

Exploring the 6G Software Business Ecosystem: A Morphological Analysis Approach

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Abstract

6G technology, enabled by modern software technologies, is under development and expected to be commercially available within the coming decade. Existing 6G research mostly focuses on technology standardization and lacks business consideration. Aiming to bridge the gap between 6G technology and business strategy, this study envisions the 6G ecosystem through the lens of software business. Exploring and understanding the 6G software business ecosystem helps the stakeholders identify their competitive strengths in the earlier stage and strategically prepare for the 6G era. This paper adopts Morphological Analysis as a future-oriented research methodology to depict the 6G software business ecosystem by decomposing that ecosystem into manageable components. It identifies the main ecosystem building blocks including technology enablers, external opportunities and challenges, and stakeholder roles. The findings are pioneers in the 6G software business field and highlight the complexity of the open 6G software business ecosystem.

Keywords

6G Software, Business Ecosystem, Morphological Analysis

1. Introduction


Sixth-generation wireless communication technology (6G) is predicted to be available and commercialized around 2030, while the 6G technical standardization and development has already started. As a novel field, there is limited discussion on the business side of 6G to date. According to the experience of previous wireless generations, it normally takes around 10 to 15 years from the initial academic research to the full industrialization and commercialization of the technology. However, one can expect that software solutions and applications will have an important role in the forthcoming 6G-based business solutions.


Although 6G technology is in its birth phase, it is now imperative to proactively consider the 6G business layout. In addition, business perspective always plays an important role in understanding the opportunities that a new technology could provide [1]. The analysis and forecasting of the 6G software business are essential for guiding 6G technology development and, thus, should be advanced before the technology matures. The current research work will provide stakeholders with a multi-dimensional understanding of the 6G software business ecosystem, enabling them to better prepare their competitive resources as well as business strategies in the following decade.


Since the 6G technology is still in its embryonic stage [2] and no real-world business application is yet available, the research on the 6G software business is future-oriented. In the future study field, *Morphological Analysis* (MA) is a method for investigating the components and their relationships in non-quantifiable socio-technical problem complexes [3]. MA divides the vague 6G software business ecosystem into various dimensions, through which it can be presented as thoroughly and precisely as possible [4]. It further provides a complete understanding and analysis of the components among those dimensions by showing the key relationships and variables involved.

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2. 6G Software Business Visions and Key Technology Enablers

As a normative approach of Technology Forecasting methodologies [4], MA starts by identifying future needs and ultimately leads to developing technology solutions to meet those requirements. In the 6G Software Business Ecosystem context, adopting MA provides potential paths from 6G Business Visions to key technology enablers.

The existing 6G vision works are context-based, and no common systematic and holistic version of 6G exists. Most of them are from a technology perspective. Some of them mix 6G visions with technology enablers or key performance indicators, such as [5] and [6]. Until now, there is no software business-oriented description of 6G vision, although 6G brings business dramatic transformation and revolution from previous generations. To cover the gap between 6G technology and business vision, we provide a 6G vision viewed through the lens of software business: with an understanding of context-based communication needs, an AI-driven 6G software business ecosystem will attract novel roles and connect businesses to the digital and virtual world through sustainable business models.

Some key enablers of 5G technologies certainly continue to contribute to 6G. Both 5G and 6G are based on the development of wireless communication and related technologies, while 6G has been accelerated by Artificial Intelligence (AI). In addition, AI is the key driving force of enabling 6G [7] and 6G would be an AI-driven world [8]. AI, as a major enabler in almost all fields, is expected to lead breakthrough innovations and crack unresolved problems in the previous generations of communication technologies [9], including network slicing, edge computing, massive data management, and security. The same as 5G, 6G is also a Software-Defined Network (SDN). Software is further decomposed with hardware in the 6G era and has become another key technology enabler for 6G. Figure 1 shows the three key technology enablers of 6G, namely wireless communication technology in the core, surrounded by SDN, and AI.

3. A Framework of 6G Software Business Ecosystem

To recognize the various dimensions of the 6G software business, we split the ecosystem into three main building blocks, including technology enablers, external opportunities and challenges, and stakeholder roles, as shown in Figure 1. The technology enablers are the foundation and core incentive factors for a novel software business ecosystem. Wireless communication technologies, software-defined network (SDN) and AI are expected to be the three main 6G technology enablers. Similar to previous generations, communication technologies, along with their associated hardware, are fundamental and essential prerequisites for the development of 6G. On top of the core network infrastructures, SDN provides flexibility and programmability by abstracting the control of network resources. As AI has already permeated every industry, it plays a crucial role in forming the 6G ecosystem. The three technologies are indispensable drivers of 6G development but not the only technology enablers of 6G. They are usually integrated with others, like AI plus edge computing or SDN plus network virtualization etc.

Novel roles are emerging in the 6G open market, while some of them are transformed from current stakeholders and others are new players. Existing stakeholders are mainly from the traditional telecom industry and software industry. The value chain of the former industry includes infrastructure vendors, software developers, and network operators. The foreseeable stakeholders from the software side are edge computing providers, AI companies, cybersecurity firms, and global tech giants. Figure 1 also presents some potential cross-industry stakeholders most mentioned by previous research work, for example, the satellite industry, aerospace, energy industry etc. In addition, 6G cloud operators, digital service operators, and resource brokers are new emerging roles, while some of them possibly transform from existing stakeholders. Each stakeholder in the ecosystem simultaneously holds multiple roles, or shifts roles in the value chain as the ecosystem develops.

All actors' success in the 6G business depends on both external impacts and internal resources. The external impacts consist of sustainability, uncertainty, and digital equity, which

can be regarded as both opportunities and challenges. Sustainability of tremendous magnitude is the core challenge when designing a 6G software business model, while it also offers business opportunities for innovative energy-efficient and eco-friendly solutions. Since 6G is indeed an open market [10], the uncertainty of that open ecosystem cannot be ignored. Uncertainty is an opportunity for new joiners, and then it can be more of a competitive challenge for stakeholders who are already in. Digital equity refers to all individuals and communities owning fair and equal access to the 6G network and getting benefits from the 6G software business. 6G has the possibility of either promoting equality or eliminating inequality. The internal resources of stakeholders are diverse and business context-related, which is not described in this universal ecosystem.

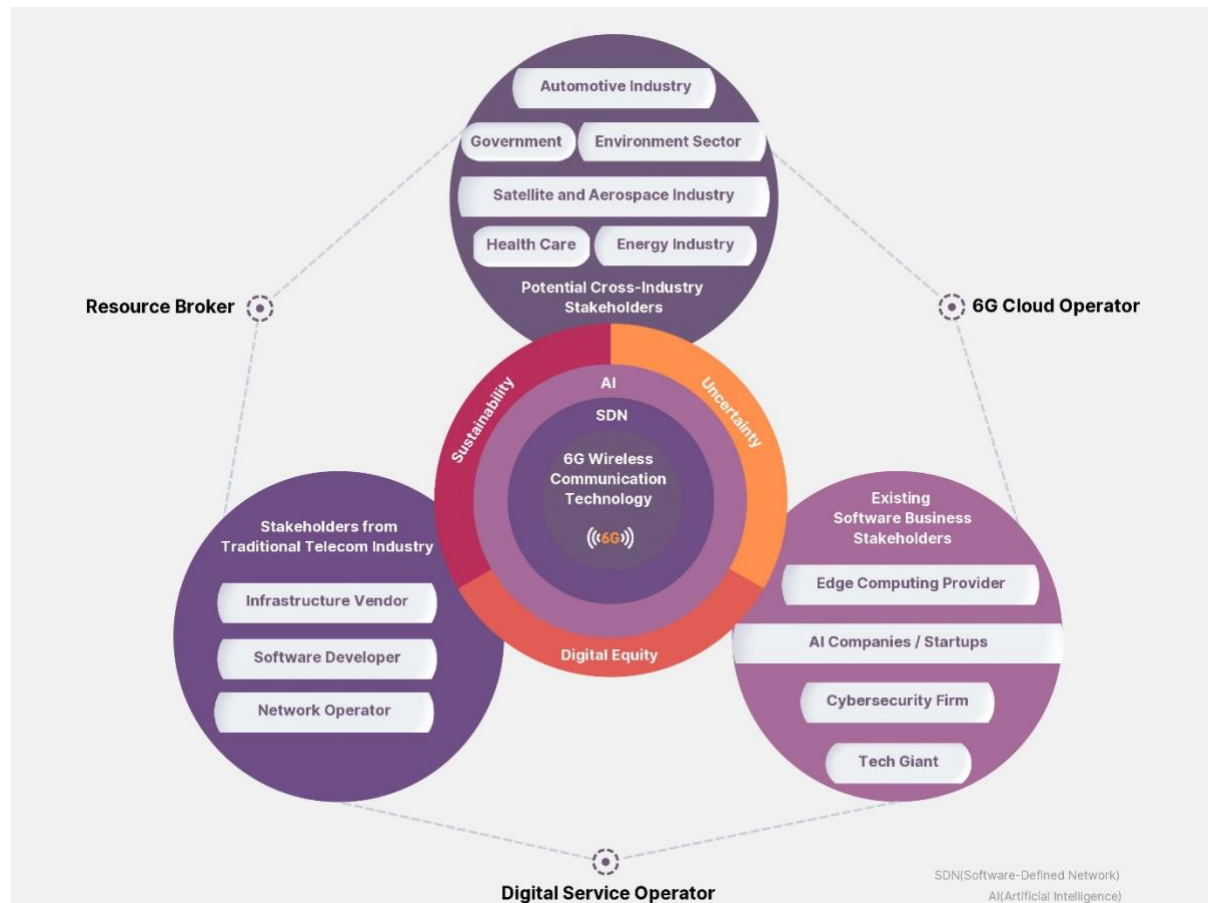


Figure 1: A Framework of 6G Software Business Ecosystem

In Figure 1, 6G enabling technologies occupied the core position of the ecosystem, yet they do not directly interact with most stakeholders. The connections between technologies and stakeholders are established through AI, in a seamless, intelligent, and comprehensive approach. AI serves as one key driving force behind 6G while it also encapsulates 6G from the business perspective. The AI-driven 6G software business ecosystem offers significant potential for the emerging and transformation of stakeholders. Each stakeholder tends to take multiple roles simultaneously, resulting in rich value propositions and interweaving value chains. One stakeholder may act as both supplier and consumer roles in varying value chains. Competitive and cooperative relationships can coexist between two stakeholders, specifically, between their different roles. Therefore, the addition of AI and diversity of roles fosters a dynamic and complex 6G software business ecosystem full of possibilities.

4. Conclusion and Future Work

6G technology has started development and aims to be available in 2030. Despite its early stage, proactive exploration 6G software business helps ecosystem formation and attract more stakeholders to participate. Based on the context of the 6G software business, a vision of the ecosystem has been generated as a starting point for bridging the path from 6G technology to 6G software business. By adopting the MA method, the complex and vague 6G software business ecosystem is broken down into smaller and manageable components. Meanwhile, this study suggests a preliminary path from 6G software business vision to 6G technology enablers. In future research work, the aim is to fill in the gaps between stakeholder roles and high-level vision by concretizing the 6G software business use cases in cooperation with industry partners. It will list all possible attributes in each MA dimension and form a practical morphological box, to support software business strategy design in the 6G era.

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