Design of P-RAN Business Model Based on Decentralized Value Co-Production

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Abstract: Based on the value co-production theory, this paper summarizes three key issues of value co-production: resource coordination, operation governance and risk management. Then, this paper constructs a decentralized value co-production model by combining with the characteristics of decentralized products. Based on this model, this paper analyzes how to realize value co-production in decentralized network P-RAN, and finds that users in decentralized network can independently control sharing and use according to their own network resources, thus forming an "Online to Earn" operation mode. The decentralized network still faces many risks, which need to be solved by technological and operational innovation in the future.

1 INTRODUCTION

The era of decentralized Web 3.0 has arrived. Web 3.0 is the next generation of "Read+Write+Own" network compared to Web 1.0 and Web 2.0. Web 1.0, where users can only read what the website provides, is a typical centralized product. Web 2.0 realizes the interaction between users and the network, and urges enterprises to shift from the typical product-led logic based on product cost performance to the typical service-led logic based on providing a full set of service solutions (Vargo, 2020; Yoo, 2010), thus leading to the development of centralized products. Under the operation and management of the centralized platform, enterprises, users, suppliers and other roles can jointly obtain value promotion (Heidenreich, 2015; Prahalad, 2000), which accordingly realize value co-production. In this case, some users can serve as resource delivery nodes. For example, social media users are both content creators and readers, which has already had the initial prototype of decentralization. With the development of blockchain technology and the improvement of computing power, as well as the urgent needs of users for personalized services and data controls in their own hands, Web3.0 comes into being.

In the Web 3.0 era, decentralized products emphasize returning control of the internet to users. At present, many decentralized products, such as Bitcoin and Decentralized Finance (DeFi) products, have been accepted and recognized by governments. It is foreseeable that decentralized Web 3.0 will become a new focus of international competition in the future. Therefore, based on the three breakthrough points of the value co-production theory and the characteristics of decentralized products, this paper analyzes and constructs the decentralized operation model. By applying the decentralized operation model, this paper focuses on how mobile network operators (MNOs) can innovate products and services in the 5G+/6G era and then puts forward business proposals for them.

2 RESEARCH ON DECENTRALIZED VALUE CO-PRODUCTION MODEL

2.1 Value Co-Production

Value co-production was first proposed by scholar Ramirez R (1999) (Ramirez,, 1999), which is jointly created by two or more participants, including mutual value and value created for other participants. Value co-production theory has developed rapidly in the era of internet economy. With the progress of Internet technology, enterprises have been liberated from the constraints of the concept and model of value creation (Hirschhorn, 1984; Trist, 1981). It is believed that

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consumers hope to Interact with professionals, service providers and other consumer groups to achieve value co-production (Prahalad, 2004), and it is believed that intangible resources such as services will also promote the improvement of value (Vargo, 2014). Some scholars have studied how enterprises coordinate to achieve value co-production from the aspects of resource coordination (Bharti, 2015; Lavie, 2006), operation governance (Dhanaraj, 2004; Gawer, 2002) and risk management (Prahalad, 2004). It can be seen from the existing research that value co-production is the process of value maximization in economic exchange of various production factors (human factors, material factors and their combination factors). To achieve value co-production, enterprises or products need to focus on three breakthrough directions: resource coordination, operation governance and risk management.

2.2 Decentralization Value Co-Production

Decentralization is initiated by the idea of Web3.0 network. Every node is the center, which can connect and influence other nodes. It has the characteristics of flat, open source and equality. A decentralized product replicates the corresponding functions of centralized products in a decentralized manner (flat, open source, equality, etc.). In order to find out how to realize value co-production of decentralized products, this paper will conduct a detailed analysis from three breakthrough directions of value co-production: resource coordination, operation governance and risk management.

(1) Resource coordination: from centralized management to spontaneous management, thus improving quality and efficiency

The resource coordination and integration of decentralized products is spontaneous. The value is mainly generated from the common authentication of each node. The traditional centralized products realize value promotion by coordinating the resources of the upstream and downstream of the whole industry and form a chain structure. Traditional centralized products review the qualifications of suppliers, distributors and other users who provide known resources, and adjust supply and demand by means of automatic algorithm matching, big data recommendation matching or stakeholder interference matching. Since the evaluation of resources in the later stage mainly depends on user evaluation, paid posters and advertisement can easily have a negative impact on the merchant platform, which will reduce the efficiency of information searching for users. For example, search engines such as Google distort search rankings for their own benefits.

Decentralized products are managed by individual nodes in coordination with each other to form a network ecosystem, so the resource management has spontaneity. Nodes identify and judge the value of resources by voting. Based on the consideration of their own benefits, nodes will make careful judgments to reduce the adverse influence caused by false information. Taking the decentralized search product Token Curated Registries (TCRs) as an example. Through the voting judgment of nodes and optimizing the screening mechanism of resources, TCRs can effectively select the candidate content with the best quality, and puts it into TCR (Asgaonkar, 2018), which is convenient for users to find valuable information.

(2) Operation governance: build X to Earn incentive mechanism to stimulate user initiative

Decentralized products emphasize the improvement of data autonomy and algorithm autonomy of users, weaken the centralized management ability of products, and enhance user activity through incentive mechanism. With the help of the control of production factors such as channels and data, the centralized products have the innate control and supervision power over users. Centralized products coordinate user behaviors through various rules, and achieve platform profits increase through flow realization, commission sharing, value-added services and charged services. The operation of the centralized products depends on the data privacy rights and content selection rights given by users. If data abuse occurs, it is difficult for users to ensure the security of their account data. For example, Facebook and Twitter blocked Trump's account.

Decentralized products do not have such centralized rights. To achieve similar operational and regulatory capabilities as centralized products, decentralized products must rely on incentive mechanism design to provide power for the flow of production factors. Therefore, decentralized products try to combine smart contracts, Decentralized Autonomous Organization (DAO), DeFi and other tools to relate user revenue to user behavior, which create a new profit model "X to Earn (X2E) (X represents user behavior, such as learn, write, play, etc.)". In the metaverse game Axie Infinity, users can earn SLP tokens to feed NFT pet Axie through pvp, pve and completing daily tasks, which realizes a new profit model of Play to Earn (P2E). Through this incentive method, rights are reserved at each node as much as possible. Even if harmful information appears, it will be recorded in the

product to facilitate supervision and governance. For example, the decentralized social media Steemit will not delete the content of low quality, but will only hide it.

In short, decentralized products use blockchain to reduce or eliminate reliance on third-party institutions, and enhance user choice. At the same time, decentralized products connect behavior with profit to form a more and richer X2E incentive mechanism in the future, which will promote the value flow of production factors.

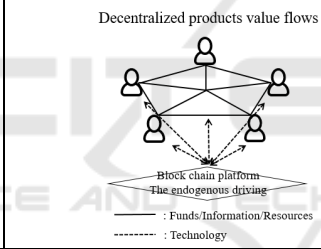
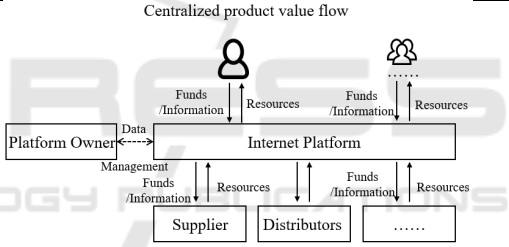
(3) Risk management: decentralization reduces risks by operational means such as limiting transactions, establishing third-party neutral institutions, and technical means such as blockchain technology

Decentralized products present a network operation because nodes do not interfere with each other. Compared with centralized products, the risk degree is higher and the risk spreads faster. Therefore, it is necessary to explore new risk management methods. Traditional centralized products can use centralized platforms to supervise or block fraudulent transactions, harmful information, data leakage, etc.

In order to solve the above risks, decentralized products, on the one hand, take advantage of technological innovation, and based on blockchain, propose Decentralized ID (DID) and smart contract to solve the issues of identity verification and property rights clarification, so as to reduce the risk of data leakage and reduce the memory cost caused by account non-communication of centralized products. On the other hand, decentralized products use certain operational innovations to reduce transaction risks. For example, Steemit reduces the risks of illegal transactions by limiting the time and frequency of transactions. In addition, third-party neutral institutions also provide support for decentralized products to reduce fraudulent transactions by providing trusts.

Based on the above analysis, this paper summarizes the comparison of operation models of decentralized products and centralized products as shown in the following Table 1:

Table 1. Comparison of value co-production models between decentralized products and centralized products.

	Web3.0 decentralized products	Web2.0 centralized products
Schematic diagram		
Value co-production subject	• Individual user nodes constitute a decentralized product ecology • Connection mode: node-node • Rights: user rights > decentralized products	• Users, suppliers, distributors and third-party organizations constitute the industrial chain • Connection method: supplier-platform; distributors - platform; user-platform • Rights: centralized products > user rights
Value Co-production resource governance	• Resource source: node creation • Value judgment criteria: node voting, subjective judgment, etc • Management mode: based on blockchain technology	• Source of resources: provided by suppliers • Value judgment criteria: the central platform is based on objective criteria • Management mode: platform management, algorithm implementation
Value Co-production operation management	• Product profit: commission sharing, etc • Incentives: X2E • Data management: data and computing power are stored in individual nodes • Operation structure: network operation	• Product profit methods: flow realization, commission sharing, value-added services, charged services, etc • Incentives: promotions, discount activities, etc • Data management: data and computing power are stored on the platform, and the platform can optimize operations through big data analysis • Operation structure: chain operation
Value Co-production risk management	• A higher risk level than centralized products • Adopt technology, operation and other means	• Rely on a centralized platform to manage risk

2.3 Design of Decentralized Value Co-Production Model

Based on the summary of value co-production theory and the characteristics of decentralized products, this paper constructs a decentralized value co-production model as shown in the Figure 1 below. Decentralized product value co-production model solves the problems of resource coordination, operation governance and risk management of production factors through flattening, open source and equalization, so as to achieve value growth. Decentralized value co-production is reflected in the spontaneous management of resources. Under the promotion of the "X2E" incentive mechanism, nodes automatically create value and judge value. It has the characteristics of endogenous autonomy, which reduces the memory cost of users, gives users real data autonomy, improves users' autonomy in front of algorithms, and establishes a new trust and collaboration relationship.

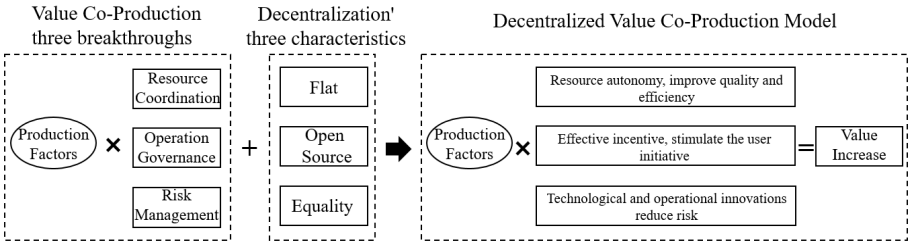


Figure 1: Decentralized value co-production model

3 APPLICATION OF P-RAN OPERATION MODEL BASED ON DECENTRALIZED VALUE CO-PRODUCTION

3.1 Introduction of P-RAN

The development of decentralization is evolving in stages, from products to services. At present, experts and scholars have put forward many products and ideas for the decentralized transformation of organizational and financial services. Similarly, web services, as the foundation to support decentralized products, have also received attention. Among them, Qi Bi (Bi, 2022), from China Telecom, proposed the idea of Web3.0 decentralized network P-RAN (as shown in the Figure 2) from the perspective of network architecture, which uses idle mobile terminals of users as mobile relay and provides network coverage services for users in areas with weak coverage or even no coverage through multi-hop connection to cellular networks. It solves the problem of decentralized infrastructure from the fundamental level of network access. From the distribution form of the network, it can be seen that P-RAN is a decentralized network. Users can use the network and share the network with others. Each person is both a terminal and a relay. This way of network implementation provides a thinking direction for exploring decentralized network services. This paper analyzes the business value model of decentralized P-RAN according to the current decentralized product value co-production operation model, which is helpful to judge the value of decentralized network service development in the future.

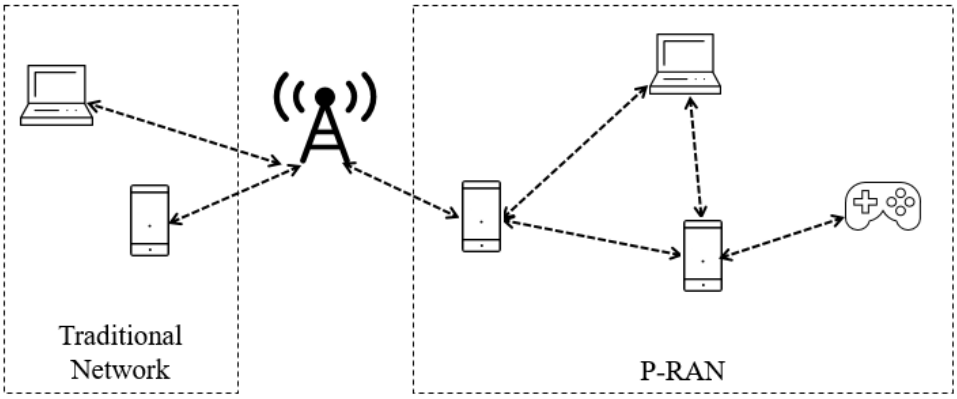


Figure 2: P-RAN Schematic Diagram.

3.2 Application of P-RAN in Decentralization Value Co-Production

Resource Coordination

Compared with the traditional network, P-RAN users have greater control over network resources. Users play a dual role in the network, not only as users but also as sharers. Traditional network resource allocation requires MNOs to build network base stations according to the demand through network planning. With the continuous update of technology, network coverage will inevitably develop towards higher frequency. However, the high-frequency signal has a low barrier-breaking ability, so more base stations are needed to achieve full coverage, and the cost of network construction will increase gradually. Furthermore, with the continuous development of mobile applications, users' demand for data usage is also very different. Although the existing data usage packages are graded according to the amount of data usage, they can't realize targeted package design according to the preferences of each user.

To solve the above problems, the P-RAN network is connected by intelligent terminals, and each network user is regarded as a node. By encouraging nodes to share the idle data usage in the package, the P-RAN network provides network for users in weak coverage areas, thus, realizing resource matching and improves the utilization rate of network resources. Through the coordination between nodes, the original network dominated by MNOs has been upgraded to a decentralized network jointly built by MNOs and users, and users can control the sharing and use of network resources independently according to their own needs.

Operation Governance

According to the network architecture of P-RAN, it can be seen that in the early stage of P-RAN, node users need to join quickly, and the rapid increase of relay nodes can form a mesh connection relationship and promote the whole network construction. Traditional MNOs have mostly used two approaches to promote network construction. One is to provide a good network experience through technical means to attract users to join, such as Deutsche Telekom's successful test of stratospheric base stations designed to help achieve mobile signal coverage in remote areas where terrestrial connecting networks are difficult to reach. The other is through marketing strategy, by promoting web application development and thus attracting users. For example, South Korea Telecom uses synergistic development with the edge cloud to build 5G clusters/communities to enable direct communication and interaction with users in the region with large bandwidth. It can be seen that P-RAN is different from the traditional way of providing high-quality network to attract users for promotion. Therefore, the incentive mechanism of P-RAN network operation is especially important.

According to the previous analysis, the incentive mechanism of decentralized products trend to use the X2E approach to manage users. P-RAN can also use "token" as an incentive method to build "Online to Earn (O2E)", thus attracting users to share. Firstly, MNOs can rely on a combination of objective and subjective network performance characteristics, such as QoS, network speed, user connection times, user ratings, etc., so as to provide a fair and objective value judgment criteria for identifying user contributions. Secondly, MNOs can also refer to the form of Tiktok topic challenge for network weak coverage areas to identify and issue rewarding "token" rewards to attract nearby users to share the network. Finally, the establishment of "token" also provides support for MNOs to supervise the traceability of illegal information, which is helpful to purify the network environment.

Traditional networks rely on connecting B-side and C-side users to gain profits. In contrast, P-RAN uses a distributed network architecture, which can expand this con-nectivity capability and incubate more business scenarios. The trend of next-generation network is the integration of space and earth, and the combination of reality and virtual reality. The decentralized network will promote the formation of full-coverage network and provide a faster and more convenient way of network coverage compared to base stations for daily weak coverage network supplement, global network roaming, emergency network construction and other scenarios. P-RAN through device-to-device (D2D) connectivity is also helpful to identify proximity connection relationships, which can be utilized to drive proximity service model innovation such as accurately identifying potential COVID-19 infected persons, accurately placing promotional information in shopping centers and etc.

Risk Management

Compared with traditional networks, decentralized networks will face more risk issues, such as technical implementation risks, identity security risks, and risks brought by "O2E" operation mode. From the current stage, it is necessary for MNOs to lead the establishment of P-RAN networks; MNOs can provide credit endorsement and legal supervision for network security issues.

To solve these problems, apart from the risk management methods of existing networks, decentralized networks can also verify users' identity through the dual method of "physical SIM card + virtual account password". When users share data usage or connect to other sharers' hotspots, their identity information will also be recorded on the blockchain along with data usage changes, thus ensuring network security from a technical perspective. In the process of asset trading, MNOs can use methods such as limiting the time and frequency of transactions to reduce the operational risks that may be associated with O2E.

Besides the risk management of the decentralized network itself, P-RAN, as a decentralized infrastructure, can provide authentication at network access level for other decentralized products. MNOs can even serve as third-party organizations to provide risk management support in other decentralized products, such as tracking illegal information or even blocking it from network access level, thus improving the network security of users at application level.

3.3 Discussion

Combined with the previous analysis, a comparison of decentralized network operation and traditional network operation is summarized as shown in Table2:

Table 2: Comparison between Decentralized P-RAN Network and Traditional Network Based on Value Co- Production.

	Decentralized Network P-RAN	Traditional Network
The main body of the network	• MNOs and users jointly build and own decentralized network • Network connection mode: user-user; user-base station	• MNOs build and own networks • Network connection mode: user-user-base station
Network resource management	• Source of Network Resource: MNOs and user • Network Judgment Criteria: QoS, network coverage time, user connection times and user ratings, etc. • Data usage management: users purchase a fixed package, and the remaining data usage can be shared with other users	• Source of Network Resource: MNOs • Network Judgment Criteria: QoS, etc. • Data usage management: users purchase a fixed package
Network Operation Governance	• Incentive Mechanism: O2E • Data management: user and MNO • Potential expansion strategies: full coverage scenarios, proximity service scenarios, other decentralized applications	• Incentive Mechanism: combination of Technological innovation (improving network coverage) and marketing innovation (package discounts, etc.) to attract user to join • Data management: MNO • Potential expansion strategies: expand users with 2B2C mode
Network Risk Management	• Identity authentication through the dual method of "physical SIM card + virtual account password" • Limiting transaction time or frequency • Potential Expansion Service: provide risk management support for other decentralized products	• Identity authentication through "Account + Password"

According to the above table, it can be seen that P-RAN decentralized network is a practice in decentralized value co-production operation model, which is reflected in the following three aspects.

First, P-RAN is a network infrastructure jointly owned by users and MNOs. P-RAN is a decentralized network dominated by MNOs and deeply involved by users.

Second, P-RAN is a new economic system which is jointly built and shared by users and MNOs. The value to MNOs is reflected in the more personalized network resources allocation. Taking advantage of the inherent network resources and user, MNOs save investment in base station construction, and expand to achieve full network coverage of Web 3.0. The value to users is reflected in the self-control of network resources; users can even make profits through the "O2E" model. For other enterprises, the value is reflected in the incubation of more Web3.0 applications and the landing of proximity service scenarios under the support of P-RAN network.

Third, in terms of network risk management, MNOs solve the risk of P-RAN network technology implementation, identity security and the risk brought by the "O2E" operation mode through technical and operational means, and build a safe, credible and valuable network. With the dual support of MNOs' credit endorsement and immutability of blockchain, P-RAN's security is fully guaranteed and provides risk management support for other decentralized products.

The relationship between decentralization value co-production and decentralized network P-RAN value co-production is shown in the following Figure 3:

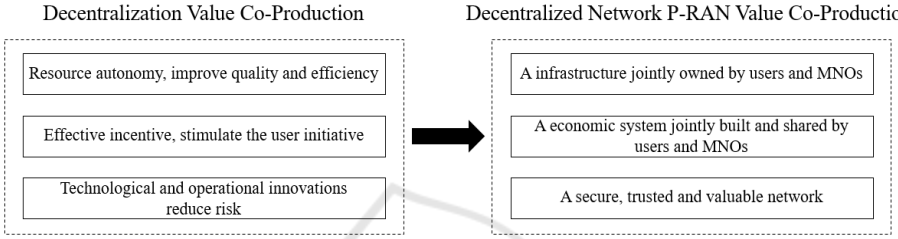


Figure 3: Decentralized network P-RAN value co- production positioning

4 CONCLUSION

In the era of Web 3.0, the rapid development of blockchain technology has promoted the birth of various decentralized products. In this paper, the decentralized product value co-production model is constructed from three breakthrough directions of value co-production (resource, operation, and risk). The value of decentralized products is reflected in the spontaneity of coordinated resource allocation. Under the incentive mechanism of "X2E", nodes have the autonomy of data and algorithm, thus realizing the real "Read+Write+Own".

On the basis of defining the value points of existing decentralized products, this paper analyzes the business model of decentralized network P-RAN. It is found that in terms of network resource allocation, decentralized networks are more autonomous and personalized than traditional networks. On the one hand, MNOs can use the 5G/6G investment savings as the fund source for the decentralized network's rewards pool, incentivizing users to share and use the network through the "O2E" model. On the other hand, users can use idle terminals to share excess data usage within their packages to gain revenue on the basis of ensuring their own network quality, while providing support for MNOs to achieve full coverage. Compared with traditional networks, risk management in decentralized networks is more difficult. In addition to technological innovation, MNOs can also reduce risk by means of authentication, limiting transaction time or frequency, etc. Ultimately, with the participation of users and MNOs, the decentralized network will become a secure and valuable network infrastructure and economic system.

On the basis of traditional network 2B2C business, the decentralized network is expected to incubate more new business and bring more potential value to other en-terprises. Driven by the decentralized network, new decentralized products will drive the rapid growth of users and data usage across the network, and finally form a value growth cycle. At the same time, the decentralized network can also promote the innovation of proximity service mode by virtue of the connection characteristics of intelligent terminals, such as providing support for precise epidemic prevention and control, merchant information promotion, etc. In the future, the decentralized network can be expanded into a global Web 3.0 network, and users traveling abroad will not need to open international roaming. Combining the above factors, the construction of a decentralized network can achieve growth in the overall value of MNOs, enterprises and users, and drive the birth of more decentralized products.

Due to limited time and energy, the vision of decentralized infrastructure con-struction in this paper

is summarized according to the characteristics of existing decentralized products. In the future, more research is needed to solve problems such as how to realize the compatibility between decentralized networks and existing networks, and how to achieve network interface among MNOs. Meanwhile, in the process of decentralized operation, the supervision of decentralized network still needs legal support; how to quickly block illegal information and how to coordinate the property rights system of network sharing are also issues that need to be addressed. These problems require not only the technical innovation by MNOs and enterprises, but also the support of government regulatory authorities. Currently, decentralized infrastructure is in its envisioned stage, but with the progress of technology, more applications will emerge.

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