Telecom Business Models for Beyond 5G and 6G networks: Towards Disaggregation?

Meroua Moussaoui[1,2] Emmanuel Bertin[1,2] Noel Crespi[1]
[1] Orange Innovation, 14000 Caen, France
[2] IMT, Telecom SudParis, Institut Polytechnique de Paris, 91764 Palaiseau, France
Emails: {meroua.moussaoui, emmanuel.bertin}@orange.com and noel.crespi@it-sudparis.eu

Abstract—**Massive technology transformations are more and more challenging the way mobile telecommunications networks are designed and deployed. Beyond purely technological impacts, these transformations are also challenging business models and strategies, requiring both adaptability and timeliness. Many stakeholders from the Telecom industry value chain are attempting to take benefit from this shift towards softwarized and disaggregated networks, to promote or consolidate their business position. In this article, we examine existing and emerging business models (BMs) in the telecommunications ecosystem and analyze these findings to derive perspectives for Beyond-5G (B5G) and 6G networks.**

Keywords—business models, stakeholders, operators, value chain, ecosystem.

I. INTRODUCTION

5G is bringing to the telecommunications ecosystem more radical changes than the previous generations. Virtualization, softwarization and open-source, network slicing and private 5G, cloud and edge computing, among other 5G-enabling technologies, raise opportunities for new business models (BMs) and innovative service offerings. These services are targeting not only the diverse needs of mass-market consumers, often driven by Big Tech players, but also a plethora of industry verticals. This ecosystem dynamism leads to the emergence of new BMs, as well to the transformation of existing ones as established players are attempting to maintain their market positions while adapting to significant changes.

The rest of this paper is organized as follows: Section II surveys the related papers and highlights the contribution of this paper. Section III narrates the evolution of telecommunication technologies over the different generations. Section IV is devoted to the evolution of telecommunication BMs, focusing on the various players of the ecosystem, and particularly Mobile Network Operators (MNOs). Section V is about the emerging enablers for 5G BMs and the new roles they introduce. Section VI focuses on the impact of telecommunication regulatory policies on 5G BMs. Section VII proposes perspectives for B5G/6G stakeholders. The paper is wrapped off with a conclusive discussion of the findings.

II. RELATED WORKS & PAPER CONTRIBUTION

Some papers in the literature have addressed the evolution of the telecoms ecosystem, and especially the evolution of MNOs, such as [1]–[3]. Other works have focused on the telecoms value chain and the value creation in the digital market [4]–[6]. The regulatory aspect of the emergence of new actors into the ecosystem, or the policies and rules related to the spectrum use and sharing have been surveyed in [7]–[10]. In this paper, we are aggregating these different dimensions, while focusing on the transformations triggered by 5G and beyond.

Contribution: the main contributions of this survey are as follows:

- Surveying the telecoms business ecosystem, focusing on the stakeholders and the value chain.
- Surveying the emerging enablers for 5G and beyond BMs and the new transformations they bring to this landscape, with a specific focus on regulation and policies.
- Proposing future directions and perspectives for Beyond-5G and 6G stakeholders.

III. EVOLUTION OF TELECOMMUNICATION MOBILE NETWORKS

Every decade, a new generation of wireless networks emerges, each with its own set of standards and features. In the late 1980s, 2G has been introduced for voice telephony service, shifting away from mainly corporate customers of radiotelephony towards the mass market. 3G was introduced in 2000. It combines high-speed mobile connectivity with IP-based applications, multimedia, and value-added services, adding data-centric capabilities in addition to the voice-centric ones, while keeping worldwide roaming capability. Combined with the iPhone revolution on the device market, this leads to the emergence of new data offers to compensate the diminishing voice usage. In the late 2000s, 4G was introduced as an all-IP network technology, with the purpose of delivering broadband connectivity, multimedia, phone and data services, in addition to improved spectral efficiency, switching from low to high speed Internet mobile access. This, however, more often ignited competition among MNOs rather than increased revenue. In 2019, 5G appeared as a fully virtualized, softwarized, IMT-2020 compliant technology. From a commercial standpoint, this enables new market offers relying on tailored network capabilities, and new BMs beside broadband subscribers [8]. 6G is expected to emerge by 2030 as an intelligent user-and-data-centric network, combining different access technologies. It should offer ubiquitous wireless intelligence and unlock new services and use-cases [11]. This would necessitate a cross-domain rethinking of network resource exploitation, and would allow the entrance of new roles into the ecosystem to supply 6G services [12].

IV. THE EVOLUTION OF TELECOMMUNICATION BUSINESS MODELS

A. Definition of Business Models (BMs)

A common definition arises from the literature [13]–[19]: BMs are a model for defining, creating, and implementing business strategies, in terms of value propositions, product and service offers, and ways to make them profitable for the company. In simple words, it describes how a firm, or an ecosystem of firms conducts its business. Building a BM usually rely on identifying and exploiting opportunities, creating and capturing value, and investigating competitive advantages [20]. Important criteria to evaluate a BM are thus *scalability*, *adaptability*, and *sustainability*.

B. Telecommunication value chain & ecosystem

A "value chain" is a sequence of multiple activities and processes, through which companies produce and distribute value to their customers in the form of products and services. Businesses' value chains intertwine into a value network of many value chains, including those of their constituting elements, creating a larger value system known as "the industry value chain" [5].

The main operators and stakeholders in the traditional telecommunication value chain have been categorized by [1] and [5] into the following roles, and their positionings inside the value chain are illustrated in Figure 1:

- *Hardware (HW) manufacturers/ Vendors*: they manufacture and sell all essential ICT (Information Communication technologies), network and radio equipment, as well as user devices. They can be infrastructure providers (such as Ericsson, Nokia, Huawei, and Samsung) or device manufacturers (like Apple, Samsung, LG, and Nokia). They are the beginning point for every networking activity and any value production.
- *Software (SW) developers*: they are companies that provide SW, middleware and applications for operating, monitoring, and controlling network infrastructures (like Juniper, Harris corp., Amazon, ZTE) and user device operating systems (like iOS, Android and Windows Mobile).
- *Infrastructure owners*: they own assets that enable mobile network coverage and connectivity, such as the necessary infrastructure for deploying, powering and linking computing and storage equipment, networking infrastructure, as well as all other resources and equipment enabling various facilities. They may be part of network operators or provide wholesale access to network operators. This category includes tower companies (TowerCo, like Cellnex telecom), facility managers, and urban furniture managers, but also datacenter providers (like Amazon Web Services "AWS").
- *Mobile Network operators (MNO)*: this category includes operators offering mobile connectivity to end-users. These companies usually own spectrum licenses and deploy and operate the whole networking infrastructure. Network operators include for example AT&T, Verizon, Vodafone, or Orange.
- *Content/ service providers*: these entities develop and provide services based on digital content. They distribute their services to end-users via network operators. They often collaborate with other content providers and end-users (for user-generated content). Examples of content providers are Google, news agencies, TV channel or Video on Demand providers, and social networks. Examples of service providers are Google, Facebook, Tencent, Epic Games or websites.
- *End-users*: they use the content/service providers' products/services via the network operator's connectivity offers. They range from basic users seeking merely connectivity to verticals with more stringent criteria. They are the final elements of the value chain but can also become content creators for service providers.

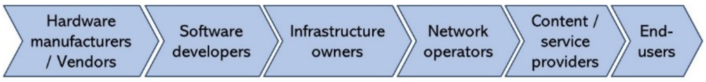

Fig. 1. The traditional telecommunication value chain [21].

5G affects the existing BMs and transforms the traditional value chain. Particularly, virtualization and softwarization technologies are opening new roles, enabling partnerships to be formed across several layers from spectrum sharing to sharply customized services.

C. The evolution of Mobile Network Operators

MNOs play a central role among the value chain stakeholders stated above. MNOs' evolution can be separated into three technologically conditioned periods.

"*The rise of MNOs*" was the first phase, which lasted from 1990s to 2000s. MNOs arose in the 1990s as companies that offered 2G mobile telecommunications, as well as mobile voice and messaging services. Many telcos that provided fixed line communication extended their business to ground MNOs, and wireless mobile network systems became an important source of revenue. At the end of the 1990s, MNOs expanded further due to these advancements and metamorphosed from state-owned organizations to private corporations, which helped them become global market leaders. In 2001, 3G was introduced to combine voice and messaging with internet access. MNO used to provide their services as multi-country organizations with end-to-end value creation spanning many aspects of their value chain: selling user devices, owning spectrum, managing network operations, billing, retail, and distribution [22].

The second phase, called "*The fall of MNOs*", lasted for the whole 4G decade, from 2010s to 2020. As voice and messaging revenues dropped, MNOs transitioned from telecommunications service providers to broadband platform providers, with internet access as their principal source of revenue. MNOs were required to share their network infrastructure with mobile virtual network operators (MVNOs) and with newly created MNOs, resulting in increased competition among market players and lower-cost mobile services. Meanwhile, digital platform companies such as Google, Amazon, and Meta began offering a variety of mobile services that included free telephony and messaging. MNOs responded by including phone and messaging in their mobile internet access offerings. However, they lacked the technical and operational skills required for delivering digital services and were tied to a limited footprint (i.e., their subscribers) in face of these emerging global players. As a result, they resorted to providing best-effort internet connectivity to enable the end-users' access to global digital firms' services, which became the new market leaders [22].

Another factor is that most MNOs remained strongly focused on building and running network infrastructure as well as providing associated services of voice (e.g., IMS) and messaging (e.g., RCS), that were challenged by pricing evolutions. Moreover, telecom equipment suppliers began offering Network-Infrastructure-as-a-service (NIaaS) to MNOs, leading some of them to limit themselves to spectrum license ownership and retail of connectivity offers, achieved by the orchestration of external resources [22].

The third phase, which begins with the launch of 5G, may be labeled "*The rebirth or the agony of MNOs?*" since the telecom ecosystem will either see MNOs reclaiming their dominant position or see their slipping further into the background. To secure a place in this new ecosystem, MNOs should adapt their architecture to the 5G's disruptive perception of telecommunication, aiming to improve coverage, increase bandwidth, optimize spectrum usage, and enable customized networks tailored to users' specific needs and requirements through network slicing (NS) and other virtualization technologies. To be consistent with the 5G objectives, MNOs should also promote spectrum reuse, higher-frequency spectrum usage, Multi-access Edge Computing (MEC), and enhanced energy efficiency. Moreover, spectrum license ownership enable MNOs to share or resell spectrum, with other MNOs as well as for building private 5G networks [3].

To reach this target, MNOs will probably rely on an intelligent virtualized core network architecture, using technologies like SDN (Software-Defined Networking) and NFV (Network Function Virtualization) [3]. MNOs could also go further by exploiting the MEC paradigm to reduce the latency for specific services and efficiently process users' data closer to the edge to improve privacy and data protection (as only caution to national legal frameworks, unlike cloud providers that process user's data in remote data centers more vulnerable to cross-domain regulatory conflicts). As a result, MNOs should invest in edge enabling infrastructure to deliver their services, but also to collaborate with other digital firms for providing the underlaying edge infrastructure [22]. For that, they probably should acquire and exploit technological and management capabilities to collaborate with other firms (and even with enterprise customers) for delivering value-added services, in particular for the B2B market. The challenge is whether MNOs can "monetize" 5G by developing revenue-generating BMs beside simple connectivity. Otherwise, MNOs will continue to provide best-effort connection while living in the shadow of the Big Tech players [22].

D. *New stakeholders for 5G networks*

The introduction of 5G comes at a time when more than 5 billion people around the world are connected to the internet, accounting for 63% of the global population. Mobile Internet is massively rolled out, and this progress has resulted in a drop in growth rates for MNOs. To remain competitive, many players are trying to expand their revenue, from improved internet connectivity to assuring specialized and customized services. One potential opportunity is to focus on verticals market, especially with the rise of Internet-of-Things (IoT), smart cities and e-health, and well as Factories-of-the-future (Industry 4.0). Manufacturing, automotive industry, and public safety are examples of such verticals. These actors usually have specific bandwidth and latency requirements, as well as other QoS metrics, emphasizing the need for personalized and completely adapted and customized network services.

This transition from a "horizontal" paradigm, in which services are provided independently of their eventual users, to a "vertical" paradigm, in which services are provided with tailored network requirements and QoS based on the demands of the final users, constitutes a significant shift in telecommunications momentum, and introduces new actors to the scene, namely verticals and vertical associations.

Vertical associations are organizations grouping several stakeholders of the same vertical market. They may specify requirements for the connectivity services, as well as standards and timetables for the expansion of respective verticals. Examples of vertical associations are 5GACIA for manufacturing, 5GAA for the automotive industry and ECSO for public safety.

V. EMERGING BUSINESS MODEL OPPORTUNITIES FOR 5G AND BEYOND

A. *Spectrum sharing*

Two general types are usually mentioned for spectrum sharing: licensed access for sharing methods in licensed bands, and license exempt access for sharing methods in unlicensed bands. The allowed methods are specified by each National Regulatory Authority (NRA), which determines the spectrum mobile operators can share or can use [23]. Figure 2, inspired from [23], [24] summarizes the taxonomy of the emerging spectrum technologies discussed in this section. Other spectrum access and sharing technologies exist, however, they are out of the scope of this paper.

Dynamic Spectrum Sharing (DSS) is a technology for 4G/5G compatibility to allow a smooth transition from LTE to 5G New RAN (NR), which enables the sharing of frequency ranges assigned for 4G and 5G services simultaneously within the LA spectrum as well as the dynamic resource allocation [23].

Licensed Shared Access (LSA) is a European Union (EU)-developed regulatory solution for controlled spectrum sharing in which incumbent users, who are the primary users of the spectrum with exclusive rights of access for their band, allow a number of LSA Licensees (MNOs) to share their spectrum resources. Its frequency range is 2.3–2.4 GHz. ETSI is now working on evolved LSA (eLSA), which intends to expand LSA's potential to give spectrum access to vertical sector operators' local networks. [24].

The Federal Communications Commission (FCC) has approved the shared use of the Citizens Broadband Radio Service (CBRS), which is comparable to the LSA. It targets the 3.55–3.7 GHz bands, for spectrum sharing between three types of users: *Incumbent users*, who are the primary spectrum users with exclusive access rights, *Priority access licensees (PALs)*, who can be allotted up to 70 MHz of bandwidth, and finally, *General authorized access (GAA)*, in which users can only access the spectrum by getting a license from the regulator and are prioritized last for interference protection. They benefit from at least 80 MHz of CBRS bandwidth [24], [25].

The main purpose of NR-U is to extend the applicability of NR to unlicensed bands and to use a scheme that allows for fair coexistence of various radio access methods (e.g., with WiFi). It can operate in a variety of bands, including bands below 7 GHz and mmWave bands at 60 GHz and 37GHz [24].

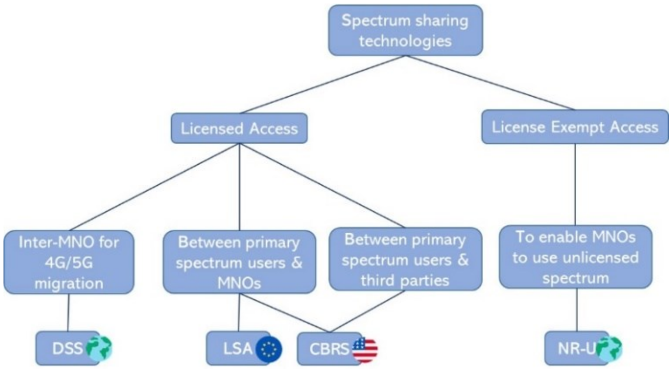

Fig. 2. Taxonomy of spectrum sharing technologies in the scope of this paper [23], [24].

B. Open RAN (O-RAN)

O-RAN is a set of disaggregated, virtualized, softwarized and cross-vendor compatible components via open and standardized interfaces. Disaggregation and virtualization make the RAN more programable, robust, simply configurable and customizable, and flexibly deployable using cloud technologies. It is feasible to mesh equipment from many manufacturers using open, standardized interfaces, allowing new players and businesses of all sizes to enter the ecosystem. However, this comes with the drawback of maximizing possible interoperability issues and failures. Softwarization of the RAN entities (i.e., the shift from appliances to pure software modules) help to increase network control in a more efficient, closed-loop, and data-oriented way. The integration of Machine Learning (ML) and Artificial Intelligence (AI) for O-RAN optimization and control, will profoundly revolutionize the design, deployment, and operations of networks in the era of 5G and beyond that. [26].

C. Connectivity-as-a-service (CaaS)

Connectivity-as-a-Service (CaaS) extends the NIaaS paradigm by providing not only network infrastructure maintenance services, but also a complete network administration and management framework that can be used to provide customized services and respond to the customer's QoS requirements. Starting from connectivity needs, it helps define, plan, develop, implement, manage, and monitor connectivity solutions in real time. CaaS packages a comprehensive set of physical and virtual resources, thanks to the utilization of cloud-based services. It includes embedded services that are incorporated into the proposed network, as well as synchronous, asynchronous, or hybrid integration between on-premise and off-premise applications. CaaS might help for providing to businesses more control over their data and connection (on-demand network services), while ensuring security, privacy, data protection, as well as resilience [27]. CaaS providers are today mainly new players (e.g., Redtea Mobile, Tiviti, Linchpin Networks, Unitas global). However, MNO seems also perfectly suitable to position on that BM, with a more global reach.

D. Neutral Host (NH)

A neutral host is defined as a "service provider that constructs and manages an integrated technological platform only for sharing purposes" [28]. It owns, manages and operates network infrastructures in order to share them with a number of other operators. This BM is frequently used to alleviate cellular coverage and capacity difficulties. Its principal service is infrastructure providing, while optimizing installation costs and usage. Furthermore, the NH BM is a technologically, economically, and environmentally sustainable model, as network infrastructure sharing allows for an efficient use of infrastructure through dynamic resource allocation algorithms while maintaining perfect isolation between the different operators. Additionally, it allows for an effective usage of space and energy resources, lowering carbon footprint. This BM is an excellent choice for crowded networks and places with limited service. However, several challenges occur for NH management, such as spectrum concerns and regulatory issues, imprecise specifications and interoperability issues [29].

E. Micro-operators (µOs)

Micro-operators (µOs) are a new generation of network operators who run local 5G networks. They provide customized services that are suited to the network's use-cases requirements and specifications. Because a local 5G network is built in a geographically restricted region, it often targets one or a few categories of users. It therefore provides one or a few use-cases, which require the network's deployment to be highly tailored to these use-cases, for example within a city for specific smart cities use-cases. The three primary business scenarios for µO networks are: a) a closed network for a limited group of customers, where the µO serves specific entities, that are not served by an MNO, in a confined environment (e.g., connected machines in a factory), b) an open network for customers of other MNOs where the µOs operates as a NH, supplying the MNOs customers with connectivity and other tailored services, in specific regions, and for specific use-cases (e.g., concerts and stadiums), or c) a hybrid of the two, as the µO caters to its own as well as the MNO's customers (e.g., in a hospital where the µO serves the connected machines which are its primary customers, and the different devices of visitors, which are the MNOs subscribers). The µOs concept opens up the telecom ecosystem and industry to new participants that may become operators in a geographically restricted network, bringing a new BM to the landscape that is radically different from the conventional one with a few large MNOs operating as monopolies serving the general public. Unlike MNOs, which provide fewer customized services and try to provide one-size-fits-all QoS to aggregated groups of users, µOs have the advantage of providing fine-grained QoS specifications and perfectly responding to users' requirements in terms of reliability, data rates, latency, security, and data protection [30]. The interplay between emerging µOs and MNOs, on the flip side, is defined as *coopetitive* in [31], suggesting that they are both *cooperating* and *competing*.

F. Network slicing (NS)

Unlike its predecessors, 5G is projected to offer specific services to various stakeholders (e.g., verticals, see section IV.D), while meeting the -potentially conflicting- demands and requirements of each category of users, in a tailored and customized manner. Network slicing (NS) has been designed as a potential solution for addressing this issue. It enables the establishment of several virtually isolated networks, called slices, on top of a common shared infrastructure, each with its own specifications and QoS parameters.

Single domain NS and multi-domain NS are the two main types of NS BMs. In single domain NS, only one slice provider provides requested slices to the slice requester (even if each kind of resource (e.g., virtual, physical, and cloud resources) may be offered by different resource providers). In multi-domain NS, various resource providers contribute to the establishment of a shared resource pool, and multiple slice providers use these resources to generate and deliver required slices.

The multi-domain NS BM enables the business to be opened to additional players, resulting in a wider range of available and re-usable virtual and physical resources. It also allows fair competition and transparency in service offerings, as resources from multiple providers can be combined to offer a personalized network slice, primarily based on the price/performance ratio. This provides users with more options in selecting the best resources suiting their needs and financial capabilities. This environment is a fertile ground for the emergence of new roles and functions, such as the Slice broker, who acts as a middleman between the slice requester and the various slice suppliers that may deploy the requested slice. Another role is that of the Infrastructure Broker, who collects infrastructure resources from a variety of sources and provides resource negotiation tools. Other roles, like physical/virtual infrastructure suppliers, slice managers and orchestrators (MANOs), may also become increasingly important for this BM [32].

Many 5G research initiatives, including 5G-NORMA, 5G-Exchange (5GEx), 5G-TRANSFOMER (5G-T), and 5G-MONARCH, have deployed innovative BMs for NS [33]. NS, like any other technology, could be a boon or a bane, as it still faces a multitude of challenges, including a lower security level than private 5G (due to inter-slice shared resources and isolation issues), as well as the inflexibility of slice templates, and the difficulty to define optimal resource usage with dynamic modeling. Furthermore, the termination (or extension) of a slice within the User Equipment (UE) remains a disputed topic [34].

G. Private 5G

A private 5G network is a local area wireless network relying on 5G technology that only serves a single specific customer (typically an enterprise, a factory), which is the owner of this private network. It may be managed independently by the owner, who has total control over all characteristics, including priority scheduling, resource allocation, security, privacy and access rights. This enables a perfect fit with the use-cases and requirements from the owner, with a high level of security, reliability and privacy, as the connections between nodes are made using a specific network. On the radio level, it enables high peak data rates, reliability and low latency. Another advantage of moving to private 5G networks is that KPIs can be monitored locally based on narrowed network-specific statistics, allowing customized ML models to be used with low-variability data and a monotonous range of user behavior to provide tailored predictable QoS and personalized vertical services [35]. An enterprise customer may choose to fully build and operate its own private network. However, design, deployment and/or operations will be most often delegated to MNOs, IT services companies, or even to Big Tech players like Amazon (with its private 5G AWS offer).

H. Industry 4.0

Industry 4.0 is a technical, economic, and industrial trend in which production processes are fully automated through modern information technologies. It brings digital and smart technology into factories and production lines, as well as making vendor-customer interactions more safe, cost-effective, and time-effective [36]. Industry 4.0 goal is to improve the economic efficiency of the manufacturing process by making the production process more flexible. Industrials will have more options to generate a larger scope of products. It also allows the consumer to be more integrated into the production chain by utilizing feedbacks, and by being able to build highly customized items, for fitting market demands and for accelerating innovation. Companies trying to implement the Industry 4.0 wave have also often created customized open BMs, by deeply integrating many stakeholders in the value-creation process (from suppliers to customers), allowing them to diversify legacy production processes, while becoming more adaptable to both competition and cooperation [37]. Crowd-Sourced Innovation (CSI) or Manufacturing-as-a-Service (MaaS) are examples of the BMs offered by Industry 4.0 [36]. Enterprises shifting towards this model are expected to make use of Network Slicing and/or private 5G in order to fulfill the associated connectivity needs.

I. Open-Source

A last important game changer for 5G BMs may be the emergence of open source 5G RAN and Core Network solutions. For example, Magma [38], an open-source Core Network platform initially promoted and built by Meta and now under the umbrella of the Linux Foundation. Open Air Interface (OAI) [39] is another example, covering both the Radio Access Network (RAN) and the Core Network.

These solutions could enable the building of customized core networks in hard-to-reach areas, providing high dependability, rapid service delivery, and expanded coverage. They are interesting solutions for micro-operators, or for enterprises for deploying their own private 5G networks. This could also help operators or other Big Tech players to build fully virtualized and softwarized networks with cross-border or local management and administration

VI. Regulations & policies impacts for 5G BM

Telecom regulatory framework is composed of a set of policies coming from different levels: national, regional (e.g., European Commission), and international. Moreover, MNOs are regulated both by telecom-specific rules (e.g., for spectrum or net neutrality) and by general rules (e.g., competition and antitrust policies). Several papers, such as [40] have emphasized the various regulatory domains affecting the telecoms ecosystem and BMs evolution, that come from different bodies in a sometimes conflictive way:

- *Spectrum regulations & authorization* intend to regulate and control spectrum usage. Many spectrum management choices have been made by regulatory bodies to guide the rollout of 5G networks. They have granted local 5G spectrum access rights in order to meet the location-specific demands of vertical businesses.

Germany has for example opened spectrum licensing to non-MNO in order to enable companies or industrial consortiums to setup private 5G networks. Some regulatory bodies has also opened specific spectrum bands for general access, without bidding procedures and heavy licensing requirements [10]. This is for example the case in the US with the CBRS band (3550 to 3700 GHz, freely granted in 10Mhz blocks for a specific location). Finally, as far as µOs are concerned, studies are still ongoing for micro-licensing regulations [41]. Government policy on pricing radio spectrum access, which might account for a major portion of the cost of offering 5G services, is particularly crucial. The engineering value of additional spectrum is concerned with the infrastructure cost reductions due to its availability [9]. The economic value of the spectrum takes into consideration the prospective value derived from the usage of the spectrum and the potential future profits. The strategic value of the spectrum is about the control of market positions through spectrum allocations [42].

- *Innovation policies* intend to maintain the competitive dynamics of the communications industry. Beside technology and economics environment, legislation and incentives for innovation investment will heavily influence the pace, direction and scope of the 5G market's innovation. In that context, the cost of coordination among actors for building innovative BMs should be especially considered. Here, two forms of innovation processes with distinct needs of coordination among participants can be considered: "modular innovation," which targets a single aspect of the system, and "architectural innovation," which targets the whole system's design [43]. The second one is usually bringing the most value, and public policies may be designed to encourage it, for example by inciting to the emergence of actors taking in charge coordination costs.
- *Net neutrality* states that the Internet should be opened to any content/service providers without discrimination between them by the MNOs (e.g., by providing priority routing, better bandwidth or latency). Net neutrality supporters argue it encourages innovation and protects civil liberties, by guarantying each data is handled equally. Net neutrality opponents argue it might diminish investment incentives, and thus it curbs technical advancement and innovation [44]. 5G technologies like QoS management, everything-as-a-service, and NS may be considered as commercial traffic discrimination. However, regulatory bodies generally acknowledge that some services cannot be offered using best-effort networks, requiring traffic optimization (e.g., European Commission's Telecom Single Market (TSM) Regulation [8]). "Reasonable network management" and "specialized services" are the two exceptions for net neutrality [45]. However, whether such 5G concepts fall inside these two exclusions, is still up for discussion.
- *Competition and antitrust policies*: 'In the market' competition is the normal competition way, where many firms compete to sell products/services to consumers in the same market. However, in certain circumstances, the characteristics of a product encourage a limited number of dominant enterprises to develop and compete ('for' the market) to become the dominant firm. This creates a dynamic in which large firms are more likely to flourish and customers are less likely to switch to new smaller competitors. Competition regulations are thus usually prohibiting them from abusing their position [46]. Detecting the capacity of influential 5G ecosystem companies to manipulate competition for their own profit remains a major problem for regulators who must improve their analysis capabilities. Because there is an “inverted, U-shaped” link between competition and innovation, 5G market and regulatory designs should set critical boundaries for competition to flow in productive ways without stifling innovation [43]. However, at the worldwide scale, the competitive environment of MNO is today more open than that of content/service providers dominated by a few Big Tech companies.
- *Privacy & data protection regulations*: Privacy rules guarantee that only authorized entities have access to users' data, how they may use it, and how much control the user has over it. Data protection, on the other hand, guards the data from unauthorized entities. Many privacy and data protection legislation exist, such as the European Union's General Data Protection Regulation (GDPR), which contains a set of laws including the right to erasure and de-listing, privacy by design, and consent conditions. Another example is Japan's Act on the Protection of Personal Information (APPI). To favor innovation, these rules could evolve to harmonize legal instruments on a global scale and coordinate across jurisdictions to ensure their compliance with new technologies and to allow cross-border information flow. These guidelines should also be in line with the norms of other regulatory bodies at the national, regional, and global levels, as part of the globalization of privacy and data protection legislation. Another required measure to favor 5G and beyond would be to synchronize technical development with regulatory requirements: as technology is quickly evolving, regulatory agencies appear to be having difficulty keeping up with it. These rules are important for beyond-5G networks because they bring additional architectural and service-oriented standards, which help shape innovation and the level of technical advancement while also ensuring public acceptance. Privacy-aware routing methods leveraging SDN, hybrid cloud, and privacy by design are some of the broad lines that will characterize 5G and beyond privacy [47].
- *Pricing regulations*: In some countries, specific rules targeting the Telecom market aim to establish a pricing framework that permits internet services to be affordable and accessible to the mass market (while also fairly remunerating all players involved in the value-creation chain). This telecom ruling framework has an impact on the feasibility of 5G deployments since pricing discrimination may impede innovation, inhibit the introduction of new services, and limit customers' choices, but it can also stimulate innovation by providing greater incentives. It's crucial to note that there are a variety of ways to reduce the cost of establishing 5G services, including infrastructure sharing [8].

VII. Business models' perspectives for B5G/6G

As novel 5G BMs are still emerging, we should already consider how they could be transformed or altered by forthcoming technologies and market dynamics, in order to start shaping future 6G networks that are beginning to be standardized [12]. This standardization work should actually be fed with perspectives on BMs, stakeholders, services and market dynamics to build an adequate B5G/6G technology. Table 1 summarizes and categorizes some key B5G/6G BMs directions.

Table 1 Perspectives and future direction for B5G/6G BMs.

Decentralization	By extending the 5G trends, 6G will probably bring a great variety of new players into the ecosystem, as well as the establishment of open and distributed BMs. The most likely technology to shape and support this openness is blockchain, which will not only shape transaction and smart contract-based BMs, but could also enable "network asset marketplaces", such as spectrum but also VNFs and other softwarized and virtualized resources [48]. It also enables network services to be monetized via digital currencies, as well as data privacy and immutability. Decentralized resource brokering via smart contracts enables BMs for automatic time-and-cost efficient coordination between tenants [49].
Sustainability	Future 6G BMs will have to consider sustainability from a variety of perspectives, including environmental and societal ones. 6G will usher in new Green Business Models (GBMs) and circular economy designs in which value creation is made more eco-friendly by utilizing renewable energy sources, encouraging infrastructure sharing to reduce space and energy costs, and developing new business strategies that encourage collaboration among the value chain members. Customers can also act as nodes to outsource various resources like storage, computation, and renewable energy harvesting.
New Public Policies	Regulations governing shared spectrum licensing and localized micro-licensing must further mature to allow a better implementation of 6G new services. With the promise of extensive AI use in 6G networks, regulators must adapt to this environment by issuing policies to govern AI and IoT usage in order to safeguard citizens in terms of data privacy and other aspects such as safety (e.g., intelligent automated cars, integration of robots in manufactories). Moreover, regulatory positions are needed to clarify virtual execution of resources through cloud computing services, particularly in terms of cybersecurity, privacy, and data governance (e.g., storing some data in a specific region renders it subject to its privacy rules). This highlights the importance of a greater coordination amongst regulatory organizations.
Non-MNO Networks	Private networks' groups are going to arise independently of MNOs, because of trends like micro-licensing, µOs and private 5G networks. Customers will have a larger role in the B5G/6G era, contributing to value generation and participating in crowdsourcing resources such as connectivity in the Helium [50] and Pollen [51] networks. Users may share end devices like home routers while they are not in use, which helps maximize the utilization of the underpinning physical infrastructure. Moreover, the Everything-as-a-Service paradigm, which encourages platformization and data-driven models, will probably be emphasized further in 6G, leading to the emergence of new BMs. Companies will be able to benefit from services on demand, which offloads them from multiple aspects of their traditional value creation phases. This helps to increase the efficiency of a company's work by allowing it to focus only on its major expertise domains, while the rest can be outsourced to third parties. This will probably lead to a further disaggregation of the telecom ecosystem by forming companies that are highly skilled in specific sectors and monetize their knowledge by offering it as a service to other businesses.
Industry 5.0	Industry 5.0 will enable mass product personalization by combining human intelligence and know-how with machine capabilities for efficient, reliable, and cost- and time-effective manufacturing. By incorporating more robots and smart systems into the production chain, it will also leverage AI and deep learning. Another factor is that the value chain will become increasingly decentralized, making blockchain an ideal option for asset management and decision-making via smart contracts. Virtualization, cloud, edge, digital twins, big data and local private networks will be used by BMs in Industry 5.0 to provide a more robust, secure, and performant production environment, allow remote production and enable new BMs such as factory-as-a-service, supply-chain-as-a-service and assembly-as-a-service. In B5G/6G, the Internet-of-Everything (IoE) paradigm will be a prominent trend, allowing millions of intelligent heterogeneous nodes to be connected for the delivery of specialized services. This new technology will undoubtedly change vertical BMs, which will become more fragmented in a highly decentralized and geographically spread network. Again, blockchain and smart contracts appear to be viable options for assisting vertical network management.

VIII. Conclusive remarks

The telecom value chain is fragmenting into a complex system with several interactions and a wide range of actors competing for value generation. This movement may be evident in some portions of the traditional linear value chain, as businesses increasingly outsource and collaborate to create value. Also, they are becoming increasingly concentrated on a single type of value delivery and less diverse service/product creation, which takes us away from the "global dominant player" pattern seen in the 2G/3G period for MNOs. Thanks to the introduction of virtualization, softwarization, and cloud technologies, companies can now offload their entire network to third parties via the CaaS BM, while new companies can become µOs that operate only a spatially-limited network via the Private 5G network BM and micro-licensing. These companies are progressively becoming nodes in a web of interconnected value chains, allowing for more competition and innovation. This disruptive transformation is not expected to decrease in the 5G/6G era, as value chains will be even more fragmented and decentralized, connecting intelligent systems, using blockchain and smart contracts for better security and automation, and involving new players (inc. customers) with outsourcing BMs. Every company must target a place in the ecosystem, while continually assessing external elements to react to the ever-changing telecom markets by adapting their BMs and plans. This ongoing shift will result in the formation of new BMs, which will require greater investigation and scrutiny in order to assess their efficiency and likely outcomes. This suggests that the telecom ecosystem will remain in flux and will be far from stable, nonetheless, this merely means that we will see new entries and maybe the re-emergence of firms that had faded into a kind of decline. As a result of the disaggregated and fragmented nature of B5G/6G BMs, the authors of this survey believe that blockchain and smart contracts could be a viable solution for managing this rapid expansion of the ecosystem and the intertwining of actors and value chains, by providing automation, security, and immutability, and modeling the various relationships as transactions, as well as by monetizing the exchanged value (e.g., via digital tokens).

References

[1] F. Pujol, S. E. Elayoubi, J. Markendahl, and L. Salahaldin, "Mobile telecommunications ecosystem evolutions with 5G," *Commun. Strateg.*, no. 102, p. 109, 2016.

[2] S. Yrjola, "Technology antecedents of the platform-based ecosystemic business models beyond 5G," in *2020 IEEE Wireless*

Communications and Networking Conference Workshops (WCNCW), 2020, pp. 1–8.

[3] W. Lehr, F. Queder, and J. Haucap, "5G: A new future for Mobile Network Operators, or not?," *Telecommun. Policy*, vol. 45, no. 3, p. 102086, 2021.

[4] J. Peppard and A. Rylander, "From value chain to value network:: Insights for mobile operators," *Eur. Manag. J.*, vol. 24, no. 2–3, pp. 128–141, 2006.

[5] Y.-F. Kuo and C.-W. Yu, "3G telecommunication operators' challenges and roles: A perspective of mobile commerce value chain," *Technovation*, vol. 26, no. 12, pp. 1347–1356, 2006.

[6] F. Li and J. Whalley, "Deconstruction of the telecommunications industry: from value chains to value networks," *Telecommun. Policy*, vol. 26, no. 9–10, pp. 451–472, 2002.

[7] A. Morgado, K. M. S. Huq, S. Mumtaz, and J. Rodriguez, "A survey of 5G technologies: regulatory, standardization and industrial perspectives," *Digit. Commun. Netw.*, vol. 4, no. 2, pp. 87–97, 2018.

[8] Z. Frias and J. P. Martínez, "5G networks: Will technology and policy collide?," *Telecommun. Policy*, vol. 42, no. 8, pp. 612–621, 2018.

[9] E. J. Oughton, N. Comini, V. Foster, and J. W. Hall, "Policy choices can help keep 4G and 5G universal broadband affordable," *Technol. Forecast. Soc. Change*, vol. 176, p. 121409, 2022.

[10] M. Matinmikko-Blue, S. Yrjölä, and P. Ahokangas, "Spectrum management in the 6G era: The role of regulation and spectrum sharing," in *2020 2nd 6G Wireless Summit (6G SUMMIT)*, 2020, pp. 1–5.

[11] A. Dogra, R. K. Jha, and S. Jain, "A survey on beyond 5G network with the advent of 6G: Architecture and emerging technologies," *IEEE Access*, vol. 9, pp. 67512–67547, 2020.

[12] E. Bertin, N. Crespi, and T. Magedanz, *Shaping Future 6G Networks: Needs, Impacts, and Technologies*. John Wiley & Sons, 2021.

[13] M. M. Al-Debei and D. Avison, "Business model requirements and challenges in the mobile telecommunication sector," *J. Organ. Transform. Soc. Change*, vol. 8, no. 2, pp. 215–235, 2011.

[14] J. Magretta, "Why business models matter." Harvard Business School Boston, MA, USA, 2002.

[15] G. Camponovo and Y. Pigneur, "Business Model Analysis Applied to Mobile Business.," in *ICEIS (4)*, 2003, pp. 173–183.

[16] J. Linder, *Changing business models: Surveying the landscape*. 2000.

[17] T. Haaker, E. Faber, and H. Bouwman, "Balancing customer and network value in business models for mobile services," *Int. J. Mob. Commun.*, vol. 4, no. 6, pp. 645–661, 2006.

[18] M. M. Al-Debi, R. El-Haddadeh, and D. Avison, "Defining the business model in the new world of digital business," *AMCIS 2008 Proc.*, p. 300, 2008.

[19] J. Hedman and T. Kalling, "The business model concept: theoretical underpinnings and empirical illustrations," *Eur. J. Inf. Syst.*, vol. 12, no. 1, pp. 49–59, 2003.

[20] P. Ahokangas *et al.*, "Business models for local 5G micro operators," *IEEE Trans. Cogn. Commun. Netw.*, vol. 5, no. 3, pp. 730–740, 2019.

[21] I. Neokosmidis *et al.*, "Are 5G networks and the neutral host model the solution to the shrinking telecom market," in *IFIP International Conference on Artificial Intelligence Applications and Innovations*, 2018, pp. 70–77.

[22] P. N. Gooderham, F. Elter, T. Pedersen, and A. M. Sandvik, "The digital challenge for multinational mobile network operators. More marginalization or rejuvenation?," *J. Int. Manag.*, vol. 28, no. 4, p. 100946, 2022.

[23] V. Tikhvinskiy, R. Umanskiy, A. Plossky, and V. Makarov, "Utilization of Organizational-Economic Mechanism for Selection and Management of Spectrum Sharing Scenarios to Increase Economic Efficiency of 5G Operators," in *Internet of Things, Smart Spaces, and Next Generation Networks and Systems*, Cham, 2022, pp. 95–107. doi: 10.1007/978-3-030-97777-1_9.

[24] M. Parvini *et al.*, "A Comprehensive Survey of Spectrum Sharing Schemes from a Standardization and Implementation Perspective," *ArXiv Prepr. ArXiv220311125*, 2022.

[25] S. Yrjölä and H. Kokkinen, "Licensed Shared Access evolution enables early access to 5G spectrum and novel use cases," *EAI Endorsed Trans. Wirel. Spectr.*, vol. 3, no. 12, 2017.

[26] M. Polese, L. Bonati, S. D'Oro, S. Basagni, and T. Melodia, "Understanding O-RAN: Architecture, Interfaces, Algorithms, Security, and Research Challenges," *ArXiv Prepr. ArXiv220201032*, 2022.

[27] Y. Ni, C. L. Xing, and K. Zhang, "Connectivity as a Service: Outsourcing Enterprise Connectivity over Cloud Computing Environment," in *2011 International Conference on Computer and Management (CAMAN)*, 2011, pp. 1–7.

[28] J. Lähteenmäki, "The evolution paths of neutral host businesses: Antecedents, strategies, and business models," *Telecommun. Policy*, vol. 45, no. 10, p. 102201, 2021.

[29] V. Vasconcellos and P. H. P. de Carvalho, "A Framework for Evaluating 5G Infrastructure Sharing with a Neutral Host," in *Conference of Open Innovations Association, FRUCT*, 2021, no. 28, pp. 659–663.

[30] Y. Siriwardhana, P. Porambage, M. Liyanage, J. S. Walia, M. Matinmikko-Blue, and M. Ylianttila, "Micro-operator driven local 5G network architecture for industrial internet," in *2019 IEEE Wireless Communications and Networking Conference (WCNC)*, 2019, pp. 1–8.

[31] P. Ahokangas *et al.*, "Future micro operators business models in 5G," *Bus. Manag. Rev.*, vol. 7, no. 5, p. 143, 2016.

[32] S. Kukliński, L. Tomaszewski, K. Koz\lowski, and S. Pietrzyk, "Business models of network slicing," in *2018 9th International Conference on the Network of the Future (NOF)*, 2018, pp. 39–43.

[33] E. Borcoci, A.-M. Drăgulinescu, F. Y. Li, M.-C. Vochin, and K. Kjellstadli, "An Overview of 5G Slicing Operational Business Models for Internet of Vehicles, Maritime IoT Applications and Connectivity Solutions," *IEEE Access*, 2021.

[34] I. Afolabi, T. Taleb, K. Samdanis, A. Ksentini, and H. Flinck, "Network slicing and softwarization: A survey on principles, enabling technologies, and solutions," *IEEE Commun. Surv. Tutor.*, vol. 20, no. 3, pp. 2429–2453, 2018.

[35] M. Wen *et al.*, "Private 5G Networks: Concepts, Architectures, and Research Landscape," *IEEE J. Sel. Top. Signal Process.*, vol. 16, no. 1, pp. 7–25, 2021.

[36] M. Ghobakhloo, "Industry 4.0, digitization, and opportunities for sustainability," *J. Clean. Prod.*, vol. 252, p. 119869, 2020.

[37] S. Grabowska and S. Saniuk, "Business Models in the Industry 4.0 Environment—Results of Web of Science Bibliometric Analysis," *J. Open Innov. Technol. Mark. Complex.*, vol. 8, no. 1, p. 19, 2022.

[38] "Magma – Linux Foundation Project." https://magmacore.org/ (accessed Jun. 21, 2022).

[39] "OpenAirInterface – 5G software alliance for democratising wireless innovation." https://openairinterface.org/ (accessed Jun. 22, 2022).

[40] M. Matinmikko, M. Latva-aho, P. Ahokangas, and V. Seppänen, "On regulations for 5G: Micro licensing for locally operated networks," *Telecommun. Policy*, vol. 42, no. 8, pp. 622–635, 2018.

[41] K. S. Manosha, M. Matinmikko-Blue, and M. Latva-aho, "Framework for spectrum authorization elements and its application to 5G micro-operators," in *2017 Internet of Things Business Models, Users, and Networks*, 2017, pp. 1–8.

[42] M. Matinmikko-Blue, S. Yrjölä, P. Ahokangas, V. Seppänen, H. Hämmäinen, and R. Jurva, "Value of the spectrum for local mobile communication networks: Insights into awarding and pricing the 5G spectrum bands," 2019.

[43] J. M. Bauer and E. Bohlin, "Regulation and innovation in 5G markets," *Telecommun. Policy*, p. 102260, 2021.

[44] H. Øverby and J. A. Audestad, "Net Neutrality," in *Introduction to Digital Economics*, Springer, 2021, pp. 323–334.

[45] C. S. Yoo and J. Lambert, "5G and net neutrality," in *THE FUTURE OF THE INTERNET–INNOVATION, INTEGRATION AND SUSTAINABILITY (Guenter Knieps & Volcker Stocker eds., Nomos 2019), TPRC47: The 47th Research Conference on Communication, Information and Internet Policy*, 2019, pp. 19–17.

[46] D. Deller, T. Doan, F. Mariuzzo, S. Ennis, A. Fletcher, and P. Ormosi, *Competition and innovation in digital markets*. 2021.

[47] M. Liyanage, J. Salo, A. Braeken, T. Kumar, S. Seneviratne, and M. Ylianttila, "5G privacy: Scenarios and solutions," in *2018 IEEE 5G World Forum (5GWF)*, 2018, pp. 197–203.

[48] S. Yrjölä, "How could blockchain transform 6G towards open ecosystemic business models?," in *2020 IEEE international conference on communications workshops (ICC workshops)*, 2020, pp. 1–6.

[49] L. U. Khan, I. Yaqoob, M. Imran, Z. Han, and C. S. Hong, "6G wireless systems: A vision, architectural elements, and future directions," *IEEE Access*, vol. 8, pp. 147029–147044, 2020.

[50] "Helium – Introducing The People's Network." https://www.helium.com/ (accessed Jun. 21, 2022).

[51] "Own Your Network | Pollen Mobile." https://www.pollenmobile.io/ (accessed Jun. 21, 2022).