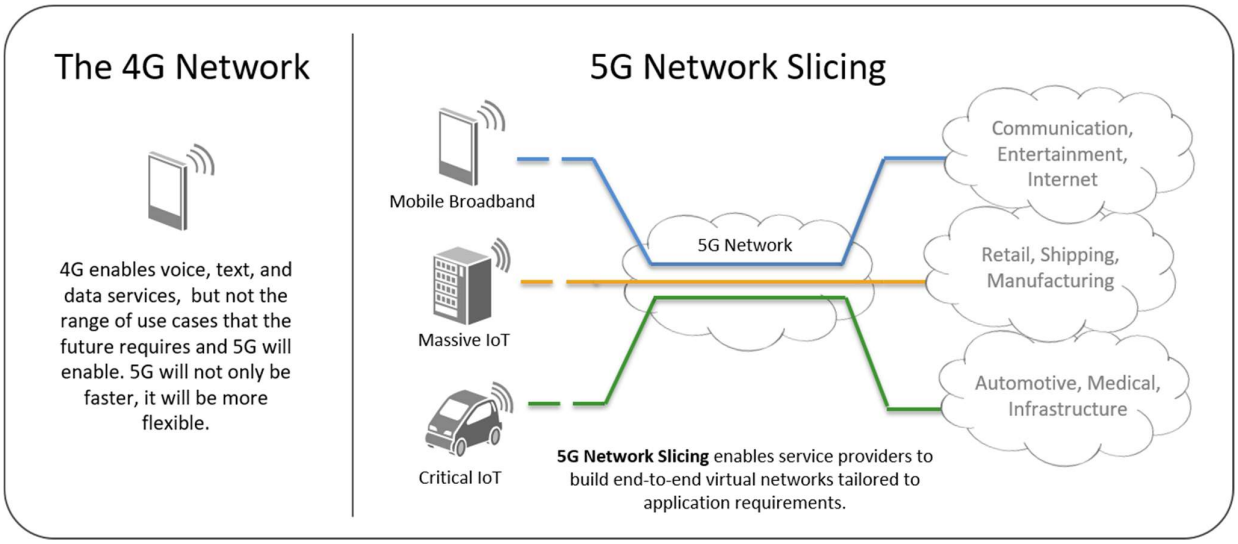
3.2.2 Network Slicing

One of the characteristics of 5G technology is the possibility of 'segregating' the network in several sub-networks, to manage them independently. In fact, Network Slicing consists of dividing the network into different instances. Each of them adapted to the requirements of the service. They are different networks from the logical point of view but sharing the same physical infrastructure.

Network Slicing is one of the key capabilities that will enable flexibility in 5G networks, as it allows multiple logical networks to be created on top of a common shared physical infrastructure. The greater

elasticity brought about by Network Slicing will help to address the cost, efficiency, and flexibility requirements imposed by the large variety of industrial vertical services. Moreover, Network Slicing will help new services and new requirements to be quickly addressed, according to the needs of the industries (GSA with contributions from Ericsson, Huawei, and Nokia, 2017). Some examples of how this technology enables those characteristics will be explained in Case Study chapter.

A Network Slice is a logical network that provides specific network capabilities and network characteristics for a specific service/tenant. These last 2 words are the more important ones since for the first time, it will be possible to offer different capabilities for different customers using the same physical network. It includes Network Functions (Virtual-VNF or Physical-PNF), computing resources and networking resources (spectrum, fiber) it comprises of a group of network functions, resources, and connection relationships. It typically covers multiple technical domains, which includes a terminal, access network, transport network, core network, data center domain that hosts third-party applications, as well as network management system, etc. (Marco Gramaglia, 2018).

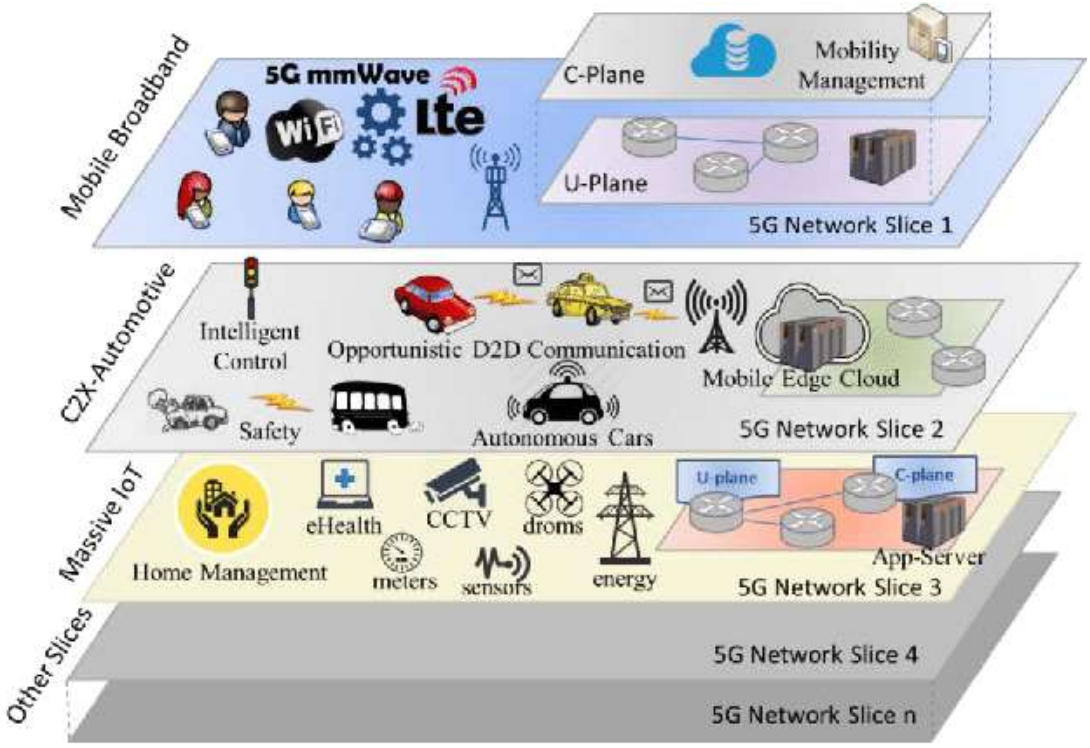


Due Network Slicing (NS) uses similar principles to those behind software-defined networking (SDN) and network function Virtualization (NFV), NS can introduce greater network flexibility by partitioning network architectures in virtual elements, that can then be linked through software. This will become essential in 5G deployments as singular core networks (CN) can be sliced into multiple virtual networks that could each support a different radio access network (RAN) as well as the different service types running across those RANs. It is then imagined that the virtual networks would be able to cater to different requirements in a more flexible manner than the previous 3G/4G. To fully mature NS as an enabling technology, other technologies will have to evolve with it (Ericsson, 2018).

There is a consensus of opinions that NS has the potential to unlock the full potential 5G.

From the business perspective, this new way, to offer and divide (logically) the same network to different customers, is opening the door to infinite possibilities of use cases that can be created. It comprises both Radio and Core then, this NS technology enables a new vertical business paradigm:

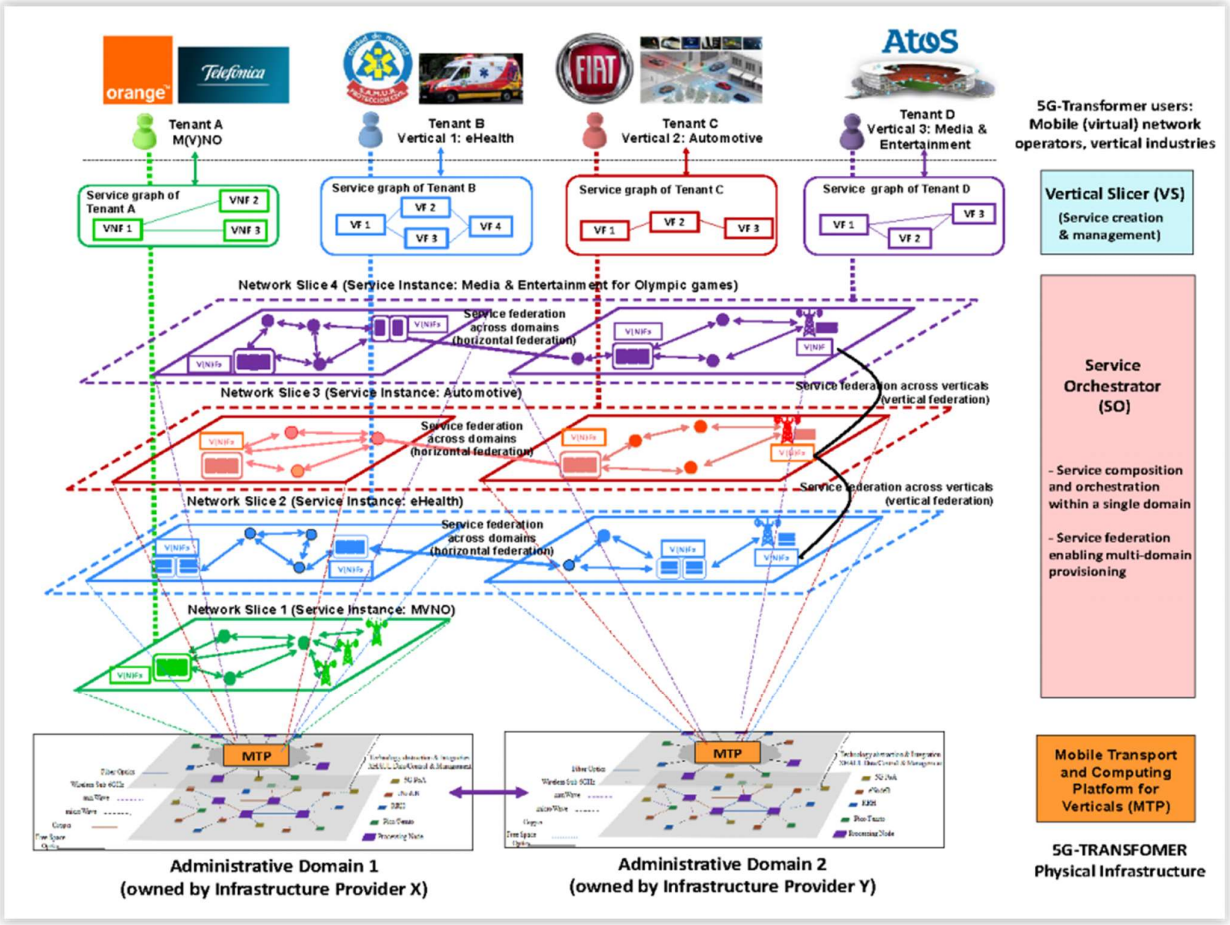
Different tenants get their own network customized for a specific purpose.



An infrastructure provider models the required resources for an NS, slices can be offered by a network operator from its portfolio. New services can, hence, be enabled by just modifying the controller functions or services that were not initially included by an operator in its architectural design, can now be introduced and implement service-specific enhancements (Marco Gramaglia, 2018). One example of this could be when one vertical like a bank uses its own network slide from branch offices and over the same real telco operator infrastructure a delivery company uses its own network slide to communicate the van drivers using RAN and CN. The figure illustrates how different NS support verticals using different technologies.

In the focus of this research, NS are mainly created for a business purpose. This business purpose is implemented using a specific technology that turns internally uses other technologies like Cloud, NFV, SDN, etc. Where previously, such opportunities were addressed by building multiple dedicated infrastructure solutions, with NS, these network solutions can be provided by software on common network infrastructure. Network Virtualization and slicing represent a similar shift as when dedicated computing hardware was replaced by Virtualization and Cloud computing (Håkan Andersson, 2017).

In the next figure, a real example of this 5G Network Slicing (NS) for several verticals and customers is shown.



Source: http://www.5gsummit.org/greece/slides/Session1_02_Xavier%20Costa%20Perez.pdf

Assuming that companies in the same sector (verticals) have similar requirements of bandwidth, latency, type of traffic, etc. it is possible to group them inside the same vertical (1,2 and 3 in this example).

Each tenant (A, B, C, D) can use the NS defined for its vertical. Each tenant can have one or more NS instances active at the same time, depending on its needs and contract. For example, in the case of the Automotive, Fiat has the NS-3 with instances NS-3-1 and NS-3-2. But also, any other company like Ford can have the same NS-3 defined but using their own NS-3-4 instance. In this example, it is possible to see also NS composed by different telcos, with two different administrative domains created over two telco infrastructures. The possibilities are almost infinite.

As the different business contexts or customers which they serve are very diverse, NS will need to come in very different shapes and forms. This calls for a very high degree of flexibility and agility. Therefore, also as part of the Network Slicing concept comes much more automation, orchestration and advanced service creation capabilities (GSA with contributions from Ericsson, Huawei, and Nokia, 2017). The orchestration is still key for NS, as important as for telco Clouds.

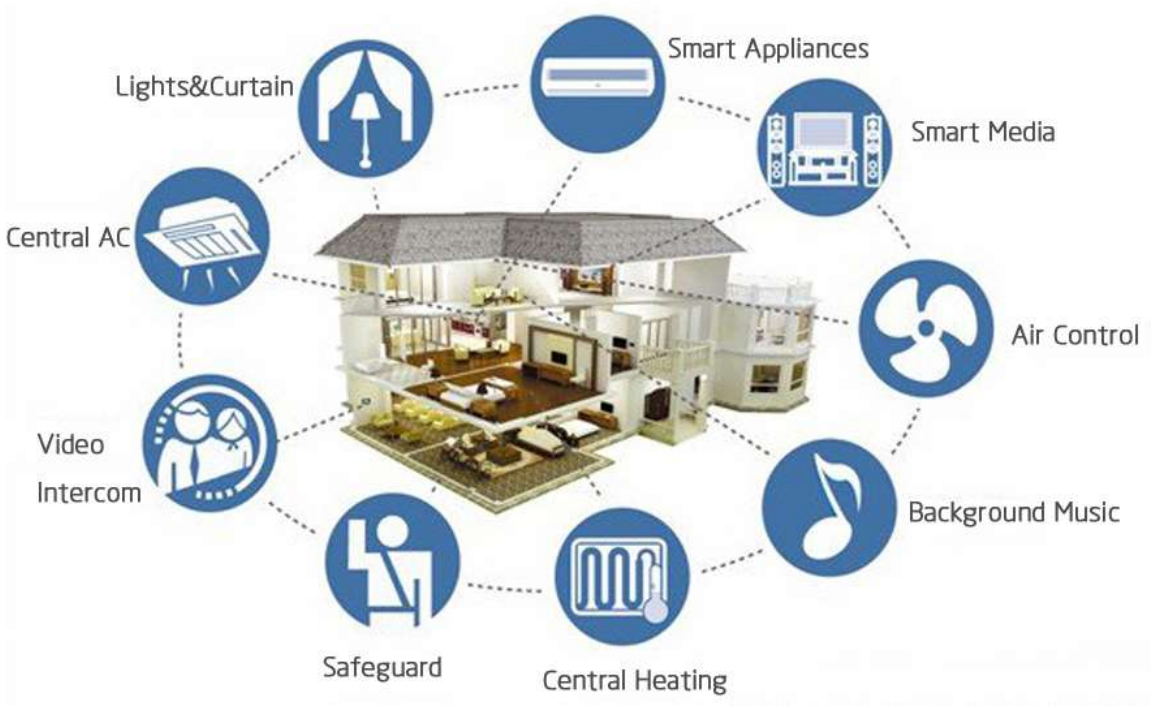
Summarizing,

NS is expected to play a critical role in 5G because of the multitude of use cases and new services 5G will support. It allows a flexible system architecture able to deal with various requirements of the vertical industries and serve them without sacrificing efficiency while keeping costs low.

The expectations of the market, since some authors mention that NS enables new business opportunities, is relevant for telco operators on how to evolve to 5G (Ericsson, 2018).

3.2.3 Internet of Things

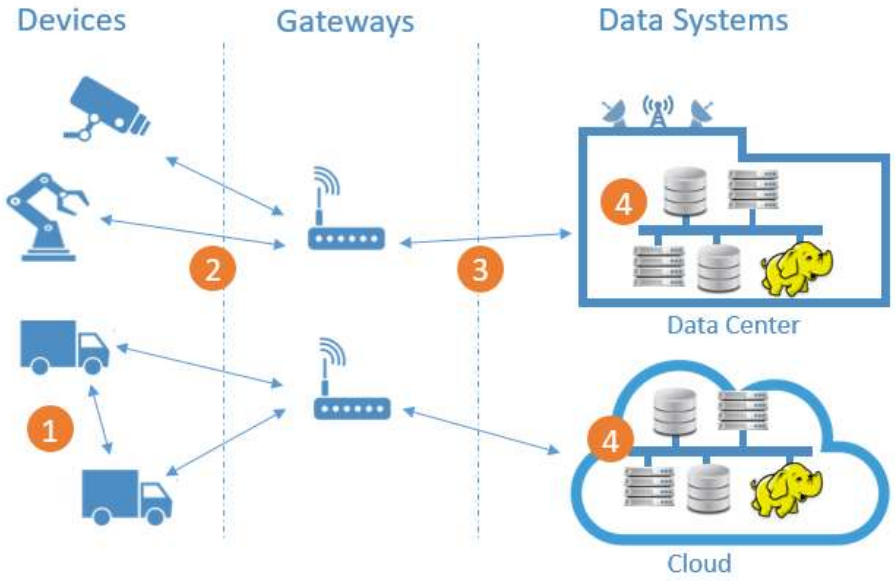
5G network plunges us into the age of "everything connected", or the Internet of Things (IoT). It will allow us to create a true ecosystem capable of transcending the smartphone world, possibly becoming the missing piece of the puzzle to build true Smart Cities/Smart Homes (Gizmodo, 2019).



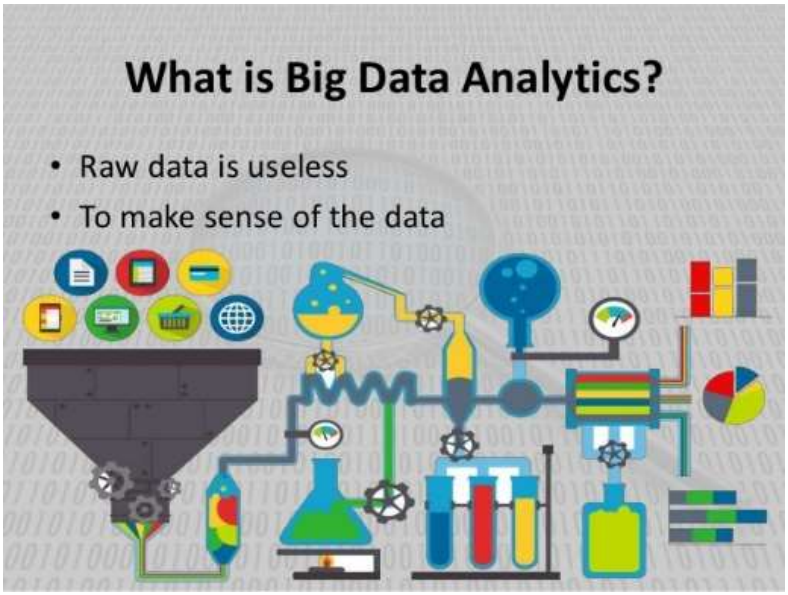
Internet of Things' industry has been growing exponentially since its initial launch in 2012. Latest standards are designed to work anywhere and can connect low-power devices to the mobile network. They are optimized to handle infrequent data transfers, which makes it ideal for devices that are deployed in remote locations, and only need to transfer data every so often (Zach Supalla, 2018). 5G will be 10-100 times faster than 4G and offer such low latency that communications are almost real-time. So, running an improved IoT technology over 5G networks, it will be possible to enable autonomous vehicles, remote medical care, expert surgery from half a world away, or the operation of machinery in hazardous environments (Atmosphere, 2018). But monetizing the value of IoT platforms isn't easy. Operators hope to become the key enablers, but they face two problems here.

- First, the industry players have built their own end-to-end applications, and the only need operators to provide pipes.
- Second, platforms must attract and retain industry players, build an active partner ecosystem, and generate their own values (Cheng Qingjun, 2018).

IoT seen as a new type of business, service providers are investing in new technologies and establishing new business models for revenue sharing and increased use of indirect channels (Jeff Travers, 2018). To have the ability of elasticity, flexibility, scalability and so on, Virtualization/Cloud and NVF/SDN are the technologies where IoT use as a baseline. Then, Big Data Analytics will be useful to process the big amount of data that IoT generates represented in the figure by orange blocks. Representing the same process in a different way is shown in the figure.



What is relevant today is that operators can start addressing the interest from industries on IoT already now, testing new business models and create additional revenue streams. Current IoT technologies enable massive IoT use cases already in existing networks. Only, in this case, they will be prepared to capture the full business potential of 5G (Ericsson, 2019).



3.2.4 Big Data Analytics

Big Data Analytics refers to the complex process of examining and analyzing large and varied data sets - or big data - to uncover information including hidden patterns, unknown correlations, market trends and customer preferences that can help organizations make informed business decisions.

Popular new data sources like clickstream data from the web server, weblogs, inbound customer email, external data from open government websites, and weather data are generating a tremendous amount of data. Also, sensors are being deployed in manufacturing production lines,

supply chains, assets, and products all under the name of IoT, to produce data needed to optimize operations and understand the product or asset usage. In other words,

> Data must be analyzed to be useful.

The number of data sources is exploding, and many companies are struggling to cope with data of all varieties being consumed and analyzed (Mike Ferguson 2019). These massive amounts of data, when captured wisely and analyzed professionally can reveal powerful insights. Big Data Analytics provides telcos with the tools and techniques to harness and integrate new sources, and new types of data in larger volumes in real-time (Exastax,2017), and get closer to their customers compete on quality. In this image, it is represented a typical source of data like mobile phones, the social networks, the data is stored and managed in the Cloud, and IoT for collecting data automatically from the sensors. All these massive data must be processed by the BDA to be useful.

A recent study found that consumers have high expectations, including that their problems will be solved quickly and easily. The report also found that 70% of smartphone users expect their telco service provider to improve their experience through better use of Big Data Analytics. 51% of consumers want marketing offers relevant to them. More meaningful customer data, the marketing and promotions departments can now recommend services, devices, based on users' unique needs (Andrea Parascandolo, 2019). A centralized point of management represents a big advantage. Data Analytics can help operators enhance the overall value of their business regarding service optimization, customer satisfaction and revenues (Exastax,2017). The user sees data in a more business-friendly way, without having to understand connectivity to all underlying data sources irrespective of whether they are in the Cloud, multiple Clouds or in the Data Center or across all of it.

> Big Data Analytics abstraction of the other technologies is needed. Technologies used as baselines for it like Cloud, NFV/SDN shall be hidden for the final user (Mike Ferguson 2019).

Which are the telcos benefits using Big Data Analytics?

Enhanced Customer Insights: with the help of Big Data Analytics capabilities, telcos can turn an enormous structured and unstructured data into actionable customer insights.

Churn Prediction: customer retention is one of the most critical challenges which telco operators face (Industry trends show that there's over 20–40% churn annually, especially in the telecommunication

industry), and one of the biggest cost items since they spend a lot of effort and resources. Then, operators can accurately identify customers who are likely to leave.

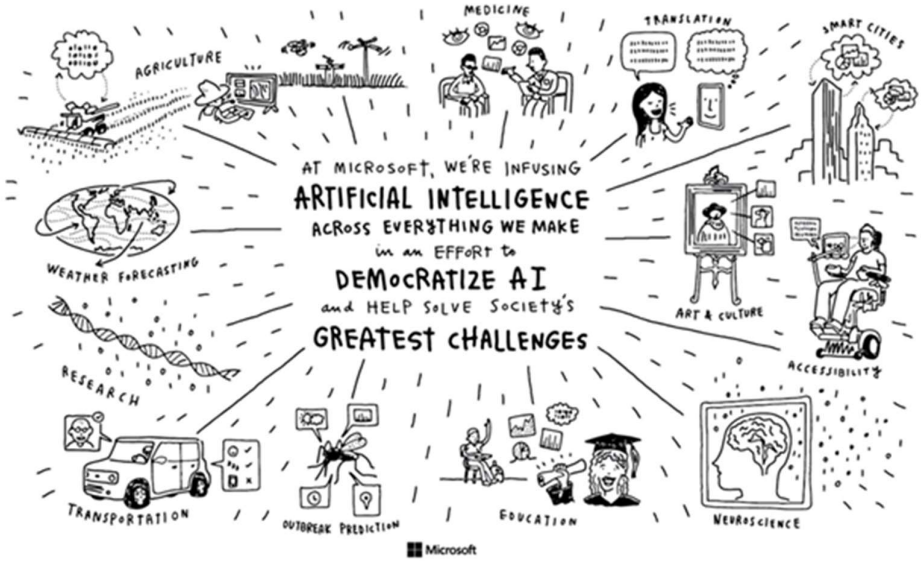
Leveraged Customer Experience: Big Data Analytics allows telcos to unlock new insights in real-time, enabling them to proactively offer services/products to their customers at the exact time they are most likely to subscribe, buy, or respond.

Finally, Big Data Analytics provides operators business optimization capabilities, which help them to increase revenue through more-targeted marketing activities and to reduce costs by identifying expense and revenue leakages.

Big Data Analytics solutions are fundamentally changing the way that telco operators manage their daily operations, some of them are aggressively pursuing Big Data Analytics and information strategies that will be differentiating themselves from their competition.

3.2.5 Artificial Intelligence and Machine Learning

Artificial intelligence (AI) makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks. Most AI examples that you hear about today – from chess-playing computers to self-driving cars – rely heavily on deep learning and natural language



processing. Using these technologies, computers can be trained to accomplish specific tasks by processing large amounts of data and recognizing patterns in the data (SAS Institute, 2018).

> If AI is the science of computers emulating humans, then the ML is one method behind how machines learn from data by training an algorithm.

Artificial Intelligence (AI) and Machine Learning (ML) are being applied across many industries to increase profits, reduce costs, save lives and improve customer experiences. Consequently, organizations which understand how to use them are benefiting at the expense of their rivals (Steven Finlay, 2018).

To understand how these technologies work, we take Google's car. It has lasers on the top which are telling it where it is in terms of the surrounding area, it has radar in the front, which is informing the car of the speed and motion of all the cars around it. And it uses all that data to figure out, not only how to drive the car, but also to predict what potential drivers around the car are going to do. That's almost a gigabyte a second of data that that car must process.

In the case of Finland, AI/ML are being considered relevant for the economy at the national level. The government, University of Helsinki, and a consulting firm plan to train 1% of its population in Artificial Intelligence offering an open, free online course "Elements of AI" was made available to anyone who would be interested in understanding the basics of AI. The government has integrated the AI into a national strategy plan (Wei Shi, 2019).

For telcos companies, why they are highly interested in the potential of AI/ML? One use that they are considering is to tacking customer service (personalized offers recommendations based on a user's behavioral patterns and content preferences), or to improve service delivery via optimizing the networks (network analysis & predictive maintenance) (Mindtitan, 2019). There is no question that AI/ML have huge potential. What is not entirely clear is how this potential in telcos will play out (Erwin Huizenga, 2017). In the other hand, today's, it seems to be a narrow view on AI/ML from the telcos view. They see AI/ML directly translated into "network optimization" only. This is not totally bad, for the short term, it could be useful to securing new revenues improving and enhancing the connectivity, but for all the money which is being spent on that, others in the ecosystem are claiming the clear majority of the new value creation (Davies, 2018).

This AI technology will exist at the Cloud backend, down the data pipe and AI will also have a key role on the device itself. Specially for 5G, in a world where the requirement of each network connection is more and more diversified, and where latency requirements are less than one millisecond (such as in the use of remote autonomous vehicles and online gaming), 5G needs to bring AI advantages to bear in the new era to maximize network value (Adrian Bridgwater, 2018).

> Data is the new oil. It's valuable, but if unrefined it cannot really be used.

This second part the quote is especially interesting, and it addresses some very important things in the telecom industry. Today, massive amounts of data constantly hit a mobile network. For example, 4 terabits of data hit a US service provider's mobile network every second, and that same network registers 15 million 'data events' every second. The thing is, these figures won't be slowing down anytime soon as IoT and 5G come into play. In fact, the ecosystem will become much more complex in the future. The number of new use cases enabled by 5G and Network Slicing, Virtualization of networks, and the continued explosion of data volumes in mobile networks propelled by video and more devices will force networks to transform into dynamic networks that are able to react in real-time to increased demands, problems, and shifts in traffic. We mortals won't be able

to manage all this alone. We'll need huge amounts of data and Artificial Intelligence just to manage the networks, let alone the devices that demand its attention.

> The data in itself is not valuable, it must be refined to add value.

The AI and automation look closer today, open the door to exciting challenges and opportunities to find out new horizons, shaping the digital economy (Anders Kälvemark, 2019).

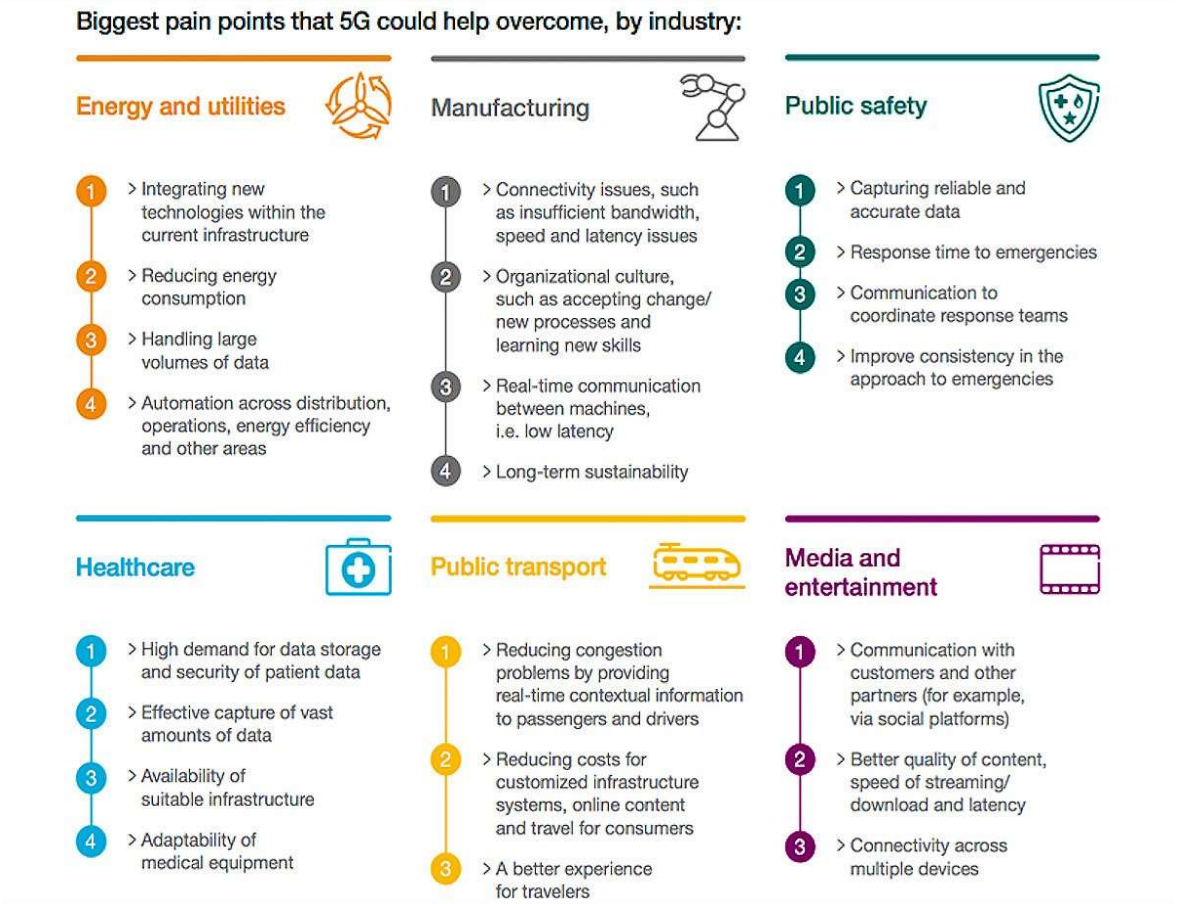
3.2.6 5G as a Technology System

Some basics of 5G from different aspects were previously provided (chapter 2.4). Now, a 5G concept from a different angle will be covered: as a group of technologies that work together to establish a system. The focus is to study this system as a vehicle to generate ecosystems and disruptive new services. Grouping some of the technologies (chapters 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5), will provide a basic thought, to understand later, how the business models are impacted.

It was already mentioned that 5G networks will look very different than other mobile technologies that were built in the past. In general, if we look at 2G, 3G, or 4G technologies, they are focused on throughput and capacity. Even in the future, we are going to see a hundred times faster throughput, but 5G is not interpreted just as another evolution from previous technologies. Of course, most of the good things will be reused, but, the nature of 5G is based on some use cases that have been already identified and cataloged. It is the first time that a mobile technology (standard) itself is defined by use cases. Based on them, the technical requirements are being defined. Some examples are the latency[29] and battery life 10 times more than we have today. Many others are classified according to 5G features. Those are possible with the combination of the technologies, working together as a system. In chapter 6, some examples of how they work together as a system will be mentioned.

5G will open whole new types of applications for consumers and business customers. With features and technical requirements, 5G categorizes the use cases by verticals (chapter 2.4), as it is shown in detail in the figure.

[29] *Latency: the physical consequence of the limited velocity with which any physical interaction can propagate.*



To have in the table all the potential benefits of 5G, a significant transformation of networks, operations, business processes, and business models must take place. To compete, telcos must reorganize and retrain their IT, engineering, operations organizations, cultures to develop NFV, SDN, and service orchestration software collaboratively. These tasks will not be easy. A global strategy for the development of the operator is needed. Some authors like Volodymyr Krolivets (2017) announced a very important affirmation about technology usage:

> Only replacing one specialized hardware platform with a standard server and virtualized service function will not suffice.
>
> The technology combination, working at the same time is the key.

In fact, this is already happening, most operators began optimizing OPEX[30] and CAPEX[31] using Cloud, NFV/SDN exploring the separation of the hardware and software components of networking devices. This is disruptive for many existing business models, and 5G will continue even more with this disruption since the new rules of the DT create conditions for transitioning from oligopolies to a competitive market, in which small players with pure software products and solutions gain a certain

[30] *An operational expenditure (OPEX) is the money a company spends on an ongoing, day-to-day basis to run a business or system.*

[31] *CAPEX stands for the money spent to acquire or upgrade physical assets such as buildings and machinery.*

authority. The case in which the OTT entered in the telecom industry represents a fundamentally new paradigm of the telecommunications ecosystem (chapter 3.1.2.).

Focusing on the business aspects of 5G, the majority opinion in the telecom industry can be summarized as:

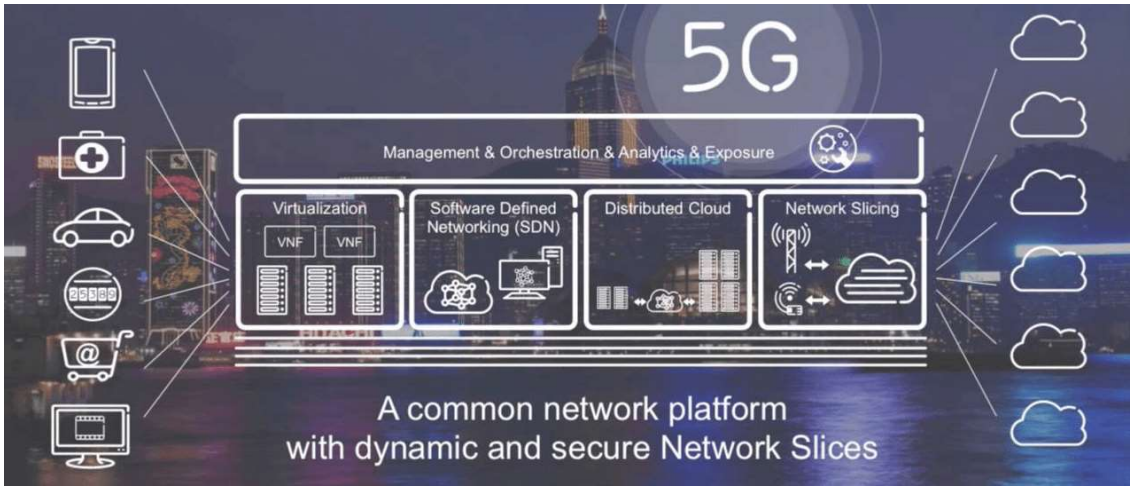
> 5G is all about evolving ecosystems. A key theme is the concept of collaboration, rather than competition.

How operators will need to work together for more nimble, smooth and effective delivery to customers. How to find their enterprise customers, their potential business partners. There is no doubt, the 5G ecosystem is evolving, and it is up to telecom industry to help realize it (Neil Lilley, 2019). This concept is totally aligned with the evolution (chapter 3.1.1) with multi-vendors scenarios and OTT introduction in the telecommunication industry (chapter 3.1.2).

Disruptive trends with 5G are getting closer. Integrating AI, ML and Big Data Analytics will be key to develop 5G use cases. Things like orchestration in Cloud, SDN/NFV are needed to make end goals a reality (Neil Lilley, 2019). It is all about:

- Integration of capabilities
- Integration of data
- Integration of effort between the operators and providers

It is estimated that roughly half of all connected devices will be used for business. To cope with the sheer number of devices and massive volumes of accompanying data, 5G networks will have to be capable of customizing their functionality to support and deliver on the specific needs of services, devices, applications, or operators. To do this, some technologies have been identified as viable technologies to achieve such capabilities and further enhance to 5G. This is the case of Virtualization, NFV, SDN, telco Clouds, Network Slices, BDA, IoT, AI/ML. It seems completely feasible that they should all be used to enhance and enable 5G networks (Ericsson, 2017).



Finally, 5G will promote the transformation of the entire digital economy and many people are interested in having a leading role. In the case of telco operators, it is important to review that the deployment of 5G requires significant disbursements in investments (Julio Cerezo y Pepe Cerezo,

2018). Evidently, telco operators and manufacturers (vendors), are the main candidates, but they will not be the only ones. It is observed that other vertical sectors are moving fast and begin to organize themselves in ecosystems, that hope to also some benefit from 5G. Although telcos will remain the main owners and administrators of the network infrastructures and maintain the degree of competition, providers of new services will be of vital importance.

3.3 CONCLUSIONS AND RESEARCH QUESTION

Enterprises are increasingly focused on Digital Transformation as a competitive advantage. Many companies, across a wide range of industries, are at the tipping point of this transition. Their challenge is to develop new business models that increase connection and engagement. What is needed is a Digital Transformation platform (chapter 2.3), that connects intelligence, data, and devices, enabling them to increase engagement with partners and develop applications that foster innovation (Huawei, 2017). In fact, worldwide companies are investing in DT, creating the digital goods and services needed to thrive in the digital economy. Telcos are uniquely positioned to provide these emerging innovations as services consumed by business customers, they are expanding their own value proposition on the digital economy. They can collaborate for success creating new ecosystems and new business models, products and services, by applying various capabilities coming from some of the technologies (chapter 3.2) (GSMA Webinar, 2018).

We are already in the process of the digitalization of the commodities. We have new technologies that are evolving towards new use cases, involving new verticals coming from inside and outside of the telecommunication industry. In fact, the connectivity transformed into a commodity, brings new challenges to telcos, that they must learn how to create new business models. Therefore, new actors in the ecosystem will come and new business models will be created to cover their demands. Since telcos are the owners of the infrastructures, they can play a key role there.

Traditionally, telco ecosystems were integrated by telco members only. They were evolving towards "open" ecosystems (chapter 3.1.1). Because of the technological change, new actors, who are oriented to "value-added services", will require networks capabilities at the multi-operator level. All these changes represent a huge challenge for telcos at technological and business levels.

Since we cannot cover all these uncertainties in this paper, we try to reduce the scope focusing our research in the conditions that telcos need to create these new business models.

As companies enter the digital era, they need to form global transformational processes to stay competitive in the global economy. A quality partnership can help players, across the telco landscape, master new ways to coordinate these global business processes (Volodymyr Krolivets, 2017). Nowadays, we can say that we are in a pre-5G phase and telcos companies need to play a role of service enablers/creators. A typical case of this situation (chapter 3.1.2) is regarding the role of OTTs. In the next phase, when 5G will be commercially deployed, since the model of "one size for all", telcos will move the model, offering a customized network for each use case. The telecommunication network will be co-developed with vertical partners for each one, to adapt to its specific needs. A scenario where telco operators will be invited as simple partners (operators just as pipes providers), seems impossible.

Considering that most of the authors agreed on offering differentiated extra values to the ecosystem is a key factor, we try to limit the Research Question to:

> Which are the necessary conditions for telcos, to offer a differentiated and sustainable, value capture proposition in the 5G use cases?

The conditions are not for telcos, but for all the ecosystem's partners that are part of the business model, including OTTs and verticals. One of the business model's condition is that they need to have a distinguished value proposition, and its differentiation will come by the customization. The value capture will depend on the position role that each partner will have, and the constructed relations with each other within the ecosystem.

The analysis of, which are factors that promote to attract innovation and rich partners to the platform for 5G, can be the subject for another specific study research. In our case, we consider it as an open subject and it is out of the scope of this paper. Our focus is to study under what conditions 5G business models can be successful (profitable), and sustainable, in terms of required conditions.

Finally, we reformulate the Research Question to:

> Which are the necessary conditions for telcos, to develop differentiated, and sustainable business models based on the opportunities opened by 5G?

4. METHODOLOGY

The previous Research Question aims to explore how to find out the conditions for creating values in the new deployments of 5G. The literature review pointed out the novelty of this topic, and therefore no single and clear outcome is expected (Yin, 2017).

Qualitative and quantitative research differ in terms of the format of the data used. While quantitative research uses numbers, qualitative research is mainly word-based. For the present study, qualitative research seems to be a more appropriate approach, as it can provide a deeper understanding of the problem (Bryman & Bell, 2015).

The "Case Studies", as the method of Qualitative Research, is spreading in recent years, especially to investigate complex social phenomena, not reducible to stylized variables, and simple cause-effect relationships. Within the research on business, problems are spreading for the investigation of organizational aspects. One of the pioneering authors about the case of methodology for research purposes is Yin R.K, who points out that the appropriate research method is in relation to the type of question is answered. Then, Yin R.K. 84 remarks that when we asked: who, what, where, how much, the appropriate method is the Survey. However, when we ask "how" and "why" the method is "Case Studies" (Yin, 2017).

Case Studies are used to explore a contemporary phenomenon to understand the dynamics in a predefined context and eventually gain a holistic view on the topic (Bryman & Bell, 2015; Yin, 2017). In the literature it was found two lines of investigation, which are: A representation of Eisenhardt, K.M. Case Studies which are proposed with a blank sheet to avoid prejudices when observing the phenomenon, and another stream headed by Yin R.K. 84, and Bonache J. 99: who presented the need for a preliminary theoretical model that will refine and extend with Case Studies.

For this study, since the Research Question is related to find out the needed conditions, this last line of investigation of "Case Studies" methodology is followed, proposing a Preliminary Theoretical Model. To increase the validity of the research, a comparative Case Studies design is applied, which allows the author to extract knowledge from within and across cases (Yin, 2017). The unit of analysis in this research is based on telco companies from the operators and vendors.

The analysis of cases will provide a richer view of the most important topics, enabling the author to illustrate the ways of thinking and understanding the potential business models. Furthermore, it helps the reasoning of telcos companies hesitating to incorporate new technologies as soon as possible into their business models.

5. PRELIMINARY THEORETICAL MODEL

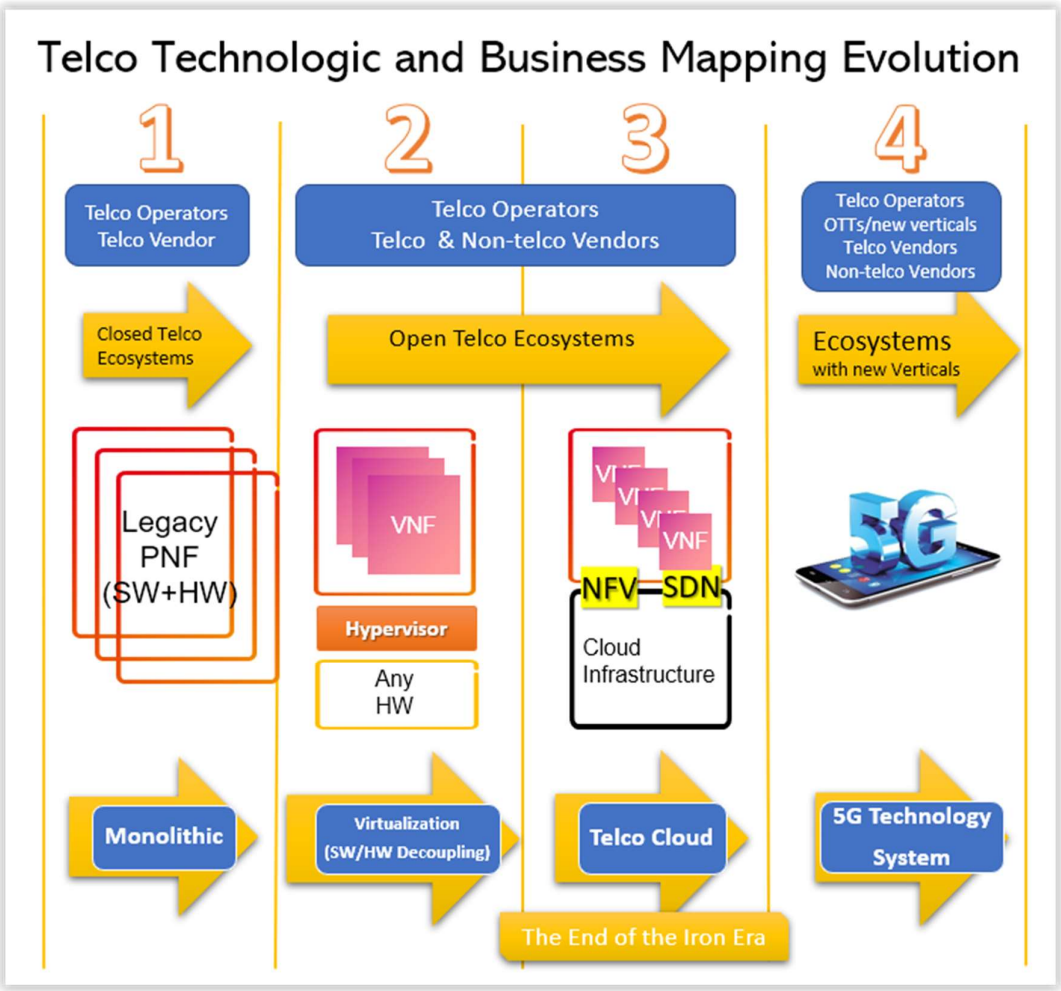
With all the background (chapter 2), literature review (chapter 3), 5G technologies (chapter 3.2), and the methodology (chapter 4), in place, the interesting and challenging part now is, to intertwine to create a new Preliminary Theoretical Model that proposes a new conceptual framework for telco companies.

The Preliminary Model consists of a complex hypothesis to ask, under which needed conditions, telcos can obtain a significant sustainable business model to generate recurrent incomings, within 5G environments? That is our Research Question (chapter 3.3).

The content applied to this model is gathered from previous chapters. Now, in this chapter, we are going to construct the building blocks, where our Preliminary Theoretical Model is built up.

5.1 TECHNOLOGY AND BUSINESS MAPPING EVOLUTION

The analysis done in chapter 3.1.1 will be used to build the mapping. The intention is to put in order the technologies used and to evidence, how the ecosystems have been evolved with the technological changes. The following figure shows this mapping represented by 4 main steps of a journey towards 5G.



1. The first step was the scenario composed by a traditional telco infrastructure. It was built by Physical Network Functions (PNF), also called bare metal equipment's. Basically, telecommunication nodes were composed of legacy[32] hardware and proprietary software. The telco services offered, were managed by one or few legacy products, working as monolithic blocks. The network was statically configured and mostly manually managed by a unique tenant. In this primitive scenario, a "single-tenant environment" is present. One typical example in Spain is considering a telco operator, like Telefonica, who buys products to a few telco vendors like Ericsson or Nokia. This situation can be mapped to the "Original Telco Ecosystem" (chapter 3.1.1), and it is represented in the first vertical step, delimited by yellow lines in the figure.

2. Step 2 represents the current situation by many operators who have already started this journey as part of this natural evolution towards 5G. Driven by IT technology evolution, the business rules for telcos has changed. Around 2005, an incipient Virtualization technology, with the first free desktops virtualized, used only in the IT industry, starting to be evolved, reaching to the telco industry many years later. Here, the operator's main intention is to reduce costs in terms of HW and infrastructure in general. Because the SW and HW decoupling, new non-telco vendors joined the ecosystem. A typical case is when one telco operator uses HW from IT manufactures, like Vodafone who buys HP servers, or ATT who uses Oracle DDBB. In this step, the telco networks became a mix of physical network functions (PNFs) and virtual network functions (VNFs), containing both the legacy hardware and the new virtualized infrastructure that can be run under any kind of HW. This new duality brings new challenges too. The operator can build the telco services and applications using SW from several vendors with the possibility to combine and reuse the same HW for more than one proposes. Typical examples are, HP HW running Ericsson's UDC[33], Nokia's EPC[34] (both Core Network functions) and Oracle DDBB.

3. The End of the Iron[35] Age. With the massification of Virtualization, the telcos demanded an easy way to manage hundreds and thousands of those new virtual network functions (VNFs). With this objective added to the scalability and other advantages, the telcos adopted the Cloud model combined with NFV and SDN technologies. Some authors call this The Telco Cloud (chapter 3.2.1). The definition itself could be considered for new research work because of the complexity of the different scenarios that can be present. But for this paper, the implication is about the telco Data Center (DC) which has changed dramatically because thousands of VNFs can be deployed under a Cloud and controlled by a Cloud orchestrator, that implements closed-loop automation. Service providers can give a wide variety of new services, addressing the complexity of a hybrid environment. With these technologies at hand, it becomes possible to view the telco network in a new way.

> Logical networks can be designed, instantiated and operated in a dynamic "on-demand" basis, targeting the precise needs of specific customers, services or

[32] *A legacy is a generic name assigned to any old SW or HW or a network, which is rarely used today. For this paper, legacy is associated to equipment's proprietary to individual vendors. Legacy is the opposite concept to "open".*

[33] *UDC stands for User Data Consolidation (telecommunications) is one of the most critical functions in telecommunication networks. With the arrival of 5G and the evolution to cloud architectures, managing all subscribers' data and services efficiently has never been so essential to ensure an operator's business profitability. Refers to the standard to centralize user data into a single, robust and secure User Data Repository (UDR).*

[34] *Evolved Packet Core (EPC) is a framework for providing converged voice and data on a 4GLong-Term Evolution (LTE) network.*

[35] *Iron term refers to HW and bare metal.*

business segments, which are related with service characteristics, self-management of resources/service, etc.

This process of networking customization in real time generates efficient customization of the resources with a qualitatively higher level of performance. This situation can be mapped to "Multi-vendor Telecom Ecosystem" (chapter 3.1.1). As a result, efficiency increases significantly, and additional savings can be achieved in the network. With this, enterprises gain benefits, such as new services being deployed in hours instead of weeks, and the ability to make those services quickly available in self-service portals for ordering. Better user experience can also be achieved by implementing analytics-driven closed loops (chapter 3.2.4). In a simple way, most telco organizations are transitioning to the cloud since they provide new capabilities in a self-service and automates way to increase productivity and agility while reducing costs. Some telcos can think that they are in this step just because there are in a cloud. But, only replacing one specialized hardware platform with a standard server and virtualized service function is not suffice (chapter 3.2.6). They need full automatization of the entire VNF life cycle management, HW independence, central orchestration, elasticity, etc., and new business models based on these characteristics.

4. For 5G architecture, the technological evolution is bringing new ecosystems oriented to specific services to be consumed by verticals. These vertical industries determine new partnerships and agreements in the ecosystems, joining the existing ones based on Cloud, IoT, analytics, AI, etc., or create new ones. All technologies mentioned in chapter 3.2 are included in step 4. As well as, it is not only about new technologies, also about the new actors which arrived in the ecosystem, verticals and especially the OTTs (chapter 3.1.2). All those factors represent a totally new way of doing business for telco companies, and a tremendous challenge for them. In fact, to be competitive, one of the most important challenges is to discover how to offer a differentiated and sustainable value proposition.

5.1.1 Motivations for the transition adopting new technologies:

From step 1 to step 2, the operators wanted to reduce the cost of, because of the virtualization technology. Operators can place several VNFs in the same HW, reducing the HW (in step 1 they need one proprietary HW for each function.

From 2 to 3, the main focus was to reduce OPEX and CAPEX with the automatization that Cloud offers. So, in this transition, the main motivation was also originated due to internal cost reduction.

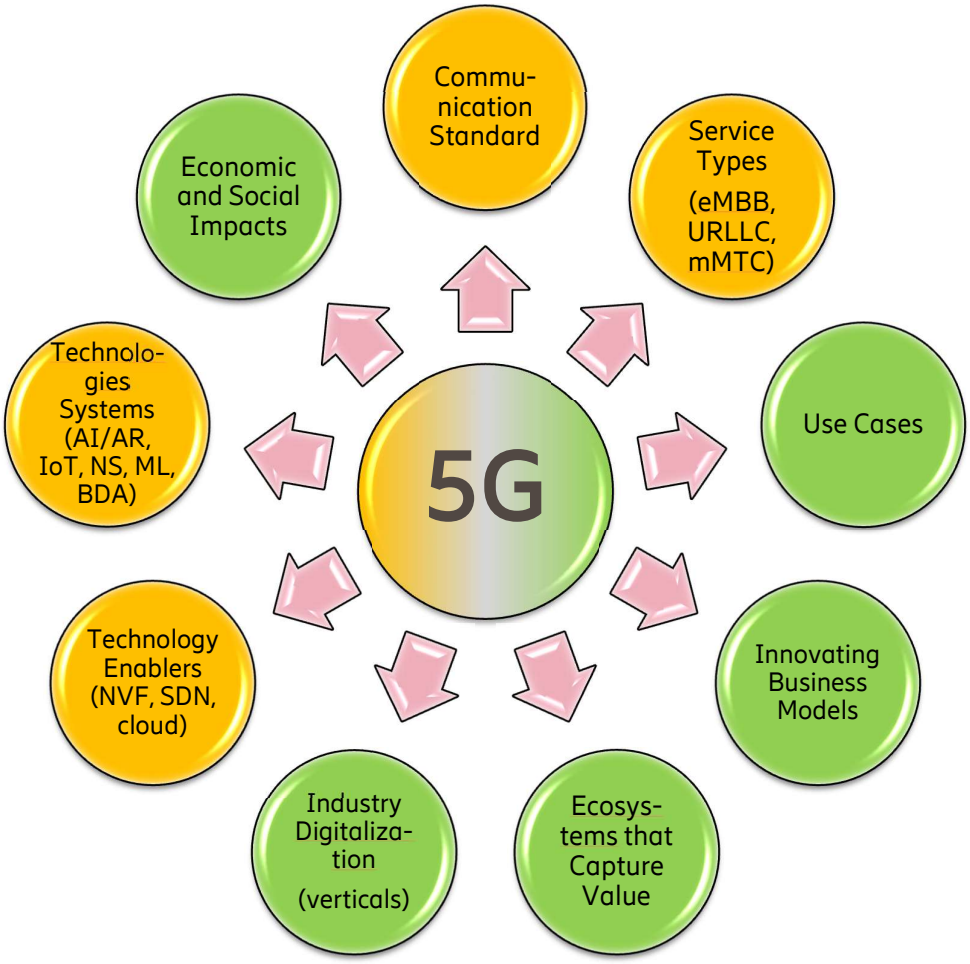
But the difference is between 3 and 4, since they need to invest new money. Unlike the previous situation, nowadays they must spend money and resources. For this reason, they are so interested in finding new ways to monetize the 5G. Added to this, the scenario becomes more complex if we consider that they are playing in another league (non-telco exclusive), with new partners.

5.2 REDEFINING THE 5G

From chapters 2.3 and 3.2.6, it was concluded that the digital platforms are defining the digital era and that the new technologies like Cloud, are the building blocks (Martin Kenney, 2015), that are composing systems driving the Digital Transformation (Gens, 2013). IoT, Network Slicing, and others are acting as accelerator technologies (IDC, 2017). Some common characteristics, that different actors mention, like interaction (Masaharu Tsujimoto, Yuya Kajikawa, Junichi Tomita, Yoichi Matsumoto, 2018), acts as a system (Oxford. English. Dictionary, 2017), others act like an innovator and self-organized (McKinsey Quarterly, 2017). Relevant, for our research, results that business cannot be managed without managing the entire ecosystem (Power & Jerjian, 2001), and the key role

of orchestrator should define the value chain (McKinsey Quarterly, 2017). The idea is to be in the middle connecting the dots (McKinsey Quarterly October 2017), creating value within the ecosystem and sharing that value with others (Harvard Business Review, 2009).

As it was already noticed in this paper, 5G is becoming the communication standard of the fourth industrial revolution (Nokia, 2017), but 5G is a very wide concept used to call different contexts. Joining those different definitions, we will put all the concepts in order and we construct the following schema:



Depending on the area of interest, 5G brings a new definition. For technicians, for marketing people, for economists, for SW architects, and for the society in general one branch is more relevant than others.

The aspects of 5G related to technology are colored in yellow, and the ones related to the business are colored in green. It is notorious to see that the number of technical aspects and business are equilibrated. This is the first time that happens in mobile telecommunication history. The analysis of both aspects and how they are related are crucial, which is the main goal of this research.

Then, let's try to elaborate on the following own definition:

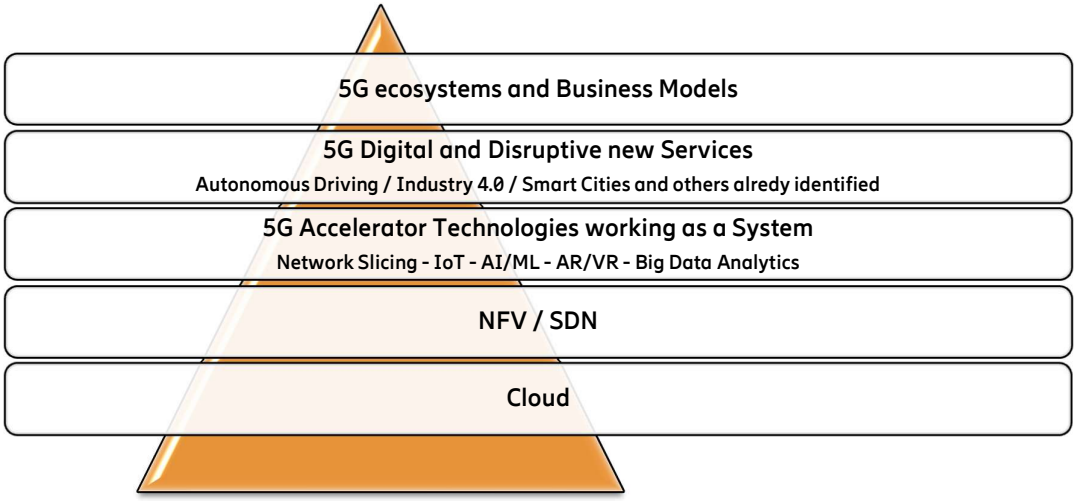
- 5G is a telecommunication standard with a connected world vision, created to offer new services allowing the generation of thousands of use cases.

- Some of them will generate new business models, involving an amazing variety of verticals and digitalizing the industries.
- The 5G is based on some modern technologies that work together in building blocks. Those blocks are combined in a way that enables a flexible architecture to adapt the infrastructure to the customers' requirements, in an automatic way.
- This will trigger the developing of a system of technologies, which will have a huge impact on the society at different levels, as never before.
- The role of 5G is to serve as a channel to get DT to the whole economy, which causes 5G to present a huge opportunity for the modernization of most of the industry sectors.
- To achieve the full potential, the creation of new ecosystems shall capture value to all partners, who they work together towards common objectives."

5.3 5G TECHNOLOGY BLOCKS

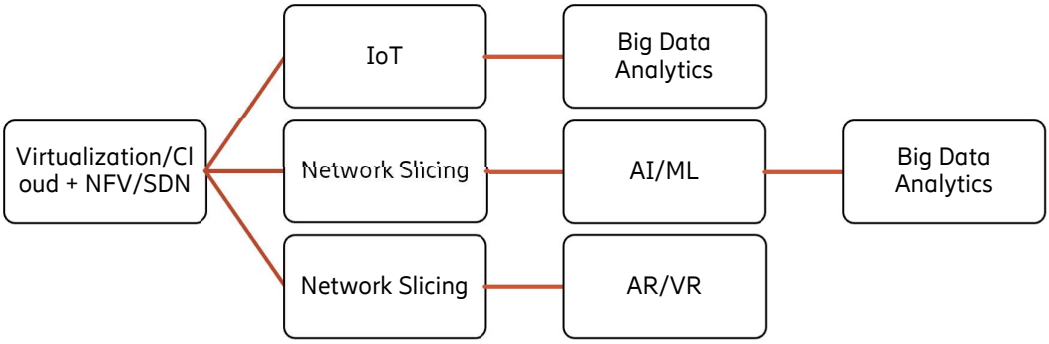
In the literature review, it was already mentioned by many authors, that 5G constitutes a system of technologies (chapter 3.2.6), where each technology is used as a baseline to construct the next brick.

To construct our model, based on this 5G new definition, let reorganize the technologies in blocks at different levels. Putting these technologies in an ordered sequence, we obtain the horizontal pillars as shown in the next figure.



In the 1st block, there is Cloud technology. This paper explains several times that virtualization and Cloud are the baselines and supported technologies needed to construct others, like NFV and SDN which are situated in the next level. In fact, as NFV/SDN are based on Virtualization/Cloud, they allow telco operators to have flexible networks, with the capability to adapt itself to different requirements and to be consumed by another block as follows.

In the 3rd level or block, there are located the main 5G accelerator technologies that work as a system offers most of the 5G services that have been already identified. For example, Network Slicing is possible due to the NFV/SDN realization, which is on Cloud. The interesting thing about it is that they can be combined in a different way, depending on the services demands. Services (in the next level), will determine the technologies used in the 3rd level. For example. technologies like IoT, that use a tremendous number of devices, and generates a huge amount of data, needs BDA to extract the value of that data collected.

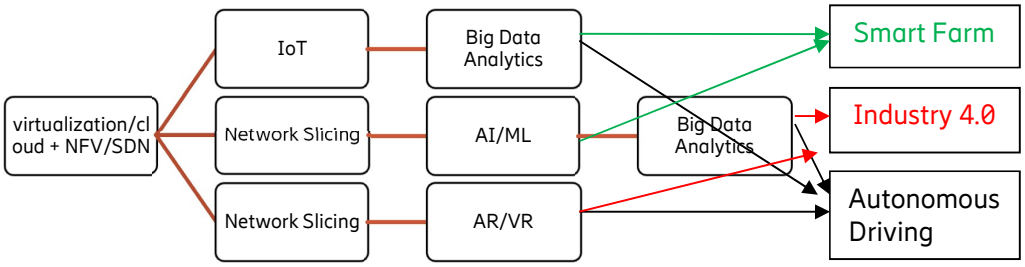


In another example, thinking about AI/ML and AR/VR, it is logical to assume that the need of specific slices to ensure the high KPI demanded by the services, which are in the next level. For example, a robot that is being managed remotely by an operator needs very low latency, speed, and stability. Having a NS dedicated, all these characteristics in terms of KPI can afford for that specific moment, then all those resources will be liberated dynamically after the operation is concluded. In the case of IoT, the enormous amount of data must be proceeded and analyzed with intelligence, using BDA and AI, to be offered as value (and not just "data"). Please, notice that these are just examples to have a better understanding of the subject. The possibilities and combinations in this area are amazing. This is one of the foundations of the potential of 5G. The idea of this paper is not to mention all the foundations because it will be impossible.

In the 4th stage, all the 5G services are located, which consume what is offered by the technologies on the 3rd level. Applications and functions can be delivered by new players in the verticals[36].

[36] *Note that in the context of this paper, the verticals are abstracts. They represent an aggregation of verticals of specific industries as it was mentioned in the beginning of the paper.*

In the figure, some services are represented by the most important technologies used. As an example, it is noticed that for Smart Farms case, the most representative technologies needed are: IoT, for sensors located in the farms, and Big Data Analytics, to process the information received. Also, Smart Farms need AI/ML to do the predictions for harvesting and improving the yield. Even if AR/VR could be used in some use cases for Smart Farms, they are not critical for it. Therefore, they can be critical for other verticals, such as Industry 4.0, where AR/VR is needed as the main technology for remote control, learning, and maintenance. In a similar way, other services that require most of the technologies working together, such as Autonomous Driving, are found. It is clear, that more technologies are involved in a system, the integration and the deployment in the cellular network will be more complex. The more restricted requirement in terms of KPIs will be asked to the 5G network operator. These cases are mentioned just to clarification proposes, some of them will be used in the Case Study (chapter 6).



Now, it is the time for mapping of technologies and business in time organized in the 5G building blocks, let's try to construct the Preliminary Model in the next chapter.

5.4 Preliminary Theoretical Model Definition

From all precedent work, it is known that:

> Telcos need to design ecosystems for specific verticals focused on value creation.

Answering the Research Question, the formulation of the necessary conditions to a telco can create a sustainable business model over time, is presented in this chapter. It is important to clarify, that these conditions are the necessary ones, but they are not all of them. Because sufficient conditions change in time and depend on the case, they are impossible to enumerate and most of them are unknown nowadays. But, it is not possible to create a sustainable business without the necessary conditions, which is already very important for the research.

At this point, we are able to elaborate on the two first competitive factors that must be considered by telcos to reach their goal are:

Customization	Eficiency and Costs
• To offer a maximal quality of service. • It is possible thanks to Big Data Analytics/AI/ML, Network Slicing	• Subordinated to customization and speed requisites. • It is possible thanks to virtualzation/cloud, NFV/SDN, Network Slicing

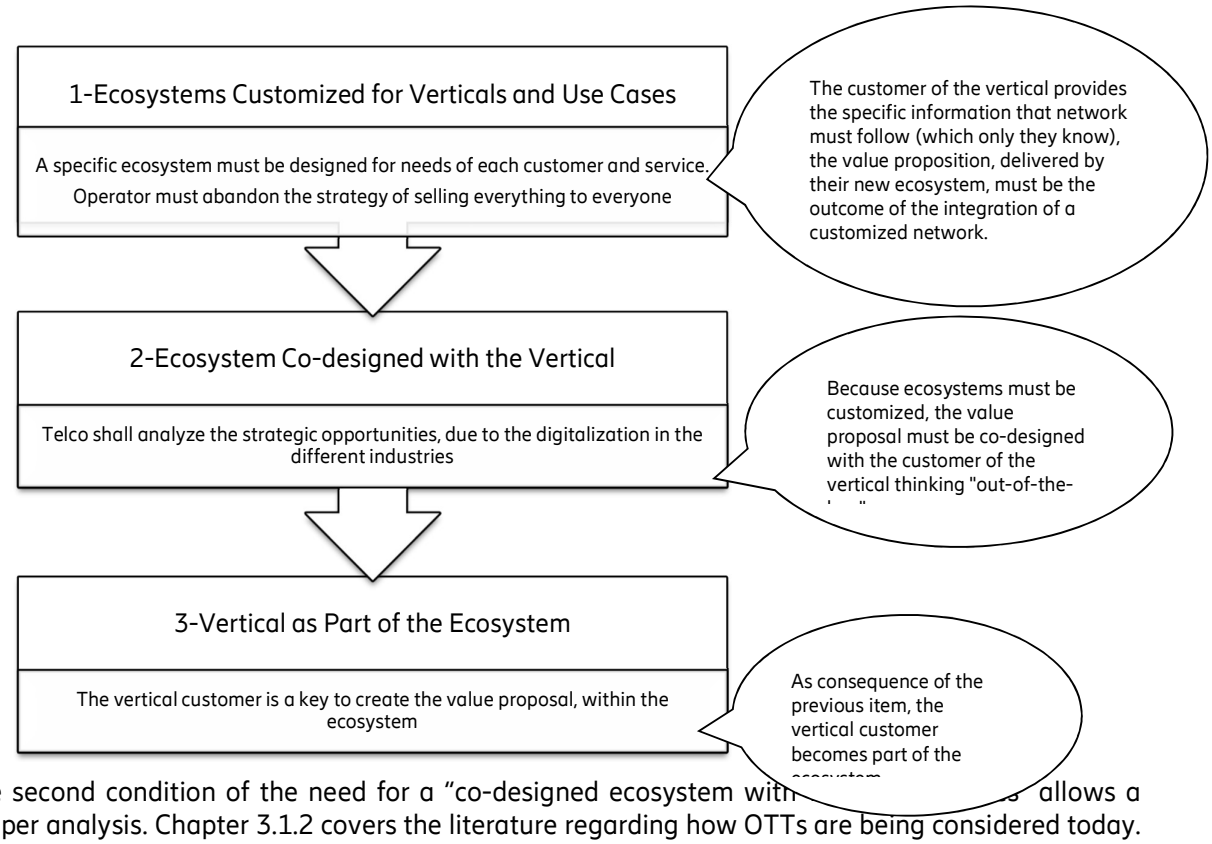
Let construct the model starting from logical reasoning. The 5G technologies can be built like a Lego (chapter 5.3), depending on the services characteristic needs, resulting in a customized networks and services scenario. Because of the proper technology nature, it is not possible using 4G or other previous cellular technologies. The following constitutes the baselines for the Preliminary Model:

> We consider, 5G as a Customized Technology System, where technologies (chapter 3.2) allow the customization of networks and services, combining to adapt them to customers and services requirements.

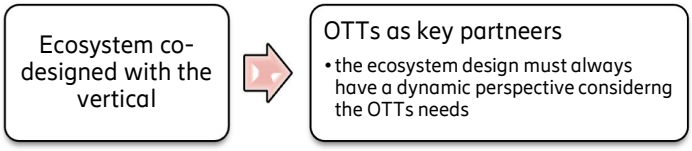
With the baselines in place, thanks to the nature of the 5G technology's flexibility,

> All ecosystems based on 5G must be specific for a vertical.

Now, we can enumerate the first three necessary conditions to create new ecosystems, as follows.



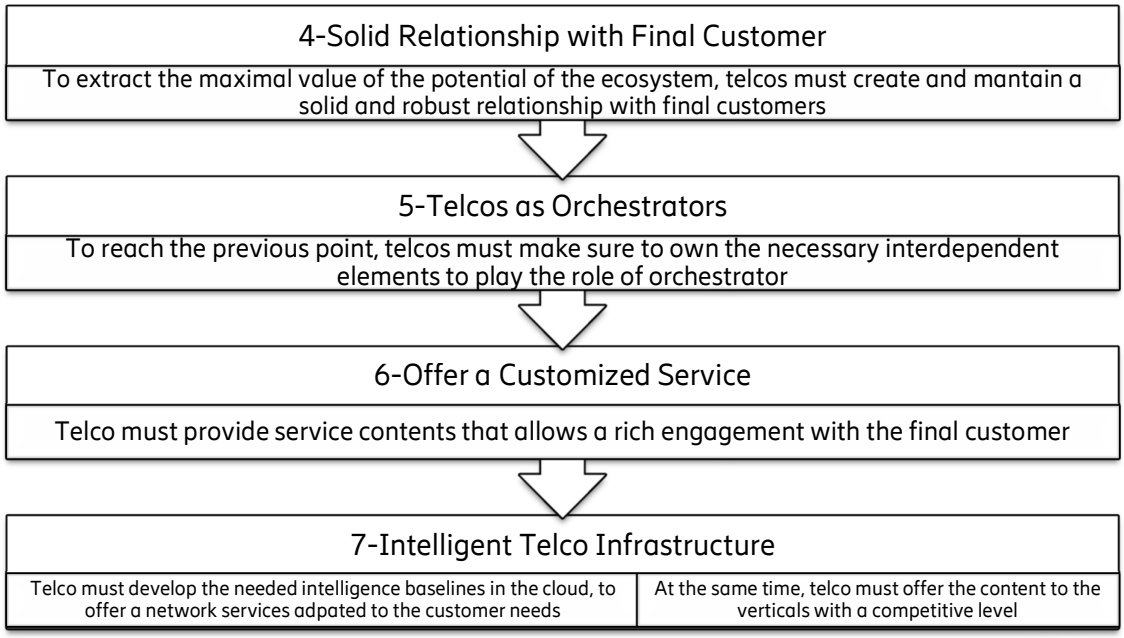
The second condition of the need for a "co-designed ecosystem with [illegible] allows a deeper analysis. Chapter 3.1.2 covers the literature regarding how OTTs are being considered today. Now, the focus is the OTTs[37] as a specific case of a vertical with similar characteristics. Telcos can



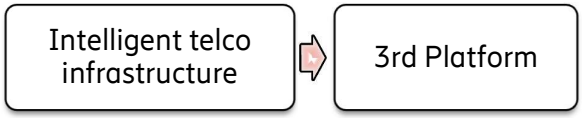
[37] *We are going to consider an OTT as any content provider (non-Telco) that can offer a service using a digital platform. OTTs' are connected to companies that act as big content providers, like Google, Netflix, Amazon, etc.*

create new rich ecosystems with them. Telcos can join one or more OTTs from different sectors, depending on the specialization of the ecosystem. Each of them can be designed to add an extra and rich contribution to the ecosystem. Doing that, the ecosystem will be able to grow with health from the beginning. A disruptive OTT "missed" can have painful consequences for the ecosystem. A disruptive application or service by an OTT that has been "forgotten" in the ecosystem could impact in the telco network with unpredictable consequences, technically and commercially speaking. Imagine a case where an Augmented Reality application offered by Google o Facebook, becomes massive. The low latency and high speed, that it will be required, can cause the network to not have enough capacity to follow those KPIs. If the OTT is invited from the beginning in the use case definition within the ecosystem, those requirements can be managed to "prevent" further network capabilities.

At social and massive levels, many operators are currently starting to separate the systems for verticals and for final consumers. But they will need to evolve their organization structure and processes to reap the benefits of 5G at the same time. The complexity is not only technologic, but it is also administrative, internally and externally of the telcos. Based on these factors, let's analyze how creating ecosystems in 5G, is applicable for telcos and final customers and their relationships, enumerating other four imperative conditions.



All these concepts, relationships with others, and infrastructure are related with offering a digital platform (chapter 3.2.1) that can connect the intelligence, the data, and all the devices in a very easy and friendly way. Amount of data without the intelligence to process it is useless. Millions of devices



that cannot be connected nor controlled from a unique central site are unmanaged. If MANO[38] (Management and Orchestration) is not simple, the entire system will be replaced for others that it will be. The concept of 3rd Platform (chapter 3.2.1) remains a key within the last item regarding the intelligent infrastructure that the telco must offer.

To summarize this Preliminary Model, a mapping for each of the points to the technologies more relevant to create the need, are shown in the table.

	Most representative technologies that make it possible or relevant						
	Cloud	NFV/SDN	IoT	Network Slicing	AI/ML	AR/VR	Big Data Analytics
Ecosystems Customized for Verticals and Use Cases	X	X	X	X	X	X	X
Ecosystem Co-Designed with The Vertical	X	X		X			X
Verticals as Part of The Ecosystem	X	X	X	X	X	X	X
Solid Relationship with Final Customer				X	X	X	X
Telcos as Orchestrators	X	X	X	X	X		
Offering a Customized Service	X	X	X	X	X		X
Intelligent Telco Infrastructure	X	X	X	X	X		X

To illustrate this table reading, let's take the "Offering a Customized Service" case. Telcos will be able to offer services specified for each case due the flexibility, simplicity, and easy adaptation to new demands, provided by technologies like Cloud and NFV/SDN. Without them, it will be almost impossible (or too difficult), to have it. Thanks to IoT with data coming from the customer sensors and a data processing (Big Data Analytics), telcos will be able to offer new services based the customers' real needs and not just "massive services". Network Slicing makes possible the customization of the network for each customer (chapter 3.2.2), based on their needs and in real time. But nevertheless, AR/VR could also contribute to new services for verticals that play in those sectors, but they are not essential in this case. AI/ML seems to be critical for most of the conditions, this is the reason why many companies are starting to invest in these areas today.

[38] *By nature, Network functions virtualization (NFV) changes the way networks are managed. From initial set up to day-to-day operations, NFV management and network orchestration (MANO) fills the management role. MANO layer is composed by NFV Orchestrator, VNF Manager and Virtualized Infrastructure Manager (VIM)*

Continuing with the elaboration of the model, let's make the logical reasoning in the opposite direction. What will be the reason for 5G if the offer will not be customized? High bandwidth could be reached anyway, some IoT services (in a similar way as today using other IoT technologies) could still exist. But services with different traffic requirements, someone's low latency, other high speeds, could not be customized, because they must use the same network. It is easy to hypothesize that the quality of the network in these conditions will not be the best, and some bottlenecks could occur. Most probably, without a good NS solution, many services will not be possible at all. For sure, operators will not be able to offer virtual networks from end to end (E2E), and the costs of developing ad-hoc infrastructures will be so high that it will not be likely. Another important consequence regards the commercial aspect. Most of the telcos operators will offer the same to the market (as today), finding out a differentiation will be so difficult for them on these conditions. Not only the proposal cannot be differentiated, but it also will not be sustainable along the time and without an important extra value. Since the technology could permit flexibility then operators still offering prizing models based on the bandwidth and number of subscribers.

Under these arguments, one conclusion is that

> 5G technologies, not only make possible the imperative conditions to the success of a rich ecosystem, but they also become imperative.

Without them, the telcos will be "out of the game"[39], all the new models will crash, and the DT will not be totally possible.

Coming back to the positive reasoning,

- We need a system that combines 5G technologies
- The technologies shall adapt to the customer needs
- Without building physical infrastructures one by one (thanks to NFV and others)
- Instead, having virtual infrastructures it is possible to adapt the resources of the Data Center to the needs and in real time (thanks to Cloud, NFV and others)
- Especially, the network shall be also flexible, configurable and easy to adapt to different traffic needs in real time (thanks to Cloud, NFV, SDN, NS, and others), working together with the virtual infrastructure[40].

Then,

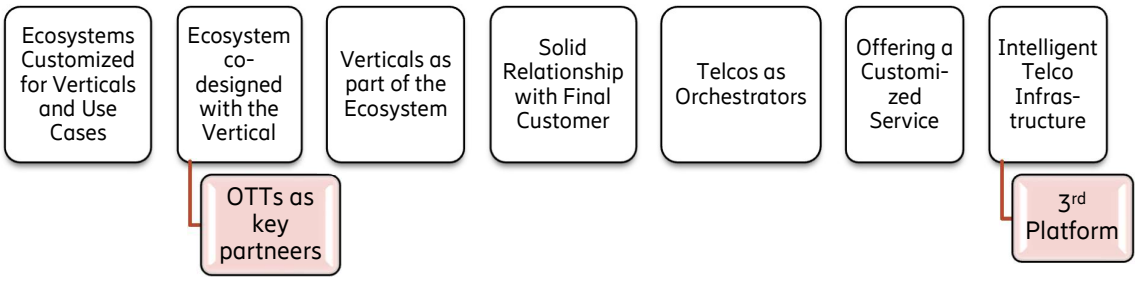
- Telcos will save costs
- They can reuse the same network for several verticals and tenants (chapter 3.3)
- They will be able to offer the great quality required for each customer/case
- All new uses cases will be technically possible
- New ecosystems can be created
- New actors in different verticals can enter in the DT era
- A modernization of society is possible

Now, the entire model works again.

[39] *It refers to be out of the market.*

[40] *For example, when a VNF needs to scale out, new VMs have to be created by the infrastructure, but also the networking associated with that VNF instance has to grow also, in order to support the new load of traffic. All the resources must be coordinated and automatized by the Cloud.*

How this Theoretical Model was built is shown in the following overall schema.



6. EMPIRICAL RESEARCH: CASE STUDY

This chapter mentions some use cases to illustrate how the telcos and non-telcos are creating new business and ecosystems in the transition towards a 5G model.

These use cases are real and try to cover a variety of companies of different verticals, and what are they doing to create rich ecosystems. If it is possible, they contribute to new enforcement to the Preliminary Model. Technical details of them remain out of the scope of this paper.

6.1 SMART RAIL

The use case: DT applicable to the railway industry.

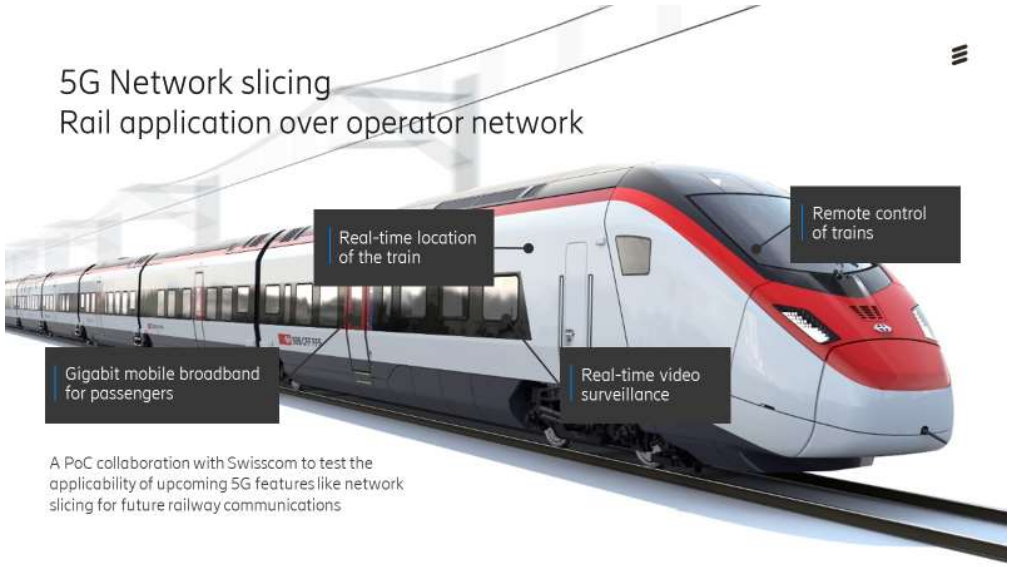
Verticals: This is an ecosystem between a big telco operator, telco vendor, and a big non-telco industry company.

Partners: It is a collaboration with Swisscom, Ericsson, and SBB, a railway company operating in Switzerland, to test the applicability of upcoming 5G features such as Network Slicing for future railway communications. The intention is to show how the rail-based critical communications can be supported by a public network with 4G and 5G.

It is based in SBB plans towards a thorough digitalization of end-to-end operations up to fully automatic train operation in the longer term, called "Smart Rail 4.0". This will also require much more bandwidth for operationally critical communications. Unlike today, all objects that use SBB tracks should be permanently supervised, localized and automatically operated, requiring the exchange of a significantly larger amount of status messages and command messages than today.

Problem and Solution: SBB needs cameras that deliver an HD video signal transferred in "real time". Transmission over a railway-specific mobile network is difficult to execute due to the narrow bandwidth. That's why the reliable transmission of the HD video signal via a public network of a public provider is aimed. In order not to build again a railway-dedicated mobile network infrastructure, Railway like SBB could buy wholesale capacity from a public provider like Swisscom for all or at least most of its critical communication requirements.

Alternatively, the most critical narrowband messages would still be transferred using a dedicated railway-specific mobile network, but everything broadband (including slightly less critical messages) is transmitted via a public network.



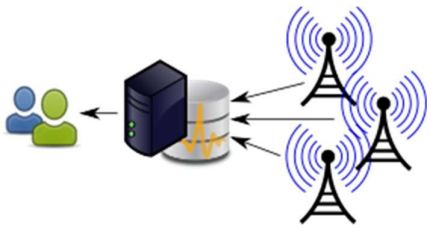
In terms of prioritization, the critical communications such as automatic train control (ATC), and automatic train operation (ATO), would have the highest priority with a preferred latency over the two other categories. Real-time video traffic, which belongs to the performance of the communication category, has priority over business communications, such as Wi-Fi Internet.

6.2 ILLEGAL EMISSIONS DETECTION IN REAL TIME

The use case: VR applicable to communication and military industries.

The problem: Today, when a telco operator receives a complaint of a frequency occupied illegally, they must deploy an operative, using a piece of expensive equipment mounted on mobile units that triangle the source of emission until detecting the physical position.

In addition to being an expensive operation, it is completely reactive, and in many cases, it is late, since these emissions can be accurate locating position and for brief periods of time.



What would happen if operators could monitor in real time frequency, frequencies that are assigned in much of their geography, where they provide services and where they legally have the frequencies purchased?

The need: Telco operators need a real-time way to check remotely, their reserved frequencies to avoid interferences and acts in consequence.

The verticals: A similar business case can be mapped for the military forces, that need to use their reserved frequencies for national security reasons.

The ecosystem: ElectroSense.org tries to cover these two use cases with a singular proposal. The ElectroSense network is a crowd-sourcing initiative, that collects and analyzes spectrum data. It uses

small radio sensors, based on cheap commodity hardware and offers a piece of aggregated-spectrum information over an open API. Those sensors are remotely located. The initiative's goal is to sense the entire spectrum in populated regions of the world and to make the data available in real-time, for different kinds of stakeholders, which requires a deeper knowledge of the actual spectrum usage.

ElectroSense is an open ecosystem since everyone can contribute to spectrum measurements and access the collected data. Today is an open project, where any company or institution could become a partner and it is open to academic and private enthusiasts. The project offers the sensors for free and asks participants to leave them connected 24/7 to the Internet for a fast-growing and establishing a win2win ecosystem.

In their demo in the Ericsson Innovation Day in Madrid 2018, they showed in real time, the swept in frequency from 0 up to 6GHz using some low-cost sensors located in Switzerland and other in Madrid. Also, historical data can be saved to further analysis, everything with friendly graphical interfaces.

Conclusions: It represents a very good example of an open ecosystem participated by actors coming from different sectors, opened to society.

6.3 SMART FARM

The use case: DT applicable to farm industry.

The vertical: As part of a business Impact Lab, a group of Ericsson specialists studied the business case related with the agricultural sector as one of the most globally relevant, by contribution, economic, and social development in both large and emerging economies.

The opportunity: Despite the evident potentialities of agriculture, it is a sector that has wide opportunities in the optimization of their processes, because of the low implementation of technological solutions in daily works. Even farmers from developed economies. In the case of Europeans farmers, their needs that they have in terms of technology implementation and automatization of tasks.

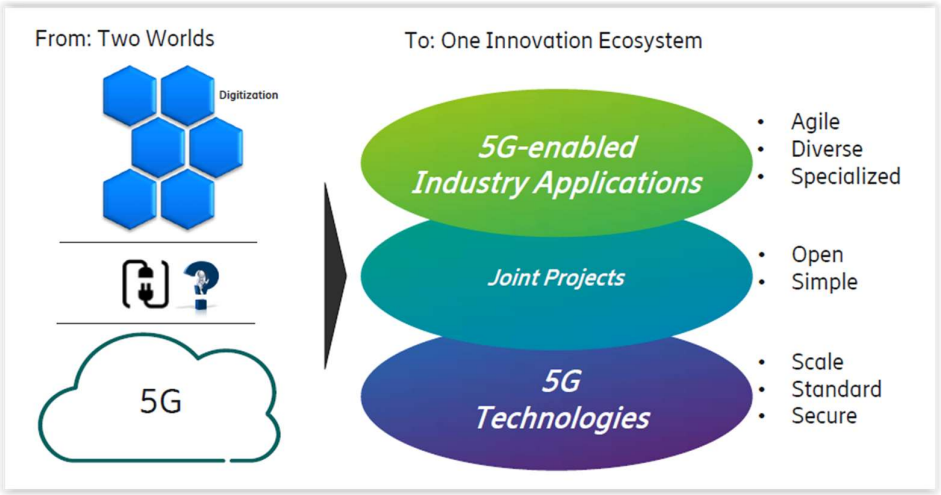
The business case: Specialists studied the implications in the business process of Digital Transformation focused on the creation of a Smart Farm Ecosystem composed of Entrepreneurs + Partner + companies + Early Birds Farmers using IoT technology.

The ecosystem: Ericsson as an orchestrator, is going to implement, as well as being profitable and maintainable in the time, it is scalable. It is possible to be migrated into several markets since current needs are applicable in emerging and developing markets. It is monetizable from agreements with partners, until the big data collection. It is based on technology that allows very low marginal costs and economies of scale.

6.4 5TONIC ECOSYSTEMS

5TONIC is an open research and innovation laboratory focusing on 5G technologies and ecosystems. Created in 2015, its objective is to create a global open environment member from industry and academia working together in specific research projects in 5G, with a view to boosting technology and business innovate ventures.

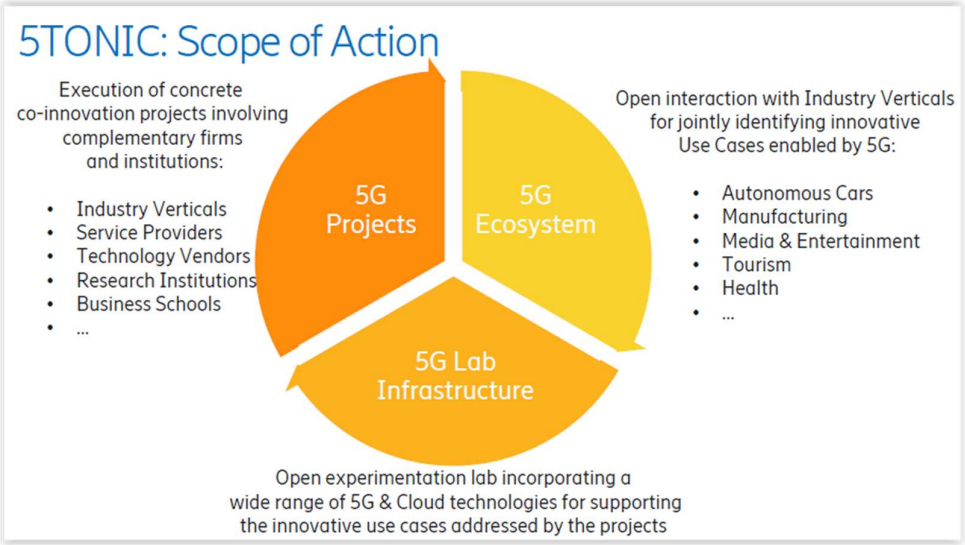
Use cases are composed of different actors and a variety of ecosystems. 5TONIC is a success case of the first approach for ecosystem creations. 5TONIC also proposes the realization of several 5G testbeds as catalyzers for 5G take-off in Europe. It is a place to develop and test new products and services in collaboration with industries, suppliers, and customers. It is used as a perfect place for pre-commercial trials with customers in different vertical sectors. It is also an important access point for research activities for Ph.D. students, internship programs, and other academic activities. It has the focus on E2E performance of 5G, promoting the different technology trends with whitepapers, workshops conferences, etc.



This paper remarks the importance of knowledge exchange of 5G, at the technologic and business level, to discover new ecosystems, and this is exactly what 5TONIC is doing. They are following 3 steps to create the engagement with verticals:

1. Visualize concrete synergies between the industry/verticals
2. Identify, evaluate and plan for key use cases enabled by 5G

3. Sketch a strategy & roadmap for unlocking the 5G potential



5TONIC have a 5G lab, with an infrastructure for experimentation of those use cases that are later addressed by the projects. In this environment, the community join forces to develop new business cases as an assessment process. The collaboration is between telco, several non-telco industries, and the academic society, as a very good example of engagement with different verticals for 5G projects.

6.5 CONCLUSIONS

Using the Case Study as part of the empirical research, this chapter offers the possibility to show different levels of the 5G investigation for the new ecosystems' creation.

A modify of the Preliminary Model (chapter 5.4), can be done, defining the final conditions under which the Preliminary Model is fulfilled as a theoretical model, that explains the Research Question (chapter 3.3). As a conclusion of four Use Cases, mapping them with the seven major conditions of the Preliminary Model (chapter 5.4), the following table is obtained:

	5G for Small Rail	Smart Farm	Illegal Emissions Detection in Real Time	5TONIC Ecosystems
Ecosystems Customized for Verticals and Use Cases	Yes	Yes	Yes	Yes
Ecosystem Co-Designed with The Vertical	Yes	Yes	Yes	Yes
Verticals as Part of the Ecosystem	Yes	Yes	Yes	Yes
Solid Relationship with Final Customer	Yes	Yes	Yes	Yes
Telcos as Orchestrators	Yes	Yes	No	Yes
Offering a Customized Service	Yes	Yes	Yes	Yes
Intelligent Telco Infrastructure	Yes	Yes	Yes	Yes

In this checklist, it is easy to see the weaknesses and strengths of the cases. With this clear picture of the situation, actions could be taken. Behind each case, there is a specific combination of 5G technologies. As it was mentioned,

> the challenge is to find out synergies between 2 different sectors that "speak" different languages: technical and business and then creates innovative ecosystems.

It seems that most of the market is aligned in the opinion that testbeds are needed, and they could be used as a starting point to reach this final goal.

Let's summarize other characteristics of 4 cases presented, to have an overview of comparative analysis.

5G for Small Rail

- Vertical: Railway Industry
- Ecosystem and use case very well defined
- Good example on different technologies working together
- Easily transferable to other cases in other countries
- Easy to use

Smart Farm

- Vertical: Farm industry
- Amazing powerful projected to improve the life of people in a sector that today is technologiycally delayed
- Orchestrated by a telco with an international presence
- Using IoT and BDA as primary technologies

Illegal Emission Detection

- Vertical: Communication and Military industries
- Open ecosystem to academic and private enthusiasts
- Available today, ready to be expanded with 5G

5Tonic

- Incubator project focused on ecosystems generation
- Different verticals
- Telco, non-telco, industries and academic society working together

As a conclusion of the empirical research based on the case study, the following points have been finally identified:

Our first conclusion is that ecosystems need a trust factor between the actors. Without a confidence relationship, the ecosystem is not possible. The old relationship between buyers and sellers must evolve to another stage of collaboration. Customers demand to be part of the process from the beginning, exposing their needs and working hand by hand within the ecosystem.

Use the trust to enforce the relationship with all actors in the ecosystem

If customers and verticals are inside, then the times from the developing phases until the commercialization must follow the rhythms. This is the second conclusion relative to timing. The orchestrator must create the conditions in the development of the ecosystem so that the rhythm is the adequate one. The best-designed ecosystem for a fast pace will have better conditions to win in the market.

Telcos shall prepare the deployments in a very fast and agile way

Another common characteristic, that all these cases have, is the usability. 5G Smart Rail has a console to control and monitor the trains, cameras, etc., The Smart Farms has a customer interface to show the results and predictions of the harvests. The Illegal Emission Detection has a webpage where frequencies are shown in real time. Similar situation for most of the ecosystems proposed by 5TONIC. So, the concept of "easy to use", is present everywhere, especially for a non-specialized final user. Consider the case of Smart Farm. Here the final user is a farmer, not an engineer. This is a dramatic point of relevance of 5G use cases and ecosystems, that marks a tremendous difference compared with 4G and previous technologies. The usability was moved from "engineers in the telcos companies" to "any" final user without technological knowledge. This is not an option anymore, like in 4G. It is needed in 5G. If a business case is not easy to be used by non-technical people, it will not succeed.

Usability for non expert people

Finally, some conclusions come specially from the 5TONIC case which demonstrates the creation of brainstorming projects, with different objectives and so specialized, combining 5G technologies for new ecosystems creation. This is aligned with the rest of the principles explained in this paper. Industry, students, governments, private companies, and universities are working to create new ecosystems for 5G.

Reseaching 5G Ecosystems with others

7. FINAL THEORETIC MODEL

The Theoretical Preliminary Model tried to answer the Research Question:

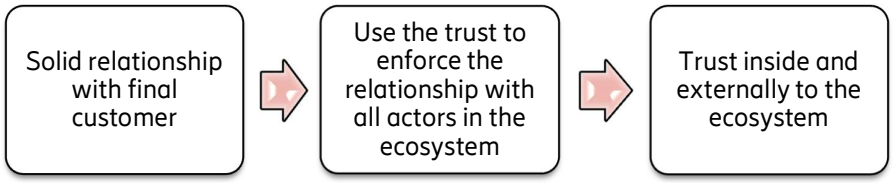
> Which are the necessary conditions for telcos, to develop differentiated, and sustainable business models based on the opportunities opened by 5G?

The Final Model tries to elaborate a group of actions that telcos could afford considering the variables correlated in the Preliminary Model. After revisiting the Case Study (chapter 6), new points are added to be considered in the Final Model.

More in details, "The Solid Relationship with Final Customer" of the Preliminary Model (Chapter 5.4) relates to some conclusions of the Case Study (chapter 6.5).

> Generating trust internally and externally to the ecosystem is the key (Wei Shi, 2019).

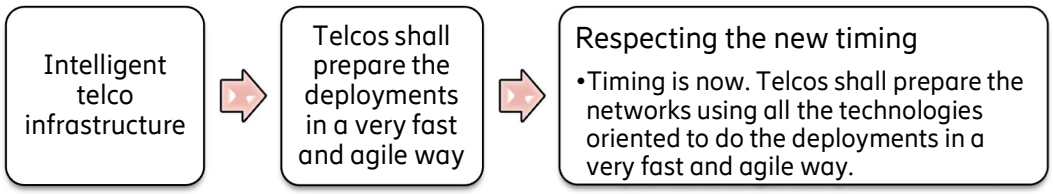
Telcos are managing and accessing the data all the time. Based on that reliability, telcos shall explore and produce new forms of value to encourage users' interactions, being flexible to adopt changes as soon as possible. If telcos generate this trust in the new ecosystems, data consumed will enrich customer interactions and enrich the ecosystem. Only with confidence, a data aggregation by telco and partners will be possible. Considering that this relationship is always needed in all cases of the Empirical Research (chapter 6), this figure is elaborated:



It was mentioned that telco infrastructure must be intelligent to offer the flexibility, automatization, scalability, and all other characteristics the 5G technologies provide. The timing is another critical factor.

> Nothing of this intelligence will be useful if the timing is not adjusted to new social demands.

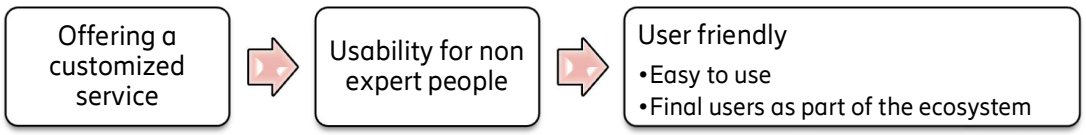
In the past (and today in some cases), new implementations could take months or even years to be deployed in the telco networks, and other extra time until they will be commercially available in the market. This is not acceptable anymore. We live in a world of immediacy, especially for millennials (more than 20% of the population of the planet) is assumed that everything shall have an immediate response, for them timing is now. The usage of all the technologies oriented to that direction like Dev/Ops[41], B2B[42] and open projects like OpenStack[43], Opendaylight[44], Dockers[45], etc are examples of that. Without them, technologies like Cloud/NVF and SDN will not be so popular as they are nowadays. Responsiveness is a requirement in B2B and B2C and, it is possible due to the Virtualization/Cloud technologies used as a baseline for the others. Considering the previous conclusions (chapter 6.5) related to timing, the second contribution to the Final Model is as shown in the figure.



The 3rd point is going forward in the concept of "Offering a customized service", adding an important point: the usability. Telcos can call actors from private, public, academic sectors with a lot of variety of usability, and final users from different profiles. Each of them will add an extra and rich contribution to the ecosystem, but in the end, the operation that the final user needs to do must be easy. Complex solutions that only nerds can use are not useful. Nothing new here. But, how can user-friendly ecosystems focus on the value creation can be built, if the final user receives a terminated and closed service? In 5G, services will be many, and so different. If each service will require specialization of the final user, why not to involve them in the ecosystem to understand how are their needs in terms of usability? To reach a superior business design of ecosystems, final users must be part of the ecosystem to determine the usability of the product/service from the initial phases. Within the DT era, to hide a complex technology to the final user is a key factor.

> The technology involved in the ecosystem could be great, but if people without technical knowledge do not have an easy way to use it, the ecosystem will fail.

The usability is key in 5G (chapter 6). The contribution to the Final Model continues as follows:



[41] *DevOps is a new term emerging from the collision of two major related trends. The first is "agile infrastructure" or "agile operations". The second refers to the value of collaboration between development and operations staff throughout all stages of the development life cycled.*

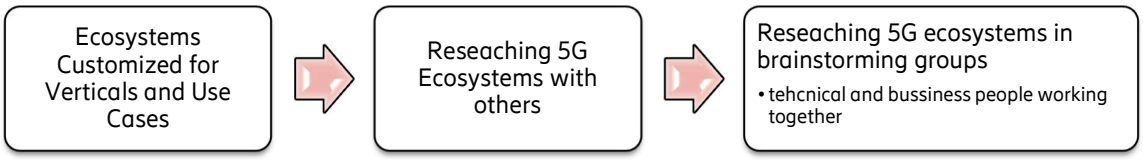
[42] *B2B refers to business-to-business, also known as e-biz, is the exchange of products, services or information (e-commerce) between businesses, rather than between businesses and consumers B2C.*

[43] *OpenStack is a set of software tools for building and managing cloud computing platforms for public and private clouds. OpenStack lets users deploy virtual machines and other instances that handle different tasks for managing a cloud environment on the fly.*

[44] *OpenDaylight Project (ODL) is an open source SDN project hosted by the Linux Foundation, was created to advance software-defined networking (SDN) adoption and create the basis for a strong network function virtualization (NFV). www.opendaylight.org*

[45] *Docker container is an open source software development platform. Its main benefit is to package applications in "containers,"*

Finally, from the previous "Ecosystems Customized for Verticals and Use Cases" in the Preliminary Model (chapter 5.4), the last point in the final model will be added. The incubator labs are offering

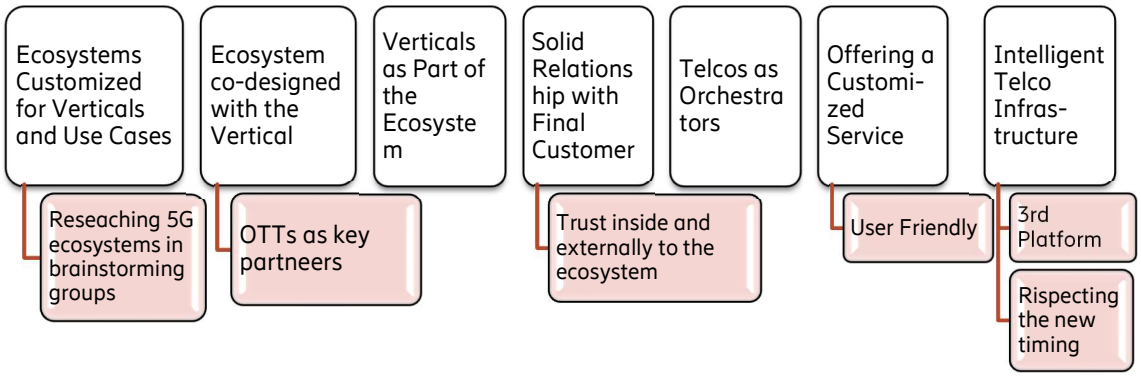


good results (chapter 6.4), especially during the first years before the first 5G commercial deployments. They represent a good opportunity to test the technology. They can generate new ideas for very specialized new use cases. Telcos have not to experience in business creation out of telco industry, expert people related to business areas can help telcos to find out this new ecosystem, participating in brainstorming groups. On the opposite side, people from business have not to experience in technical and telco areas. It seems a great idea that both sides collaborate.

> The 5G environment establishes new relationships for investigation and experimentation at the technological and commercial level.

They are new because in the past the common approach of "same for everybody" was used. Without having the possibility to offer real network customization, there was no reason to do it. A clear example of this is the 5G Incubator projects case, mentioned in this paper (5Tonic). They try to execute co-innovation projects, involving firms and institutions of different industry verticals, service providers, technology vendors, research institutions and business schools, to identify some 5G use cases like Autonomous Cars, Manufacturing, Media & Entertainment, Tourism, and Health.

With all these new 4 contributions located and identified, now it is possible to combine all of them to reach the Final Model, as it is shown in the following figure:



The path to success for capturing the full business potential in 5G can be started now, following these imperative conditions of the Final Theoretic Model.

8. CONCLUSIONS

We are in a true landmark moment – the commercial introduction of 5G.

The new ecosystem definition and how to create them is something that everybody is asking in the new telecommunication industry because in the answer there will be a success for most of the telcos companies. The field of research on how to monetarize 5G is going to be wider than how technology can become a reality.

This paper refers to offering a contribution for a better understanding, what is happening today setting some of the following points:

- Updated background and literature review, considering the latest trends (chapter 2 and 3)
- An integrated synthesis of the technological evolution for the telco market (chapter 3.1.1)
- An organized and structural synthesis of 5G from a new point of view: as a group of technologies combined as a system (chapter 3.2.6)
- An innovative mapping between technologies and business over the years (chapter 5.1)
- A complete new ambitious 5G definition (chapter 5.2)
- A Preliminary Theoretical Model with seven needed conditions to answer the Research Question (chapter 5)
- Illustrations of different use cases, that are being developed today as the first incubators labs, to find out new ecosystems for 5G, describing them in a very pragmatic way (chapter 6)
- A Final Theoretic Model, joining some specialization of the previous seven needed conditions (chapter 7)

To be sure that telcos follow the seven necessary conditions, these were formulated. Later, in the Final Model, some particularities were added. But, what happened if the Research Question is reformulated in the opposite logical direction: Why a 5G ecosystem must be developed individually for verticals (customized)? 5G, in its nature technologic fundaments, allows developing customized networks that follow the specific requirements of each customer in a very efficient way. At this point, this behavior becomes a minimal requirement of the market, then,

> Telcos who will not offer customized solutions will be at a competitive disadvantage compared with the rest.
>
> It is simple, in 5G the new technological base imposes it.

It is known that the impact 5G technology can have in society is underestimated. Just following marketing trends and the latest technologies, is not enough to be ahead to the competence (chapter 2.3). Neither integrating the technologies but reusing the current model, does not exploit all the possibilities of the 5G technologies. Because of a competitive factor for telcos in 5G, they must find out different ways of regrouping the technologies and make them work together as a system. At the same time, old business models are replaced by telcos in 5G. Both are imperatives.

Coming back to the Research Question (chapter 3.3):

> Which are the necessary conditions for telcos, to develop differentiated, and sustainable business models based on the opportunities opened by 5G?

Considering the theoretical and empirical sides, putting limits to this question, and ordering the technologies and most of the relevant ideas behind 5G. Our seven main points (chapter 5.4), can help

telcos to take a good chance, to define rich and profitable ecosystems along the years. Considering that, these points are required and imperative, but not enough. The work for telcos is just in the beginning, but with this research paper, they have an excellent starting point.

9. FOR FURTHER STUDY

Many authors agreed that we are in a market situation where there is not a clear business model defined yet for 5G. The huge concern of the telco operators' sector is to be dragged into a new investment cycle without a clear business model. Considering this business cases definition missing for 5G, several areas of research investigation are opening. In fact, the field of research in 5G is very broad. Following, some of the further researches can be supported by the conclusions in this paper.

It was mentioned the concept of Telco Cloud (chatper3.2.1). This paper offers a brief definition, but a complete definition could be studied with deep analysis, underlying networks and applications transform to new architectures and technologies. This creates more complexity in operations and life cycle management of services. Many times, in this paper appeared the Automation as a key to manage these complex networks, like for applications in various stages such as PNF (Physical Network Functions), VNF (Virtual Network Functions) and CNF (Cloud Native Network Functions), massive number of devices, different types of devices, and services across many industries. This automation is one aspect to focus on other research paper; the study of the industry effort towards automation. Very simple reason:

There is no 5G without automatization

Another area for further investigation is the relationship between telcos and OTTs (chatper3.12). The recommendation in this paper is to join forces, but nobody knows today how this power balance will evolve in the future, and the literature is not conclusive.

OTTs in 5G: How?

Also, the mapping between the technology evolution and the business in the telecommunication market (chapter 5.1), could be studied deeper. Technology and business will remain sync to create value to the society. A first approach mapping the two areas have been offered in this paper for the first time but, considering that is not the main matter of study for this research, it could be analyzed in depth.

5G Technology and Business Evolution

During the conclusions (chapter 6.5), the role of orchestrator seems to be cleared for now. But, the factors that promote and constrain to this centralized model, are not clear. It may be for other models that the orchestrator is not the same as the owner or the controller. In the case of 5G, this point seems to be for further research.

The role of orchestrator in 5G ecosystems

The final model (chapter 7) was elaborated the usage of the trust to enforce the relationship with all actors in the ecosystem, as a specialization of a solid relationship with final customers. A new area of research was discovered.

How to use new technics to enforce this mutual trust relationship within the 5G ecosystem to create confidence

Most recently in this paper, after having all the seven needed conditions in place (chapter 8), a new question comes to our mind: when and how to start working on it? This point remains for further investigation.

5G: When and How to start?

Finally, this paper has left some other technologies that are related to 5G, out of scope; like Edge Computing, Cloud Native, Containers-Dockers, etc. How they are evolving and impacting the business for telcos in 5G could also matter of further study separately.

Impacts in 5G business by other technologies

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