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Platform-Based Business Models in Future Mobile Operator Business

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Abstract

Purpose: As an emerging field, the fifth generation, 5G, mobile communications technologies related business models have only been discussed to a limited extent in the literature, and platform business models in general have seldom been examined. The purpose of this paper is to explore how to understand and capture the evolution of future mobile operators' platform-based business models in the 5G/6G context?

Approach: Building on economics and engineering traditions, this study utilizes the 4C (connectivity, content, context, commerce) and the as-a-Service (aaS) digital service business model typologies. This research follows a cyclical process of research-oriented action research, collecting data in two phases from the future-oriented World Cafe workshops held at Nokia RadioActive! user group event in Espoo in November 2017 and 6G Wireless Summit in Levi in March 2019.

Findings: The paper uncovers the extended ecosystemic platform architecture for the business model and ecosystem research consisting of components, interfaces, data and algorithms.

Value: We are currently lacking a coherent approach for researching ecosystemic platform-based business models as the extant discussions tend to focus either on ecosystem(ic) features of business models or platform business models that, however, share common characteristics. The study adopts a value-based and service-dominant lens focused on business model research at the ecosystemic level. For the first time, the study introduces the extended ecosystemic platform architecture, investigating how this business framework can enable the transformation of the 5G.

Keywords: action research, business ecosystem, business model, platform, 5G, 6G

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Introduction

Recent discussions on platform-based business models have started to converge and build a basis for a more unified research agenda (Gawer, 2014; de Reuver, Sørensen and Basole, 2018; Helfat and Raubitschek, 2018) for understanding and capturing such business models. With roots in economics and engineering, platform research has an intrinsically dualistic perspective to business (Gawer, 2014). In the economics tradition, platforms have been seen as two- or multisided markets connecting supply and demand, whereas, in the engineering tradition, they have been seen as modular technological designs for facilitating innovation. Moreover, there is also a tendency in these works of literature to see platforms and ecosystems as intertwined (Teece, 2018), as both traditions acknowledge platforms to be consisting of a complex networked/layered system of modular components and interfaces the scope and scale of which go beyond the immediate platform actors.

The business model concept has emerged as a solution to deal with this duality of perspectives—the increased platformization of businesses is well exhibited in extant business model discussions. For example, the demand-side business models have come to complement supply-side business model discussions (Priem, Wenzel and Koch, 2018), and open and mixed business models have come to challenge traditional closed business models (Casadesus-Masanel and Llanes, 2011; Langley, van Doorn, Ng, Stieglitz, Lazovik and Boonstra, 2021). Platform interactions and convergence have emerged as an increasingly important topic (Zhao, von Delft, Morgan-Thomas and Buck, 2020), and the discussions on ecosystemic business models have fundamentally influenced how the environment of the organization is seen (Demil, Lecocq and Warnier, 2018). However, we are currently lacking a coherent approach for researching ecosystemic, platform-based business models as the extant discussions tend to focus either on the ecosystem(ic) features of business models (Iivari, Ahokangas, Komi, Tihinen and Valtanen, 2016; Gomes, Iivari, Pikkarainen and Ahokangas, 2018) or platform business models (e.g., Fehrer, Woratschek and Brodie, 2018; Täuscher and Laudien, 2018). These two streams of literature, however, share common characteristics.

Researching platform-based business models call for a systemic approach that considers both platform and ecosystem viewpoints to business models and can delve into the phenomena discernible in this kind of research setting. In addition, an appropriate research context is needed. As the fifth generation, mobile communications technologies are expected to transform the future wireless communications services and networks businesses—including business models—it serves as a research context foundational to new theory development and deriving managerial implications. (Yrjölä, Ahokangas and Matinmikko-Blue, 2020a; Ahokangas, Yrjölä, Matinmikko-Blue and Seppänen, 2020)

Mobile networks, such as 5G and 6G, can be regarded as connectivity-focused platforms (Pujol, Elayoubi, Markendahl and Salahaldin, 2016) or ecosystems (Basole and Karla, 2011; Ahokangas et al., 2020) where the mobile operator has the focal role as the platform owner. Beyond engineering, the 5G- and 6G-related businesses and business models have been discussed only to a limited extent in the literature (Ahokangas, Matinmikko-Blue, Latva-aho, Seppänen, Arslan and Koivumäki, 2021b) as multi-faceted, mobile platforms are difficult to categorize. Gawer and Cusumano (2014) identify company-internal platforms that serve firms' internal purposes, supplier-network platforms that integrate firms and serve information flow purposes, and ecosystem platforms that serve various purposes of changing partners. Later, Gawer (2020) differentiated between innovation and transaction platforms. In turn, Zhao et al. (2020) coin pipeline platforms that serve buyer-seller relationships, manufacturing platforms that operate within a network of suppliers, and multisided platforms that enable (as an intermediary) interaction between users. Thus, considering platform categorizations, mobile platforms can be seen as hybrid platforms (c.f., Ahokangas, Matinmikko-Blue, Yrjölä and Hämmäinen, 2021a), characterized by each of the types presented by Gawer and Cusumano (2014) or Zhao et al. (2020). Existing 5G/6G business model research in the engineering context highlights the research's overly technical starting points, pointing out the importance of platforms (c.f., Camps-Aragó, Delaere and Ballon, 2019; Hmoud, Salim and Yaakub, 2020).

Recently, the evolution of future platform businesses and business models has raised various interests. For example, Zhao et al. (2020) pay attention to competitive battles and Jullien and Sand-Zantman (2021) to competition policy. Wallbach, Coleman, Elbert and Benlian (2019) examine multisided platform diffusion in a competitive business-to-business context. Gawer (2020), in turn, pays attention to scope, sides, and interfaces when combining platforms. In close connection to platforms, Langley et al. (2021) are interested in the role of smartness and connectedness on business modes, and Climent and Haftor (2021) examine industry evolution and business models. In the mobile communications context, Ahokangas et al. (2021a) pay attention to platform convergence in a multi-platform context and Yrjölä, Ahokangas and Matinmikko-Blue (2020a, 2020b) in the 5G/6G transition context. However, scant research beyond engineering research considers mobile operators' platform business models (Ahokangas et al., 2021b).

Building on the above, a practical challenge that we identify is how future platform business models unfold, especially in the context of 5G/6G business transformation, giving rise to the research question addressed in this paper:

How to understand and capture the evolution of future mobile operators' platform-based business models in the 5G/6G context?

Qualitative and exploratory research methods are recommendable in occasions where the aim is to add theoretical knowledge on phenomena that deserve more detailed research (Eisenhardt, 1989), which is the case in this research. To answer the research questions, we follow the cyclical process of research-oriented action research (Eden and Huxham, 2006). In action research aiming at theory development, the nature of the research problem guides the action research cycle, giving primacy to the flowing cycle: foreknowledge, emergent theory, action/data generation, reflection, theory exploration, and development (Dickens and Watkins, 1999). Following the action research cycle, the data for the research was collected in two phases starting from future-oriented World Cafe workshops held at Nokia RadioActive! -user group event in Espoo in November 2017 and 6G Wireless Summit in Levi in March 2019.

Our discussion is organized as follows. The following section presents the theory framework for the paper and next one provides a discussion on the 5G context and business models. These are followed by the research method section. The results of the two phases of data analysis are presented after the method section. Finally, the empirical implications, theoretical contributions, limitations, and avenues for further research arising from the study are discussed in the concluding section.

Framing the Discussion on Platform-Based Business Models

Ecosystemic platform business models

The question is how the business model might be utilized as an approach to examining businesses. Conceptually, one can distinguish between the design of the business transaction's content, structure, and governance in the business model (Zott and Amit, 2010) or their focus, modus, or locus (Onetti, Zucchella, Jones and McDougall-Covin, 2012). Practically, the technology, offering, and network architecture can also be considered the major constituent parts of a business model (Mason and Spring, 2011). Gatautis (2017) found that information and communication technologies (ICT) based infrastructure platforms have become the basis for ecosystems to orchestrate and organize activities of many companies. Weil and Woerner (2015) proposed four types of business models for the digitalized context: the supplier model works in the value chain of another company; the multichannel model makes firms restructure across several digital and physical touchpoints to serve their customers; the modular model builds on plug-and-play interfaces to complement firms' offerings; and finally, the ecosystem model builds a customer-centric platform to facilitate ecosystemic interaction among customers. In turn, Gawer (2014) categorized platforms in three categories: as a company and its internal units, i.e., the internal platforms; a network of company and its suppliers, i.e., the supply chain platforms; and an ecosystem keystone actor and its supplement actors in a technology or business ecosystem, i.e., the ecosystem platform.

Ecosystem platform architecture may be seen as a conceptual blueprint that describes how the ecosystem is partitioned into a relatively stable platform, a complementary set of varying modules, and the design rules binding on both (Baldwin and Woodard, 2009; Cusumano and Gawer, 2002; Katz and Shapiro, 1994; Sanchez and Mahoney, 1996; Ulrich, 1995). Decomposition of a platform ecosystem into constituent atomic subsystems minimizes interdependence among the evolution processes within components of the platform ecosystem, supports change and variation, and helps to cope with complexity (Simon, 1962). Schilling (2000) sees the platform ecosystem as a complex system composed of interacting subsystems that are always to some degree interdependent and interoperate exclusively using predefined, stable interfaces (Eisenmann, Parker and van Alstyne, 2006). *Modules* can be defined as an add-on software subsystem that connects to the platform to add functionality to the platform (Baldwin and Clark, 2000; Sanchez and Mahoney, 1996). Katz and Shapiro (1994) defined *interfaces* as specifications and design rules that describe how the platform and modules interact and exchange information using well-documented and predefined standards like application programming interfaces (APIs). Baldwin (2008) found that modularity decreases coordination costs and transaction costs across the module boundary while interface standardization decreases asset specificity of modules (Schilling, 2000).

Attempts made to look at ecosystemic platform business models can be found in software, web-scale, e-commerce business, cloud, Internet-of-things (IoT), the platform business, and wireless communications contexts. For example, in the digital services domain, *everything-as-a-service* (XaaS) (Lenk, Klems, Nimis, Tai, Sandholm and Alto, 2009) enables a large number of digital service providers to offer a variety of cloud-based services across the cloud stack layers. Within XaaS, the most widely deployed digital as-a-service business models are *infrastructure-as-a-service* (IaaS), *platform-as-a-service* (PaaS), and *software-as-a-service* (SaaS) (Mell and Grance, 2011).
Wirtz, Schilke and Ullrich (2010) proposed a typological 4C business model framework for the Internet age to make the business model analysis more straightforward and structured. Each of the four types of business models has varying value propositions and revenue models: *connection* (e.g., wireless), *content* (e.g., data), *context* (e.g., search or location intelligence), and *commerce* (e.g., marketplace and platforms). Thus, the typology can be interpreted as a set of nested layers from the platform ecosystem perspective, where lower layer business models are required as enablers and value levers for the higher layers (Yrjölä, Matinmikko, Ahokangas and Mustonen, 2016).

A transformation of business models and entire industries from vertical or horizontal linear towards two-sided and networked has been found (Van Alstyne, Parker and Choudary, 2016). Furthermore, with the emergence of platforms, Iivari et al. (2016) defined an "*oblique*" business model that has a focus on value sharing through value co-creation and co-capture, while the traditional vertical control-oriented business models have aimed at controlling value creation and the horizontal business models controlling value capture. In these emerging value-sharing-oriented platform ecosystems focusing on the co-creation of complementary new services, the critical issue (Casadesus-Masanell and Llanes, 2011) is the openness of the business model. Notably, they see the openness of a business model starting from closed and extending toward the open edge, open core, and open source.

Themes relevant to examine ecosystemic platform business models

The engineering approach to platforms highlights *innovation* as modularity makes managing innovation in complex technical systems more manageable and incremental (Schilling, 2000). Teece (2018) discusses profiting from innovation through enabling and general-purpose technologies in the wireless world, raising several concerns for value appropriation and positive spillover effects related to enabling and general-purpose technologies. Casadesus-Masanell and Llanes (2011) discuss closed, open, and mixed business models. They see the *openness* of a business model starting from closed and extending toward the open edge, open core, and open source. The openness of business models boils down to discussions on open innovation (Chesbrough, 2003;

2006), and in platform contexts, this brings the ecosystem and its stakeholders close. An equally important aspect to innovation and openness is *complementarity*, related to production, customers, asset prices, inputs, technologies, or innovation (Teece, 2018). Complementarity raises business model-related concerns. More importantly, it puts forth the question of the platform type–whether internal, supply-chain, or industry (Gawer, 2014)—as different types of platforms may exhibit different *configuration* types and levels (lightly or loosely coupled) of complementarity. Helfat and Raubitscheck (2018) focus on dynamic and integrative capabilities in platforms and argue that when designing platform business models, on top of the usual business model elements, attention should be paid to the core product innovation, functionalities, and features, number of sides of the platform, degree of outsourcing as related to complementarity, and governance.

The increasing volume of *data* has transformed today's business practices (McAfee, Brynjolfsson, Davenport, Patil and Barton, 2012; Bharadwaj, El Sawy, Pavlou and Venkatraman, 2013; Jeble, Kumari and Patil, 2018). In terms of defining new business strategies to deal with digital technologies, expanding business networks and collaborating to build interconnected relationship business models, and then figuring out new insights for the value creation strategy have been found essential (Bharadwaj et al., 2013). The *algorithmic* revolution and enabling cloud computing can be seen as the foundations of the platform economy. Computing power is converted into economic tools using algorithms operating on the raw material of data. The software layer that stretches across and is interwoven with the economy is a fabric of algorithms. That software layer, that algorithmic fabric, is being extended to cover manufacturing, giving birth to the Internet of Things, the Internet of Everything, or the Industrial Internet, with its implied webs of sensor networks (Kenney and Zysman, 2016). However, the existing literature has not yet proved how different business models can align with data-oriented systems. Also, to date, there is only limited research found on how to link the big data with the business model thinking, as the previous research efforts focused on the technical aspects of data related to data monetization, clustering, and data lifecycle, ignoring customers and business requirements (Khaloufi, Abouelmehdi, Benihssane and Saadi, 2018).

Competition in platforms may appear at three levels, between platforms, between the platform and its partners, and between complementors (Teece, 2018). Inter-platform competition has resulted in winner-takes it all outcomes in cases of great demand, supply-side economies, multi-homing costs, or no niche specialization. However, competition between platforms leads also to increased openness. However, all platform contexts require careful balancing of *cooperation* and competition at the three identified levels. Casadesus-Masanel and Llanes (2011) found that open and mixed business models have come to challenge traditional closed business models. Priem et al. (2018) complement supply-side business model discussions with the demand-side business models. Furthermore, how an organization's environment is seen has been fundamentally influenced by the discussions on ecosystemic business models (Demil, Lecocq and Warnier, 2018).

Gawer (2014), de Reuver et al. (2018), and Teece (2018) all raise the question of how to *organize and govern* platforms, discussing what types of platforms exist, how to deal with the openness of interfaces in the platform, what capabilities (i.e., services) are accessible by or through the platform, and whether the governance of the platform is based on ownership (managerial authority), contractual relationships, or ecosystem governance. The traditional engineering discussion on platforms has been directed to economies of scale in service provisioning, i.e., on the supply-side (Teece, 2018), while in business model discussions, attention has been paid to business model scalability (Nielsen and Lund, 2018). In addition, network effects of the platforms have been seen to increase the value of platforms, but Gawer (2014) also relates economies of scope regarding service provisioning and innovation to platforms.

5G business models as the research context

The application of big data, new algorithms, cloud computing, and 5th generation (5G) wireless connectivity will change the nature of work and the structure of the economy. As basic mobile broadband connectivity service becomes increasingly commoditized and is under significant pricing pressure, mobile network operators (MNOs) are exploring ways to diversify their businesses. These might involve bundling connectivity subscriptions with utility services, providing platforms for e-commerce, increasing focus on the business-to-business (B2B) market, or emphasizing new areas such as enterprise cloud and the Internet of things (IoT) verticals (Yrjölä, Ahokangas and Matinmikko-Blue, 2018). As a result, MNOs worldwide are reinventing their businesses to better position against digital transformation and take them beyond the traditional communication service provider role. That shift requires more focus on innovation, disruption, and experimentation to build and execute platforms and ecosystems that drive new business and establish an agile corporate culture that embraces change (Ahokangas et al. 2020).

5G architecture and key enabling technologies

Compared to today's 4G technology, initially designed for high-speed mobile broadband, 5G is a complete redesign of network architecture with the capabilities, flexibility, and agility to support an array of future service opportunities not available in previous generations of network technologies. 5G will enable networks to go beyond traditional human-to-human interaction, connect further billions of connected things and reliably control machines in real-time. Consumer entertainment will be enhanced with super-fast download of high definition (HD) video in seconds and new virtual reality experiences. Connectivity for billions of IoT devices will enable smart factories, where robots, sensors, and remotely located human operators work synchronized.

A critical aspect of the 5G network is creating customized network slices that enable services tailored to specific customer needs with service level agreed (SLA) and performance on demand (Ordonez-Lucena, Ameigeiras, Lopez, Ramos-Munoz, Lorca and Folgueira, 2017). Network slices enable mobile operators to generate new revenues through customized industrial automation and enterprise services while exploiting the benefits of a common network infrastructure. Third-party application and service providers will use the sub-set of the network capabilities flexibly in a configurable and programmable manner and use network resources needed for their service offerings. Moving from hierarchies to the marketplace for the connectivity and underlying network resources can more efficiently balance supply and demand, raise the utilization of infrastructure, and ultimately maximize economic value within the industry.

Increased network elasticity and scalability introduced with 5G and adaptation of resource usage to needed capacity and service level on demand will improve business agility and reduce capital and operational expenses. Furthermore, software-based networks enable efficient infrastructure sharing by different network users, open the ecosystem to new players, and accelerate time to market by reducing service creation and activation times. The service orchestrator acts as the logical interface between network and business applications by providing an abstraction of the network towards applications and interfaces for easy service creation and optimization and exposes actionable network insights to application and content providers, enterprises, and industry verticals (Ahokangas, Matinmikko-Blue, Yrjölä, Seppänen, Hämmäinen, Jurva, and Latva-aho, 2019).

5G business models

Due to the transition from mobile voice services to mobile data services (Kallio, Tinnilä and Tseng, 2006) and industry convergence and digital disruption in telecommunications industries (Ghezzi, Cortimiglia and Frank, 2015), the value is rapidly migrating across industries and between firms (Hacklin, Björkdahl and Wallin, 2018). However, the existing 5G studies focus on traditional mobile network operator business models and discuss 5G in rather technical and general terms, mainly at the industry level. From the technical perspective, the focus has been on analyzing the cost, coverage, and rollout implications of 5G networks, e.g., highlighting the impact of the spectrum and infrastructure deployment (Oughton and Frias, 2018), network densification to increase capacity (Bouras, Kollia and Papazois, 2016), strategies for infrastructure sharing (Meddour, Rasheed and Gourhant, 2011), fixed-mobile substitution (Briglauer, Gugler and Haxhimusa, 2016), neutral host deployments of small cells for local services (Fund, Shahsavari, Panwar, Erkip and Rangan, 2017), and integration of utilized radio frequencies (Nikolikj and Janevski, 2015). Table 1 presents the

Table 1.
• Partnerships and collaboration (Camponovo and Pigneur, 2003). • Context level mobile services' business model designs from service, technology, organizational, and financial domain perspectives (Reuver and Haaker, 2009). • Characterization of various core components and roles in mobile communications includes platform types as enablers, system integrators, neutral, or brokers (Ballon, 2009). • MNOs' capabilities to adopt web-based software-as-a-service and platform-as-a-service models (Gonçalves and Ballon, 2011). • Envisioning aggregator- and service-centric models in addition to telco- and device-centric models (Kuoa and Yub, 2006; Ballon, 2009; Zhang and Liang, 2011). • The impact of the Internet on the telecommunications industry, predicting integration between Internet companies and the telecommunication networks, and the Internet companies building networks themselves using unlicensed spectrum technologies or acquiring telecommunication companies (Feasey, 2015). • Recommendation for MNOs to move from market protection to specify and manage the implementation of an innovative ecosystem (Ghezzi et al., 2015; Weber and Scuka, 2016). • The nature of 5G services is local (Ahokangas, Moqaddamerad, Matinmikko, Abouzeid, Atkova, Gomes and Iivari, 2016). • Transformation is needed to utilize IoT opportunities (Palattella, Dohler, Grieco, Rizzo, Torsner, Engel and Ladid, 2016; Sarfaraz and Hämmäinen, 2017). • Listing antecedents and perspectives that are needed to understanding business models and their success factors (Neokosmidis, Rokkas and Xydias, 2017; Chochliouros, Kostopoulos, Spiliopoulou, Dardamanis, Neokosmidis, Rokkas and Goratti, 2017). • Introduction of the local 5G micro-operator concept, its related roles and stakeholders, and business models (Matinmikko, Latva-aho, Ahokangas, Yrjölä and Koivumäki, 2017; Matinmikko, Latva-aho, Ahokangas and Seppänen, 2018). • Presenting key business opportunities for local 5G micro operators: hosting local connectivity to MNOs, offering secure local networks for verticals, providing differentiating local services, and acting as a data operator governing application and user data for various customers (Matinmikko et al., 2017). • Transformation of MNOs towards value creation in content and applications and increasing competition with verticals in supplying these utilizing network sharing, multitenancy, and wholesale models (Cave, 2018). • Proposition of novel resource orchestration and configuration-based business models and decentralized marketplace concept for the supply chain of data and virtualized network resources utilizing distributed ledger (Yrjölä, 2019). • Vision papers on future communication needs, enabling technologies, the role of AI, and emerging use cases and applications (Viswanathan and Mogensen, 2020; Latva-aho and Leppänen, 2019; Saad, Bennis and Chen, 2020; Letaief, Chen, Shi, Zhang and Zhang, 2019). • Presentation of 6G indicators of value and performance (Ziegler and Yrjölä, 2020), • The role of regulation and spectrum sharing in 5G (Matinmikko-Blue, Yrjölä and Ahokangas, 2020). • The antecedents of multisided transactional platforms (Yrjölä, 2020) and 6G ecosystems (Ahokangas et al., 2020). • Presentation of exploratory scenarios of future 6G business (Yrjölä et al., 2020). • Analysis of the convergence of connectivity and data platform configurations (Ahokangas et al., 2021a)

Table 1. Discussions related to 5G business models.

key discussions related to 5G business models.

The research method

This research applies the anticipatory action learning (AAL) approach that is a particular type of action research (AR) conducted in a future-oriented mode (Inayatullah, 2006). AR is an iterative, participatory, and collaborative research method developed to address the management of change and develop foresight utilizing cross-disciplinary knowledge, involving practitioners and researchers, which impacts participants and organizations beyond the research project (Coghlan and Brannick, 2010). This research method was chosen to provide rich data to characterize a multi-stakeholder environment where different stakeholders can also have conflicting goals. In addition, action research provides contextual relevance in future-oriented situations.

This research follows the cyclical process of research-oriented action research (Eden and Huxham, 2006). In action research aiming at theory development, the nature of the research problem guides the action research cycle, giving primacy to the flowing cycle: foreknowledge, emergent theory, action/data generation, reflection, theory exploration, and development (Dickens and Watkins, 1999). Following the cyclical process of research-oriented action research, the data collection comprised two phases. The results from phase one (RadioActive! World Café workshop, Espoo in November 2017) were utilized as a foreknowledge for the second phase of data collection from the 6G Wireless Summit World Café workshop at Levi in March 2019. World Café is a structured conversational AAL process intended to facilitate open and intimate discussion and link ideas within a larger group to access the collective intelligence represented by the participants (Carson, 2011). The participants in the 5G workshop in 2017, representing business and technology management of the 32 MNOs worldwide, were divided into ten heterogeneous groups that moved between a series of roundtables where they continued discussion moderated by the organizers in response to a set of questions. The groups focused on 5G opportunities with a potentially significant techno-economic impact on the mobile industry: technology innovations on architecture, telco cloud, artificial intelligence, use cases, and business models. The moderated questions were: *What include the major emerging architecture and technology triggers that can have a significant techno-economic impact on the 5G industry? What are the business drivers for Telco cloud? What are the 5G business opportunities and use cases that will generate the most revenue? How to capture the value? How and why do business models change due to 5G?*

The 6G Wireless Summit (6Gsummit, 2019) event was organized by the Finnish 6G Flagship Programme (6G Flagship, 2018) with 300 participants from 29 countries, including significant infrastructure manufacturers, operators, regulators, and academia. In conjunction with the summit, a 6G White Paper Workshop was organized with 60 participants to launch the process for drafting the first 6G White Paper (Latva-aho and Leppänen, 2019). The workshop's target was to identify the key drivers, research requirements, challenges, and critical research questions related to 5G evolution. The workshop was run in 6 groups: *use cases, societal and business drivers, radio hardware progress and spectrum bands, new air-interface opportunities, new network technologies, and enablers for new services.*

At phase one, the first author facilitated the phase one RadioActive! World Café workshop, Espoo in November 2017. In the second phase of data collection, the authors facilitated the societal and business drivers World Café workshop as a part of the 6G Wireless Summit at Levi in March 2019. The ideas presented by the participants were written down on post-it notes and placed on the whiteboards. Also, numerous connections were drawn between the items written or drawn on the whiteboard. The objective was that each subsequent group would build on the results of the previous group and themes. The World Café ended with a wrap-up summary where the participants also got an opportunity to assess and provide responses on their collective results. Participants were encouraged to create new, shared knowledge through a set of questions with a specific focus on the next three to five years.

In qualitative foresight-focused future research, external validity is challenging to control (Yin, 2009). Although particular attention was paid to arranging workshops to engage practitioners from different parts of the ecosystem and researchers from different research disciplines, other researchers could have interpreted the data differently. Furthermore, this research focused on studying business models, platforms, and ecosystems—business models should always be calibrated to context (Teece, 2010). To increase construct and external validity of the research, after each workshop, all the systematically documented raw data, as well as outputs in forms of use cases and business opportunities, were analyzed, using the theoretical framework of the widely appreciated futures research methodology, the causal layered analysis (CLA) (Inayatullah, 1998). Furthermore, the integral futures four-quadrant method within the business model framework was applied to deepen the foresight and ensure the quality of the research (Inayatullah, 2006). In this method, the futures were backcasted against the past and present experience and knowledge of the participants by discussing alternatives and transforming the futures to identify technologies, use cases, and business models to connect the future to the present. The participants' integral futures four-quadrant results were validated in the assessment phase of the workshops, in which key results such as business drivers and scenarios were summarized and documented.

Data analysis and results

In the following, the results of the World Café workshops will be presented as structured and summarized. In phase one, the results are presented in four scenarios; market penetration, market development, service development, and diversification scenario named based on Ansoff (1957). In addition, this study applied the exploratory scenarios approach by Schwartz (1991), and Suchman (1995), representing a foresight method that provides a means to depict, make sense of, and assess alternative future events, trends, and choices holistically. In phase two, the discussion will build around platform thinking by looking at components, interfaces, data, and algorithms.

Results – Phase one

The participating mobile network operators (MNOs) find it increasingly difficult to grow their revenues in a situation where the internet and mobile markets are nearly saturated. As subscriber growth slows down and price levels fall, many MNOs are focusing on acquiring customers from competitors. In emerging markets with growth potential but lower average-revenue-per-user (ARPU), most creative operators make headway by tapping into new revenue sources and engaging their customers in unique and non-traditional ways.

New 5G technology enablers and business approaches allow MNOs to fine-tune or change their traditional operations, making their existing systems more efficient and cost-effective. In the face of disruptive new competition, many operators are adopting disruptive strategies and are in the process of reinventing their business models. They start looking at their services and infrastructure in a new light, shifting away from core telco connectivity services to innovative new offerings made possible by emerging technologies and business models.

As a result, MNO's top objectives comprise achieving a better experience for enhanced mobile broadband services, enabling digital transformation in different industries, and finding new revenues in enterprise and IoT. These are followed by the clear expectation of lowering the total cost of ownership compared to current technologies. Most operators are not looking to identify killer applications, but the flexibility to drive multiple services and support a wide variety of new revenue streams and user bases. Four different business opportunity scenarios for operators were identified with a different set of success factors in each: making more out of existing markets (market penetration), expanding the business into new segments or offerings (market or service development), and doing both: entering new market segments with entirely new offers (diversification).

An MNO enhances the established mobile broadband connectivity service offering to current consumer and enterprise market segments to gain revenues at a lower total cost of ownership in the *market penetration scenario*. Keys to a profitable business are spectral efficiency, lower site deployment costs, the network's energy efficiency, and the fast time-to-market, which enable significant market share gain, although time-to-market may not be a prime strategic concern. This business opportunity is considered mandatory for an established MNO to grow and protect its core business. 5G is seen as a solution for three challenges: First, overcoming capacity constraints of the 4G. Overall, it is expected that 4G networks will not be able to meet the demand for capacity by 2022, and in some markets and hotspots even faster. Second, overcoming cost issues, depending on the used spectrum bands and the radio configuration, 5G provides the same capacity 2.5 to 7 times more cost-efficiently than 4G. Third, dealing with energy costs, the inherent technological advantages of 5G are estimated to lead to 10% overall network operational expense savings.

The business case for the opportunity largely depends on the timely availability and the cost of the spectrum. Beyond the general investment and rollout approach, the viability of the 5G business case depends on the general readiness of the ecosystem (i.e., tested and 3GPP compliant network gear and a range of 5G devices), which will be a potential bottleneck for an early mover advantage. In addition, the business case is seen to depend on a set of vendor-specific technological capabilities like the implementation of novel antenna innovations, infrastructure site acquisition and solution deployment for the multi-spectrum band, multi-technology, and multi-capacity equipment, deployment costs of the network infrastructure, and efficiency of end-to-end network scalability.

The *market development scenario* builds on MNOs' capabilities to serve new dedicated user groups or locations which form new target market segments in the content provisioning domain. Differentiation will be based on unique services like smart stadiums, coverage of enterprise campuses, enhanced mobile broadband in vehicles within public transportation, and video surveillance for smart cities. Success factors for the business opportunity are similar to the enhanced mobile broadband for consumers scenario. The MNO could win revenue from high-value passengers and governments by supplying 5G bandwidth to public transport. However, many use cases such as smart stadiums will require localized edge cloud implementations. Furthermore, 5G ultra-low latency performance will be needed to support virtual reality, gaming, and other delay-sensitive applications.
An operator wanting to provide good video quality would not realistically use 4G as this would reach too few subscribers and incur too high a cost. In contrast, 5G can simultaneously deliver high-definition video to many subscribers, e.g., within the stadium as a free or almost-free service covered by the cost of the stadium entry ticket. Moreover, many new target segments need ultra-high capacity in specific locations.

Diversification brings challenges to traditional telco business processes and platforms when adding new technologies. Collaboration with third-party services and ecosystems such as cloud services, content distributors, and mobile payment/identification platforms is essential. That will require a unified front-end system for billing and other customer-facing processes that bring together all the underlying services, along with a single integrated product catalog and a streamlined approach to integrating new technology acquisitions. As an example, the emergence of over-the-top (OTT) offerings has caused classical media distribution to plateau. With so much content running through mobile networks, many MNOs see the aggregation, advertising, sell-through, or even exclusive distribution rights for TV, movies, and sports, whether through partnerships or vertical integration, as a key potential area for growth and differentiation. To take on a more significant role in content and media, accessing and understanding a broad range of audiences will be critical to the success of any media venture emphasizing the need for enhanced user data management and analytics systems to gain insight into the behavior and allowing the network to evolve accordingly.

The *service development scenario* stems from existing market segments with new context services leveraging 5G beyond enhanced mobile broadband, particularly the low latency capabilities providing intense consumer experience, e.g., for augmented, virtual and mixed reality, cloud gaming, and fixed-mobile services. Such services require the proficient deployment of edge clouds distributing processing of the applications and technical openness to collaborate with the ecosystem. In this scenario, the business opportunity will not necessarily rely on direct traditional average-revenue-per-user (ARPU) increases but on collaboration with global web-scale companies and application developers to serve their local customers. These new services add low latency localization to the equation. These use cases rely on openness and massive deployment of edge clouds.

In the *diversification scenario*, diversification leverages 5G slicing and service-oriented architecture (SOA) capability for dedicated services and applications. The offering of new customized services to vertical enterprise markets requires an MNO to transform its business model from connectivity centric comfort zone into a new digital service provider (DSP) role, utilizing platformization and commerce business models extensively. The critical success factors for this role are the close link between IT and the network domain, adaptation to business-to-business customer's processes and new partnerships, and radically improving go-to-market to enterprise verticals.

Compared to the other 5G business opportunities found and discussed above, the DSP deep-slicing business heavily relies on capabilities on top of the network, in particular, network management and orchestration and business support systems. Therefore, it requires the capabilities of providing high availability and reliability needed for many operations from the network, also from a management and orchestration point of view. Furthermore, end-to-end security automation is needed to protect critical business processes, and openness is needed to include third-party components, bring close-to-zero-touch automation, and integrate the network with business support systems.

Several MNOs engage in various network sharing and virtual network operator agreements as a new source of revenue. These lower the traditionally high barriers to entry into the telecoms industry and open the door to out-of-industry players whose non-traditional thinking and aggressive pricing may have significant potential to disrupt the marketplace. As outside players disrupt and leapfrog established players, MNOs are being forced to accelerate their digitalization efforts by creating new digital ecosystems for services and focusing on innovative customer-facing areas like sales and service. Further, MNOs should explore opportunities to deploy converged fixed-mobile infrastructure to enable new offers and service bundles to their customers.

To summarize, four assets were seen as essential in capturing value to achieve MNOs key objectives: a better experience for existing services in enhanced mobile broadband, enabling digital transformation in different industries, and finding new revenues in enterprise and IoT: 1) the new differentiating performance level of 5G networks, 2) new control point at the edge cloud, 3) the billions of transactional and control data points produced by networks, and 4) dedicated virtual sub-networks and resources, which can be offered as-a-Service that provide tailored capabilities required for different industries and their various use cases.

Results – Phase two

To ensure data richness, building on the foreknowledge of the first scenario phase data collection and analysis on MNOs key objectives and assets essential in capturing value, we run the second phase workshop focusing on the 5G evolution towards 6G. The workshop was to identify the key drivers, challenges, and critical research questions related to the 5G evolution towards future wireless networks and services. The workshop was run in 6 groups: *use cases, societal and business drivers, radio hardware progress and spectrum bands, new air-interface opportunities, new network technologies, and enablers for new services.* The vision statement outcome of the summit was *Ubiquitous Wireless Intelligence*. According to the vision, ubiquitous services follow users everywhere seamlessly; wireless connectivity is part of critical infrastructure; intelligent context-aware smart services and applications are also available for non-human communications.

As discussed above, 5G was mainly targeted to address the traditional MNOs' productivity demand and, to some extent, utilize new technology opportunities driven by the verticals. With the 5G evolution, the need for a substantially more holistic approach was seen essential, including a larger community into the definition of future wireless networks to address the goals, trends, and demands to avoid merely commercially driven system definition.

The transition to ever higher frequencies with smaller radio ranges and the increasing role of indoor networks will boost network sharing in cities and indoors, drive integration of short-range connectivity solutions with large-coverage cellular systems and introduce a local operator paradigm in the market resulting in new ecosystems. One of the key business-related findings was the transformation from connectivity-driven networks towards more holistic and ecosystemic platforms.

Building on the key outcomes from the phase 1 scenario workshop, it was considered to extend the traditional engineering platform thinking from modules and interfaces (Katz and Shapiro, 1994) to look at the role of data and intelligence. Furthermore, in the phase 2 workshop focusing on identifying the key drivers, challenges, and critical research questions related to 5G evolution towards future wireless networks and services, the role of data access, data ownership, and AI/ML in 5G/6G networks were evident in the workshop results. The workshop results provided a new view to platforms; in addition to components and interfaces, the roles of data and intelligence, especially AI/ML algorithms, were recognized.

Components
Future network targets at 10-100 times better performance in most technology domains at the connectivity layer. Dependable use cases such as wireless factory automation will require ultra-high reliability, ultra-low latency, high-accuracy inter-device synchronicity, high-resolution localization, among others, corresponding to the current requirements for wired industrial control networks. The future wireless networks are expected to seamlessly interface terrestrial, satellite, and airborne networks to support the coverage and capacity requirements. Short wavelength and wider available bandwidth above 100 GHz will enable increased data rates and angular and ranging precision not seen before for imaging and radar applications for localization, 3D imaging, and sensing.

Advances in virtualization, automation, and orchestration, combined with the new networking power, will also enable data, intelligence, and transactional decision-making to be distributed to the edge of the network. These advances in virtualization include the ability to tie mobility, edge cloud, public/private cloud, and traditional security solutions together into a single, seamless, and integrated system that can follow and protect workflows, applications, and services that need to span the network, from the mobile device to data center, regardless of where either is located.

Virtual (VR), augmented (AR), and mixed reality (MR) technologies are merging into extended reality (XR), which encompasses wearable displays and interaction mechanisms that create and maintain perceptual illusions. The users quickly accept an alternative version of reality that enhances their ability to consume media, search the Internet, explore real and virtual worlds, collaborate on work projects, connect with family and friends, and engage in restorative activities. Telepresence will be made possible by high-resolution imaging and sensing, wearable displays, mobile robots and drones, specialized processors, and next-generation wireless networks. Autonomous vehicles for ecologically sustainable logistics of humans and shipments are made possible by advances in wireless networks and distributed AI and sensing.

Interfaces
The need for an open architecture and open collaboration using open common interfaces and toolkits are seen as essential in every level of the network architecture, from hardware to services and applications. The complexity of radio frequency transceivers and digital signal processing will increase substantially at chip and system levels. Dealing with this complexity calls for open-source platforms that enable low-level algorithmic development and possibly go much deeper into specific technologies than any open-source software or hardware has seen before. Via softwarization and virtualization of networks and opening of interfaces, sharing economy concepts will be utilized not only at higher platform business layers but widely in network connectivity and data context layers. Changes in the ownership of spectrum access rights, networks, network resources, facilities, and customers will result in different

combinations depending on the situation as different facilities have different requirements and infrastructures. New incentives will arise, including the functioning of society. The sharing economy will continue to expand, and even the nature of transactions will be further disrupted by digital currencies making trust and security essential. Dynamic networks of everything will be built on the foundation of embedded trust and dynamic data security.

Data

Wireless networks will generate an unprecedented amount and types of information about people, things, and environments at large. Private information collected from the physical world can be of sensitive nature and be used against people, companies, and societal interests in many ways. The protection of private and critical information was seen as a key enabler to realize the full potential of future networks and make them acceptable to society. The data generated by novel devices and elements in public and private networks have value for many societal functions and possibly to other private corporations than the one that collects the data.

Edge cloud computing elements and interfaces enable a local and instant information service, e.g., for fast discovery of people, services, devices, resources, and any local information near the user that centralized search engines cannot collect. Such edge information service platform could be used, e.g., in the creation of a highly local and dynamic marketplace for services, things, and information. An extreme case for edge computation would be a thin user client, essentially a light, low-energy device capable of interacting with human senses or neural systems, with all user-specific computing occurring in the edge cloud.

Wireless network data markets offer a natural new business opportunity, where data ownership is a source of value creation and control. Data ownership has evolved from specific context data towards big data with the large volume of detailed data, real-time velocity, and wide variety in types and sources. The pervasive influence of AI and digital twins will reflect what something looks like and what constitutes its context, meaning, and function. We will interact with this "*mirror world*" (Gelernter, 1993), manipulate it, and experience it as we do in the real world. For robots, this will be the way they see the world.

Creating a Big Data system that transforms how data are gathered, organized, prioritized, synthesized, and distributed can create strong initial controversy, e.g., by raising serious privacy concerns over location and data. Furthermore, how to do business with data itself becomes a key question. The contractual policies between the actors will define the relative strengths of information and data ownership between parties, for example, how the trust and ownership of information and data will be established in the future's autonomous smart device and service entities.

Algorithms

Artificial intelligence (AI) and machine learning (ML), relying on Big data mined to gain information and knowledge, was seen to play a significant role from link to system and management and orchestration to business-level solutions of wireless networks to "*connect intelligence*." Employment of machine learning algorithms was seen as essential in addressing the design complexity of radio frequency (RF) systems and improving RF characteristics such as channel bandwidth, antenna sensitivity, and spectrum monitoring. More importantly, deep learning-based training models facilitate a better awareness of the operational environment and promise end-to-end learning to create an optimal radio system. New air interface enablers require extensive ML and AI algorithm usage to enhance the optimality of the air interface design. In the semantic communications scenario, the meaning of the messages is utilized in making connectivity and networking more efficient.

In the hyper-flexible and configurable future network, AI and ML can be used in concert with radio for sensing and positioning. For management and orchestration of networks, intelligence needs in self-configuration, optimization, and orchestration of virtual resources meet the dynamic content, contextual, and event defined needs. The programmable network will utilize a Digital twin as an exact digital replica of complex physical assets, processes, and systems, providing a detailed understanding of how the real system is behaving and predict what it will do next. Resources and assets needed to meet the versatile needs of the wireless network are then provided by different stakeholder roles providing physical infrastructure (facilities, sites), equipment (devices, networks), data (content, context), under the regulatory framework set by the policymakers. Demands and resources are brought together by matching/sharing stakeholder roles, including operators (local or vertical-specific operators, fixed operators, mobile network operators, satellite operators), resource brokers, and various service/application providers such as trust/security providers.

Blockchain or distributed ledgers technology is attracting high hopes as AI/ML complementing technologies. Without central authority in a distributed manner, this technology allows storing and sharing information that does not change too often such that the complete record of the changes is kept as well, giving rise to, e.g., new ways of organizing data markets or helping to maintain trust in an inter-operator setting. The matching and sharing of resources to meet the demands will occur through new activities that ensure inclusion, sustainability, and transparency. Ultimately, the emergence and shape of the new ecosystem are dependent on regulations that promote or hinder the developments.

Discussion and conclusions

This paper has explored the evolution of future ecosystemic platform-based business models in the context of 5G evolution, the 5th generation of mobile communications, applying a research-oriented action research approach in two phases. Our analysis and discussion give rise to both managerial and theoretical contributions. As the 5G mobile communications technologies are expected to transform the future wireless communications services and networks businesses, including business models, it serves as a research context foundational to new theory development and managerial implications.

This paper's practical implications are related to the possibilities of analyzing 5G and future wireless mobile network business models with platform-oriented logic. The study presents the insight for traditional mobile network operators and the novel type of future digital service companies and practitioners to explore new opportunities of creating, capturing, and sharing value in 5G exploiting novel data and algorithm technologies in content, context, and commerce business model layers. The findings coincide with Ahokangas, Matinmikko, Yrjölä, Okkonen, and Casey (2013) and Ahokangas, Matinmikko-Blue, Yrjölä, Seppänen, Hämmäinen, Jurva and Latva-aho (2018) that the 5G business opportunities can be seen to represent two basic mobile operator business models: *connectivity service provider* and its *differentiation*. Moreover, the paper shows that collaborative business models introduced by Noll and Chowdhury (2011), brokerage business model by Rasheed, Radwan, Rodriguez, Kibilda, Piesiewicz, Verikoukis and Moreira (2015), and the cloud-assisted business model by Zhang, Cheng, Gamage, Zhang, Mark and Shen (2015) can be applied through *diversification* that leverage 5G deep slicing and service-oriented architecture capability for dedicated services and applications. The offering of new customized services to vertical enterprise markets requires an MNO to transform its business model from the connectivity-centric comfort zone into a new digital service provider role utilizing platformization and commerce business models extensively. The critical success factors for this role are the close link of the IT and the network domain, adaptation to B2B customer's processes and new partnerships, and radically improving go-to-market to enterprise verticals. More precisely, the findings illustrate the majority of emerging positions in a highly collaborative type of business around the context- and commerce-related requirements in the 5G context.

Theoretical contributions

In the second phase of the study, business opportunity scenario work was expanded to 5G evolution towards future wireless networks. The novelty value of the research relates to the introduction of two new complementing elements into the platform architecture: ***data*** and ***algorithms***. The findings agree with Baldwin and Clark (2000) and Katz and Shapiro (1994), demonstrating that in 5G, modules can be defined as an add-on software subsystem that connects to the platform to add functionality to the platform defined interfaces as specifications and design rules that describe how the platform's ***components*** interact and exchange data and other information using well-documented, and predefined standards like application programming ***interfaces***. This finding is supported by Lenk et al. (2009), who claim that everything-as-a-service business models enable a large number of digital service providers to offer various cloud-based services across the network layers. Also, the 4C-typology of business models (Wirtz et al., 2010) can be seen as a set of nested layers (Yrjölä et al., 2016), where the lower-layer business models are required as enablers and value levers for the higher layers to existing. Connectivity (e.g., 5G) enables sending and receiving content (e.g., data, radar), context (e.g., search or location AI/ML algorithms) is needed for making sense of the content, and commerce (e.g., marketplace AI/ML algorithms) are needed for doing seamless business. One of the key findings was the transformation from connectivity-driven 5G towards a more holistic and ecosystemic future network as a platform, seen as a continuation of the 5G diversification scenario discussed above.

With roots in economics and engineering, the academic contribution of the study is the proposition of an ecosystemic platform architecture for the business model and ecosystem research to complement the existing modular perspective (Schilling, 2000) and the 4C ecosystemic framework (Wirtz et al., 2010) and the as-a-Service (aaS) digital service business model typologies (Lenk et al., 2009). The framework integrates supply- and demand-side thinking and describes and explains the logic of how ecosystem platform architecture configurations enable complementarity and novel services as companies can choose to focus on any element or combination of elements to do business in an ecosystemic manner. The proposed novel architecture and framework consists of components, interfaces, data, and algorithms, as depicted in Figure 1 below.

We aimed at forming and utilizing a framework or approach for understanding platform business models. Our attention paid to innovation, openness, complementarity, competition and cooperation, organization and governance, economies of scale and scope, and type of business models. Our findings agree with Ahokangas et al. (2019), who found three generic business models for future wireless networks: vertical, horizontal, and oblique, each of them having a different logic of ***innovation***. The engineering approach to platforms highlight innovation as modularity makes managing innovation easier and incremental. The ***openness*** of business models boils down to discussions on open innovation, and in platform contexts, this brings the ecosystem and its stakeholders close. For example, a software-based, service-oriented cloud-native network enables efficient infrastructure and resource sharing by different tenants, can open the ecosystem to new players, and accelerate time to market by reducing service creation and activation times. Our findings are supported by Helfat and Raubitscheck (2018), who claimed that when designing platform business models on top of the usual business model elements, attention should be paid to the core product innovation, functionalities, and features, the number of sides of the platform, degree of outsourcing as related to ***complementarity***, and governance. The orchestration layer can incorporate an exposure function opening the assets of a network to other service providers like mobile virtual network operators, micro-operators, industry verticals, enterprises, and third-party applications. Exposing valuable infrastructure and data assets to the developer community through a set of interfaces and setting up effective partnerships will allow service providers to grow their

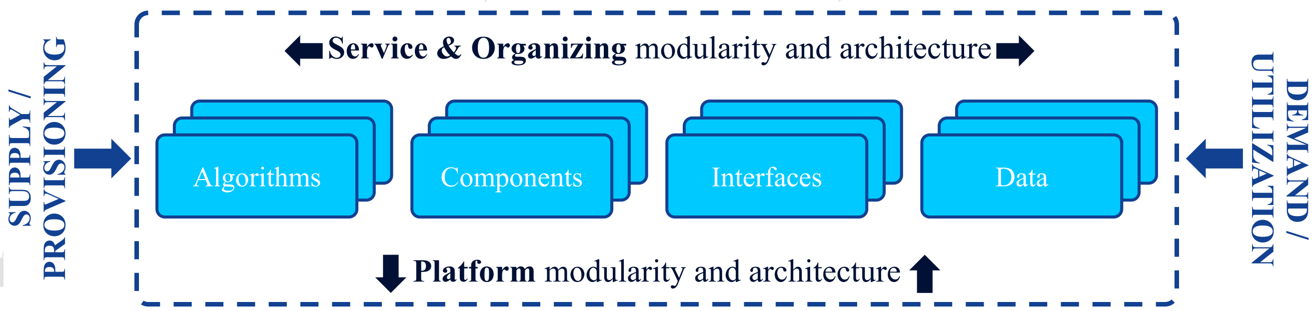

Figure 1: The elements of ecosystemic platform business model approach in future mobile operator business.

businesses by sharing their services with these external partners. Future wireless system architecture enables different levels of exposure to resources and network functions between business actors. Depending on the relationships between business actors and customers, there are different transparency levels in network slice provisioning and other different forms of ***cooperation*** models.

Regarding ***organization*** and ***governance***, our findings draw attention to discussing different types of platforms, the openness of platform interfaces, accessibility of capabilities (i.e., services) in the platform, and the basis of ownership of governance in the platform, whether managerial authority, contractual relationships, or ecosystem governance. The standardization of wireless technology has been essential for the global success of the wireless network and the related ecosystem. Standardization ensures global (multi-vendor) interoperability between networks, devices, and operators and economies of scale. Furthermore, it minimizes the complexity and thereby reduces the cost of interfaces. Developing a new telecom standard within a standardization organization is based on a consensus of different parties across the ecosystem: vendors, operators, users, interest groups, academia, and governments. The key domains of the future wireless system are wider than previous generations, including support for virtualized network function, slicing, converged wireless and wired access, transport, cloud, applications, and orchestration. With the further diversity in use cases and standardization, open-source platforms are foreseen to become an essential new cross-domain collaboration and interoperability tool for the industry and business agility to provide tailored solutions.

Platformization works hand-in-hand with virtualization that will enable separation of the software from the hardware and offer the possibility to instantiate many functions on a common infrastructure leveraging commodity-of-the-shelf. Introduced network elasticity and scalability enable network and resource usage adaptation to needed capacity and service levels on demand that, in turn, improves business agility while reducing both capital and operational expenses. The findings are in line with (Teece, 2018) regarding platforms offering economies of scale in service provisioning and Gawer (2014) regarding economies of scope related to service provisioning and innovation on platforms. Finally, our study anticipates the increase ***in two- or multisided business models***. Traditionally, the context of wireless networks has been dominated by supply-side business models. In the future, different types of distinct demands will be placed on mobile networks. Future consumers will demand contextualized video, smart home services, highly interactive gaming applications, and high-resolution immersive content, all delivered from the cloud. On the enterprise and industrial front, "physical" industry sectors will be massively transformed by gaining the ability to become automated and to exist independent of physical space and infrastructure—essentially to become virtualized. The nature of applications will range from millions of simple low-power sensors to mission-critical operations technologies (OT), putting unprecedented demands on tailoring and scalability (Yrjölä et al., 2018). Likewise, different third-party services can seamlessly be integrated and provided to end-users.

With respect to the limitations, the study limits its research context to the mobile telecommunication domain, focusing on business models. On the one hand, this approach offers the advantage of diving deep into a focused context, enabling the research outcomes to have vertical depth. On the other hand, the research has not investigated the applicability of the resulting framework in other contexts based on different industry verticals. Although the study's approach is only tested in the mobile telecommunication domain, the research sees the potential for the insights to be applied in other industries, especially those that require or rely on ecosystemic platform-based business models. Therefore, this study invites scholars to test further, experiment, and evaluate the ecosystemic platform architecture in a broader range of industry and business model contexts.

To conclude, since the findings demonstrate that content, context, and commerce specific platform-based ecosystemic business (c.f., Wirtz et al., 2010; Yrjölä et al., 2016) that utilize data and algorithms is the most potential emerging business opportunity of

MNOs in 5G evolution, deeper investigation in those scopes aiming at clarifying potential businesses opportunities in these specific areas is suggested. Moreover, we recommend future research to study how the MNOs' hybrid business models will evolve towards product-service model building on higher 4C layers, context, and commerce. Finally, we suggest extending the study from mobile network operators' business models to other stakeholders in the business ecosystem, particularly, to actors having a role in resource aggregation and brokering.

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