# How could Blockchain transform 6G towards open ecosystemic business models?

Seppo Yrjölä
Nokia; University of Oulu
*Center for Wireless Communications*
Oulu, Finland
seppo.yrjola@nokia.com; @oulu.fi

***Abstract*— Future 6G scenarios in 2030 envision society that will be data-driven, enabled by near-instant and unlimited wireless connectivity to intelligence. This calls for a multidisciplinary approach and a re-imagining of how we create, deliver and consume network resources, data and services. This development will change the traditional business models and ecosystem roles, as well as open the market for new stakeholders like micro-operators, edge cloud operators and resource brokers. This paper discusses unprecedented challenges of enabling and stimulating multiple stakeholders to have a more active participation in the future 6G ecosystem and gives a brief outline of key implications of blockchain technologies for related business model transformations. The research extends the existing archetypes of closed and supply focused mobile broadband business models and proposes the novel open ecosystem-focused scenario in which value configuration is leveraging distributed ledger technologies. This expands the architecture from centralized innovation and transaction platforms towards decentralization without a focal resource-orchestrating entity. Results showed that blockchain enabled 6G business can be built on novel business opportunities, value generation and competitive advantage that have positive strategic consequences on scalability, replicability and sustainability.**

***Keywords—blockchain, business model, cyber-physical systems, ecosystems, Internet-of-things, value, 6G***

## I. Introduction

Digitalization have been disrupting traditional industries in an unprecedented speed, and the telecommunications is no exception. The mobile broadband (MBB) technology is transforming both the digital and physical industries through wireless services provided at gigabit speeds, millisecond latency, support of wide range of novel applications connecting devices, objects and cyber-physical systems, and versatility by virtualization and softwarization [1]. Contrarily, present 5G business models continue to be structured around connectivity service mass provisioning with high advance investments in infrastructure and exclusive long-term licenses granted by the national regulators [2]. On the other hand, enabled by the ongoing 5G architecture evolution leveraging software defined networks (SDN), network function virtualization (NFV) and network slicing, edge cloudification, and service based architecture (SBA) delivery of resources and services is being transformed from centralized incumbent mobile network operator (MNO) centric system towards ecosystemic platform mode of operation [3].

As wireless communication service provisioning continues to be commoditized, telecommunication industry is exploring new ways to better position itself for digital transformation and going beyond the traditional role of connectivity provisioning [1]. Access to human and increasingly industrial Internet-of-things (IoT) data is becoming the major factors in value creation in communications industry. Real time data collection, exchange, sharing and analyzing exploiting pervasive artificial intelligence can create strong drivers for future value, introduce novel stakeholder roles, but may also lead to serious privacy and ethical concerns over the location and use of data. Furthermore, the future 6G will be increasingly shaped by the growing societal requirements like inclusivity, sustainability and transparency. [4]

To date, MBB business studies have focused on two traditional MNO business models, connectivity service provider and its differentiation [2] and [5] in rather technical terms, and ecosystem-focused business models have seldom been examined. In [6] collaborative business models were discussed, and related system integrator, local micro-operator, neutral host and brokerage roles introduced in [7]-[10]. MNOs capabilities to utilize cloudification in their business models was analyzed in [11], exposure of network functionalities through adopting web-based service models in [12], and 5G as the catalyst for the fusion of IoT technologies in [13]. As an emerging field, 6G business models have not been discussed in literature to date, however vision papers on enabling technologies, the role of AI and emerging use cases and applications have been recently published in [4], [14] and [15].

The preceding discussion is indicative of increased importance of openness and ecosystems from both engineering and economics perspectives. Engineering research, stemming from product and manufacturing platforms and lately service modularity [16], is focusing on components and open interfaces aiming at creating economies of scale. The economics, on the other hand discusses how to connect demand and supply in order to grow in sustainable manner, create innovation ecosystems and enter new markets [17]. Recently, [18] discusses how the transformation from current centralized closed network-for-connectivity business models towards network-of-services model builds on platform with data and algorithms. The decentralized and consensus-driven blockchain [19] with the combination of cryptographic processes is proposed to enable the scale up of 5G evolution to meet the demands of future in cyber-physical systems and IoT while ensuring trustworthiness [20]. References [10] and [21] discuss blockchain's applications in 5G and smart energy grids, enabled by the decentralized architectures and novel value configurations.

Building on the above discussion, with roots in engineering and economics, the research question of this paper is: *How could the 6G business models transform from closed and supply-focused towards open ecosystem-focused exploiting blockchain technologies?* This study follows the future-oriented anticipatory action research methodology [22]. The paper introduces open ecosystem-focused 6G business model elements and scenarios and identifies related key blockchain enablers and framing elements. The data utilized in this paper is based on the future-oriented workshop [23] held at 6G Wireless Summit 2019.

The rest of the paper is organized as follows. First, the methodological and theoretical underpinnings are addressed in the following section. Section III presents and discusses the results of the analysis and finally, section IV draws conclusions and highlights perspectives for future studies.

## II. Methodology and Theoretical Foundation

This section presents and discusses the relevant methods, theories and concepts that build the foundation for the paper.

### A. Future Orinted Anticipatory Action Research Methodology

This study applied qualitative research methodology. The 6G architecture and ecosystem scenarios analyzed were created using the anticipatory action research (AR) method conducted in a future-oriented mode [22]. Iterative and participatory AR method addresses the management of change through developing foresight utilizing cross-disciplinary knowledge, involving practitioners and researchers, and which impacts participants and organizations beyond the research project [24]. Action learning is best utilized through collaborative workshops for data and content generation action, where participation of various stakeholders and the representation of multiple perspectives becomes possible.

The empirical study for the paper was conducted with facilitated workshop at the 6G Wireless Summit [23] event organized by Finnish 6G Flagship Program in Levi, Finland, March 2019. The 6G white paper workshop was attended by 60 participants including major infrastructure manufacturers, operators, regulators and academia in order to launch the process for drafting the first 6G white paper [4]. Workshop was run in 6 groups: use cases, societal and business drivers, radio hardware and spectrum bands, new air-interface, new network technologies and enablers for new services.

### B. Business Model Concept

The business model that centers on value creation processes has become the tool for making boundary-spanning analyses in contemporary business research [25]. Classical definition of the business model from the activity perspective [26] assumes a focal firm, "*we define the business model as the way a company structures its own activities in determining the focus, locus and modus of its business*" while more recent views e.g., [27] does not necessitate a focal point: "*a business model depicts the design of transaction content, structure, and governance so as to create value through the exploitation of business opportunities*". Furthermore, business models are seen to connect to three strategic choices and related key activities of firms within ecosystems: 1) *opportunities* to be explored/exploited, 2) *value* to be created/captured, and 3) *advantages* to be explored and exploited [28] - [31]. Exploring and exploiting opportunities and advantages can be seen to motivate ecosystemic interaction from a dynamic capability perspective [32], while the value creation, delivery, sharing and capture are considered the key elements of a functioning business model [33]. Similarly, successful business models are considered to have three strategic consequences: 1) *scalability* [34], 2) *replicability* [35], and 3) *sustainability* [36]. The *growth* of business is frequently connected to scalability and replicability. While scalability refers to an internal growth potential and flexibility, replicability indicates its external flexibility to adapt. Moreover, sustainability stems from a business model's feasibility, viability and environmental or societal impact. In this study, these three strategic choices and related three consequences comprise the business model approach as depicted in Fig. 2. Furthermore, in this study business ecosystem is seen as a "*bundle of interlinked business models*," where value co-creation, co-capture and co-opetition as well as co-evolution are visible [37].

### C. Value Configuration of the Business Model

The analysis in this paper is based on the integrated business model configurations and value configurations framework [38]. The classical business model conceptualization and value discussions builds on Porter's [39] value chain theory and a *supply-focused* mentality which sees the business model as means to capture value from customers [40], and where the producer with the system of activities and resources is the sole creator of the value, focal firm [41]. *Demand-focused* view shifts away from the supply-focused business model configuration through emphasizing the utilization of customer interaction mechanisms to enable value co-creation incorporating a means of creating and delivering value to a target group of consumers, and a means of using existing resources and processes to promote the stable interaction of mechanisms [42]. The value perspective of the *ecosystem-focused* business model is about value co-creation and co-capture to maximize the overall ecosystem value, which in turn will increase the value shared and acquired not only by a focal firm, but by the actors within the ecosystem [38]. From a structural perspective the ecosystem can be seen to have four aspects: 1) network governance, 2) the platform keystone agents and complementors, 3) open interfaces and pool of innovative capabilities and resources, and 4) a modular core and periphery design [43].

## III. Open Ecosystemic 6G Business Model

This section discusses the applications of the blockchain technologies as enablers for the business models transformation from closed and supply-focused towards open ecosystem-focused in 6G.

### A. The Business Perspective of Distributed Ledger and Blockchain Technology Eneblers

The key capability of blockchain is to track and settle decentralized transactions and implement contract enforcement across a diverse range of digital assets, for example, conventional currency, digital currency, IP, data, contracts or physical assets [44]. The extant literature suggests that the blockchain is embodied in a range of existing technologies, such as peer-to-peer (P2P) networks, cryptographic algorithms, distributed data storage, and decentralized consensus mechanisms [45]. Bitcoin, the cryptocurrency, is the very first and prominent example of blockchain applications in practice [19]. As such, blockchain can be seen as a decentralized and distributed database maintaining an ever-growing list of data entries that are confirmed by the nodes participating in the blockchain. Blockchain generates a public ledger that records data on every transaction in the blockchain. A blockchain network is a distributed P2P network with no "middle-man", such as a central server or intermediary. The consensus mechanisms [46] act as the insurance for the coherency of data among the nodes. The utilization of cryptography in the blockchain ensures the authoritativeness behind all transactions [47] as information on every completed transaction is shared and made available to all nodes. Therefore, blockchain can be seen to enable a more transparent system than centralized solutions [48].

A key element of the many blockchain deployments is the *smart contract* that functions autonomously with self-executing scripts, making general-purpose computations taking place on the blockchain to be entirely predictable. As initially proposed by [49], the smart contract is defined as a computerized transaction protocol that executes the terms and content within a contract, which is often digitalized. All peers in a P2P blockchain network can audit or inspect the cryptographically verifiable trace of smart contract's operation. Furthermore, the smart contract enables automated workflows that are complex and involve multi-step and distributed processes [47]. There have been numerous applications and use cases of smart contracts that facilitate decentralized operations, for instance, voting, escrow systems, crowdfunding, auctions, as well as micropayments [50].

Based on the aforementioned characteristics and functions of the blockchain, use cases can be categorized in lightweight transactions, provenance tracking inter-organizational record keeping, and multiparty integration [51].

A blockchain shared ledger marketplace can be deployed for the exchange and *transaction* of assets among a limited number of peers e.g., for network sharing and roaming, wholesale connectivity, micro-operators, neutral hosting, network assets marketplace (edge cloud resources, network slices, spectrum sharing, local licensing), data-as-a-service (DaaS), network function virtualization (NFV) and software-defined network (SDN) transaction-based networking and services.

*Provenance tracking* focuses on the trace of origin and movement of assets across the entire supply chain utilizing virtual or digitalized certificates of authenticity and can benefit system tests, certification, and integrity checking related to operations security, supply chain and asset tracking, trustworthiness of the machine learning enabled applications and solutions, and privacy preserving and trust-service for IoT machines.

Furthermore, *inter-organizational record keeping* blockchain is used as an authoritative final transaction log mechanism for recording and notarizing all types of data of high importance or financial meaning in a collective manner while *multiparty integration* records data in a jointly managed data record/ledger aiming to overcome friction while proving redundancy. Related use cases stem from audit trail of critical inter-network element data exchange, service level agreement (SLA) and performance monitoring and fault detection, and official registry for government licensed assets, certified elements, and rules databases [52].

### B. *The Business Perspective of 5G Architecture Evolution towards 6G*

5G is transforming traditional product platform based mobile communication business models from the 4G network-for-connectivity towards network-of-services models utilizing service modularity. The main characteristics differentiating service modularization from the traditional product platforms are that the manifold services are composed by a process dimension, i.e., interactions among service providers and customers as well as activities involved in transforming the customer inputs into outputs, and by an outcome dimension i.e., services offered by the company [53]. The 4G and its evolved packet core architecture were standardized utilizing a reference point approach in which the interfaces and protocols between network entities were standardized represents product and manufacturing engineering platform approach and focal firm centered value chain supply-focused business model. On the other hand, the 5G service based architecture (SBA) can be decomposed into modules, interfaces, boundaries, standards, and resources that are shared and remain constant from service to service within a given service family. The service modularization can be used in composing a new service offering, or for the decomposition of an integral service in a modular service. The modularization focus on managing demand heterogeneity, complexity, service customization, and efficiency of functional units.

5G service modularity is expected to have several strategic benefits. Modularity enables structuring service portfolios, reducing complexity and increased transparency; it increases service variety, adaptability and process visibility to the customers; the ability to work in parallel increases improvements and innovation in modules; efficient use of reusable resources, reduce cost and lead-times in improving an existing service offering or in implementing a new offering. For the management and orchestration (MaNo), SBA and well-defined slicing and outcomes, are easy to manage, resulting in higher quality and reliability, and increasing the customer satisfaction. As a result, 5G business model can be seen to transform towards demand-focused mixed value creation as depicted in Fig. 3.

### C. *Open Ecosystem-focused 6G Business Model*

Exploring and exploiting *opportunities* and *advantages* can be seen to motivate ecosystemic interaction from a dynamic capability perspective. In the 6G workshop results, novel opportunities were found in local networks, dedicated tail of services, human-machine-interface and sensors stemming from advantages in ubiquitous connected cognition, cloud native architecture, and services related to security, privacy & trust. *Value* creation, delivery, sharing and capture are considered the key elements of a functioning business model. Three value drivers were seen essential: the new differentiating performance level of networks, the billions of transactional and sensing data points produced by networks, and dedicated virtual local sub-networks and resources, which can be offered as-a-service that provide the exact tailored capabilities required for different industries and their diverse use cases.

6G technology enablers with virtualization of the resource ownership and alteration of the valuation and utility, will lead to an overall shift from hierarchies towards more use of markets to coordinate economic activity related to network assets. This transition is triggered first by platform economy antecedents that reduce asset specificity and complexity of product description. A shift from the mixed model of today towards one where more emphasis is placed on converged cooperation within ecosystem and across domains will further stress the importance of security and trust. Traditionally, centralized businesses have overseen resource and service production, aggregation and distributing, searching efficiency gains by integrating both horizontally and vertically. As summary, enablers for 6G growth via *scalability* and *replicability* were found as data flow & stream based architecture, open collaboration, platformization, service agility, and zero touch management and orchestration. Furthermore, compared to 5G use cases and requirements in 6G scenarios digital inclusion, zero energy devices, resource efficiency and user privacy were found essential contributors to *sustainability*.

6G facilitates the envisioning and designing the unique combinations of physical, virtualized and digital, multi-sourced resources and linking them with various needs originating from the ecosystem of multiple stakeholders as illustrated in Fig. 1. In the value creation process firms may have one or more roles for conceiving of and designing novel ways to link heterogeneous resources with heterogeneous needs in 6G, particularly stressing the role of needs and resources of all value co-creators in the ecosystem [54].

As an *integrator*, a focal orchestrating firm converts resources into a new form and thus creates value for customers. This can be regarded as a traditional type of closed value chain resource configuration.

*Collaborator* orchestrates with partners generating assets to supply and service the demand of consumers. The resources to meet the consumption are not solely from the disintegrated retailer but are contributed by its partners. Thus, the company does not transform resources like the integrator, but it creates value by collaborating and engaging other complementor firms' resources with its own.

A *transaction enabler* is associated with platform business model enabled by digitalization. Broader and easier access to resources allows orchestrating firm to build two or multi-sided markets to match resources and needs.

A *bridge provider* bridge certain groups of market participants that are not connected before based on the proliferation of virtual resources and benefiting from bridging unconnected needs.

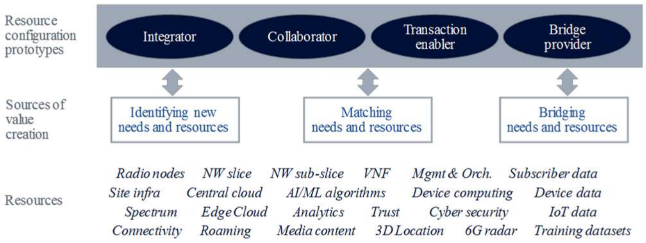


Fig. 1. Value creating processes identify, match and bridge supply and demand in open ecosystem-focused 6G business.

Blockchain technology could assist the progression of value-creation processes and transformation from closed integrator and collaborator models towards ecosystem-focused transaction and bridging models. As being distributed, cryptographically secured, consensus-based network which can securely transfer value and build trust, the role of companies and smart contracts deployed by them may further change towards open novel fully decentralized resource configuration prototype [38]. This is the opposite of the traditional platform models where a portion of the value flows out of the direct value co-creation and is captured by the platform orchestrator, and further there is theoretically minimal value flowing out of the direct value co-creation.

Fig. 2. summarizes how 6G business exploiting blockchain technologies and concepts can be built on novel business opportunities, value generation and competitive advantage that have positive strategic consequences on scalability, replicability and sustainability. In addition to discussed enablers, there are a number of framing elements that would need to be considered in applying blockchain-based solutions into 6G systems. General challenges often associated with blockchain technologies are, e.g., scalability, throughput, transaction verification time, power consumption as well as issues concerning privacy and anonymity. The value creation potential is highly conditional on the deployment of the blockchain system and particularly on the platform selection. Issues and research topics related to the platform includes e.g., platform and application governance, interoperability between blockchains, integration with legacy enterprise systems and IoT platforms. As for any platform, network effect is essential emphasizing the importance of inter-blockchain interoperability enabling effortless multi-sided integration of resources and need to the business ecosystem.

Typically, industrial blockchain use cases builds on partnerships and alliances i.e., a consortium ecosystem that needs to govern various platform-related aspects and the applications. Key value related considerations are, e.g.; how the consortium governance guarantee the integration of the most relevant business partners in the most efficient way, while at the same time distributing evenly the benefits but also the costs and responsibilities between the alliance members; how to deal with incumbent power; and how to incorporate sufficient flexibility to adapt to the constant changes in ecosystem. Besides the technical challenges, the role of and differences in regulation and legislation on country and state level will impact the scalability and replicability of the solution. Particularly, the discussion on restructured business roles and hierarchies as well as responsibilities of stakeholders in 6G provokes questions on to what extent traditional contract law doctrines can be applied to smart contract becomes critical.

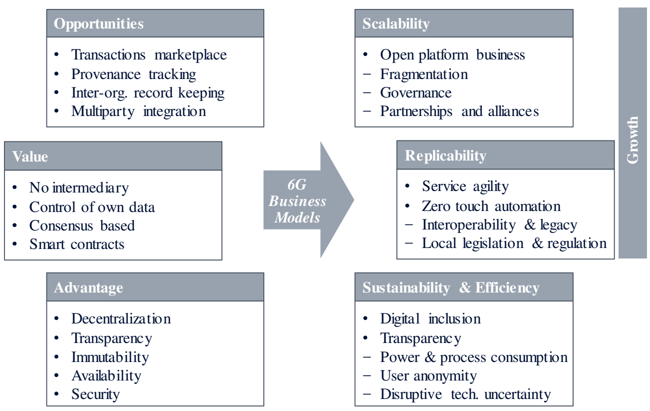


Fig. 2. Indicators of value and performance enablers (·) and framing elements (-) of the future 6G business exploiting blockchain technology enablers.

Fig. 3 summarize the key findings on how the existing archetypes of closed and supply focused mobile broadband business models can be transformed towards the novel open ecosystem-focused scenario in which value configuration is leveraging blockchain technologies. Open ecosystem-focused business model can benefit of indicators of value and performance benefits of the 6G business exploiting blockchain summarized in Fig. 2. On the other hand, structural aspects of the ecosystem: network governance, platform keystone agents and complementors, open interfaces and pool of innovative capabilities and resources, and a modular core and periphery design should be addressed in each deployment scenario as potential framing elements.

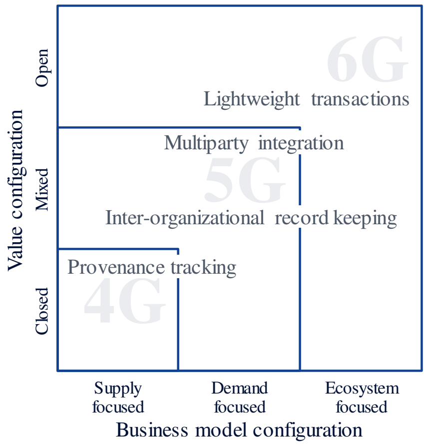


Fig. 3. Blockchain technology opportunity enablers in the integration of ecosystem-focused business model configuration and open value configuration in 6G. Adapted from [38].

## IV. Conclusions

With roots in economics and engineering research, this paper looks at 6G future scenarios through the lenses of ecosystemic business model framework utilizing value configuration typology. Unprecedented challenges of enabling and stimulating multiple cross industry stakeholders to have a more active participation in the 6G calls for an open ecosystem-focused value configuration scenario. Study shows that the transformation from service modularity-based 5G business models towards 6G builds on a transaction platform, a marketplace for all the virtualized 6G network resources, and particularly, access to data and related analytics. Blockchain technologies may give rise to new ways of organizing and configuring resources and data markets and helping to maintain trust, privacy and transparency. Moreover, this paper's implications relate to the possibilities of analyzing wireless mobile network business models with value configuration and ecosystem oriented logic. The study presents the insight for traditional connectivity driven mobile network operators and the novel type of future digital service companies to explore new opportunities of creating, capturing and sharing value in 6G exploiting novel blockchain. The study derives its findings from the analysis of business model scenarios identified by experts representing 60 participants including major infrastructure manufacturers, operators, regulators and academia globally, providing a solid ground for conceptualization on a larger scale. On the other hand, the scope of this research is limited to the 5G and its evolution towards 6G which mostly focused on mobile network operator business.

Given the high level of development activity and interest in blockchain technology today, and the continued need for 5G evolution beyond connectivity, themes discussed in this paper are worth further study. In addition to business research on more detailed 6G business strategies and business models with and around ecosystems of various types, proof of concepts and pilots are needed to reduce uncertainties related to potentially disruptive technology, business and regulatory implications of the blockchain.

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